

September 13, 1999



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(970) 484-0359 Fax: (970) 484-0454

City of Fort Collins  
Engineering Department  
281 North College Avenue  
Fort Collins, Colorado 80524

Attn: Mr. Rick Richter

Re: **Pavement Thickness Evaluation**  
**Alumbaugh Court – Quail Ridge Residential Development**  
**And Taft Hill Road between Horsetooth Road and Harmony Road**  
**Fort Collins, Colorado**  
**Terracon Project No. 20995151**

Terracon has completed a limited pavement thickness evaluation and subgrade exploration analysis for:

- Alumbaugh Court within the Quail Ridge Residential Development, and
- Taft Hill Road between Horsetooth and Harmony Roads in Fort Collins, Colorado.

The purpose of our exploration services for Alumbaugh Court was to determine the existing pavement thicknesses and evaluate the subgrade soils for expansive potential. The primary purpose for our exploration services with regards to Taft Hill Road was to determine the existing pavement thicknesses for a future roto-milling and overlay construction project for this section of roadway.

#### Alumbaugh Court

Alumbaugh Court is a 5 to 7 year old cul-de-sac roadway situated within the Quail Ridge Estates in southwest Fort Collins, Colorado. The roadway section of Alumbaugh Court, as observed by Terracon on September 3, 1999 has experienced some differential movement. The subgrade soils appears to have caused the pavement section to either heave or settle due to expansive potential or compressibility. Excessive "alligator cracking", ponding of surface water, rutting of pavement, as well as heaving of the pavement sections was observed.

Three random areas were analyzed to evaluate the cause of pavement distress. At these locations, asphalt concrete cores and samples of the subgrade materials were obtained for evaluation. The subgrade samples were subjected to laboratory testing consisting of soil classification, in-situ moisture and density characteristics, swell-consolidation characteristics, and free swell expansive potential. The enclosed table presents the existing pavement thicknesses and the laboratory test results for the three random areas within the cul-de-sac.

The asphalt pavement thickness of the retrieved core samples varied between 3 to 8-inches. Terracon was unable to differentiate between possible subgrade fill material consisting of sandy

lean clay with gravel and a possible aggregate base course layer. However, it did not appear to Terracon that there actually was an aggregate base course layer.

The subgrade soils varied from a sandy lean clay to a weathered siltstone/claystone bedrock. The in-situ moisture contents varied between 15 to 28 percent and the dry densities varied between 77 to 91 pounds per cubic foot (pcf). Based on the dry densities, it appears the subgrade soils may not have been adequately compacted. Typical maximum dry unit weights for clay soils varies between 90 to 110 pcf. With these values the correlated percent compaction values based on Standard Density Proctor curves, ASTM D698 range between 70 to 100 percent. It is usually recommended the subgrade soils be compacted to at least 95 % of Standard Proctor density ASTM D698.

The swell-consolidation index characteristics based upon the City of Fort Collins Pavement Design Criteria with a loading at 150 psf indicated a swell index of 0.04 to 0.4% which is within the 2 percent criteria set by the City of Fort Collins for stabilization of the subgrade for expansive potential. However the free swell expansion testing conducted by Terracon indicated between 215 to 725 psf of swell potential. However, the existing swell index values are based on existing in-situ moisture content and dry density conditions. The swell index could have been higher at the time of construction.

Based on the current site conditions and the laboratory classification and free swell characteristics of the subgrade soils, in our opinion stabilization of the subgrade soils is necessary. Terracon recommends removing the entire existing asphalt pavement section, over-excavating the subgrade soils and stabilizing the subgrade. The subgrade soils should be either chemically stabilized with lime and/or fly-ash soil treatment for a depth of twelve inches or replaced with a granular imported fill material. Laboratory evaluation and mix designs are recommended to determine the effect of chemical stabilization on subgrade soils as well as percentages of soil treatment additives and procedures prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping. Terracon is available for further consultation with regards to the necessary stabilization technique and procedures as well as performing the required laboratory tests and mix designs.

### Taft Hill Road

Terracon was requested by the City of Fort Collins Engineering Department to core and evaluate the existing pavement thicknesses for Taft Hill Road between Horsetooth Road to the north and Harmony Road to the south. The primary purpose of this exploration was to determine the existing pavement sections to aid in the engineering decision of a roto-mill and overlay improvement project for this location. Based upon the existing pavement conditions, the City of Fort Collins' Engineering Department will determine the depth of roto-milling and the required overlay thickness for Taft Hill Road. The following table presents the existing pavement thicknesses at three randomly selected locations between Horsetooth Road and Harmony Road.

Table 2  
 Existing Pavement Thicknesses for Taft Hill Road

Core No.	Core Location	Existing Pavement Thicknesses	
		Asphalt Concrete (inches)	Aggregate Base Course (inches)
1	3908 Taft Hill Road NBL	3	6
2	3828 Taft Hill Road NBL	6	6-1/2
3	Intersection with Imperial Drive NBL	8	6

Based on the existing asphalt concrete pavement varying between 3 to 8 inches in depth, it is recommended to roto-mill no greater than 2-inches in depth. The overlay section should be a minimum of 4-inches. Terracon can provide additional recommendations with regards to the actual pavement thickness evaluation based on AASHTO design criteria as well as provide preventative pavement maintenance recommendations upon request.

We appreciate the opportunity to be of service to you on this phase of your project. If you have any questions concerning this report, or if we may be of further service to you, please feel free to contact us at your convenience.

Sincerely,  
**TERRACON**  
 Prepared by:



David A. Richer, P.E.  
 Geotechnical Engineer/Department Manager

Reviewed By: William J. Attwooll, P.E.  
 Office Manager

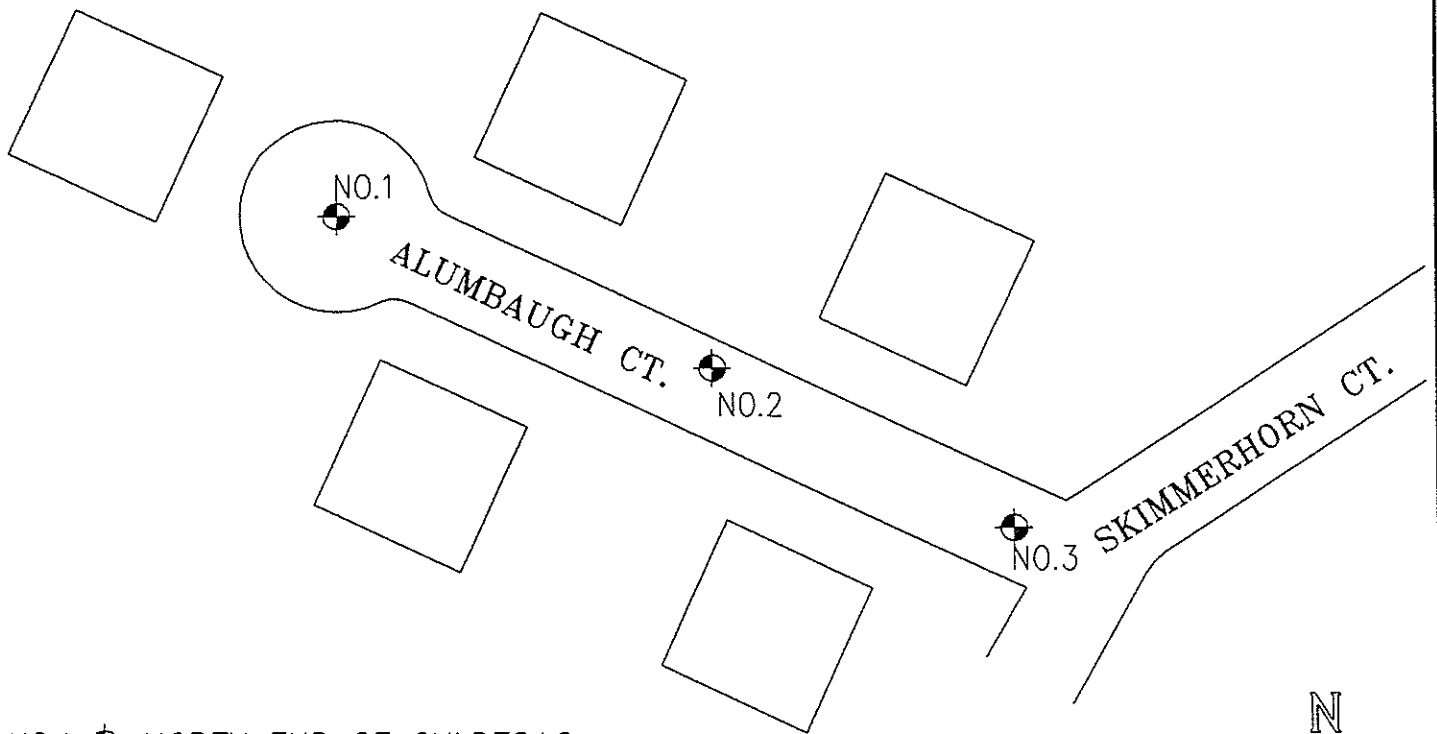
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Enclosure: Field and Laboratory Test Results – Table I  
 Site Plans – Figures 1 and 2  
 Swell-Consolidation Data Curves  
 Grain Size Distribution Curves

TABLE I

FIELD AND LABORATORY TEST RESULTS  
ALUMBAUGH COURT – QUAIL RIDGE ESTATES

LOCATION	EXISTING PAVEMENT THICKNESSES		SUBGRADE DESCRIPTION	SOIL CLASSIFICATION			IN-SITU MOISTURE AND DENSITY		FREE SWELL EXPANSION TEST (PSF)	SWELL INDEX @ 150 PSF
	ASPHALT CONCRETE (inches)	BASE COURSE (inches)		LIQUID LIMIT	PLAST. INDEX	% PASSING # 200 SIEVE	MOISTURE CONTENT %	DRY DENSITY (PCF)		
1	3	N/A	Sand Lean Clay	28	12	52	15	91	725	.04
2	6	N/A	Siltstone-Claystone Bedrock	44	22	78	21	85	400	.40
3	8	N/A	Lean Clay	42	24	86	28	77	215	.17



- NO.1  NORTH END OF CULDESAC SITUATED ON ELEVATED PAVEMENT RUT/HEAVE
- NO.2  NORTH BOUND LANE ADJACENT TO 3200 ALUMBAUGH COURT BETWEEN SIDEWALK AND PAVEMENT RUT. (STANDING AND/OR PONDING WATER OBSERVED)
- NO.3  ADJACENT TO CONCRETE CROSS PAN AT INTERSECTION



**FIGURE I: SITE PLAN  
PAVEMENT DISTRESS EVALUATION  
ALUMBAUGH COURT - QUAIL RIDGE  
FORT COLLINS, COLORADO**


Project Mngr:	DAR	 <b>Terracon</b> 301 N. HOWES STREET FORT COLLINS, COLORADO 80521	Project No.	20995151
Designed By:	DAR		Scale:	1" = 60'
Checked By:	DAR		Date:	9/14/99
Approved By:	DAR		Drawn By:	SCA
File Name:	151FIG1		Figure No.	1

DIAGRAM IS FOR GENERAL LOCATION ONLY,  
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

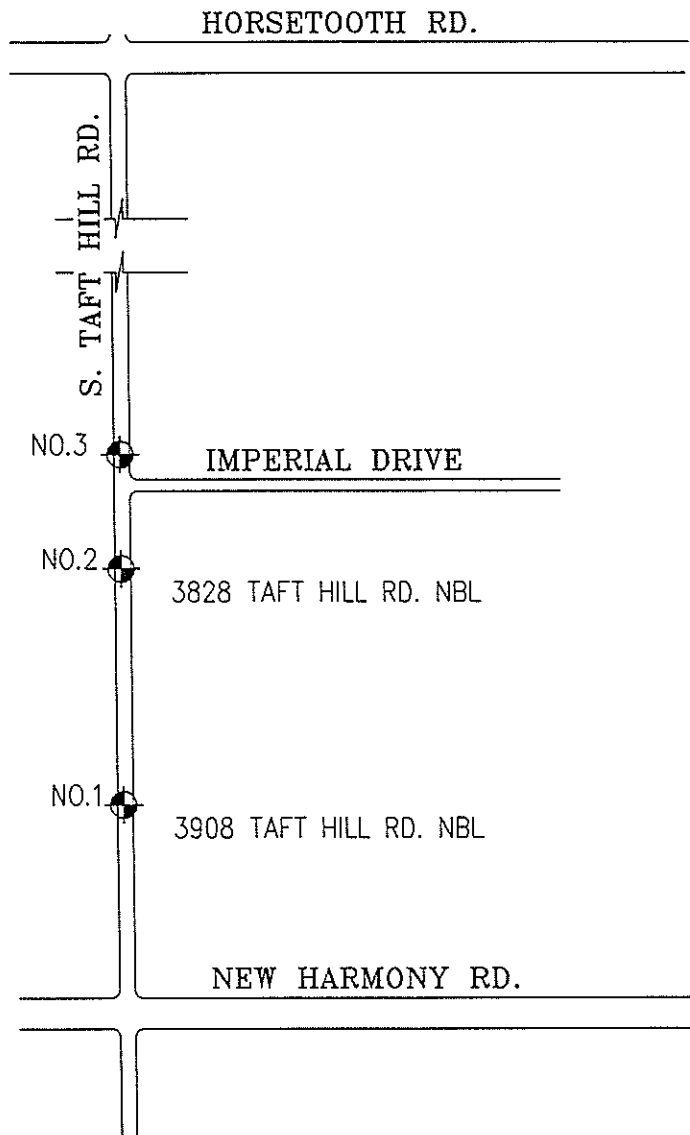

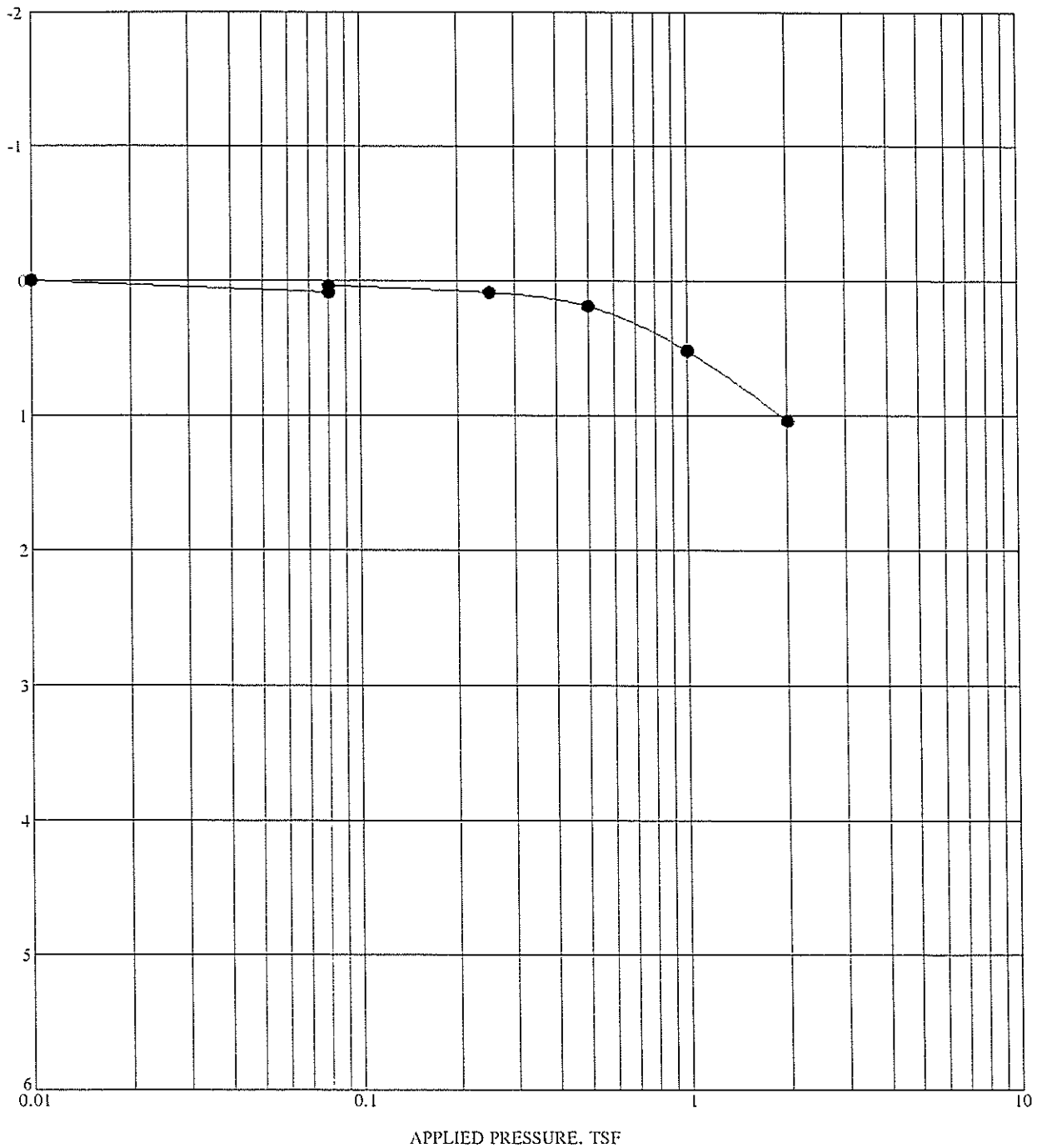


DIAGRAM IS FOR GENERAL LOCATION ONLY,  
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

**FIGURE 2: SITE PLAN  
PAVEMENT DISTRESS EVALUATION  
S. TAFT HILL & HARMONY  
FORT COLLINS, COLORADO**

Project Mngr:	DAR	 301 N. HOWES STREET FORT COLLINS, COLORADO 80521	Project No.	20995151
Designed By:	DAR		Scale:	1" = 500'
Checked By:	DAR		Date:	9/14/99
Approved By:	DAR		Drawn By:	SCA
File Name:	151FIG2		Figure No.	2

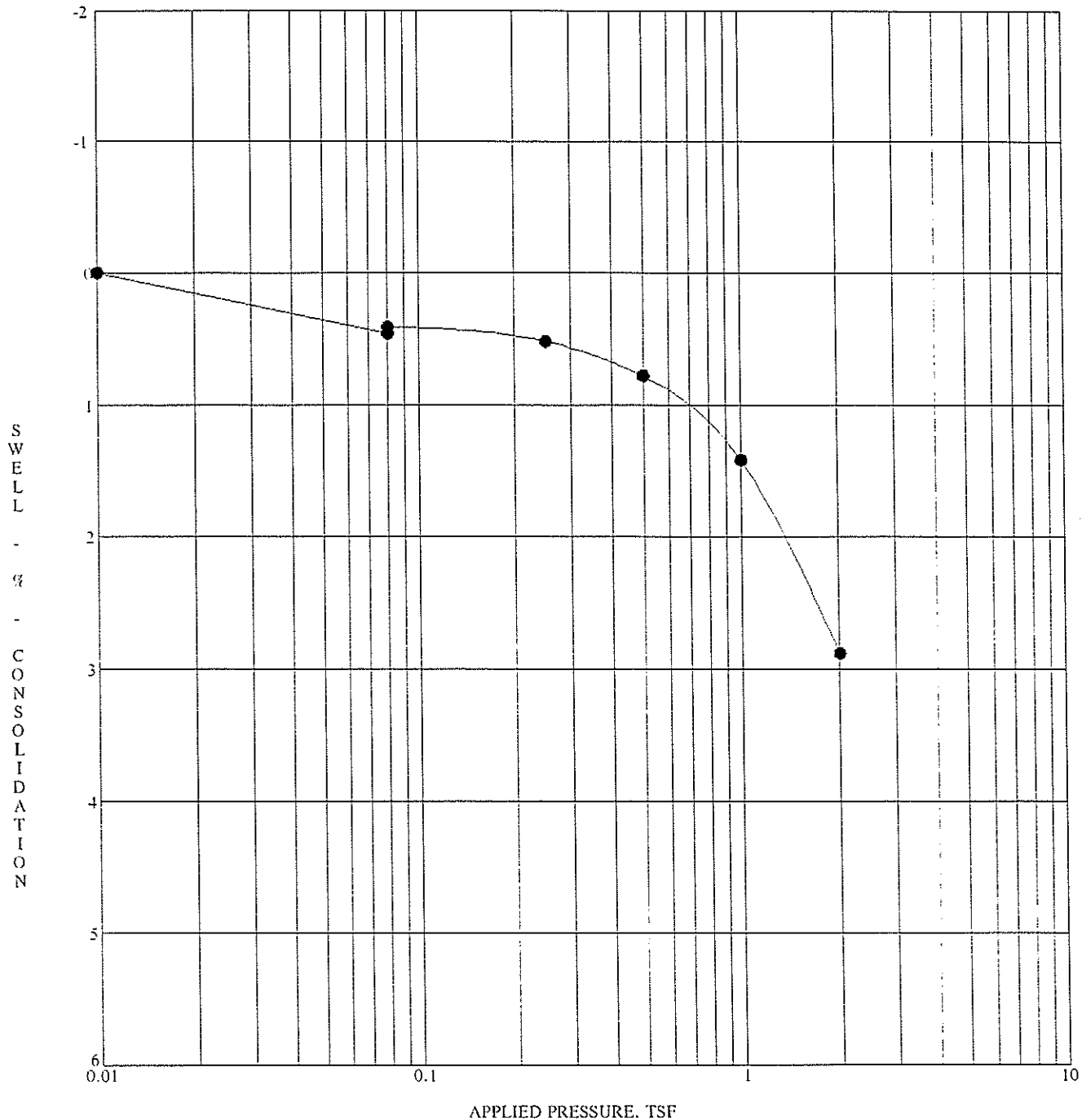
S W E L L  
-  
%  
-  
C O N S O L I D A T I O N



Boring and depth (ft.)	Classification	DD	MC%
● 1      1.0	SANDY LEAN CLAY CL	91	15

PROJECT Pavement Subgrade Evaluation - Alumbaugh      JOB NO. 20995151  
Court - Quail Ridge Estates      DATE 9/14/99

**CONSOLIDATION TEST  
TERRACON**



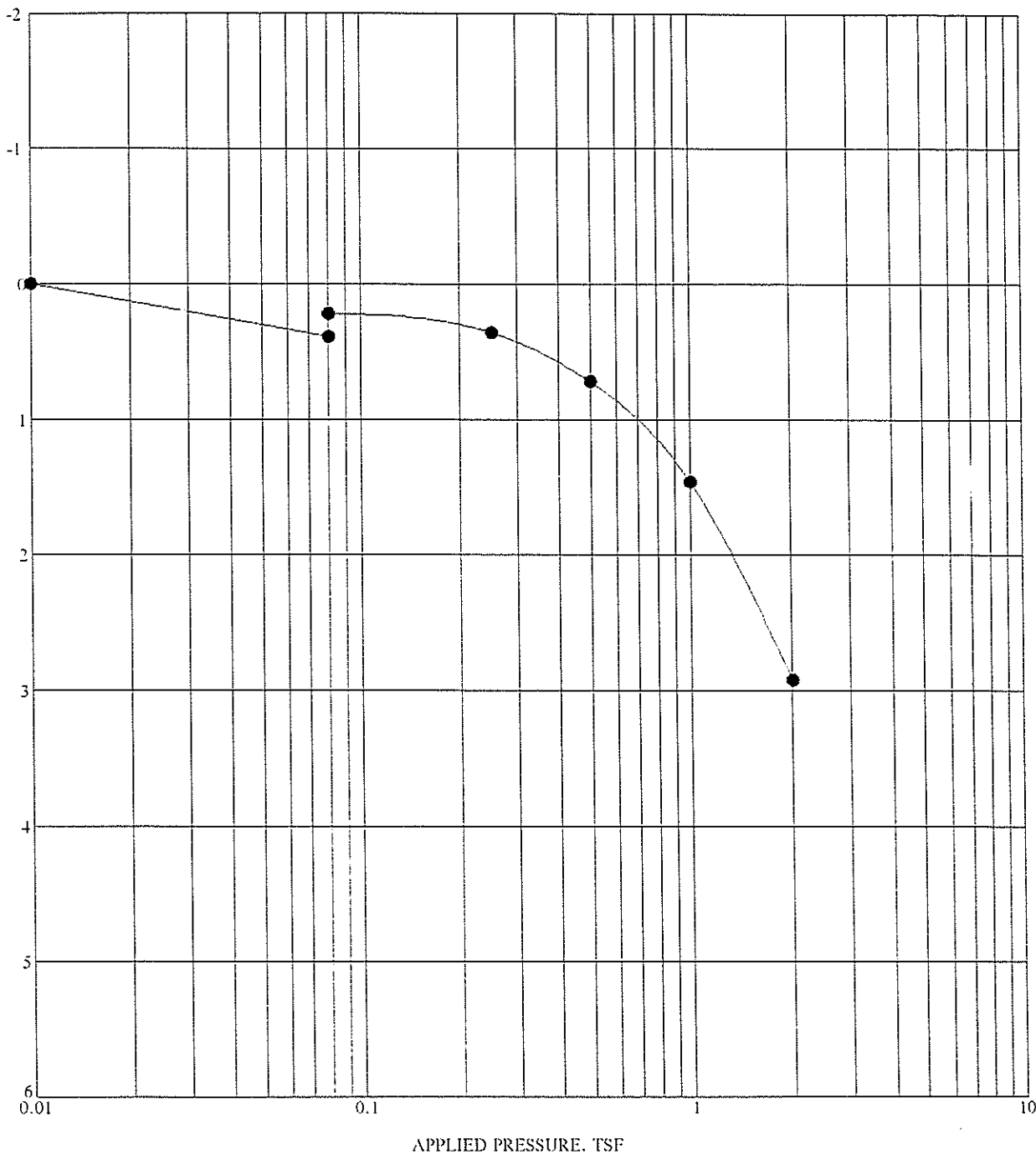
Boring and depth (ft.)	Classification	DD	MC%
● 2 1.0	LEAN CLAY with SAND CL	85	21

PROJECT Pavement Subgrade Evaluation - Alumbaugh JOB NO. 20995151  
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**CONSOLIDATION TEST  
TERRACON**



S W E L L  
-  
%  
-  
C O N S O L I D A T I O N



Boring and depth (ft.)	Classification	DD	MC%
● 3      1.0	LEAN CLAY CL	77	28

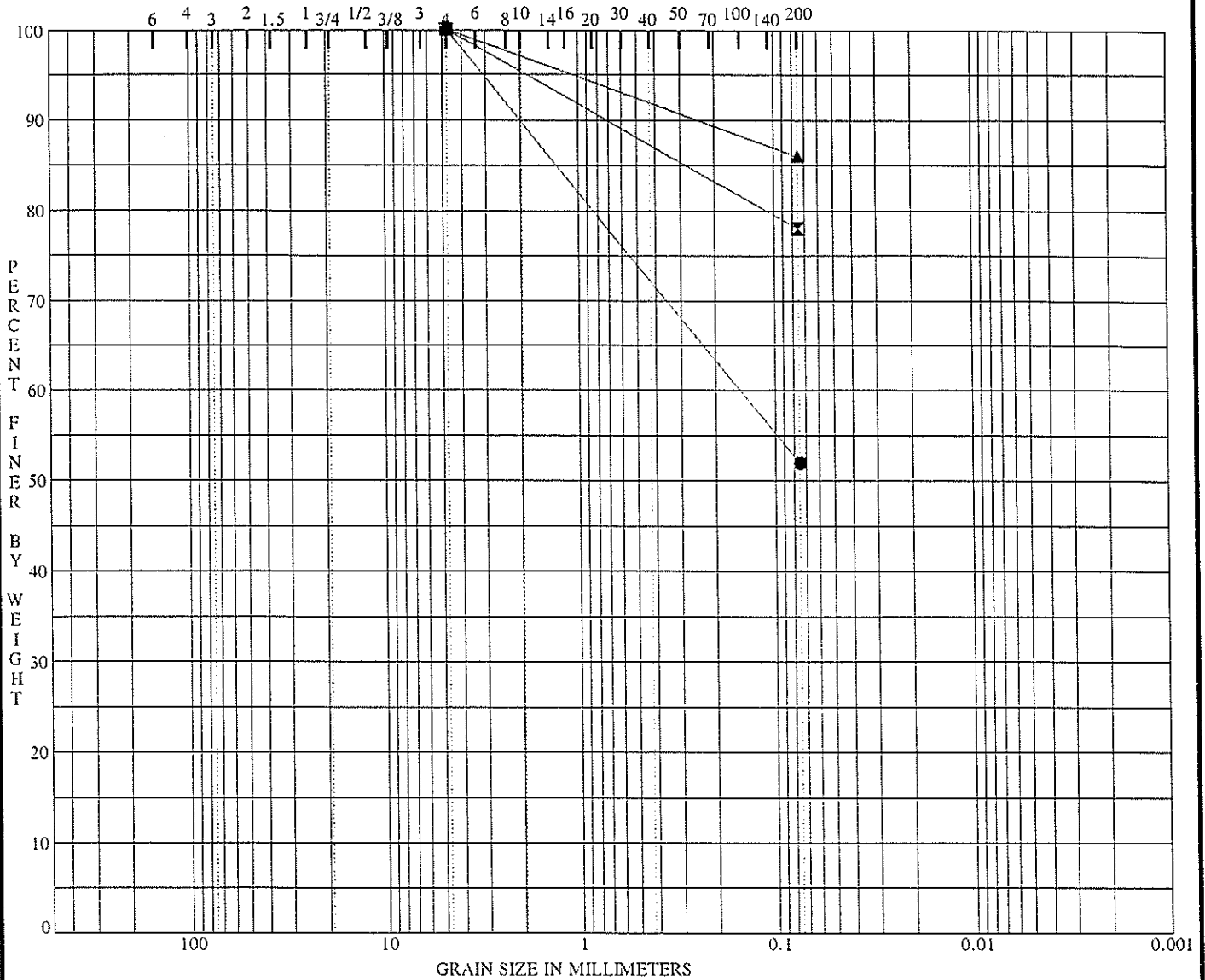
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**CONSOLIDATION TEST  
TERRACON**

U.S. SIEVE OPENING IN INCHES

U.S. SIEVE NUMBERS

HYDROMETER



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● 1	SANDY LEAN CLAY CL	15	28	16	12		
⊗ 2	LEAN CLAY with SAND CL	21	44	22	22		
▲ 3	LEAN CLAY CL	28	42	18	24		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 1	1.0	4.75	0.15		0.0	48.0		52.0
⊗ 2	1.0	4.75			0.0	22.0		78.0
▲ 3	1.0	4.75			0.0	14.0		86.0

PROJECT Pavement Subgrade Evaluation - Alumbaugh  
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**GRADATION CURVES  
 TERRACON**