City of Doral

Canal
Feasibility Study Report

FINAL

Prepared for:

Prepared by:

A-D-A ENGINEERING

and

DUNKELBERGER
engineering & testing, inc.

in association with

Professional Service Industries, Inc.
F.R. Aleman and Associates, Inc.

May 2008

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May 14, 2008

Erick Carrillo
Stormwater Utility Manager
City of Doral
8300 Northwest 53rd Street, Suite 200
Doral, Florida 33166

REFERENCE: City of Doral Final Canal Feasibility Study Report

Dear Mr. Carrillo:

A.D.A. Engineering, Inc. (ADA) and Dunkelberger Engineering and Testing (DET) are pleased to submit the attached Final Canal Feasibility Study Report. This report was prepared in accordance with the Scope of Work outlined in the February 27, 2008 Work Order (Resolution 08-04), which is part of the General Consultants for Engineering and Architectural Services between the City of Doral (City) and ADA.

We are pleased to be of service to the City of Doral on this important project assignment. If you have any questions or need additional information, please do not hesitate to contact Alberto Argudin, P.E. or me at (305) 551-4608.

Sincerely,

A.D.A. ENGINEERING, INC.

Alex Vazquez, P.E.
Vice President
FL Registration No. 42108

DUNKELBERGER ENGINEERING & TESTING, INC.

Kevin Aubry, P.E.
Geotechnical Service Manager
FL Registration No. 38175

Enclosures: Final Canal Feasibility Study Report

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EXECUTIVE SUMMARY

The City of Doral (City) is located in the western-central portion of Miami-Dade County and encompasses approximately 15 square miles (9,600 acres). There are approximately 11.1 miles of canals that are maintained by the City as follows:

- Dressels Canal from the Palmetto Expressway to the Florida Turnpike (approximately 5.2 miles)
- Northline Canal (along NW 25th Street) from the Palmetto Expressway to the Florida Turnpike (approximately 3.9 miles)
- C-2 Extension (along NW 117th Avenue) from NW 25th Street to NW 58th Street (approximately 2.0 miles)

These canals and City limits are depicted on **Figure 1-1**.

The canals maintained by the City have exposed canal slopes that are somewhat erratic in terms of width, slope angle, vegetative cover, and erosion. The level of canal bank erosion of these canals varies throughout the City. Severely eroded canal banks will require some level of canal bank stabilization to avoid potential damage to adjacent properties, reduce sedimentation of the canal cross section (which could impact the carrying capacity of the canals), minimize potential safety hazards created by steep canal banks, and improve the aesthetics of the canal banks.

The City retained A.D.A. Engineering, Inc. (ADA) under the General Consultants for Engineering and Architectural Services agreement between the City and ADA to perform a Canal Feasibility Study (Resolution No. 08-04). The purpose of this Canal Feasibility Study is to document the existing conditions of the canal banks maintained by the City, identify potential needs for stabilization, recommend conceptual methods for stabilizing the canal slopes in areas that require remedial action, summarize planning-level costs for stabilizing the canal slopes, and identify the permit agencies having jurisdiction over proposed improvements and their pertinent regulatory criteria.

ADA retained Dunkelberger Engineering and Testing, Inc. (DET) to assist with the data collection, geological reconnaissance, canal bank stabilization assessment and preparation of the Canal Bank Stabilization Feasibility Study Report. ADA also retained F.R. Aleman & Associates, Inc. (FRA) to obtain canal cross sections (including the sub aqueous portions) at 17 representative canal locations and retained Professional Service Industries, Inc. (PSI) to drill and sample six (6) Standard Penetration Test (SPT) borings throughout the City.

The results of the geologic reconnaissance were utilized to classify and categorize the canal system maintained by the City, in terms of the severity of the erosion of the canal banks and the potential need for stabilization. The categories are as follows:

1. **High –** The canal slopes are very steep, and/or the horizontal position of the top of bank varied considerably along the canal alignment and large amount of bank erosion.
2. **Medium –** Canal slopes are moderately steep, somewhat irregular, and having moderate erosion and vegetation.
3. **Low –** The canal slopes are relatively uniform and reasonably well maintained with only minor erosion observed.
4. **None -** Canal slopes are uniform and very well maintained.

Appendix G includes several maps summarizing the canal bank erosion level of severity observed. The classifications were based largely upon the visual appearance (i.e. aesthetics) of the exposed portions of the canal slopes at the time of the observation and were based on professional engineering judgment. Criteria used for the classification included the relative steepness of the slopes, the consistency of the alignment of the top of canal bank, amount of erosion, and condition of the vegetative cover.

The stability of the existing canals was assessed for a typical or representative City canal condition using the information gathered from the engineering borings, the surveyed cross sections and the geologic reconnaissance. The results of the stability analyses indicate that the typical canal bank has a minimum Factor of Safety of approximately 18, which is very high (i.e. safe) compared to standard Factor of Safety of 2 or 3. Therefore, the canal banks within the City do not appear to be unstable from the standpoint of a potential slope failure. However, the relatively steep canal banks do present difficulties with respect to mowing and maintenance, aesthetics, and may represent a safety concern for pedestrians and/or cyclists.

Several canal bank stabilization methods were considered for armoring the slopes against surficial erosion as well as improving the aesthetic appearance of the banks, reducing maintenance efforts, and reducing the steepness of the slopes. **Table 4-2** outlines five (5) viable canal bank stabilization options, planning-level unit costs for design and construction, slope required for placement, and anticipated level of aesthetics. Of the conceptual bank stabilization measures considered for this project, it is proposed that Options 1 and 2 (Articulated Block and Geoweb, respectively) are the most appropriate for use on the City canal slopes. However, based upon review of the unit costs, advantages and disadvantages of these two options, it is proposed that Canal Bank Stabilization Option 2 (Geoweb) provides the optimum combination of aesthetics and economy, and is therefore the most practical for stabilizing canal banks within the City of Doral. Localized sections of canals may require other stabilization methods due to right-of-way limitations or other restrictions. The final determination for the most appropriate stabilization methods should be made as part of a design level study.

It is recommended that the City implement the necessary canal bank improvements in a two-phase Canal Capital Improvement (CIP) Plan. Phase I should include the high

erosion severity classified areas. The Phase I should be implemented over a two-year period (Years 1 and 2). Phase II should include the medium to low erosion classified areas and should be implemented over a eight-year period (Years 3 through 10). Using the unit prices for canal bank stabilization presented in the previous section of this report, use of the Geoweb method to remediate all portions of the canal banks that are currently classified as highly eroded (Phase I) will cost approximately $2.5 million. Remediation of the same length of canal banks using Articulated Block will result in a capital expenditure of about $3.4 million. Extending these repairs to the portions of the canal banks that are classified as medium and low in terms of bank erosion severity will result in additional costs of approximately $2.1 million and $2.8 million for the Geoweb and Articulated Block methods, respectively.

Tables 5-5 and **5-6** summarizes the planning-level construction and design costs to implement Geoweb and Articulated Block methods, for comparative purposes, for each the high erosion canal and bank erosion classification and combined medium and Low canal and bank erosion classification (CIP Phase I and II). **Table 5.7, 5-8 and 5-9** further subdivide the construction and design cost (combined) for specific reaches for the Dressels Canal, Northline Canal, and C-2 Extension Canal, respectively.

The final determination for the most appropriate stabilization methods should be made as part of a design level study. The design level study needs to include a property boundary survey in order to select the most appropriate alternative on a case-by-case basis. It should also be noted that these planning-level costs should be considered in order of magnitude and for planning and cost comparison only. More rigorous cost estimates should be completed prior to finalization of designs for canal bank stabilization.

All canals within the City are within Miami-Dade County owned or controlled canal right-of-way, reservation, or easement. A Class III permit is required for any construction activities within Miami-Dade County owned or controlled canal right-of-way, reservation, or easement. Therefore, all of the proposed canal bank stabilization options will require a Miami-Dade County Department of Environmental Resources Management (DERM) Class III Permit.

1.0 INTRODUCTION

1.1 Background

The City is located in the western-central portion of Miami-Dade County and encompasses approximately 15 square miles (9,600 acres). The City is bounded by NW 90th Street to the north, the Florida Turnpike to the West, State Road 836 (Dolphin Expressway) to the South and State Road 826 (Palmetto Expressway) to the East. **Figure 1-1** shows the City limits. There are several canals within the City:

- Dressels Canal
- 58th Street Canal

- Northline Canal (NW 25th St Canal)
- C-2 Extension Canal (NW 117th Avenue Canal)

The City maintains portions of these canals as follows:

- Dressels Canal from the Palmetto Expressway to the Florida Turnpike (approximately 5.2 miles)
- Northline Canal (along NW 25th Street) from the Palmetto Expressway to the Florida Turnpike (approximately 3.9 miles)
- C-2 Extension (along NW 117th Avenue) from NW 25th Street to NW 58th Street (approximately 2.0 miles)

The limits of the canals located within the City and canals maintained by the City are also shown in **Figure 1-1**. The approximate 11.1 miles of canals maintained by the City have exposed canal slopes that are somewhat erratic in terms of width, slope angle, vegetative cover, and erosion. These canals are adjacent to both residential neighborhoods and commercial properties located throughout the City. The level of canal bank erosion of these canals varies throughout the City. Severely eroded canal banks will require some level of canal bank stabilization to avoid potential damage to adjacent properties, reduce sedimentation of the canal cross section (which could impact the carrying capacity of the canals)), minimize potential safety hazard created by steep canal banks, and improve the aesthetics of the canal banks.

1.2 Purpose and Scope

The City retained A.D.A. Engineering, Inc. (ADA) under the General Consultants for Engineering and Architectural Services agreement between the City and ADA to perform a Canal Feasibility Study (Resolution No. 08-04). The purpose of this Canal Feasibility Study is to document the existing conditions of the canal banks maintained by the City, identify potential needs for stabilization, recommend conceptual methods for stabilizing the canal slopes in areas that require remedial action, summarize planning-level costs for stabilizing the canal slopes, and identify the permit agencies having jurisdiction over proposed improvements and their pertinent regulatory criteria.

The scope of services associated with this canal feasibility study is outlined in the December 19, 2007 Services Order. This Service Order includes project coordination with the City staff, data collection, canal surveying and mapping, subsurface exploration, and preparation of a Canal Bank Stabilization Feasibility Study Report. ADA retained Dunkelberger Engineering and Testing, Inc. (DET) to assist with the data collection, geological reconnaissance, canal bank stabilization assessment and preparation of the Canal Bank Stabilization Feasibility Study Report

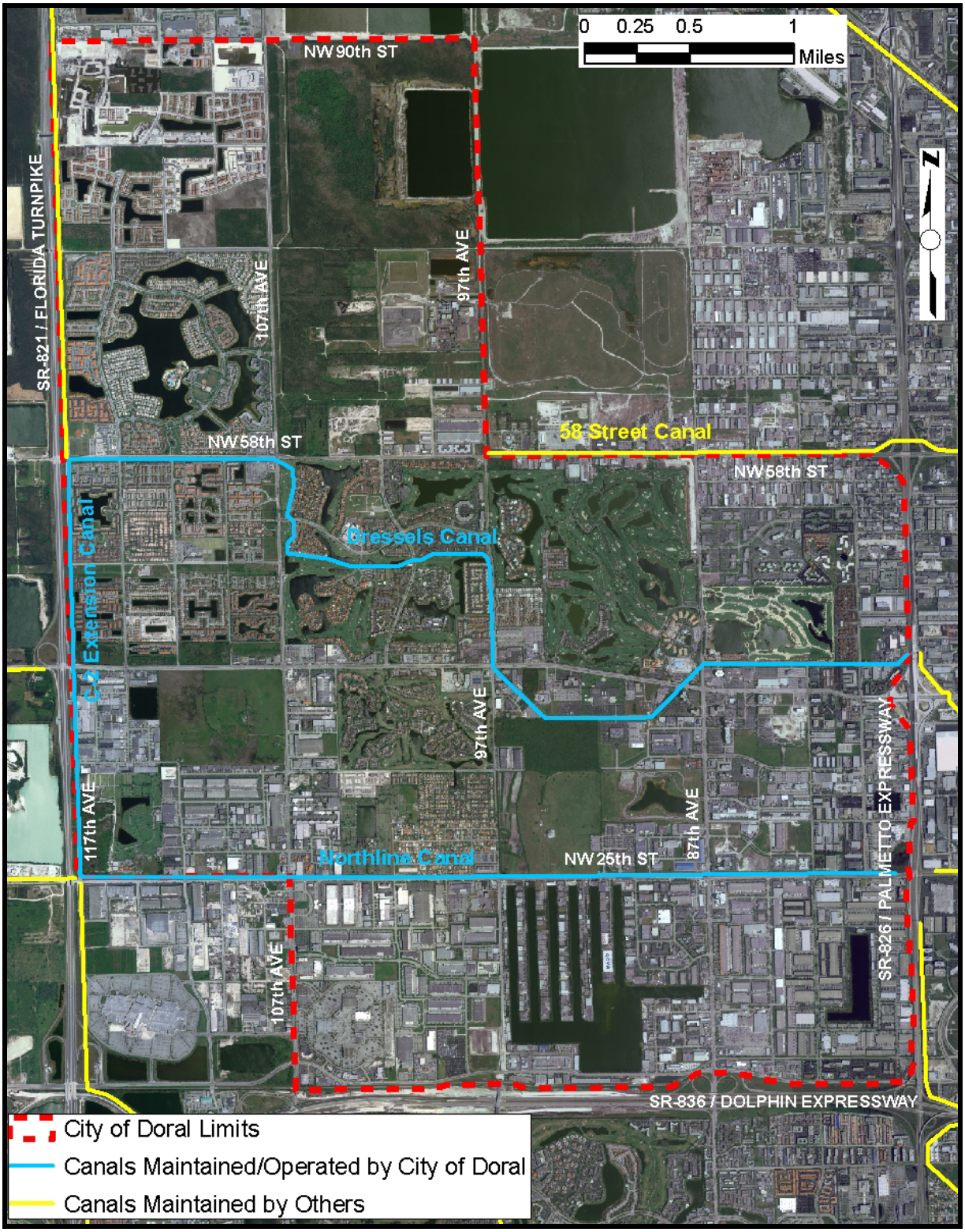


Figure 1-1 : City of Doral Limits and Canals

2.0 DATA COLLECTION AND EVALUATION

Evaluation of the existing canal banks within the City was completed by 1) measuring the cross section of the canals at 17 locations considered to be representative of the canal system, 2) drilling and sampling six (6) engineering borings at strategic locations throughout the City, 3) review of published surficial soils maps for the project vicinity, and 4) on-the-ground reconnaissance of the canal bank conditions and mapping of the canal bank erosion in terms of severity. Discussions related to the data acquisition methodology, key findings from the surveys, subsurface exploration, and geological mapping are described in the following subsections.

2.1 Canal Surveying and Mapping

ADA retained F.R. Aleman & Associates, Inc. (FRA) to obtain canal cross sections (including the sub aqueous portions) at 17 representative canal locations. The locations of the cross sections were selected by DET as representative of the typical canal bank conditions that are found within the canal system and are depicted on **Figure 2-1**. The cross sections were tied horizontally to the State Plane Coordinate System, Florida East Zone, North American Datum (NAD) of 1983 (adjustment of 1990) and vertically to the National Geodetic Vertical Datum of 1929 (NGVD 1929). The cross sections elevations were determined using differential leveling techniques with accuracy to the nearest 0.01 foot. Right of way surveying was not included as part of the canal surveying and mapping scope included in the December 19, 2007 Services Order. The cross sections are included in **Appendix A**.

Using the information provided on the cross sections, average side slopes for the canal banks were estimated. These slopes are presented in **Table 2-1**.

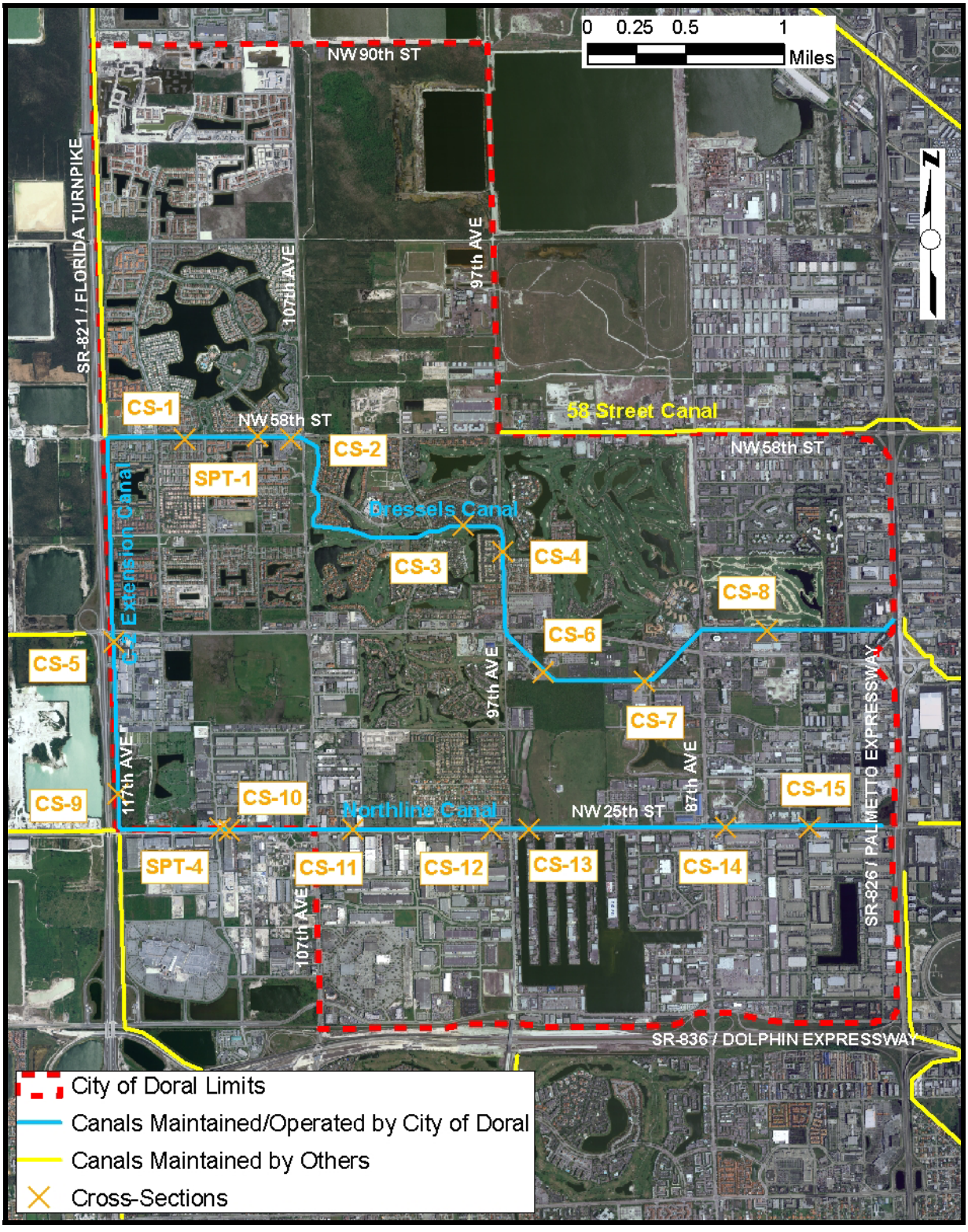


Figure 2-1 : Canal Cross Section Location

Table 2-1 : Canal Cross Section Average Slopes

Canal Cross Sections – Average Slope Angles				
Cross Section No.	Above Water	Below Water	Above Water	Below Water
	Left Slope (H:V)		Right Slope (H:V)	
CS – 1	1.43:1	0.67:1	1.19:1	1.19:1
CS – 2	0.49:1	1.73:1	1.48:1	0.89:1
CS – 3	1.54:1	1.04:1	1.11:1	0.58:1
CS – 4	1.00:1	1.54:1	1.38:1	0.84:1
CS – 5	1.80:1	0.51:1	1.80:1	0.91:1
CS – 6	1.73:1	1.73:1	1.60:1	1.19:1
CS – 7	2.61:1	1.60:1	1.60:1	0.62:1
CS – 8	1.54:1	1.15:1	0.90:1	2.36:1
CS – 9	0.93:1	1.43:1	1.48:1	1.19:1
CS – 10	1.38:1	1.19:1	1.43:1	1.15:1
CS – 11	2.48:1	1.07:1	2.48:1	0.58:1
CS – 12	1.38:1	1.00:1	1.23:1	0.70:1
CS – 13	1.88:1	1.15:1	1.38:1	1.38:1
CS – 14	1.66:1	1.33:1	1.60:1	1.00:1
CS – 15	0.93:1	3.08:1	0.97:1	0.97:1
SPT – 1	1.23:1	3.73:1	1.19:1	2.48:1
SPT – 4	1.48:1	0.90:1	1.80:1	0.81:1
High (i.e. Flat)	2.61:1	3.73:1	2.48:1	2.48:1
Low (i.e. Steep)	0.49:1	0.51:1	0.90:1	0.58:1
Average	1.50:1	1.46:1	1.45:1	1.11:1

2.2 Subsurface Exploration

ADA retained Professional Service Industries, Inc. (PSI) to drill and sample six (6) Standard Penetration Test (SPT) borings, each to a depth of 25 feet below the land surface. The locations of the SPT borings were selected by DET's representative to assess the regional geology and subsurface conditions within the City limits and are depicted on **Figure 2-2**. Subsurface profiles and pertinent data of the six (6) SPT borings are included in **Appendix B**. The elevation of the top of ground and horizontal location of the SPT boring were determined by FRA, relative to NGVD 1929 and NAD 1983/1990, respectively, and are included in **Appendix C**.

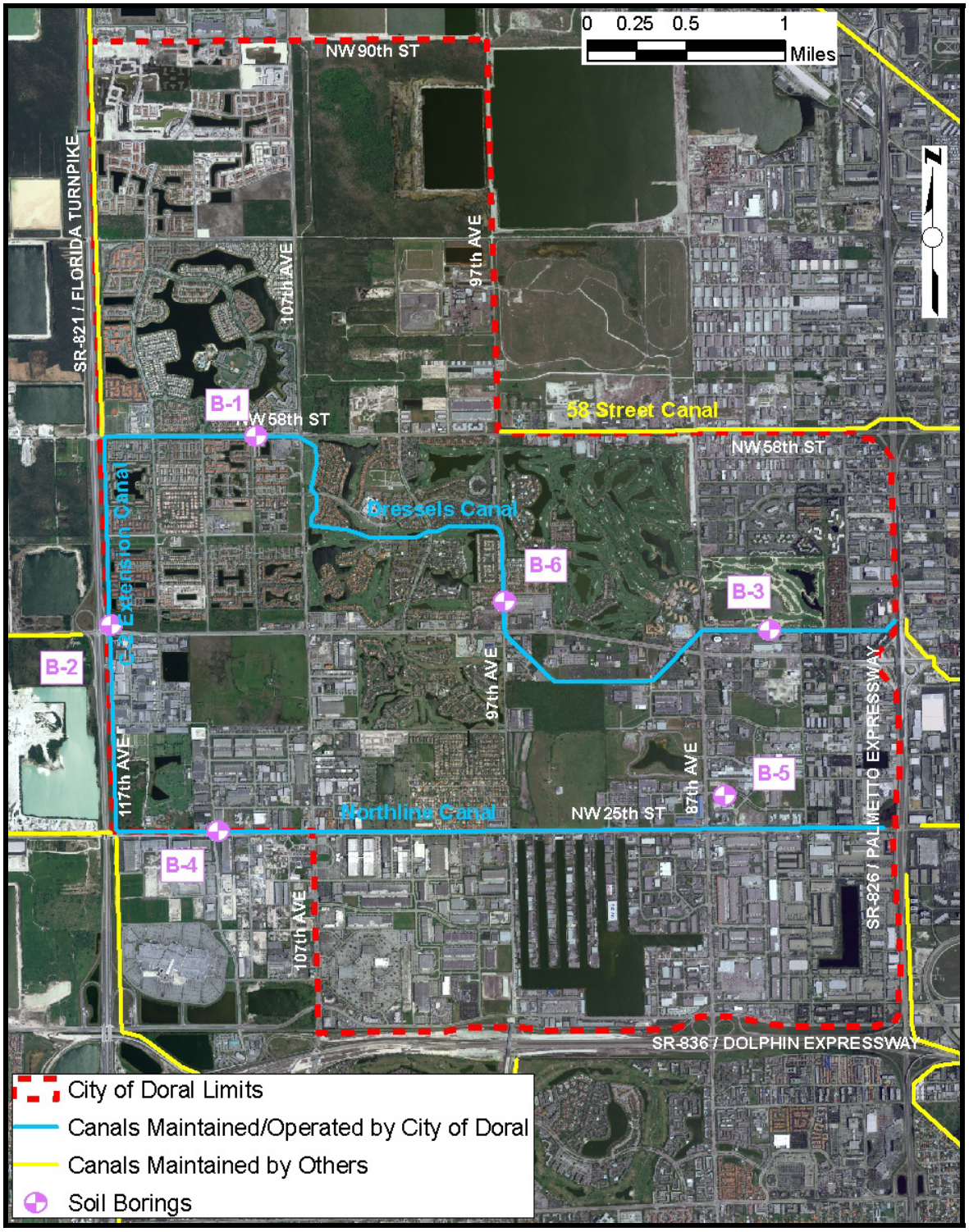


Figure 2-2: Soil Boring Location

2.2.1 Exploration Methodology

The SPT borings were drilled using a truck mounted Central Mine Equipment (CME) 75 drilling rig and mud rotary procedures. Samples of the subsurface materials were obtained by driving a 2-inch diameter standard split barrel under the weight of a 140-pound hammer freely falling a vertical distance of 30 inches (the SPT after ASTM D 1586). The number of such blows required to drive the sampler 12 inches is recorded as the SPT N-Value. The SPT data was gathered using the CME-75 drilling rig equipped with an automatic hammer. The samples were obtained continuously in the upper 10 feet of the subsurface profile, and at 5-foot vertical centers below 10 feet deep. The samples were visually classified in the field, placed in sealed glass jars and then transported to the laboratory for inspection and classification by a geotechnical engineer. Upon completion, each borehole was sealed with cement grout in a bottom to top manner.

2.2.2 Stratigraphy

Samples from the engineering borings were visually classified by a geotechnical engineer in accordance with the Unified Soil Classification System (ASTM D 2487) and appropriate geological nomenclature. Subsurface conditions disclosed by the borings generally indicate that the City project area is underlain by a moderately thick layer of man-placed fill over thin to moderate thicknesses of sands, silty sands and sandy silts over a formation of weakly cemented to well-cemented sandy limestone that continues to the maximum depth explored of 25 feet. The man-placed fill generally consists of sand-gravel mixtures and extends to depths of approximately 1 to 6 feet below the ground surface. The underlying sands, silty sands and sandy silts are 1 to 4 feet in combined thickness. In Boring B-3, these soils were found within the depth interval of 6 to 10 feet below surface grades, and were in a very loose condition. Based upon our experience with Miami-Dade County geology, it is anticipated that this condition reflects a soil filled solution feature within the limestone formation that otherwise occupies that portion of the stratigraphic column. A relatively thin (i.e. 6-inches thick) layer of silty peat was found below the fill in Boring B-4. A formation of sandy limestone was found next in the profile and to the maximum depths drilled.

Table 2-2 provides basic subsurface profile components in terms of average depths, material descriptions and average relative density/consistency/hardness for the subsurface components that underlie the City.

Table 2-2 : City of Doral Subsurface Profile Summary

Depth (feet)	Material Description	Range of SPT N-Values (blows/foot)	Relative Density/ Consistency/ Hardness
0.0 to 3.5	Sandy GRAVEL and/or gravelly SAND (FILL)	5 to 82 (Ave = 21)	Loose to Dense
3.5 to 5.0	SAND, silty SAND and/or sandy SILT (SP, SM, ML)	WOH to 19 (Ave = 9)	Very Loose to Medium Dense
5.0 to 25.0	Sandy LIMESTONE with sand lenses and layers (LIMESTONE)	1 to 50/3" (Ave = 55)	Weakly cemented to very well cemented

2.2.3 Groundwater

Groundwater was measured in the SPT borings when first encountered at depths that ranged between 3.0 and 4.9 feet below surface grades on the dates that the borings were drilled (March 31 through April 4, 2008). Based upon ground surface elevations that were provided by FRA (**Appendix C**), the groundwater elevations generally varied between +1.8 and +3.1 feet with respect to the NGVD 1929. Groundwater levels are likely influenced by surface water level controls in the City canal system.

2.3 Soils Survey Maps

Research of the *Soil Survey of Dade County Area, Florida* (published by the U.S. Department of Agriculture Soil Conservation Service (SCS) in 1996) indicates the surficial soils existing throughout the project alignments generally consist of *Hallandale fine sand, Lauderhill muck, depressional, Dania muck, depressional, Udorthents, water complex, Udorthents, limestone substratum, 0 to 5 percent slopes,* and *Urban land*. These units are described by SCS and as follows:

- **Hallandale – fine sand –** Hallandale fine sand is characterized as a shallow, nearly level, poorly drained sandy soil that has soft, porous limestone bedrock at a depth of about 16 inches. It is found on broad flats between the Everglades and the low, sandy coastal ridge. Slopes are smooth and are less than 2 percent.
- **Lauderhill muck – depressional –** Lauderhill muck, depressional is described as a moderately deep, nearly level, very poorly drained organic soil that is underlain by hard, porous, oolitic limestone at a depth of about 30 inches.
- **Dania muck – depressional –** Dania muck, depressional is described as a shallow, nearly level, very poorly drained organic soil that has soft, porous limestone bedrock at a depth of about 15 inches.
- **Udorthents – water complex –** Udorthents, water complex is described as very shallow to deep fill materials underlain by limestone. Fill materials are described as unconsolidated or heterogeneous geologic materials removed during the excavation of ditches, canals, lakes, ponds and quarries. Fill material typically

consists of limestone gravel and loamy carbonatic material, which extend to a depth of 80 inches or more.

- **Udorthents – limestone substratum – 0 to 5 percent slopes –** Udorthents, limestone substratum, 0 to 5 percent slopes is described as nearly level or gently sloping, moderately well drained or well drained soils consisting of thin or thick deposits of fill material, commonly about 30 inches thick, overlying hard, porous limestone bedrock. Characteristics of the fill materials vary and are described as typically gravelly sand to sandy gravel, which has been excavated from nearby sources and spread over the surface.
- **Urban land –** The Urban land map unit is in areas where more than 85 percent of the surface is covered by shopping centers, parking lots, streets, sidewalks, airports, large buildings, houses and other structures. The natural soil cannot be observed. The soil exposed in open areas (i.e. lawns, vacant lots, playgrounds, etc.) have generally been altered by land grading and shaping or have been covered with about 18 inches of extremely stony, loamy fill material.

Generally, the subsurface materials mapped by the SCS are described as predominately sandy soils with a limestone substratum. The limestone layer is expected to outcrop near the water surface of the canals. The SCS mapping is presented in **Appendix D**.

2.4 Geological Reconnaissance

DET performed a detailed field reconnaissance of the approximate 11.1 miles of canal maintained by the City. The canals were accessed by vehicle and on foot. The reconnaissance included observation and photographic documentation of the above and below water slopes and the materials exposed thereon. Canal bank slopes and conditions varied considerably across the project area. Some slopes are relatively flat while others are near vertical. Some portions of the canal banks were heavily overgrown with vegetation while others appeared to be grass covered and under a program of regular mowing and maintenance. In general, canal banks that have grass-covered, gentle slopes are considered to be more stable. Photographic documentation of canal slope conditions observed during the field reconnaissance is provided in **Appendix E**. Locations of the photographs are depicted in **Appendix G**.

At certain locations chosen by DET's representative in the field, hand drilled auger profile borings were completed along the canal slopes to determine the stratigraphy at specific locations. Details from the auger borings are provided in **Appendix F**. The results of the geologic reconnaissance generally indicate that the canal slopes consist of sandy soils that overlie limestone in some areas.

3.0 CANAL BANK EXISTING CONDITIONS ASSESSMENT

The results of the geologic reconnaissance were utilized to classify and categorize the canal system maintained by the City, in terms of the severity of the erosion of the canal banks and the potential need for stabilization. The classification of the canal banks described herein is based largely upon the visual appearance (i.e. aesthetics) of the exposed portions of the canal slopes. Criteria used for the classification included the relative steepness of the slopes, the consistency of the alignment of the top of canal bank, amount of erosion, and condition of the vegetative cover. It is noted that the classifications are subjective and were based on professional engineering judgment and upon the conditions that existed at the time of the field reconnaissance. The categories are as follows:

1. **High –** The canal slopes are very steep, and/or the horizontal position of the top of bank varied considerably along the canal alignment and large amount of bank erosion.
2. **Medium –** Canal slopes are moderately steep, somewhat irregular, and having moderate erosion and vegetation.
3. **Low –** The canal slopes are relatively uniform and reasonably well maintained with only minor erosion observed.
4. **None -** Canal slopes are uniform and very well maintained.

Appendix G includes several maps summarizing the canal bank erosion level of severity observed. This appendix includes an overall plan showing the canal system and overall canal bank erosion level of severity at a scale of 1 inch equal 2,000 feet, and also on subsequent sheets prepared at a scale of 1 inch equal 600 feet. Review of the existing conditions survey indicates that approximately 10,000 lineal feet (1.89 miles) of canal bank is classified as having a high severity of erosion. An additional approximately 14,000 lineal feet (2.65 miles) of canal bank is classified as medium in terms of relative severity of erosion, and the remaining portions of the canal system have banks that have experienced relatively little erosion. **Table 3-1** includes a summary of the classifications and approximate lengths of each class of canal bank erosion observed.

Table 3-1 : Canal Bank Existing Conditions Survey Summary

Category	Length Of Canal Bank (Feet)	Approximate Percent Of Canal Bank
1. High	17,000 (3.22 miles)	15%
2. Medium	13,800 (2.61 miles)	12%
3. Low	65,700 (12.44 miles)	60%
4. None	14,300 (2.71 miles)	13%
Total	**110,800 (21 miles) Note: these lengths include both sides of canal banks**	**100%**

4.0 CANAL BANK STABILIZATION METHODS

Using information gathered from the engineering borings, the surveyed cross sections and the geologic reconnaissance, a typical canal bank cross section was developed for the City canal system. This typical section is shown on Sheet H-1 in **Appendix H**.

The topographic and subsurface conditions described above were used to evaluate the embankment slope stability for a representative (typical) City canal bank. The water surface elevation in the canal was set at +3 feet NGVD 1929. Strength parameters for the subsurface components were obtained from the SPT borings and using standard correlations in the geotechnical literature. The ground surface geometry and stratigraphy were input to the computer program PCSTABLE, and the program was used to determine factors of safety for various trial failure surfaces.

This evaluation was made with the assumption that cohesion, c, was zero for the fill. Based upon the results of the SPT borings, the fill was assigned an angle of internal friction, ϕ, of 34^o. Due to the hardness of the limestone formation, the shear strength of the upper limestone was selected as 5,000 pounds per square foot (psf). The variables for moist and saturated unit weights (γ_{moist} and γ_{sat}, respectively**)** were obtained from standard correlations with the SPT N-Values found in the geotechnical literature, namely the "Foundation Engineering Handbook" by Winterkorn and Fang, and the Florida Department of Transportation (FDOT), District 1 materials laboratory.

Table 4-1 provides a summary of the strength parameters used for this evaluation.

Table 4-1 : City of Doral Summary of Soil Strength Parameters

ID	Material	γ_{sat} (pcf)	γ_{moist} (pcf)	ϕ (degrees)	C (psf)
1	Levee Fill	120	105	34	0
3	Sand	115	100	30	0
4	Limestone	130	115	0	5,000

The results of the stability analyses for a typical City canal bank is summarized on Sheet H-2 in **Appendix H**. The results of the analysis indicate that the typical canal bank has a minimum Factor of Safety of approximately 18, which is very high (i.e. safe), compared to typical values of 2 to 3, and reflects the hardness of the limestone formation that dominates the subsurface profiles in the City region.

In summary, the canal banks do not appear to be unstable from the standpoint of a potential slope failure, even with the relatively steep, above water and below water, slope conditions. However, the relatively steep canal banks do present difficulties with respect to mowing and maintenance, aesthetics, and may represent a safety concern for pedestrians and/or bicyclers.

Considering that the canal slopes are stable, owing to the presence of and hardness of the near surface limestone formation, the bank stabilization methods should be focused upon armoring the slopes against surficial erosion as well as increasing the aesthetic appearance of the banks, reducing maintenance efforts, and reducing the steepness of the slopes. Several canal bank stabilization measures were evaluated as conceptual for this stage of the project. These include the following:

1. **Articulated Block** - These are used to cover canal banks in areas of potential erosion and consist of individual concrete blocks that are structurally connected by wires oriented in two directions. They are normally placed over a filter fabric after the slopes are cut and/or filled to 2 horizontal to 1 vertical. The articulated nature of the system enables it to be placed on slightly undulating slopes, and to adjust to the slope conditions without compromising the structural integrity of the erosion protective system. The sand and gravel fill materials that exist on site may be utilized to fill the voids within the block, provided these materials are screened to remove oversized materials. A typical canal bank section including articulated block is provided on Sheet H-3 in **Appendix H.**

2. **Geoweb** - This geosynthetic product consists of open cells that can be filled with concrete or gravel to cover canal slopes. The geoweb is placed and stretched over the slope, anchored to grade using short lengths of steel rebar, then filled as appropriate to limit erosion. For this application, we recommend that the geoweb sections be filled with the native materials (sand and gravel) that currently exist on the canal banks, provided these materials are screened to remove gravel sized materials in excess of 1-inch. The geoweb sections should then be covered with topsoil and sod. A typical canal bank section with the geoweb armoring is shown on Sheet H-4 in **Appendix H**.

3. **Geo-Filter Tube** - Geotube construction uses a woven geotextile that is formed into the shape of a tube. The tube is filled with sand by direct coupling to a hydraulic dredge. The geotextile is designed to retain the granular fill portion of the dredge slurry, while appropriately sized openings in the geotextile allow the excess water in the slurry to permeate through the tube walls. The procedure can be implemented in both dry and underwater conditions. The tubes can be fabricated in various circumferences, which, when filled, will form a roughly elliptical shape.

   The Geo-Filter Tube (GFT) system consists of a spun bound polyester filter fabric that is sewn together to form a tube which is placed along the waters edge and filled with sand to form an erosion barrier that has the characteristics of a permeable, gravity type retaining wall. The system is especially well adapted to lake and canal bank stabilization where the height of the erosional scarp is not more than about three feet. Use of this system for retention of erosional scarps with greater height would require special analysis of the stability of the system and its components to sliding.

   The Geotube system will be covered with grass. Proximity to a dredged sand source is considered to be a necessity for use of this product from a cost effective

stand point. This consideration should be evaluated prior to any decision to move forward with the Geotube system option. Sheet H-5 in **Appendix H** shows a typical section inclusive of the Geotube system.

4. **Sand-Cement Bag Rip-Rap** - This involves the construction of a slope cover or retaining wall using bags that are filled with a mixture of sand and cement. When the cement portion of the mix hydrates, the bags become hardened and are capable of being stacked on a nearly vertical orientation. A typical canal bank section with the Sand-Cement Bag Rip-Rap is shown on Sheet H-6 in **Appendix H**.

5. **Stone Rip-Rap** - This method includes placement of graded stone over the finished canal slopes. Typically the method includes placement of a geosynthetic filter fabric, followed by bedding stone and then stone rip-rap. Selection of the filter fabric and the gradation of the bedding stone and rip-rap should be designed based upon anticipated wave forces and canal bank seepage forces.

6. **Geogrid Reinforcement** - This system involves the use of sequential layers of geogrid and backfill, with the grid forming the face of the slope. The geogrid extend horizontally into the slope such that the weight of the overlying fill and the frictional resistance at the grid-fill interface enables the system to be stable. Geogrid layers are normally designed to be 1.5 to 2 feet apart vertically.

7. **Fabric Formed Concrete** – These are fabrics that are filled in place with concrete or flowable fill to provide erosion protection. Filled-in-place fabric forms accommodate themselves to uneven subgrades at the time that they are filled. Some forms create discrete concrete units, attached to each other with fabric perimeters and/or embedded cables. As a result, the concrete mats can articulate to adapt to uneven settlement.

8. **Gabions** - These consist of wire or synthetic baskets that are filled with stone and then stacked upon each other. The baskets are filled in place, which makes their construction rather time consuming and labor intensive.

9. **Synthetic Turf Mats** - There are many products on the market that involve placement of mats that become reinforcement for the growth of natural grass roots. These fabrics are placed prior to sodding and include a high percentage of open areas that allows the grass roots to penetrate the fabric and to develop into the embankment slope.

10. **Seawall** - Steel sheet piles may be driven or vibrated in place to create a vertical grade separating wall. This method is considered to be very expensive. Further, installation of the sheet piles may trigger ground vibrations that transmit laterally to residential building foundations. Such vibrations may be (at worst) damaging to existing structures, or (at least) a nuscience to the occupants of the structures. For these reasons, we do not recommend use of sheet piles for this project.

Additional photographic documentation of the Articulated Block, Geoweb, GFT and Sand-Cement Bag Rip-Rap options are also provided in **Appendix H**. Of the conceptual bank stabilization measures considered for this project, it is our opinion that Options 1 and 2 (Articulated Block and Geoweb, respectively) are the most appropriate for use on the City canal slopes. GFT stabilized canal slopes may also be practical. However, the source of the materials used to fill the GFT is not likely to be readily available for the adjacent canals. **Table 4-2** presents planning-level unit costs for design and construction, slope required for placement, and anticipated level of aesthetics of the various stabilization measures.

Table 4-2 : Canal Bank Stabilization Method Planning-Level Unit Cost

Option	Conceptual Bank Stabilization Measure	Slope Requirement	Aesthetics	Cost Per Foot
1	Articulated Block	2H:1V	High	$200
2	Geoweb	2H:1V	High	$150
3	Geo-Filter Tubes (GFT)	3H:1V	Medium	$200
4	Sand-Cement Rip-Rap	1H:1V	Low	$400

The unit costs shown in the table above are based upon discussions with local contractors, material suppliers and our experience with similar bank stabilization projects. These unit prices should be considered in order of magnitude and for planning and cost comparison only. More rigorous cost estimates should be completed prior to finalization of designs for canal bank stabilization.

Advantages associated with Options 1 and 2 are that they will both provide a relatively uniform, aesthetically pleasing finished slope. The disadvantage of these two options is that they will require that the existing canal slope be cut and shaped to a considerably flatter slope than the existing condition. The Articulated Block (Option 1) will result in a concrete face appearance, whereas the Geoweb will be covered with grass. Options 3 and 4 both require that the canal slope be benched into (i.e. cut) in order to provide room for their installation. The Sand-Cement Rip-Rap has the distinct advantage of requiring less right-of-way, and results in a relatively steep finished slope. The Geo-Filter Tubes require that an adequate borrow source be available within the canals. Based on the subsurface conditions for this project setting, it is not likely that the canal bottoms will include such a source.

Based upon review of the unit costs, advantages and disadvantages of the conceptual slope stabilization measures, it is our professional opinion that Option 2 (Geoweb) provides the optimum combination of aesthetics and economy, and is therefore the most practical for stabilizing canal banks within the City. Localized sections of canals may require other stabilization methods owing to right-of-way limitations or other restrictions. The final determination for the most appropriate stabilization methods should be made as part of a design level study. The design level study needs to include a property boundary survey in order to select the most appropriate alternative on a case by case basis.

5.0 CANAL BANK REMEDIATION PLAN

The results of this feasibility study generally indicate that the canal banks within the City are safe with respect to global stability. We expect that the canal banks have a relatively low potential for ground movement, slumping and/or sloughing into the canals. It is noted that this evaluation did not include the use of an underwater survey, and there is a likelihood that cantilevered limestone ledges may exist. Based upon the results of the borings drilled for this project, the potential for this to occur is, in our opinion, also relatively low. Based on this assessment, one option that the City may wish to consider is to leave the canal banks in their current condition and to accept the increased maintenance cost associated with that decision. However, due to the relative steepness of the canal banks, consideration must also be given to the safety of the canal banks from the standpoint of pedestrian and bicycle traffic using the canal banks for recreational or other purposes.

Each of the canals maintained by the City was classified as described earlier in this report regarding their existing conditions in terms of bank erosion. The lengths of each and their severity of erosion are provided in **Table 5-1**.

Table 5-1 : Canal Bank Erosion Classification by Canal

Canal Name	Existing Canal Bank Erosion			
	High (feet)	Medium (feet)	Low (feet)	None (feet)
Dressels Canal	700	7,000	28,800	14,300
Northline Canal	3,600	4,500	32,100	0
C-2 Extension Canal	12,700	2,300	4,800	0
Totals	**17,000**	**13,800**	**65,700**	**14,300**

The existing canal bank erosion classifications were further classified according to specific reaches along each of the project canals as described in **Table 5-2, 5-3 and 5-4** for the Dressels Canal, Northline Canal and C-2 Extension Canal, respectively.

Table 5-2 : Canal Bank Erosion Classification for Dressels Canal by Reach

Canal Name & Reach	Existing Canal Bank Erosion							
	Left Bank (Feet)				Right Bank (Feet)			
	High	Med.	Low	None	High	Med.	Low	None
Dressels Canal								
NW 117th - 114th Ave	-	-	1,200	-	-	-	1,200	-
NW 114th - 112th Ave	-	1,200	-	-	-	1,200	-	-
NW 112th - 109th Ave	-	1,200	-	-	-	-	1,200	-
NW 109th Ave - Delia.	-	-	500	-	-	500	-	-
Delia Plaza	-	-	700	-	700	-	-	-
NW 107th - 104th Ave	-	-	-	4200	-	-	-	4,200
NW 104th - 102th Ave	-	-	-	1,300	-	-	700	600
NW 102th - 97th Ave	-	-	-	2,000	-	-	-	2,000
W. side of 97th Ave	-	-	1,800	-	-	800	1,000	-
NW 97th - 87th Ave	-	600	5,400	-	-	1,200	4,800	-
NW 87th - Palmetto	-	-	5,300	-	-	300	5,000	-
Subtotals	**0**	**3,000**	**14,900**	**7,500**	**700**	**4,000**	**13,900**	**6,800**
Note: For the Dressels Canal, Left and Right are defined when viewing from west to east.								

Table 5-3 : Canal Bank Erosion Classification for Northline Canal by Reach

Canal Name & Reach	Existing Canal Bank Erosion							
	Left Bank (Feet)				Right Bank (Feet)			
	High	Med.	Low	None	High	Med.	Low	None
Northline Canal (NW 25th Street Canal)								
Palmetto - 79th Ave	-	-	700	-	-	-	700	-
NW 79th - 82th Ave	500	-	700	-	500	-	700	-
NW 82th - 87th Ave	-	-	2,600	-	-	-	2,600	-
NW 87th - 97th Ave	-	-	5,200	-	-	1,700	3,500	-
NW 97th - 99th Ave	-	-	1,300	-	1,300	-	-	-
NW 99th - 102th Ave	-	-	1,300	-	-	700	600	-
NW 102th - 107th Ave	-	-	2,600	-	1,100	1,500	-	-
NW 107th - 112th Ave	-	-	2,600	-	-	-	2,600	-
NW 112th - 117th Ave	100	-	2,500	-	100	600	1,900	-
Subtotals	**600**	**0**	**19,500**	**0**	**3,000**	**4,500**	**12,600**	**0**
Note: For the Northline Canal, Left and Right are defined when viewing from east to west.								

Table 5-4 : Canal Bank Erosion Classification for C-2 Extension Canal by Reach

Canal Name & Reach	Existing Canal Bank Erosion							
	Left Bank (Feet)				Right Bank (Feet)			
	High	Med.	Low	None	High	Med.	Low	None
C-2 Extension Canal (NW 117th Avenue Canal)								
NW 25th - 34th St.	2,800	-	-	-	2,800	-	-	-
NW 34th - 41st St.	2,200	-	-	-	-	-	2,200	-
NW 41st - 50th St.	2,300	-	-	-	-	2,300	-	-
NW 50th - 58th St.	2,600	-	-	-	-	-	2,600	-
Subtotals	**9,900**	**0**	**0**	**0**	**2,800**	**2,300**	**4,800**	**0**

Note: For the C-2 Extension, Left and Right are defined when viewing from south to north.

It is recommended that the City implement the necessary canal bank improvements in a two-phase Canal Capital Improvement (CIP) Plan. Phase I should include the high erosion severity classified areas and should be implemented over a two-year period (Years 1 and 2). Phase II should include the medium to low erosion classified areas and should be implemented over an eight-year period (Years 3 through 10). Using the unit prices for canal bank stabilization presented in the previous section of this report, use of the Geoweb method to remediate all portions of the canal banks that are currently classified as highly eroded (Phase I) will cost approximately $2.5 million. Remediation of the same length of canal banks using Articulated Block will result in a capital expenditure of about $3.4 million. Extending these repairs to the portions of the canal banks that are classified as medium and low in terms of bank erosion severity will result in additional costs of approximately $2.1 million and $2.8 million for the Geoweb and Articulated Block methods, respectively. **Tables 5-5** and **5-6** summarizes the planning-level costs to implement Geoweb and Articulated Block methods, for comparative purposes, for each canal and bank erosion classification and Canal Bank Capital Improvement Phase. Included in that table are cost estimates for construction and separate cost estimates for design. In this table, design costs are assumed as 10% of the construction costs.

Table 5-5 : Canal Capital Improvement Plan Planning-Level Cost Estimate

Geoweb				
Canal Name	Phase I High Eroded Areas (Years 1 and 2)		Phase II Medium + Low Eroded Areas (Years 3 through 10)	
	Construction	Design	Construction	Design
Dressels Canal	$94,500	$10,500	$4,671,000	$519,000
Northline Canal	$486,000	$54,000	$4,941,000	$549,000
C-2 Extension Canal	$1,714,500	$190,500	$958,500	$106,500
Totals	**$2,295,000**	**$255,000**	**$10,570,500**	**$1,174,500**

Table 5-6 : Canal Capital Improvement Plan Planning-Level Cost Estimate

Articulated Block				
Canal Name	**Phase I High Eroded Areas (Years 1 and 2)**		**Phase II Medium + Low Eroded Areas (Years 3 through 10)**	
	Construction	**Design**	**Construction**	**Design**
Dressels Canal	$126,000	$14,000	$6,228,000	$692,000
Northline Canal	$648,000	$72,000	$6,588,000	$732,000
C-2 Extension Canal	$2,286,000	$254,000	$1,278,000	$142,000
Totals	**$3,060,000**	**$340,000**	**$14,094,000**	**$1,566,000**

As previously described in Section 4 of this report, localized sections of canals may require other more expensive stabilization methods such as sand-cement Rip-Rap, depending on right-of-way limitations or other restrictions. The final determination for the most appropriate stabilization methods should be made as part of a design level study. The design level study needs to include a property boundary survey in order to select the most appropriate alternative on a case-by-case basis. It should also be noted that these planning-level costs should be considered in order of magnitude and for planning and cost comparison only. More rigorous cost estimates should be completed prior to finalization of designs for canal bank stabilization.

Table 5.7, 5-8 and 5-9 further subdivide the construction and design costs (combined) for specific reaches for the Dressels Canal, Northline Canal, and C-2 Extension Canal, respectively.

Table 5-7 : Canal Bank Remediation Plan & Cost Estimate for Dressels Canal by Reach

Canal Name & Reach	**Phase I High Eroded Areas (Years 1 and 2)**		**Phase II Medium + Low Eroded Areas (Years 3 through 10)**	
	Stabilization Methodology		**Stabilization Methodology**	
	Geoweb	**Art. Block**	**Geoweb**	**Art. Block**
Dressels Canal				
NW 117th - 114th Ave	None	None	$360,000	$480,000
NW 114th - 112th Ave	None	None	$360,000	$480,000
NW 112th - 109th Ave	None	None	$360,000	$480,000
NW 109th Ave - Delia	None	None	$75,000	$100,000
Delia Plaza	$105,000	$140,000	$105,000	$140,000
NW 107th - 104th Ave	None	None	None	None
NW 104th - 102th Ave	None	None	None	None
NW 102th - 97th Ave	None	None	None	None
W. side of 97th Ave	None	None	$540,000	$720,000
NW 97th - 87th Ave	None	None	$1,800,000	$2,400,000
NW 87th - Palmetto	None	None	$1,590,000	$2,120,000
Subtotals	**$105,000**	**$140,000**	**5,190,000**	**$6,920,000**

Table 5-8 : Canal Bank Remediation Plan & Cost Estimate for Northline Canal by Reach

Canal Name & Reach	Phase I High Eroded Areas (Years 1 and 2)		Phase II Medium + Low Eroded Areas (Years 3 through 10)	
	Stabilization Methodology		Stabilization Methodology	
	Geoweb	Art. Block	Geoweb	Art. Block
Northline Canal (NW 25th Street Canal)				
Palmetto - 79th Ave	None	None	$210,000	$280,000
NW 79th - 82th Ave	$150,000	$200,000	$210,000	$280,000
NW 82th - 87th Ave	None	None	$780,000	$1,040,000
NW 87th - 97th Ave	None	None	$1,560,000	$2,080,000
NW 97th - 99th Ave	$195,000	$260,000	$195,000	$260,000
NW 99th - 102th Ave	None	None	$390,000	$520,000
NW 102th - 107th Ave	$165,000	$220,000	$615,000	$820,000
NW 107th - 112th Ave	None	None	$780,000	$1,040,000
NW 112th - 117th Ave	$30,000	$40,000	$750,000	$1,000,000
Subtotals	**$540,000**	**$720,000**	**$5,490,000**	**$7,320,000**

Table 5-9: Canal Bank Remediation Plan & Cost Estimate for C-2 Extension Canal by Reach

Canal Name & Reach	Phase I High Eroded Areas (Years 1 and 2)		Phase II Medium + Low Eroded Areas (Years 3 through 10)	
	Stabilization Methodology		Stabilization Methodology	
	Geoweb	Art. Block	Geoweb	Art. Block
C-2 Extension Canal (NW 117th Avenue Canal)				
NW 25th - 34th St.	$840,000	$1,120,000	None	None
NW 34th - 41st St.	$330,000	$440,000	$330,000	$440,000
NW 41st - 50th St.	$345,000	$460,000	$345,000	$460,000
NW 50th - 58th St.	$390,000	$520,000	$390,000	$520,000
Subtotals	**$1,905,000**	**$2,540,000**	**$1,065,000**	**$1,420,000**

Table 5-10 provides a breakdown of the Canal Capital Improvement Plan by fiscal year (FY). In order to arrive at the **Table 5-10**, a series of assumptions and constraints were implemented which were as follows:

- All eroded lengths for a given reach were grouped and cost together. These reaches, when remediated, would likely be engineered and constructed at the same time.
- Reach priority was based on the most severe erosion classification contained in a reach – i.e., if a reach contained a high erosion and a low erosion length, the reach was classified as high and scheduled in Phase I.
- Reaches with a medium erosion severity preceded low erosion severity reaches in Phase II.
- A budgetary constraint of $2-million was maintained per FY.
- FY costs were tapered off in the latter portions of Phase II.

In order to maintain a FY maximum cost of no more than $2-million, and based on the grouping method described previously, two reaches that are part of the Northline Canal were shifted to FY 2010-2011 which would coincide with Phase II.

Table 5-10: Canal Capital Improvement Plan

Canal Name & Reach	FY 2008-2009	FY 2009-2010	FY 2010-2011	FY 2011-2012	FY 2012-2013	FY 2013-2014	FY 2014-2015	FY 2015-2016	FY 2016-2017	FY 2017-2018
Dressels Canal										
NW 117th 114th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 355,523
NW 114th 112th Ave	$ -	$ -	$ -	$ 355,523	$ -	$ -	$ -	$ -	$ -	$ -
NW 112th 109th Ave	$ -	$ -	$ -	$ 355,523	$ -	$ -	$ -	$ -	$ -	$ -
NW 109th Ave Delia.	$ -	$ -	$ -	$ 148,135	$ -	$ -	$ -	$ -	$ -	$ -
Delia Plaza	$ -	$ 207,389	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 107th 104th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 104th 102th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 103,694	$ -	$ -
NW 102th 97th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
W. side of 97th Ave	$ -	$ -	$ -	$ 533,285	$ -	$ -	$ -	$ -	$ -	$ -
NW 97th 87th Ave	$ -	$ -	$ -	$ -	$ 1,777,617	$ -	$ -	$ -	$ -	$ -
NW 87th Palmetto	$ -	$ -	$ -	$ -	$ -	$ 1,570,228	$ -	$ -	$ -	$ -
Northline Canal (NW 25th Street Canal)										
Palmetto 79th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 207,389
NW 79th 82th Ave	$ -	$ 355,523	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 82th 87th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 770,301	$ -	$ -
NW 87th 97th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,540,601	$ -	$ -	$ -
NW 97th 99th Ave	$ 385,150	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 99th 102th Ave	$ -	$ -	$ 385,150	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 102th 107th Ave	$ -	$ -	$ 770,301	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 107th 112th Ave	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 770,301	$ -
NW 112th 117th Ave	$ -	$ -	$ 770,301	$ -	$ -	$ -	$ -	$ -	$ -	$ -
C2 Extension Canal (NW 117th Avenue Canal)										
NW 25th 34th St.	$ 829,554	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 34th 41st St.	$ -	$ 651,793	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 41st 50th St.	$ -	$ 681,420	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NW 50th 58th St.	$ 770,301	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fiscal Year Totals	**$ 1,985,005**	**$ 1,896,124**	**$ 1,925,751**	**$ 1,392,466**	**$ 1,777,617**	**$ 1,570,228**	**$ 1,540,601**	**$ 873,995**	**$ 770,301**	**$ 562,912**
Total	**$14,295,000**									

Table 5-11 is derived from the data in **Table 5-10** and provides a cost breakdown by FY and by canal.

Table 5-11: Canal Capital Improvement Plan Summary

	Fiscal Year	Canals			Totals
		Dressels Canal	Northline Canal (NW 25th Street Canal)	C2 Extension Canal (NW 117th Avenue Canal)	
Phase I	**2008-2009**	$ -	$ 385,150	$ 1,599,855	**$ 1,985,005**
	2009-2010	$ 207,389	$ 355,523	$ 1,333,212	**$ 1,896,124**
Phase II	**2010-2011**	$ -	$ 1,925,751	$ -	**$ 1,925,751**
	2011-2012	$ 1,392,466	$ -	$ -	**$ 1,392,466**
	2012-2013	$ 1,777,617	$ -	$ -	**$ 1,777,617**
	2013-2014	$ 1,570,228	$ -	$ -	**$ 1,570,228**
	2014-2015	$ -	$ 1,540,601	$ -	**$ 1,540,601**
	2015-2016	$ 103,694	$ 770,301	$ -	**$ 873,995**
	2016-2017	$ -	$ 770,301	$ -	**$ 770,301**
	2017-2018	$ 355,523	$ 207,389	$ -	**$ 562,912**
	Totals	**$ 5,406,917**	**$ 5,955,016**	**$ 2,933,067**	**$ 14,295,000**

All canals within the City are within Miami-Dade County owned or controlled canal right-of-way, reservation, or easement. A Class III permit is required for any construction activity within Miami-Dade County owned or controlled canal right-of-way, reservation, or easement. Therefore, all of the proposed canal bank stabilization options will require a Miami-Dade County Department of Environmental Resources Management (DERM) Class III Permit. The DERM Class III Permit application fee is expected to be $490, since the project construction costs are anticipated to be greater than $2,500. The following are the submittal requirements for a Class III Permit:

- 3 sets of signed and sealed construction plans and specifications
- 1-copy of signed and sealed calculations or pertinent information
- 1-copy of topographic survey / boundary survey/ vertical aerial photograph/ project location map
- 1-copy of proof of ownership, agreements, or authorization to do work on subject property.
- Applicant/authorized agent's statement that plans and work are prepared and supervised by a registered engineer
- Substantiating letter from zoning authority of municipality or county stating that proposed work does not violate applicable zoning law

A standard form permit application, W.C. FORM 501S, needs to be completed and submitted to the DERM Water Control Section, along with the above items.

6.0 LIMITATIONS

This canal bank stabilization study was performed for the City to aid in the evaluation of subsurface conditions and to provide geotechnical and survey information for the proposed canal bank stabilization project. ADA, DET, PSI and FRA warrant that the recommendations and professional advice presented in the report are based on recognized practice in the disciplines of land surveying, soil mechanics, foundation engineering and engineering geology. No other warranties are implied or expressed.

Additional studies should be completed for design of the canal slope stabilization project. Such work should utilize the cross section data provided by the project surveyor as well as global stability analyses of the design options to be considered.

APPENDIX A

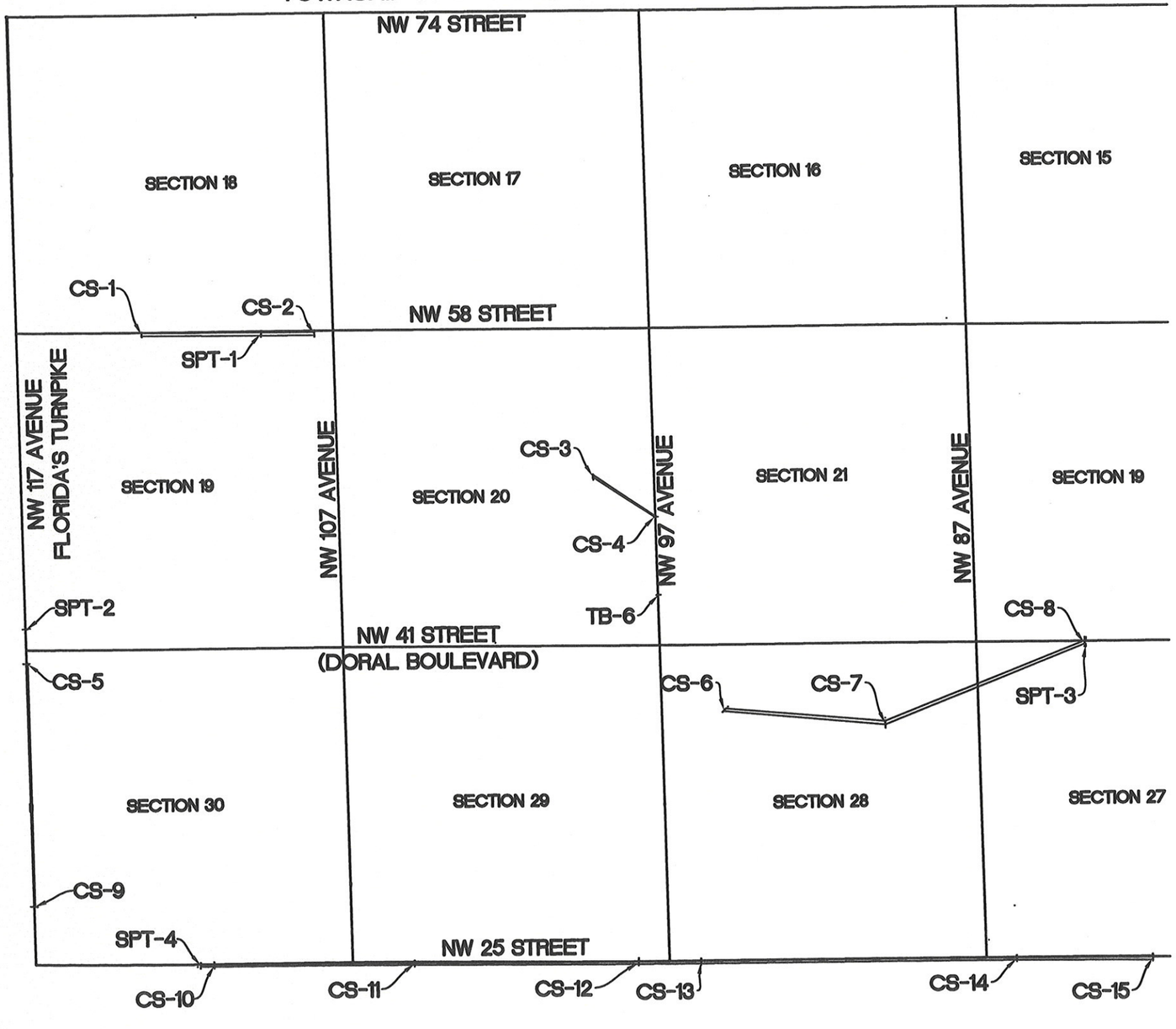
CANAL CROSS SECTION MAPS

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

LOCATION MAP

NOT TO SCALE

TOWNSHIP 53 S RANGE 40 E



SURVEYOR'S NOTES:

1–THE SPECIFIC PURPOSE OF THIS SURVEY IS TO PROVIDE TOPOGRAPHIC INFORMATION OF 15 LOCATIONS AT CITY OF DORAL CANALS, AS REQUESTED BY CLIENT.

2–THIS IS NOT A BOUNDARY SURVEY.

3–HORIZONTAL DATUM IS THE STATE PLANE COORDINATE SYSTEM, FLORIDA EAST ZONE, NORTH AMERICAN DATUM OF 1983 (ADJUSTMENT OF 1990).

GPS SOTO	N=558414.457	E=873247.407
GPS THOMAS AZ	N=548213.9702	E=861136.4316

4–ELEVATIONS SHOWN REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 1929) AS DETERMINED MIAMI–DADE COUNTY– PUBLIC WORKS DEPARTMENT BM# N–534 LOCATOR 3033, BEING A PK NAIL AND BRASS WASHER IN SOUTH END OF A CATCH BASIN LOCATED 65' SOUTH OF SOUTH EDGE OF PAVEMENT OF NW 58 STREET AND 2' EAST OF EAST EDGE OF PAVEMENT NW 87 AVE. ELEV=7.42 FEET (NGVD 1929) AND BM# N–407R LOCATOR 3035 BEING A PK NAIL AND BRASS WASHER ON A CATCH BASIN LOCATED 375' NORTH EDGE OF PAVEMENT OF NW 25 STREET AND 2' EAST OF EAST EDGE OF PAVEMENT NW 87 AVE. ELEV=7.66' FEET (NGVD 1929).

5–ELEVATIONS REFER TO THE NATIONAL GEODETIC VERTICAL DATUM (N.G.V.D.) OF 1929.

6–ELEVATIONS SHOWN ARE TO THE BOTTOM OF CANAL AS MEASURED WITH ROD OR CANNON BALL

I HEREBY CERTIFY:

THAT THE ATTACHED SPECIFIC PURPOSE SURVEY MEETS THE REQUIRED MINIMUM TECHNICAL STANDARDS SET BY THE FLORIDA STATE BOARD OF PROFESSIONAL LAND SURVEYORS PURSUANT TO CHAPTER 472.027 FLORIDA STATUTES AND CHAPTER 61G17 OF THE FLORIDA ADMINISTRATIVE CODE.

LAST DAY FIELD WORK : 04/08/08
SIGNED : 04/14/08
FIELD BOOK: 633, PG.6–52
CAD FILE: X/PROJECTS/2136W01Canals doral/2136W01.DWG

NOT VALID WITHOUT THE SIGNATURE AND THE ORIGINAL RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

FERNANDO Z. GATELL P.S.M.
CERTIFICATE No. 2821
STATE OF FLORIDA

REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

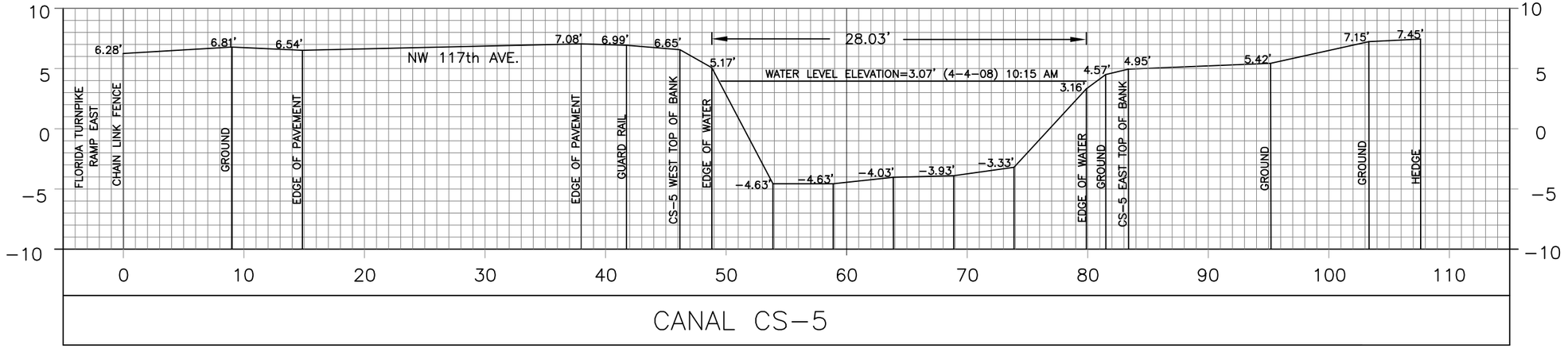
F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
MIAMI , FLORIDA 33178
TEL. (305) 591–8777 FAX. (305)599–8749

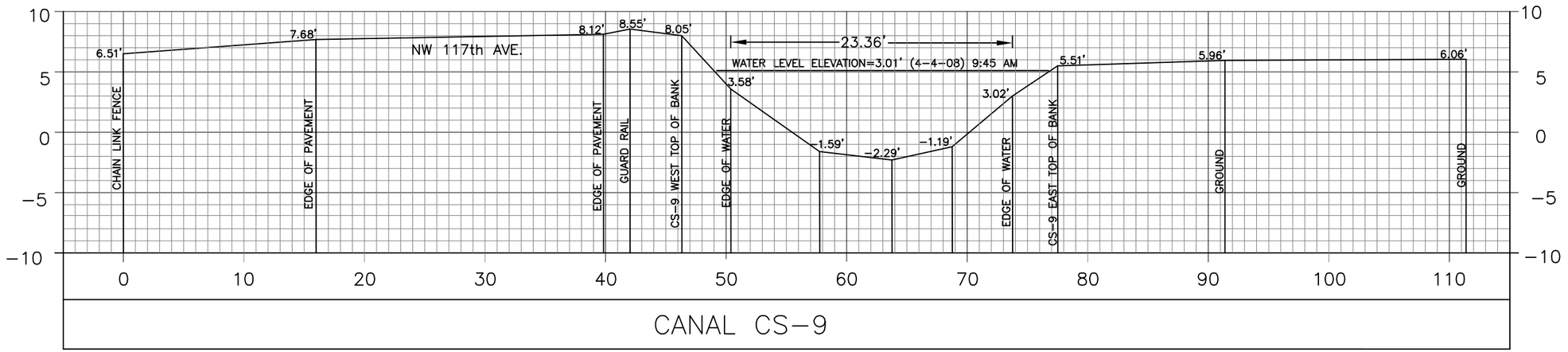
DATE 04/14/08
SCALE 1"=10'
DRAWN A.P.
JOB: 2136W01

SHEET 1
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
MIAMI , FLORIDA 33178
TEL. (305) 591-8777 FAX. (305)599-8749

DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

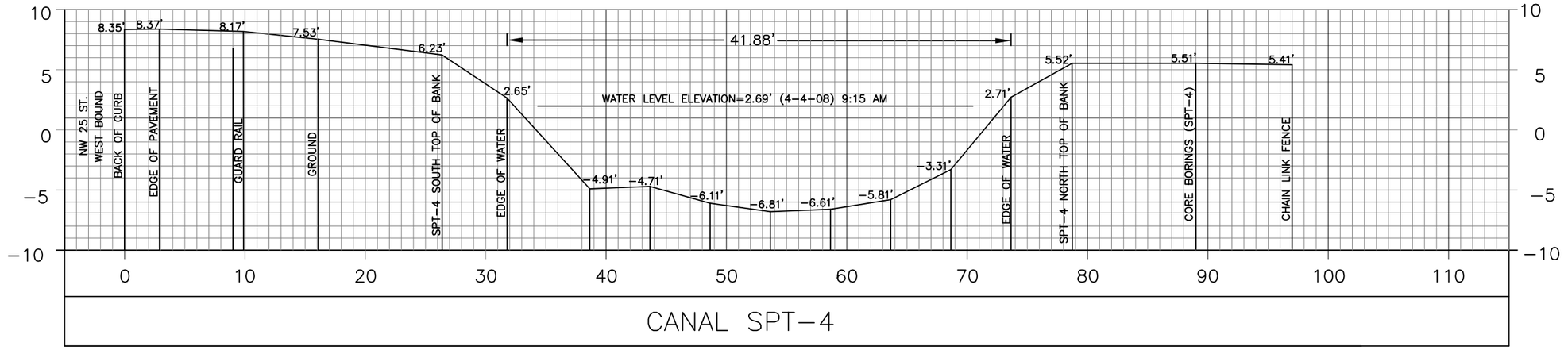
JOB: 2136W01

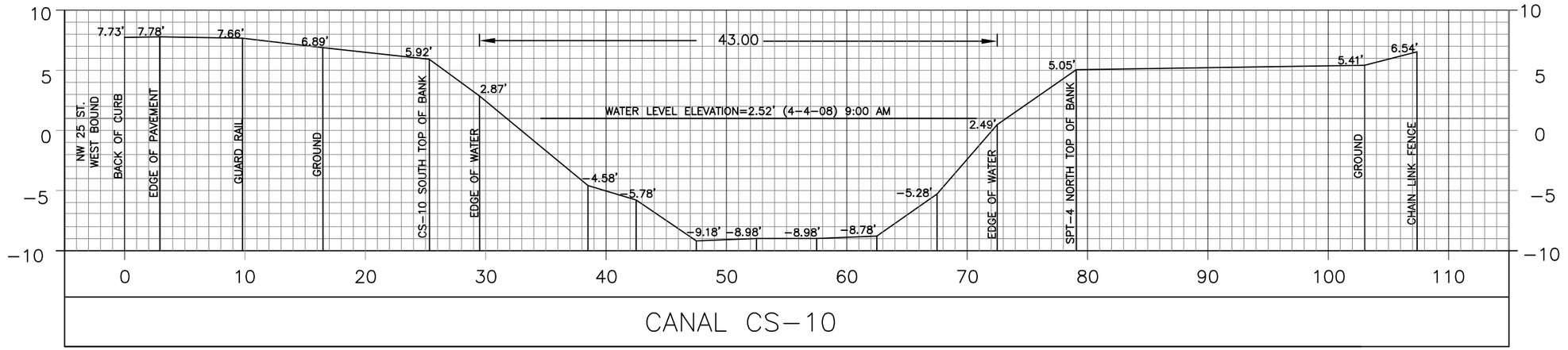
SHEET 2
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

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DATE 04/14/08

SCALE 1"=10'

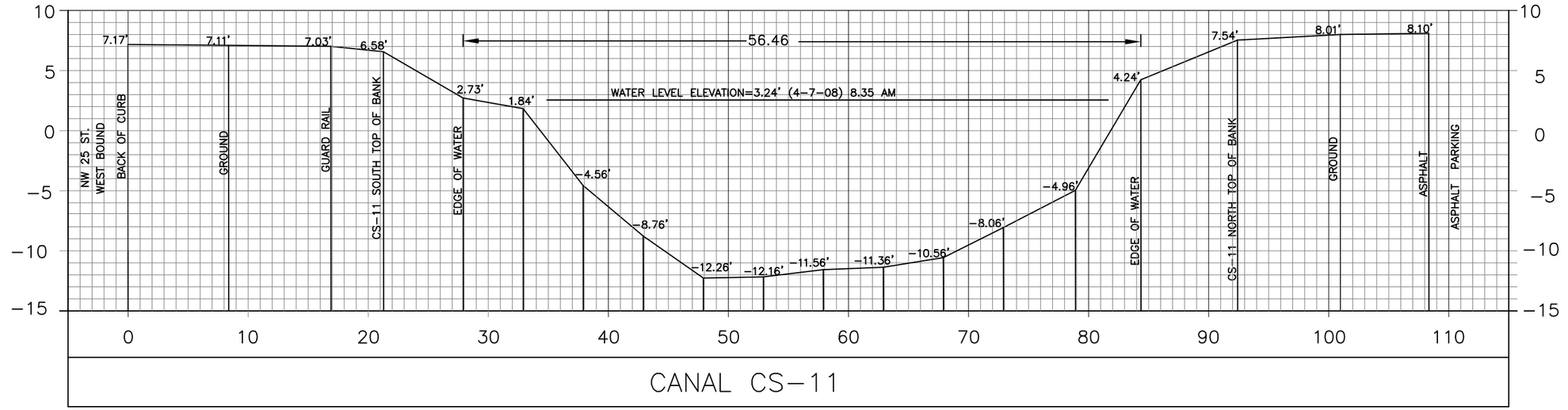
DRAWN A.P.

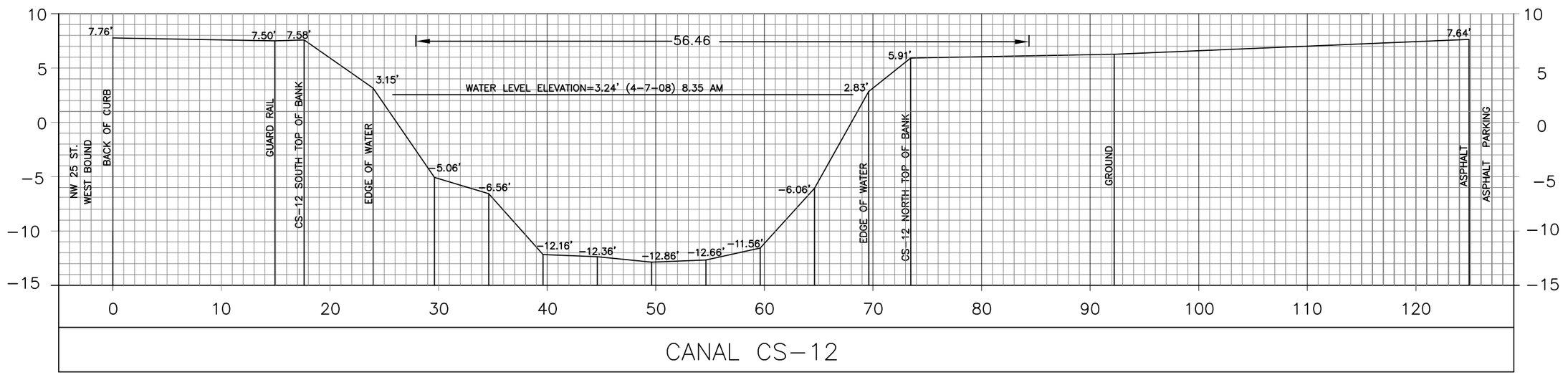
JOB: 2136WO1

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
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TEL. (305) 591-8777 FAX. (305)599-8749

DATE 04/1408

SCALE 1"=10'

DRAWN A.P.

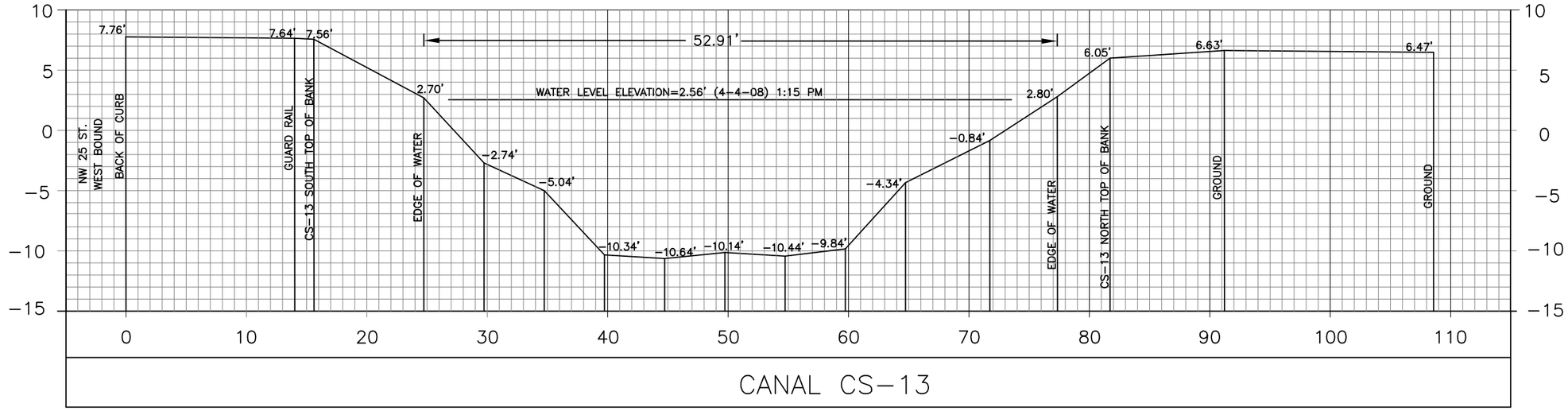
JOB: 2136WO1

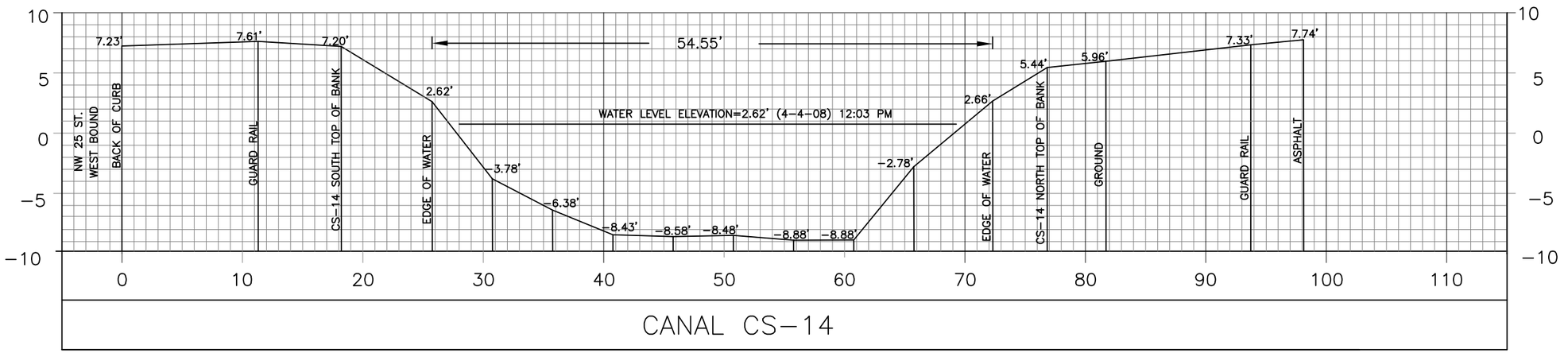
SHEET 4
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
MIAMI , FLORIDA 33178
TEL. (305) 591-8777 FAX. (305)599-8749

DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

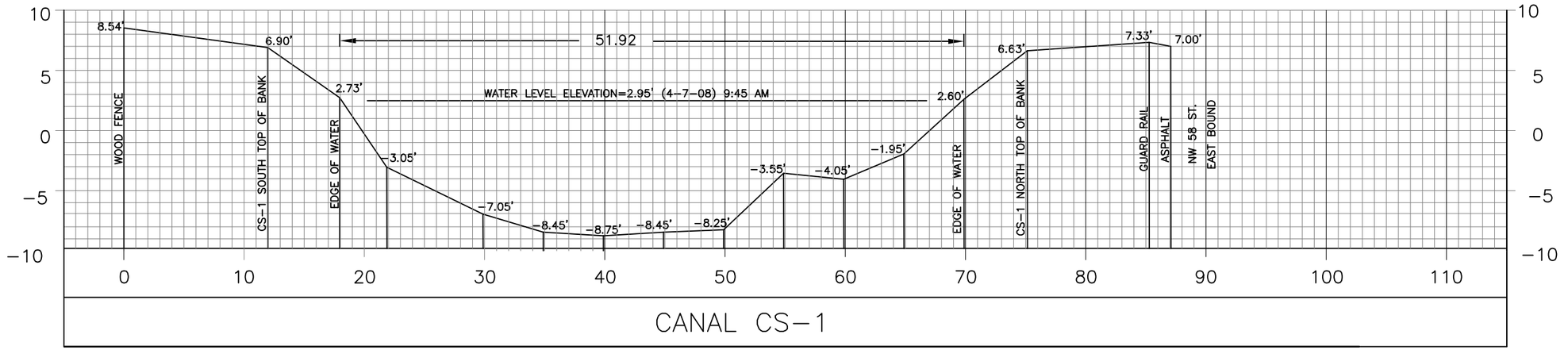
JOB: 2136WO1

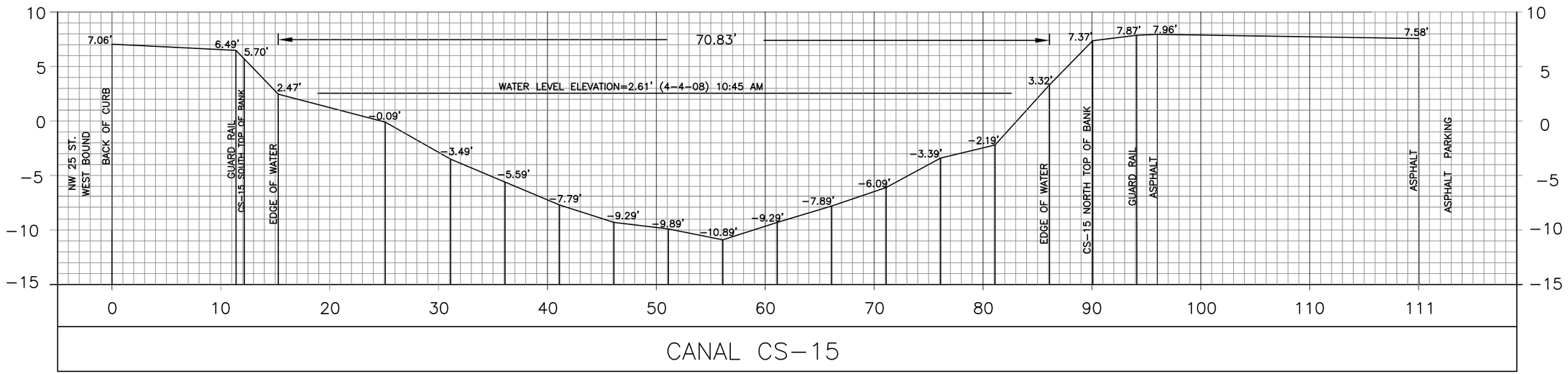
SHEET 5
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

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DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

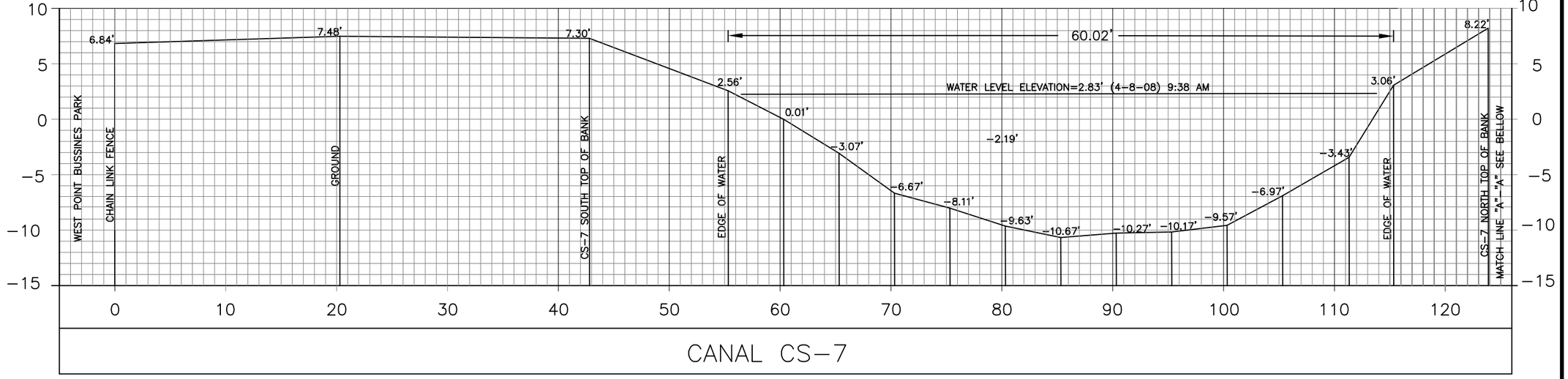
JOB: 2136WO1

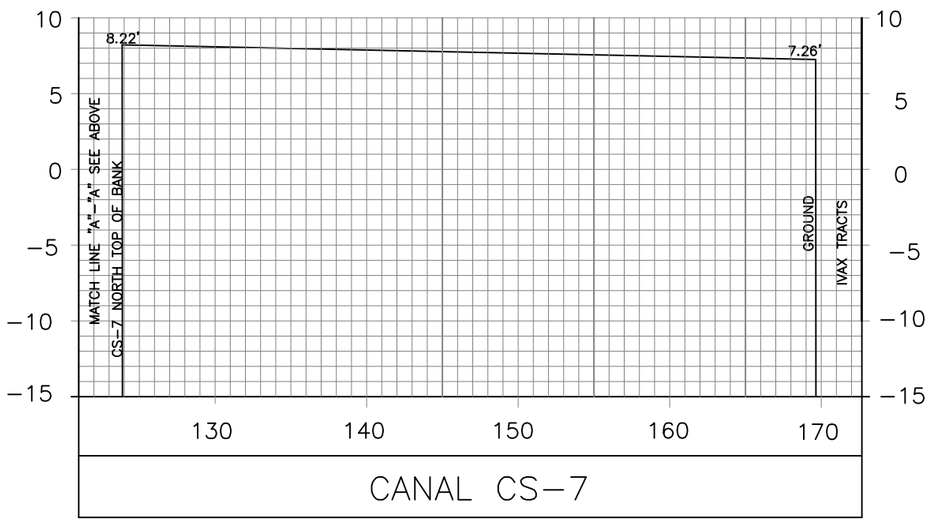
SHEET 6
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
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TEL. (305) 591-8777 FAX. (305)599-8749

DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

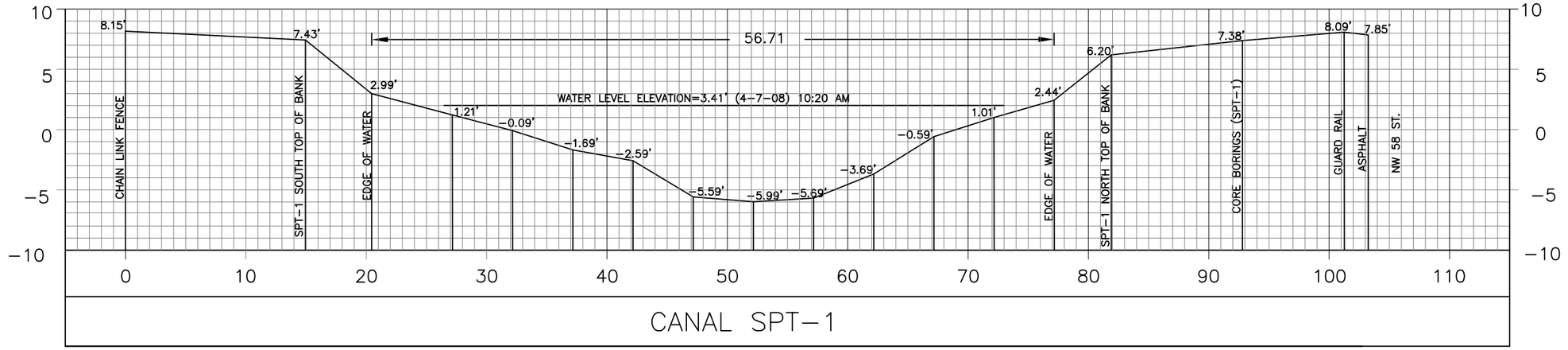
JOB: 2136WO1

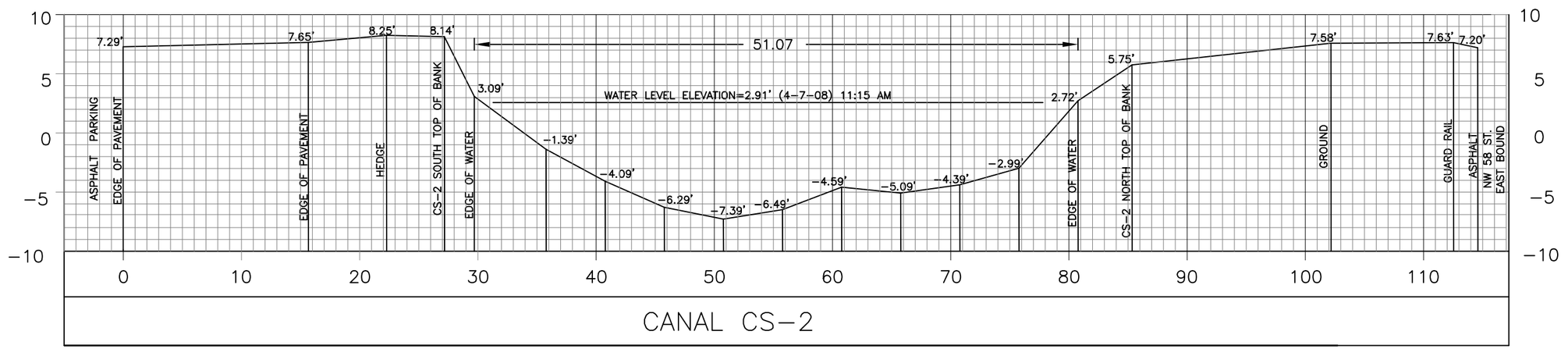
SHEET 7
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

NORTH

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
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10305 NW 41ST STREET, SUITE 200
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DATE 04/14/08

SCALE 1"=10'

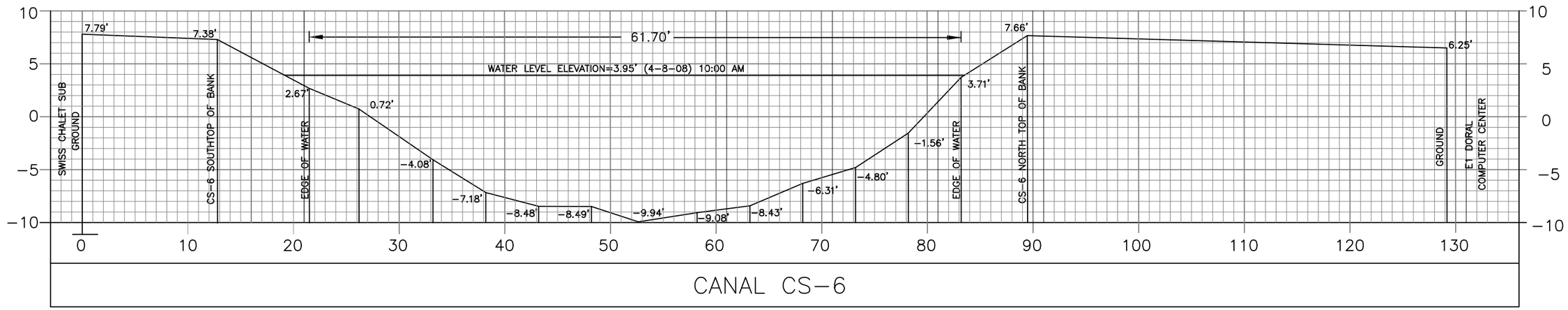
DRAWN A.P.

JOB: 2136WO1

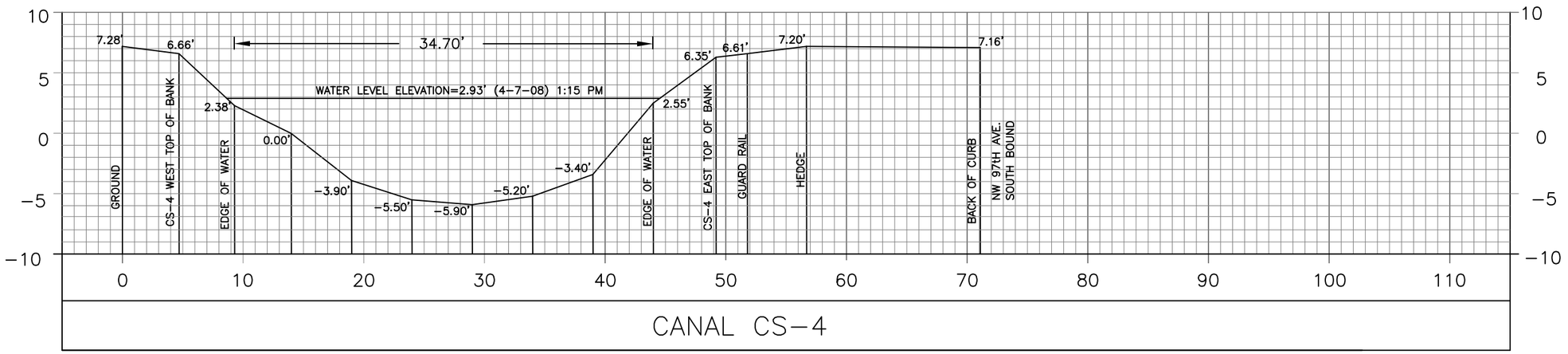
SHEET 8
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

SCALE 1"=10'



SCALE 1"=10'



REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

F.R. Aleman And Associates, Inc. LB #6785
Consulting Engineers and Surveyors
10305 NW 41ST STREET, SUITE 200
MIAMI , FLORIDA 33178
TEL. (305) 591-8777 FAX. (305)599-8749

DATE 04/14/08

SCALE 1"=10'

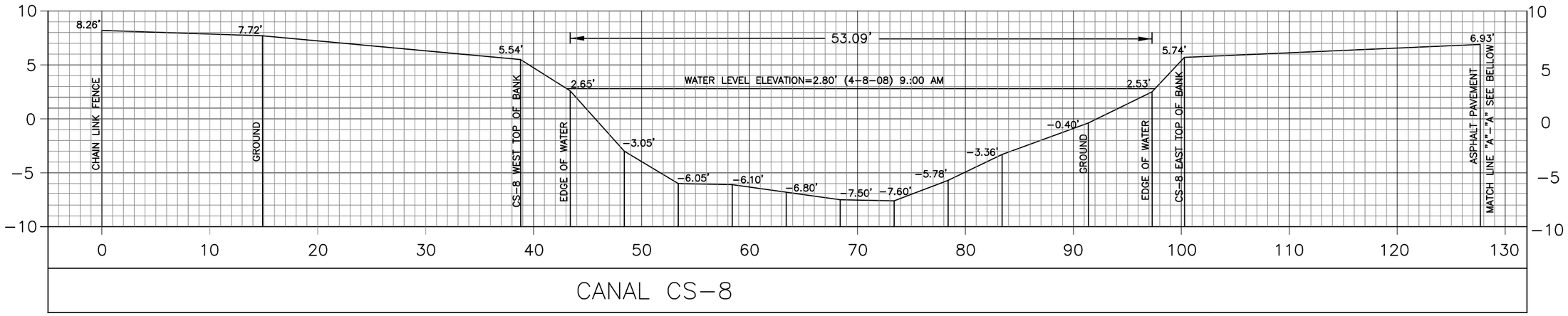
DRAWN A.P.

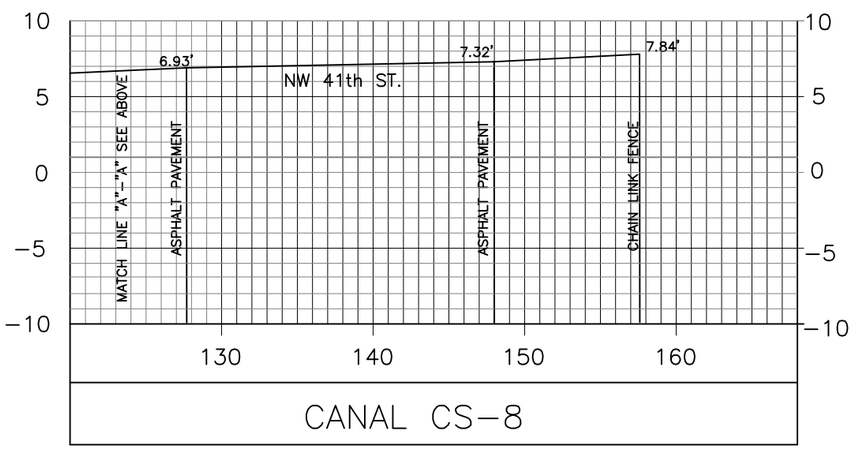
JOB: 2136WO1

SHEET 9
OF 11

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL

SCALE 1"=10'





REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

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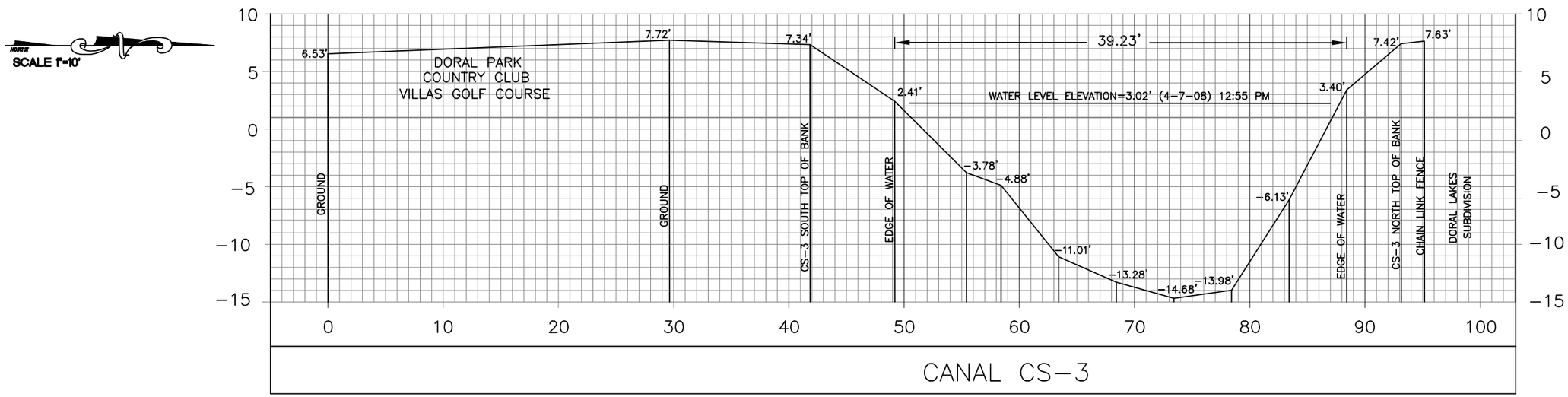
DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

JOB: 2136WO1

SPECIFIC PURPOSE SURVEY
CANAL CROSS-SECTIONS
CITY OF DORAL



REVISIONS

CANAL CROSS-SECTIONS
FOR: A.D.A. ENGINEERING, INC.

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10305 NW 41ST STREET, SUITE 200
MIAMI , FLORIDA 33178
TEL. (305) 591−8777 FAX. (305)599−8749

DATE 04/14/08

SCALE 1"=10'

DRAWN A.P.

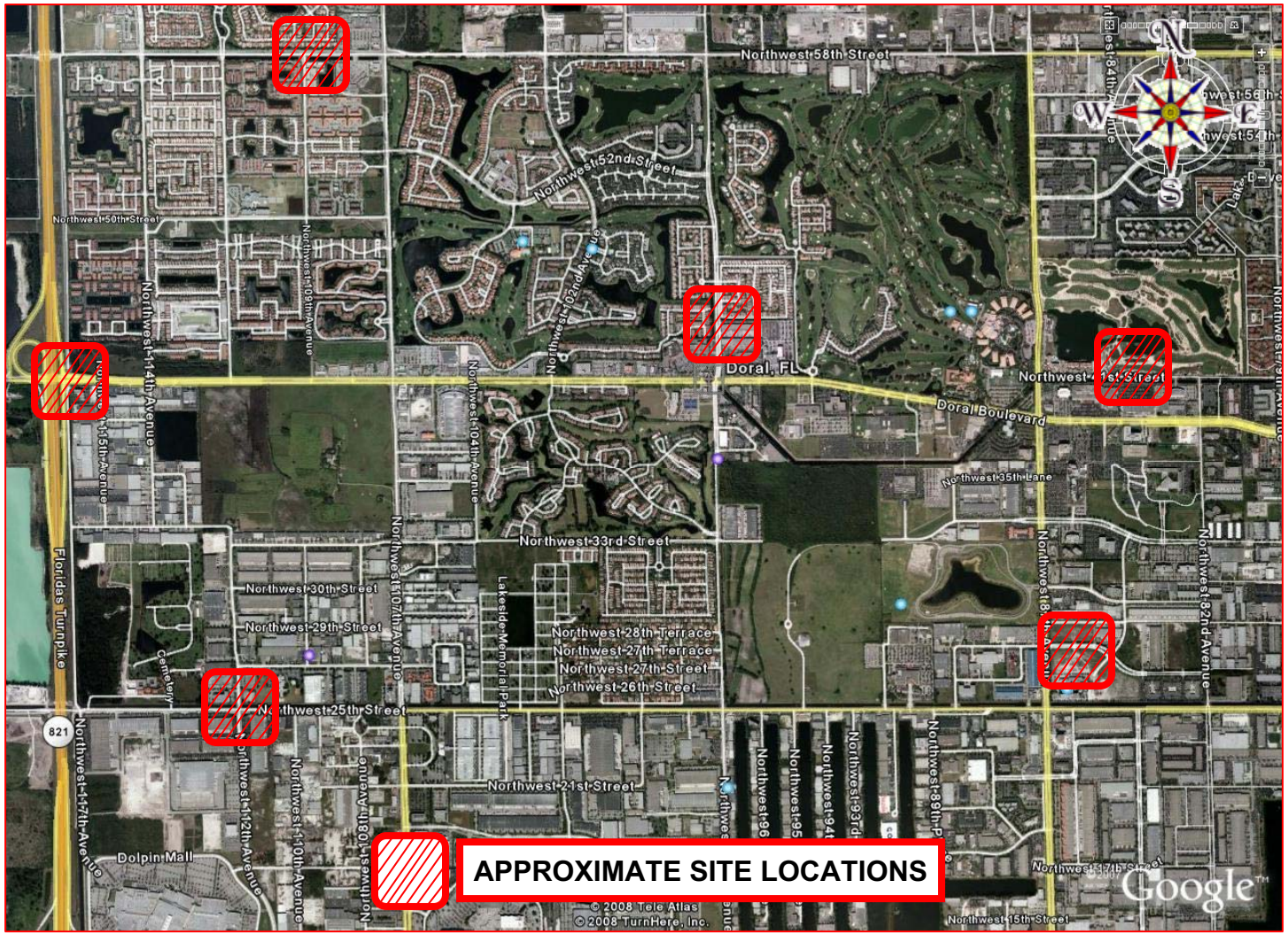
JOB: 2136WO1

SHEET 11
OF 11

APPENDIX B

SOIL BORING PROFILES

SITE VICINITY MAP



GEOTECHNICAL ENGINEERING SERVICES

CITY OF DORAL CANAL FEASIBILITY STUDY

DORAL, FLORIDA

SHEET NO.: 1	PSI PROJ. NO.: 397-85026	CHKD: HS

DATE: 04/10/2008

DRAWN CD

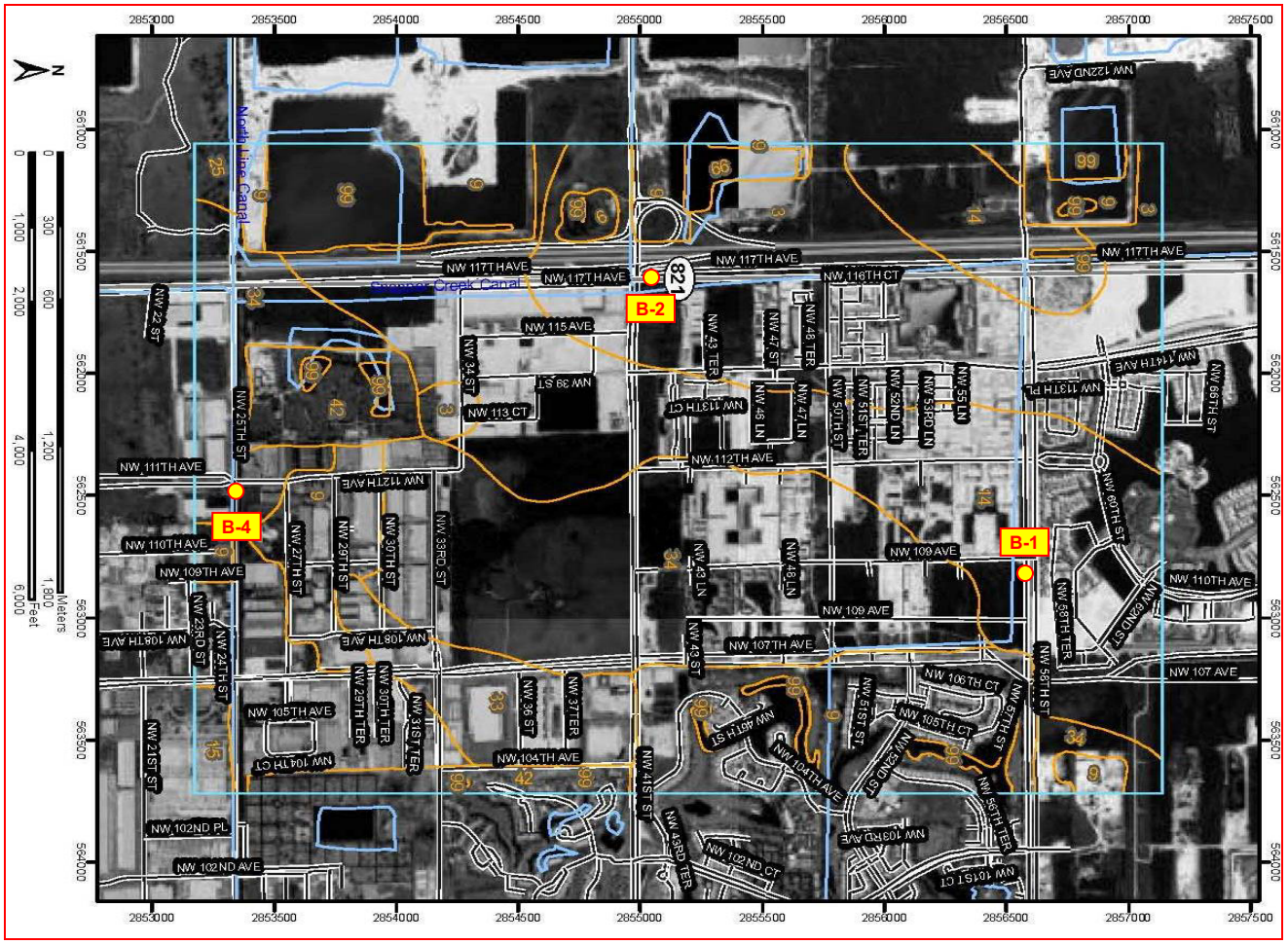
psi Information To Build On

Engineering • Consulting • Testing

SITE PHOTOGRAPHS

GEOTECHNICAL ENGINEERING SERVICES **CITY OF DORAL CANAL FEASIBILITY STUDY** DORAL, FLORIDA		DATE: 04/10/2008 DRAWN CD	psi Information To Build On Engineering • Consulting • Testing
SHEET NO.: 2	PSI PROJ. NO.: 397-85026	CHKD: HS	

BORING LOCATION PLAN – USDA MAP



Map Unit Symbol	Map Unit Name
3	Lauderhill muck, depressional
9	Udorthents-Water complex
14	Dania muck, depressional
15	Urban land
25	Biscayne marl-Rock outcrop complex
33	Plantation muck
34	Hallandale fine sand
42	Udorthents, limestone substratum, 0 to 5 percent slopes
99	Water

○ APPROXIMATE SPT BORING LOCATION

GEOTECHNICAL ENGINEERING SERVICES

CITY OF DORAL CANAL FEASIBILITY STUDY

DORAL, FLORIDA

DATE: 04/10/2008

DRAWN CD

CHKD: HS

SHEET NO.: 3

PSI PROJ. NO.: 397-85026

psi Information To Build On

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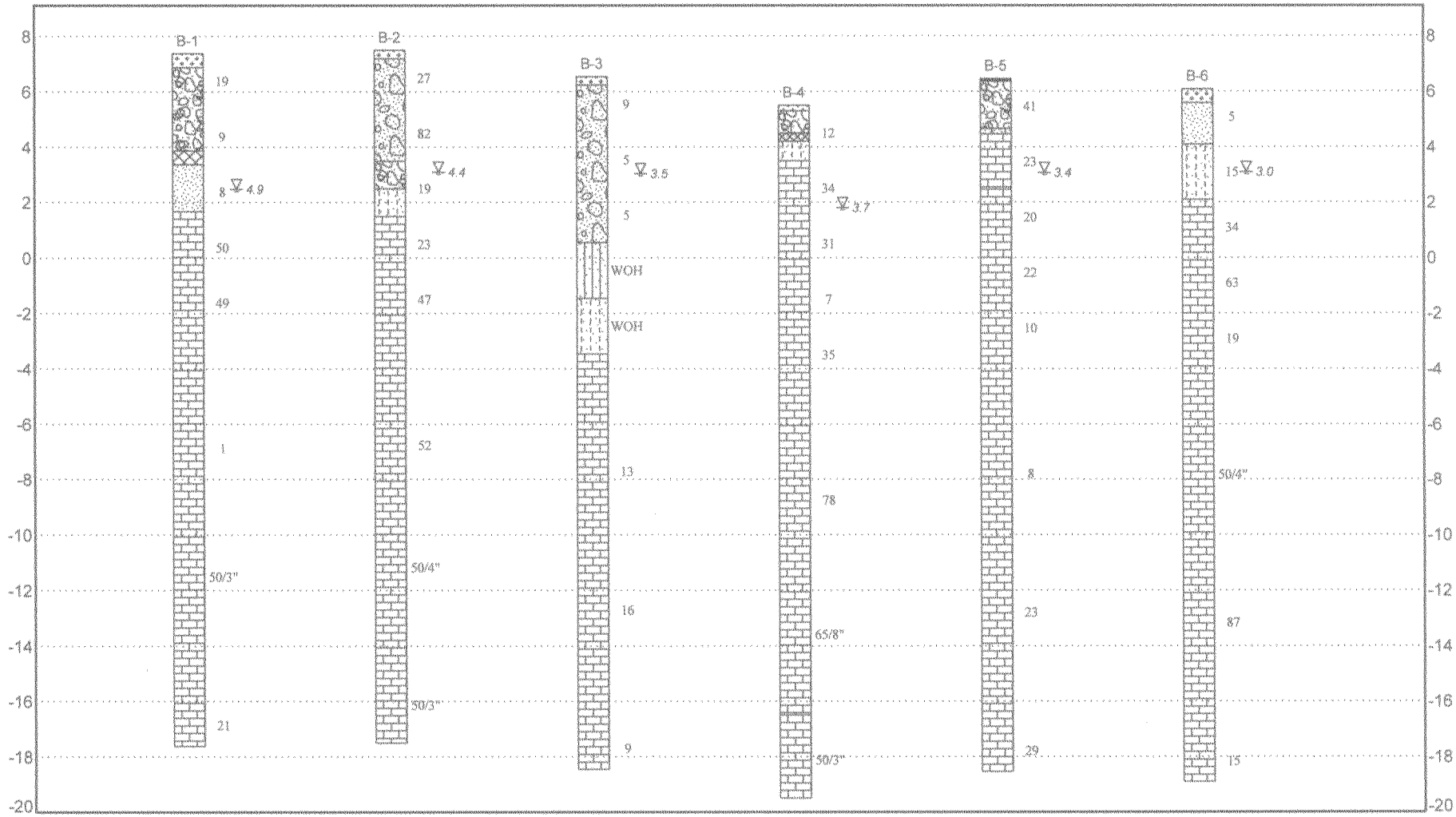


Topsoil
Gravelly Sand
Muck/Peat
Limestone
Silty Sand
Asphaltic Pavement
Organic Silt
Sandy Gravel
Sand
Sandy Silt

GENERALIZED SOIL PROFILE

DATE DRAWN	DRAWN BY / APPROVED BY	SHEET NO.:
04/10/2008	CD / DB	5

Client: A.D.A. ENGINEERING, INC.

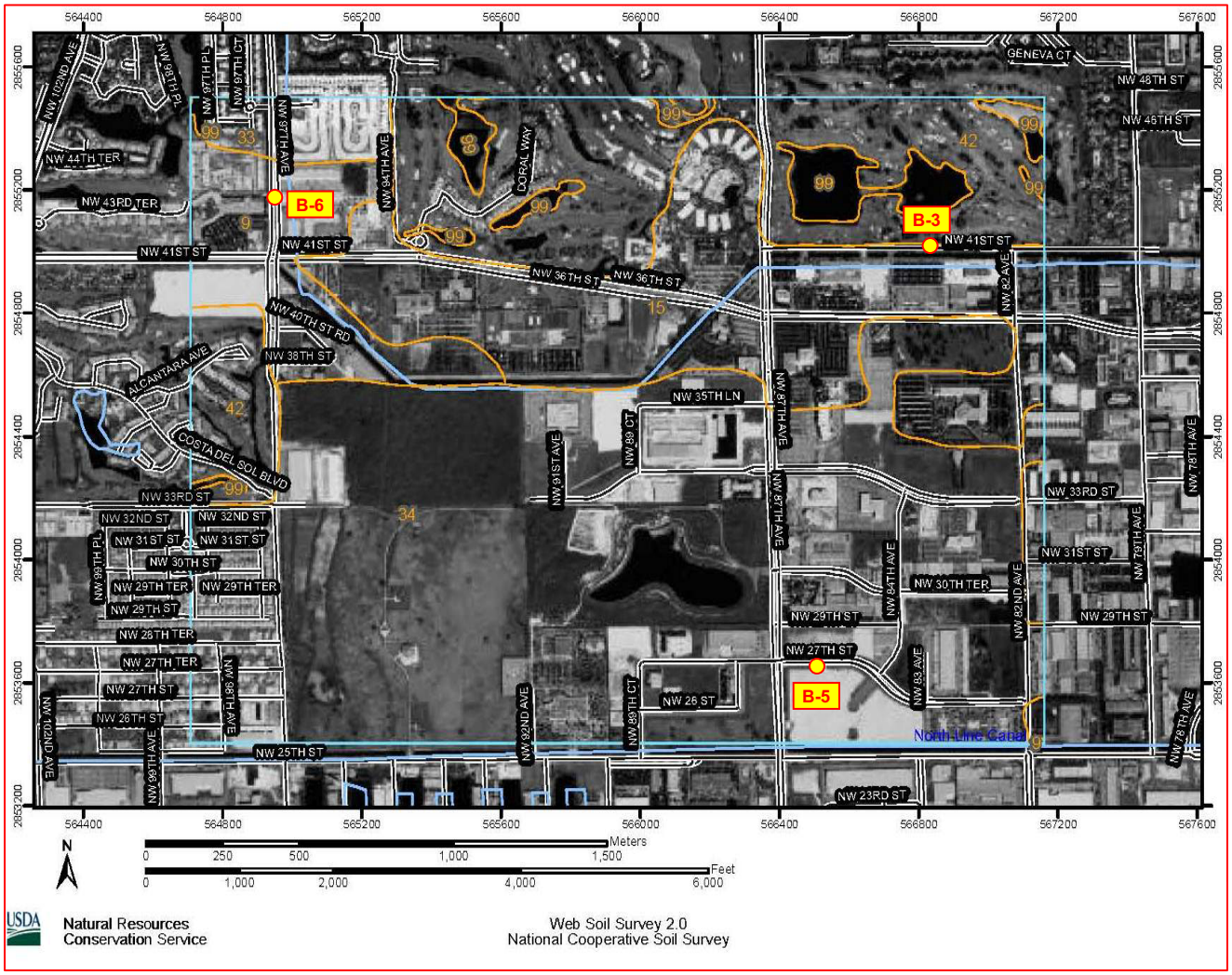
Project: CITY OF DORAL CANAL FEASIBILITY STUDY

Location: MIAMI-DADE COUNTY

Number: 397-85026

ELEVATION FENCE 397-85026.GPJ PSI_CORP.GDT 4/12/08

BORING LOCATION PLAN – USDA MAP



Map Unit Symbol	Map Unit Name
9	Udorthents-Water complex
15	Urban land
33	Plantation muck
34	Hallandale fine sand
42	Udorthents, limestone substratum, 0 to 5 percent slopes
99	Water

APPROXIMATE SPT BORING LOCATION

GEOTECHNICAL ENGINEERING SERVICES

CITY OF DORAL CANAL FEASIBILITY STUDY

DORAL, FLORIDA

DATE: 04/10/2008

DRAWN: CD

CHKD: HS

SHEET NO.: 4

PSI PROJ. NO.: 397-85026

psi Information To Build On

Engineering • Consulting • Testing

LOG OF BORING NO. B-1

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

NORTHING: 542987.8923
EASTING : 862223.6543

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT	STANDARD PENETRATION TEST ●N-VALUE (ASTM D-1586) 10 20 30 40 50 60 70 80 90
			(TOPSOIL) Dark Brown Fine SAND with Trace Roots (SP)						
			(FILL) Light Brown/Gray LIMEROCK with Fine Sand (GP)				5-6-13-32	19	
5							30-8-1-1	9	
			(FILL) Dark Brown Organic Sandy SILT with Limerock (OL)						
			Light Brown/Gray Fine SAND (SP)				5-5-3-21	8	
			Light Brown/Gray LIMESTONE with Fine Sand				26-29-21-23	50	
0							15-27-22-21	49	
-5							2-1-WOH	1	
-10							38-(50/3")	50/3"	
-15							8-9-12	21	

COMPLETION DEPTH (FT): 25.0 | DEPTH TO WATER (FT): 4.9 | SURF. ELEV.: 7.4
DATE DRILLED: 3/31/08 | CHECKED BY: DB/CD | DRILLER: LR

psi
Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

LOG OF BORING NO. B-2

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.

NORTHING: 537948.7948
EASTING : 858326.6640
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL / SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT
		(TOPSOIL) Dark Brown Fine SAND with Trace Roots (SP)					
		(FILL) Light Brown/Gray Fine SAND with Traces of Limerock (SP)				11-13-14-22	27
5						29-40-42-19	82
		(FILL) Light Brown/Gray LIMEROCK with Fine Sand (GP)					
		Brown Silty fine SAND with Limestone Lenses/Layers (SM)				10-9-10-7	19
		Light Brown/Gray LIMESTONE with Fine Sand				8-11-12-10	23
0						13-24-23-9	47
-5						18-28-24	52
-10						(50/4")	50/4"
-15						(50/3")	50/3"

STANDARD PENETRATION TEST
● N-VALUE (ASTM D-1586)
10 20 30 40 50 60 70 80 90

COMPLETION DEPTH (FT): 25.0 | DEPTH TO WATER (FT): 4.4 | SURF. ELEV.: 7.5
DATE DRILLED: 3/31/08 | CHECKED BY: DB/CD | DRILLER: LR

Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

ELEVATION LAB SPT 397-85026.GPJ PSI_CORP.GDT 4/12/08

LOG OF BORING NO. B-3

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.

NORTHING: 537816.7221
EASTING : 875959.8945
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT	STANDARD PENETRATION TEST ● N-VALUE (ASTM D-1586) 10 20 30 40 50 60 70 80 90
			(TOPSOIL) Dark Brown Fine SAND with Trace Roots (SP)						
5			(FILL) Light Brown/Gray Fine SAND with Traces of Limerock (SP)				4-5-4-6	9	
							4-2-3-4	5	
							4-3-2-3	5	
0			Brown Sandy SILT with Limestone Lenses/Layers (ML)	53		63	1-(WOH)	WOH	
			Light Brown/Gray Silty Fine SAND with Limestone Lenses/Layers (SM)	35		52	(WOH)	WOH	
-5			Light Brown/Gray Very Porous LIMESTONE and Fine Sand				7-6-7	13	
-10							7-6-10	16	
-15							10-6-3	9	

COMPLETION DEPTH (FT): 25.0 | DEPTH TO WATER (FT): 3.5 | SURF. ELEV.: 6.6
DATE DRILLED: 4/1/08 | CHECKED BY: DB/CD | DRILLER: LR

psi
Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

ELEVATION LAB SPT 397-85026.GPJ PSI_CORP.GDT 4/12/08

LOG OF BORING NO. B-4

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.

NORTHING: 532445.0271
EASTING : 861208.4890
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT
5			(TOPSOIL) Dark Brown Fine SAND with Trace Roots (SP)					
			(FILL) Light Brown/Gray LIMEROCK with Fine Sand (GP)		44	171	17-5-7-6	12
			Dark Brown Silty PEAT (PT)	25	3	33		
			Dark Brown Slightly Organic Silty fine SAND (SM)					
			Light Brown/Gray LIMESTONE with Fine Sand				4-3-31-29	34
0							14-16-15-17	31
							8-4-3-3	7
-5							22-19-16-14	35
-10							10-41-37	78
-15							43-15-(50/2")	65/8"
			Light Brown/Gray LIMESTONE with Silty Fine Sand				(50/3")	50/3"

STANDARD PENETRATION TEST
●N-VALUE (ASTM D-1586)
10 20 30 40 50 60 70 80 90

COMPLETION DEPTH (FT): 25.0
DATE DRILLED: 3/31/08

DEPTH TO WATER (FT): 3.7
CHECKED BY: DB/CD

SURF. ELEV.: 5.5
DRILLER: LR

Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

ELEVATION LAB SPT 397-85026.GPJ PSI_CORP.GDT 4/12/08

LOG OF BORING NO. B-5

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.

NORTHING: 533385.5301
EASTING : 874757.8818
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT	STANDARD PENETRATION TEST ● N-VALUE (ASTM D-1586) 10 20 30 40 50 60 70 80 90
6.5			Asphalt						
			(FILL) Light Brown/Gray LIMEROCK with Fine Sand (GP)				32-21-20-10	41	
5			(FILL) Light Brown/Gray Fine SAND with Traces of Limerock (SP)						
			Light Brown/Gray LIMESTONE with Silty Fine Sand				5-11-12-14	23	
			Light Brown/Gray LIMESTONE with Fine Sand				3-11-9-8	20	
0							13-17-5-9	22	
							3-2-8-9	10	
-5									
							2-2-6	8	
-10									
							15-9-14	23	
-15									
							12-15-14	29	

COMPLETION DEPTH (FT): 25.0 | DEPTH TO WATER (FT): 3.4 | SURF. ELEV.: 6.5
DATE DRILLED: 4/1/08 | CHECKED BY: DB/CD | DRILLER: LR

psi
Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

ELEVATION LAB SPT 397-85026.GPJ PSI_CORP.GDT 4/12/08

LOG OF BORING NO. B-6

CITY OF DORAL CANAL FEASIBILITY STUDY
DORAL, FLORIDA
MIAMI-DADE COUNTY

BORING TYPE: 2" SPLIT BARREL (SPT)
CLIENT: A.D.A. ENGINEERING, INC.

NORTHING: 538586.7983
EASTING : 868858.2309
PROJECT NO: 397-85026

ELEVATION, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	% PASSING #200 SIEVE	% ORGANIC CONTENT	% MOISTURE CONTENT	BLOWS PER 6"	BLOWS PER FOOT
5			(TOPSOIL) Dark Brown Organic Silty Fine SAND with Trace Roots (OL)					
			(FILL) Light Brown/Gray Fine SAND (SP)				2-3-2-7	5
			Light Brown/Gray Silty Fine Sand with Limestone Lenses/Layers (SM)				6-7-8-8	15
0			Light Brown/Gray LIMESTONE with Fine Sand				14-18-16-23	34
							43-46-17-15	63
							6-9-10-11	19
-5								
							30-(50/4")	50/4"
-10								
							26-46-41	87
-15								
							6-7-8	15

STANDARD PENETRATION TEST
● N-VALUE (ASTM D-1586)
10 20 30 40 50 60 70 80 90

COMPLETION DEPTH (FT): 25.0 | DEPTH TO WATER (FT): 3.0 | SURF. ELEV.: 6.1
DATE DRILLED: 4/4/08 | CHECKED BY: DB/CD | DRILLER: LR

Geotechnical Consulting Services
7950 N.W 64th Street
Miami, FL 33166
305/471-7725
Fax 305/593-1915

BLOWS / FT.	DENSITY
<3	Very Loose
3-8	Loose
8-24	Medium Dense
24-40	Dense
>40	Very Dense

BLOWS / FT.	CONSISTENCY
<1	Very Soft
1-3	Soft
3-6	Medium Soft
6-12	Stiff
12-24	Very Stiff
>24	Hard

APPENDIX C

SOIL BORING ELEVATION & HORIZONTAL LOCATION REPORT

F.R. ALEMAN
& Associates, Inc.

CONSULTING ENGINEERS & SURVEYORS
www.FR-Aleman.com

10305 NW 41 Street, Suite 200
Miami, Florida 33178
TEL: (305) 591-8777
FAX: (305) 599-8749

April 8, 2008

ELEVATION AND COORDINATES REPORT FOR CORE BORINGS
CITY OF DORAL CANAL PROJECT
DADE COUNTY, FLORIDA

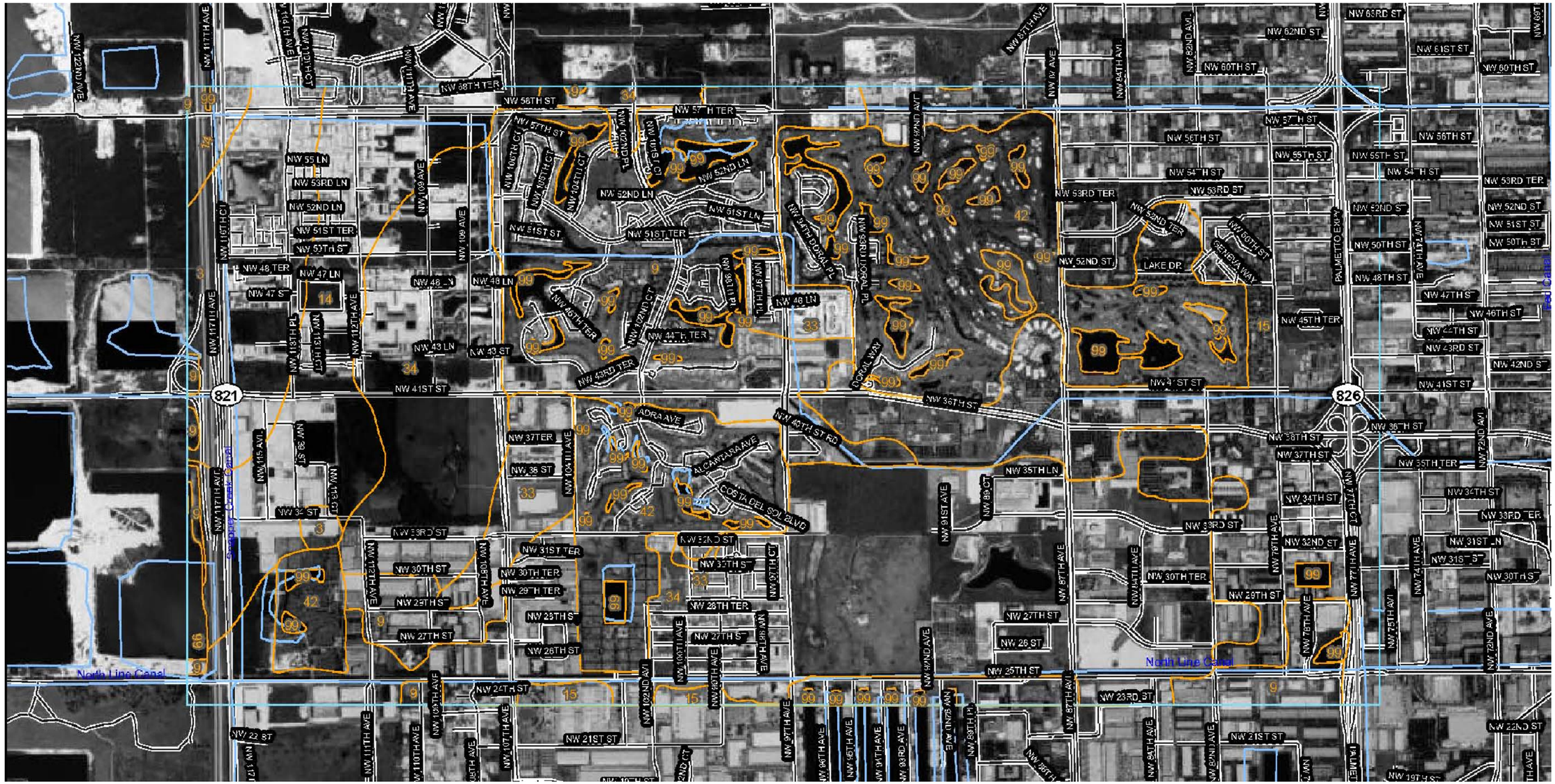
PROJECT No.:
Work Order No. FRA Job No.: 2136WO1

NORTHING	EASTING	ELEVATION	DESCRIPTION
542987.8923,	862223.6543	7.38	SPT-1
537948.7948	858326.6640	7.50	SPT-2
537816.7221	875959.8945	6.55	SPT-3
532445.0271	861208.4890	5.51	SPT-4
533385.5301	874757.8818	6.47	SPT-5
538586.7983	868858.2309	6.10	TB-6

APPENDIX D

CITY OF DORAL SOIL CONSERVATION SERVICE (SCS) MAPPING

SOIL MAP - MIAMI DADE COUNTY AREA, FLORIDA



MAP UNIT LEGEND

Miami-Dade County Area, Florida (FL686)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Lauderhill muck, depressional	321.1	5.4%
9	Udorthents-Water complex	881.9	14.7%
14	Dania muck, depressional	469.0	7.8%
15	Urban land	1,322.4	22.1%
33	Plantation muck	168.5	2.8%
34	Hallandale fine sand	1,656.1	27.7%
42	Udorthents, limestone substratum, 0 to 5 percent slopes	940.2	15.7%
99	Water	221.1	3.7%
Totals for Area of Interest (AOI)		5,980.4	100.0%

0' 1000' 2000' 4000'

Scale: 1" = 2000'

SOURCE: NATURAL RESOURCES CONSERVATION SERVICE

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 2000'
REVISED	

CITY OF DORAL SOIL CONSERVATION SERVICE MAP

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	D1

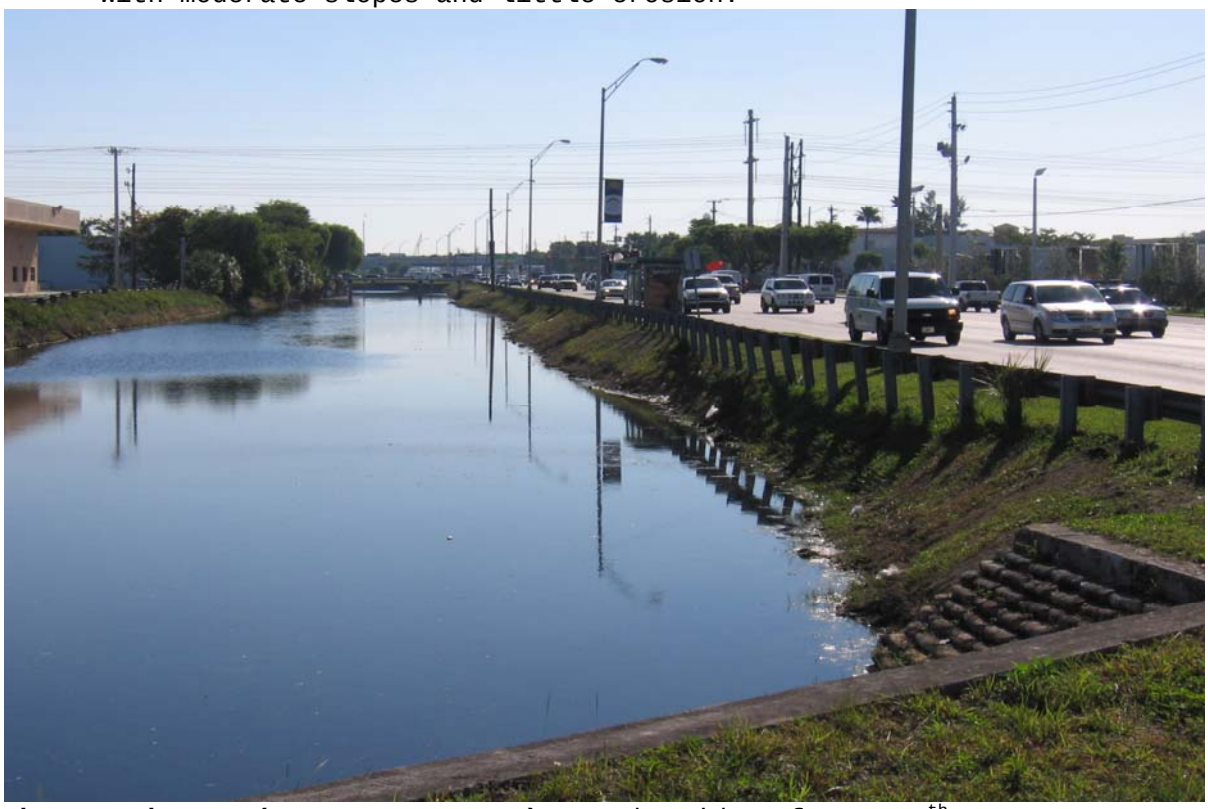
APPENDIX E

CANAL GEOLOGICAL RECONNAISSANCE PHOTOGRAPHIC DOCUMENTATION

Photograph 1: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 78th Ave, facing east. Shows limestone boulders similar to that found along the canal banks throughout the area.

Photograph 2: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 78th Ave, facing west. Shows canal banks with gentle slopes and little erosion.

Photograph 3: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 79th Ave, facing west. Shows canal banks with moderate slopes and little erosion.



Photograph 4: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 82nd Ave, facing east. Shows canal banks with steep slopes and severe erosion. Guardrail is rotating towards canal.

Photograph 5: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 27th St, facing east. Shows canal banks with gentle to moderate slopes and little erosion.

Photograph 6: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 27th St, facing west. Shows canal banks with moderate slopes and little erosion.

Photograph 7: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 94th Ave, facing east. Shows canal banks with gentle to moderate slopes and little erosion. Numerous boulders visible along northern canal bank.

Photograph 8: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 94th Ave, facing west. Shows canal banks with moderate slopes and little erosion.

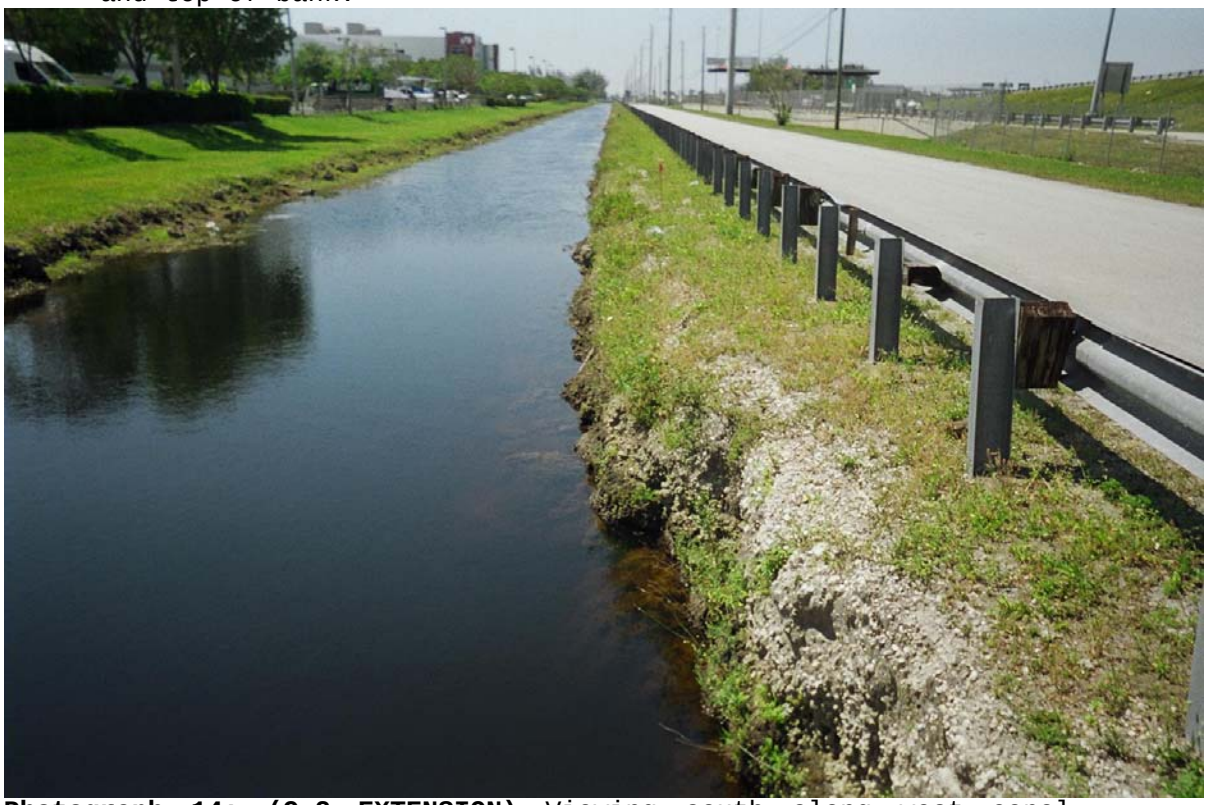
Photograph 9: (NORTHLINE CANAL) North side of NW 25th St at intersection with NW 97th Ave, facing west. Shows canal banks with steep slopes, moderate erosion and irregular canal width.

Photograph 10: (C-2 EXTENSION) East side of NW 117th Ave just north of NW 25th St, facing south. Shows canal banks with moderate to steep slopes, moderate to severe erosion and irregular canal width.

Photograph 11: (C-2 EXTENSION) East side of NW 117th Ave just north of NW 25th St, facing north. Shows canal banks with moderate to steep slopes, moderate to severe erosion and irregular canal width.

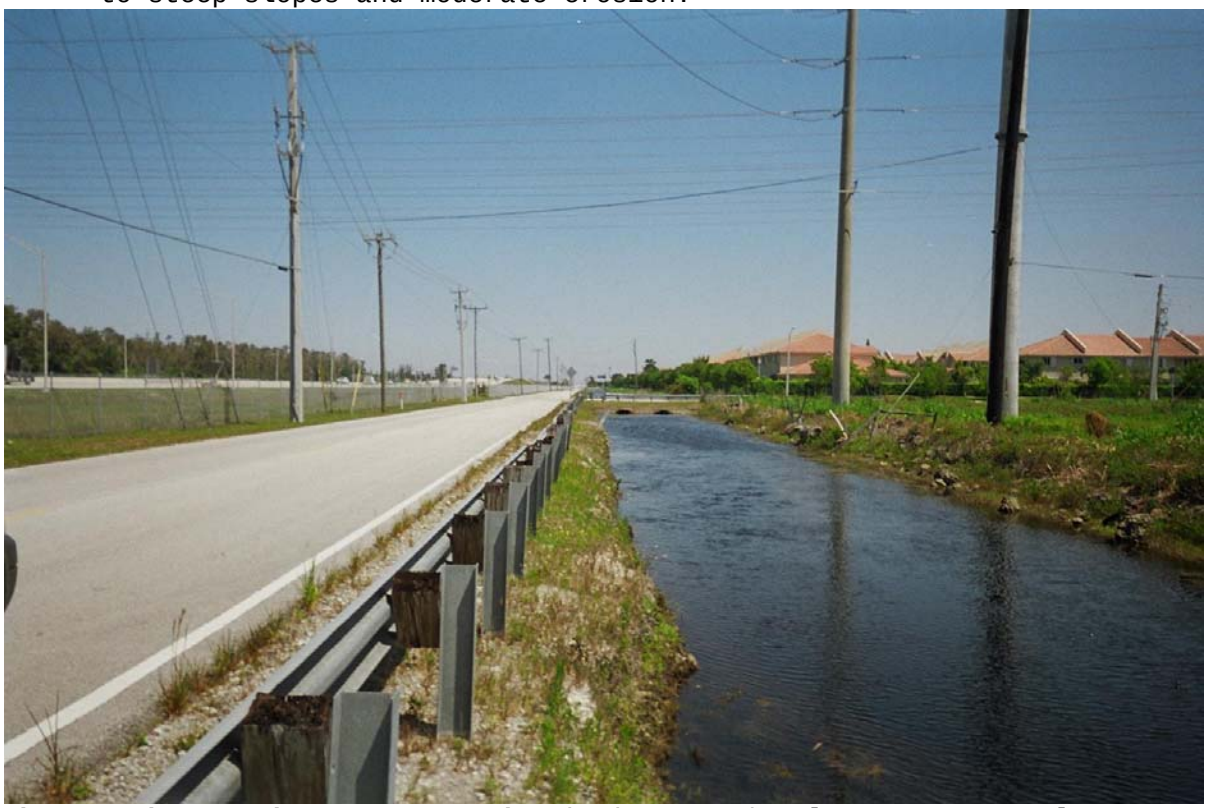
Photograph 12: (C-2 EXTENSION) East side of NW 117th Ave just south of NW 34th St, facing north. Shows canal banks with moderate to steep slopes, moderate to severe erosion and irregular canal width.

Photograph 13: (C-2 EXTENSION) Viewing north along west canal bank, shows moderate to steep canal slopes with moderate erosion, little horizontal distance between guard railing and top of bank.



Photograph 14: (C-2 EXTENSION) Viewing south along west canal bank, shows moderate to steep canal slopes with moderate erosion, little horizontal distance between guard railing and top of bank.

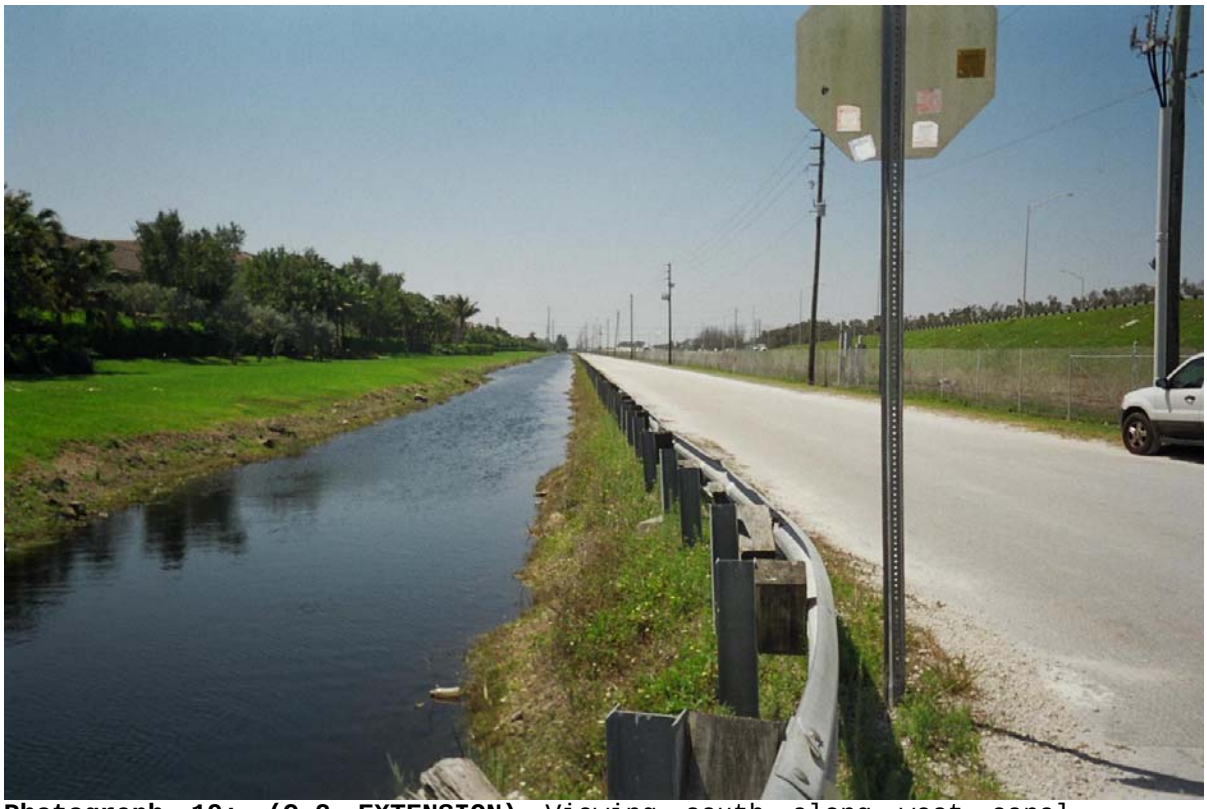
Photograph 15: (C-2 EXTENSION) East side of NW 117th Ave just north of Doral Blvd, facing north. Shows canal banks with moderate to steep slopes and moderate erosion.



Photograph 16: (C-2 EXTENSION) Viewing north along west canal bank, shows moderate to steep canal slopes with moderate erosion, little horizontal distance between guard railing and top of bank.

Photograph 17: (C-2 EXTENSION) East side of NW 117th Ave just north of NW 50th St, facing south. Shows canal banks with moderate to steep slopes and moderate erosion.

Photograph 18: (C-2 EXTENSION) East side of NW 117th Ave just north of NW 50th St, facing north. Shows canal banks with moderate to steep slopes and little to moderate erosion.



Photograph 19: (C-2 EXTENSION) Viewing south along west canal bank, shows moderate to steep canal slopes with moderate erosion, little horizontal distance between guard railing and top of bank.

Photograph 20: (DRESSELS CANAL) South side of NW 58th St just east of NW 112th Ave, facing southwest. Shows canal banks with moderate slopes and little to moderate erosion.

Photograph 21: (DRESSELS CANAL) NW 109th Ave at intersection with NW 58th St, facing west. Shows canal banks with gentle to moderate slopes and little to moderate erosion.

Photograph 22: (DRESSELS CANAL) NW 109th Ave at intersection with NW 58th St, facing east. Shows canal banks with moderate to steep slopes and moderate erosion.

Photograph 23: (DRESSELS CANAL) NW 58th St just west of NW 107th Ave, facing west. Showing steep slopes and severe erosion on south canal bank (adjacent to "Delia Plaza").

Photograph 24: (DRESSELS CANAL) NW 58th St just west of NW 107th Ave, facing east. Showing steep slopes and severe erosion on south canal bank (adjacent to "Delia Plaza").

Photograph 25: (DRESSELS CANAL) Canal section between NW 104th Ave and NW 102nd Ave, facing southeast. Showing heavy overgrowth along south bank.

Photograph 26: (DRESSELS CANAL) Canal section between NW 104th Ave and NW 102nd Ave, facing southwest. Showing heavy overgrowth along south bank.

Photograph 27: (DRESSELS CANAL) Canal crossing at NW 102nd Ave, facing west. Showing steep, grass-covered slopes with little erosion.

Photograph 28: (DRESSELS CANAL) Canal crossing at NW 102nd Ave, facing east. Showing moderate to steep grass-covered slopes with little erosion.

Photograph 29: (DRESSELS CANAL) West side of NW 97th Ave just south of NW 49th Ter, facing north. Showing moderate grass-covered slopes with little erosion.

Photograph 30: (DRESSELS CANAL) West side of NW 97th Ave just south of NW 45th Ln, facing north. Showing moderate grass-covered slopes with little erosion.

Photograph 31: (DRESSELS CANAL) Canal section along NW 40th St, showing moderate slopes and little to moderate erosion. Also numerous boulders along west bank.

Photograph 32: (DRESSELS CANAL) Canal section along NW 40th St, facing east. Showing moderate slopes and little to moderate erosion.

Photograph 33: (DRESSELS CANAL) Canal section just south of Federal Reserve (Doral Blvd), facing west. Showing moderate slopes and little erosion. Numerous boulders visible along south bank.

Photograph 34: (DRESSELS CANAL) Canal section just south of Federal Reserve (Doral Blvd), facing northeast. Showing moderate slopes and little erosion.

Photograph 35: (DRESSELS CANAL) NW 41st St just west of NW 79th Ave, facing southeast. Showing moderate to severe erosion and heavy overgrowth.

APPENDIX F

HAND AUGER BORING PROFILE LOGS

DUNKELBERGER ENGINEERING & TESTING, INC.

LOG OF AUGER BORING	
Project Number: FTL-07-0124	**Boring Number:** HA-1
Client: A.D.A. Engineering, Inc.	
Project: Canal Feasibility Study, City of Doral, FL	
Boring Location: N 25° 49.557' / W 80° 22.698'	
Date Drilled: 3/28/2007	**Drilled By:** SW
Ground Elevation: Unknown	**Depth of Groundwater Table:** Not Encountered

Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 0.2	Topsoil	Brown fine SAND with gravel-sized limestone fragments, trace to some grassroots
0.2 – 2.9	SP,GP	Brown fine SAND with gravel-sized limestone fragments, trace silt
@ 2.9	----	Refusal (Limestone)

LOG OF AUGER BORING	
Project Number: FTL-07-0124	**Boring Number:** HA-2
Client: A.D.A. Engineering, Inc.	
Project: Canal Feasibility Study, City of Doral, FL	
Boring Location: N 25° 48.289' / W 80° 23.118'	
Date Drilled: 3/28/2007	**Drilled By:** SW
Ground Elevation: Unknown	**Depth of Groundwater Table:** Not Encountered

Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 0.3	Topsoil	Brown fine SAND, trace to some grassroots
0.3 – 1.2	SP,GP	Brown fine SAND with gravel-sized limestone fragments
@ 1.2	----	Refusal (Limestone)

DUNKELBERGER ENGINEERING & TESTING, INC.

LOG OF AUGER BORING	
Project Number: FTL-07-0124	**Boring Number:** HA-3
Client: A.D.A. Engineering, Inc.	
Project: Canal Feasibility Study, City of Doral, FL	
Boring Location: N 25° 47.828' / W 80° 22.224'	
Date Drilled: 3/28/2007	**Drilled By:** SW
Ground Elevation: Unknown	**Depth of Groundwater Table:** Not Encountered

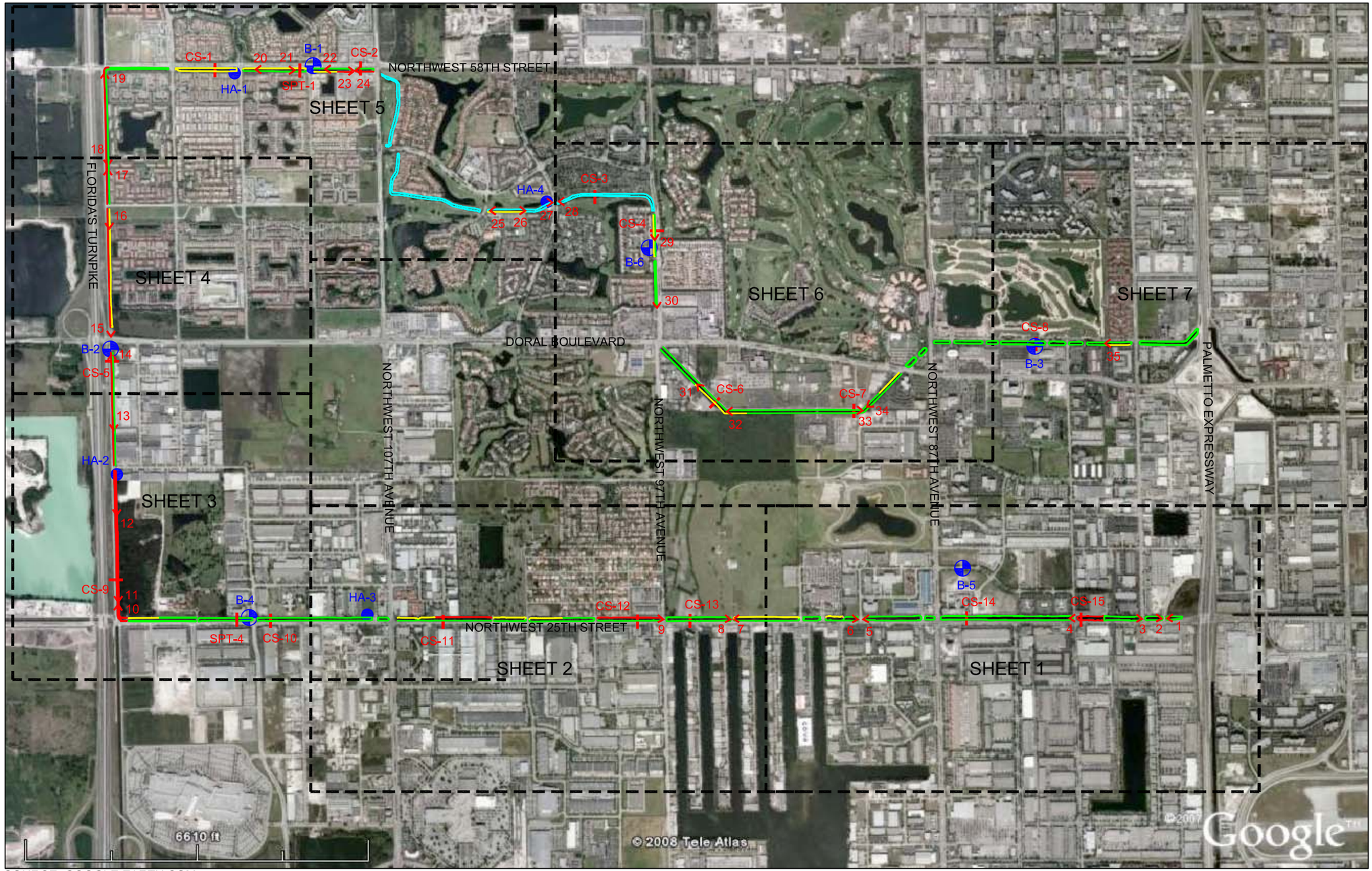
Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 0.2	Topsoil	Brown fine SAND, trace grass roots
0.2 – 3.4	SP,GP	Brown fine SAND, some gravel-sized limestone fragments
@ 3.4	----	Refusal (Limestone)

LOG OF AUGER BORING	
Project Number: FTL-07-0124	**Boring Number:** HA-4
Client: A.D.A. Engineering, Inc.	
Project: Canal Feasibility Study, City of Doral, FL	
Boring Location: N 25° 49.136' / W 80° 21.605'	
Date Drilled: 3/28/2007	**Drilled By:** SW
Ground Elevation: Unknown	**Depth of Groundwater Table:** 4.3 feet below ground surface

Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 0.3	Topsoil	Dark brown fine SAND with grassroots
0.3 – 4.4	SP	Gray to brown fine SAND with gravel-sized limestone fragments, trace silt
4.4 – 4.6	GP	Light brown sandy LIMESTONE
@ 4.6	----	Refusal (Limestone)

APPENDIX G

EXISTING CONDITIONS SURVEY



SOURCE: GOOGLE EARTH.COM

LEGEND

CANAL BANK EROSION SEVERITY - HIGH		CS-1	- CROSS SECTION LOCATION AND NUMBER
CANAL BANK EROSION SEVERITY - MEDIUM			
CANAL BANK EROSION SEVERITY - LOW		B-1	- STANDARD PENETRATION TEST (SPT) BORING LOCATION AND NUMBER
CANAL BANK EROSION SEVERITY - NONE			
PHOTO LOCATION AND NUMBER - <1		AB-1	- HAND AUGER BORING LOCATION AND NUMBER

0' 1000' 2000' 4000'

Scale: 1" = 2000'

Locations are approximate

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 2000'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-0

0' 300' 600' 1200'

Scale: 1" = 600'

LEGEND

CS-15 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

<1 - PHOTO LOCATION AND NUMBER

Locations are approximate

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-1

LEGEND

CS-11 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

14 - PHOTO LOCATION AND NUMBER

Locations are approximate

0' 300' 600' 1200'

Scale: 1" = 600'

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FLT-07-0124	G-2

LEGEND

CS-9 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

<30 - PHOTO LOCATION AND NUMBER

Locations are approximate

0' 300' 600' 1200'

Scale: 1" = 600'

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

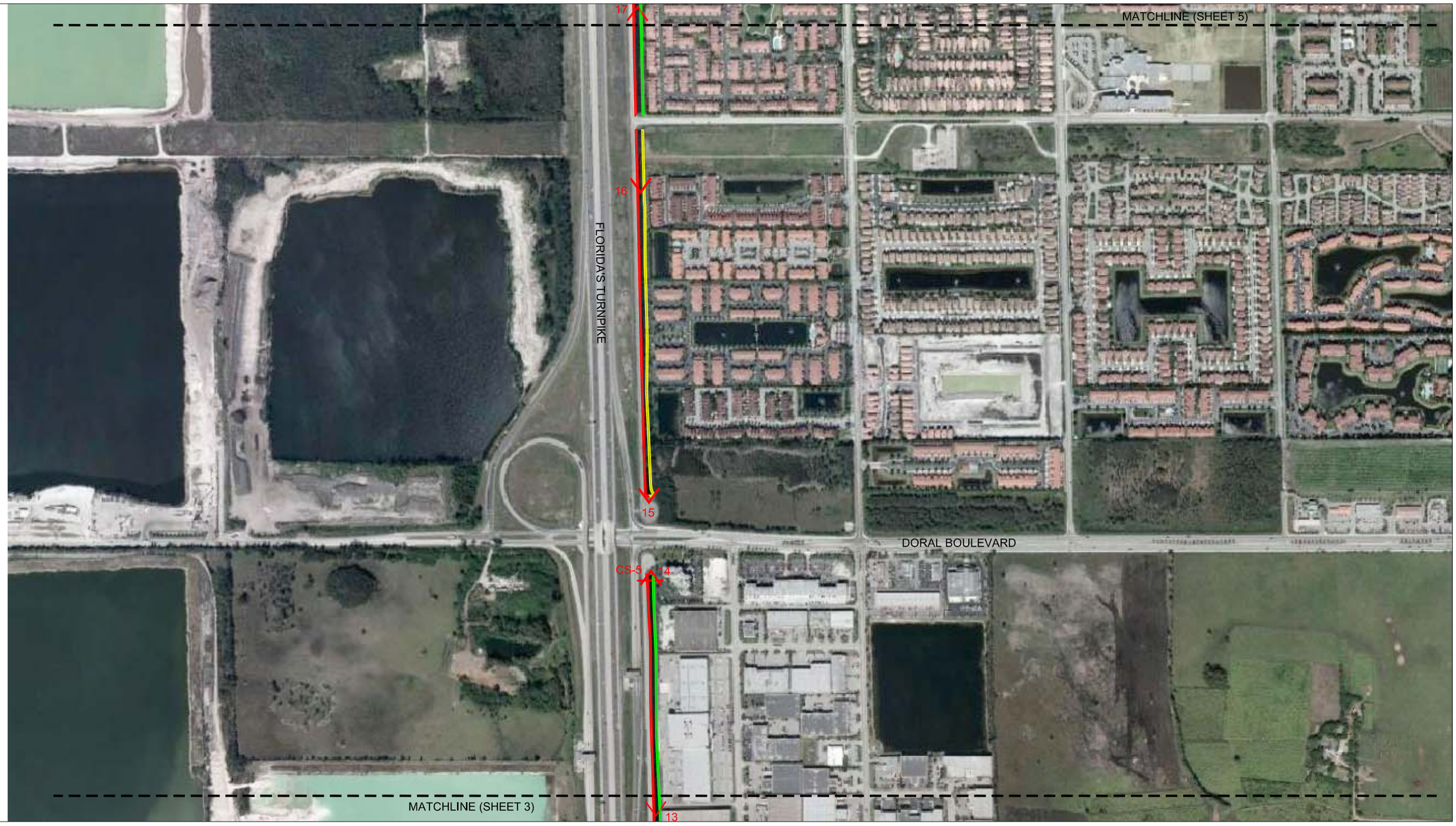
CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-3



0' 300' 600' 1200'

Scale: 1" = 600'

LEGEND

CS-5 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

7 - PHOTO LOCATION AND NUMBER

Locations are approximate

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.
Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-4

LEGEND

CS-1 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

CANAL BANK EROSION SEVERITY - NONE

8 - PHOTO LOCATION AND NUMBER

Locations are approximate

0' 300' 600' 1200'

Scale: 1" = 600'

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-5

0' 300' 600' 1200'

Scale: 1" = 600'

LEGEND

CS-6 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

CANAL BANK EROSION SEVERITY - NONE

19 - PHOTO LOCATION AND NUMBER

Locations are approximate

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

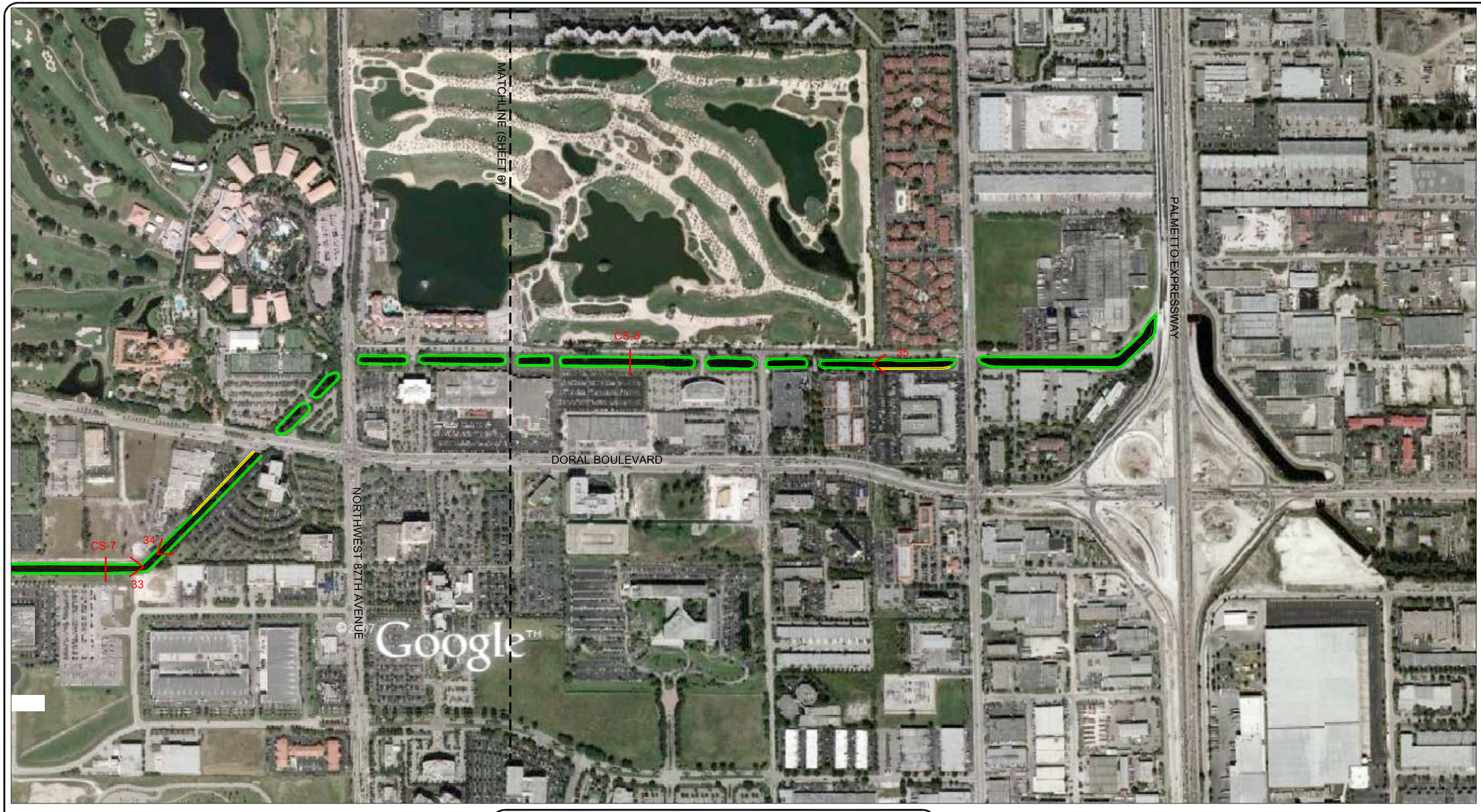
CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-6



LEGEND

CS-7 - CROSS SECTION LOCATION AND NUMBER

CANAL BANK EROSION SEVERITY - HIGH

CANAL BANK EROSION SEVERITY - MEDIUM

CANAL BANK EROSION SEVERITY - LOW

23 - PHOTO LOCATION AND NUMBER

Locations are approximate

0' 300' 600' 1200'

Scale: 1" = 600'

DRAWN	GD
CHECKED	SW
APPROVED	KA
SCALE	1"= 600'
REVISED	4-25-08

EXISTING CONDITION SURVEY

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

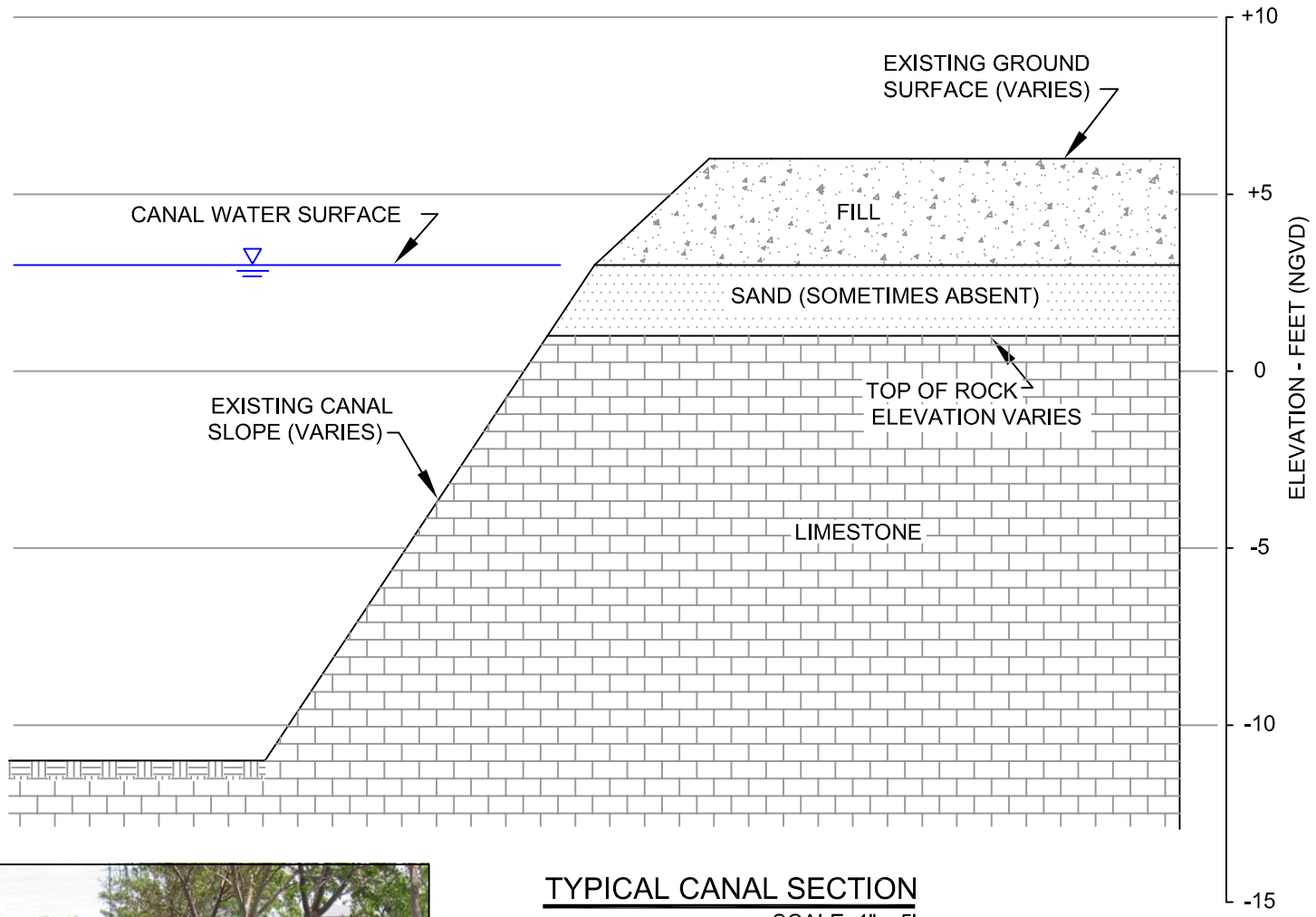
DUNKELBERGER ENGINEERING & TESTING, INC.

Geotechnical • Materials Testing/Inspection Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	G-7

APPENDIX H

BANK STABILITY & CONCEPTUAL CANAL BANK STABILIZATION METHODS



TYPICAL CANAL SECTION

SCALE: 1" = 5'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 5'
REVISED	

TYPICAL CANAL SECTION

CANAL FEASIBILITY STUDY

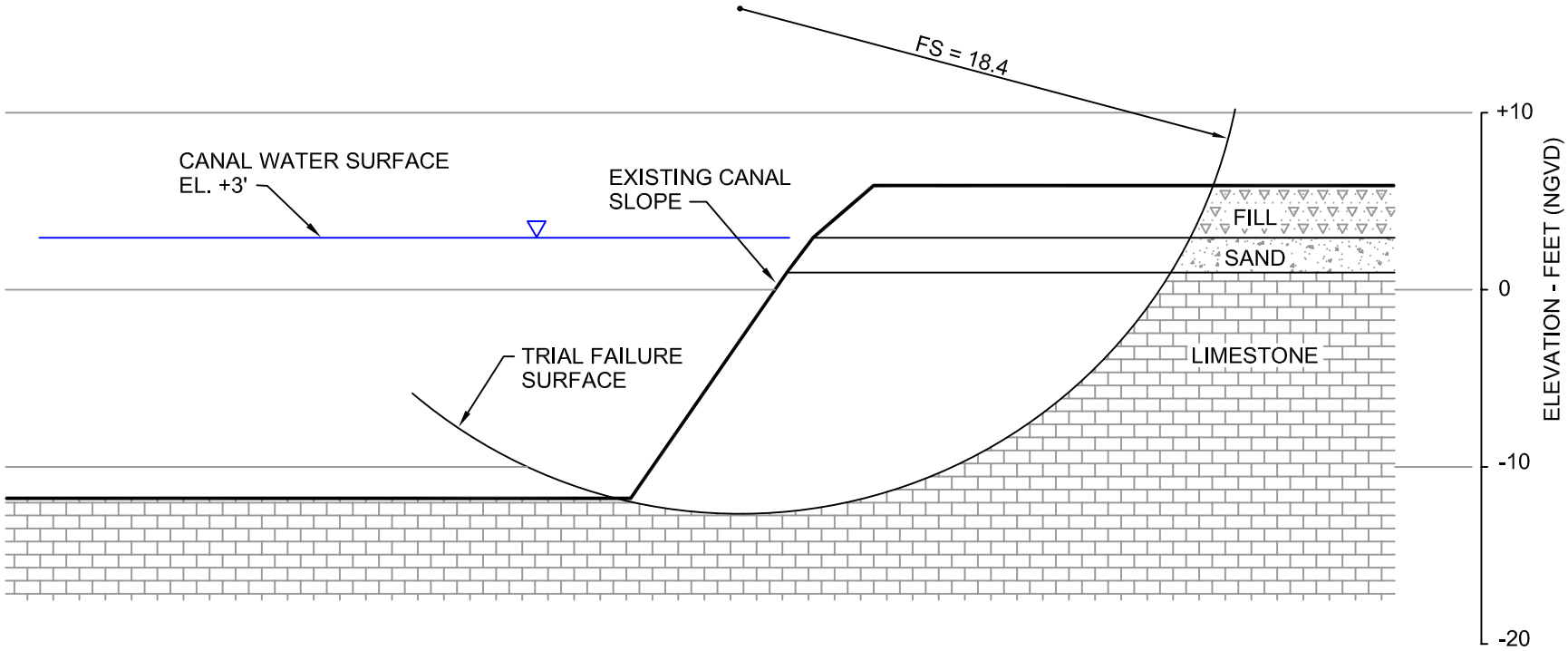
CITY OF DORAL, FLORIDA

DUNKELBERGER ENGINEERING & TESTING, INC.
Geotechnical • Materials Testing/Inspection • Environmental

DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	H1

STRENGTH PARAMETERS

SYMBOL	DESCRIPTION	UNIT WEIGHT (PCF) SAT.	UNIT WEIGHT (PCF) MOIST	Ø (DEG)	C (PSF)
	FILL	120	105	34	0
	SAND	115	100	30	0
	LIMESTONE	130	115	0	5000



CANAL SLOPE STABILITY ANALYSIS RESULTS

SCALE: 1" = 10'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 10'
REVISED	

CANAL SLOPE STABILITY ANALYSIS RESULTS

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

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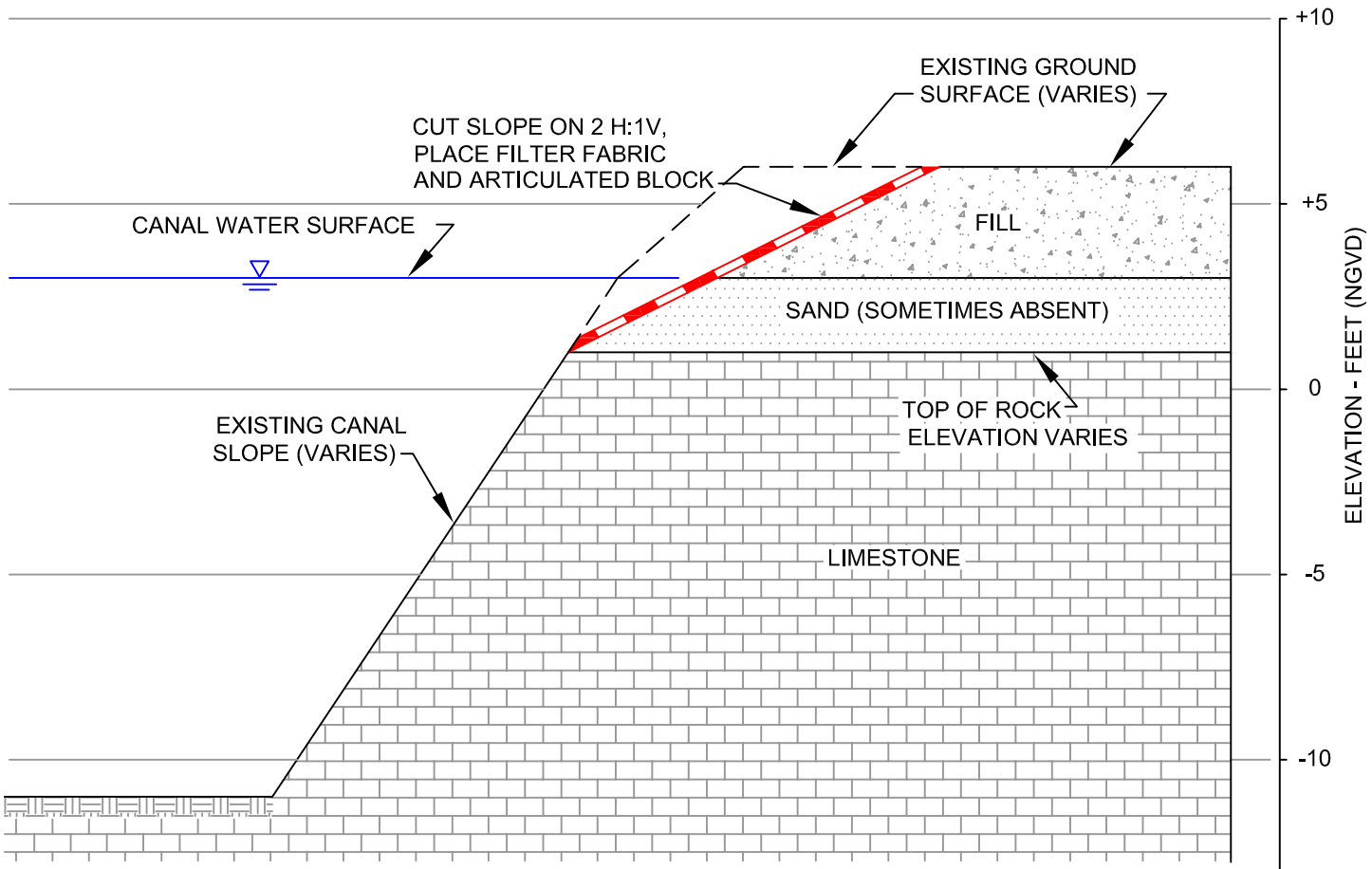
DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	H2



TYPICAL ARTICULATED BLOCK SECTION

SCALE: 1" = 5'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 5'
REVISED	

TYPICAL ARTICULATED BLOCK SECTION

CANAL FEASIBILITY STUDY

CITY OF DORAL, FLORIDA

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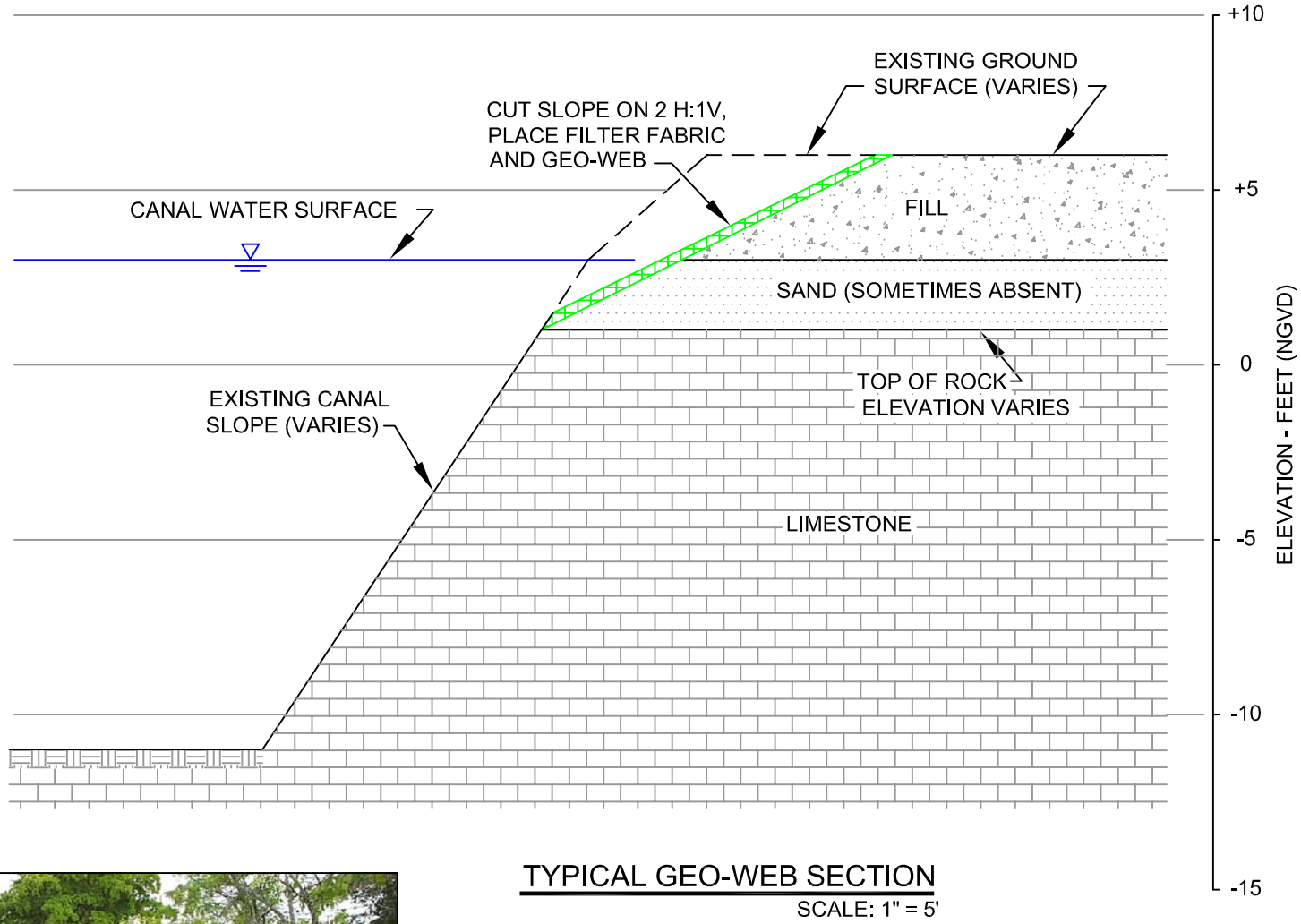
DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	H3



TYPICAL GEO-WEB SECTION

SCALE: 1" = 5'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 5'
REVISED	

TYPICAL GEO-WEB SECTION

CANAL FEASIBILITY STUDY

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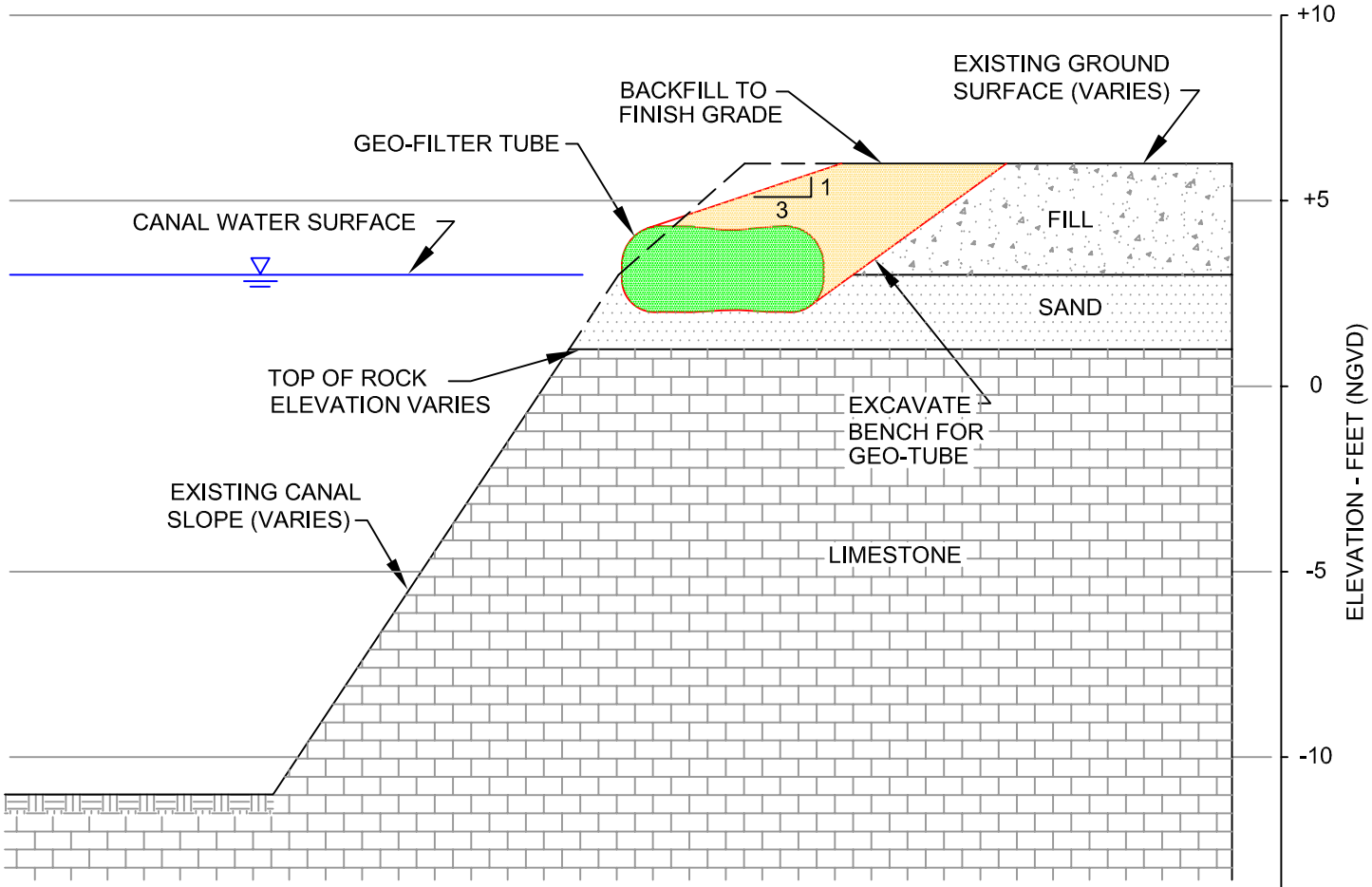
4-18-08	FTL-07-0124	H4



TYPICAL GEO-TUBE SECTION

SCALE: 1" = 5'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 5'
REVISED	

TYPICAL GEO-TUBE SECTION

CANAL FEASIBILITY STUDY

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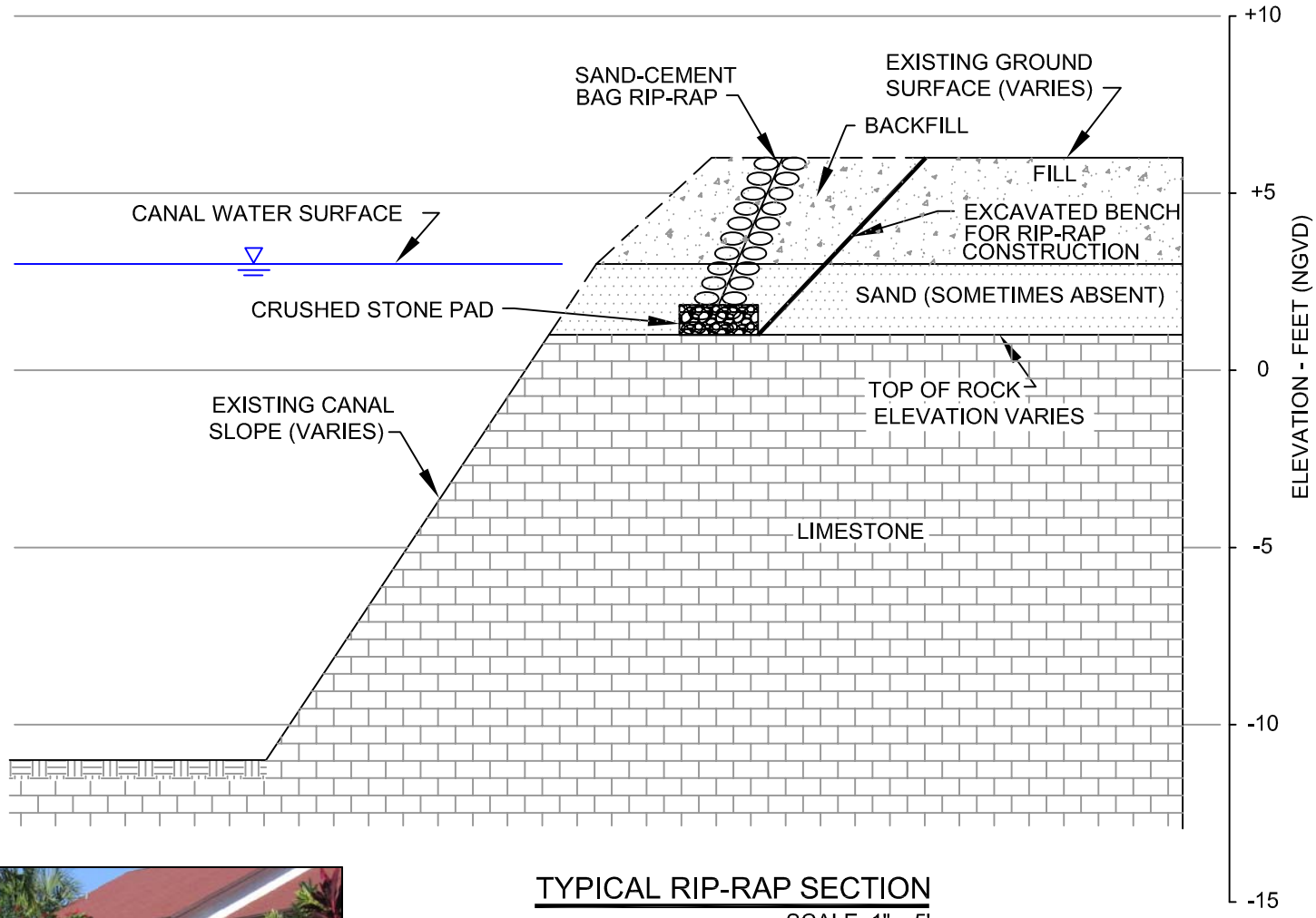
DATE	PROJ. NO.	SHEET
4-18-08	FTL-07-0124	H5



TYPICAL RIP-RAP SECTION

SCALE: 1" = 5'

DRAWN	GD
CHECKED	KA
APPROVED	KA
SCALE	1"= 5'
REVISED	

TYPICAL RIP-RAP SECTION

CANAL FEASIBILITY STUDY

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