CTL | THOMPSON INCORPORATED

October 6, 2010

Paulson & Company, Inc.
c/o Raintree Investment Corporation
110 Tiburon Boulevard, Suite 203
Mill Valley, California 94941

Attention: Mr. Michael McDonnell

Subject: Due Diligence Geotechnical Review
Portions of Bridgewater Subdivision
Northwest of Leon Wurl Parkway and
Weld County Road 5
Erie, Colorado
Project No. DN45,212-115

We understand Paulson & Company is considering the purchase of a portion of the Bridgewater Subdivision project in Erie Colorado. Bridgewater includes Section 17, the southeast quadrant of Section 8, and the east portion of Section 18, Township 1 North, Range 67 West. The proposed project includes single and multi-family parcels and associated open space; Paulson is evaluating purchase of the single-family areas.

CTL | Thompson, Inc. completed a Preliminary Geotechnical Investigation of the Bridgewater site (formerly known as Tallgrass) and presented results in a report dated June 30, 2005 (Project No. DN40,507-115). We were requested to review our records to assist in your due diligence assessment. The scope was described in our Proposal and Service Agreement DN10-0566R dated September 14, 2010. This letter contains descriptions of subsoil and ground water conditions found during our previous investigation and discussion of future residential construction as influenced by geotechnical considerations. The information contained in this letter is intended for due diligence assessment purposes only. Additional investigation will be required to develop development recommendations and design-level criteria. We are also performing environmental site assessment which will be reported under separate cover.

Site Description and Geologic Setting

Bridgewater is located northwest of the intersection of Leon Wurl Parkway and Weld County Road 5 in Erie, Colorado, and extends north of County Road 10 and west of County Road 3 (Fig. 1). The overall site contains about 950 acres. Portions of the site have been used as farmland. Gas wells are scattered across the site. Coal Creek is located to the west; water was flowing in the Creek at the time of this investigation. There is also a ditch east of County Road 5 which was active when we visited the site. Erie Cemetery is located in the west portion of the site adjacent to Weld County Road #3. A Union Pacific Railroad right-of-way crosses the northern parcel and extends along the western property line. A

school building is east of County Road 5. Residential development is located north and south of the site. The ground surface slopes down towards the west. Total relief across the site is about 135 feet, from elevation 5165 to 5030. Existing ground surface contours are shown on Fig. A-1.

Geologic mapping[1] indicates the site is underlain by wind-blown deposits of clay, silt and sand underlain by sedimentary bedrock of the Laramie formation. Our experience suggests there may be scattered alluvium (sand, gravel and cobble) below the wind-blown soils. The wind-blown soils can contain both expansive and collapsible clay and sand. The alluvium is comparatively stable, and may conduct water seepage if a source is nearby. The underlying bedrock includes claystone which is expansive.

The presence of expansive soils and bedrock, and collapsible (compressible) soils is considered a geologic hazard. Exhibit A contains a discussion about these geologic hazards.

The Laramie formation contains coal seams which were mined historically in Boulder and Weld Counties. Bridgewater is underlain by abandoned mine workings of three mines. We are evaluating mine subsidence risk under a separate project.

Soil and Ground Water Conditions

During our 2005 investigation we drilled 20 exploratory borings on the Bridgewater site; 15 of which were located within parcels which Paulson is considering. We were also provided a copy of a 1998 report prepared by Scott, Cox & Associates, Inc. and they had drilled five borings. The approximate locations of the borings are shown on Fig. 1. Appendix A contains copies of graphics from our 2005 report, Appendix B includes logs of our borings, and laboratory data is in Appendix C. Excerpts from the Scott, Cox & Associates report are in Appendix D.

The soils found in the 20 borings which have been drilled in the parcels under consideration included 3 to 22 feet of clay, sandy clay, clayey sand and some sand/gravel underlain by sedimentary claystone and sandstone bedrock. Some of the sand is loose. Select clay and claystone samples exhibited compression to very high swell. The sand and sandstone are generally low swelling or non-expansive. Low density, collapsing clays were identified at two test holes (TH-16 and TH-19). Samples of the bedrock exhibited compression (0.4 percent) to very high swell (14.7 percent), with about 85 percent swelling 4 percent or more when wetted under an applied pressure of 1,000 psf. Volume change of more than 4 percent implies high to very high risk for distress to ground-supported improvements unless mitigation is performed, as discussed later in this letter. Selected claystone samples swelled 4.1 to 9.6 percent after wetting under overburden pressures (1,800 to 3,600 psf). Claystone samples exhibited high plasticity,

[1]Colton, R.B. and Anderson, L.W., "Preliminary Geologic Map of the Erie Quadrangle…", U.S.G.S., 1977

Ground water was measured in two of our borings (TH-15 and TH-20) during the 2005 investigation at depths of 15.5 and 31.5 feet below the existing ground surface. Scott, Cox did not report any water in their borings.

Discussion

The primary geotechnical issue associated with development and residential construction at Bridgewater will be the presence of highly expansive claystone bedrock. Where this material is present within about 15 to 20 feet of the proposed ground surface, it could impose risk of significant heave and associated damage to foundations, flatwork, pavements and other improvements. During our 2005 study, we judged the risk of swelling soil (or bedrock) damage to be high or very high at about half of the exploratory borings which were drilled in the parcels Paulson is evaluating (Fig. A-4). In the north portion of the site, sand and sandstone were found in six borings which represent low risk of movement. Exhibit B describes the swell risk assessment.

In the areas where highly expansive claystone will be present near proposed grades, we believe potential movements (heave) are high enough that construction of residences and associated improvements without mitigation will not be prudent. The common method to mitigate the potential movements is over-excavation to depths on the order of 18 to 22 feet below proposed grade in residence areas, with over-excavation of 3 to 7 feet (or more) below streets. This excavation is followed by placement of on-site materials re-worked as high moisture, compacted fill. It is normally possible to reduce potential swell to levels which allow use of footing-type foundations and slab-on-grade basement floors. Given the high plasticity of the claystone at Bridgewater, it may not be practical to achieve low swelling conditions, so use of drilled pier foundations and structurally supported basement floors may be necessary even if over-excavation is performed. For preliminary budgeting purposes, we suggest an assumption of 20 feet of over-excavation in 50 percent of the site to include the areas where preliminary data suggest high or very high swell risk. If the moderate risk areas are also included, the area would increase to about 70 to 75 percent of the site.

The presence of high plasticity soils will also affect the stability of subgrade soils below streets. We suggest budgets include at least 5 feet of over-excavation for 70 percent of the pavements, with chemical stabilization (fly ash or lime treatment) of subgrade in about 50 percent of the streets.

Control of surface and subsurface water will be critical to performance of residence foundations and other improvements. We typically advocate installation of underdrain systems below sanitary sewer mains to help control subsurface water. The alluvial soils found in a few borings may also provide a conduit for subsurface water. Interceptor drains may be necessary along portions of the perimeter of various parcels or filings.

We believe our 2005 soils investigation was performed using methods consistent with those used by other geotechnical engineers practicing in this area at the time. Further preliminary studies will be needed to allow better assessment

of areas where over-excavation will be merited and other geotechnical measures for site development.

Limitations

We have reviewed previous records to provide a general characterization of subsurface conditions beneath Bridgewater for due diligence assessment. Design criteria contained in our previous report may not be valid. We believe this review was conducted in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made.

If we can be of further service in discussing either the contents of this letter or the influence of subsurface conditions on the future construction, please call.

Very truly yours,

CTL | THOMPSON, INC.

Ronald M. McOmber, P.E., D.GE
Chairman & CEO

Reviewed by:

David A. Glater, P.E., C. P.G.
Principal Geological Engineer

RMM:DAG/rmm/nt/bg
(2 copies)

via email: jerrybrichmond@gmail.com

EXHIBIT A

GEOLOGIC HAZARDS

Colorado is a challenging location to practice geotechnical engineering. The climate is relatively dry and the near-surface soils are typically dry and relatively stiff. These soils and related sedimentary bedrock formations tend to react to changes in moisture conditions. Some of the soils swell as they increase in moisture and are called expansive soils. Other soils can settle significantly upon wetting and are referred to as collapsing soils. Most of the land available for development east of the Front Range is underlain by expansive clay or claystone bedrock near the surface. The soils that exhibit collapse are more likely west of the continental divide; however, both types of soils occur all over the state.

Covering the ground with houses, streets, driveways, patios, etc., coupled with lawn irrigation and changing drainage patterns, leads to an increase in subsurface moisture conditions. As a result, some soil movement is inevitable. It is critical that all recommendations in a soils report are followed to increase the chances that foundations and slabs-on-grade will perform satisfactorily. After construction, home owners must assume responsibility for maintaining the structures and use appropriate practices regarding drainage and landscaping.

Expansive soils and bedrock and compressible soils are present at this site. The presence constitutes a geologic hazard. There is risk that ground heave or settlement will damage slabs-on-grade and foundations. The risks associated with swelling and compressible soils can be mitigated but not eliminated by careful design, construction and maintenance procedures. We believe the recommendations our reports will help control risk of foundation and/or slab damage; they will not eliminate that risk. The builder and home buyers should understand that slabs-on-grade and, in some instances, foundations may be affected by swelling soils. Homeowner maintenance will be required to control risk. We recommend builders provide a booklet to home buyers that describes swelling soils and includes recommendations for care and maintenance of homes constructed on expansive soils. Colorado Geological Survey Special Publication 43[2] was designed to provide this information.

[2] **"A Guide to Swelling Soils for Colorado Homebuyers and Homeowners," Second Edition Revised and Updated by David C. Noe, Colorado Geological Survey, Department of Natural Resources, Denver, Colorado, 2007.**

EXHIBIT B

SWELL RISK EVALUATION

As part of our previous evaluation of the subsoils and bedrock, samples were tested in the laboratory using a swell test. In the test procedure, a relatively undisturbed sample obtained during drilling is first loaded and then flooded with water and allowed to swell or compress. The pressure applied prior to wetting can approximate the weight of soil above the sample depth or be some standard load. This judgment has been described by the Colorado Association of Geotechnical Engineers[3] (CAGE, 1996) as it relates to basement slab-on-grade floors. It can also be used to help judge performance risk for other slabs-on-grade such as garage floors, driveways, and sidewalks. The risk evaluation is considered when we evaluate appropriate foundation systems for a given site. In general, more conservative foundation designs are used for higher risk sites to control the likelihood of excessive foundation movement.

As a result of the Swell Risk Evaluation, sites are categorized as low, moderate, high, or very high risk. This is a judgment of the swelling characteristics of the soils and bedrock likely to influence performance of improvements.

REPRESENTATIVE MEASURED SWELL AND CORRESPONDING SLAB PERFORMANCE RISK CATEGORIES

Slab Performance Risk Category	Representative Percent Swell* (500 psf Surcharge)	Representative Percent Swell* (1000 psf Surcharge)
Low	0 to <3	0 to <2
Moderate	3 to <5	2 to <4
High	5 to <8	4 to <6
Very High	$\geq$ 8	$\geq$ 6

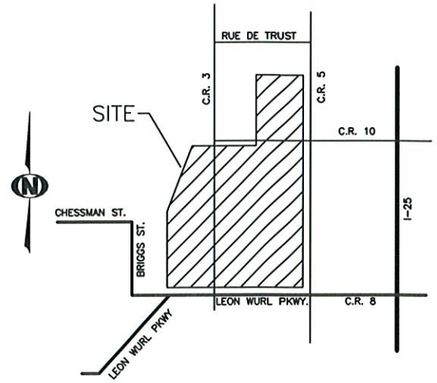
*Note: The representative percent swell values presented are not necessarily measured values; rather, they are a judgment of the swelling characteristics of the soil and bedrock likely to influence slab performance.

The rating of risk on a site as low or high is not absolute. Rather, this rating represents a judgment. Movement of slabs and foundations may occur with time in low, moderate, high, and very high risk areas as the soils respond to increases in moisture content. Overall, the severity and frequency of damage usually is greater in high and very high rated areas. Heave of slabs-on-grade of 3 to 5 inches is not uncommon in areas rated as high or very high risk. On low and moderate risk sites, slab heave of 1 to 2 inches is considered normal and we believe in the majority of instances, movements of this magnitude constitute reasonable slab performance; more heave can occur. Slabs can be affected on all sites.

[3]"Guideline for Slab Performance Risk Evaluation and Residential Basement Floor System Recommendations", Colorado Association of Geotechnical Engineers, December 1996.

0 500 1000

SCALE: 1" = 1000'



VICINITY MAP
NOT TO SCALE

LEGEND:

TH–1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED FOR PROJECT NO. DN40,507–115 (2005)

TH–1 ⊕ INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED BY SCOTT, COX & ASSOCIATES, INC. (PROJECT NO. 98697; REPORT DATED NOVEMBER 1998).

PAULSON & COMPANY, INC.
PORTIONS OF BRIDGEWATER SUBDIVISION
Project No. DN45,212-115

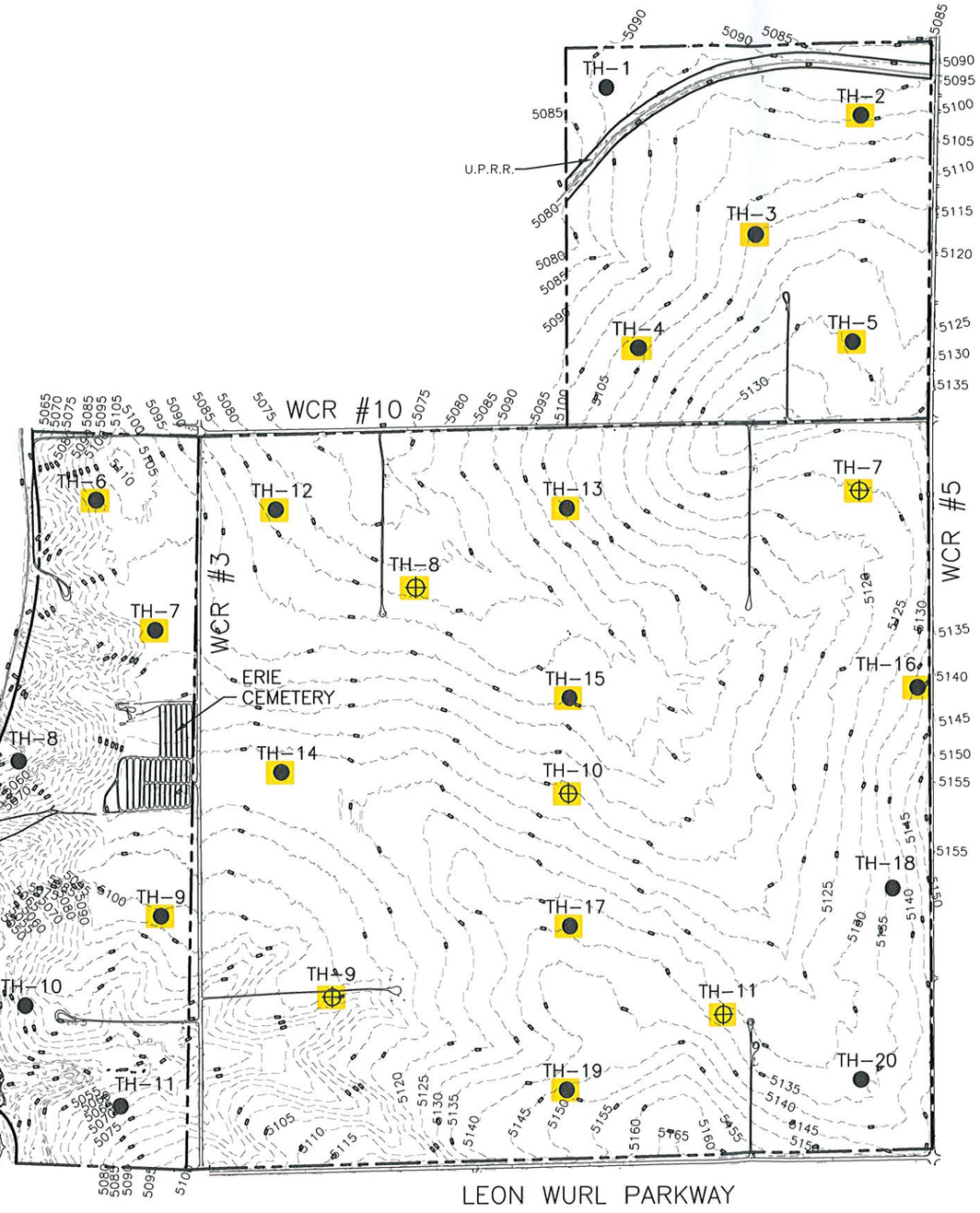
Locations of Exploratory Borings

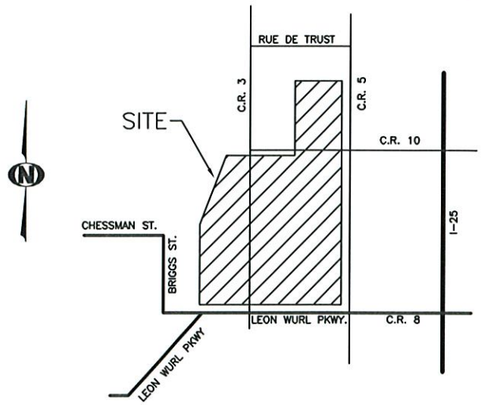
Fig. 1

APPENDIX A

LOCATION OF BORINGS
BEDROCK SURFACE EVALUATION
PRELIMINARY SWELL RISK EVALUATION UNDERDRAIN DETAILS
(PROJECT NO. DN40,507-115; REPORT DATED JUNE 30, 2005)

SCALE: 1"= 1000'





VICINITY MAP
NOT TO SCALE

LEGEND:

TH-1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING

TH-1 ⊕ INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED BY SCOTT, COX & ASSOCIATES, INC. (PROJECT NO. 98697; REPORT DATED NOVEMBER 1998).

5100 INDICATES EXISTING GROUND SURFACE ELEVATION (FEET)

BORINGS IN AREAS PAULSON IS EVALUATING

Locations of Exploratory Borings

Project No. DN40,507-115

Fig. A - 1

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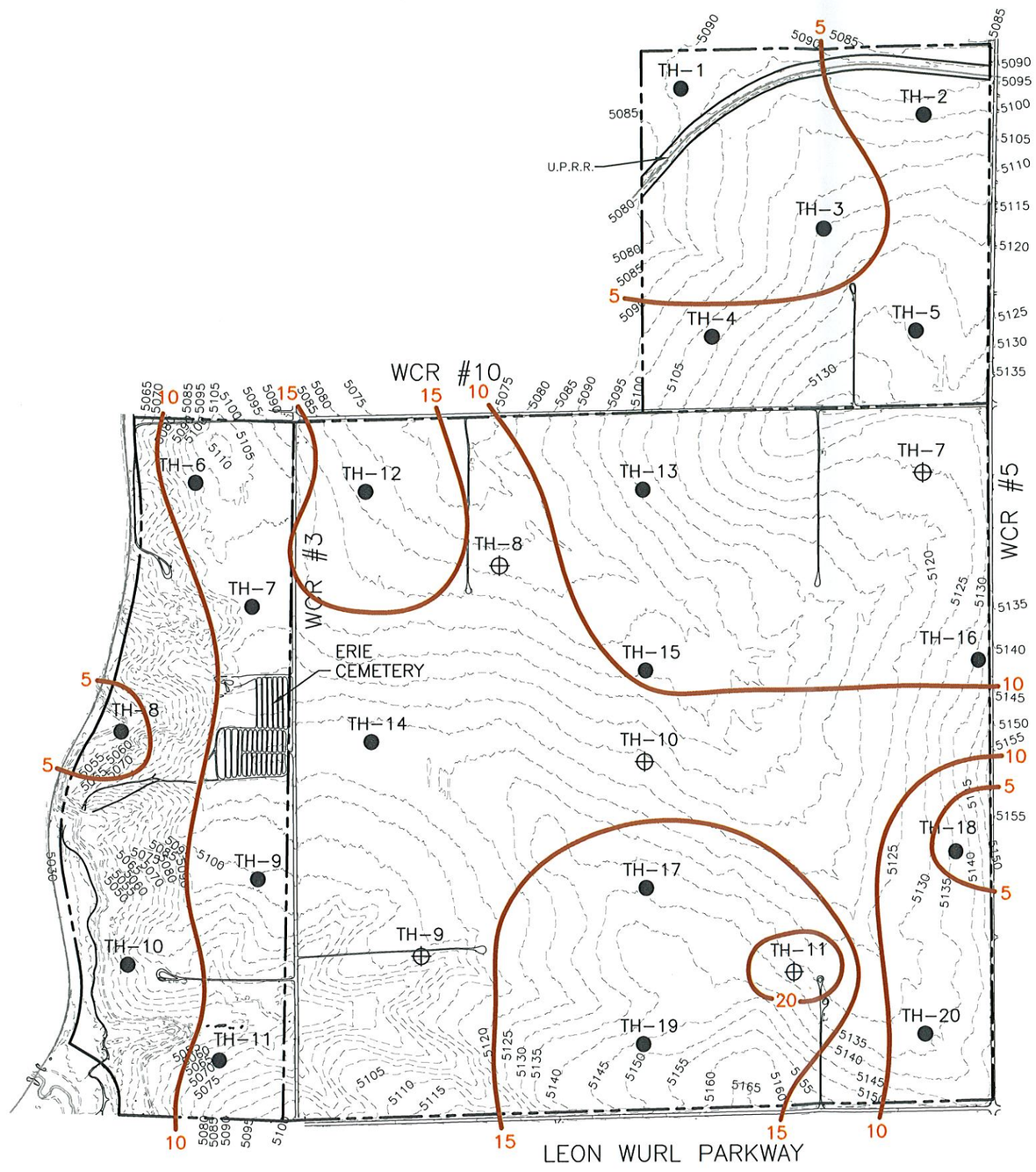
SCALE: 1"= 1000'



LEGEND:

- TH-1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING
- TH-1 ⊕ INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED BY SCOTT, COX & ASSOCIATES, INC. (PROJECT NO. 98697; REPORT DATED NOVEMBER 1998).
- 5100 INDICATES EXISTING GROUND SURFACE ELEVATION (FEET)
- 5 INDICATES ESTIMATED DEPTH TO BEDROCK (FEET)

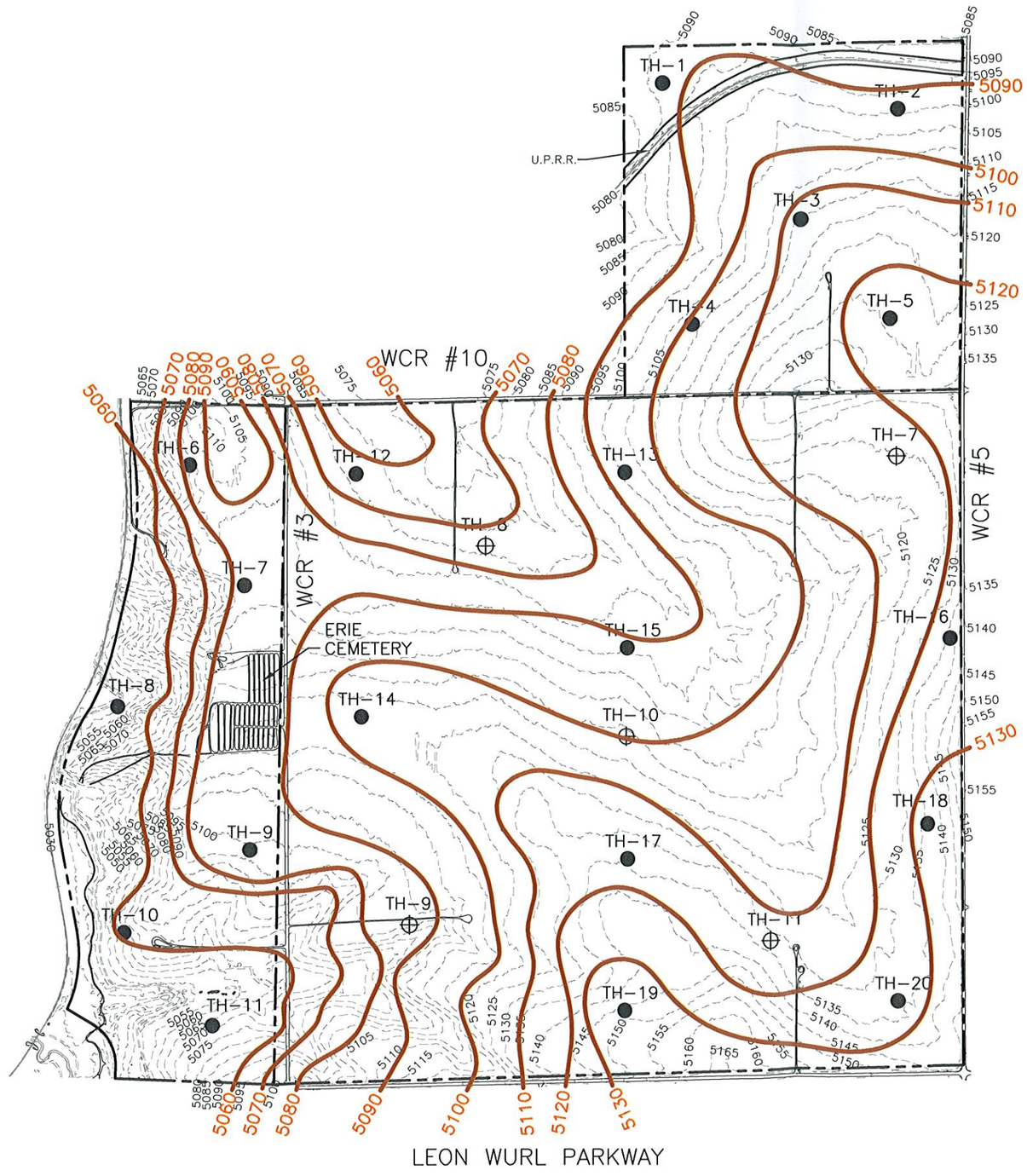
NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS

Estimated Depth to Bedrock

Project No. DN40,507-115

Fig. A - 2

SCALE: 1"= 1000'



LEGEND:

TH–1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING

TH–1 ⊕ INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED BY SCOTT, COX & ASSOCIATES, INC. (PROJECT NO. 98697; REPORT DATED NOVEMBER 1998).

5100 – – – INDICATES EXISTING GROUND SURFACE ELEVATION (FEET)

5060 ——— INDICATES ESTIMATED BEDROCK ELEVATION (FEET)

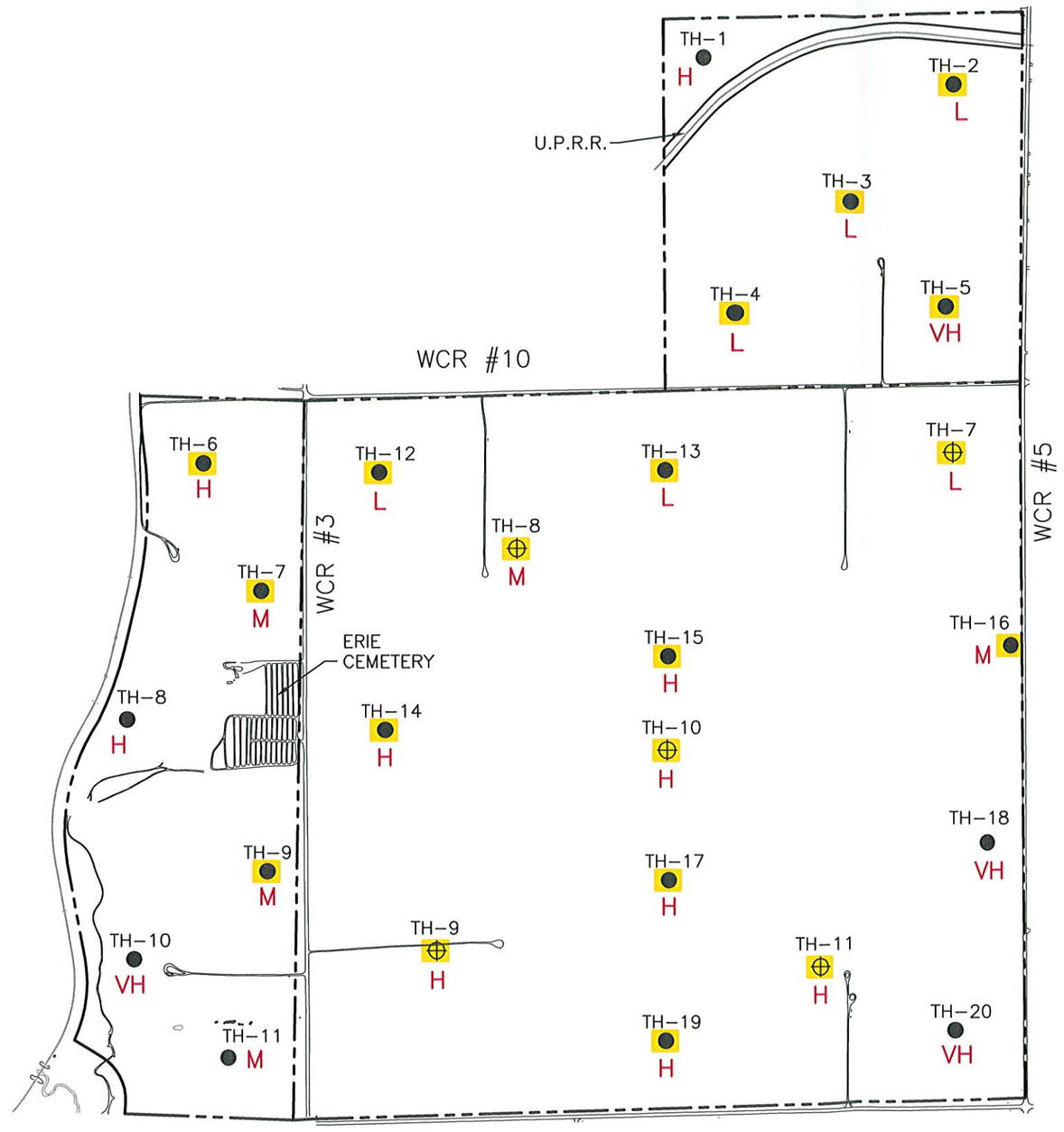
NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS

Estimated Bedrock Elevation

Project No. DN40,507-115

Fig. A - 3

SCALE: 1"= 1000'



LEGEND:

TH-1 ●	INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING
TH-1 ⊕	INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING DRILLED BY SCOTT, COX & ASSOCIATES, INC. (PROJECT NO. 98697; REPORT DATED NOVEMBER 1998).
L	LOW RISK
M	MODERATE RISK
H	HIGH RISK
VH	VERY HIGH RISK

NOTES:

1.) RATING OF SCOTT, COX & ASSOCIATE'S BORINGS WAS BASED ON OUR EVALUATION OF THEIR TEST DATA.

2.) THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF LABORATORY TEST RESULTS AND DRILL HOLE DATA. SWELL RISK WILL VARY BETWEEN BORINGS. ADDITIONAL INVESTIGATION AT CLOSER TEST HOLE SPACING IS RECOMMENDED TO BETTER DELINEATE SWELL RISK.

3.) DEEP CUT AND FILL FOR SITE GRADING WILL AFFECT SWELL RISK RATING. WE SHOULD REVIEW GRADING PLANS TO BETTER EVALUATE SWELL RISK.

BORINGS IN AREAS PAULSON IS EVALUATING

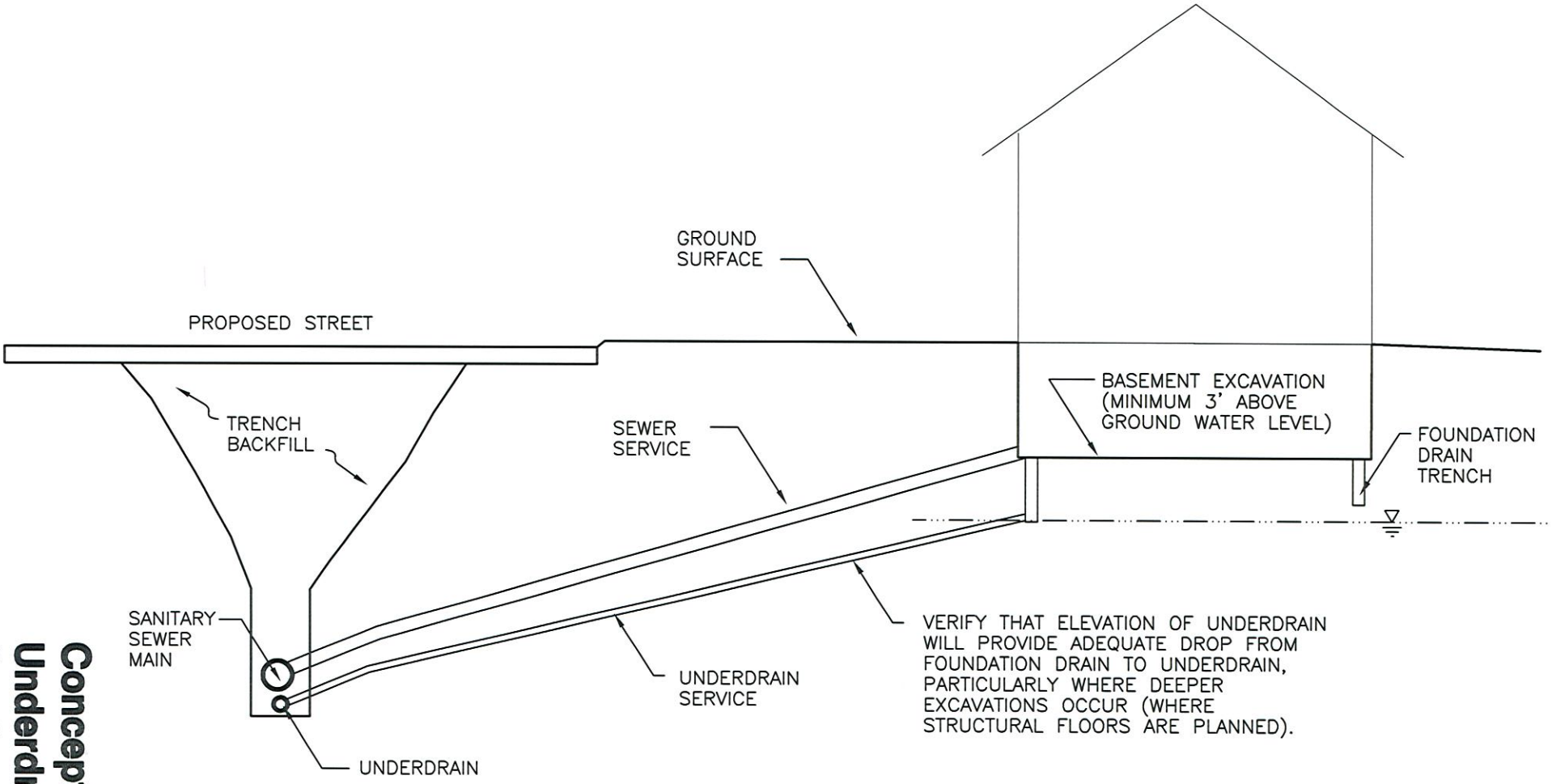
Swell Risk Evaluation

Project No. DN40,507-115

Fig. A - 4

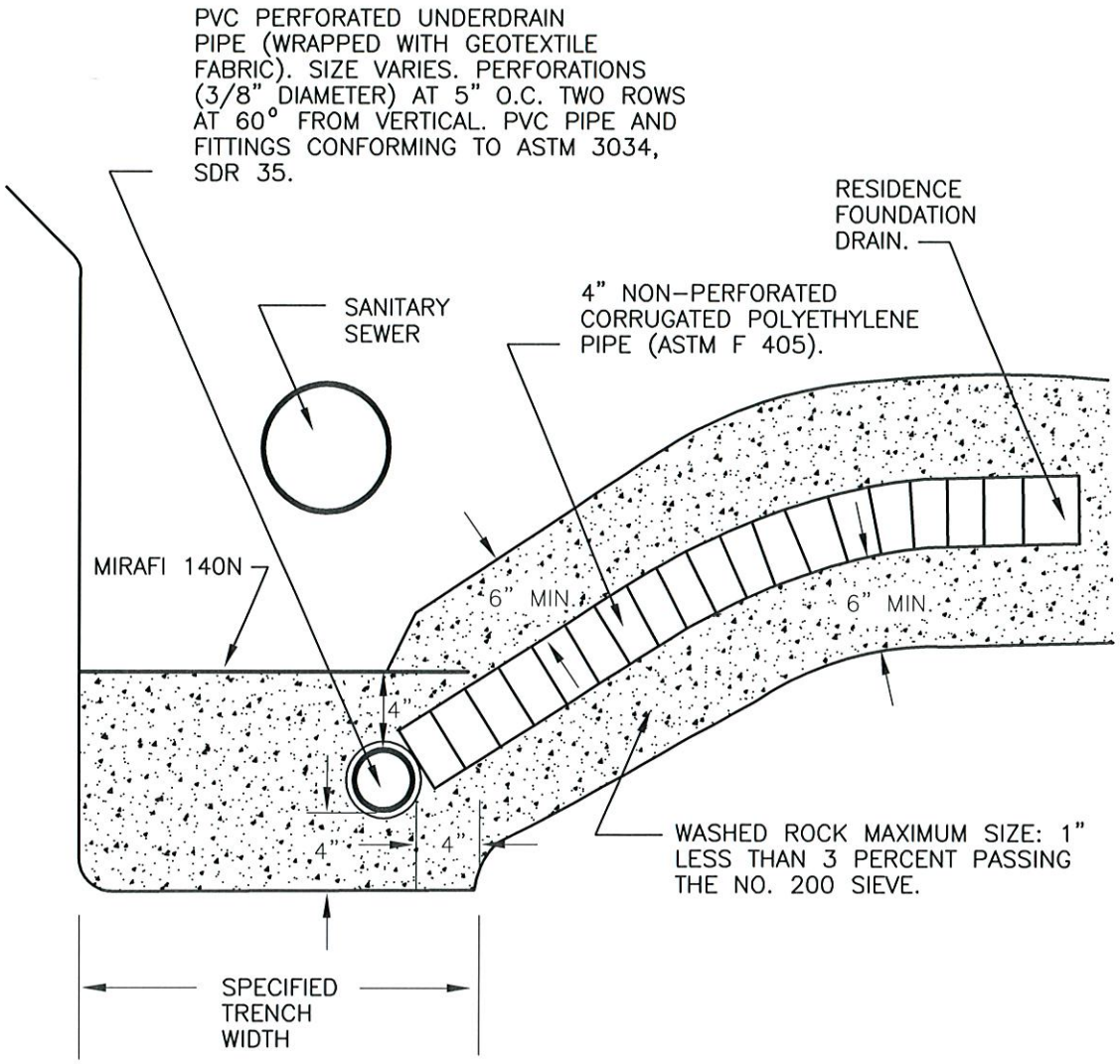
Project No. DN40,507-115

Conceptual Underdrain Service Profile



NOT TO SCALE

Fig. A-5

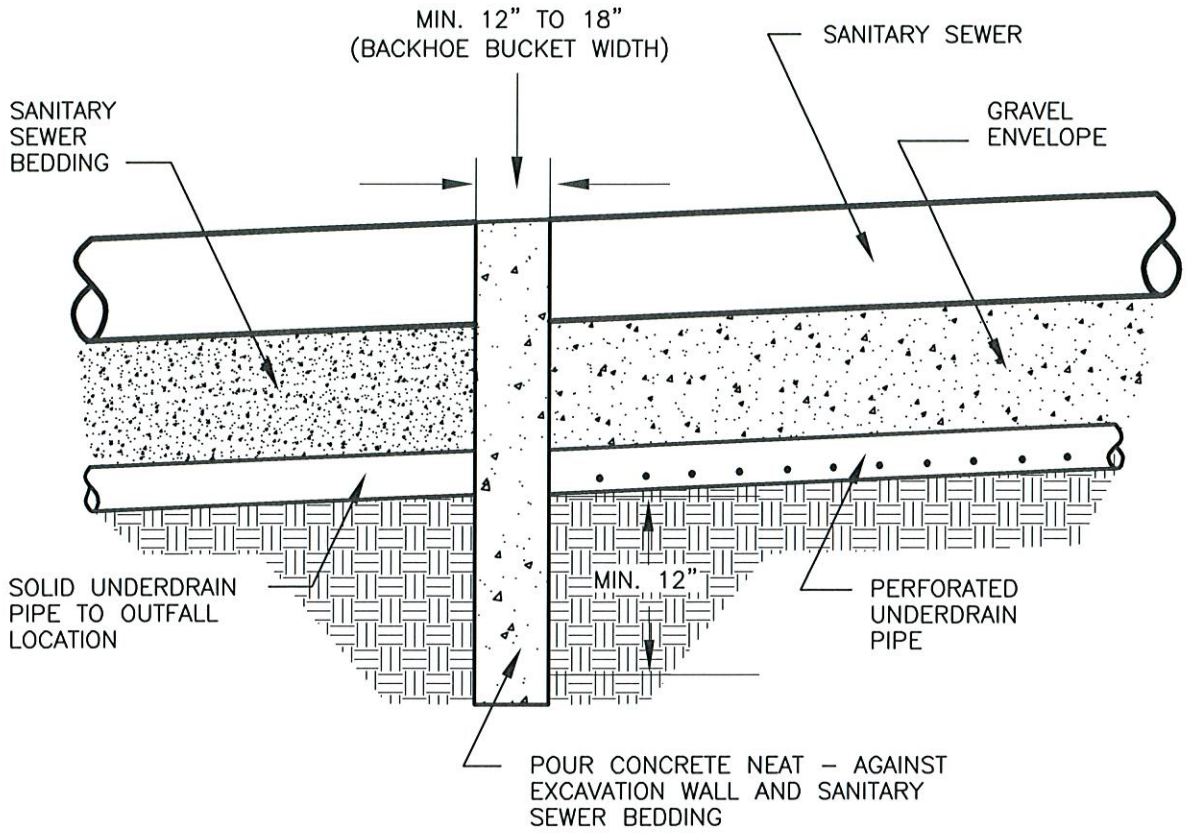


NOTE: NOT TO SCALE.

Sewer Underdrain Detail

Project No. DN40,507-115

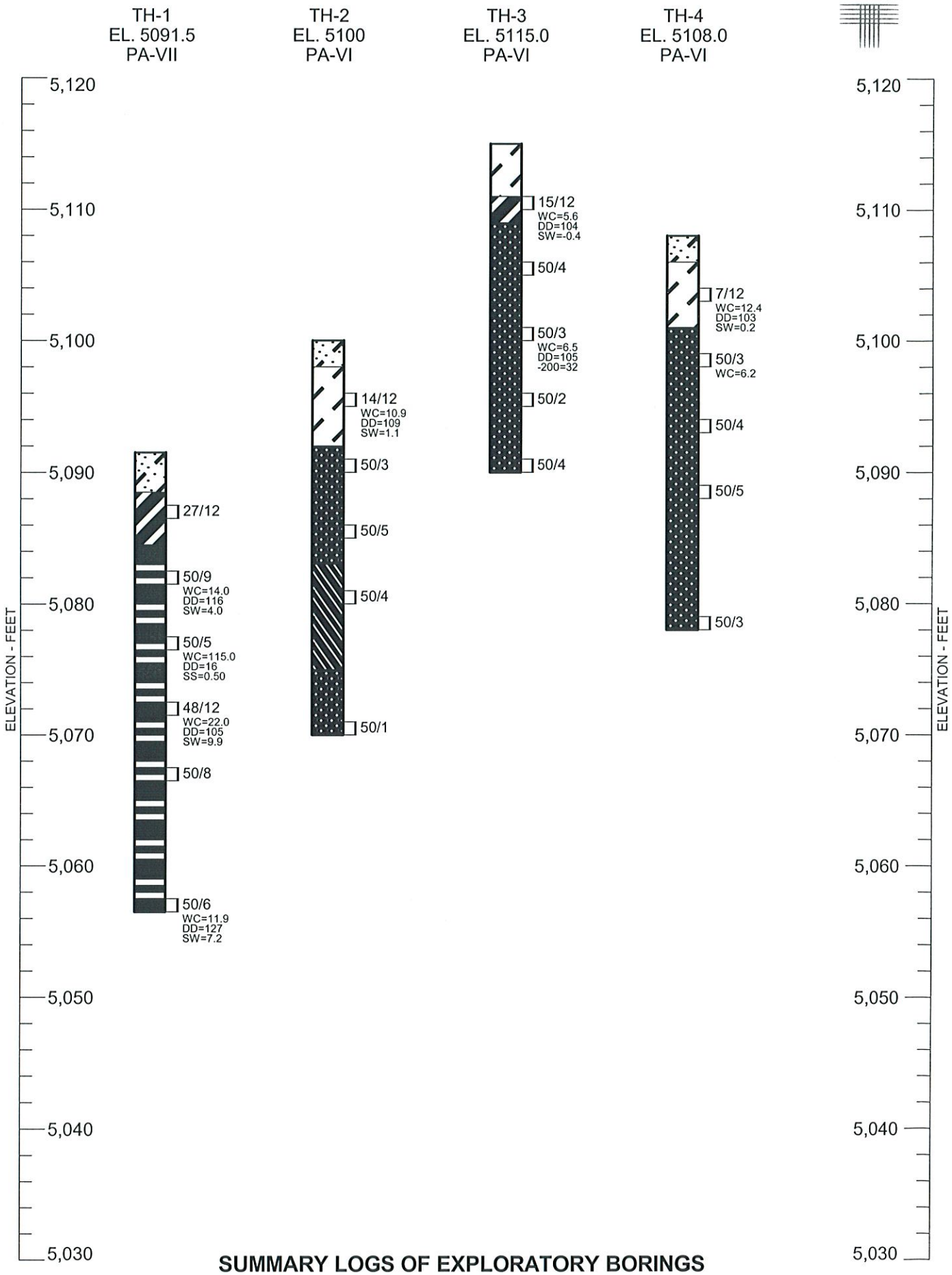
Fig. A-6



NOTE:
THE CONCRETE CUTOFF WALL SHOULD EXTEND INTO THE UNDISTURBED SOILS OUTSIDE THE UNDERDRAIN AND SANITARY SEWER TRENCH A MINIMUM DISTANCE OF 12 INCHES.

Underdrain Cutoff Wall Detail

APPENDIX B
SUMMARY LOGS



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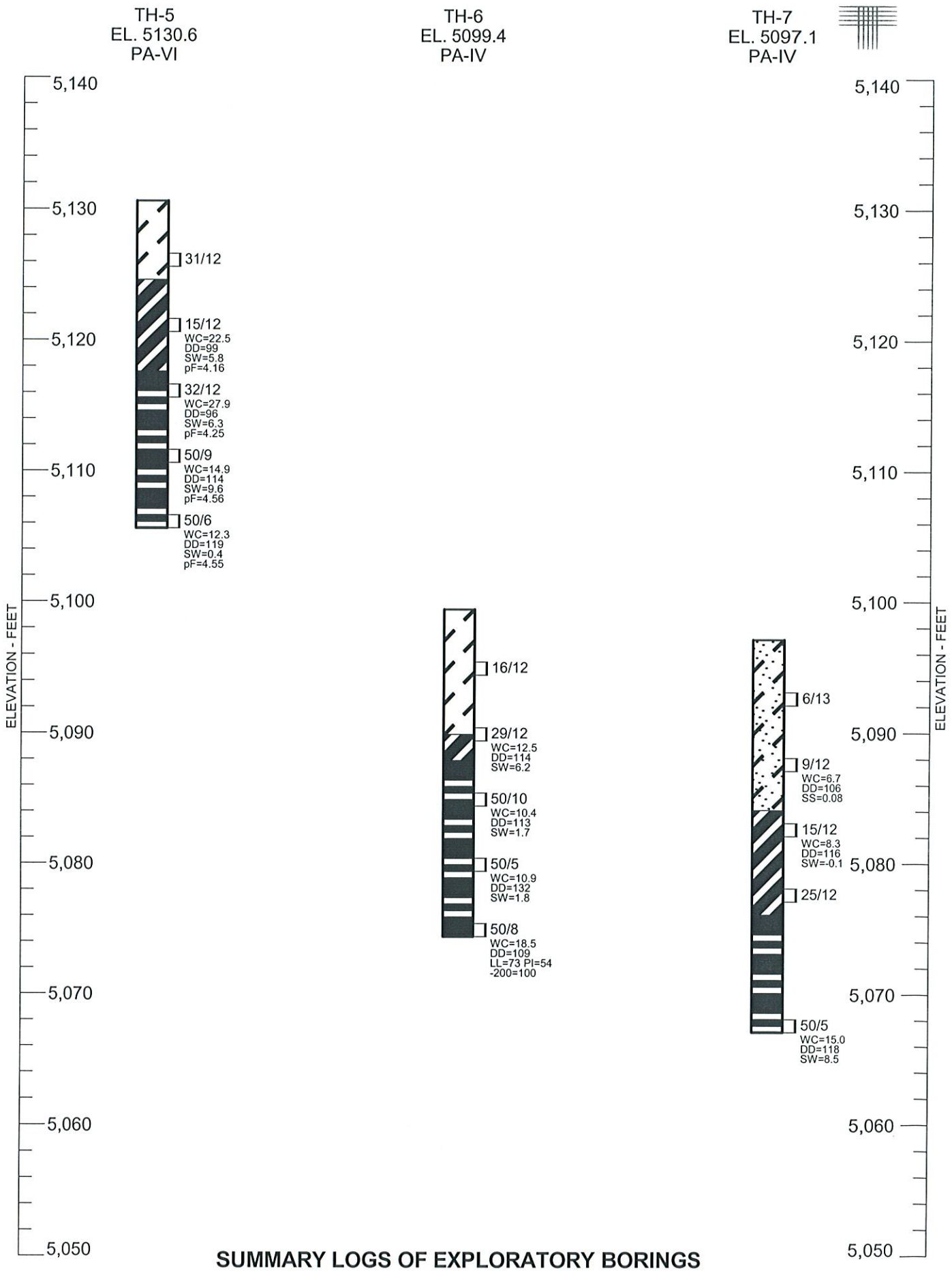
SUMMARY LOGS OF EXPLORATORY BORINGS

PROJECT NO. DN40,507-115

FIG. B- 1



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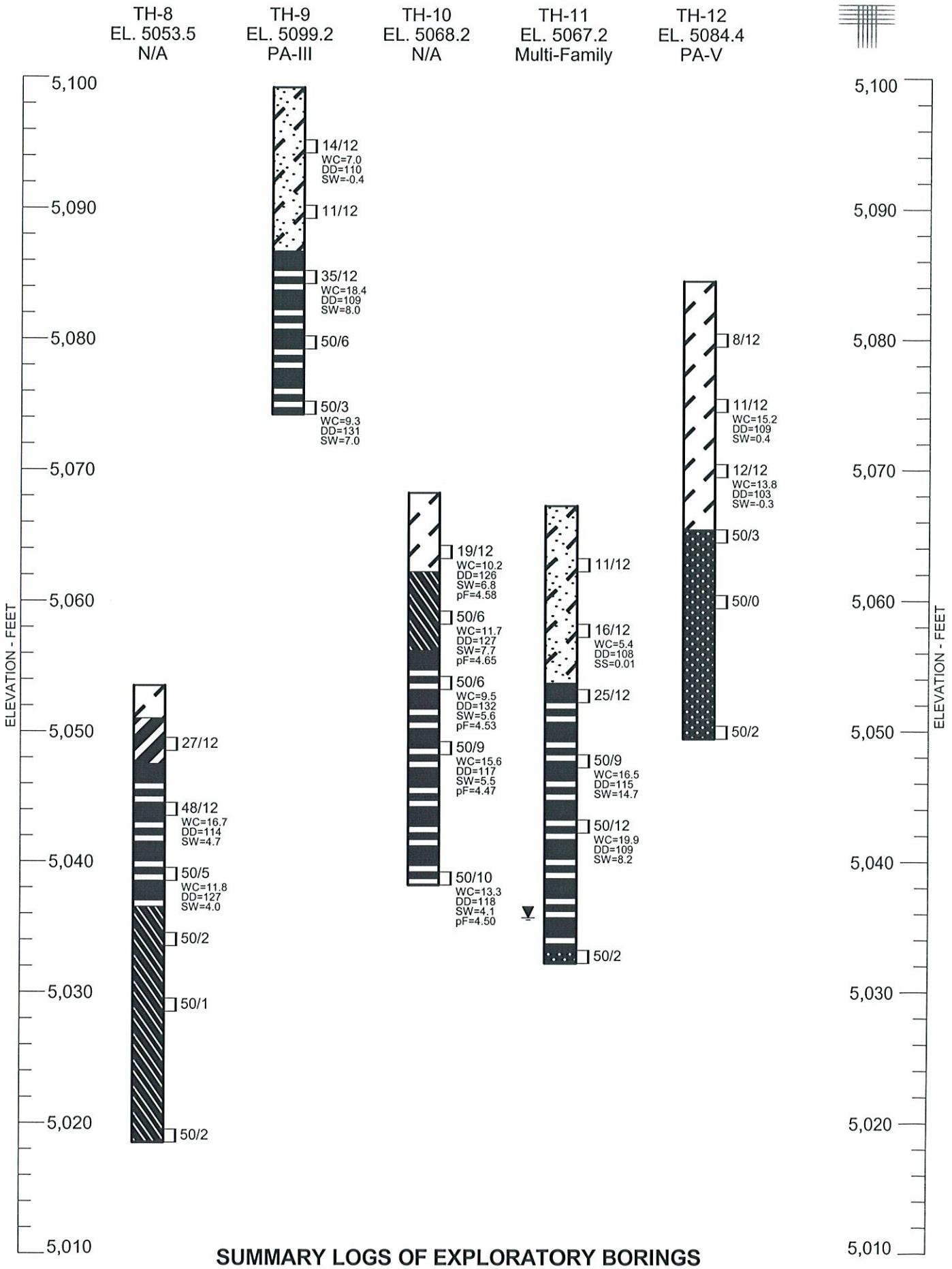
SUMMARY LOGS OF EXPLORATORY BORINGS

PROJECT NO. DN40,507-115

FIG. B- 2



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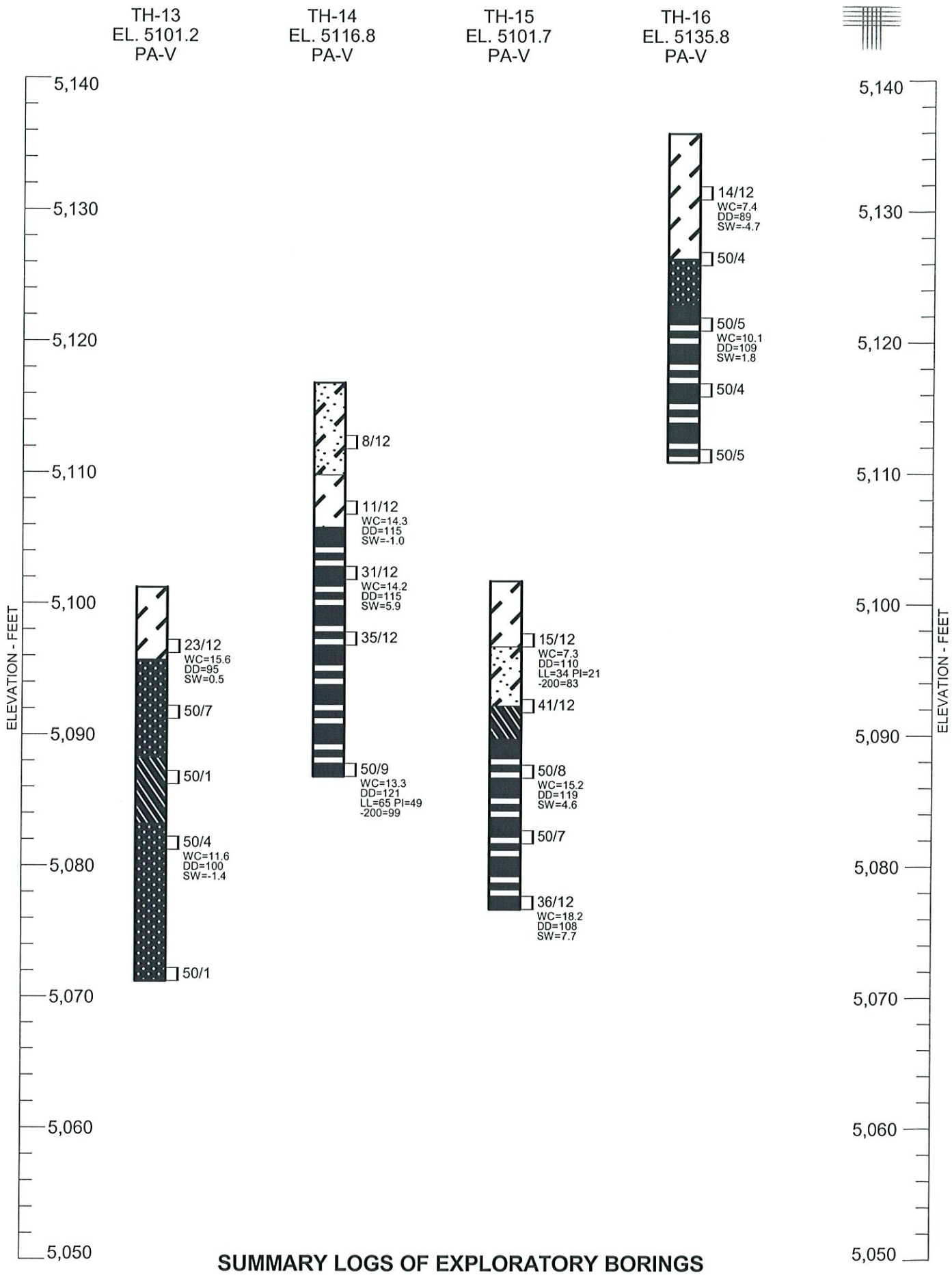
SUMMARY LOGS OF EXPLORATORY BORINGS

PROJECT NO. DN40,507-115

FIG. B- 3



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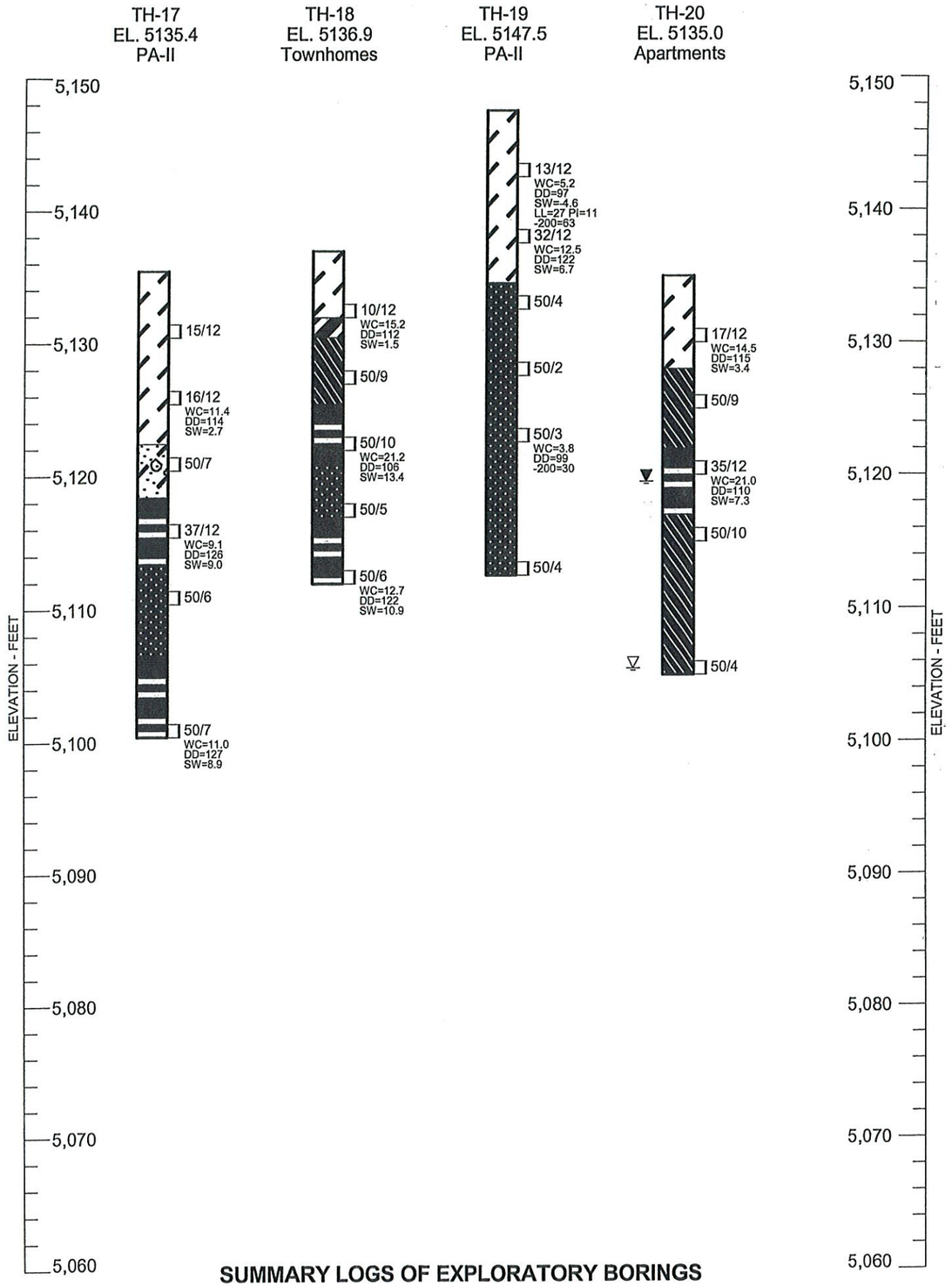
SUMMARY LOGS OF EXPLORATORY BORINGS

PROJECT NO. DN40,507-115

FIG. B- 4



SUMMARY LOGS OF EXPLORATORY BORINGS

PROJECT NO. DN40,507-115

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LEGEND:

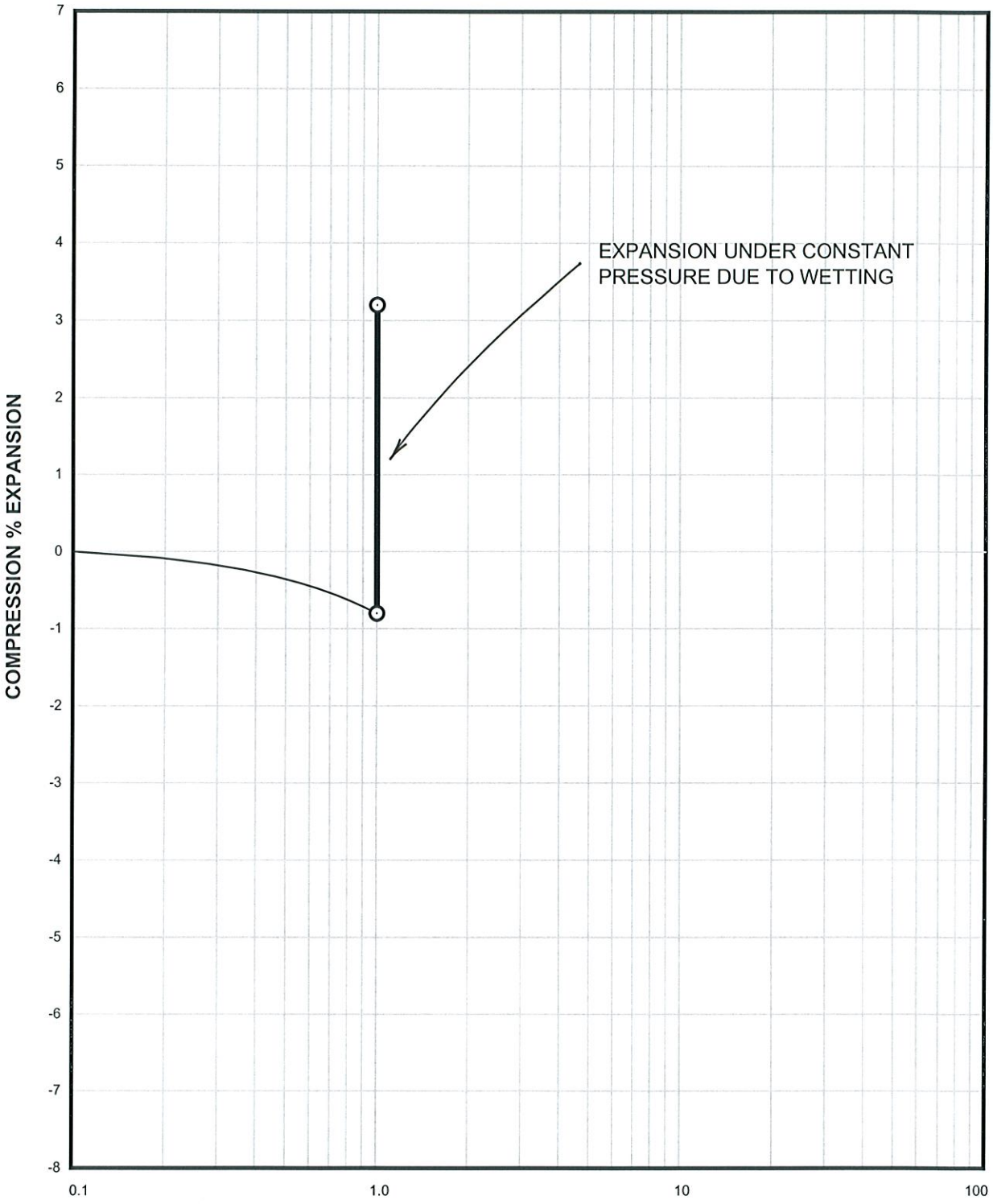
- CLAY, SANDY, MEDIUM STIFF TO VERY STIFF, SLIGHTLY MOIST, BROWN (CL).
- SAND, CLAYEY, LOOSE TO MEDIUM DENSE, SLIGHTLY MOIST, BROWN, RUST (SC).
- GRAVEL, CLAYEY, VERY DENSE, SLIGHTLY MOIST, BROWN, GRAY (GC).
- WEATHERED CLAYSTONE, MOIST, BROWN, RUST.
- BEDROCK, CLAYSTONE, MEDIUM HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, OLIVE, BROWN, GRAY.
- BEDROCK, SANDSTONE, HARD TO VERY HARD, SLIGHTLY MOIST, BROWN, TAN.
- BEDROCK, INTERBEDDED CLAYSTONE/SANDSTONE, HARD TO VERY HARD, SLIGHTLY MOIST, BROWN, GRAY.
- DRIVE SAMPLE. THE SYMBOL 27/12 INDICATES 27 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- ▽ WATER LEVEL MEASURED AT TIME OF DRILLING.
- ▼ WATER LEVEL MEASURED SEVERAL DAYS AFTER DRILLING.

NOTES:

1. THE BORINGS WERE DRILLED BETWEEN MAY 6 AND 16, 2005 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A TRUCK-MOUNTED DRILL RIG.
2. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (pcf).
   SW - INDICATES SWELL WHEN WETTED UNDER APPLIED PRESSURE (%).
   LL - INDICATES LIQUID LIMIT (%).
   PI - INDICATES PLASTICITY INDEX (%).
   SS - INDICATES WATER-SOLUBLE SULFATE CONCENTRATION (%).
   pF - INDICATES SOIL SUCTION VALUE (pf).
   -200 - INDICATES PERCENT PASSING NO. 200 SIEVE (%).
3. BORING LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND WERE SURVEYED BY AZTEC CONSULTANTS.
4. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS CONTAINED IN THIS REPORT.

APPENDIX C

LABORATORY TEST RESULTS
(Project No. 40,507-115, Report Dated June 30, 2005)



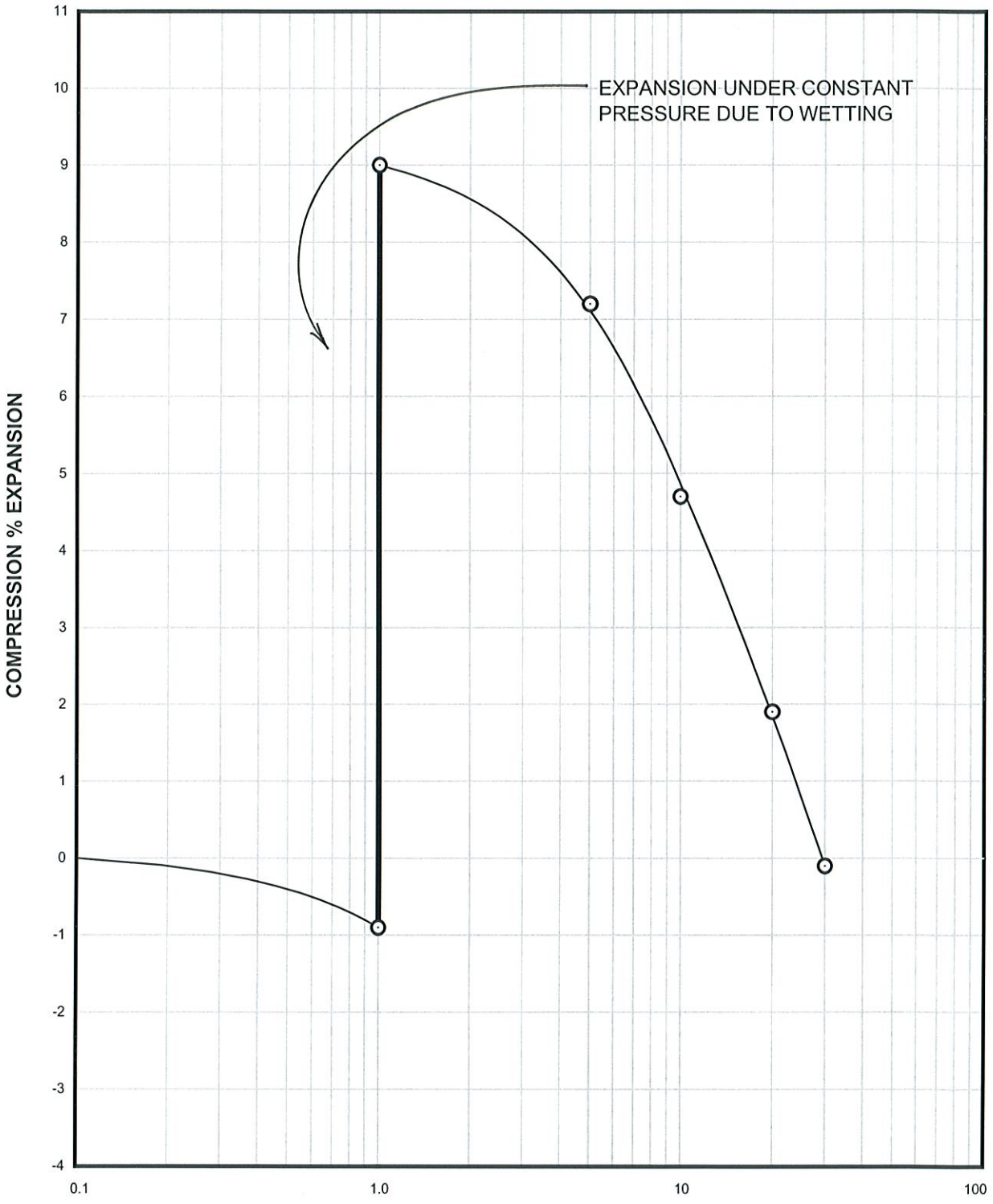
Sample of CLAYSTONE
From TH-1 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 116 PCF
SAMPLE MOISTURE CONTENT= 14.0 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-1



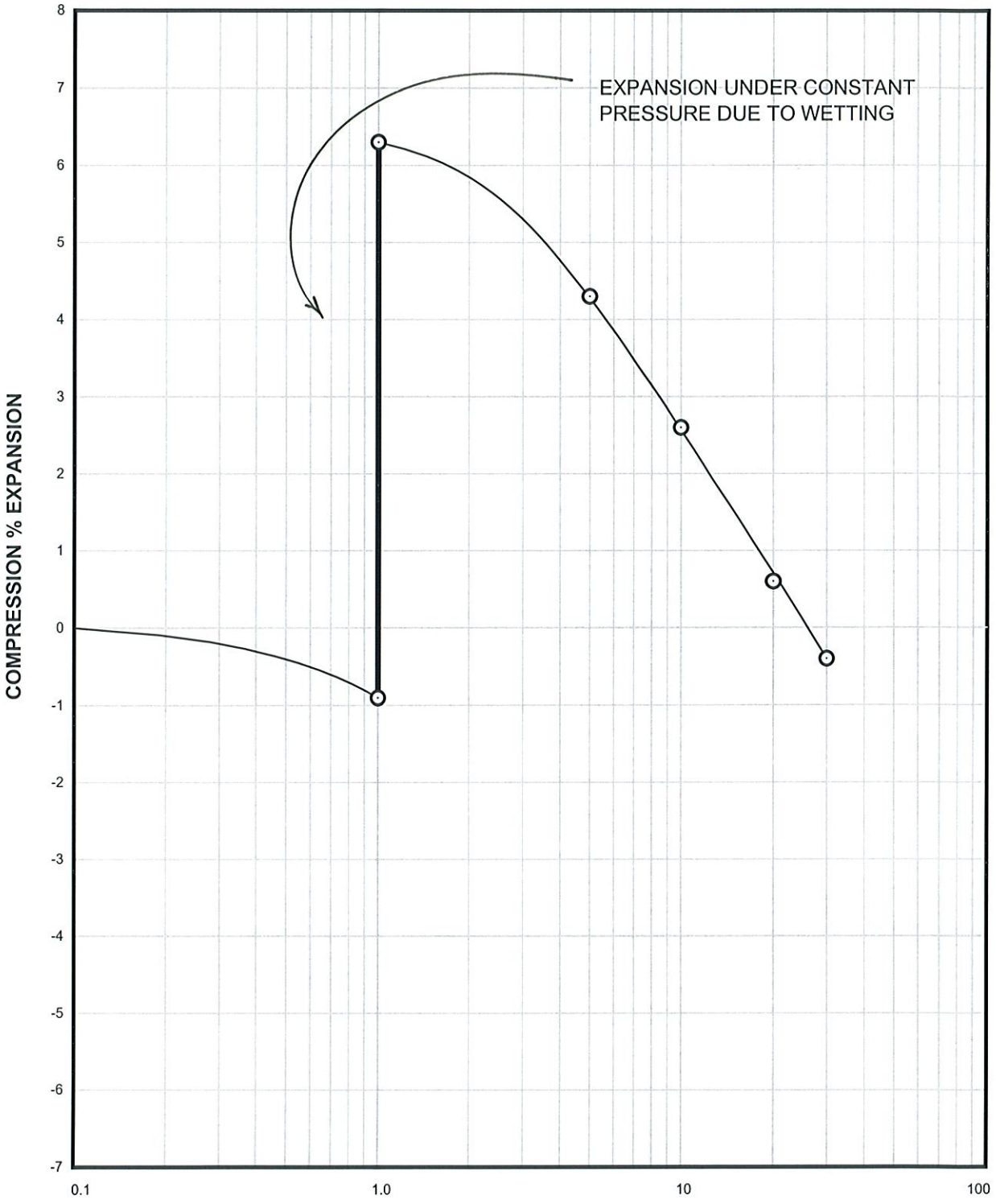
Sample of CLAYSTONE
From TH-1 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 105 PCF
SAMPLE MOISTURE CONTENT= 22.0 %

Swell Consolidation Test Results

FIG. C-2

PROJECT NO. DN40,507-115



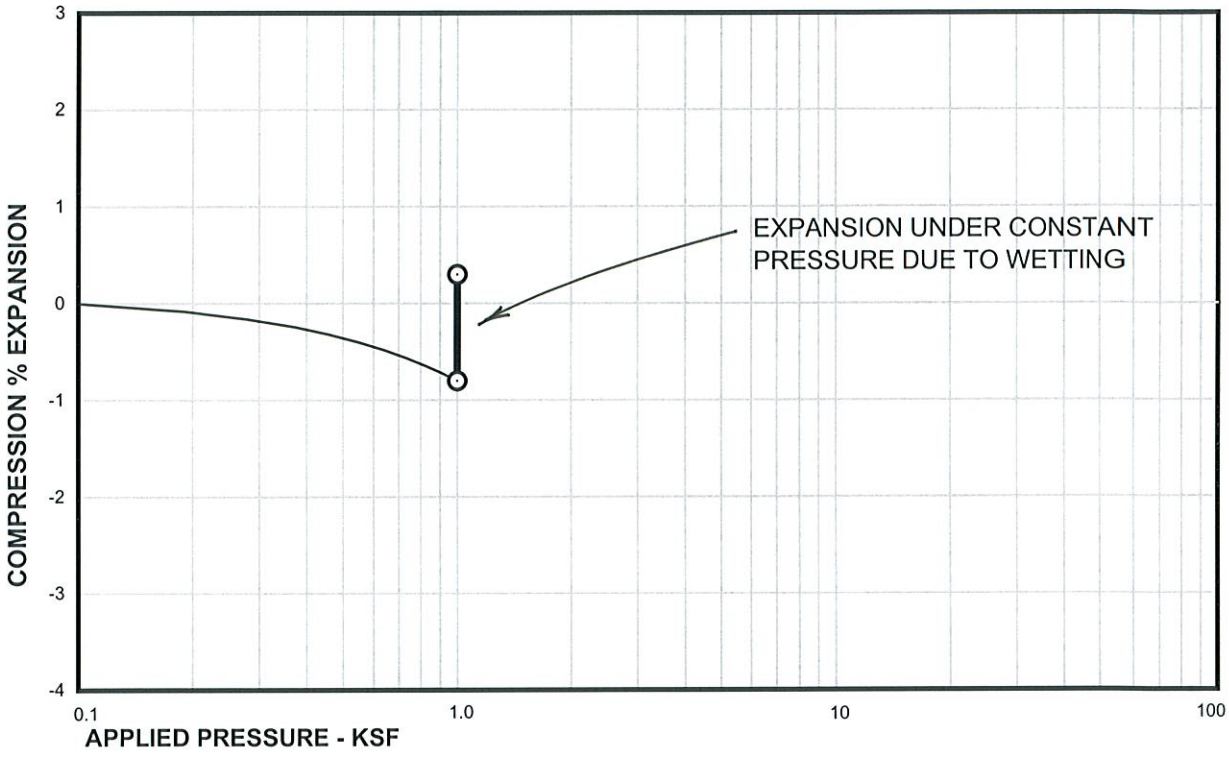
Sample of CLAYSTONE
From TH-1 AT 34 FEET

SAMPLE DRY UNIT WEIGHT= 127 PCF
SAMPLE MOISTURE CONTENT= 11.9 %

Swell Consolidation Test Results

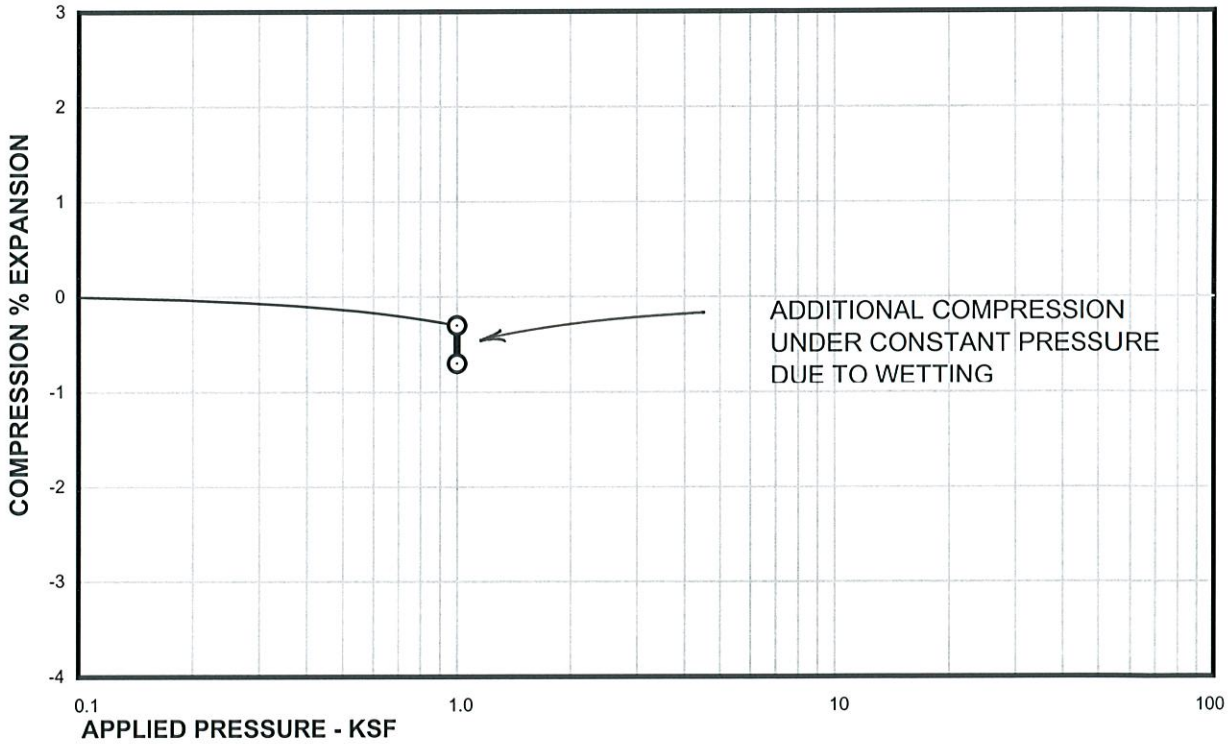
PROJECT NO. DN40,507-115

FIG. C-3



Sample of CLAY, SANDY (CL)
From TH-2 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 109 PCF
SAMPLE MOISTURE CONTENT= 10.9 %



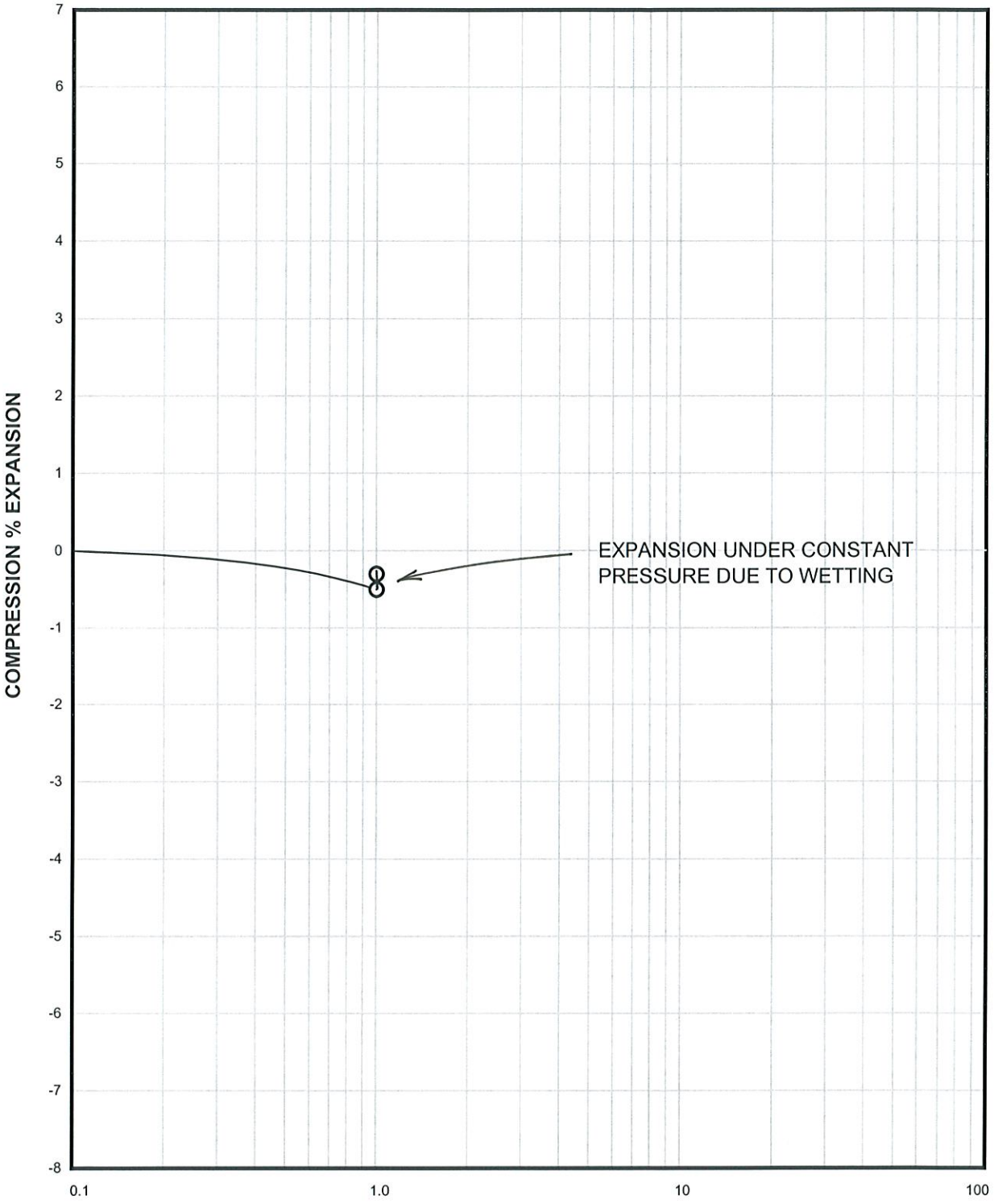
Sample of WEATHERED CLAYSTONE
From TH-3 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 104 PCF
SAMPLE MOISTURE CONTENT= 5.6 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-4



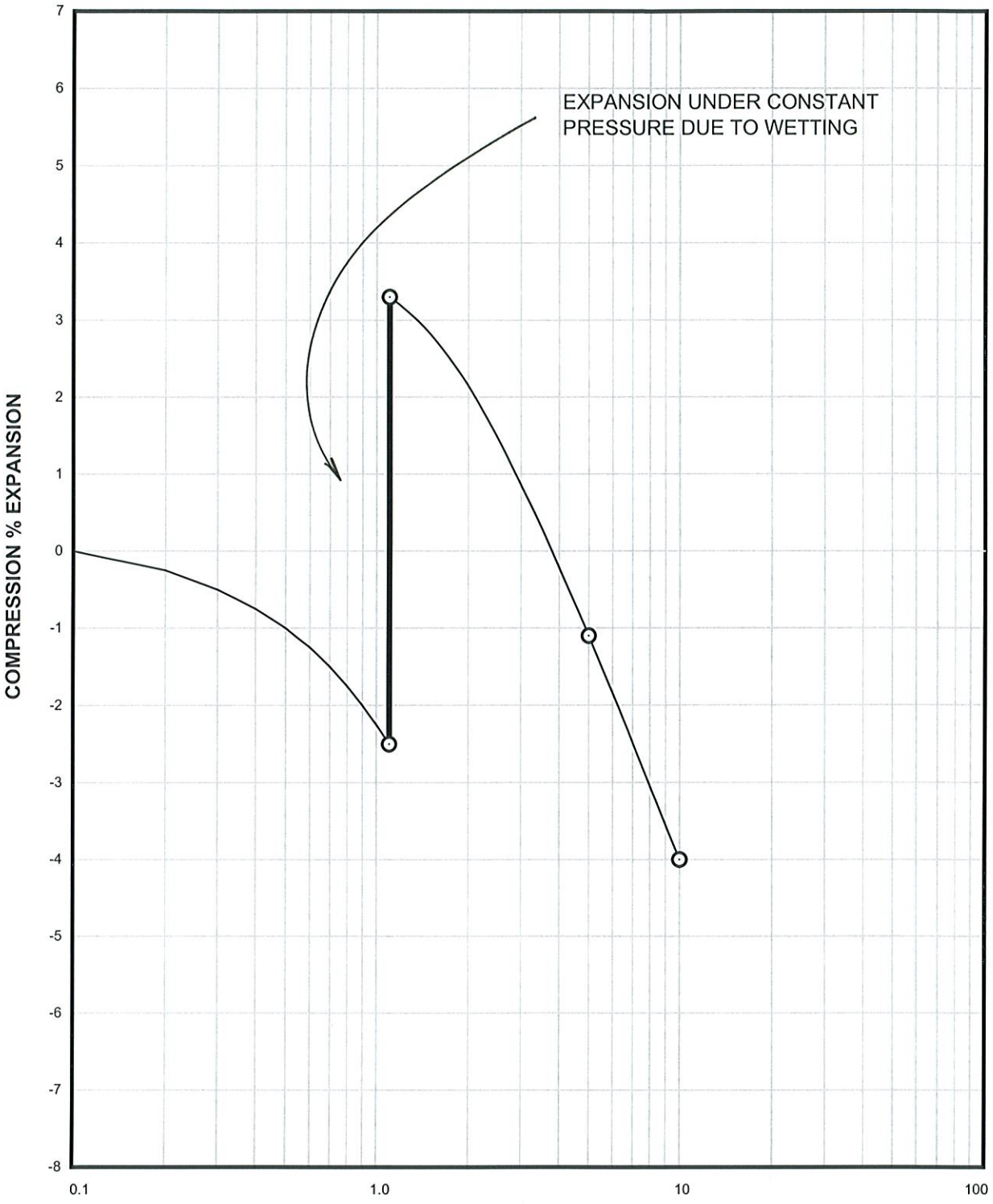
Sample of CLAY, SANDY (CL)
From TH-4 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 103 PCF
SAMPLE MOISTURE CONTENT= 12.4 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-5



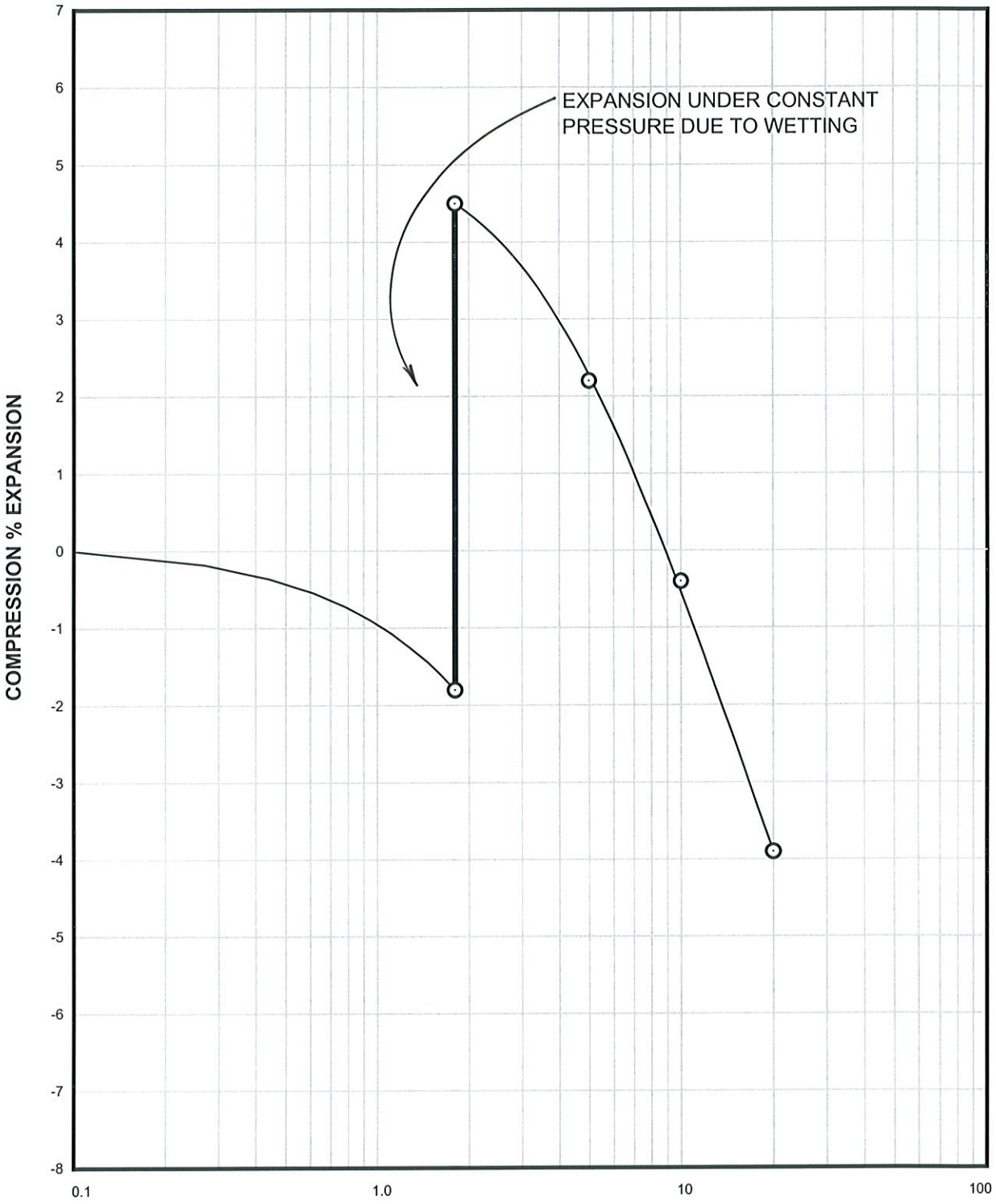
Sample of WEATHERED CLAYSTONE
From TH-5 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 99 PCF
SAMPLE MOISTURE CONTENT= 22.5 %

Swell Consolidation Test Results

FIG. C-6

PROJECT NO. DN40,507-115



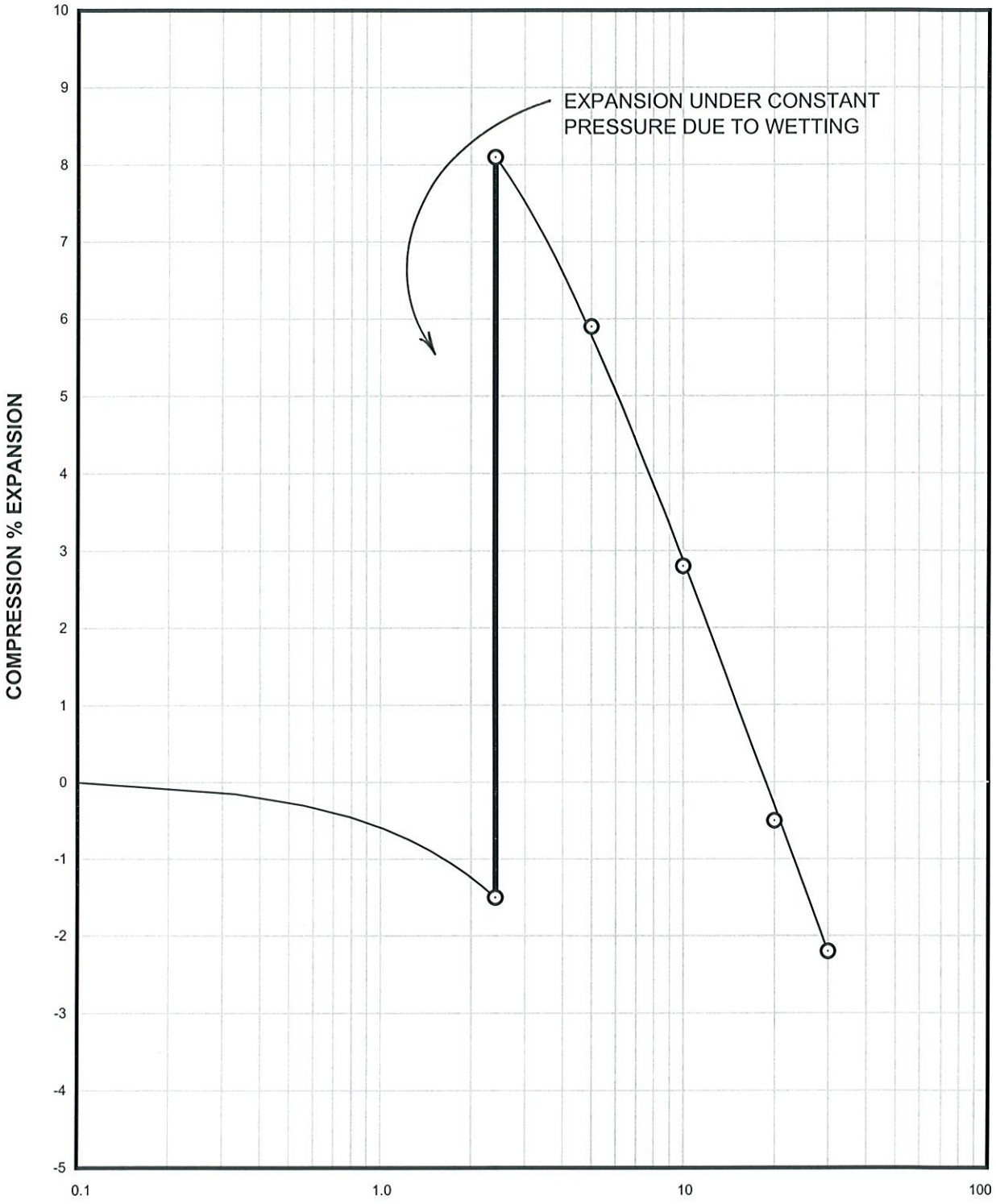
Sample of CLAYSTONE
From TH-5 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 96 PCF
SAMPLE MOISTURE CONTENT= 27.9 %

Swell Consolidation Test Results

FIG. C-7

PROJECT NO. DN40,507-115



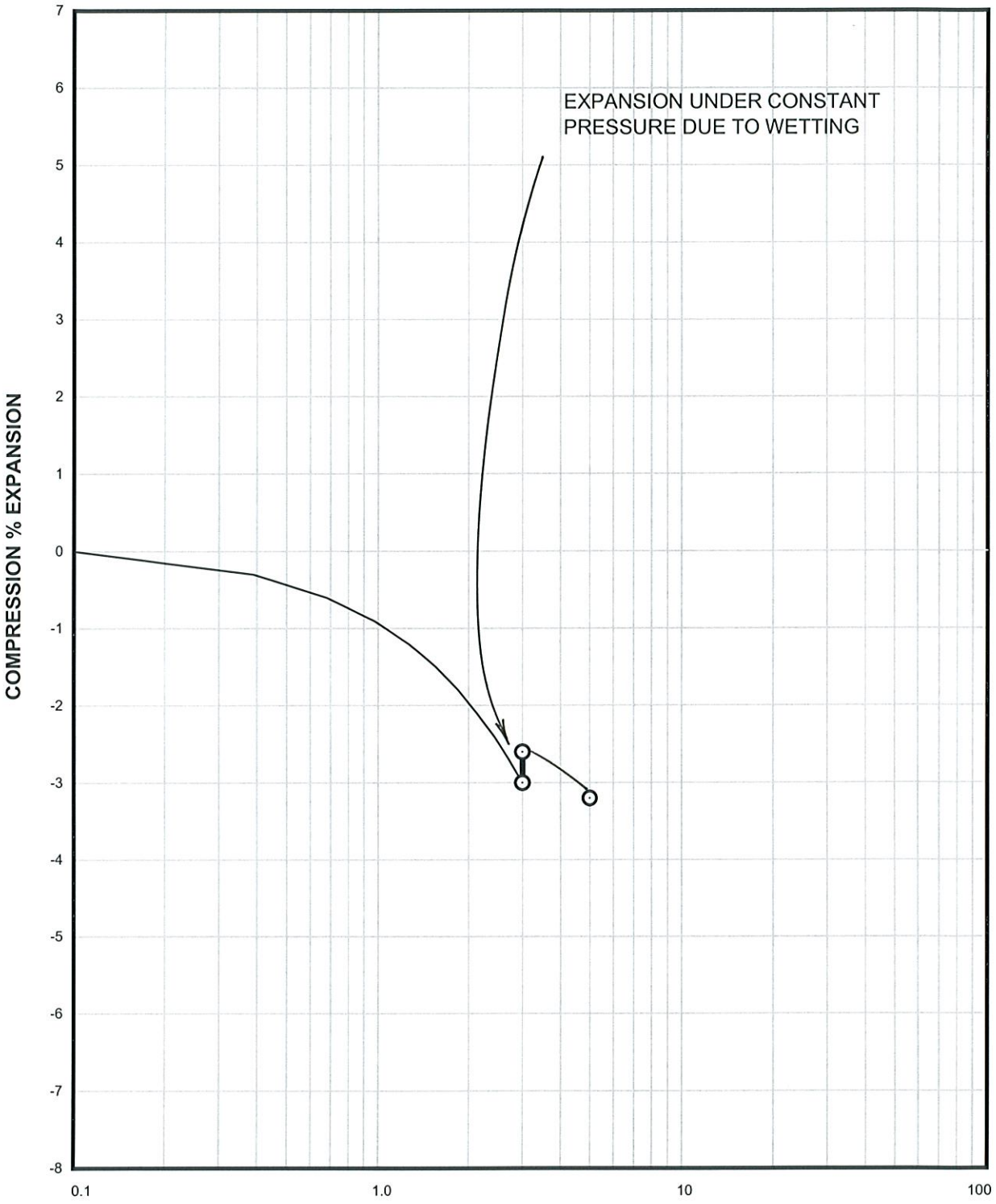
Sample of CLAYSTONE
From TH-5 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 114 PCF
SAMPLE MOISTURE CONTENT= 14.9 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-8



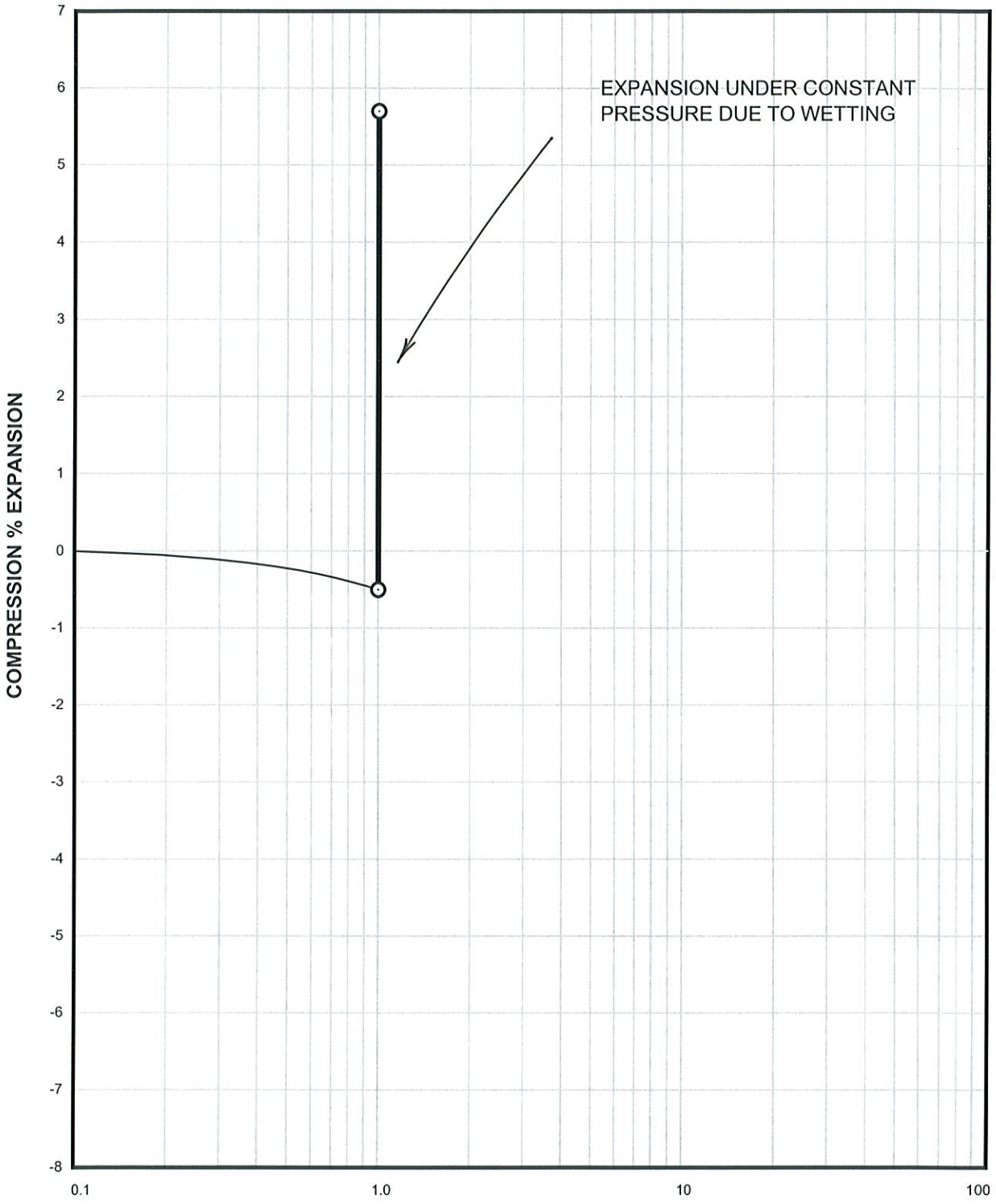
Sample of CLAYSTONE
From TH-5 AT 24 FEET

SAMPLE DRY UNIT WEIGHT= 119 PCF
SAMPLE MOISTURE CONTENT= 12.3 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-9

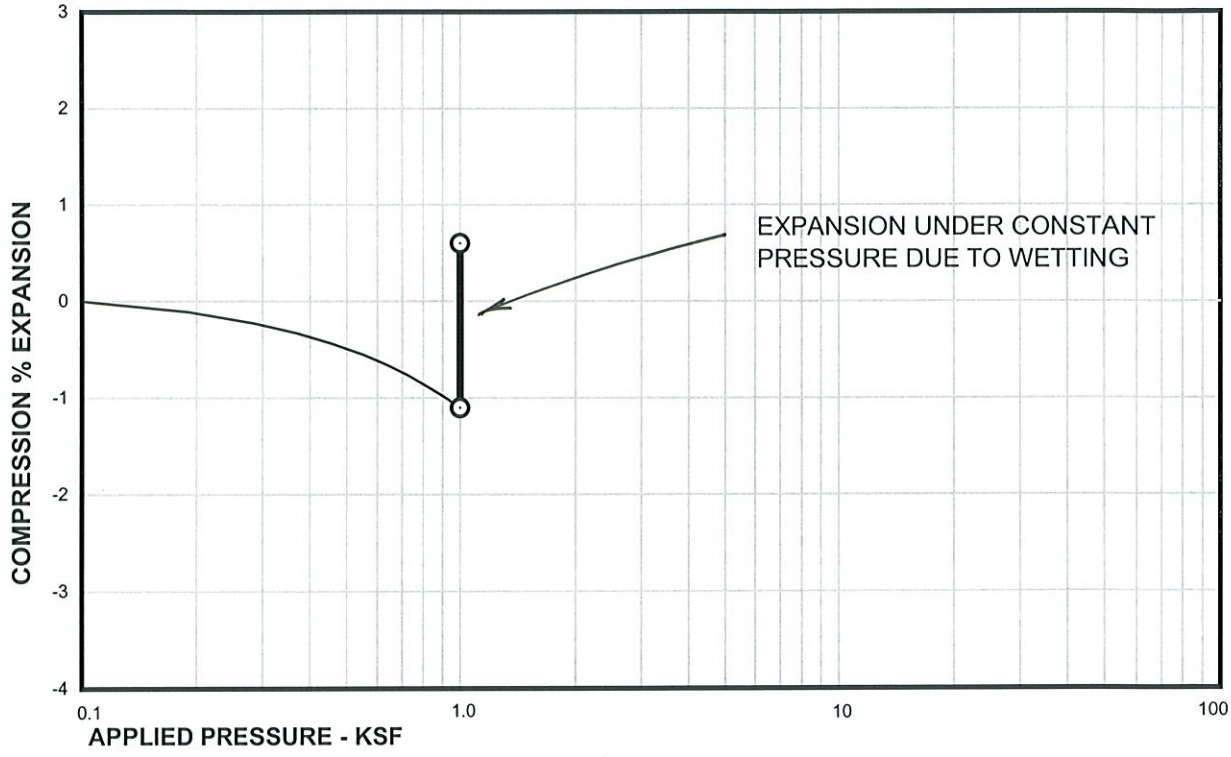


Sample of WEATHERED CLAYSTONE
From TH-6 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 114 PCF
SAMPLE MOISTURE CONTENT= 12.5 %

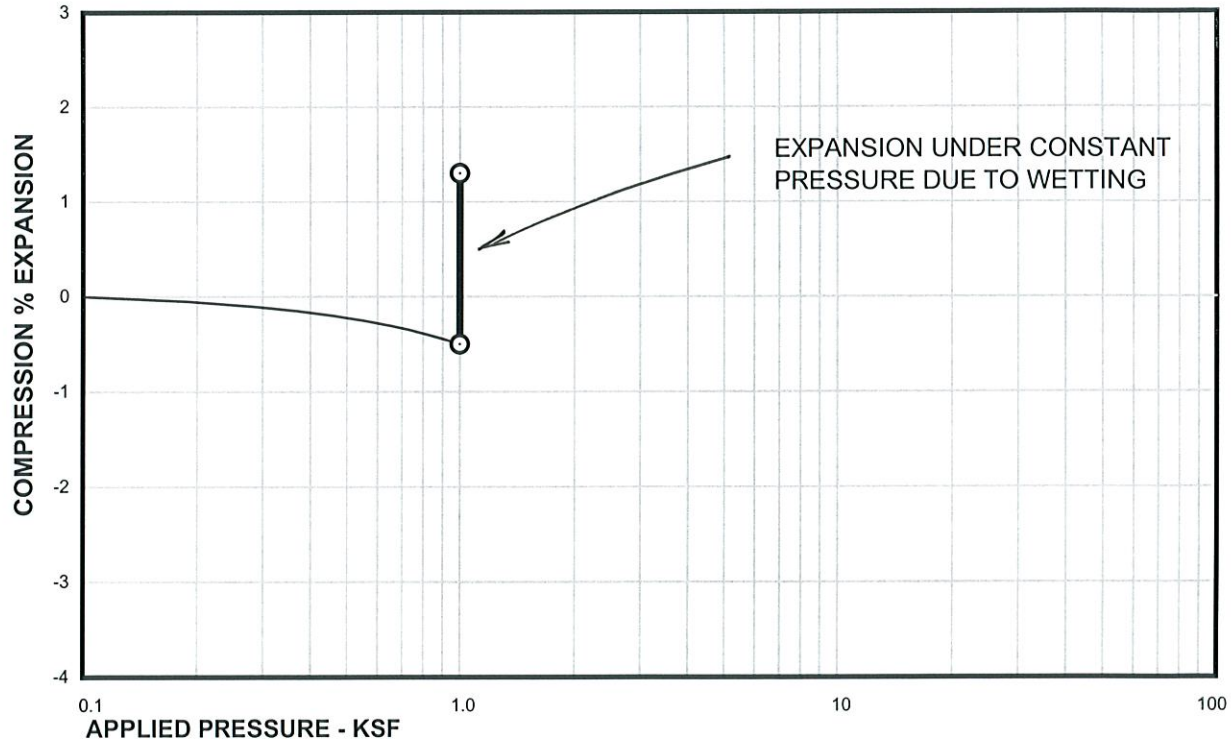
PROJECT NO. DN40,507-115

Swell Consolidation Test Results FIG. C-10



Sample of CLAYSTONE
From TH-6 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 113 PCF
SAMPLE MOISTURE CONTENT= 10.4 %



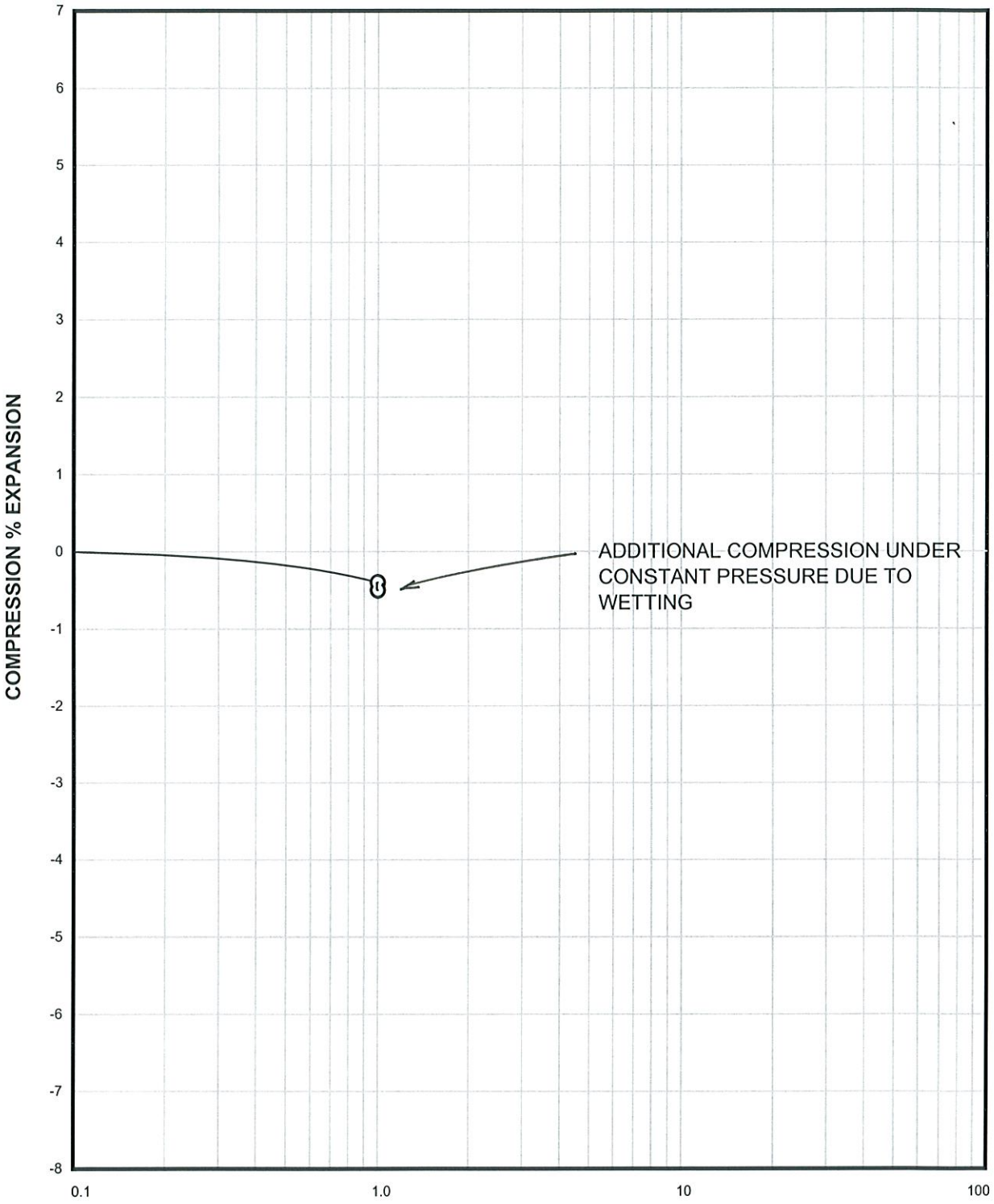
Sample of CLAYSTONE
From TH-6 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 132 PCF
SAMPLE MOISTURE CONTENT= 10.9 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-11



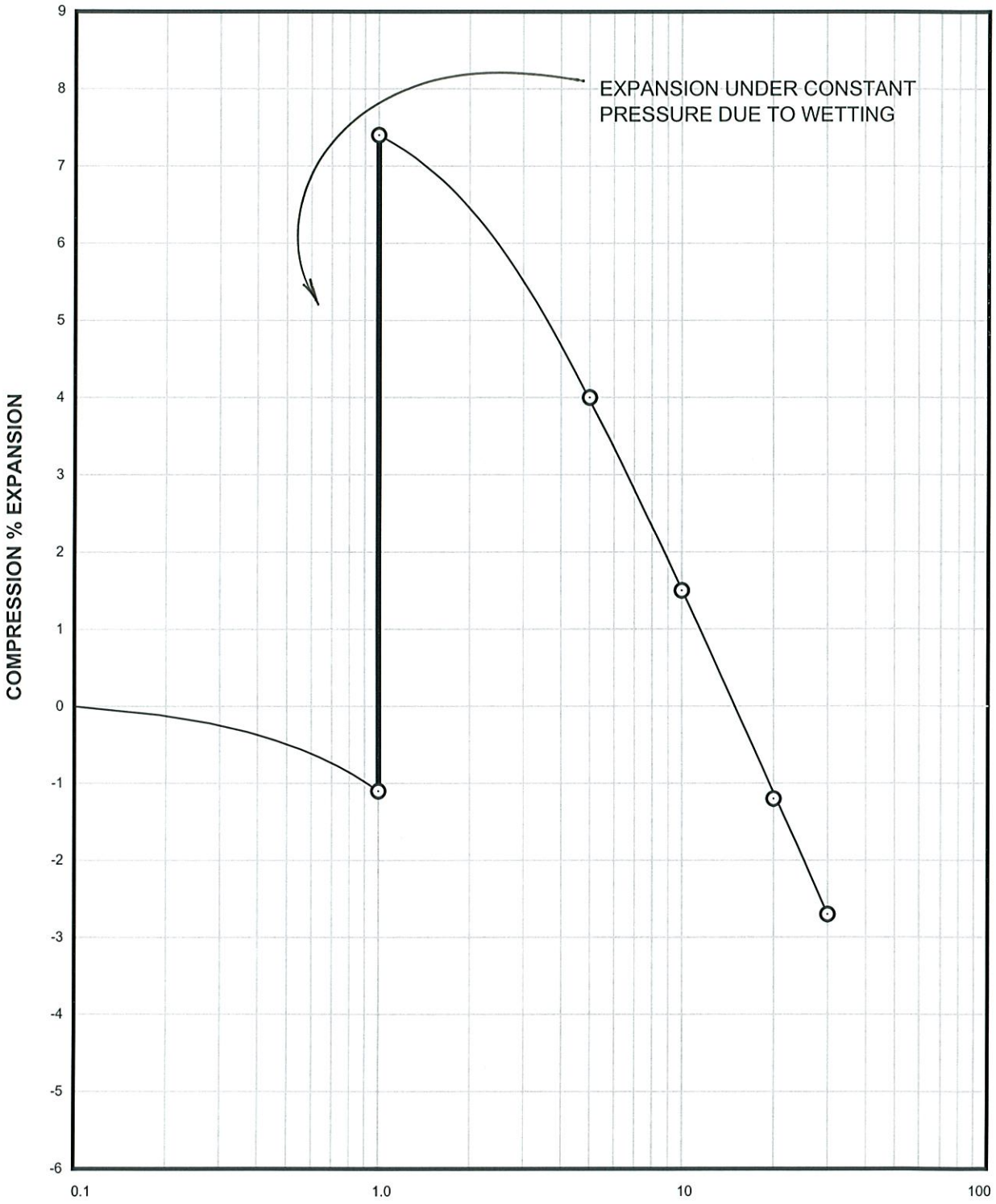
Sample of WEATHERED CLAYSTONE
From TH-7 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 116 PCF
SAMPLE MOISTURE CONTENT= 8.3 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-12



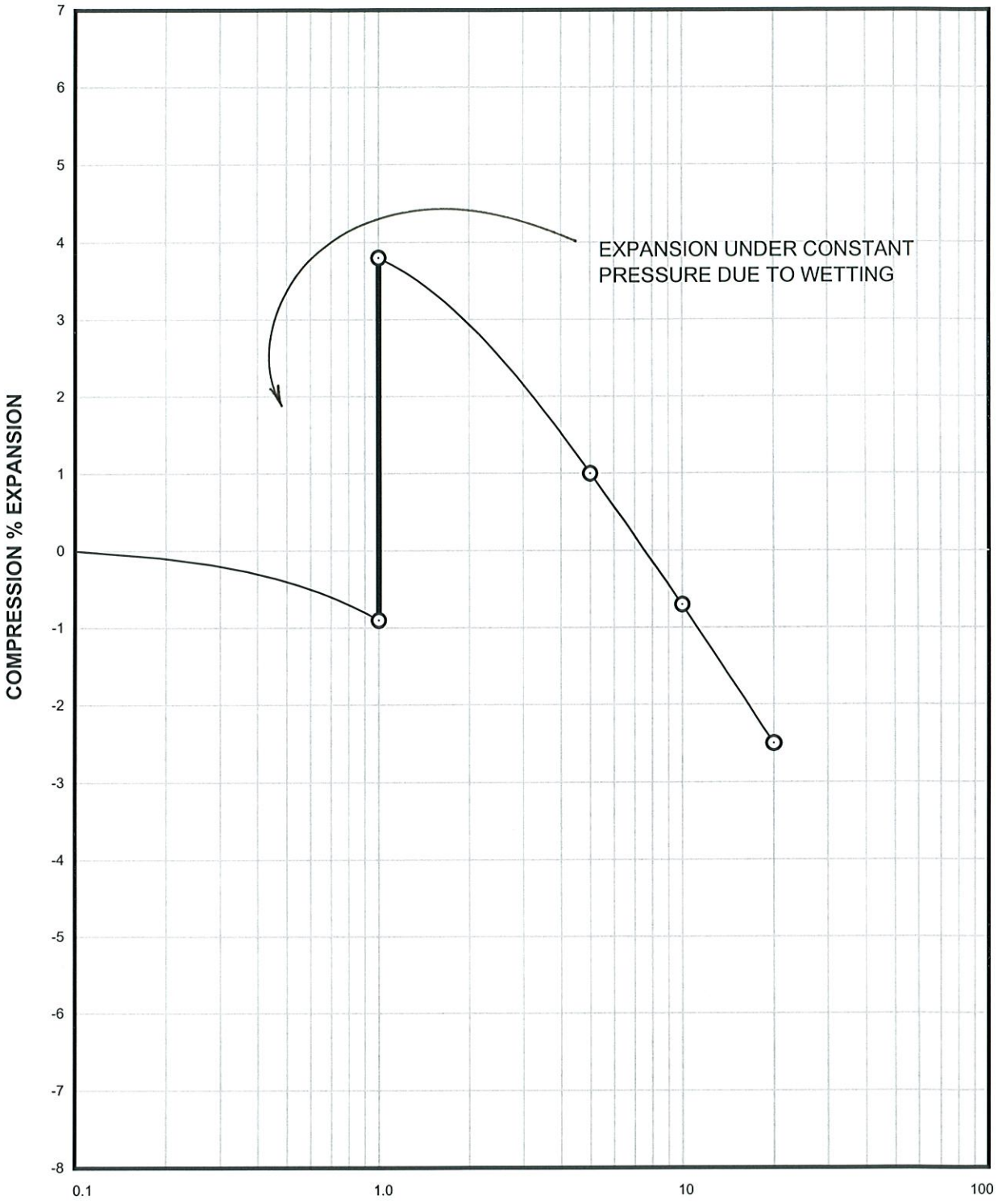
Sample of CLAYSTONE
From TH-7 AT 29 FEET

SAMPLE DRY UNIT WEIGHT= 118 PCF
SAMPLE MOISTURE CONTENT= 15.0 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-13



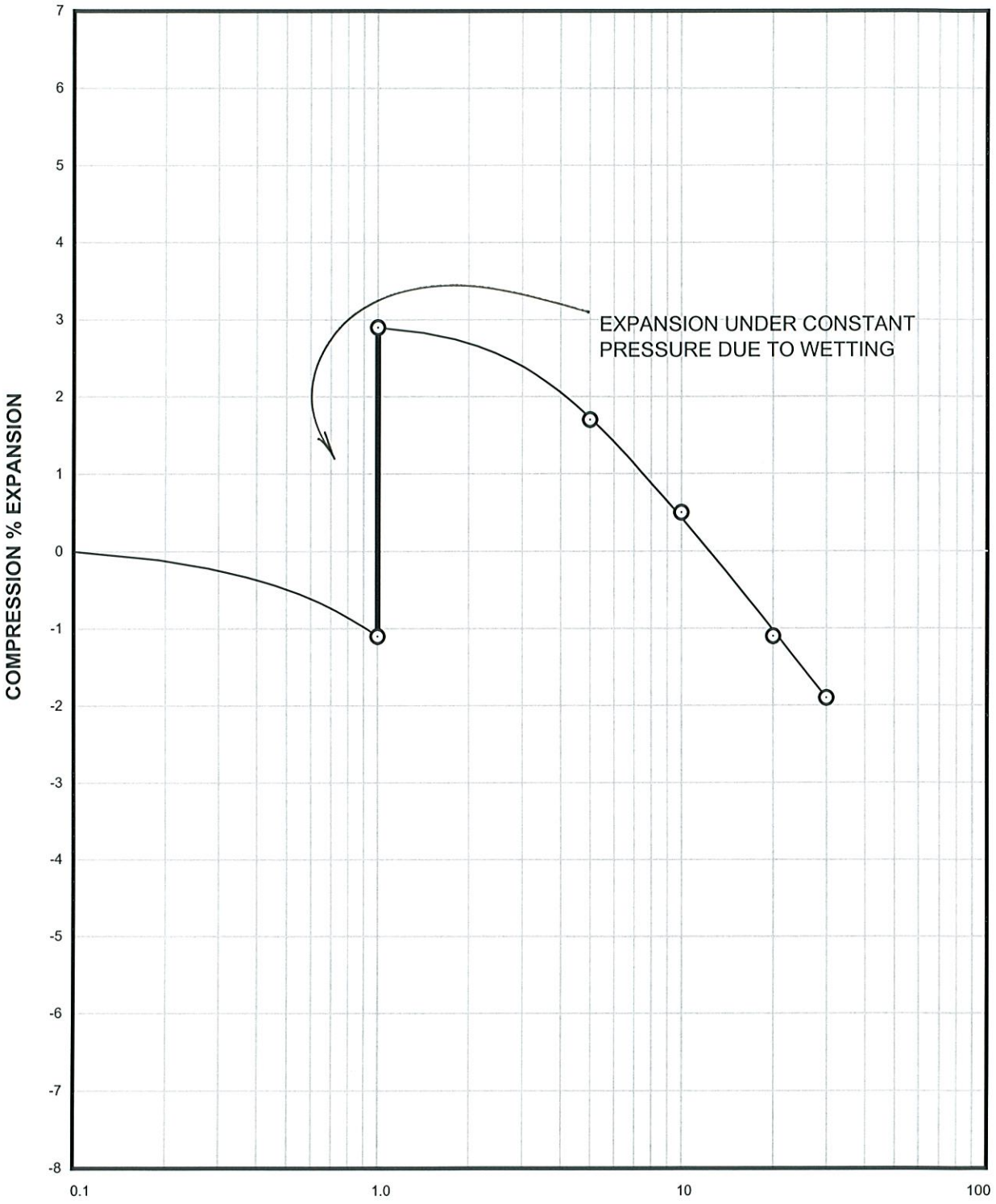
Sample of CLAYSTONE
From TH-8 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 114 PCF
SAMPLE MOISTURE CONTENT= 16.7 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-14

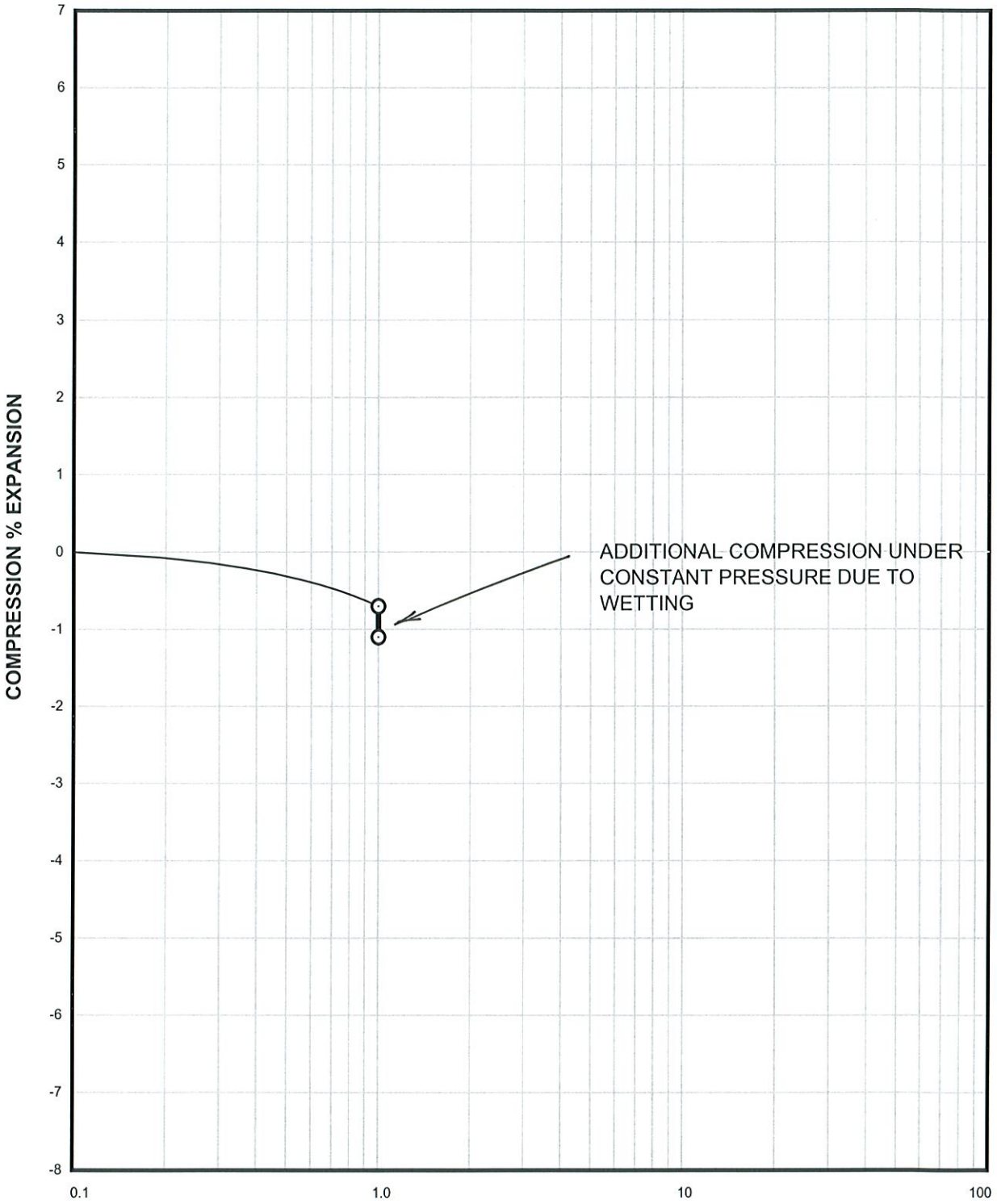


Sample of CLAYSTONE
From TH-8 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 127 PCF
SAMPLE MOISTURE CONTENT= 11.8 %

PROJECT NO. DN40,507-115

Swell Consolidation Test Results FIG. C-15



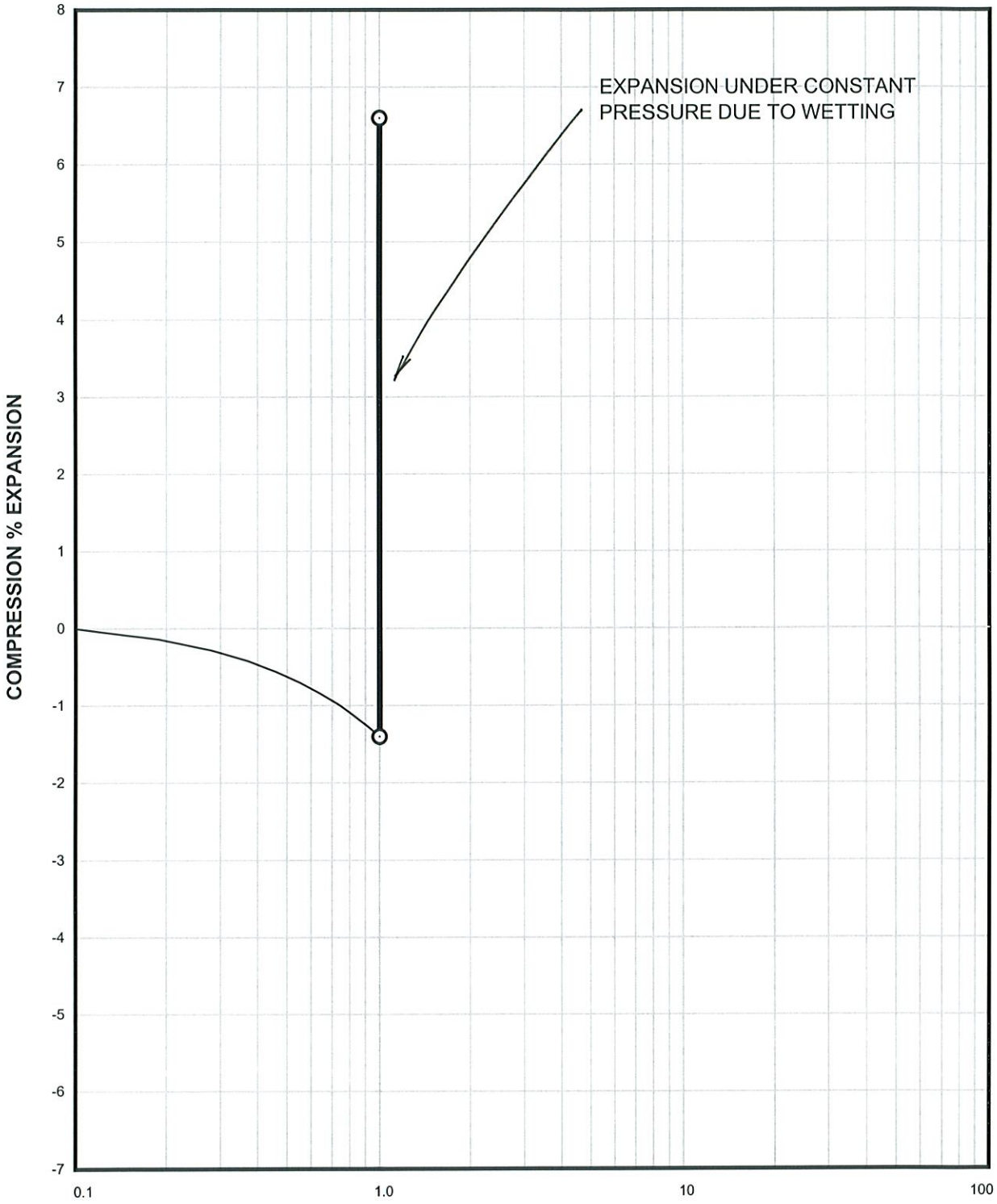
Sample of SAND, CLAYEY (SC)
From TH-9 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 110 PCF
SAMPLE MOISTURE CONTENT= 7.0 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-16



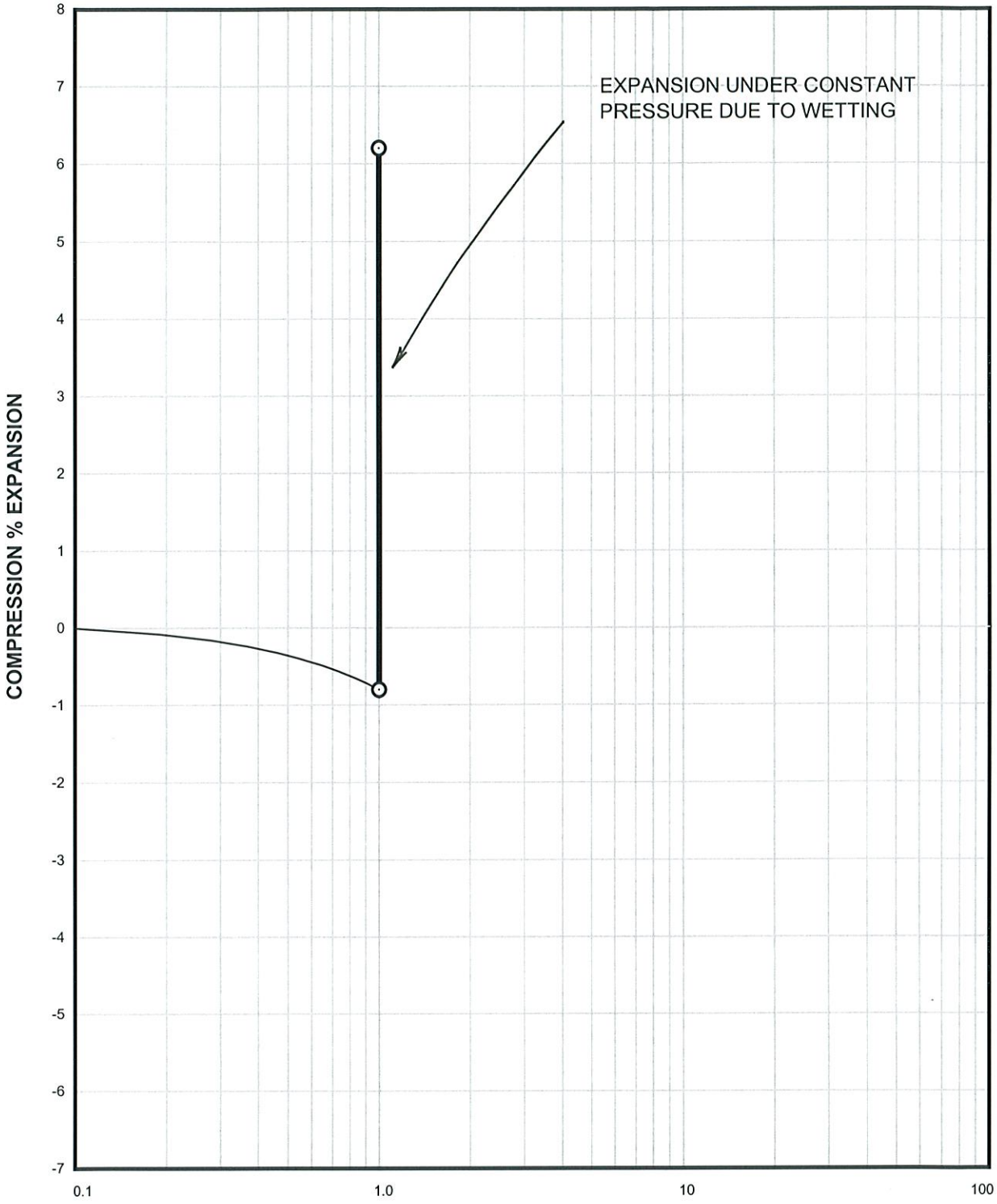
Sample of CLAYSTONE
From TH-9 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 109 PCF
SAMPLE MOISTURE CONTENT= 18.4 %

Swell Consolidation Test Results

FIG. C-17

PROJECT NO. DN40,507-115



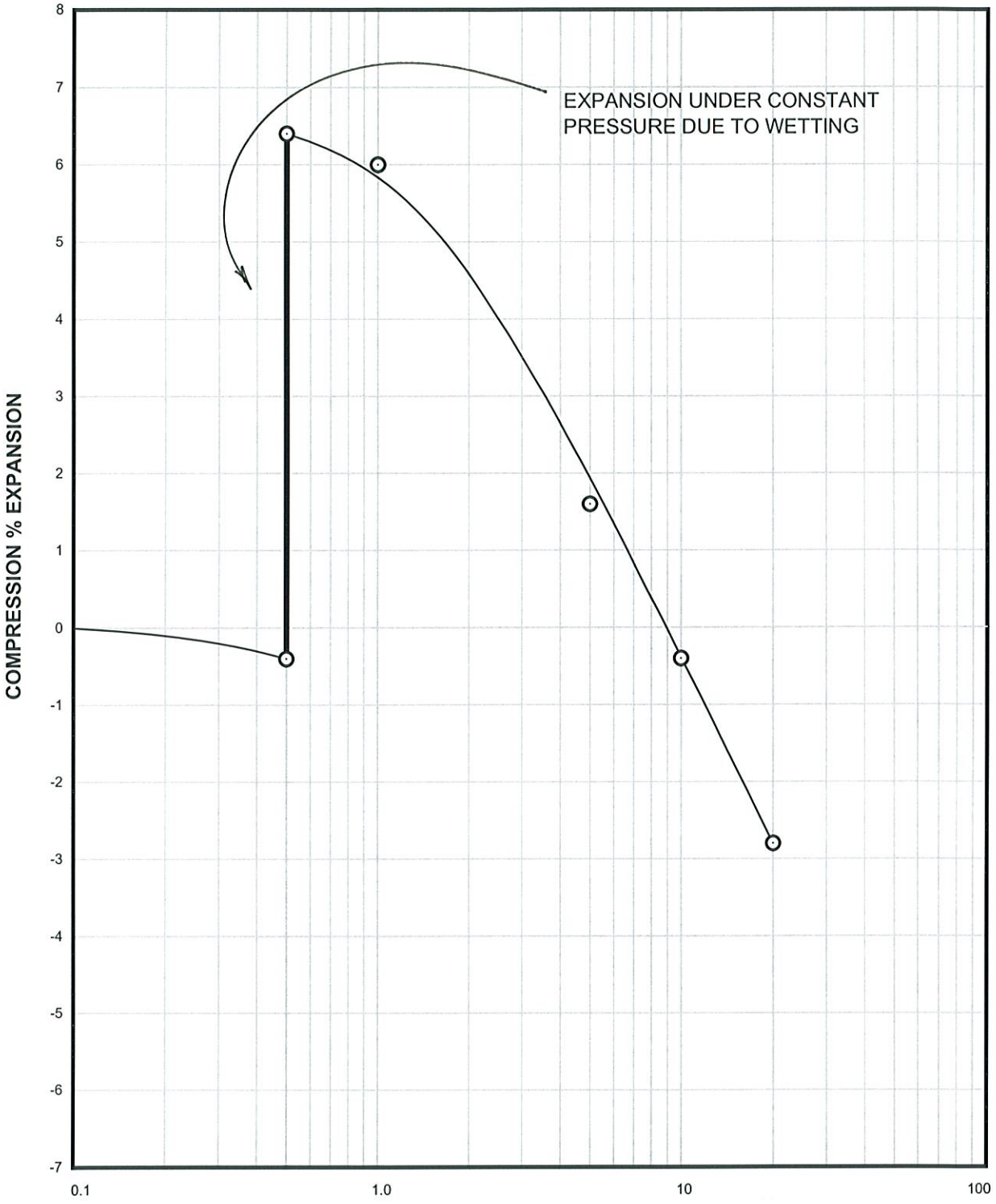
Sample of CLAYSTONE
From TH-9 AT 24 FEET

SAMPLE DRY UNIT WEIGHT= 131 PCF
SAMPLE MOISTURE CONTENT= 9.3 %

Swell Consolidation Test Results

FIG. C-18

PROJECT NO. DN40,507-115

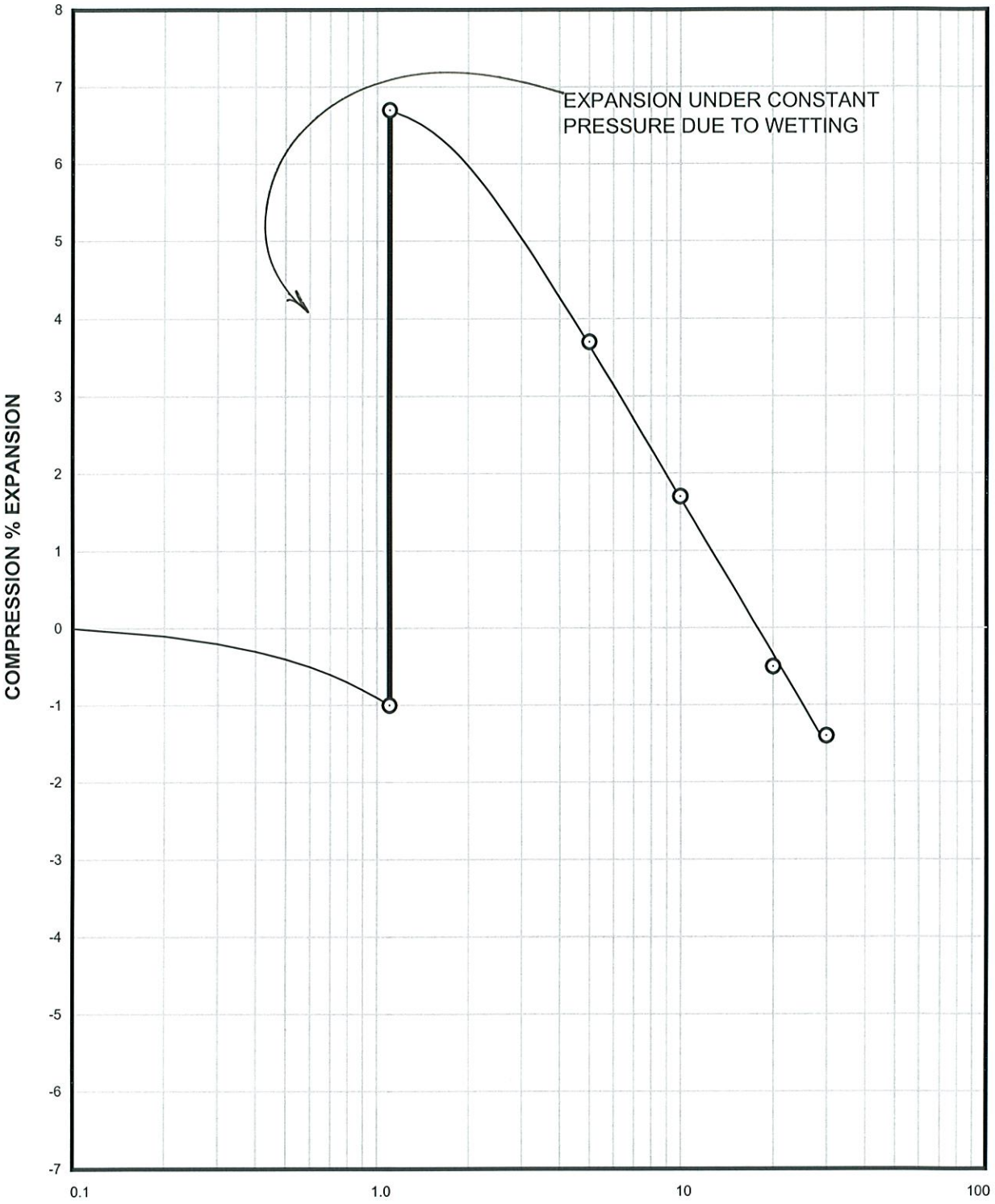


Sample of CLAY, SANDY (CL)
From TH-10 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 126 PCF
SAMPLE MOISTURE CONTENT= 10.2 %

Swell Consolidation Test Results FIG. C-19

PROJECT NO. DN40,507-115

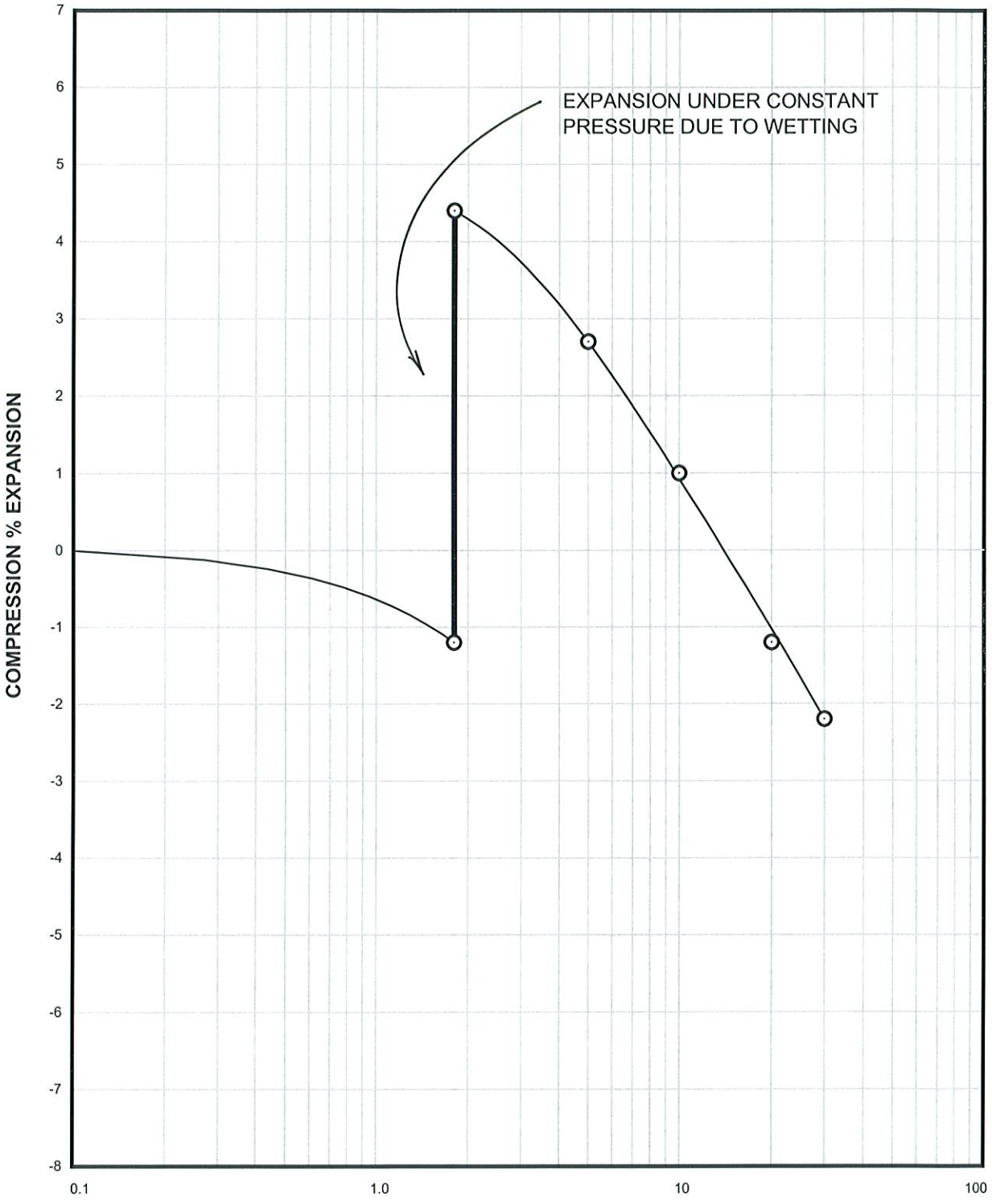


Sample of INTERBEDDED CLAYSTONE/SANDSTONE
From TH-10 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 127 PCF
SAMPLE MOISTURE CONTENT= 11.7 %

PROJECT NO. DN40,507-115

Swell Consolidation Test Results FIG. C-20



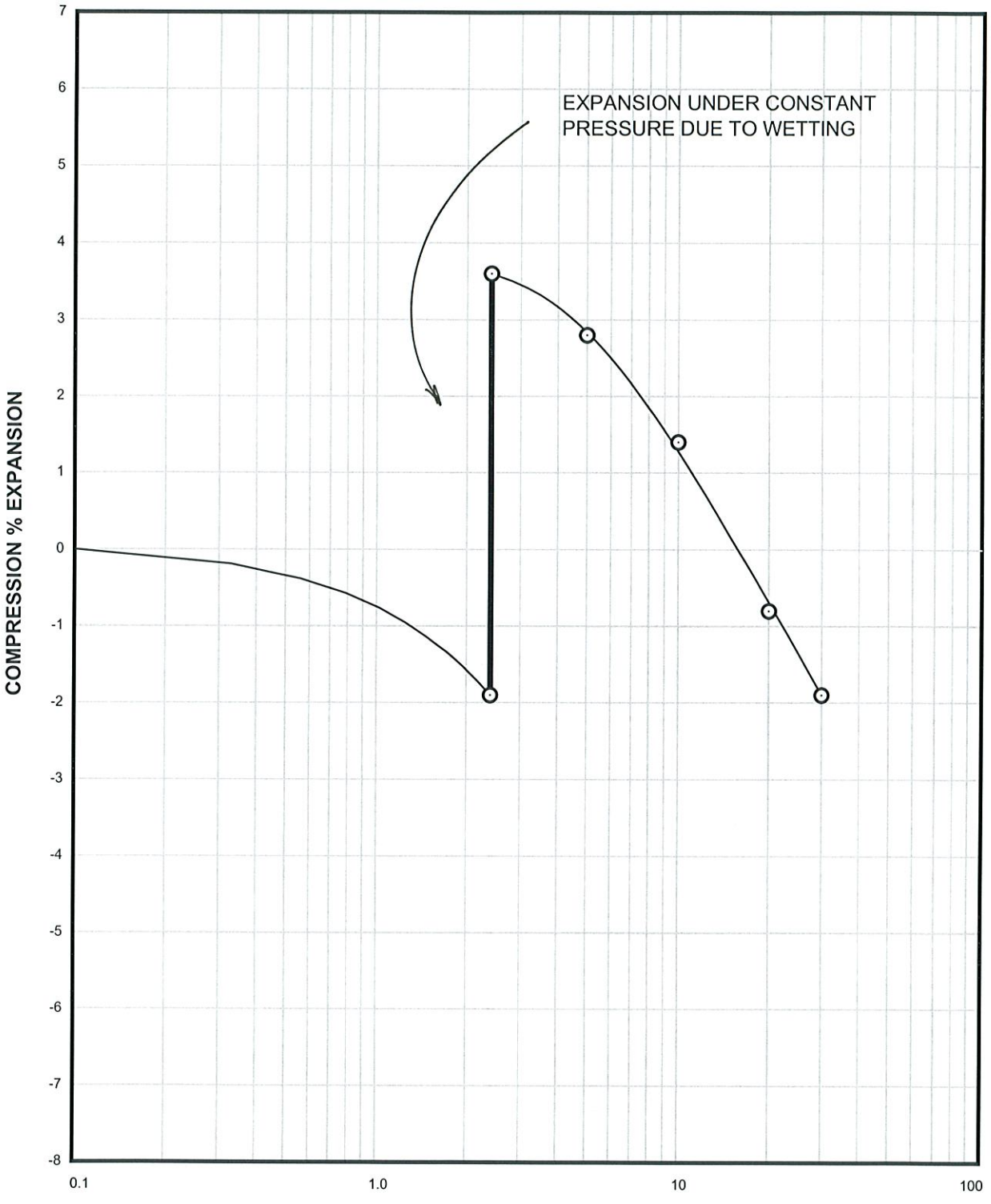
Sample of CLAYSTONE
From TH-10 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 132 PCF
SAMPLE MOISTURE CONTENT= 9.5 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-21



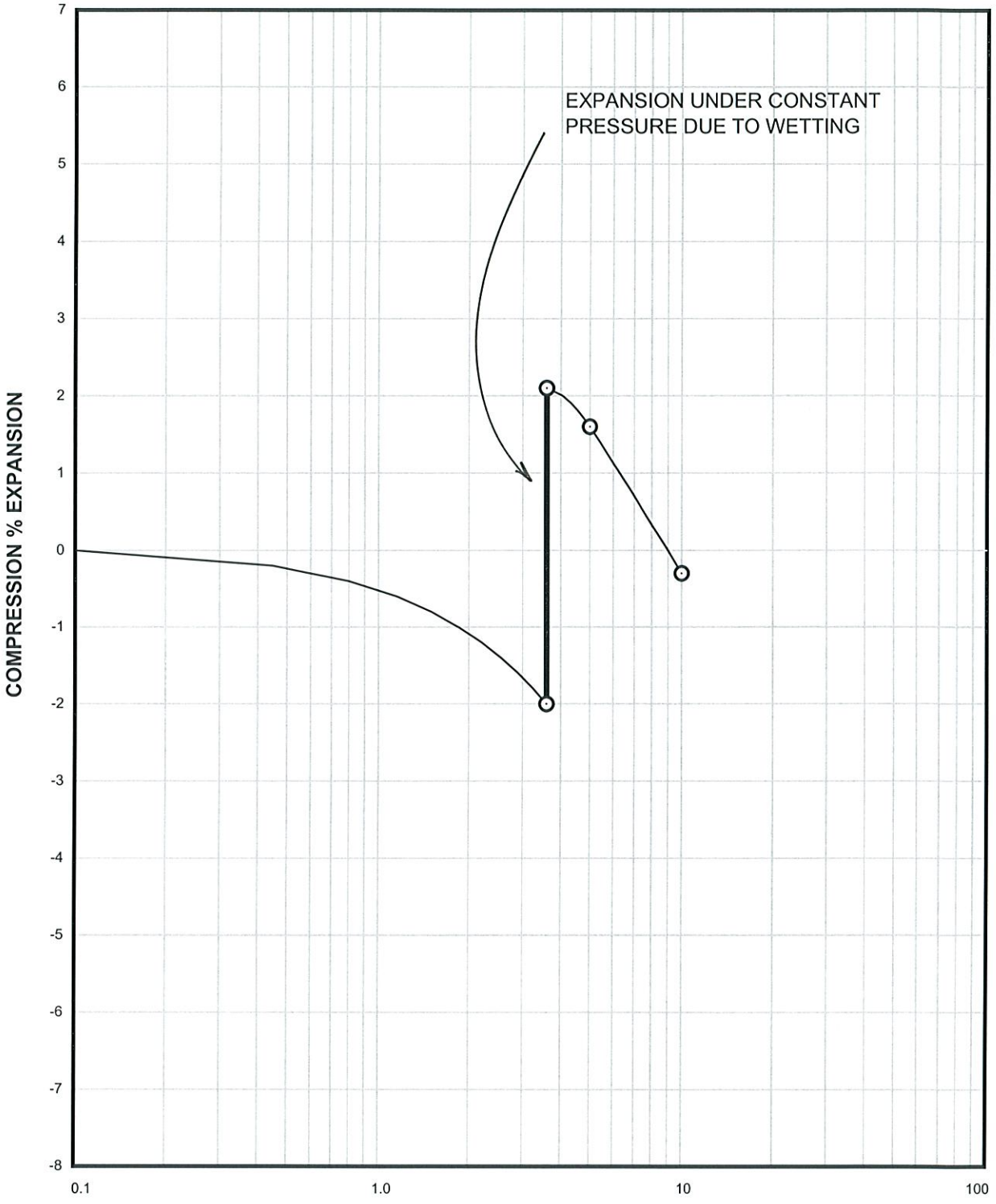
Sample of CLAYSTONE
From TH-10 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 117 PCF
SAMPLE MOISTURE CONTENT= 15.6 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-22



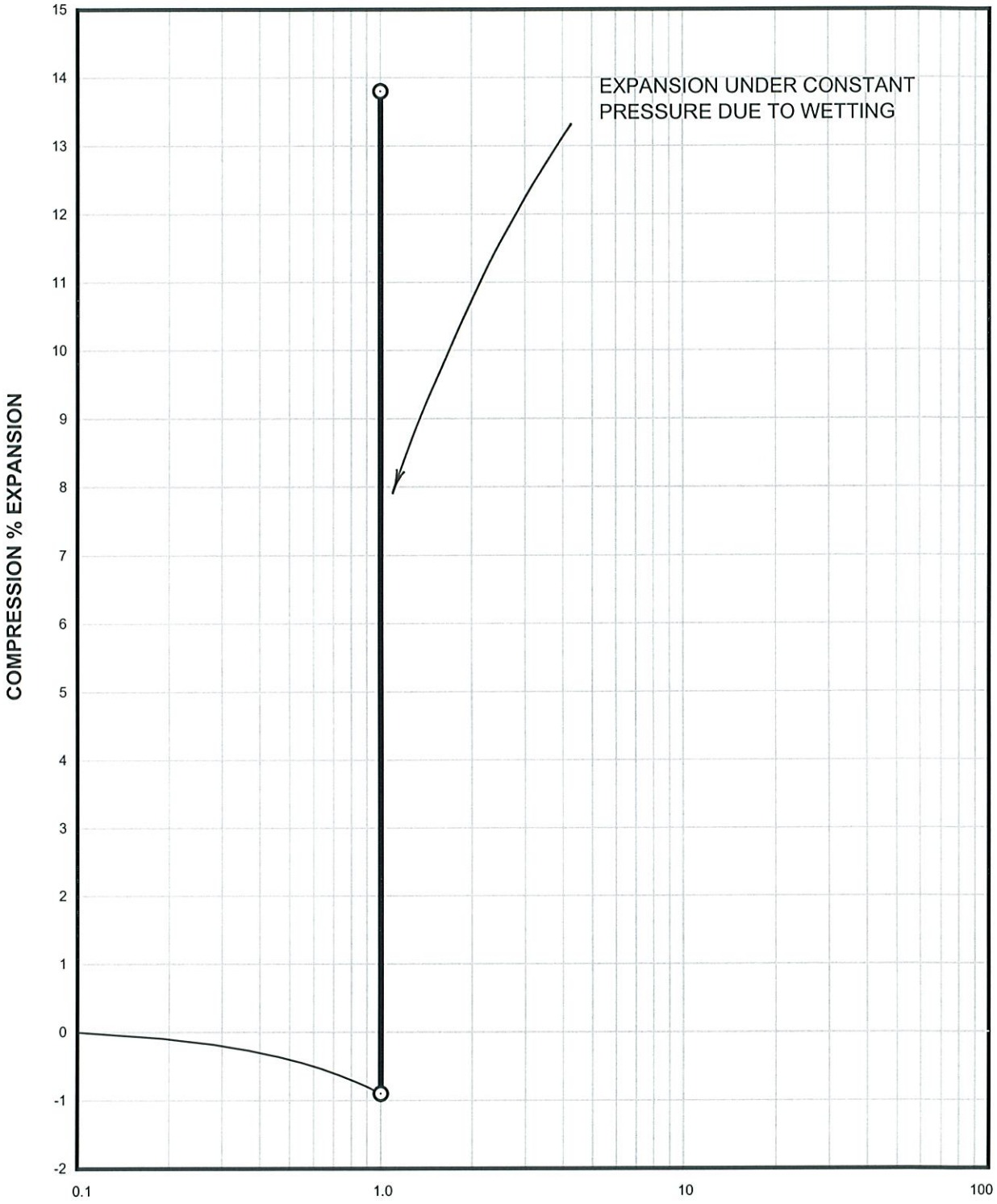
Sample of CLAYSTONE
From TH-10 AT 29 FEET

SAMPLE DRY UNIT WEIGHT= 118 PCF
SAMPLE MOISTURE CONTENT= 13.3 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-23



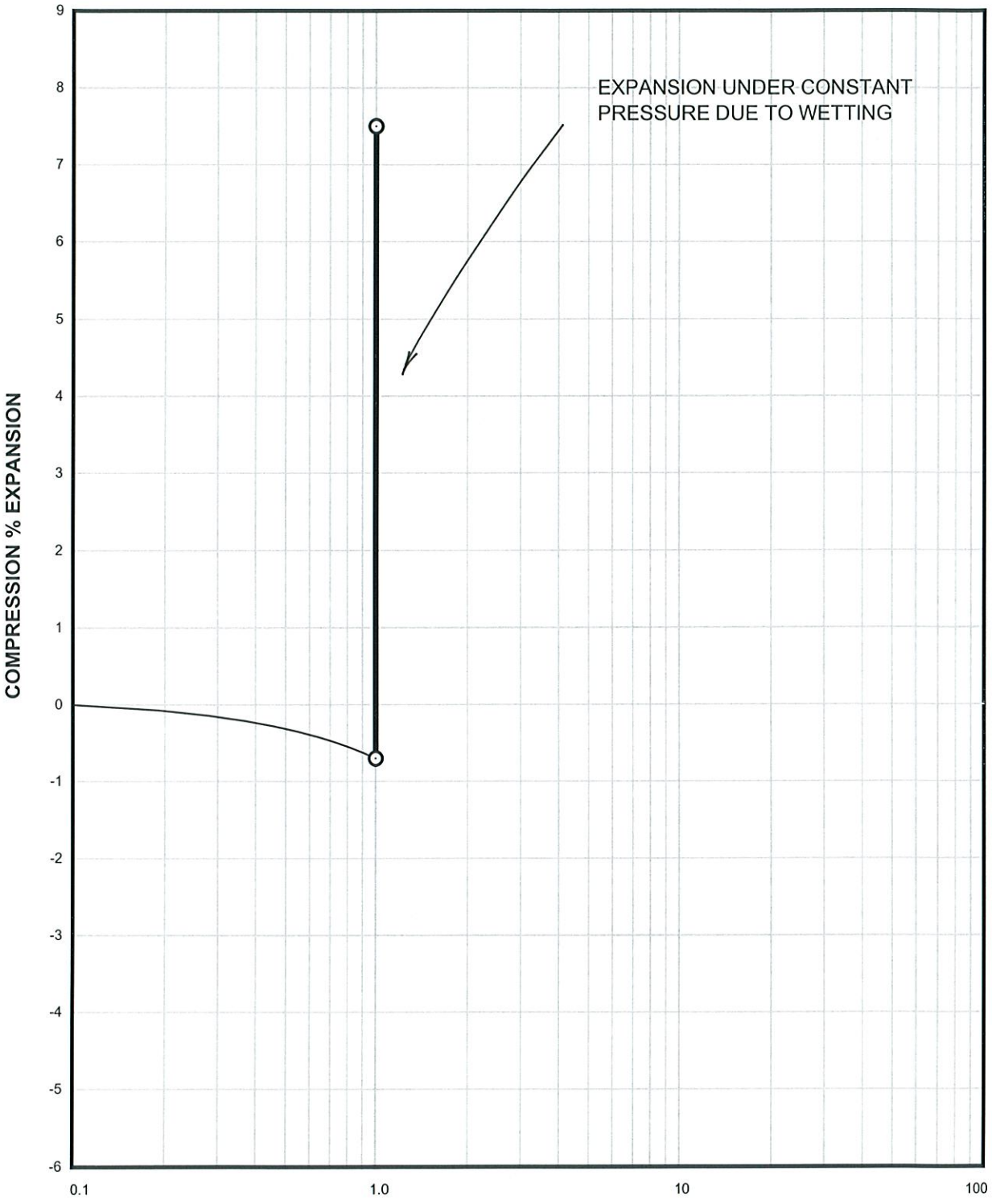
Sample of CLAYSTONE
From TH-11 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 16.5 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-24



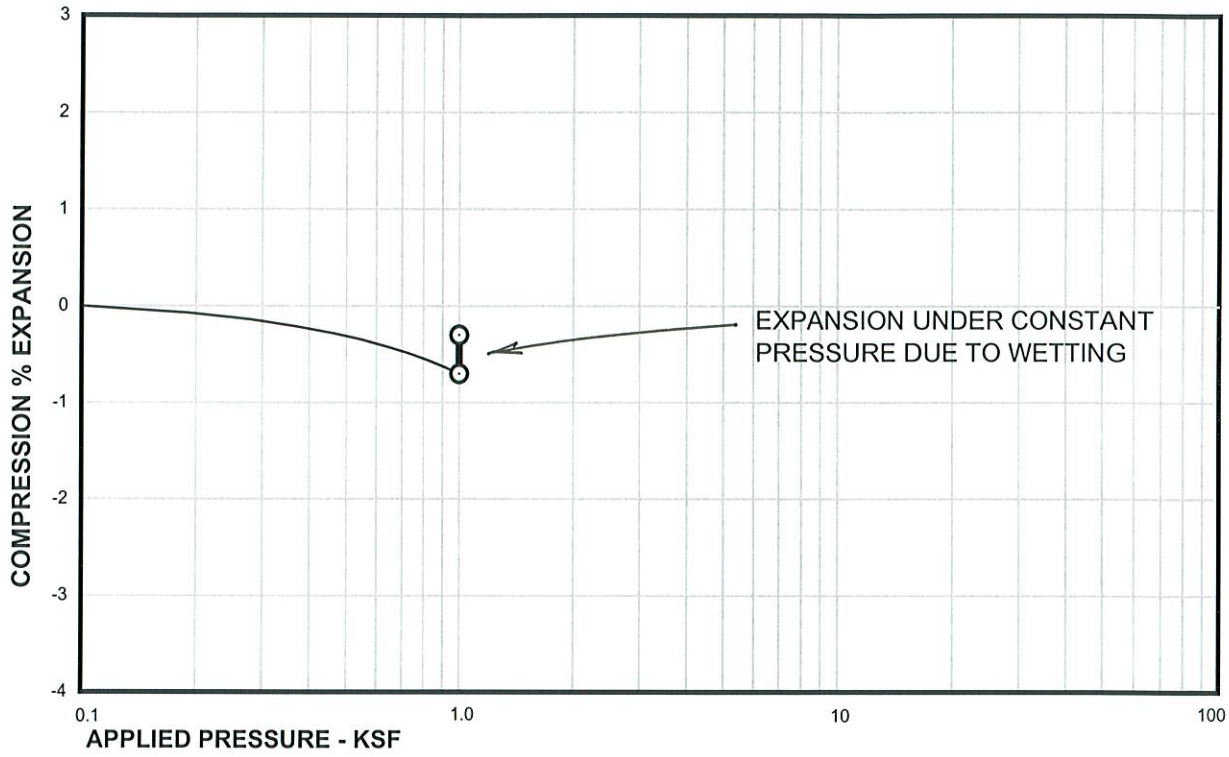
Sample of CLAYSTONE
From TH-11 AT 24 FEET

SAMPLE DRY UNIT WEIGHT= 109 PCF
SAMPLE MOISTURE CONTENT= 19.9 %

Swell Consolidation Test Results

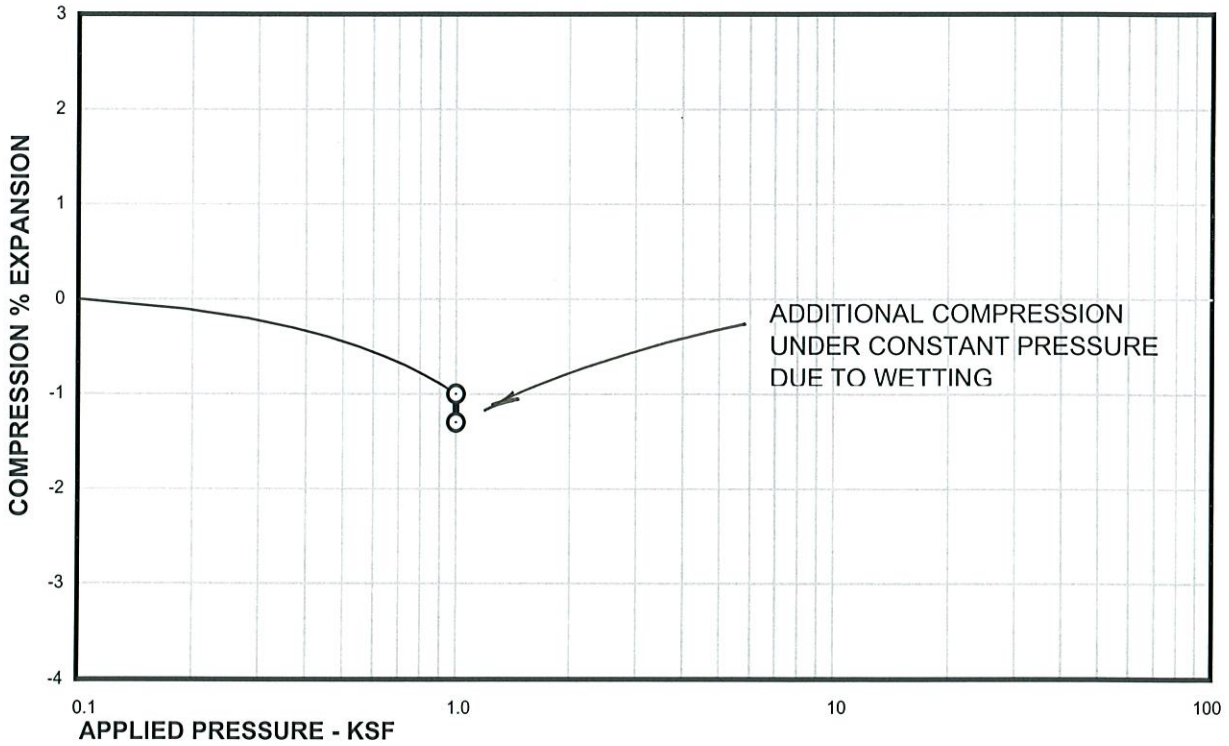
FIG. C-25

PROJECT NO. DN40,507-115



Sample of CLAY, SANDY (CL)
From TH-12 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 109 PCF
SAMPLE MOISTURE CONTENT= 15.2 %

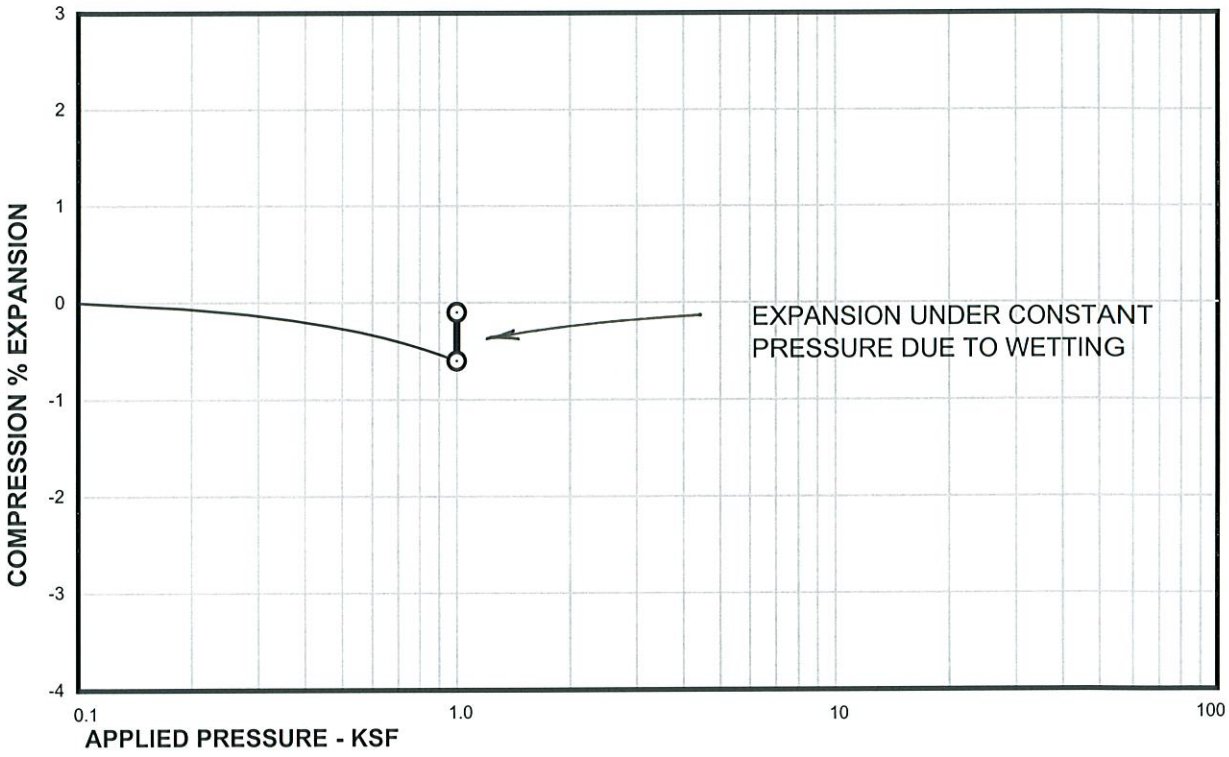


Sample of CLAY, SANDY (CL)
From TH-12 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 103 PCF
SAMPLE MOISTURE CONTENT= 13.8 %

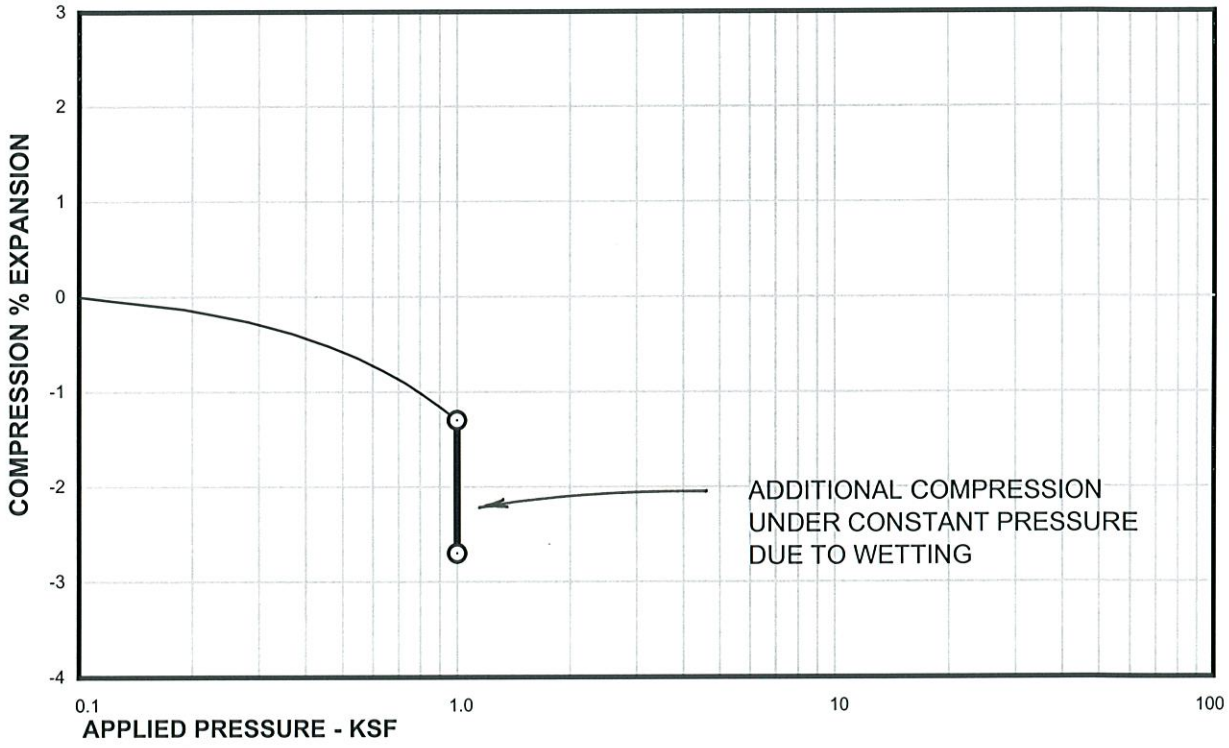
PROJECT NO. DN40,507-115

Swell Consolidation Test Results FIG. C-26



Sample of CLAY, SANDY (CL)
From TH-13 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 95 PCF
SAMPLE MOISTURE CONTENT= 15.6 %



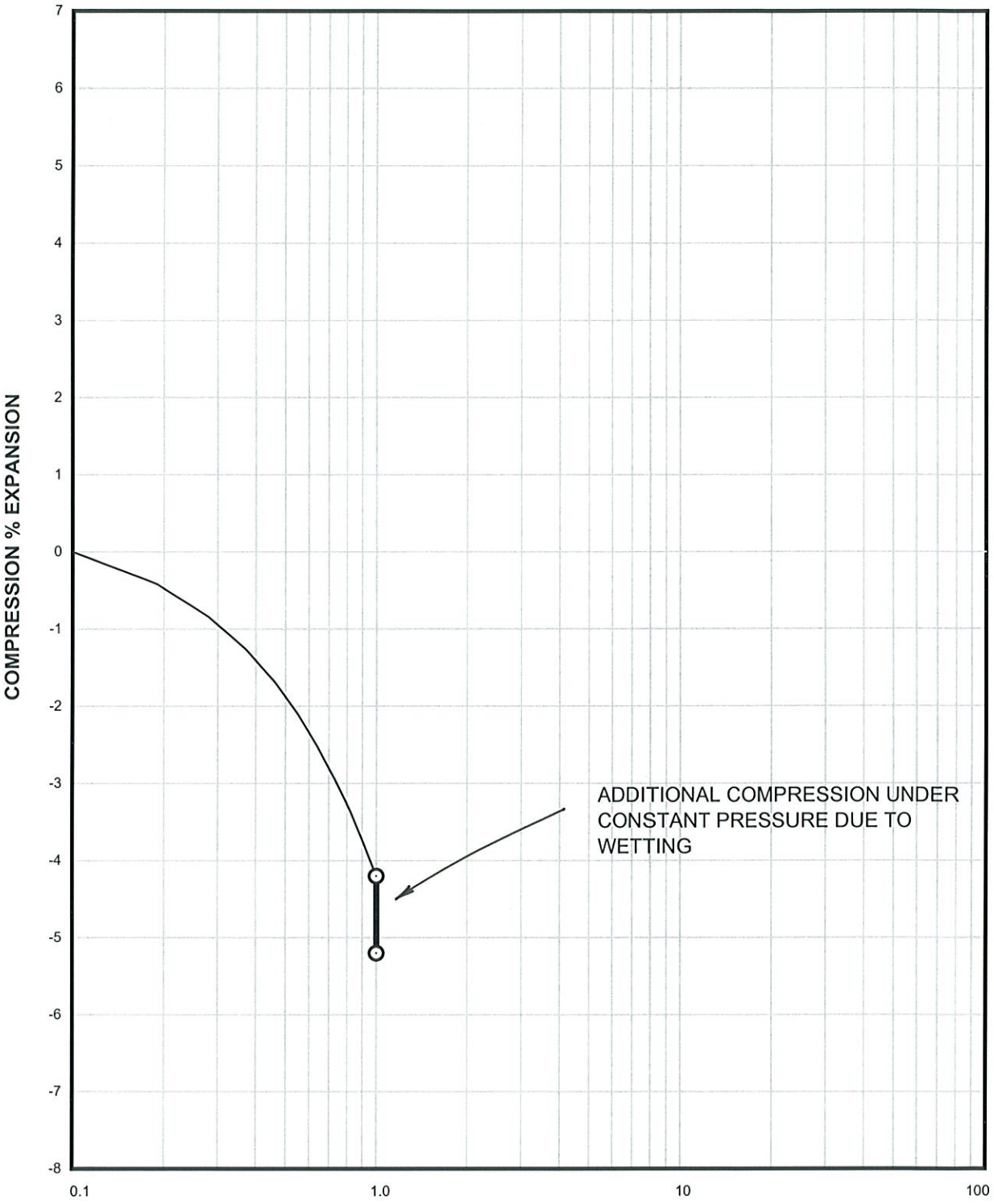
Sample of SANDSTONE
From TH-13 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 100 PCF
SAMPLE MOISTURE CONTENT= 11.6 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-27



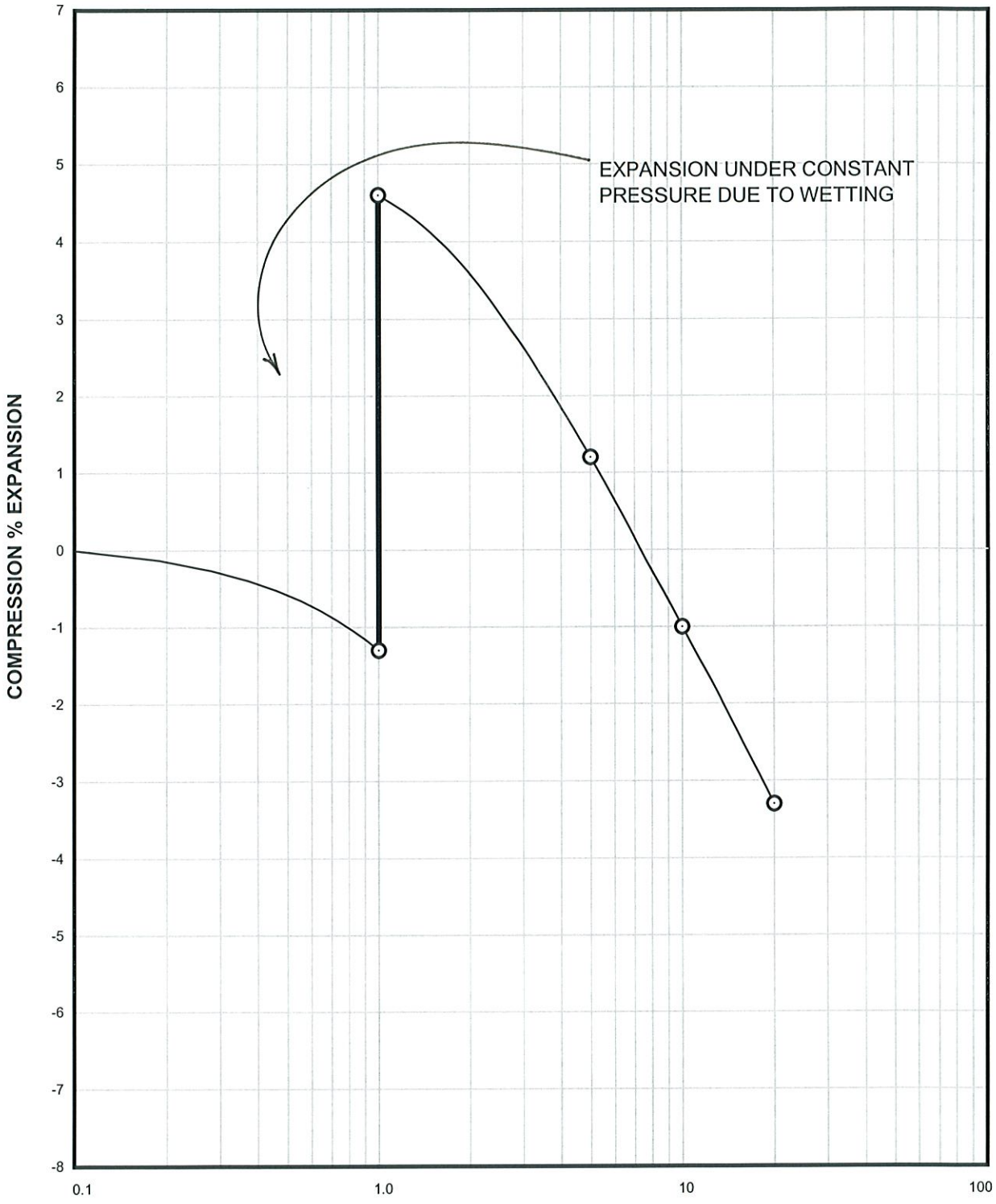
Sample of CLAY, SANDY (CL)
From TH-14 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 14.3 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-28



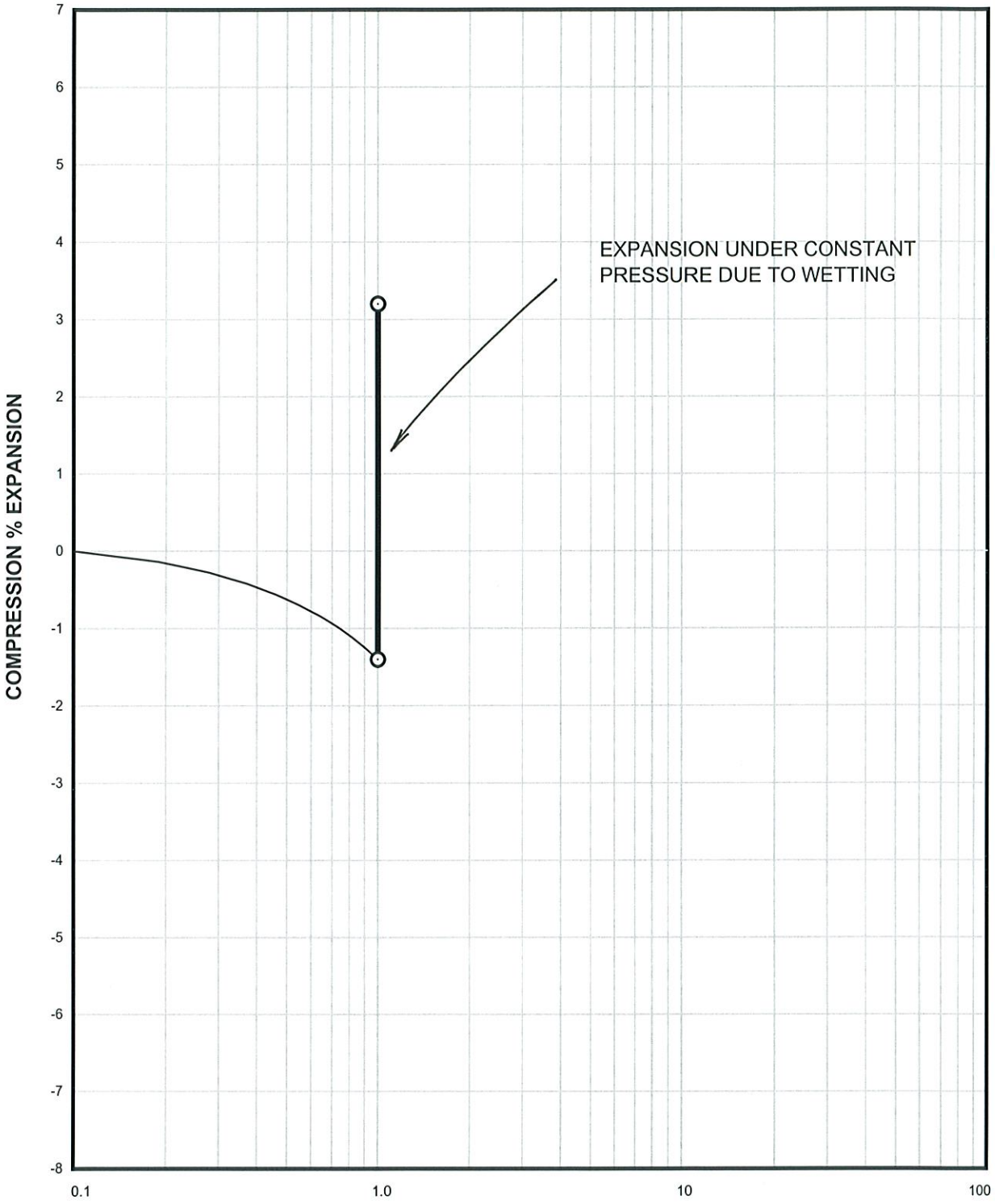
Sample of CLAYSTONE
From TH-14 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 14.2 %

Swell Consolidation Test Results

FIG. C-29

PROJECT NO. DN40,507-115



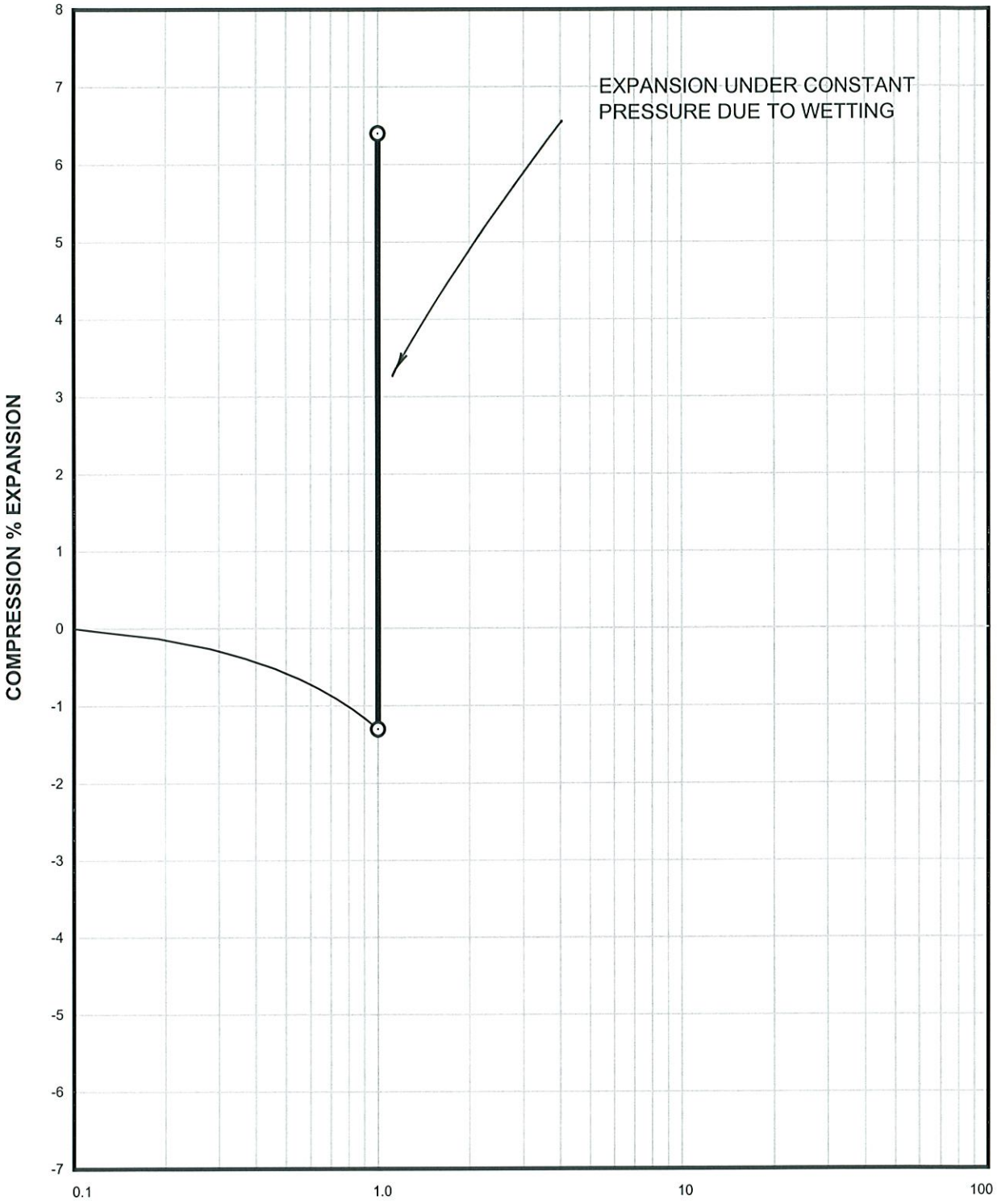
Sample of CLAYSTONE
From TH-15 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 119 PCF
SAMPLE MOISTURE CONTENT= 15.2 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-30



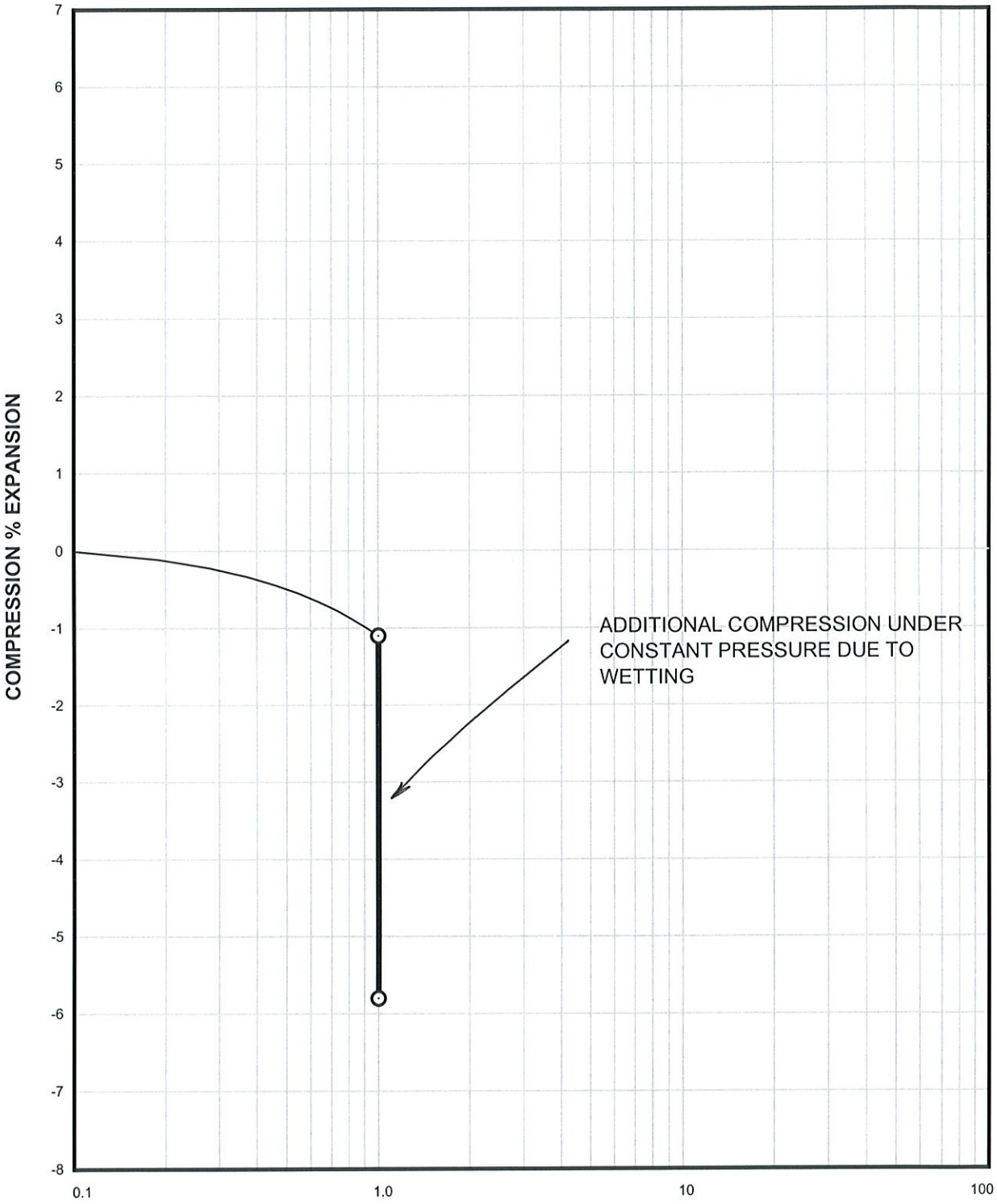
Sample of CLAYSTONE
From TH-15 AT 24 FEET

SAMPLE DRY UNIT WEIGHT= 108 PCF
SAMPLE MOISTURE CONTENT= 18.2 %

Swell Consolidation Test Results

FIG. C-31

PROJECT NO. DN40,507-115

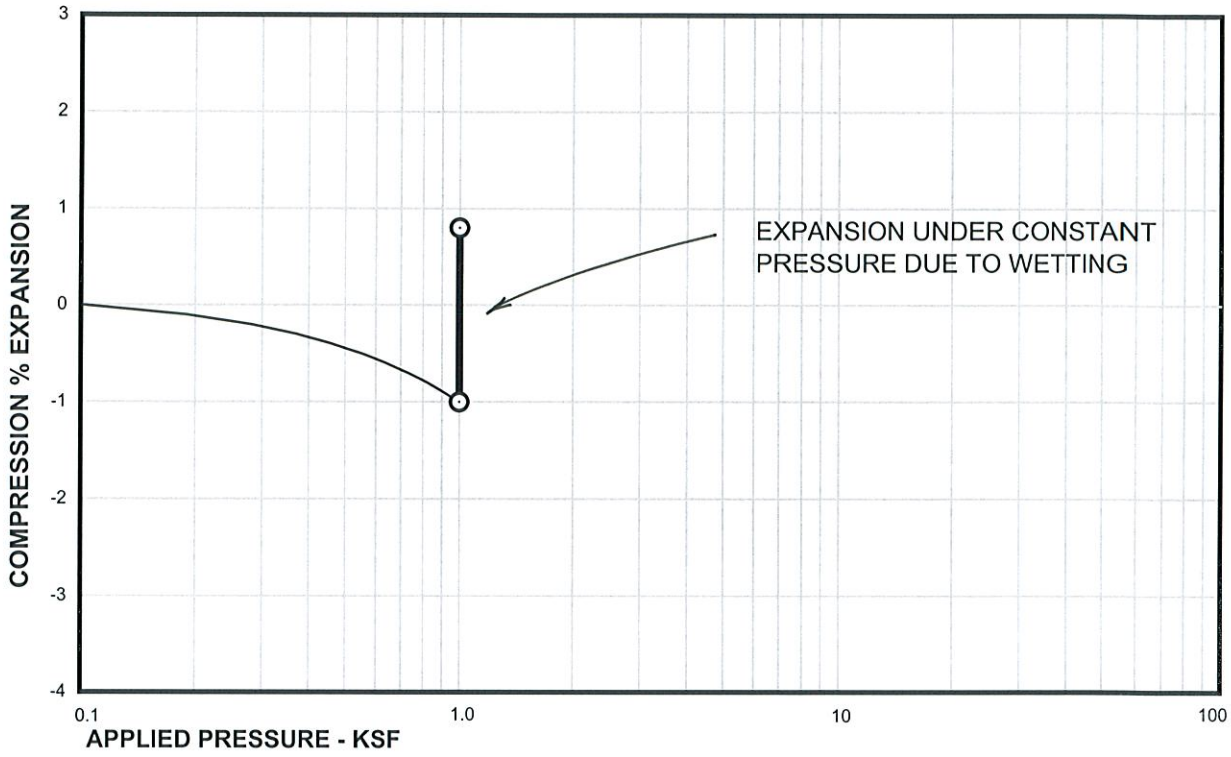


Sample of CLAY, SANDY (CL)
From TH-16 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 89 PCF
SAMPLE MOISTURE CONTENT= 7.4 %

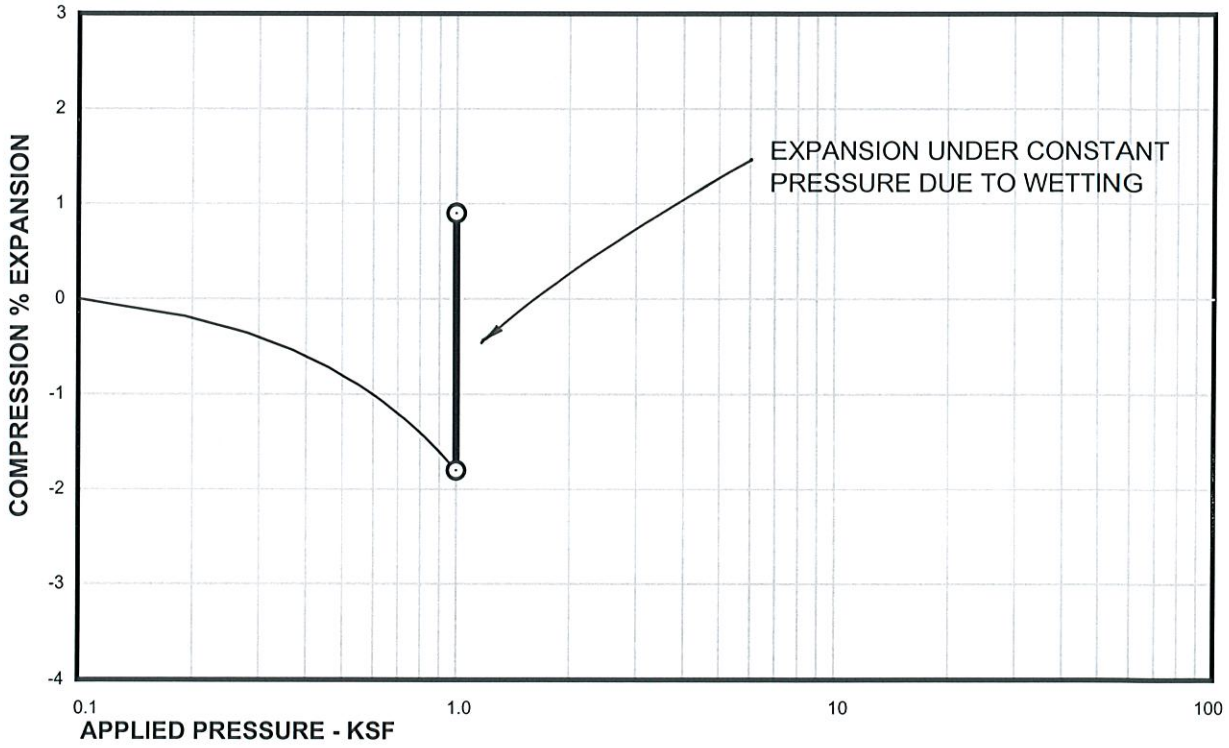
PROJECT NO. DN40,507-115

Swell Consolidation Test Results FIG. C-32



Sample of CLAYSTONE
From TH-16 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 109 PCF
SAMPLE MOISTURE CONTENT= 10.1 %



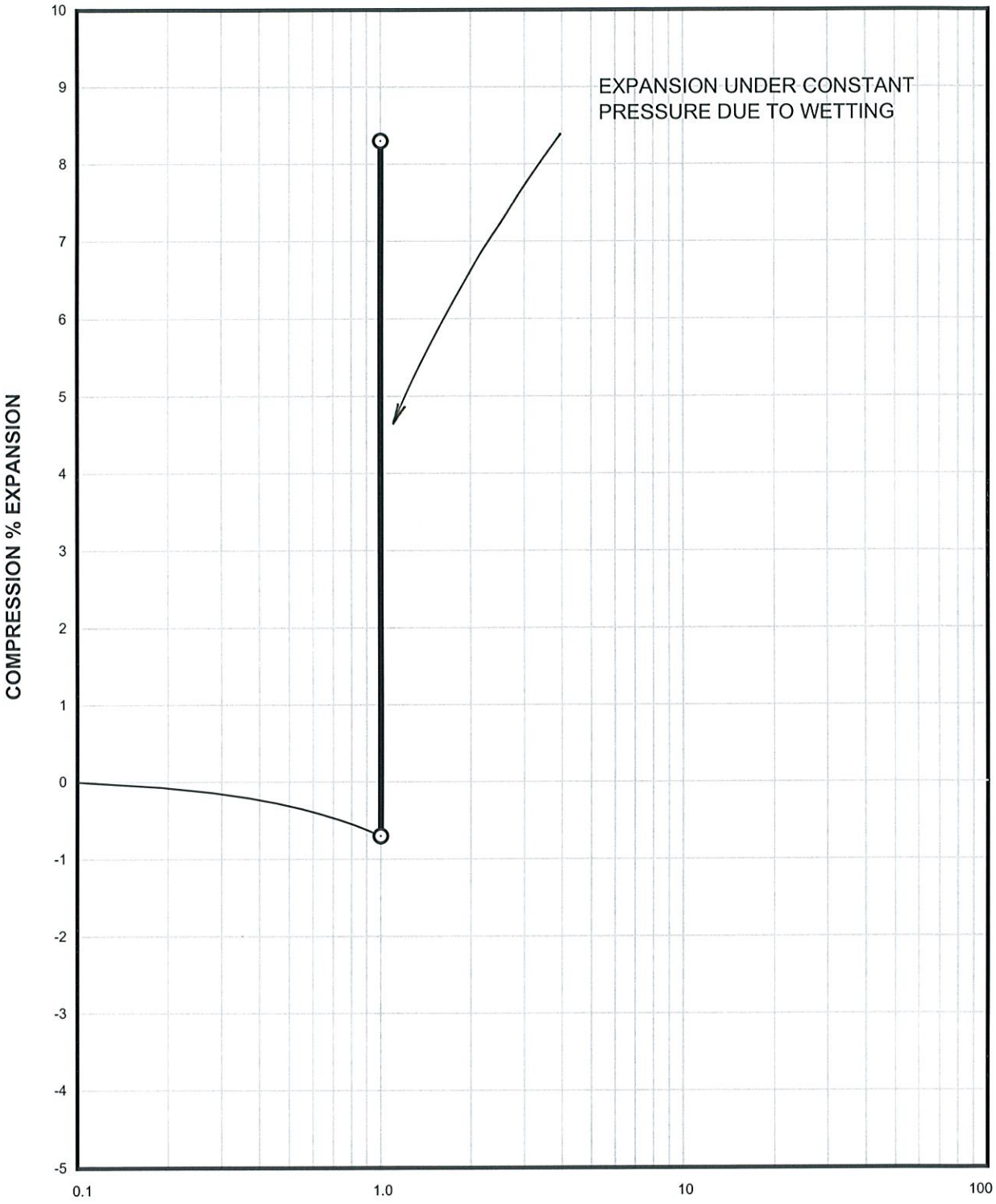
Sample of CLAY, SANDY (CL)
From TH-17 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 114 PCF
SAMPLE MOISTURE CONTENT= 11.4 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-33

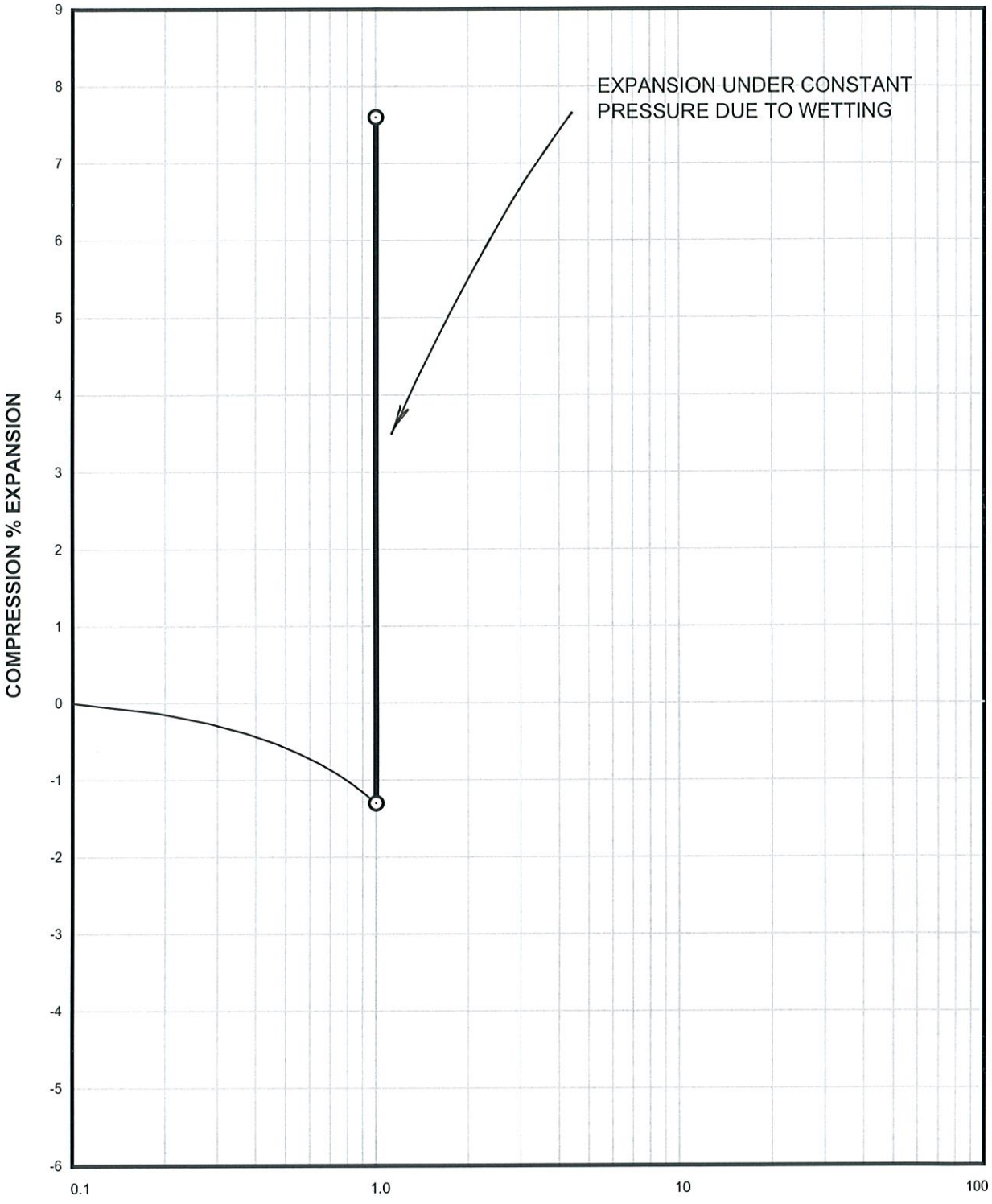


Sample of CLAYSTONE
From TH-17 AT 19 FEET

SAMPLE DRY UNIT WEIGHT= 126 PCF
SAMPLE MOISTURE CONTENT= 9.1 %

Swell Consolidation Test Results FIG. C-34

PROJECT NO. DN40,507-115



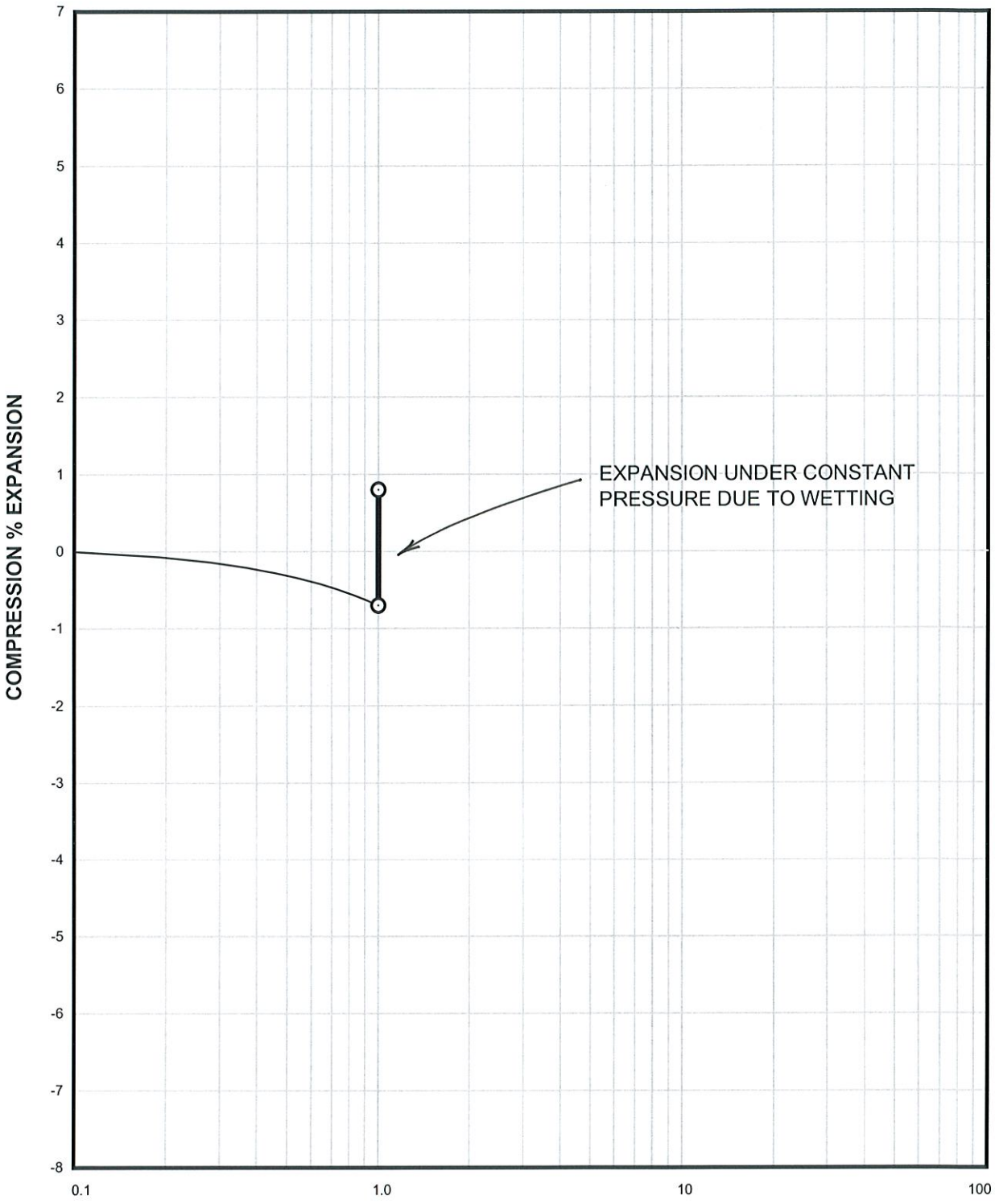
Sample of CLAYSTONE
From TH-17 AT 34 FEET

SAMPLE DRY UNIT WEIGHT= 127 PCF
SAMPLE MOISTURE CONTENT= 11.0 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-35



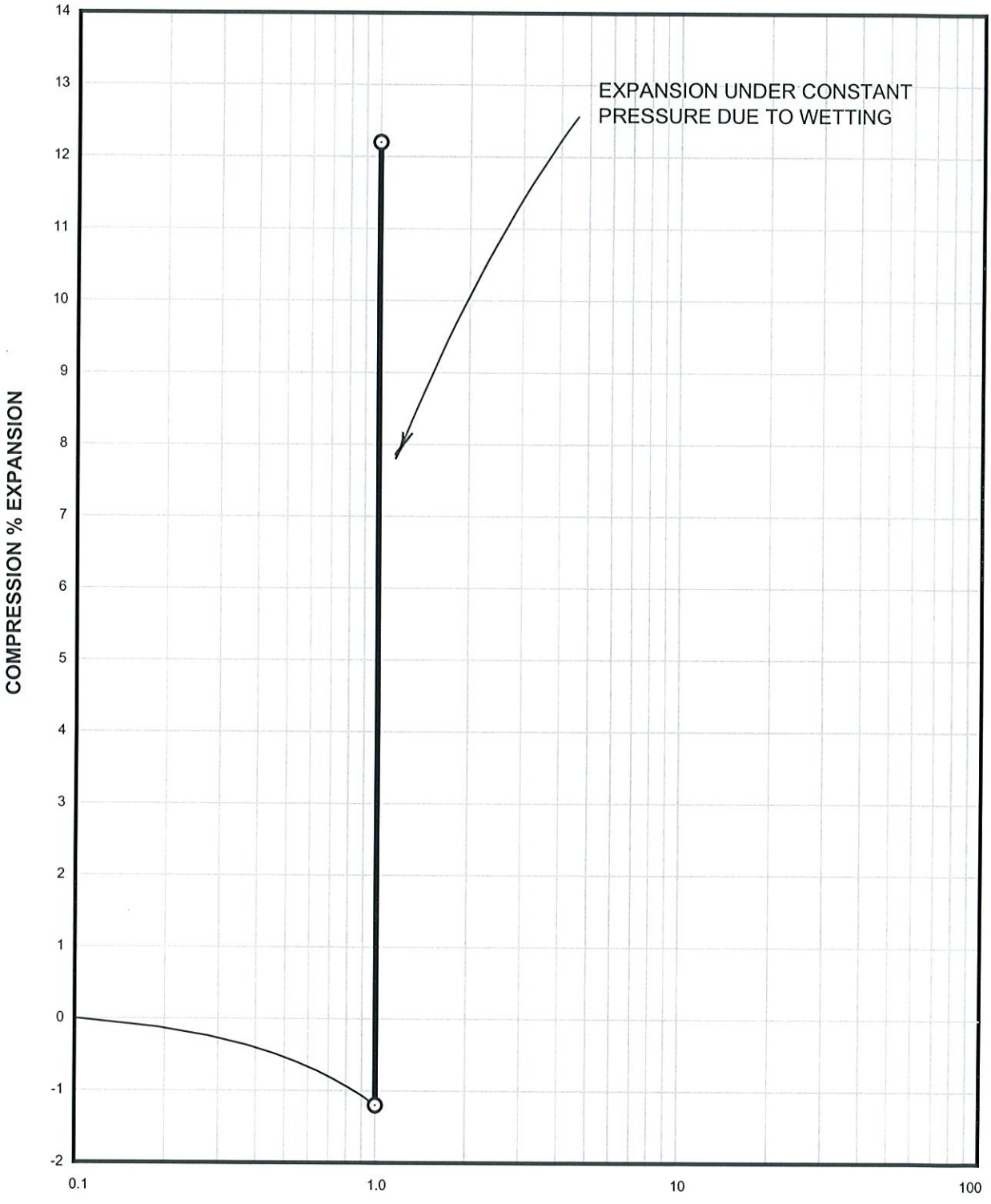
Sample of CLAY, SANDY (CL)
From TH-18 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 112 PCF
SAMPLE MOISTURE CONTENT= 15.2 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-36



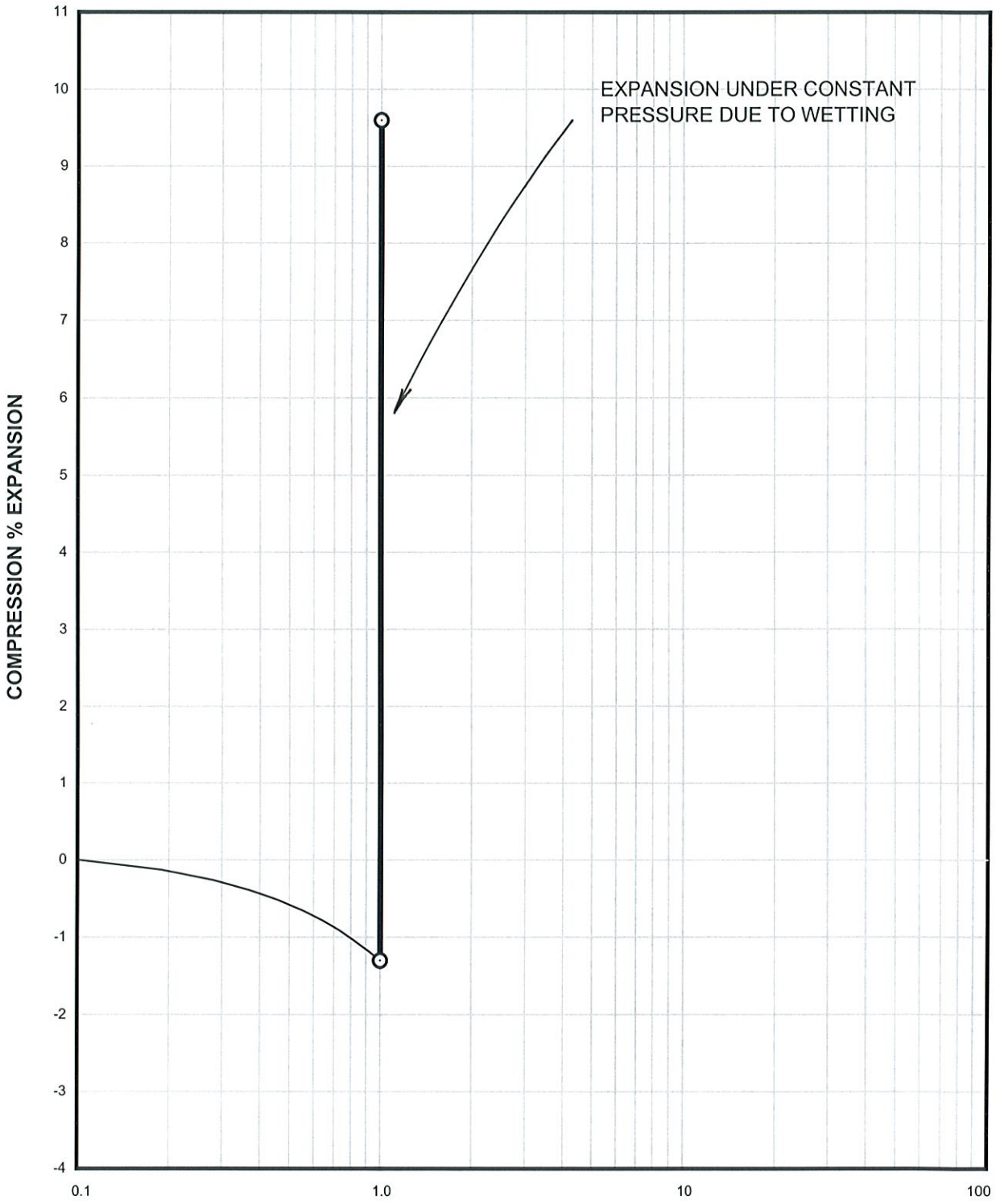
Sample of CLAYSTONE
From TH-18 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 106 PCF
SAMPLE MOISTURE CONTENT= 21.2 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-37



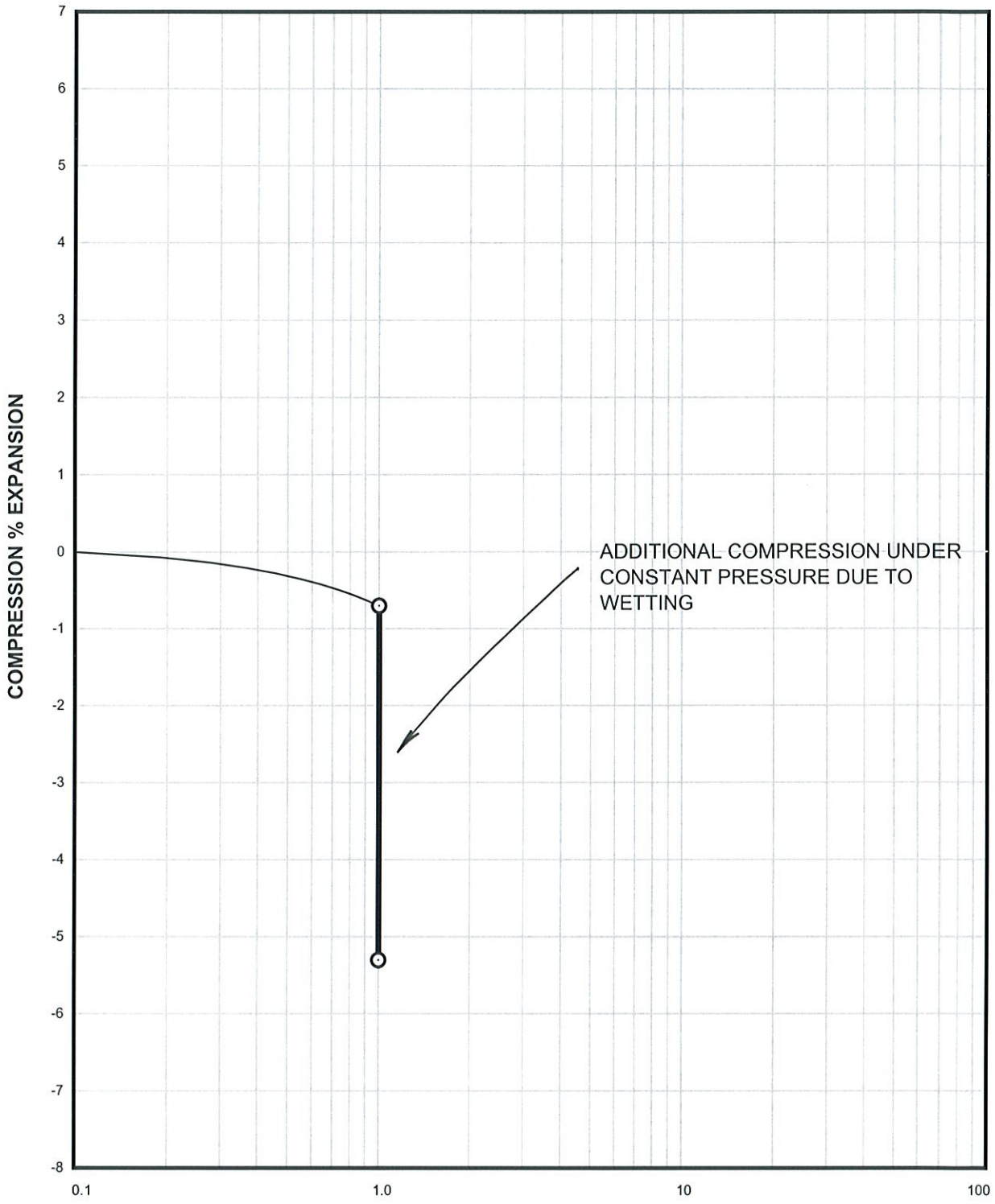
Sample of CLAYSTONE
From TH-18 AT 24 FEET

SAMPLE DRY UNIT WEIGHT= 122 PCF
SAMPLE MOISTURE CONTENT= 12.7 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-38



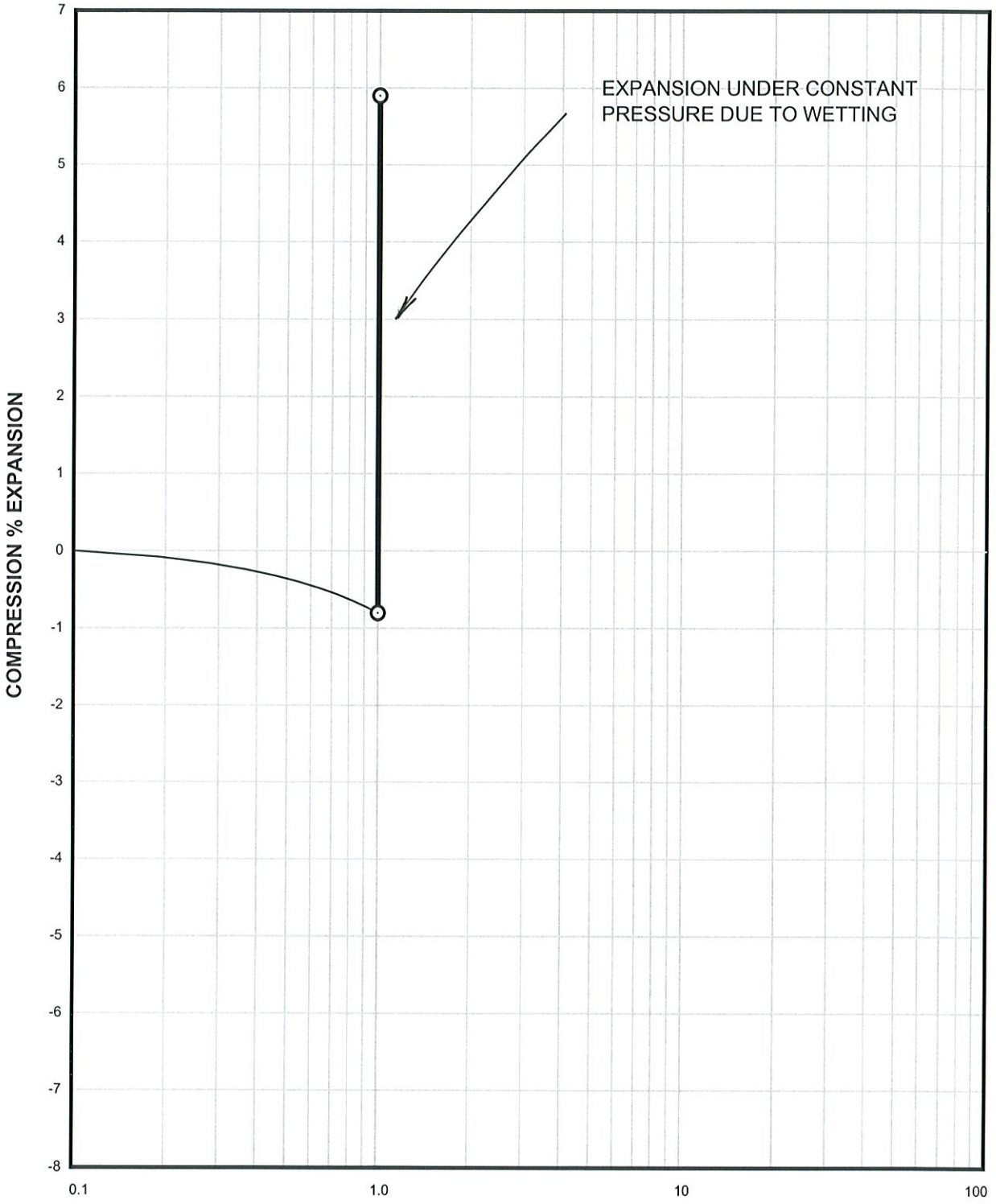
Sample of CLAY, SANDY (CL)
From TH-19 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 97 PCF
SAMPLE MOISTURE CONTENT= 5.2 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-39



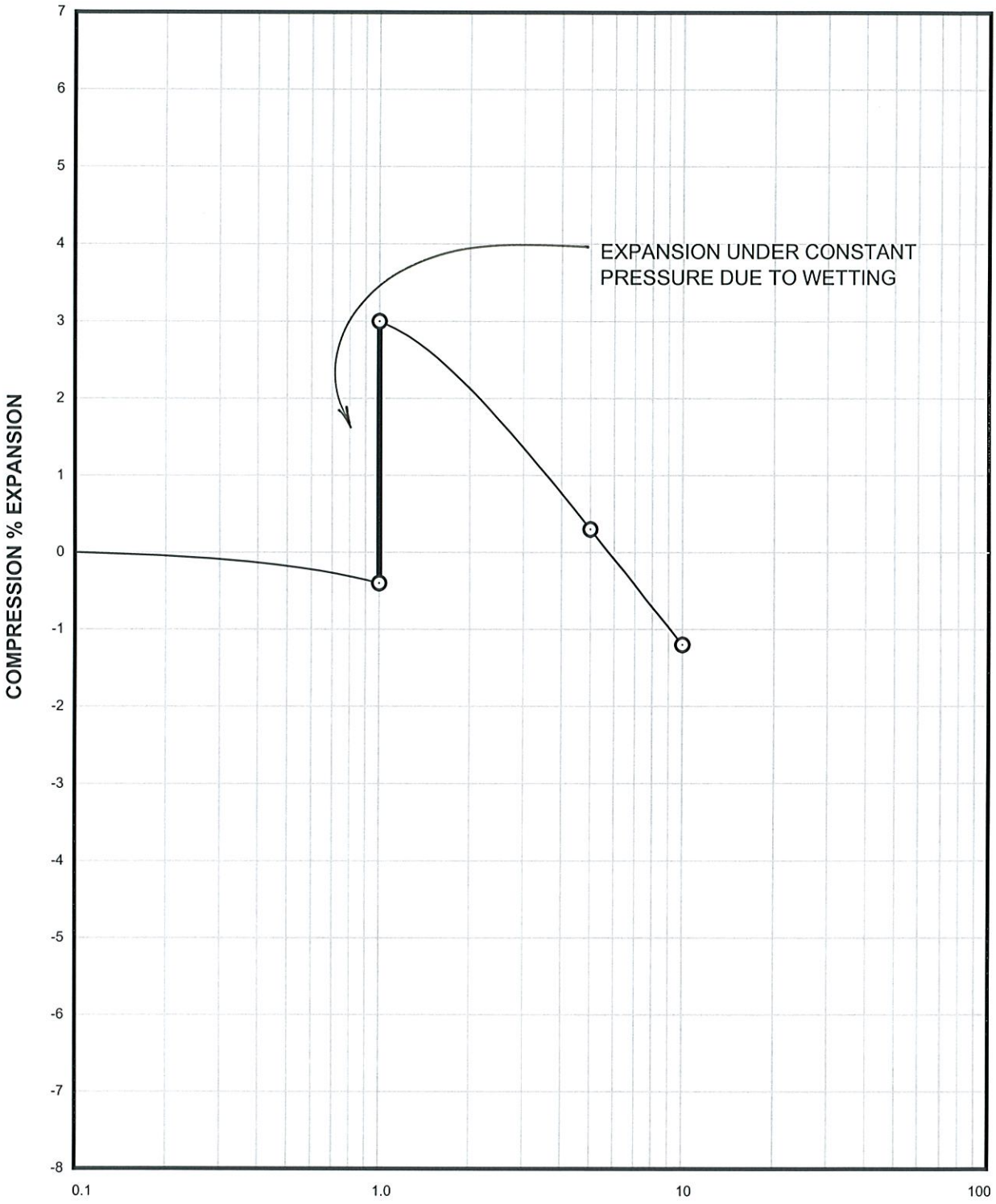
Sample of CLAY, SANDY (CL)
From TH-19 AT 9 FEET

SAMPLE DRY UNIT WEIGHT= 122 PCF
SAMPLE MOISTURE CONTENT= 12.5 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-40



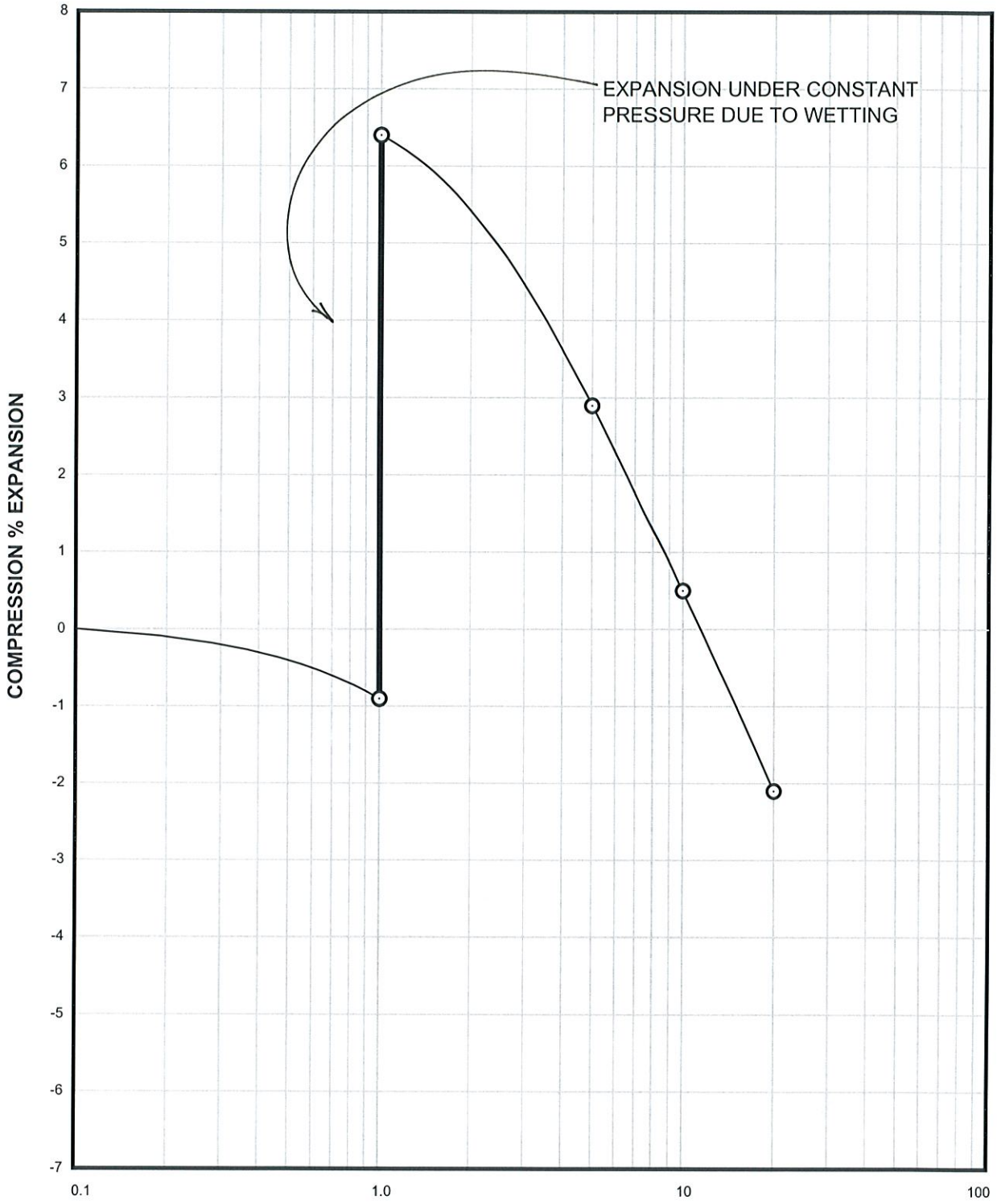
Sample of CLAY, SANDY (CL)
From TH-20 AT 4 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 14.5 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-41



Sample of CLAYSTONE
From TH-20 AT 14 FEET

SAMPLE DRY UNIT WEIGHT= 110 PCF
SAMPLE MOISTURE CONTENT= 21.0 %

Swell Consolidation Test Results

PROJECT NO. DN40,507-115

FIG. C-42

TABLE C - I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	SWELL TEST DATA			SOIL SUCTION VALUE (pF)	ATTERBERG LIMITS		SOLUBLE SULFATE CONTENT (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
				SWELL (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TH-1	9	14.0	116	4.0	1,000							CLAYSTONE
TH-1	14	16.0	115							0.5		CLAYSTONE
TH-1	19	22.0	105	9.9	1,000	35,000						CLAYSTONE
TH-1	34	11.9	127	7.2	1,000	40,000						CLAYSTONE
TH-2	4	10.9	109	1.1	1,000							CLAY, SANDY (CL)
TH-3	4	5.6	104	-0.4	1,000							WEATHERED CLAYSTONE
TH-3	14	6.5	105								32	SANDSTONE
TH-4	4	12.4	103	0.2	1,000							CLAY, SANDY (CL)
TH-4	9	6.2										SANDSTONE
TH-5	9	22.5	99	5.8	1,100	7,000	4.16					WEATHERED CLAYSTONE
TH-5	14	27.9	96	6.3	1,800	14,000	4.25					CLAYSTONE
TH-5	19	14.9	114	9.6	2,400	27,000	4.56					CLAYSTONE
TH-5	24	12.3	119	0.4	3,000	4,500	4.55					CLAYSTONE
TH-6	9	12.5	114	6.2	1,000							WEATHERED CLAYSTONE
TH-6	14	10.4	113	1.7	1,000							CLAYSTONE
TH-6	19	10.9	132	1.8	1,000							CLAYSTONE
TH-6	24	18.5	109					73	54		100	CLAYSTONE
TH-7	9	6.7	106							0.08		SAND, CLAYEY (SC)
TH-7	14	8.3	116	-0.1	1,000							WEATHERED CLAYSTONE
TH-7	29	15.0	118	8.5	1,000	20,000						CLAYSTONE
TH-8	9	16.7	114	4.7	1,000	10,500						CLAYSTONE
TH-8	14	11.8	127	4.0	1,000	20,000						CLAYSTONE
TH-9	4	7.0	110	-0.4	1,000							SAND, CLAYEY (SC)
TH-9	14	18.4	109	8.0	1,000							CLAYSTONE
TH-9	24	9.3	131	7.0	1,000							CLAYSTONE
TH-10	4	10.2	126	6.8	500	10,000	4.58					CLAY, SANDY (CL)
TH-10	9	11.7	127	7.7	1,100	26,000	4.65					CLAYSTONE/SANDSTONE
TH-10	14	9.5	132	5.6	1,800	20,000	4.53					CLAYSTONE
TH-10	19	15.6	117	5.5	2,400	30,000	4.47					CLAYSTONE
TH-10	29	13.3	118	4.1	3,600	17,000	4.50					CLAYSTONE
TH-11	9	5.4	108							0.012		SAND, CLAYEY (SC)
TH-11	19	16.5	115	14.7	1,000							CLAYSTONE
TH-11	24	19.9	109	8.2	1,000							CLAYSTONE
TH-12	9	15.2	109	0.4	1,000							CLAY, SANDY (CL)
TH-12	14	13.8	103	-0.3	1,000							CLAY, SANDY (CL)
TH-13	4	15.6	95	0.5	1,000							CLAY, SANDY (CL)
TH-13	19	11.6	100	-1.4	1,000							SANDSTONE
TH-14	9	14.3	115	-1.0	1,000							CLAY, SANDY (CL)
TH-14	14	14.2	115	5.9	1,000	11,000						CLAYSTONE
TH-14	29	13.3	121					65	49		99	CLAYSTONE
TH-15	4	7.3	110					34	21		83	CLAY, SANDY (CL)

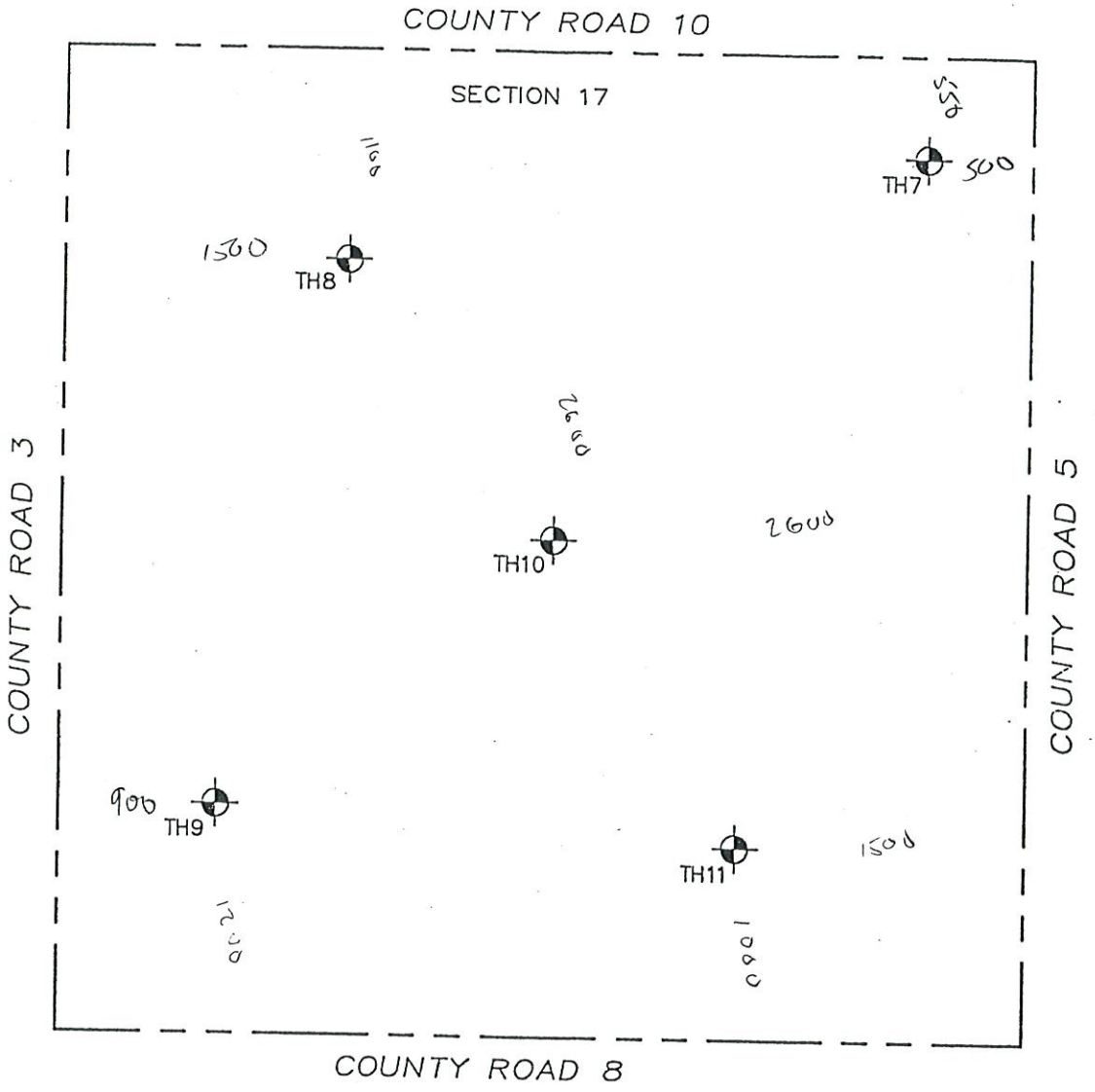
TABLE C - I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	SWELL TEST DATA			SOIL SUCTION VALUE (pF)	ATTERBERG LIMITS		SOLUBLE SULFATE CONTENT (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
				SWELL (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TH-15	14	15.2	119	4.6	1,000							CLAYSTONE
TH-15	24	18.2	108	7.7	1,000							CLAYSTONE
TH-16	4	7.4	89	-4.7	1,000							CLAY, SANDY (CL)
TH-16	14	10.1	109	1.8	1,000							CLAYSTONE
TH-17	9	11.4	114	2.7	1,000							CLAY, SANDY (CL)
TH-17	19	9.1	126	9.0	1,000							CLAYSTONE
TH-17	34	11.0	127	8.9	1,000							CLAYSTONE
TH-18	4	15.2	112	1.5	1,000							CLAY, SANDY (CL)
TH-18	14	21.2	106	13.4	1,000							CLAYSTONE
TH-18	24	12.7	122	10.9	1,000							CLAYSTONE
TH-19	4	5.2	97	-4.6	1,000			27	11		63	CLAY, SANDY (CL)
TH-19	9	12.5	122	6.7	1,000							CLAY, SANDY (CL)
TH-19	24	3.8	99								30	SANDSTONE
TH-20	4	14.5	115	3.4	1,000							CLAY, SANDY (CL)
TH-20	14	21.0	110	7.3	1,000	15,000						CLAYSTONE

APPENDIX D

DATA FROM SCOTT, COX & ASSOCIATES, INC. REPORT (November 5, 1998)



Scale: 1" = 1000'

0 250 500 1000

LEGEND

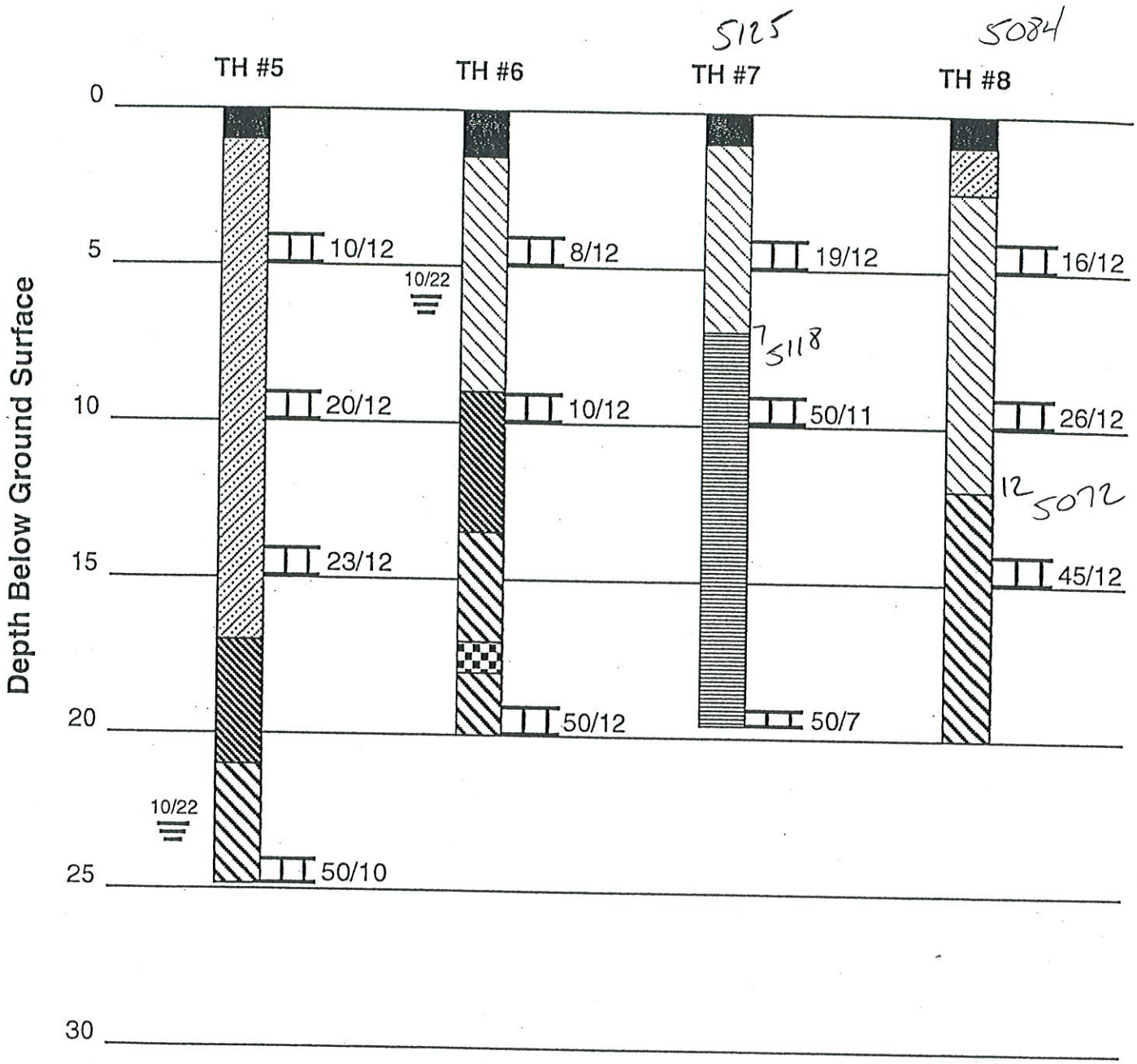
SOILS INVESTIGATION BORING LOCATION

BORING LOCATION MAP
FIGURE 1C

SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444 – 3051

11/5/98 JOB NO. 98697 DRAWING NO. 98697

Graphic Boring Logs



SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444-3051

Project 98697

Graphic Boring Logs

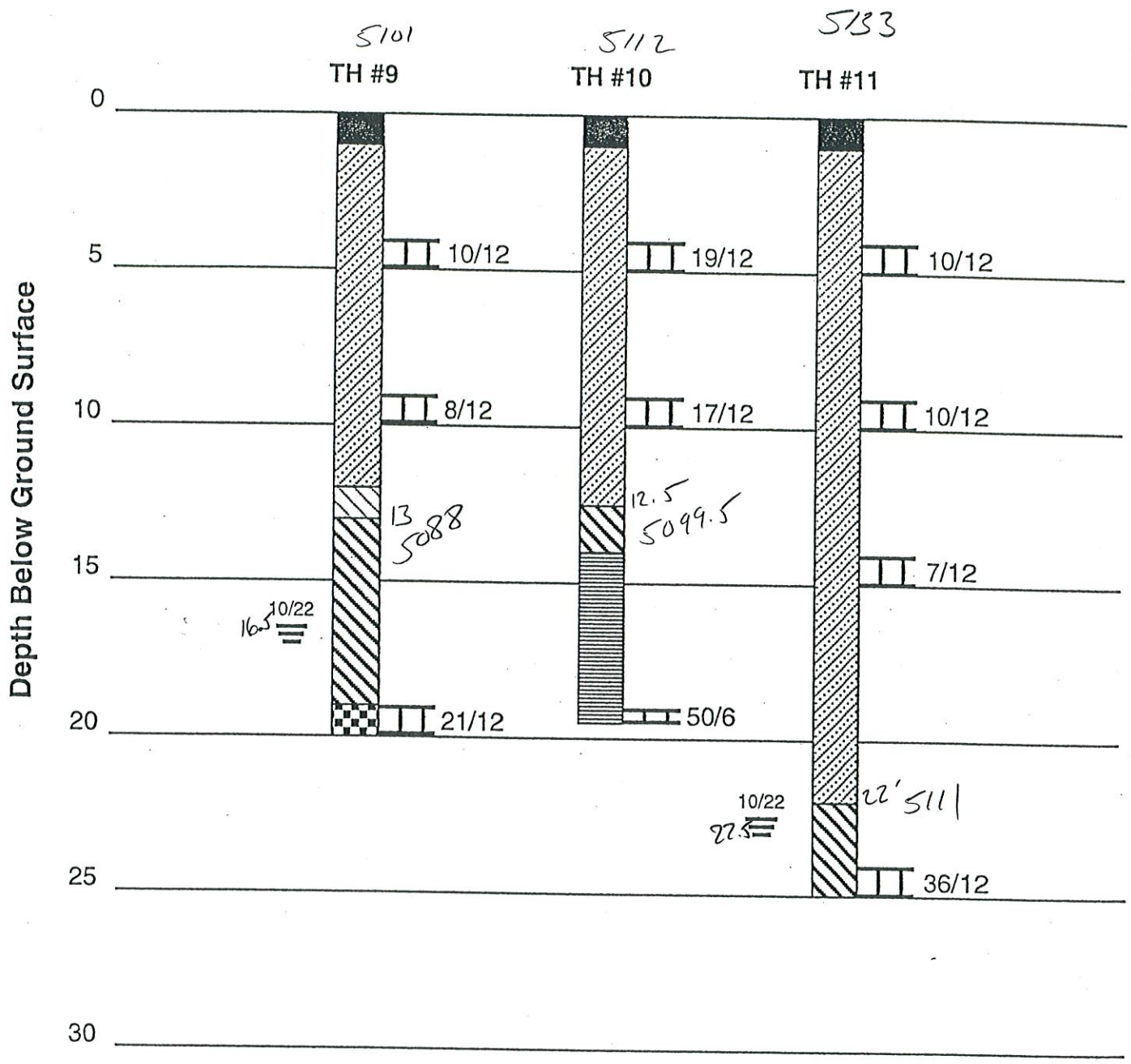


Figure 2
Page 3

SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444-3051

Project 98697

Description of Soil Types

Topsoil - Dark brown, silty, sandy to very sandy clay - Contains organics

Light brown to brown, slightly calcarious, silty, slightly sandy to sandy clay - Contains some scattered gravel

Light brown, porous, silty, very sandy clay - Contais some sand lenses

Gray to yellow brown, rust, silty, sandy, weathered claystone - Contains some sulfate crystals and lignite inclusions

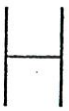
Yellow brown to gray, rust, silty to sandy claystone - Contains some thin ironstone layers and lignite inclusions

Black, carbonaceous shale or lignite

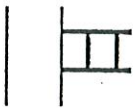
Yellow brown to gray, rust, silty, interbedded sandstone/claystone

Yellow brown, siltstone/sandstone

TH #1 — Soils investigation boring number



Indicates a change in soil type - May be gradual.



12/12 indicates that 12 blows of a 140-pound hammer falling 30 inches were required to drive a 2-inch, inside diameter sampler 12 inches.

Indicates the groundwater table and the date that the measurement was taken

Notes

1. Borings were performed October 19, 1998 with four-inch diameter, continuous flight power augers.

2. Boring logs shown in this report are subject to the limitations, explanations and conclusions of the report.

SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444-3051

Table 1
Summary of Soils Properties
Page 2/2
Project
98697

PROPERTIES AT NATURAL MOISTURE CONTENT			CONSOLIDATION/SWELL				DESCRIPTION
Natural Moisture (%)	Natural Dry Density (PCF)	Unconfined Compression (PSF)	Loading (PSF)	Settlement (Dry) (%)	Settlement (Saturated) (%)	Swell (%)	
TH # 7 @ 9							
9.7	103.1	>9000	100	0.10		0.60	Yellow brown to gray, interbedded sandstone/claystone
			1000		0.50		
			2000		1.10		
0.7 % Swell upon the addition of water							
TH # 8 @ 9							
10.9	104.5	9000	100	0.20		3.40	Brown, silty, sandy clay
			1000			1.80	
			2000		0.70		
3.6 % Swell upon the addition of water							
TH # 9 @ 4							
6.3	92.3	4000	100	0.00	2.00		Light brown, silty, very sandy clay to clayey sand
			1000		5.10		
			2000		7.70		
2.0 % Consolidation upon the addition of water							
TH # 9 @ 19							
23.0	104.8	>9000	100	0.70		6.30	Dark gray, claystone with lignite
			1000			4.10	
			2000			2.60	
			8000		0.30		
7.0 % Swell upon the addition of water							
TH # 10 @ 4							
9.5	92.7	>9000	100	0.10		2.10	Light brown, silty, very sandy clay
			1000		2.80		
			2000		6.40		
2.2 % Swell upon the addition of water							
TH # 11 @ 9							
17.9	96.8	9000	100	0.20		1.40	Light brown, silty, very sandy clay
			1000			0.60	
			2000		0.90		
1.6 % Swell upon the addition of water							
TH # 11 @ 14							
15.6	109.1	9000	100	0.20		0.60	Light brown, silty, very sandy clay to clayey sand
			1000			0.00	
			2000		0.70		
0.8 % Swell upon the addition of water							
TH # 11 @ 24							
18.8	105.4	>9000	100	0.50		12.10	Gray, silty claystone
			1000			8.90	
			2000			5.80	
			8000		0.30		
12.6 % Swell upon the addition of water							

LSC TRANSPORTATION CONSULTANTS, INC.

1889 York Street
Denver, CO 80206
(303) 333-1105
FAX (303) 333-1107
E-mail: lsc@lscdenver.com

TRANSPORTATION
CONSULTANTS, INC.

April 17, 2017

Mr. Jon Lee
Community Development Group
2500 Arapahoe Avenue, Suite 220
Boulder, CO 80302

Re: Colliers Hill - Filing No. 2A
Erie, CO
LSC #150951

Dear Mr. Lee:

In response to your request, LSC Transportation Consultants, Inc. has prepared this trip generation compliance letter for the proposed Colliers Hill - Filing No. 2A development.

The trip generation potential for this site was included in the background traffic of the December 19, 2016 *Colliers Hill Phase II Traffic Impact Analysis* by LSC. A traffic study for Filing No. 2A would have similar findings and confirm the existing and proposed roadway network is sufficient to accommodate the impacts of Filing No. 2A.

For this reason, we feel that no additional traffic analyses are necessary and request the traffic study requirement be waived.

* * * * *

We trust our findings will assist you in gaining approval of the proposed Colliers Hill Filing No. 2A development. Please contact me if you have any questions or need further assistance.

Sincerely,

LSC TRANSPORTATION CONSULTANTS, INC.

By_____
Christopher S. McGranahan, PE, PTOE
Principal

COLORADO LICENSED
CHRISTOPHER S. MCGRANAHAN
39018
PROFESSIONAL ENGINEER
4-17-17

CSM/wc

Z:\LSC\Projects\2015\150951-CollidersHill-FilingNo2A\Report\Draft-CollidersHill-Filing2A.wpd

COLLIERS HILL FILING 2A
FINAL DRAINAGE REPORT
ERIE, COLORADO

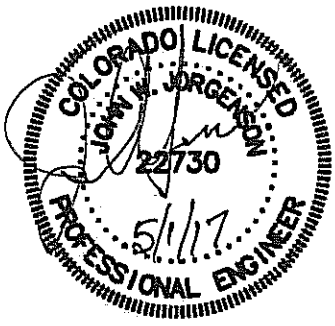
Prepared For:
Community Development Group
2500 Arapahoe Avenue
Suite 220
Boulder, CO 80302

Prepared By:
Hurst & Associates, Inc.
2500 Broadway
Suite B
Boulder, CO 80304

Job No. 2020-42
May 1, 2017

ENGINEER'S CERTIFICATION

I hereby certify that this report for the final drainage for the design of Colliers Hill Filing 2A was prepared by me (or under my direct supervision) in accordance with the provisions of the *Town of Erie Standards and Specifications* for the owners thereof. I understand that the Town of Erie does not and will not assume liability for drainage facilities designed by others, including the designs presented in this report.



John W. Jorgenson, P.E.

Colorado License #22730

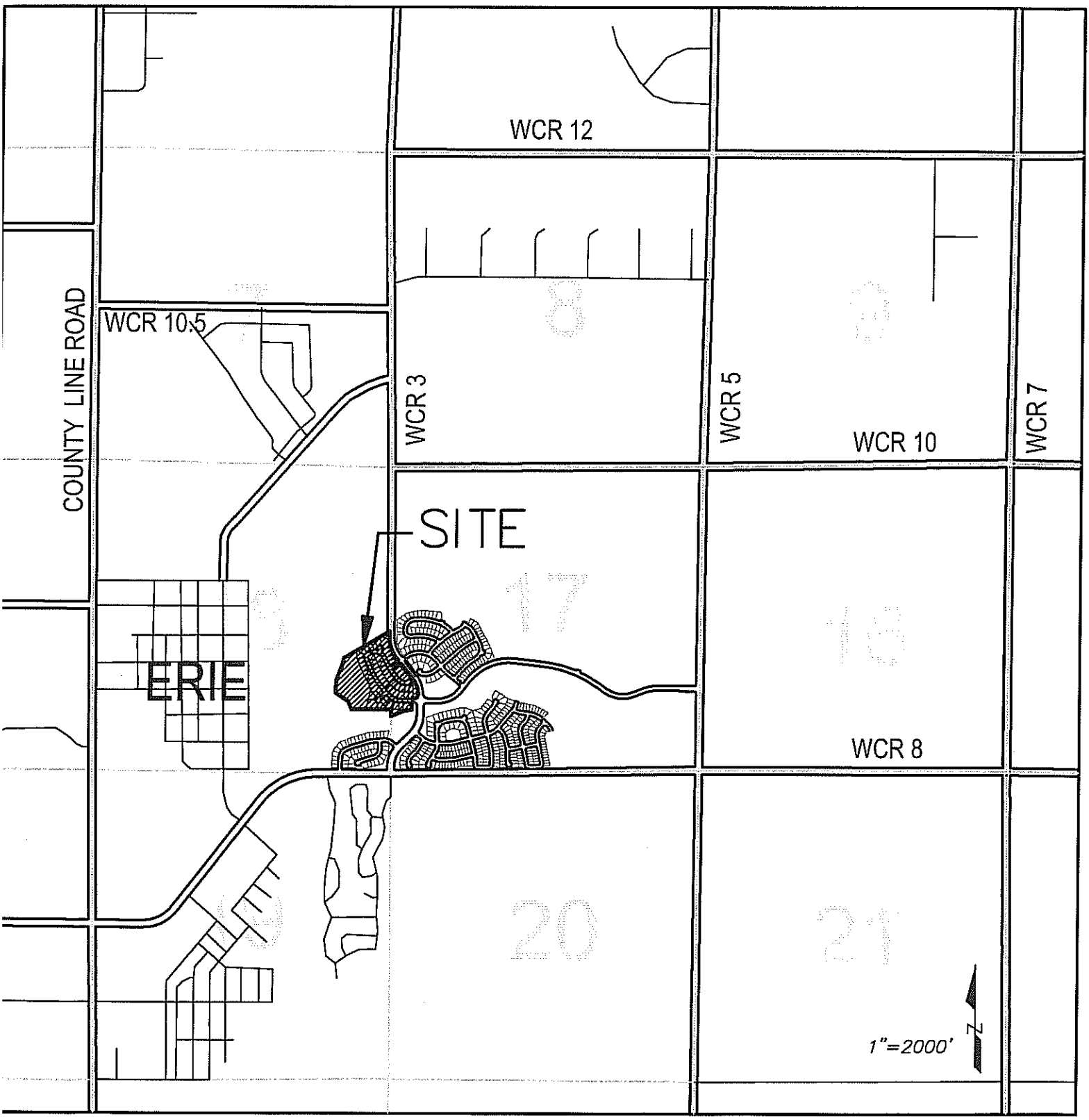
TOWN ACCEPTANCE

This report has been reviewed and found to be in general compliance with the *Town of Erie Standards and Specifications for Design and Construction* and other Town requirements. **THE ACCURACY AND VALIDITY OF THE ENGINEERING DESIGN, DETAILS, DIMENSIONS, QUANTITIES, AND CONCEPTS IN THIS REPORT REMAINS THE SOLE RESPONSIBILITY OF THE PROFESSIONAL ENGINEER WHOSE STAMP AND SIGNATURE APPEAR HEREON**.

Accepted by: _____ _____

Deputy Public Works Director Date

TABLE OF CONTENTS



VICINITY MAP

INTRODUCTION

Colliers Hill (Formerly Daybreak and Bridgewater) is a proposed 940 acre residential community located within Sections 8,17 and 18, Township 1 North, Range 68 West. Sections 8,17 and 18 are contiguous and located just east of Old Town Erie, north of Erie Parkway and west of Weld County Road 5. The area is undeveloped with native vegetation and crop land. Colliers Hill is within the Coal Creek and Boulder Creek Drainage Basins. The proposed development has a maximum overall density of 2880 residential units. Colliers Hill Filing 2A has 58 single family lots. The existing runoff from Filing 2A predominantly drains westerly to Coal Creek. Colliers Hill Filing 2A does not lie within the 100-year floodplain per FIRM Map 08013C0441J dated December 18, 2012. The purpose of this report is to present the drainage concept and computations for Colliers Hill Filing 2A. This report analyzes the impact of storm events only, and is not intended to analyze effects of future irrigation, final lot grading or ground water conditions.

DRAINAGE CONCEPT

The drainage concept for Colliers Hill Filing 2A is to convey the developed runoff from Colliers Hill Filing 2A to the existing Water Quality Pond PC1. Water Quality Pond PC1 will remove pollutants from the runoff and release the flows via 66 inch storm pipes and an overflow channel to Coal Creek. The Colliers Hill development is located within the study area of the Erie Outfall Systems Planning Preliminary Design (OSP) prepared by Love and Associates, Inc., December, 2007. The drainage concept for Colliers Filing 2A generally follows the concepts presented in the OSP. Colliers Hill Filing 2A is primarily located in OSP Basins 274, 275 and 276. These basins drain directly into Coal Creek. On-site detention is not required by

OSP. All upstream basins south of Erie Parkway are required to have upstream on-site detention. Upstream OSP Basins 272 and 273 will be conveyed by 54 inch storm pipes to the proposed Water Quality Pond PC1 of Colliers Hill Filing 1.

HYDROLOGIC/HYDRAULIC ANALYSIS

The hydrologic analysis used to determine storm runoff will be The Colorado Urban Hydrograph Procedure (CUHP) for drainage basins greater than 90 acres and The Rational Method for basins less than 90 acres. These methods are presented in *The Urban Drainage and Flood Control Criteria Manual* and *Town of Erie Design Standards*. With the exception of the outfall structure of Water Quality Pond PC1, all drainage facilities will be designed considering a 2 year minor storm event and a 100 year major storm event.

The onsite major basins, offsite basins, regional drainage channels, and the future regional drainage channel were analyzed using The Urban Drainage Storm Water Management Model (UDSWM) in the Colliers Hill Filing 1 & 2 Preliminary Drainage Report by Hurst & Associates, Inc. dated September 8, 2011. See **Appendix L&M**.

DRAINAGE FACILITY DESIGN

The stormwater runoff was determined using the Rational Method as presented in the *Urban Drainage and Flood Control District Manual.* Drainage basins were defined by the proposed grading and the locations of the inlets and storm sewers. Times of concentration (Tc) were developed for each basin. These times, the one-hour rainfall depths from Table 800-2 of the Town of Erie's *Standards and Specifications for Design and Construction of Public Improvements*, and equation RA-3 from Volume 1 of the *Urban Storm Drainage Criteria*

Manual were used to determine the minor and major storm intensities and the corresponding runoff rated for each basin. Runoff calculations are located in **Appendix A.** The proposed streets have adequate capacities to convey the runoff from the 2 year minor and 100 year major storm events. See **Appendices C and F.** Inlets are analyzed in **Appendix D.** Storm pipes are analyzed in **Appendix E.**

A pedestrian underpass will be constructed under Colliers Parkway. The underpass will be a 10'x10' box culvert. The box will be used to convey flows in excess of the minor storm event. Storm sewer piping will collect the minor storm events upstream of the box culvert. The underpass will be designed with a drainage grate at each end to capture nuisance flows. The box capacities exceed what is required for the 100 year storm event.

The design of Water Quality Pond PC1 is in accordance with the criteria within *Urban Storm Drainage Criteria Manual*, Volume 3. The released flows from Water Quality Pond PC1 cross the existing Erie Coal Creek Irrigation Ditch. To mitigate potential damage from storm runoff to the ditch, runoff from the 10-year storm event will be piped under the ditch. Major storms flows in excess of the 10 year event will pass over the top of the ditch piping. A combination of a concrete spillway and rip rap protection will be used to protect the irrigation ditch piping.

The existing natural depression at the outfall of the proposed 18 inch reinforced concrete pipe located on the north side of Erie Parkway and approximately 100 feet east of the existing gravel parking lot will remain. this depression and the downstream grassed swale will facilitate the removal of pollutants from the upstream runoff.

EROSION CONTROL & STORMWATER QUALITY

Temporary erosion control will be provided during construction and grading of the project. This includes silt fencing, inlet protection, and the seeding and mulching of disturbed areas. Permanent erosion control facilities for storm sewer outfalls will be included in the final design.

APPENDIX A
BASIN RUNOFF CALCULATIONS

Basin Runoff Coefficients

Collier's Hill Filing 2A
Job # 2020-42

Land Use	C_2	C_5	C_{100}	% Imperviousness
Concrete & Asphalt	0.87	0.88	0.93	100
Roofs	0.80	0.85	0.90	90
Lawns / Landscaping	0.05	0.15	0.50	0
Amenity Area	0.60	0.65	0.80	70
Park	0.10	0.18	0.45	7
School	0.45	0.50	0.70	50
Single-Family Residential	0.40	0.45	0.60	45

Basin	Area (acres)	Concrete & Asphalt (acres)	Roof (acres)	Lawns (acres)	Amenity Area (acres)	Park (acres)	School (acres)	SFR (acres)	C_2	C_5	C_{100}	% Imper-iousness
C10	3.81	0	0	0	0	0	0	3.81	0.40	0.45	0.60	45.0
C11	0.76	0	0	0	0	0	0	0.76	0.40	0.45	0.60	45.0
C12	0.66	0	0	0	0	0	0	0.66	0.40	0.45	0.60	45.0
C13	0.90	0	0	0	0.65	0	0	0.25	0.54	0.59	0.74	63.0
C14	2.40	0	0	0	0	0	0	2.40	0.40	0.45	0.60	45.0
C14A	2.31	0	0	0	0	0	0	2.31	0.40	0.45	0.60	45.0
C15	1.90	0	0	0	0	0	0	1.90	0.40	0.45	0.60	45.0
C24	1.12	0.45	0	0.67	0	0	0	0	0.38	0.44	0.67	40.4
C25	0.75	0.48	0	0.27	0	0	0	0	0.57	0.62	0.78	64.0
C26	1.19	0	0	0	0	0	0	1.19	0.40	0.45	0.60	45.0
C26A	0.08	0	0	0.08	0	0	0	0	0.05	0.15	0.50	0.0
C27	1.40	0	0	0	0	0	0	1.40	0.40	0.45	0.60	45.0
C28	0.82	0	0	0	0	0	0	0.82	0.40	0.45	0.60	45.0
C29	1.16	0.59	0	0.57	0	0	0	0	0.47	0.52	0.72	51.2
C30	1.75	0.57	0	1.18	0	0	0	0	0.32	0.39	0.64	32.4
C110	25.81	0.92	0	20.05	0	0	0	4.84	0.14	0.23	0.53	12.0

Basin Times of Concentration Calculations

Basin	C_5	Overland Flow			Travel Time in Channel				T_c (mins)	T_c Check		Final T_c (min = 5 mins)
		Length (ft)	Slope (%)	T_i (fig.3-1) (mins)	Length (ft)	Slope (%)	Velocity (ft/sec) (fig.3-2)	T_t (mins)		Total Length (ft)	T_c = (L/180)+10 (mins)	
C10	0.45	300	2.5	14.9	810	1.7	2.6	5.2	20.1	1110	16.2	**16.2**
C11	0.45	45	2.0	6.2	265	1.6	2.5	1.8	8.0	310	11.7	**8.0**
C12	0.45	45	2.0	6.2	415	1.0	2.0	3.5	9.7	460	12.6	**9.7**
C13	0.59	55	2.0	5.4	340	2.0	2.8	2.0	7.4	395	12.2	**7.4**
C14	0.45	215	4.5	10.4	485	1.4	2.3	3.5	13.9	700	13.9	**13.9**
C14A	0.45	210	2.5	12.5	290	1.9	2.7	1.8	14.3	500	12.8	**12.8**
C15	0.45	225	3.5	11.6	250	2.0	2.8	1.5	13.0	475	12.6	**12.6**
C24	0.44	60	7.0	4.8	620	0.9	1.9	5.4	10.2	680	13.8	**10.2**
C25	0.62	85	2.0	6.4	210	0.8	1.8	1.9	8.3	295	11.6	**8.3**
C26	0.45	45	2.0	6.2	775	1.0	2.0	6.5	12.7	820	14.6	**12.7**
C26A	0.15	-	-	-	-	-	-	-	-	-	-	**5.0**
C27	0.45	150	2.0	11.4	415	1.1	2.0	3.5	14.8	565	13.1	**13.1**
C28	0.45	165	2.0	11.9	250	1.0	2.0	2.1	14.0	415	12.3	**12.3**
C29	0.52	30	2.0	4.5	875	2.4	3.0	4.9	9.4	905	15.0	**9.4**
C30	0.39	75	2.0	8.8	790	2.4	3.0	4.4	13.2	865	14.8	**13.2**

Basin Runoff Rates

Colliers Hill Filing 2A
Job # 2020-42

Town of Erie One-Hour Rainfall Depths

2-Year = 1.01 inches
5-Year = 1.43 inches
100-Year = 2.70 inches

Intensity = 28.5 * P_1 / ((10 + T_C)$^{0.786}$)

RA-3, USDCM Vol. 1

Basin	Area (acres)	C_2	C_5	C_{100}	T_c (mins)	I_2 (in/hr)	I_5 (in/hr)	I_{100} (in/hr)	Q_2 (cfs)	Q_5 (cfs)	Q_{100} (cfs)
C10	3.81	0.40	0.45	0.60	16.2	*2.21*	*3.13*	*5.91*	**3.37**	**5.37**	**13.52**
C11	0.76	0.40	0.45	0.60	8.0	*2.97*	*4.20*	*7.94*	**0.90**	**1.44**	**3.62**
C12	0.66	0.40	0.45	0.60	9.7	*2.77*	*3.92*	*7.40*	**0.73**	**1.17**	**2.94**
C13	0.90	0.54	0.59	0.74	7.4	*3.05*	*4.32*	*8.16*	**1.49**	**2.30**	**5.45**
C14	2.40	0.40	0.45	0.60	13.9	*2.38*	*3.36*	*6.35*	**2.28**	**3.63**	**9.15**
C14A	2.31	0.40	0.45	0.60	12.8	*2.47*	*3.49*	*6.59*	**2.27**	**3.62**	**9.12**
C15	1.90	0.40	0.45	0.60	12.6	*2.48*	*3.51*	*6.63*	**1.88**	**3.00**	**7.55**
C24	1.12	0.38	0.44	0.67	10.2	*2.71*	*3.84*	*7.24*	**1.16**	**1.92**	**5.48**
C25	0.75	0.57	0.62	0.78	8.3	*2.93*	*4.15*	*7.83*	**1.27**	**1.93**	**4.58**
C26	1.19	0.40	0.45	0.60	12.7	*2.47*	*3.50*	*6.62*	**1.17**	**1.87**	**4.70**
C26A	0.08	0.05	0.15	0.50	5.0	*3.43*	*4.85*	*9.16*	**0.01**	**0.06**	**0.37**
C27	1.40	0.40	0.45	0.60	13.1	*2.44*	*3.45*	*6.51*	**1.37**	**2.18**	**5.48**
C28	0.82	0.40	0.45	0.60	12.3	*2.51*	*3.55*	*6.70*	**0.82**	**1.30**	**3.28**
C29	1.16	0.47	0.52	0.72	9.4	*2.80*	*3.97*	*7.49*	**1.53**	**2.41**	**6.26**
C30	1.75	0.32	0.39	0.64	13.2	*2.43*	*3.44*	*6.50*	**1.34**	**2.33**	**7.28**

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential:	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period

NRCS Soil Group	Storm Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
A	$C_A = 0.89i$	$C_A = 0.93i$	$C_A = 0.94i$	$C_A = 0.944i$	$C_A = 0.95i$	$C_A = 0.81i + 0.154$
B	$C_B = 0.89i$	$C_B = 0.93i$	$C_B = 0.81i + 0.125$	$C_B = 0.70i + 0.23$	$C_B = 0.59i + 0.364$	$C_B = 0.49i + 0.454$
C/D	$C_{C/D} = 0.89i$	$C_{C/D} = 0.87i + 0.052$	$C_{C/D} = 0.74i + 0.2$	$C_{C/D} = 0.64i + 0.31$	$C_{C/D} = 0.54i + 0.418$	$C_{C/D} = 0.45i + 0.508$

Where:

i = % imperviousness (expressed as a decimal)

C_A = Runoff coefficient for Natural Resources Conservation Service (NRCS) HSG A soils

C_B = Runoff coefficient for NRCS HSG B soils

$C_{C/D}$ = Runoff coefficient for NRCS HSG C and D soils.

The values for various catchment imperviousness and storm return periods are presented graphically in Figures 6-1 through 6-3, and are tabulated in Table 6-5. These coefficients were developed for the Denver region to work in conjunction with the time of concentration recommendations in Section 2.4. Use of these coefficients and this procedure outside of the semi-arid climate found in the Denver region may not be valid. The UD-Rational Excel workbook performs all the needed calculations to find the runoff coefficient given the soil type and imperviousness and the reader may want to take advantage of this macro-enabled Excel workbook that is available for download from the UDFCD's website www.udfcd.org.

See Examples 7.1 and 7.2 that illustrate the Rational Method.

Table 6-5. Runoff coefficients, *c*

Total or Effective % Imperviousness	NRCS Hydrologic Soil Group A					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2%	0.02	0.02	0.02	0.02	0.02	0.17
5%	0.04	0.05	0.05	0.05	0.05	0.19
10%	0.09	0.09	0.09	0.09	0.1	0.23
15%	0.13	0.14	0.14	0.14	0.14	0.28
20%	0.18	0.19	0.19	0.19	0.19	0.32
25%	0.22	0.23	0.24	0.24	0.24	0.36
30%	0.27	0.28	0.28	0.28	0.29	0.4
35%	0.31	0.33	0.33	0.33	0.33	0.44
40%	0.36	0.37	0.38	0.38	0.38	0.48
45%	0.4	0.42	0.42	0.42	0.43	0.52
50%	0.45	0.47	0.47	0.47	0.48	0.56
55%	0.49	0.51	0.52	0.52	0.52	0.6
60%	0.53	0.56	0.56	0.57	0.57	0.64
65%	0.58	0.6	0.61	0.61	0.62	0.68
70%	0.62	0.65	0.66	0.66	0.67	0.72
75%	0.67	0.7	0.71	0.71	0.71	0.76
80%	0.71	0.74	0.75	0.76	0.76	0.8
85%	0.76	0.79	0.8	0.8	0.81	0.84
90%	0.8	0.84	0.85	0.85	0.86	0.88
95%	0.85	0.88	0.89	0.9	0.9	0.92
100%	0.89	0.93	0.94	0.94	0.95	0.96
Total or Effective % Imperviousness	**NRCS Hydrologic Soil Group B**					
2%	0.02	0.02	0.14	0.24	0.38	0.46
5%	0.04	0.05	0.17	0.27	0.39	0.48
10%	0.09	0.09	0.21	0.3	0.42	0.5
15%	0.13	0.14	0.25	0.34	0.45	0.53
20%	0.18	0.19	0.29	0.37	0.48	0.55
25%	0.22	0.23	0.33	0.41	0.51	0.58
30%	0.27	0.28	0.37	0.44	0.54	0.6
35%	0.31	0.33	0.41	0.48	0.57	0.63
40%	0.36	0.37	0.45	0.51	0.6	0.65
45%	0.4	0.42	0.49	0.55	0.63	0.67
50%	0.45	0.47	0.53	0.58	0.66	0.7
55%	0.49	0.51	0.57	0.62	0.69	0.72
60%	0.53	0.56	0.61	0.65	0.72	0.75
65%	0.58	0.6	0.65	0.69	0.75	0.77
70%	0.62	0.65	0.69	0.72	0.78	0.8
75%	0.67	0.7	0.73	0.76	0.81	0.82
80%	0.71	0.74	0.77	0.79	0.84	0.85
85%	0.76	0.79	0.81	0.83	0.87	0.87
90%	0.8	0.84	0.85	0.86	0.89	0.9
95%	0.85	0.88	0.89	0.9	0.92	0.92
100%	0.89	0.93	0.94	0.94	0.95	0.94

Table 6-5. Runoff coefficients, *c* (continued)

Total or Effective % Imperviousness	NRCS Hydrologic Soil Groups C and D					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2%	0.02	0.07	0.22	0.32	0.43	0.52
5%	0.04	0.1	0.24	0.34	0.45	0.53
10%	0.09	0.14	0.27	0.37	0.47	0.55
15%	0.13	0.18	0.31	0.41	0.5	0.58
20%	0.18	0.23	0.35	0.44	0.53	0.6
25%	0.22	0.27	0.39	0.47	0.55	0.62
30%	0.27	0.31	0.42	0.5	0.58	0.64
35%	0.31	0.36	0.46	0.53	0.61	0.67
40%	0.36	0.4	0.5	0.57	0.63	0.69
45%	0.4	0.44	0.53	0.6	0.66	0.71
50%	0.45	0.49	0.57	0.63	0.69	0.73
55%	0.49	0.53	0.61	0.66	0.72	0.76
60%	0.53	0.57	0.64	0.69	0.74	0.78
65%	0.58	0.62	0.68	0.73	0.77	0.8
70%	0.62	0.66	0.72	0.76	0.8	0.82
75%	0.67	0.7	0.76	0.79	0.82	0.85
80%	0.71	0.75	0.79	0.82	0.85	0.87
85%	0.76	0.79	0.83	0.85	0.88	0.89
90%	0.8	0.83	0.87	0.89	0.9	0.91
95%	0.85	0.88	0.9	0.92	0.93	0.94
100%	0.89	0.92	0.94	0.95	0.96	0.96

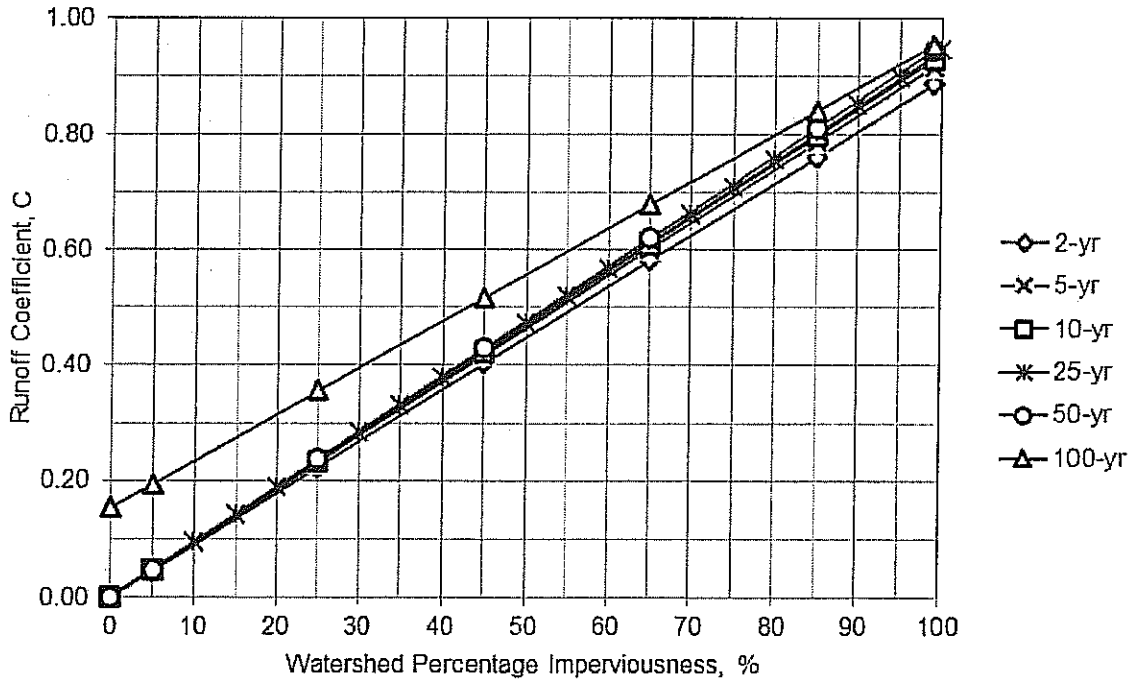


Figure 6-1. Runoff coefficient vs. watershed imperviousness NRCS HSG A

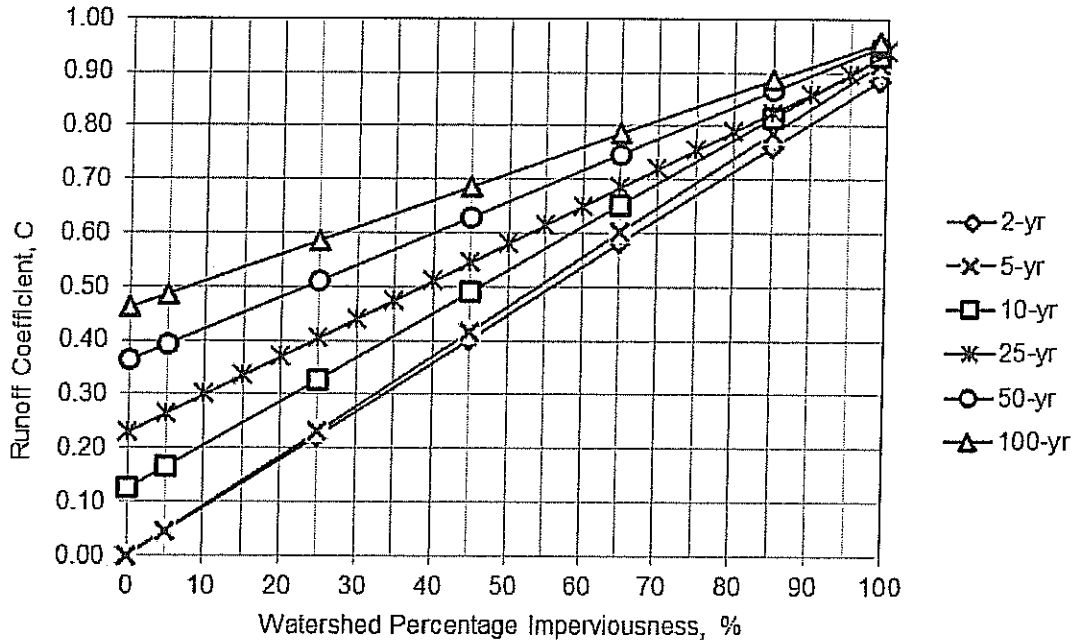


Figure 6-2. Runoff coefficient vs. watershed imperviousness NRCS HSG B

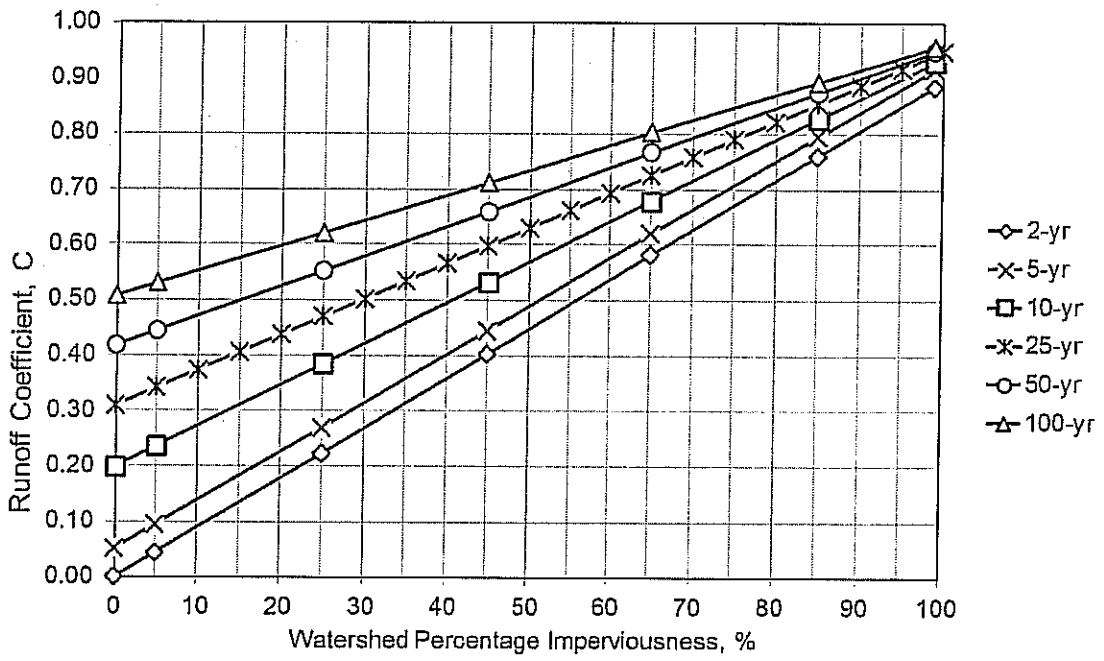


Figure 6-3. Runoff coefficient vs. watershed imperviousness NRCS HSG C and D

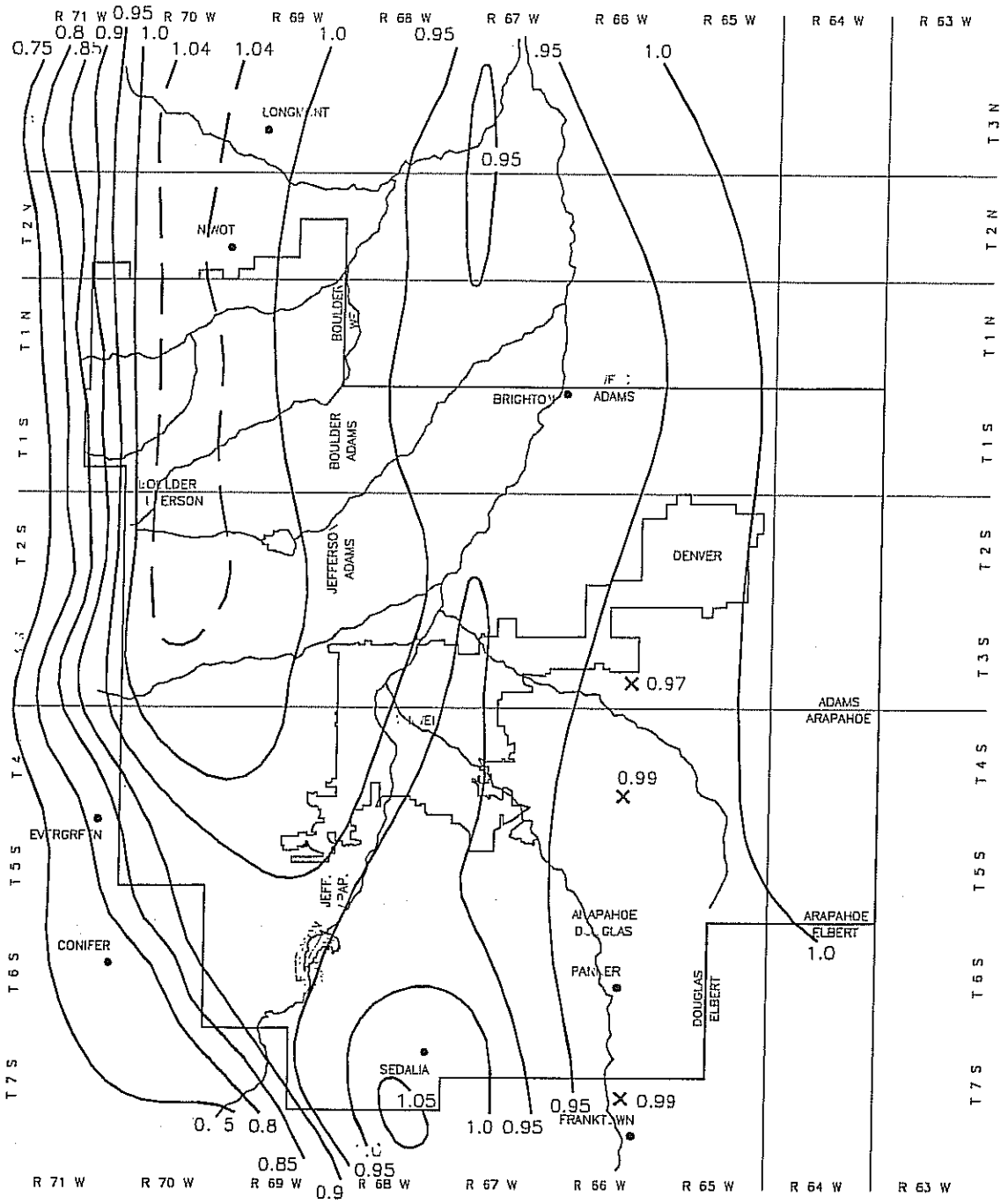


Figure 5-1. Rainfall depth-duration-frequency: 2-year, 1-hour rainfall

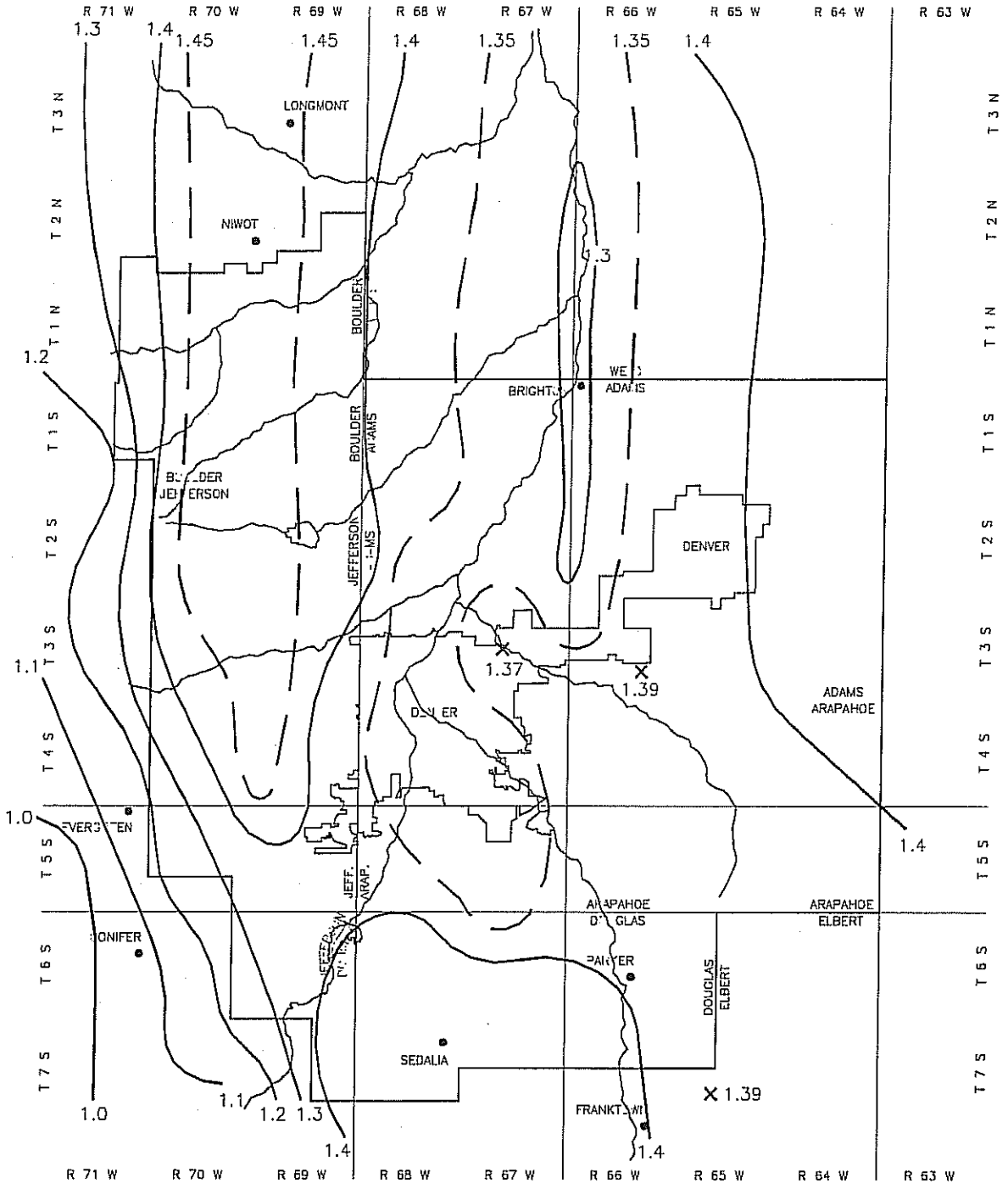


Figure 5-2. Rainfall depth-duration-frequency: 5-year, 1-hour rainfall

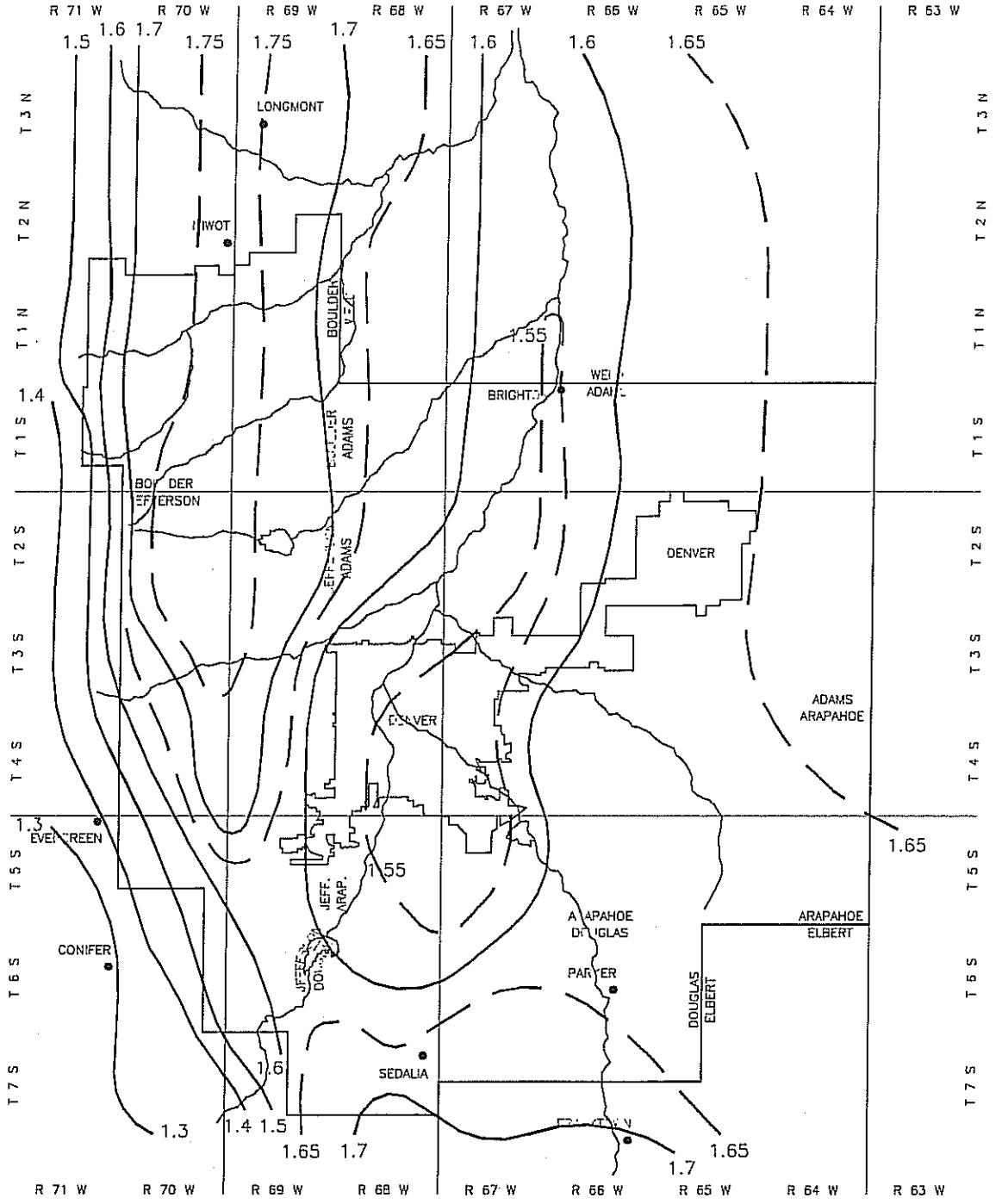


Figure 5-3. Rainfall depth-duration-frequency: 10-year, 1-hour rainfall

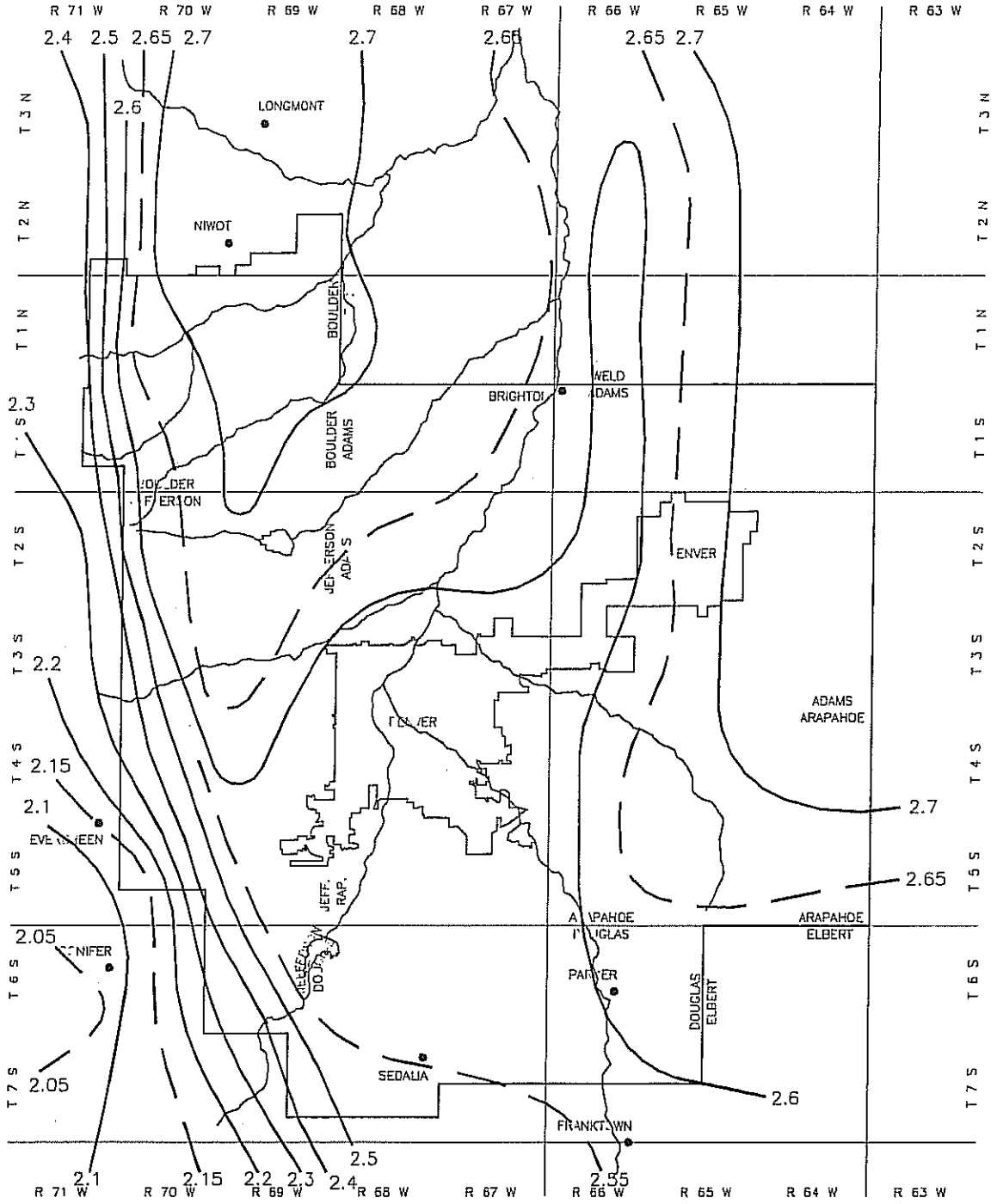
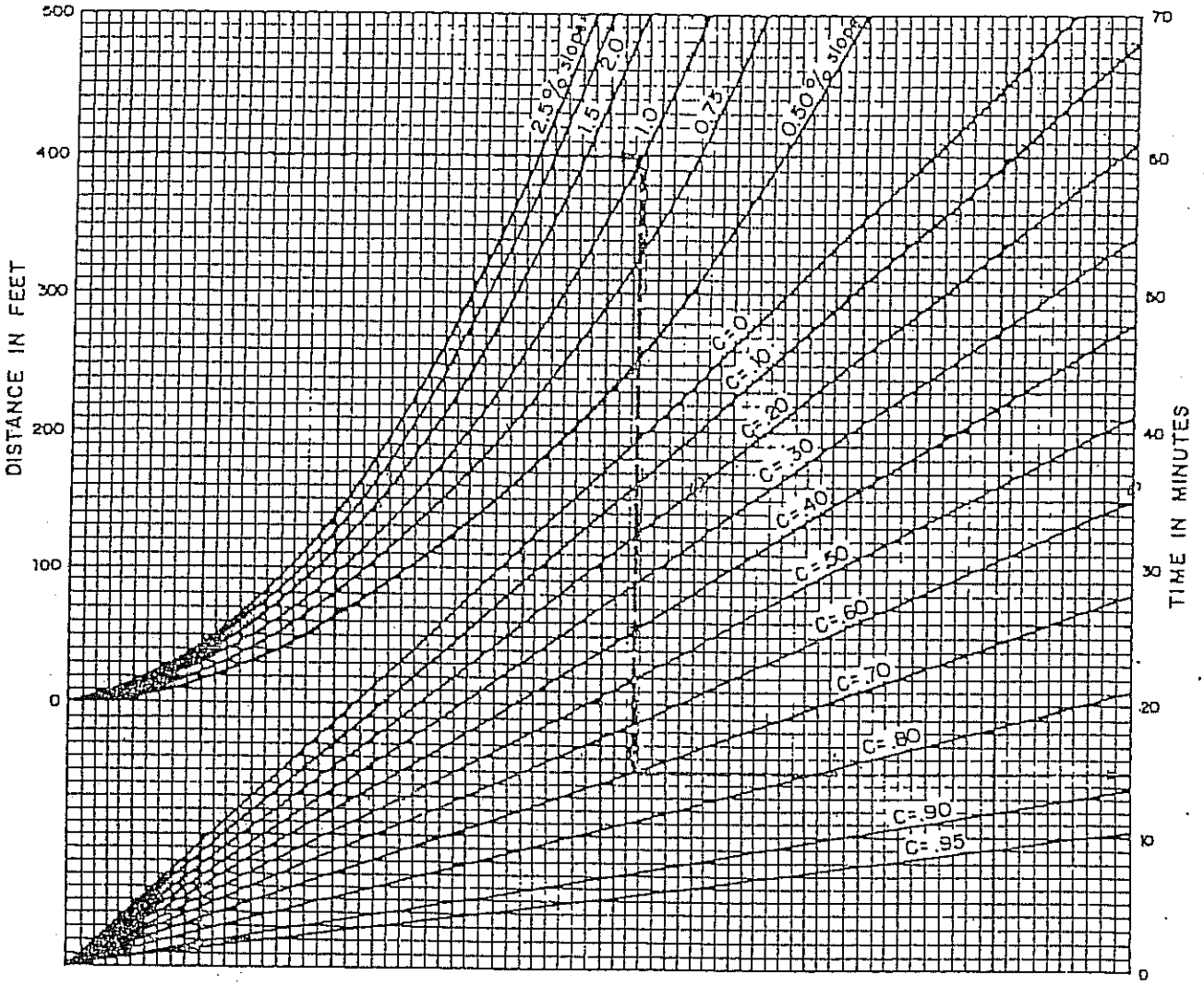


Figure 5-6. Rainfall depth-duration-frequency: 100-year, 1-hour rainfall

BOULDER COUNTY STORM DRAINAGE CRITERIA MANUAL	FIGURE 601

OVERLAND TIME OF FLOW



THE ABOVE CURVES ARE A SOLUTION OF THE FOLLOWING EQUATION:

$$t_i = \frac{1.8\,(1.1 - C_5)\sqrt{L}}{\sqrt[3]{S}}$$

where: t_i = initial flow time (min.)
S = slope of basin (%)
C_5 = runoff coeficient for 5 year frequency (Table 601)
L = length of basin (ft.)

Notes: 1. The curves are for use with the Rational Method, see Text Section 602.

2. The curves shall not be used for distances in excess of 500'.

WRC ENG.	REFERENCE: "Urban Storm Drainage Criteria Manual" DRCOG, Denver, Colorado 1969

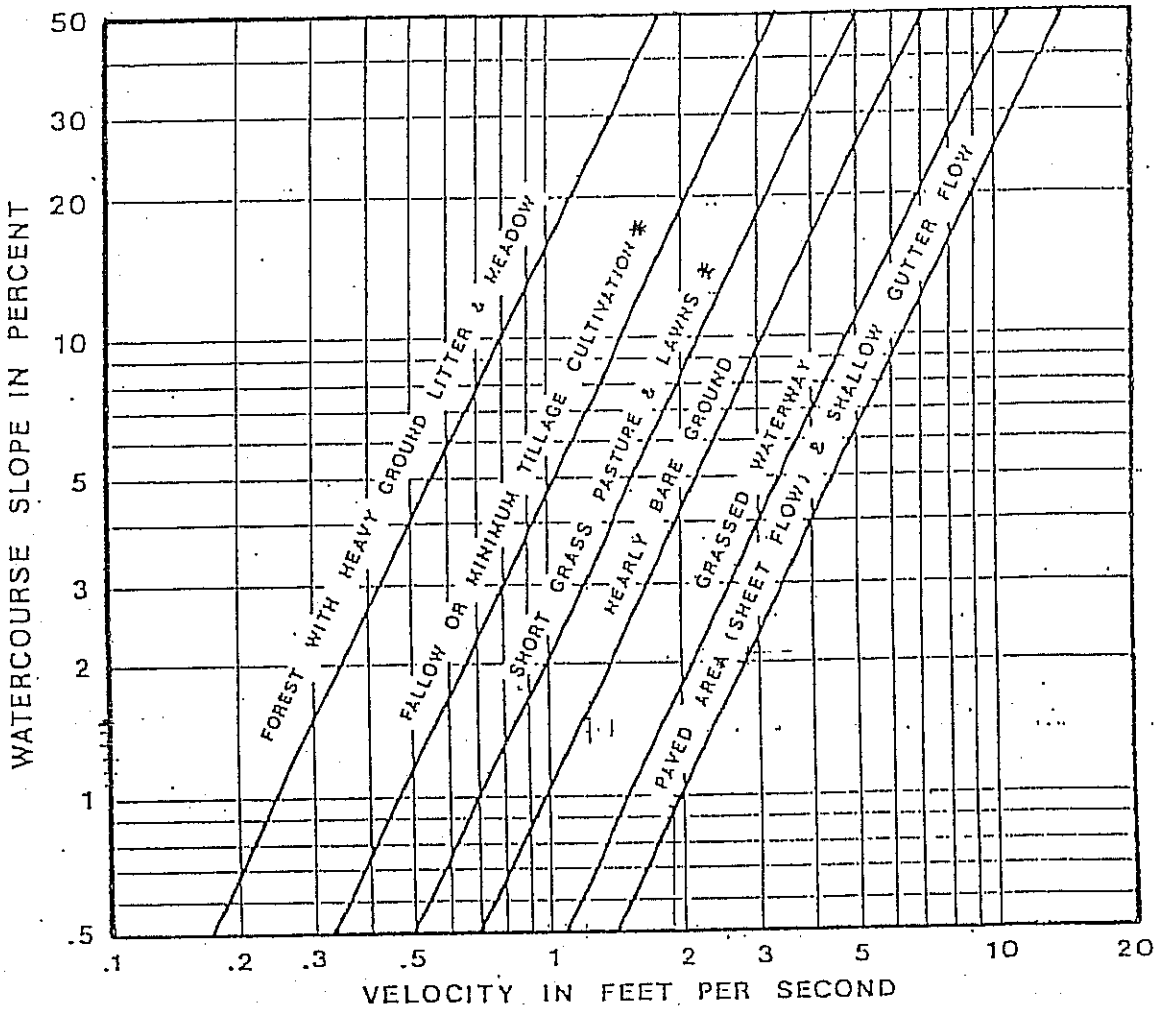


FIGURE 3-2. ESTIMATE OF AVERAGE FLOW VELOCITY FOR USE WITH THE RATIONAL FORMULA.

* MOST FREQUENTLY OCCURRING "UNDEVELOPED" LAND SURFACES IN THE DENVER REGION.

REFERENCE: "Urban Hydrology For Small Watersheds" Technical Release No. 55, USDA, SCS Jan. 1975.

APPENDIX B
WATER QUALITY POND PC1

WQ Pond PC1
Colliers Hill Filing 2A

Job Number: 2020-42

Land Use	% Imperviousness
Concrete & Asphalt	100
Roof	90
Lawns / Landscaping	0
Amenity Area	70
Park	7
Single-Family Residential	45

Contributing Basins	Area (acres)	Concrete & Asphalt (acres)	Roof (acres)	Lawns (acres)	Amenity Area (acres)	Park (acres)	SFR (acres)	% Imperv-iousness
Basins C1-C110	**218.78**	13.37	1.75	47.19	2.92	3.16	149.99	**38.7**

Water Quality Pond PC1

Water Quality Capture Volume

Design Volume = (WQCV / 12) * Area * 1.2

WQCV = a *(0.91 * i^3 - 1.19 * i^2 + 0.78 * i)

Using a 40-hour drain time, a = 1.0

Area (acres)	% Impervious	WQCV (inches)	WQ Volume (acre-feet)	WQ Volume (cubic feet)	WQ Release (cfs)
218.78	38.7%	0.18	**3.86**	**168,090**	**1.17**

Elevation	Area (s.f.)	Incremental Volume (c.f.)	Total Volume (c.f.)	Total Volume (ac-ft)	
5042.0	**253**	**0**	**0**	**0**	**Bottom**
5043.0	763	508	508	0.01	
5044.0	19,380	10,072	10,580	0.24	
5045.0	24,382	21,881	32,461	0.75	
5046.0	27,956	26,169	58,630	1.35	
5047.0	31,564	29,760	88,390	2.03	
5048.0	35,490	33,527	121,917	2.80	
5049.0	39,449	37,470	159,386	3.66	
5049.22	**40,291**	**8,704**	**168,090**	**3.86**	**WQCV**
5050.0	43,305	41,377	200,763	4.61	

WQ Pond PC1
Colliers Hill Filing 2A
Job Number: 2020-42

Forebay at SC-45

SC-45 Q_{100} =	204.0 cfs
2% of Q_{100} =	4.1 cfs
Forebay Pipe Size =	18 in
Forebay Pipe Slope =	0.0065 ft/t
Forebay Pipe Capcity =	10.0 cfs
SC-45 Onsite Contributing Area =	180.13 acres
Approximate % Imperviousness =	0.387
WQCV =	0.18 inches
Approximate WQ Volume at SC-45 =	138,395 c.f.
3% of WQCV =	**4,152 c.f.**

Elevation	Area (s.f.)	Incremental Volume (c.f.)	Total Volume (c.f.)	Note
5044.75	**0**	**0**	**0**	**Bottom**
5045.0	696	87	87	
5046.0	1,157	927	1,014	
5047.0	1,665	1,411	2,425	
5047.9	**2,169**	**1,727**	**4,152**	**Design Vol.**
5048.0	2,224	1,945	4,369	

Forebay at SC-10

SC-10 Q_{100} =	21 cfs
2% of Q_{100} =	0.42 cfs
Forebay Pipe Size =	8 in
Forebay Pipe Slope =	0.010 ft/t
Forebay Pipe Capcity =	1.4 cfs
SC-45 Onsite Contributing Area =	12.73 acres
Approximate % Imperviousness =	0.387
WQCV =	0.18 inches
Approximate WQ Volume at SC-45 =	9,781 c.f.
3% of WQCV =	**293 c.f.**

Elevation	Area (s.f.)	Incremental Volume (c.f.)	Total Volume (c.f.)	Note
5043.9	**0**	**0**	**0**	**Bottom**
5044.0	146	7	7	
5045.0	292	219	226	
5045.2	**338**	**70**	**296**	**Design Vol.**
5045.5	396	172	398	Top

WQ Pond PC1 Micropool

WQ Orifice Invert In =	5042.00
Bottom of Micropool (Min. 2.5 feet below Outfall Structure) =	5039.00
Minimum Initial Surcharge Volume (0.3% of WQCV) =	504 c.f.
Initial Surcharge Depth (Minimum of 4 inches) =	0.50 ft

Elevation	Area (s.f.)	Incremental Volume (c.f.)	Total Volume (c.f.)
5039.00	35	0	0
5040.0	92	64	64
5041.0	170	131	195
5042.0	270	220	415
5042.5	**534**	**201**	**616**
5043.0	797	534	-

Basin PC1 is that portion of Daybreak that drains to proposed Water Quality Pond PC1 at the east end of the site. The flow rates from PC1 are used to calculate the outfall structure and overflow channel of Water Quality Pond PC1.

Basin PC1 CUHP Inputs

Total Area (acres)	Total Area (mi^2)	% Impervi-ousness	Basin Length (mi)	Basin Slope (ft/ft)	Distance to Centroid (mi)	Depression Storage		Infiltration		Horton's Decay Rate	Predominant NRCS Hydrologic Soil Type
						Pervious	Impervious	Initial	Final		
218.78	0.3418	38.7	0.9091	0.0180	0.4121	0.35	0.1	4.5	0.6	0.0018	B

CUHP One-Hour Rainfall Depths per Erie Standards & Specs.

Design Storm	Rainfall Depth (in/hr)
2-Year	1.01
5-Year	1.43
10-Year	1.73
100-Year	2.70

Basin PC1 CUHP Outputs

Total Area (acres)	% Impervi-ousness	2-Yr Runoff Rate (cfs)	5-Yr Runoff Rate (cfs)	10-Yr Runoff Rate (cfs)	100-Yr Runoff Rate (cfs)
218.78	38.7	111	224	304	669

Water Quality Pond PC1 Outfall Flow Rates
Contributing Basins: PC1, 272 & 273

Basin PC1 Q_{10}:	304 cfs
Basin 272 Q_{10}:	20 cfs
Basin 273 Q_{10}:	21 cfs
Total Q_{10}:	**345 cfs**

Basin PC1 Q_{100}:	669 cfs
Basin 272 Q_{100}:	95 cfs
Basin 273 Q_{100}:	109 cfs
Total Q_{100}:	**873 cfs**

Basin	Area (acres)	% Imperv.	2-Year (cfs)	5-Year (cfs)	10-Year (cfs)	100-Year (cfs)
272	41.4	2.0	1	7	20	95
273	52.1	2.0	1	8	21	109

From Erie OSP Preliminary Design as prepared by Love Associates & date December 2007.

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE 3/19/2013 AT TIME 12:45
CUHPF/PC RELEASE 2A (32-BIT VER) SEPTEMBER 10, 1998
PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 0
Bridgewater 2013

BASIN ID: -- BASIN COMMENT: PC1

AREA (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERV. AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
0.34	0.91	0.41	38.70	0.0180	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
0.094	0.428

THIS BASIN USES TRADITIONAL DRAINAGE PRACTICES

FRACTION OF PERVIOUS AREA RECEIVING IMPERVIOUS DRAINAGE (DEFAULT)	FRACTION OF IMPERVIOUS AREA DIRECTLY CONNECTED TO DRAINAGE SYSTEM (DEFAULT)
R= 0.19	D= 0.77

CALCULATED UNIT HYDROGRAPH

TIME TO PEAK (MIN)	PEAK RATE OF RUNOFF (CFS/SQMI)	UNIT HYDROGRAPH PEAK (CFS)	VOLUME OF RUNOFF (AF)
11.71	1785.42	610.26	18.23

WIDTH AT 50 = 17. MIN. WIDTH AT 75 = 9. MIN. K50 =0.35 K75 =0.45

RAINFALL LOSSES INPUT W/ BASIN DATA
MAX. PERVIOUS RET. =0.35 IN. MAX. IMPERVIOUS RET. =0.10 IN.
INFILTRATION = 4.50 IN./HR. DECAY = 0.00180/SECOND FNINFL = 0.60 IN./HR.

TIME	UNIT HYDROGRAPH	TIME	UNIT HYDROGRAPH	TIME	UNIT HYDROGRAPH
0.	0.	30.	190.	60.	28.
5.	243.	35.	138.	65.	20.
10.	584.	40.	100.	70.	15.
15.	533.	45.	73.	75.	11.
20.	371.	50.	53.	80.	8.
25.	262.	55.	38.	85.	0.

1 BASIN ID: -- BASIN COMMENT: PC1

**** STORM NO. = 1 **** DATE OR RETURN PERIOD = 2

TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)	TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)
0.	0.00	0.000	0.	80.	0.02	0.006	26.
5.	0.02	0.000	0.	85.	0.02	0.006	23.
10.	0.04	0.000	0.	90.	0.02	0.006	21.
15.	0.08	0.013	3.	95.	0.02	0.006	19.
20.	0.16	0.046	19.	100.	0.02	0.006	18.
25.	0.25	0.093	56.	105.	0.02	0.006	17.
30.	0.14	0.060	98.	110.	0.02	0.006	16.
35.	0.06	0.024	111.	115.	0.01	0.003	15.
40.	0.05	0.018	100.	120.	0.01	0.003	13.
45.	0.03	0.009	83.	125.	0.00	0.000	11.
50.	0.03	0.009	67.	130.	0.00	0.000	8.
55.	0.03	0.009	55.	135.	0.00	0.000	6.
60.	0.03	0.009	46.	140.	0.00	0.000	4.
65.	0.03	0.009	40.	145.	0.00	0.000	3.
70.	0.02	0.006	35.	150.	0.00	0.000	2.
75.	0.02	0.006	30.	155.	0.00	0.000	1.

* LESS ANY WATER QUALITY CAPTURE VOLUME
** INCLUDES ANY WATER QUALITY CAPTURE VOLUME RELEASE FLOW

TOTAL PRECIP. = 1.17 (1-HOUR RAIN = 1.01) EXCESS PRECIP. = 0.356 INCHES
VOLUME OF EXCESS PRECIP = 6.49 ACRE-FEET
PEAK Q = 111. CFS TIME OF PEAK = 35. MIN.
INFILT.= 4.50 IN/HR DECAY =0.00180 FNINF = 0.60 IN/HR
MAX.PERV.RET.=0.35 IN. MAX.IMP.RET.=0.10 IN.

1 BASIN ID: -- BASIN COMMENT: PC1

**** STORM NO. = 2 **** DATE OR RETURN PERIOD = 5

TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)	TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)

0.	0.00	0.000	0.	80.	0.03	0.009	50.
5.	0.03	0.000	0.	85.	0.03	0.009	44.
10.	0.05	0.000	0.	90.	0.03	0.009	39.
15.	0.12	0.030	7.	95.	0.03	0.009	35.
20.	0.22	0.062	33.	100.	0.02	0.006	31.
25.	0.36	0.187	98.	105.	0.02	0.006	26.
30.	0.19	0.141	188.	110.	0.02	0.006	23.
35.	0.08	0.045	224.	115.	0.02	0.006	21.
40.	0.06	0.028	200.	120.	0.02	0.005	19.
45.	0.05	0.019	162.	125.	0.00	0.000	16.
50.	0.05	0.019	131.	130.	0.00	0.000	12.
55.	0.04	0.015	108.	135.	0.00	0.000	9.
60.	0.04	0.015	89.	140.	0.00	0.000	6.
65.	0.04	0.015	76.	145.	0.00	0.000	4.
70.	0.04	0.015	66.	150.	0.00	0.000	3.
75.	0.04	0.012	58.	155.	0.00	0.000	2.

* LESS ANY WATER QUALITY CAPTURE VOLUME
** INCLUDES ANY WATER QUALITY CAPTURE VOLUME RELEASE FLOW

TOTAL PRECIP. = 1.65 (1-HOUR RAIN = 1.43) EXCESS PRECIP. = 0.669 INCHES
VOLUME OF EXCESS PRECIP = 12.20 ACRE-FEET
PEAK Q = 224. CFS TIME OF PEAK = 35. MIN.
INFILT.= 4.50 IN/HR DECAY =0.00180 FNINF = 0.60 IN/HR
MAX.PERV.RET.=0.35 IN. MAX.IMP.RET.=0.10 IN.

1 BASIN ID: -- BASIN COMMENT: PC1

**** STORM NO. = 3 **** DATE OR RETURN PERIOD = 10

TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)	TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)
0.	0.00	0.000	0.	85.	0.03	0.010	67.
5.	0.03	0.000	0.	90.	0.03	0.010	56.
10.	0.06	0.000	0.	95.	0.03	0.010	48.
15.	0.14	0.040	10.	100.	0.03	0.010	42.
20.	0.26	0.086	44.	105.	0.03	0.010	36.
25.	0.43	0.285	141.	110.	0.03	0.010	33.
30.	0.21	0.163	267.	115.	0.03	0.008	31.
35.	0.10	0.058	304.	120.	0.02	0.006	28.
40.	0.07	0.039	266.	125.	0.00	0.000	23.
45.	0.07	0.032	218.	130.	0.00	0.000	17.
50.	0.06	0.022	179.	135.	0.00	0.000	12.
55.	0.06	0.023	147.	140.	0.00	0.000	9.
60.	0.06	0.023	123.	145.	0.00	0.000	6.
65.	0.06	0.023	107.	150.	0.00	0.000	4.
70.	0.06	0.024	95.	155.	0.00	0.000	3.
75.	0.06	0.024	86.	160.	0.00	0.000	2.
80.	0.04	0.015	78.	165.	0.00	0.000	1.

* LESS ANY WATER QUALITY CAPTURE VOLUME
** INCLUDES ANY WATER QUALITY CAPTURE VOLUME RELEASE FLOW

TOTAL PRECIP. = 2.00 (1-HOUR RAIN = 1.73) EXCESS PRECIP. = 0.933 INCHES
VOLUME OF EXCESS PRECIP = 17.01 ACRE-FEET
PEAK Q = 304. CFS TIME OF PEAK = 35. MIN.
INFILT.= 4.50 IN/HR DECAY =0.00180 FNINF = 0.60 IN/HR
MAX.PERV.RET.=0.35 IN. MAX.IMP.RET.=0.10 IN.

1 BASIN ID: -- BASIN COMMENT: PC1

**** STORM NO. = 4 **** DATE OR RETURN PERIOD = 100

TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)	TIME (MIN.)	INCREMENT RAINFALL (IN)	TOTAL* EXCESS PRECIP	STORM** HYDROGRAPH (CFS)
0.	0.00	0.000	0.	85.	0.03	0.010	137.
5.	0.03	0.000	0.	90.	0.03	0.010	106.
10.	0.08	0.002	1.	95.	0.03	0.010	84.
15.	0.12	0.035	10.	100.	0.03	0.010	68.
20.	0.22	0.062	37.	105.	0.03	0.010	55.
25.	0.38	0.206	106.	110.	0.03	0.010	44.
30.	0.68	0.621	318.	115.	0.03	0.010	37.
35.	0.38	0.334	586.	120.	0.03	0.010	33.
40.	0.22	0.178	669.	125.	0.00	0.000	28.
45.	0.17	0.131	615.	130.	0.00	0.000	21.
50.	0.14	0.101	534.	135.	0.00	0.000	15.
55.	0.11	0.075	456.	140.	0.00	0.000	10.
60.	0.11	0.075	387.	145.	0.00	0.000	7.
65.	0.11	0.075	335.	150.	0.00	0.000	5.
70.	0.05	0.022	285.	155.	0.00	0.000	3.
75.	0.05	0.022	228.	160.	0.00	0.000	2.
80.	0.03	0.010	178.	165.	0.00	0.000	2.

* LESS ANY WATER QUALITY CAPTURE VOLUME

BASIN PC1 2013.cho
** INCLUDES ANY WATER QUALITY CAPTURE VOLUME RELEASE FLOW

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXCESS PRECIP. = 2.029 INCHES
VOLUME OF EXCESS PRECIP = 36.98 ACRE-FEET
PEAK Q = 669. CFS TIME OF PEAK = 40. MIN.
INFILT.= 4.50 IN/HR DECAY =0.00180 FNINF = 0.60 IN/HR
MAX.PERV.RET.=0.35 IN. MAX.IMP.RET.=0.10 IN.

WQ Pond PC1

Job Number: 2020-42

WQCV W.S.E. =	5049.22 feet
Top of Outfall Structure =	5049.25 feet
Spillway Invert =	5052.25 feet
Invert Outfall Structure =	5040.00 feet

Outfall Structure Grate Analysis

Weir Equation: $Q = 3.0 * P * h^{3/2}$

Q_{10} =	345 cfs
Head (Water Depth at Spillway Invert) =	3.00 ft
Required Perimeter =	22.13 ft
Outfall Structure Perimeter =	25.00 ft

Orifice Equation: $Q = 0.60 * A * (2gh)^{1/2}$

Q_{10} =	345 cfs
Head (Water Depth at Spillway Invert) =	3.00 ft
Required Area =	41.37 ft^2
Approximate Grate Opening Area =	72.0 ft^2

66" RCP Analysis

Orifice Equation: $Q = 0.60 * A * (2gh)^{1/2}$

Q_{10} =	345 cfs
Head (Water Depth at Spillway Invert) =	9.50 ft
Design Pipe Size =	66 inches
66" RCP Opening Capacity =	**353 cfs**

$Q = 1.486 / n * A * (A / WP)^{2/3} * S^{1/2}$

Q_{10} =	345 cfs
Size:	66 inch
Area:	23.76 square feet
Wetted Perimeter:	17.28 square feet
Minimum Slope:	0.0173 ft/ft
Manning's n:	0.013
Capacity:	**441.7 cfs**

100-Year Spillway Analysis

Standard Weir Equation: $Q = 3.0 * P * h^{3/2}$

Q_{100} =	873 cfs
Q_{10} =	345 cfs
Required Spillway Capcity =	**528 cfs**
Spillway Length =	100 feet
100-Year Flow Depth of Spillway (h) =	**1.46 feet**
100-Year W.S.E. Over Spillway =	5053.71 feet

WQ Pond PC1

Water Quality Orifice Calculations

Job Number: 2020-42

Equation EDB–3

$$A_0 = \frac{88 Vol^{(0.95/H^{0.085})}}{T_D S^{0.09} H^{2.6(S^{0.3})}}$$

A_o is the required orifice area per row in square inches
S is the slope in feet vertical / feet horizontal (substitute 0.0001 for zero)
Vol is the storage volume in acre-feet
T_D is the prescribed drain time in hours
H is the storage depth at the outlet above the lowest orifice, in feet.

WQCV W.S.E. =	5049.22 feet
WQ Orifice Invert =	5042.50 feet
S =	0.005 ft/ft
Vol =	3.86 ac-ft
T_D =	40 hrs
H =	6.72 ft
A_o =	3.84 in^2
2 Circular Orifices per Row	
Maximum Opening diameter =	1.564 in

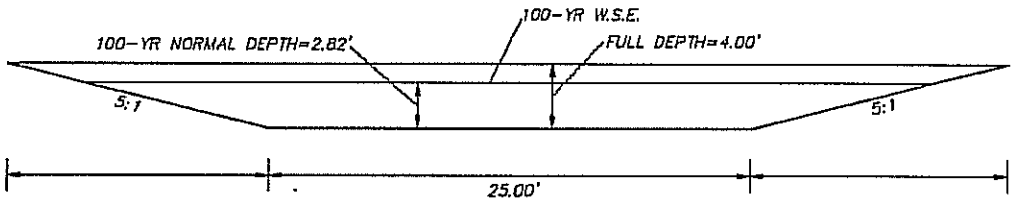
Install 20 Rows of Two 1-9/16" Inch Diameter Orifices (4 Inches on Center)

Water Quality Pond PC1 Overflow Channel

Channel Characteristics	
Design Storm:	100-Year
Q_{100}:	873
Q_{10}:	345
Design flow (Q_{100}) (cfs):	**528**
Slope of channel bank (z:1) (entre z):	5
Base width (b) (ft)	25
Minimum channel depth (ft):	**4.00**
Slope of channel (S) (ft/ft):	0.00634
Manning's n:	0.040
Normal Depth Calculations	
Normal depth (y_n) (ft):	**2.82**
Normal depth area (A) (ft^2):	110.48
Normal depth wetted perimeter (P) (ft):	53.80
Normal depth top Width (ft):	53.24
Capacity at normal depth (cfs):	**528.00**
Normal velocity (v_n) (fps):	4.8
Froude number:	0.58
Full Depth Calculations	
Full depth area (A) (ft^2):	180.00
Full depth wetted perimeter (P) (ft):	65.79
Full depth top width (ft) :	65.00
Capacity at full depth (cfs) :	**1041.54**
Minimum freeboard (ft):	1.00
Design freeboard (ft) :	1.18

WATER QUALITY POND PC1 OVERFLOW CHANNEL

Q100=528 CFS

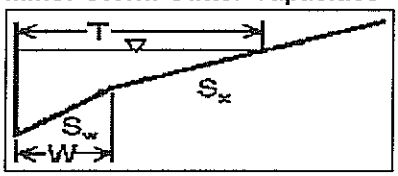


MANNING'S ROUGHNESS COEFFICIENT (n) = 0.040
LONGITUDINAL SLOPE = 0.634%

APPENDIX C
MINOR STORM STREET CALCULATIONS

Minor Storm Gutter Capacities

Colliers Hill Filing 2A
Job # 2020-42



$Q = Q_S / (1 - E_0)$

$E_0 = (1 + [(S_W / S_X) / ([1 + (S_W / S_X) / (T / W - 1)]^{8/3} - 1)])^{-1}$

$Q_S = (0.56 / n) * S_X^{5/3} * S_L^{1/2} * T_S^{8/3}$

$T_S = (T - W)$

ST-6, USDCM
ST-7, USDCM
ST-1, USDCM

Local Streets - No curb overtopping. Flow may spread to crown of street.

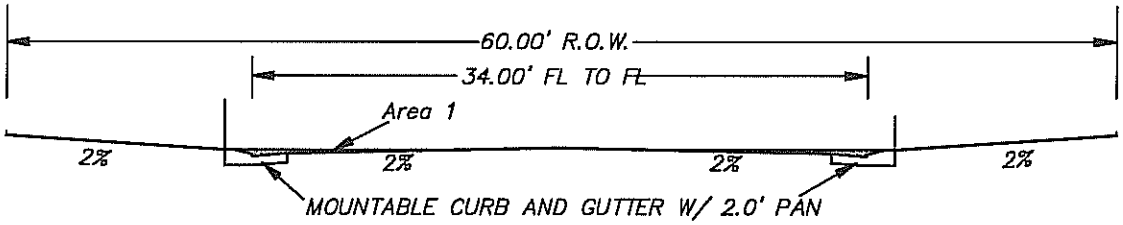
Basin	Q_2 (cfs)	Characteristics		Inputs							Calculations		
		FL - CL Width (ft)	Curb Type	S_X (ft/ft)	S_W (ft/ft)	T (ft)	W (ft)	S_L (ft/ft)	n	Reduction Factor	E_0	Q_S (cfs)	Allowable Gutter Capacity (cfs)
C10	3.37	17.0	Mountable	0.020	0.083	10.33	2.00	0.0194	0.016	1.00	0.562	2.05	4.68
C11	0.90	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C12	0.73	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C13	1.49	17.0	Mountable	0.020	0.083	10.33	2.00	0.0200	0.016	1.00	0.562	2.08	4.75
C14	2.28	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C14A	2.27	17.0	Mountable	0.020	0.083	10.33	2.00	0.0194	0.016	1.00	0.562	2.05	4.68
C15	1.88	17.0	Mountable	0.020	0.083	10.33	2.00	0.0200	0.016	1.00	0.562	2.08	4.75
C24	1.16	18.0	Vertical	0.020	0.083	8.00	2.00	0.0143	0.016	1.00	0.688	0.73	2.35
C25	1.27	18.0	Vertical	0.020	0.083	8.00	2.00	0.0080	0.016	1.00	0.688	0.55	1.76
C26	1.17	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C27	1.37	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C28	0.82	17.0	Mountable	0.020	0.083	10.33	2.00	0.0100	0.016	1.00	0.562	1.47	3.36
C29	1.53	18.0	Vertical	0.020	0.083	13.00	2.00	0.0270	0.016	0.82	0.456	5.07	7.65
C30	1.34	18.0	Vertical	0.020	0.083	13.00	2.00	0.0270	0.016	0.82	0.456	5.07	7.65

HURST & ASSOCIATES, INC.
CONSULTING ENGINEERS
2500 Broadway, Suite B
Boulder, Colorado 80304 (303) 449-9105

JOB 2020-42, Colliers Hill, Filing 2A
CALCULATED BY JR DATE 05/01/2017
CHECKED BY _____ DATE _____
SCALE: NTS SHEET NO. _____ OF _____

STREET CAPACITY ANALYSIS: MINOR STORM EVENT

LOCAL STREEET: 60 FOOT R.O.W. (MOUNTABLE CURBS)



Allowable Depth at FL = 0.375'

AREA 1: 1.79 S.F.
WET PERIMETER: 13.54 FEET
n: 0.016

$$Q_{allow.} = \frac{1.486}{n}(A)\left(\frac{A}{W.P.}\right)^{2/3} S^{1/2} * \text{Reduction Factor}$$

$$Q_{allow.} = 43.14 * S^{1/2} * \text{Reduction Factor}$$

Street Slope	Reduction Factor	Q_{ALLOW} (1/2 Street)
0.50% (min.)	1.0	3.05 cfs
0.70%	1.0	3.61 cfs
1.10%	1.0	4.52 cfs
1.53%	1.0	5.34 cfs
2.08%	0.97	6.04 cfs
3.37%	0.68	5.39 cfs
4.18%	0.56	4.94 cfs

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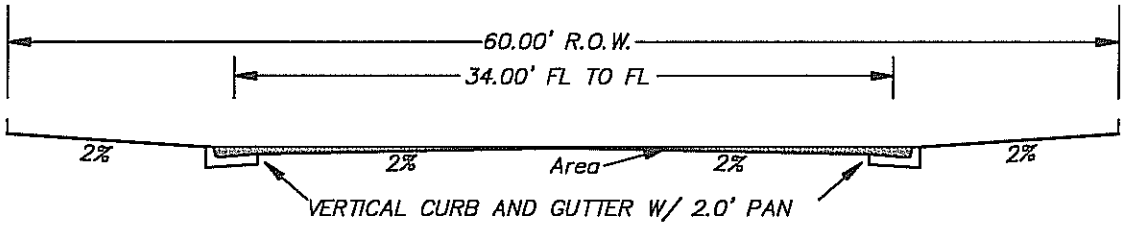
JOB 2020-41, COLLIERS HILL, FILING 2A
CALCULATED BY JR DATE 05/01/2017
CHECKED BY _____ DATE _____
SCALE: NTS SHEET NO. _____ OF _____

STREET CAPACITY ANALYSIS: MINOR STORM EVENT

LOCAL STREEET: 60 FOOT R.O.W. (VERTICAL CURBS)



Allowable Depth at FL = 0.50'

AREA: 7.52 S.F.
WET PERIMETER: 35.13 FEET
n: 0.016

$$Q_{allow.} = \frac{1.486}{n}(A)\left(\frac{A}{W.P.}\right)^{2/3} S^{1/2} * \text{Reduction Factor}$$

$$Q_{allow.} = 249.93 * S^{1/2} * \text{Reduction Factor}$$

Street Slope	Reduction Factor	QALLOW
0.50% (min.)	1.0	17.67 cfs
1.05%	1.0	25.61 cfs
1.28%	1.0	28.28 cfs
1.99%	1.0	35.26 cfs

APPENDIX D
INLET ANALYSIS

Type 'R' Inlet Analysis - Two Year Minor Storm

Structure Number	Basins	Contributing Basin 2-Yr. Flows (cfs)	Upstream Inlet By-Pass Flows (cfs)	2-Yr. Design Flow (cfs)	Curb Type	Depth of Flow (ft)	Condition	Grade (%)	Type 'R' Inlet Size	Capacity (cfs)	2-Yr. By-Pass Flows (cfs)
SC-31	C12, C13	2.22	0	2.22	Mountable	0.50	Sump	-	5 Foot	5.0	0.00
SC-33	C14, C15	4.16	0	4.16	Mountable	0.50	Sump	-	5 Foot	5.0	0.00
SC-36	C11	0.90	0	0.90	Mountable	0.50	Sump	-	5 Foot	5.0	0.00
SC-38	C10	3.37	0	3.37	Mountable	0.50	Continuous	1.9	5 Foot	4.5	0.00
SC-39	C14A	2.27	0	2.27	Mountable	0.50	Continuous	1.9	5 Foot	4.5	0.00
SC-77A	C26, C27	2.54	0	2.54	Mountable	0.50	Sump	-	5 Foot	5.0	0.00
SC-83	C28	0.82	0	0.82	Mountable	0.50	Sump	-	5 Foot	5.0	0.00

Job # 2020-42

Type 'R' Inlets - Sump Condition - 0.5 Foot Allowable Depth

5' Type 'R' Inlet Allowable Capacity from Figure 806 = 5.00 cfs
10' Type 'R' Inlet Allowable Capacity from Figure 806= 10.50 cfs
15' Type 'R' Inlet Allowable Capacity from Figure 806= 16.50 cfs

5 Foot Type 'R' Inlets - Continuous Grade - 0.5 Foot Allowable Depth

Street Grade	Figure 805 Allowable Capacity (cfs)	Figure 805 Reduction Factor	Figure 805 Theoretical Capcity (cfs)	Design Reduction Factor	Design Capcity (cfs)
0.8	3.80	0.88	4.32	0.90	3.89
1.0	4.00	0.88	4.55	0.90	4.09
1.1	4.05	0.88	4.60	0.90	4.14
1.2	4.10	0.88	4.66	0.90	4.19
1.3	4.15	0.88	4.72	0.90	4.24
1.4	4.20	0.88	4.77	0.90	4.30
1.5	4.20	0.88	4.77	0.90	4.30
1.6	4.25	0.88	4.83	0.90	4.35
1.7	4.30	0.88	4.89	0.90	4.40
1.8	4.35	0.88	4.94	0.90	4.45
1.9	4.40	0.88	5.00	0.90	4.50
2.0	4.40	0.88	5.00	0.90	4.50
2.1	4.40	0.88	5.00	0.90	4.50
2.2	4.40	0.88	5.00	0.90	4.50
2.3	4.40	0.88	5.00	0.90	4.50
2.7	4.45	0.88	5.06	0.90	4.55
4.0	4.50	0.88	5.11	0.90	4.60
4.8	4.55	0.88	5.17	0.90	4.65

10 Foot Type 'R' Inlets - Continuous Grade - 0.5 Foot Allowable Depth

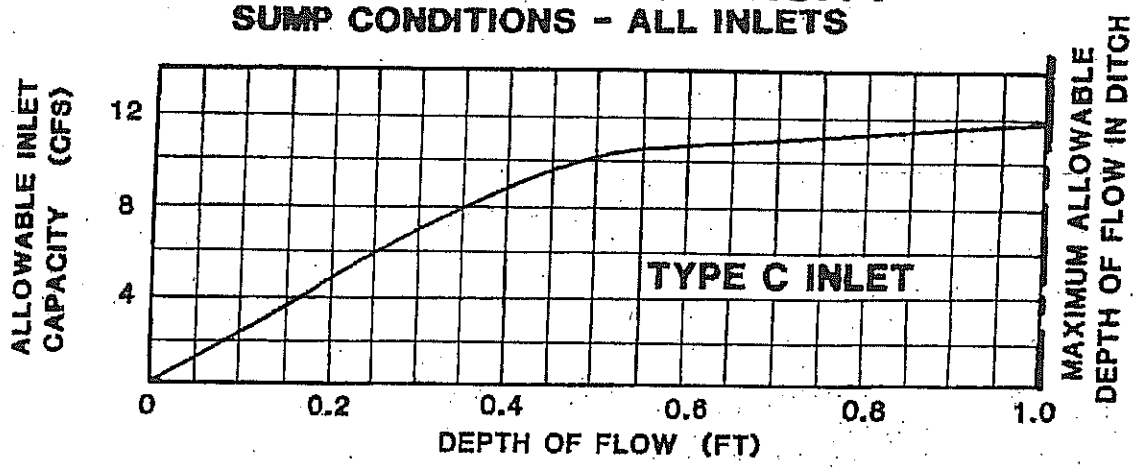
Street Grade	Figure 805 Allowable Capacity (cfs)	Figure 805 Reduction Factor	Figure 805 Theoretical Capcity (cfs)	Design Reduction Factor	Design Capcity (cfs)
0.8	6.60	0.92	7.17	0.90	6.46
1.0	7.40	0.92	8.04	0.90	7.24
1.1	7.48	0.92	8.13	0.90	7.32
1.2	7.56	0.92	8.22	0.90	7.40
1.3	7.64	0.92	8.30	0.90	7.47
1.4	7.72	0.92	8.39	0.90	7.55
1.5	7.80	0.92	8.48	0.90	7.63
1.6	7.84	0.92	8.52	0.90	7.67
1.7	7.88	0.92	8.57	0.90	7.71
1.8	7.92	0.92	8.61	0.90	7.75
1.9	7.96	0.92	8.65	0.90	7.79
2.0	8.00	0.92	8.70	0.90	7.83
2.1	8.00	0.92	8.70	0.90	7.83
2.2	8.00	0.92	8.70	0.90	7.83
2.3	8.00	0.92	8.70	0.90	7.83
2.7	7.90	0.92	8.59	0.90	7.73
4.0	7.80	0.92	8.48	0.90	7.63
4.8	7.70	0.92	8.37	0.90	7.53

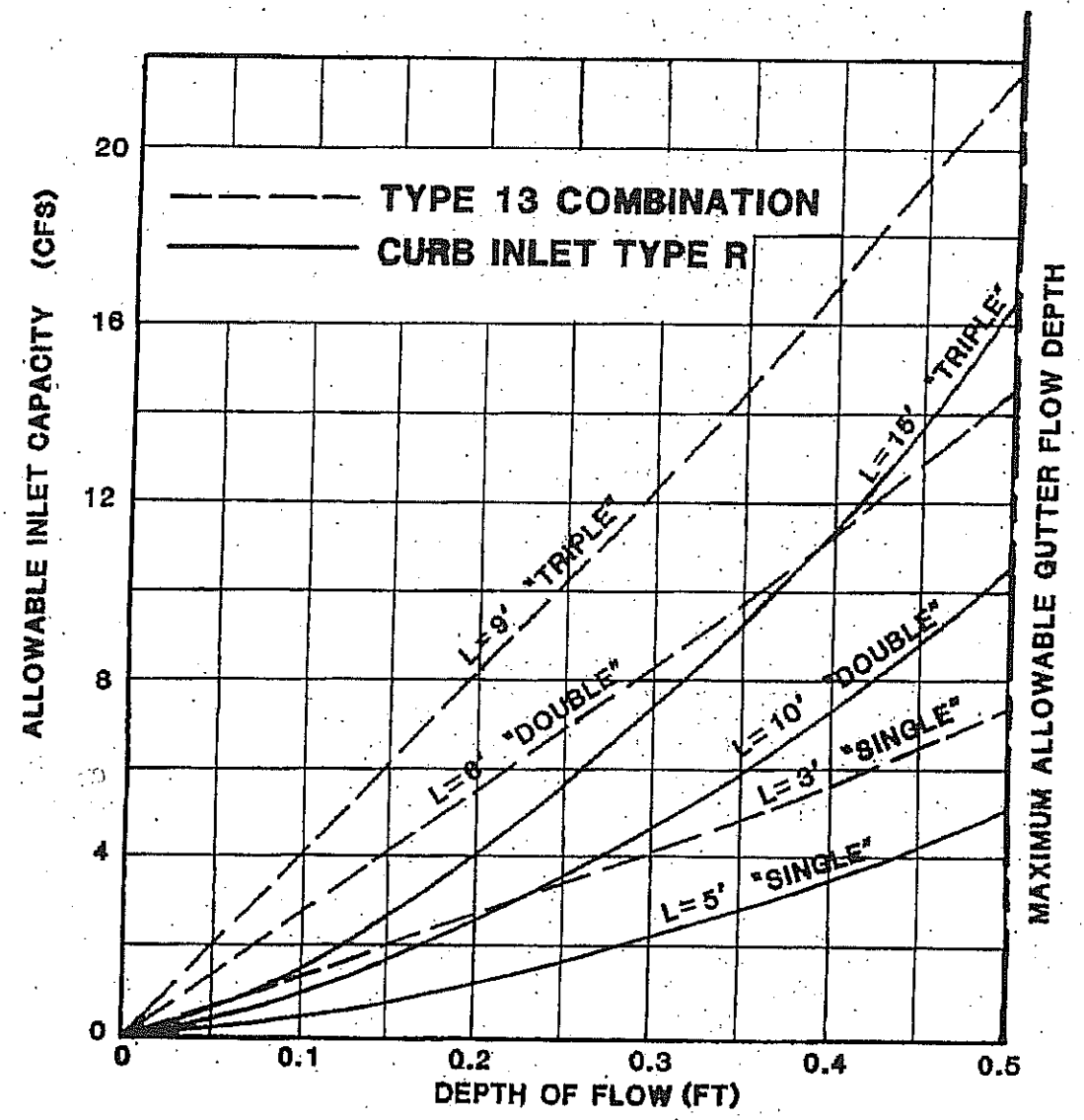
BOULDER COUNTY
STORM DRAINAGE CRITERIA MANUAL

FIGURE 806

ALLOWABLE INLET CAPACITY

SUMP CONDITIONS - ALL INLETS

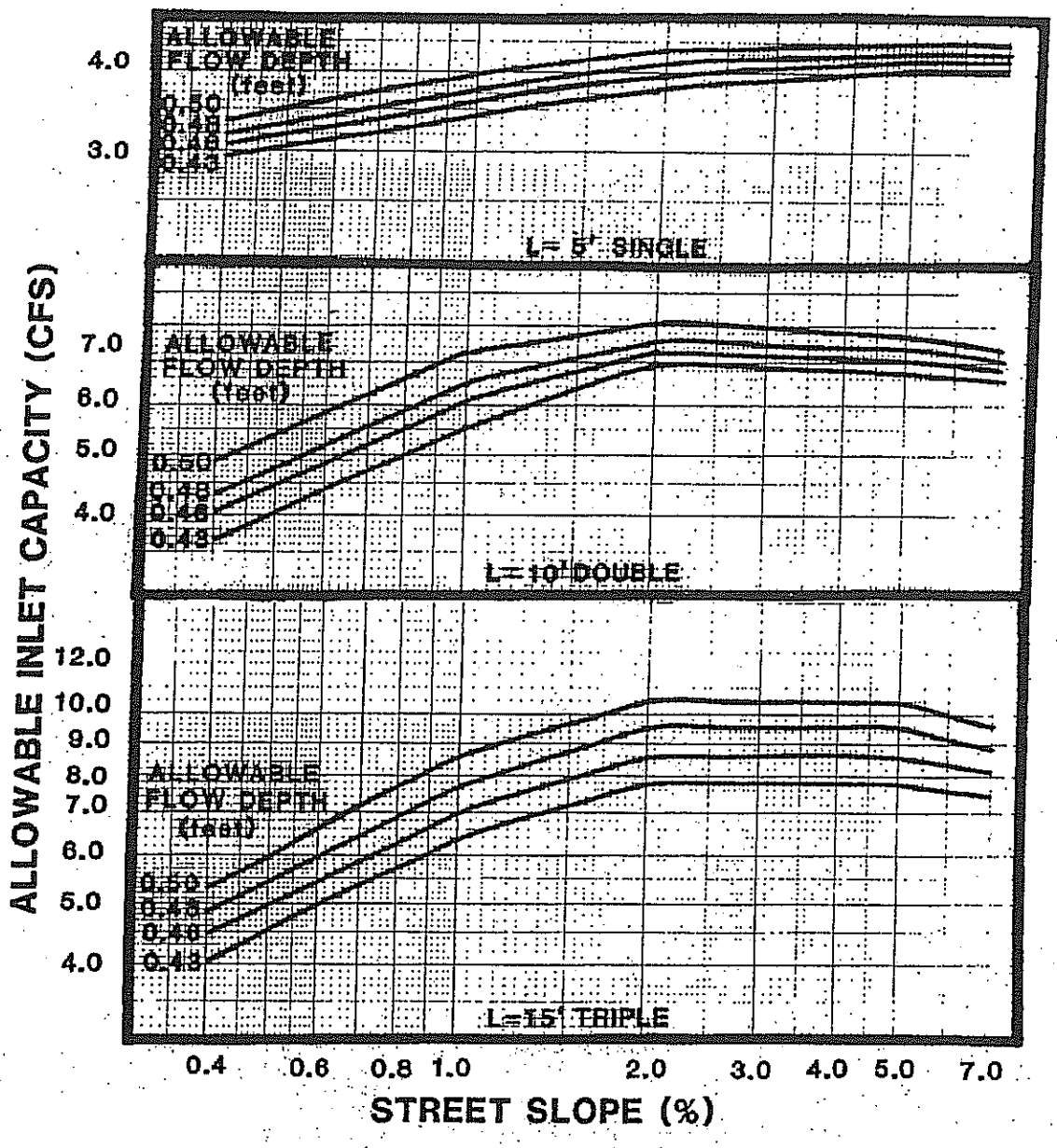




WRC. ENG.

REFERENCE: WRC ENGINEERING, INC., TM-2 FEB 1984

ALLOWABLE INLET CAPACITY
TYPE - R CURB OPENING ON A CONTINUOUS GRADE



NOTES:
1. Maximum inlet capacity at maximum allowable flow depth. Proportionally reduce for other depths.
2. Allowable capacity =
   88% (L=5')
   92% (L=10')
   95% (L=15')

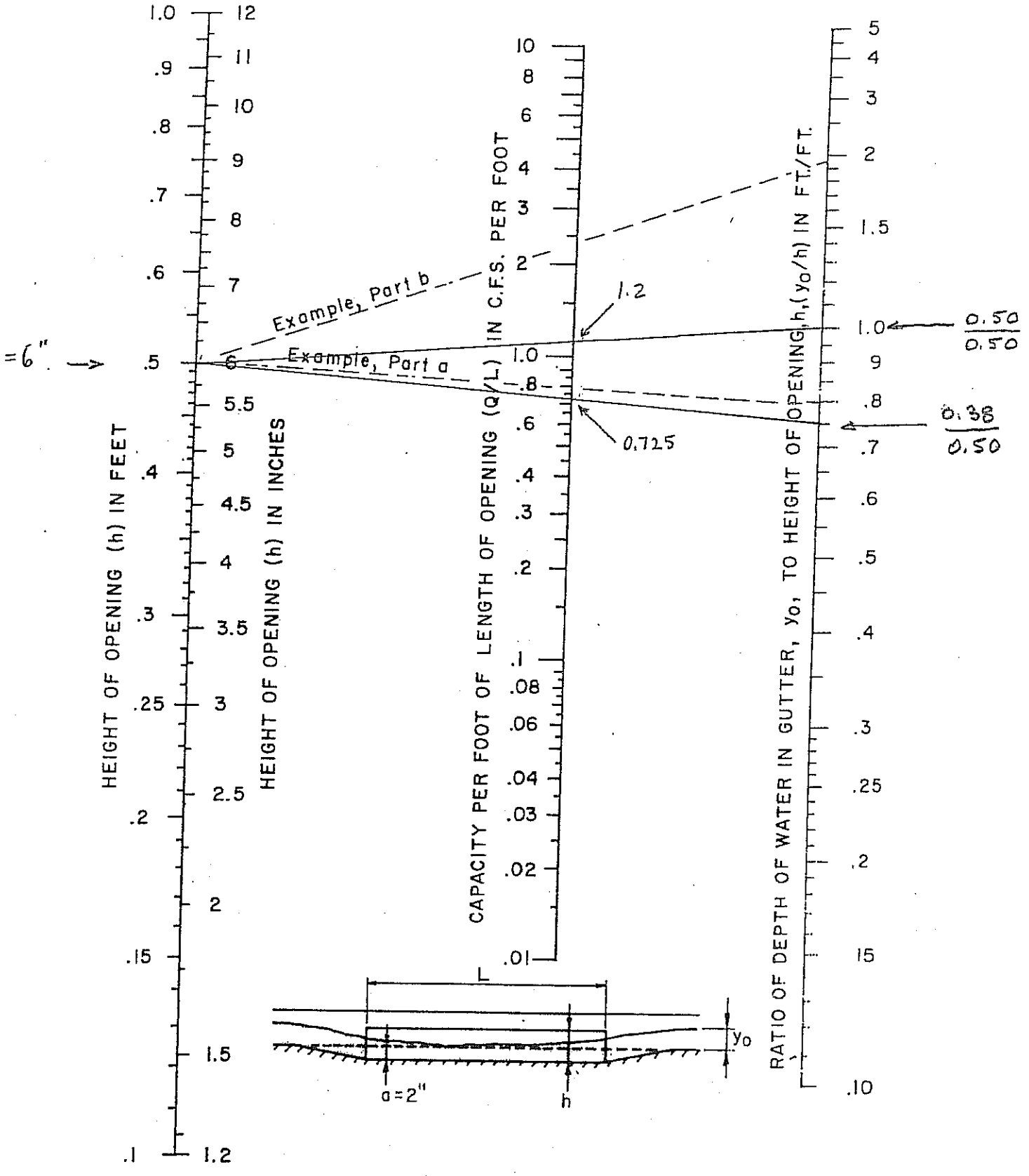


FIGURE 3-1. NOMOGRAPH FOR CAPACITY OF CURB OPENING INLETS IN SUMPS, DEPRESSION DEPTH 2"

Adopted from Bureau of Public Roads Nomograph.

APPENDIX E
STORM PIPE ANALYSIS

STORM PIPE SYSTEM C2
2-YEAR ANALYSIS

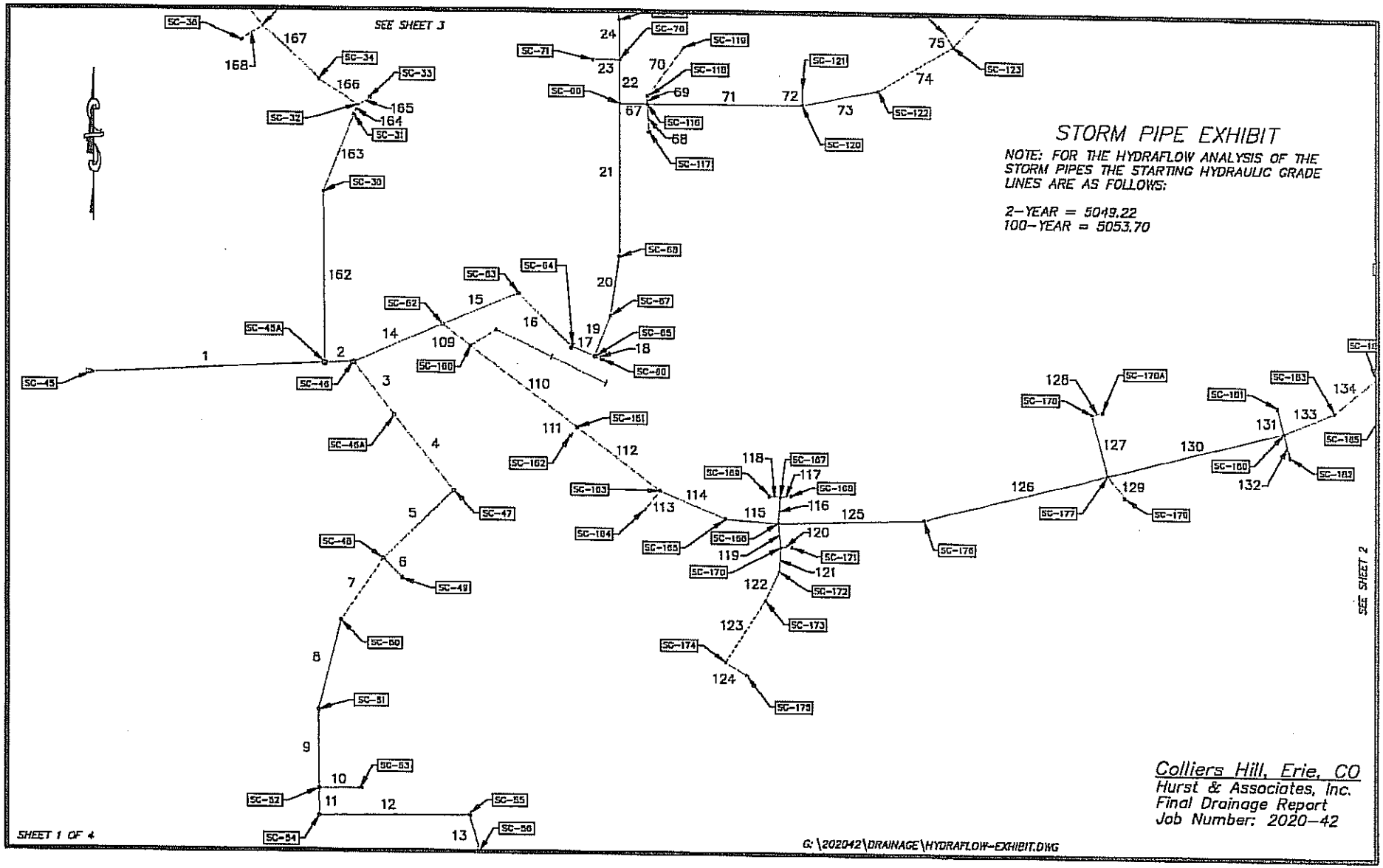
Storm Pipe Sizing - 2 Year Minor Storm Event

Colliers Hill Filing 2A

Intensity = $28.5 * P_1 / ((10 + T_C)^{0.786})$ RA-3, USDCM Vol. 1 Job # 2020-42

Town of Erie 2-Year One-Hour Rainfall Depth= 1.01 inches

Upstream & Downstream Design Points		Onsite Basins	Area (acres)	C_2	Slope (ft/ft)	Length (ft)	Routed T_C			T_c (min)	I_2 (in/hr)	2-Year Design Flow (cfs)	Pipe Size (in)	Pipe Capacity (cfs)
							Route	T_i (min)	T_t (min)					
SC-39	SC-37	C14A	2.31	0.40	0.0213	25.85	C14A	12.8	0.0	12.8	2.47	2.27	18	15.33
SC-38	SC-37	C10	3.81	0.40	0.0100	17.00	C10	16.2	0.0	16.2	2.21	3.37	18	10.50
SC-37	SC-35	C10, C14A	6.11	0.40	0.0174	267.30	SC-38	16.2	0.1	16.2	2.21	5.40	18	13.86
SC-36	SC-35	C11	0.76	0.40	0.0107	42.19	C11	8.0	0.0	8.0	2.97	0.90	18	10.87
SC-35	SC-34	C10, C11, C14A	6.87	0.40	0.0093	134.38	SC-37	16.2	0.9	17.1	2.15	5.91	18	10.13
SC-34	SC-32	C10, C11, C14A	6.87	0.40	0.0097	82.82	SC-35	17.1	0.4	17.6	2.12	5.84	18	10.35
SC-33	SC-32	C14, C15	4.30	0.40	0.0215	23.25	C14	13.9	0.0	13.9	2.38	4.09	18	15.40
SC-32	SC-31	C10, C11, C14, C14A, C15	11.17	0.40	0.0118	17.00	SC-34	17.6	0.3	17.8	2.11	9.42	18	11.41
SC-31	SC-30	C10-C15	12.73	0.41	0.0287	144.73	SC-32	17.8	0.1	17.9	2.10	10.99	18	17.80
SC-30	SC-45A	C10-C15	12.73	0.41	0.0622	292.85	SC-31	17.9	0.5	18.4	2.08	10.84	18	26.20
SC-45A	SC-45	C10-C15, C20-C43, C45-C63, C65, C70-C106	180.13	0.38	0.0125	417.08	SC-46	30.1	0.2	30.2	1.58	107.41	72	473.50
SC-83	SC-82	C28	0.82	0.40	0.0081	46.83	C28	12.3	0.0	12.3	2.51	0.82	18	9.45
SC-82	SC-81	C28	0.82	0.40	0.0080	150.38	SC-83	12.3	0.2	12.5	2.49	0.81	18	9.40
SC-81	SC-80	C28	0.82	0.40	0.0080	108.08	SC-82	12.5	0.5	13.0	2.45	0.80	18	9.40
SC-80	SC-79	C28	0.82	0.40	0.0080	83.56	SC-81	13.0	0.4	13.3	2.42	0.79	18	9.40
SC-79	SC-78	C28	0.82	0.40	0.0080	75.21	SC-80	13.3	0.3	13.6	2.40	0.78	18	9.40
SC-78	SC-77A	C28	0.82	0.40	0.0079	61.93	SC-79	13.6	0.3	13.9	2.38	0.78	18	9.34
SC-77A	SC-77	C26, C27, C28	3.40	0.40	0.0102	30.25	SC-78	13.9	0.2	14.1	2.36	3.22	18	10.61
SC-77B	SC-77	C26A	0.08	0.05	0.0086	46.26	C26A	5.0	0.0	5.0	3.43	0.01	18	9.74
SC-77	SC-74	C26, C26A, C27, C28	3.48	0.39	0.0095	79.21	SC-77A	14.1	0.1	14.2	2.36	3.21	18	10.24



STORM PIPE EXHIBIT

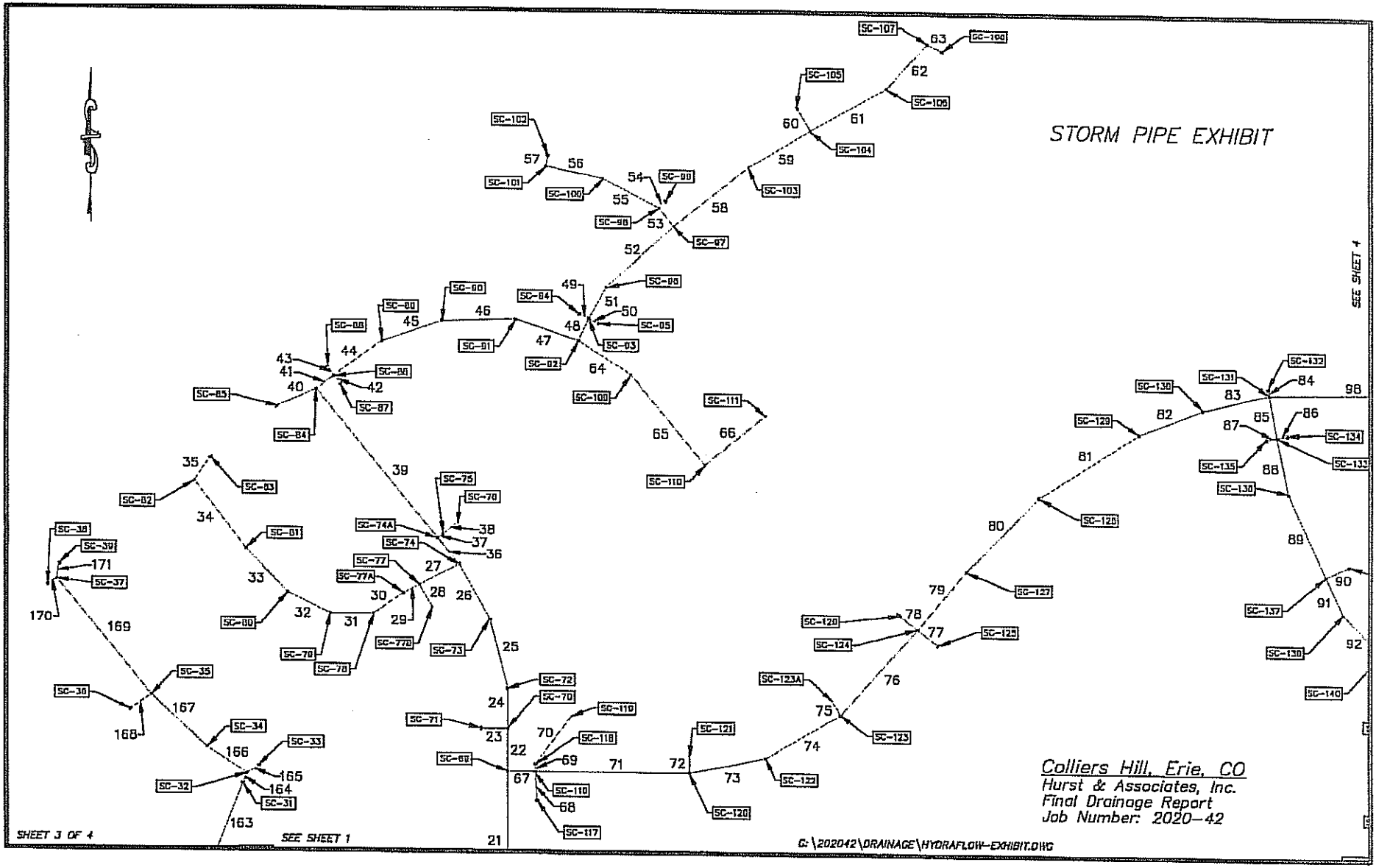
NOTE: FOR THE HYDRAFLOW ANALYSIS OF THE STORM PIPES THE STARTING HYDRAULIC GRADE LINES ARE AS FOLLOWS:

2-YEAR = 5049.22
100-YEAR = 5053.70

SHEET 1 OF 4

G:\202042\DRAINAGE\HYDRAFLOW-EXHIBIT.DWG

Colliers Hill, Erie, CO
Hurst & Associates, Inc.
Final Drainage Report
Job Number: 2020-42


STORM PIPE EXHIBIT
SEE SHEET 4
SEE SHEET 1
SHEET 3 OF 4
Colliers Hill, Erie, CO
Hurst & Associates, Inc.
Final Drainage Report
Job Number: 2020-42
G:\202042\DRAINAGE\HYDRAFLOW-EXHIBIT.DWG

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
23	22	45	-90	Curb	1.16	0.00	0.00	0.0	5082.75	2.12	5083.70	18	Cir	0.013	1.00	5092.68	SC-70 - SC-71
24	22	72	0	MH	28.85	0.00	0.00	0.0	5082.75	0.77	5083.30	30	Cir	0.013	0.28	5093.82	SC-70 - SC-72
25	24	128	-14	MH	29.15	0.00	0.00	0.0	5083.50	0.74	5084.45	30	Cir	0.013	0.30	5094.80	SC-72 - SC-73
26	25	114	-15	MH	29.43	0.00	0.00	0.0	5084.65	0.75	5085.50	30	Cir	0.013	1.00	5095.71	SC-73 - SC-74
27	26	79	-90	MH	3.21	0.00	0.00	0.0	5085.70	1.01	5086.50	18	Cir	0.013	1.00	5096.20	SC-74 - SC-77
28	27	46	-90	Grate	0.01	0.00	0.00	0.0	5086.70	4.97	5089.00	18	Cir	0.013	1.00	5094.00	SC-77 - SC-77B
29	27	30	0	Curb	3.22	0.00	0.00	0.0	5086.70	4.30	5088.00	18	Cir	0.013	0.50	5094.86	SC-77 - SC-77A
30	29	62	-7	MH	0.78	0.00	0.00	0.0	5088.20	4.28	5090.85	18	Cir	0.013	0.64	5096.23	SC-77A - SC-78
31	30	75	36	MH	0.78	0.00	0.00	0.0	5091.05	0.80	5091.65	18	Cir	0.013	0.51	5096.91	SC-78 - SC-79
32	31	84	27	MH	0.79	0.00	0.00	0.0	5091.85	0.80	5092.52	18	Cir	0.013	0.25	5097.81	SC-79 - SC-80
33	32	108	12	MH	0.80	0.00	0.00	0.0	5092.72	0.80	5093.58	18	Cir	0.013	0.15	5098.89	SC-80 - SC-81
34	33	150	7	MH	0.81	0.00	0.00	0.0	5093.78	0.80	5094.98	18	Cir	0.013	0.95	5100.40	SC-81 - SC-82
35	34	47	69	MH	0.82	0.00	0.00	0.0	5095.18	0.81	5095.56	18	Cir	0.013	1.00	5100.06	SC-82 - SC-83
36	26	60	-10	MH	26.81	0.00	0.00	0.0	5085.70	5.40	5088.95	30	Cir	0.013	1.00	5096.21	SC-74 - SC-74A
37	36	10	90	MH	3.80	0.00	0.00	0.0	5089.15	1.00	5089.25	18	Cir	0.013	0.15	5095.88	SC-74A - SC-75
38	37	48	0	Curb	2.74	0.00	0.00	0.0	5089.45	0.94	5089.90	18	Cir	0.013	1.00	5097.29	SC-75 - SC-76
39	36	338	0	MH	24.56	0.00	0.00	0.0	5089.15	1.08	5092.80	30	Cir	0.013	1.00	5098.92	SC-74A - SC-84
40	39	73	-75	MH	1.53	0.00	0.00	0.0	5094.15	0.82	5094.75	18	Cir	0.013	1.00	5098.50	SC-84 - SC-85
41	39	39	90	MH	23.56	0.00	0.00	0.0	5093.00	1.29	5093.50	30	Cir	0.013	1.00	5099.01	SC-84 - SC-86
42	41	17	90	MH	1.29	0.00	0.00	0.0	5094.30	1.18	5094.50	18	Cir	0.013	1.00	5098.51	SC-86 - SC-87
43	41	17	-90	MH	4.50	0.00	0.00	0.0	5094.30	1.18	5094.50	18	Cir	0.013	1.00	5098.52	SC-86 - SC-88
44	41	104	0	MH	18.97	0.00	0.00	0.0	5093.70	1.10	5094.85	30	Cir	0.013	0.34	5100.10	SC-86 - SC-89

Project File: 202042-C3-2YR.stm | Number of lines: 171 | Date: 04-03-2013

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
155	154	17	-90	Curb	4.63	0.00	0.00	0.0	5131.30	1.18	5131.50	18	Cir	0.013	0.68	5136.38	SC-203 - SC-204
156	155	20	23	MH	2.54	0.00	0.00	0.0	5131.70	1.00	5131.90	18	Cir	0.013	1.00	5137.30	SC-204 - SC-205
157	154	73	6	MH	5.65	0.00	0.00	0.0	5131.30	0.83	5131.90	18	Cir	0.013	1.00	5138.41	SC-203 - SC-206
158	157	42	90	MH	5.67	0.00	0.00	0.0	5132.10	0.95	5132.50	18	Cir	0.013	1.00	5137.51	SC-206 - SC-207
159	146	84	-11	MH	1.68	0.00	0.00	0.0	5120.45	1.13	5121.40	18	Cir	0.013	0.24	5127.38	SC-195 - SC-208
160	159	69	-12	MH	1.69	0.00	0.00	0.0	5121.60	1.16	5122.40	18	Cir	0.013	0.97	5128.29	SC-208 - SC-209
161	160	50	74	MH	1.70	0.00	0.00	0.0	5122.60	0.80	5123.00	18	Cir	0.013	1.00	5128.50	SC-209 - SC-210
162	1	308	-90	MH	10.84	0.00	0.00	0.0	5053.40	6.22	5072.55	18	Cir	0.013	0.43	5078.60	SC-45A - SC-30
163	162	145	22	Curb	10.99	0.00	0.00	0.0	5072.75	2.87	5076.90	18	Cir	0.013	0.50	5083.36	SC-30 - SC-31
164	163	17	0	MH	9.42	0.00	0.00	0.0	5077.10	1.17	5077.30	18	Cir	0.013	0.98	5083.83	SC-31 - SC-32
165	164	23	40	Curb	4.09	0.00	0.00	0.0	5077.50	2.15	5078.00	18	Cir	0.013	1.00	5083.15	SC-32 - SC-33
166	164	83	-78	MH	5.84	0.00	0.00	0.0	5077.50	0.97	5078.30	18	Cir	0.013	0.21	5084.50	SC-32 - SC-34
167	166	134	10	MH	5.91	0.00	0.00	0.0	5078.50	0.93	5079.75	18	Cir	0.013	1.00	5085.84	SC-34 - SC-35
168	167	42	-90	Curb	0.90	0.00	0.00	0.0	5079.95	1.07	5080.40	18	Cir	0.013	1.00	5085.16	SC-35 - SC-36
169	167	267	8	MH	5.40	0.00	0.00	0.0	5079.95	1.74	5084.60	18	Cir	0.013	1.00	5090.19	SC-35 - SC-37
170	169	17	-86	Curb	3.37	0.00	0.00	0.0	5084.80	1.00	5084.97	18	Cir	0.013	1.00	5089.72	SC-37 - SC-38
171	169	26	47	Curb	2.27	0.00	0.00	0.0	5084.80	2.13	5085.35	18	Cir	0.013	1.00	5090.10	SC-37 - SC-39

Project File: 202042-C3-2YR.stm | Number of lines: 171 | Date: 04-03-2013

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
	(in)	(cfs)									(ft)											(K)	(ft)
23	18	1.16	5082.75	5086.44	1.50	1.77	0.66	0.01	5086.45	0.012	44.86	5083.70	5086.45	1.50	1.77	0.66	0.01	5086.45	0.012	0.012	0.005	1.00	0.01
24	30	28.85	5082.75	5085.91	2.50	4.91	5.88	0.54	5086.45	0.495	71.57	5083.30	5086.27	2.50	4.91	5.88	0.54	5086.80	0.495	0.495	0.354	0.28	0.15
25	30	29.15	5083.50	5086.42	2.50	4.91	5.94	0.55	5086.96	0.505	127.82	5084.45	5087.06	2.50	4.91	5.94	0.55	5087.61	0.505	0.505	0.646	0.30	0.16
26	30	29.43	5084.65	5087.23	2.50	4.91	6.00	0.56	5087.79	0.515	113.95	5085.50	5087.70	2.20	4.57	6.43	0.64	5088.34	0.464	0.488	0.558	1.00	0.64
27	18	3.21	5085.70	5088.94	1.50	1.77	1.82	0.05	5088.99	0.093	79.21	5086.50	5089.01	1.50	1.77	1.82	0.05	5089.06	0.093	0.093	0.074	1.00	0.05
28	18	0.01	5086.70	5089.11	1.50	1.77	0.01	0.00	5089.11	0.000	46.26	5089.00	5089.11	0.11	0.06	0.17	0.00	5089.11	0.007	0.003	0.002	1.00	0.00
29	18	3.22	5086.70	5089.06	1.50	1.77	1.82	0.05	5089.11	0.094	30.25	5088.00	5089.06	1.05	1.33	2.43	0.09	5089.15	0.133	0.113	0.034	0.50	0.05
30	18	0.78	5088.20	5089.19	0.99	1.24	0.63	0.01	5089.20	0.009	61.93	5090.85	5091.19 j	0.34**	0.30	2.63	0.11	5091.29	0.450	0.230	n/a	0.64	n/a
31	18	0.78	5091.05	5091.34	0.29*	0.24	3.21	0.16	5091.50	0.798	75.21	5091.65	5091.99	0.34**	0.30	2.63	0.11	5092.09	0.450	0.624	n/a	0.51	n/a
32	18	0.79	5091.85	5092.14	0.29*	0.24	3.23	0.16	5092.31	0.802	83.56	5092.52	5092.86	0.34**	0.30	2.63	0.11	5092.97	0.450	0.626	n/a	0.25	0.03
33	18	0.80	5092.72	5093.02	0.30*	0.25	3.24	0.16	5093.18	0.795	108.08	5093.58	5093.92	0.34**	0.30	2.64	0.11	5094.03	0.450	0.623	n/a	0.15	n/a
34	18	0.81	5093.78	5094.08	0.30*	0.25	3.25	0.16	5094.24	0.799	150.38	5094.98	5095.32	0.34**	0.31	2.65	0.11	5095.43	0.450	0.625	n/a	0.95	0.10
35	18	0.82	5095.18	5095.48	0.30*	0.25	3.28	0.17	5095.65	0.808	46.88	5095.56	5095.91	0.35**	0.31	2.66	0.11	5096.02	0.450	0.629	n/a	1.00	0.11
36	30	26.81	5085.70	5088.52	2.50	4.91	5.46	0.46	5088.99	0.428	60.23	5088.95	5090.68 j	1.73**	3.63	7.40	0.85	5091.53	0.628	0.528	n/a	1.00	n/a
37	18	3.80	5089.15	5091.46	1.50	1.77	2.15	0.07	5091.53	0.131	10.02	5089.25	5091.47	1.50	1.77	2.15	0.07	5091.54	0.131	0.131	0.013	0.15	0.01
38	18	2.74	5089.45	5091.52	1.50	1.77	1.55	0.04	5091.56	0.068	47.90	5089.90	5091.55	1.50	1.77	1.55	0.04	5091.59	0.068	0.068	0.033	1.00	0.04
39	30	24.56	5089.15	5091.14	1.99	4.19	5.86	0.53	5091.68	0.378	337.66	5092.80	5094.46 j	1.66**	3.45	7.11	0.79	5095.24	0.594	0.486	n/a	1.00	n/a
40	18	1.53	5094.15	5095.23	1.08	1.36	1.12	0.02	5095.25	0.028	72.94	5094.75	5095.26	0.51	0.53	2.91	0.13	5095.39	0.350	0.189	0.138	1.00	0.13
41	30	23.56	5093.00	5094.89	1.88	3.97	5.93	0.55	5095.43	0.392	38.67	5093.50	5095.12	1.62**	3.37	6.99	0.76	5095.88	0.580	0.486	n/a	1.00	n/a
42	18	1.29	5094.30	5095.86	1.50	1.77	0.73	0.01	5095.87	0.015	17.00	5094.50	5095.87	1.37	1.69	0.76	0.01	5095.88	0.013	0.014	0.002	1.00	0.01
43	18	4.50	5094.30	5095.74	1.44	1.75	2.58	0.10	5095.85	0.160	17.03	5094.50	5095.75	1.25	1.57	2.86	0.13	5095.88	0.178	0.169	0.029	1.00	0.13
44	30	18.97	5093.70	5095.65	1.95	4.11	4.62	0.33	5095.98	0.236	104.45	5094.85	5096.31 j	1.46**	2.97	6.40	0.64	5096.94	0.520	0.378	n/a	0.34	n/a

Project File: 202042-C3-2YR.stm | Number of lines: 172 | Run Date: 02-11-2015

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = clr e = ellip b = box

Hydraulic Grade Line Computations

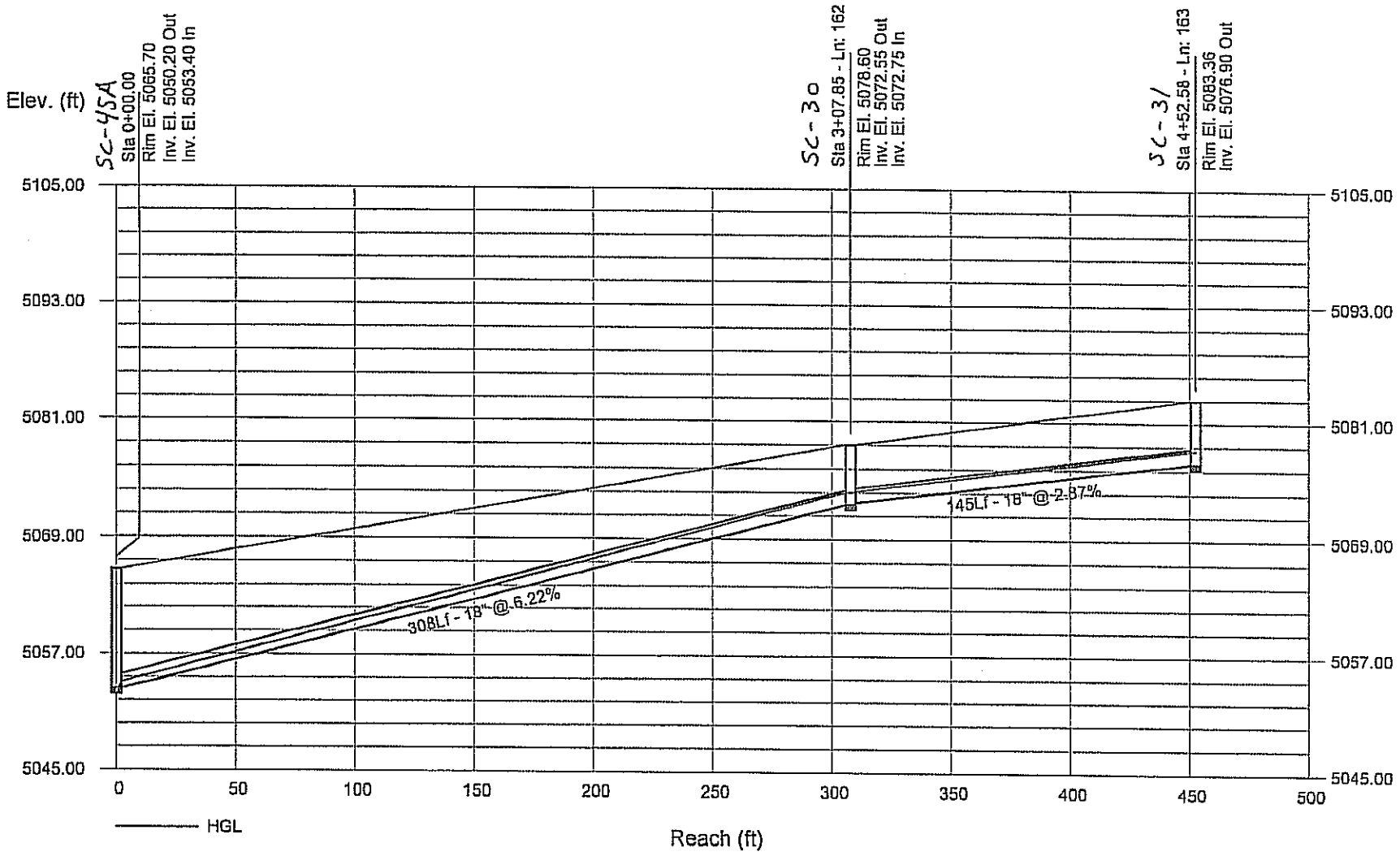
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
	(in)	(cfs)									(ft)											(K)	(ft)
155	18	5.09	5131.30	5132.85	1.50	1.77	2.88	0.13	5132.98	0.235	17.00	5131.50	5132.88	1.38	1.70	2.99	0.14	5133.02	0.204	0.219	0.037	0.68	0.09
156	18	2.61	5131.70	5133.03	1.33	1.66	1.57	0.04	5133.07	0.055	37.42	5132.08	5133.02	0.94	1.17	2.23	0.08	5133.10	0.119	0.087	0.033	0.45	0.03
157	18	5.52	5131.30	5132.85	1.50	1.77	3.12	0.15	5133.01	0.276	72.56	5131.90	5132.98	1.08	1.37	4.04	0.25	5133.24	0.363	0.320	0.232	1.00	0.25
158	18	5.54	5132.10	5133.34	1.24	1.56	3.55	0.20	5133.53	0.275	42.00	5132.50	5133.40 J	0.90**	1.10	5.01	0.39	5133.79	0.620	0.447	n/a	1.00	0.39
159	18	1.98	5120.45	5122.07	1.50	1.77	1.12	0.02	5122.09	0.036	84.14	5121.40	5122.08	0.68	0.78	2.52	0.10	5122.18	0.195	0.115	0.097	0.24	0.02
160	18	1.99	5121.60	5122.19	0.59	0.64	3.10	0.15	5122.34	0.342	69.19	5122.40	5122.94 J	0.54**	0.57	3.49	0.19	5123.13	0.472	0.407	n/a	0.97	0.18
161	18	2.00	5122.60	5123.11	0.51	0.53	3.80	0.22	5123.33	0.597	48.75	5123.09	5123.63	0.54**	0.57	3.49	0.19	5123.82	0.473	0.535	n/a	1.00	n/a
162	18	10.84	5053.40	5054.07	0.67*	0.77	14.11	3.10	5057.17	6.212	307.85	5072.55	5073.81	1.26**	1.58	6.86	0.73	5074.54	1.026	3.619	n/a	0.43	0.31
163	18	10.99	5072.75	5073.94	1.19	1.50	7.33	0.84	5074.77	1.173	144.73	5076.90	5078.17	1.27**	1.59	6.91	0.74	5078.91	1.043	1.108	n/a	0.50	n/a
164	18	9.42	5077.10	5078.47	1.37	1.69	5.58	0.48	5078.95	0.703	17.00	5077.30	5078.48 J	1.17**	1.48	6.35	0.63	5079.10	0.880	0.791	0.134	0.98	0.61
165	18	4.09	5077.50	5079.63	1.50	1.77	2.31	0.08	5079.71	0.152	23.25	5078.00	5079.67	1.50	1.77	2.31	0.08	5079.75	0.152	0.152	0.035	1.00	0.08
166	18	5.84	5077.50	5079.54	1.50	1.77	3.31	0.17	5079.71	0.309	82.82	5078.30	5079.79	1.49	1.77	3.31	0.17	5079.96	0.292	0.301	0.249	0.21	0.04
167	18	5.91	5078.50	5079.83	1.33	1.66	3.57	0.20	5080.03	0.283	134.38	5079.75	5080.68 J	0.93**	1.15	5.15	0.41	5081.09	0.640	0.461	n/a	1.00	n/a
168	18	0.90	5079.95	5081.06	1.11	1.40	0.64	0.01	5081.06	0.009	42.19	5080.40	5081.05	0.65	0.74	1.22	0.02	5081.08	0.047	0.028	0.012	1.00	0.02
169	18	5.40	5079.95	5080.95	0.99	1.24	4.34	0.29	5081.24	0.437	267.30	5084.60	5085.49 J	0.89**	1.09	4.96	0.38	5085.87	0.613	0.525	n/a	1.00	0.38
170	18	3.37	5084.80	5085.81	1.01	1.27	2.65	0.11	5085.92	0.161	17.00	5084.97	5085.78	0.81	0.97	3.49	0.19	5085.97	0.324	0.243	0.041	1.00	0.19
171	18	2.27	5084.80	5085.85	1.04	1.31	1.73	0.05	5085.89	0.068	25.85	5085.35	5085.93 J	0.58**	0.62	3.64	0.21	5086.13	0.481	0.274	n/a	1.00	0.21
172	18	2.64	5132.08	5133.10	1.02	1.28	2.06	0.07	5133.17	0.097	120.81	5132.75	5133.37 J	0.62**	0.69	3.83	0.23	5133.60	0.493	0.295	n/a	1.00	n/a

Project File: 202042-C3-2YR.stm | Number of lines: 172 | Run Date: 02-11-2015

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

Storm Sewer Profile

Proj. file: 202042-C3-2YR.stm



Storm Sewer Profile

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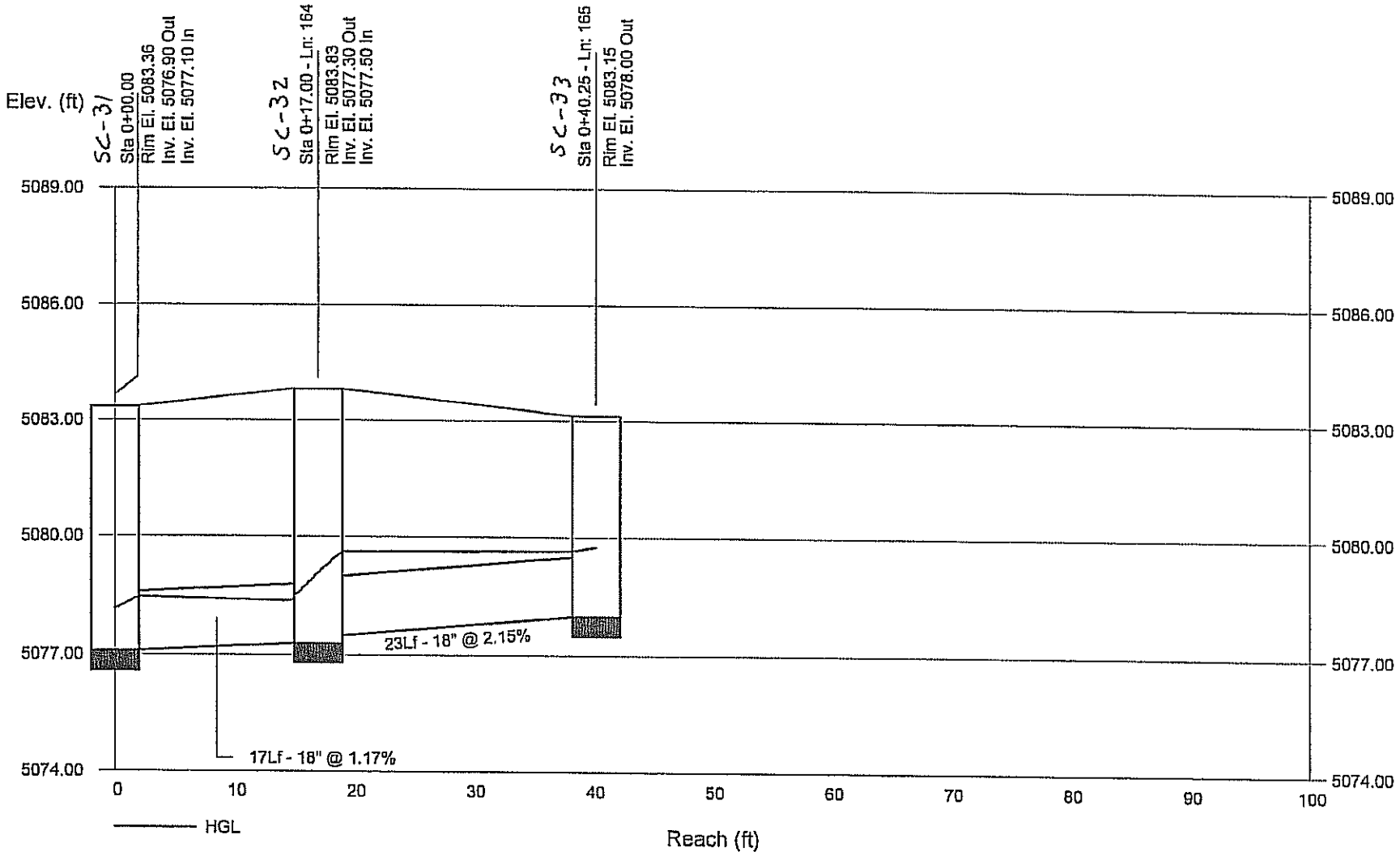

Storm Sewer Profile

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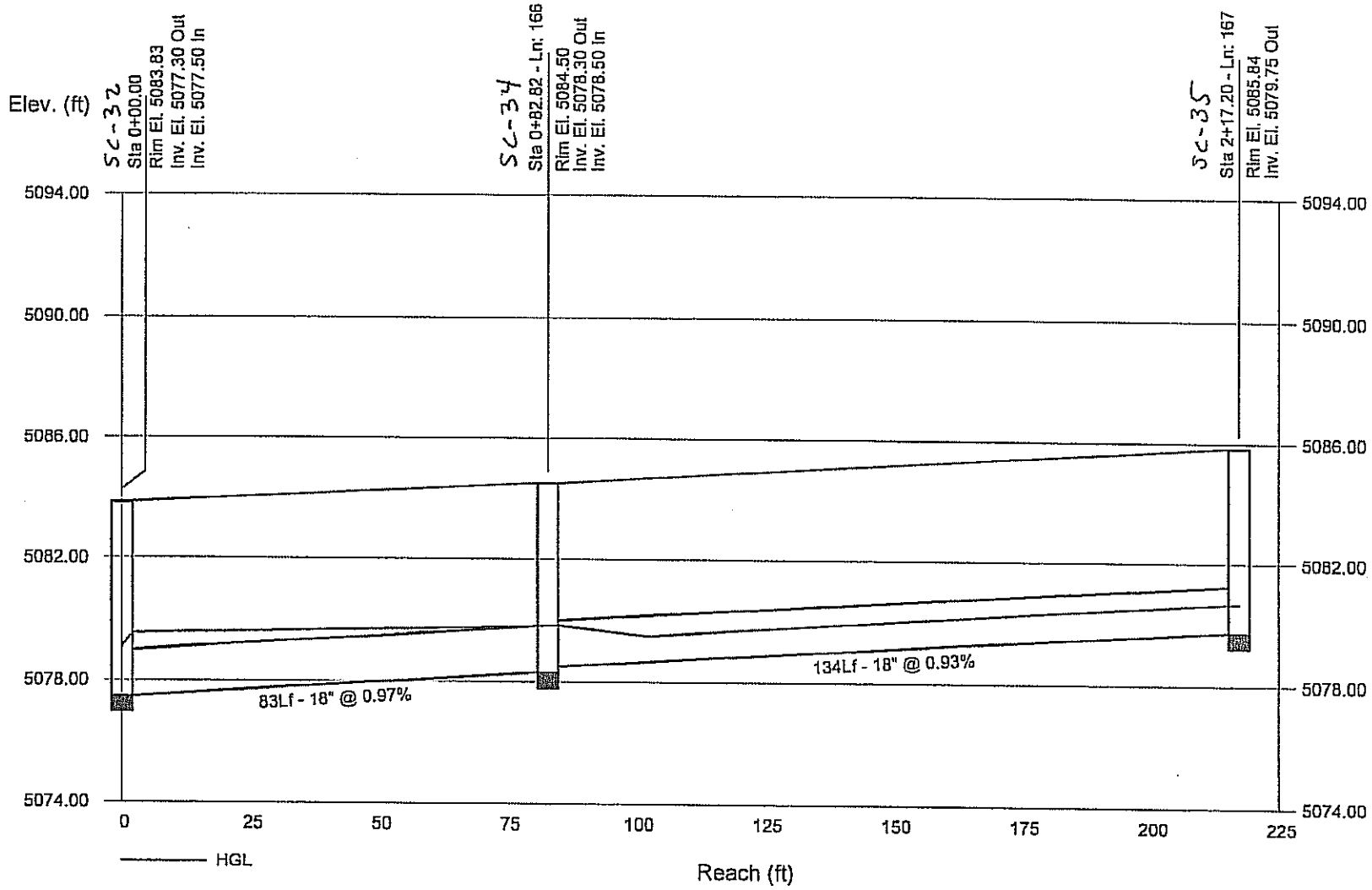

Storm Sewer Profile

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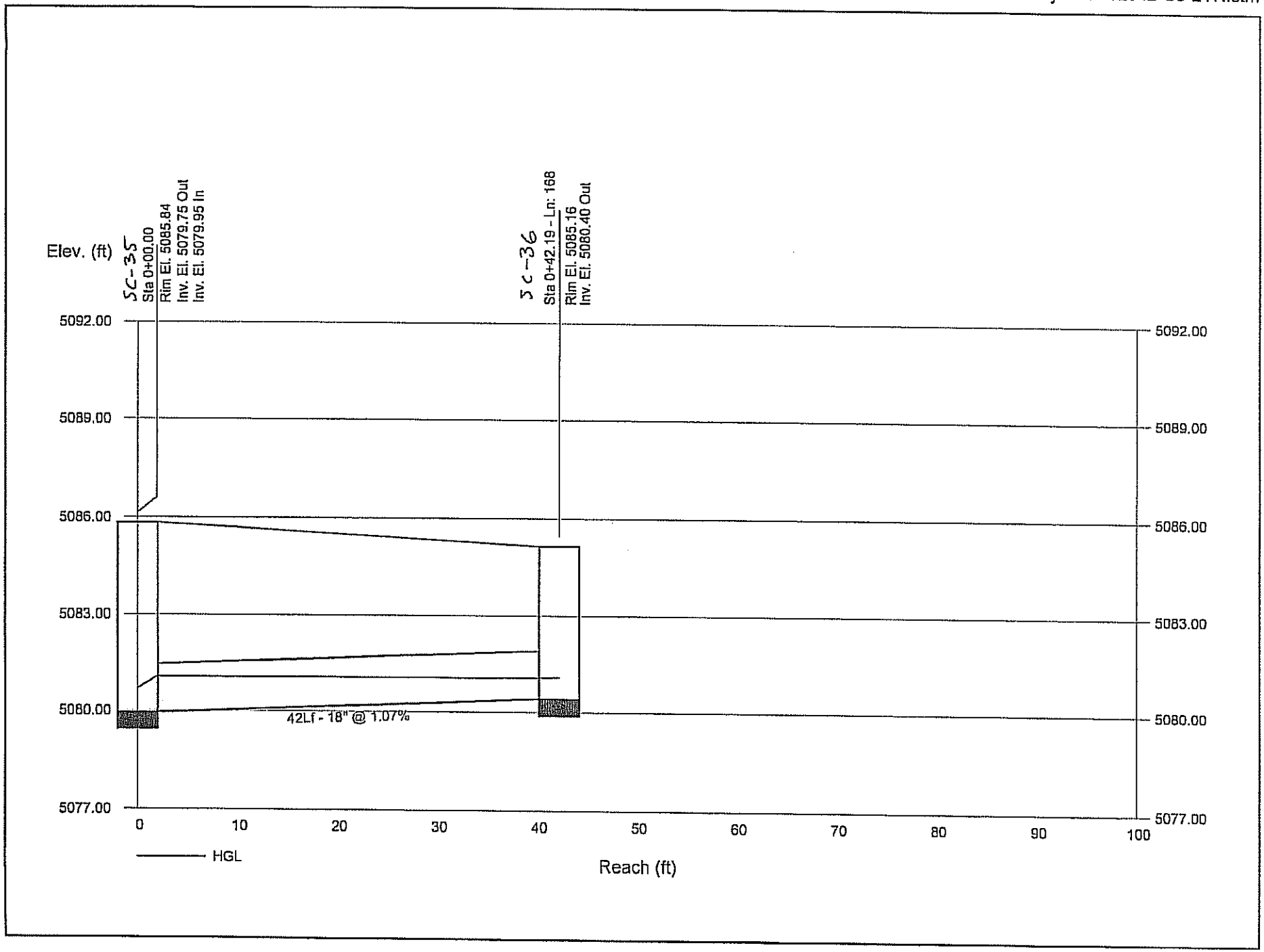
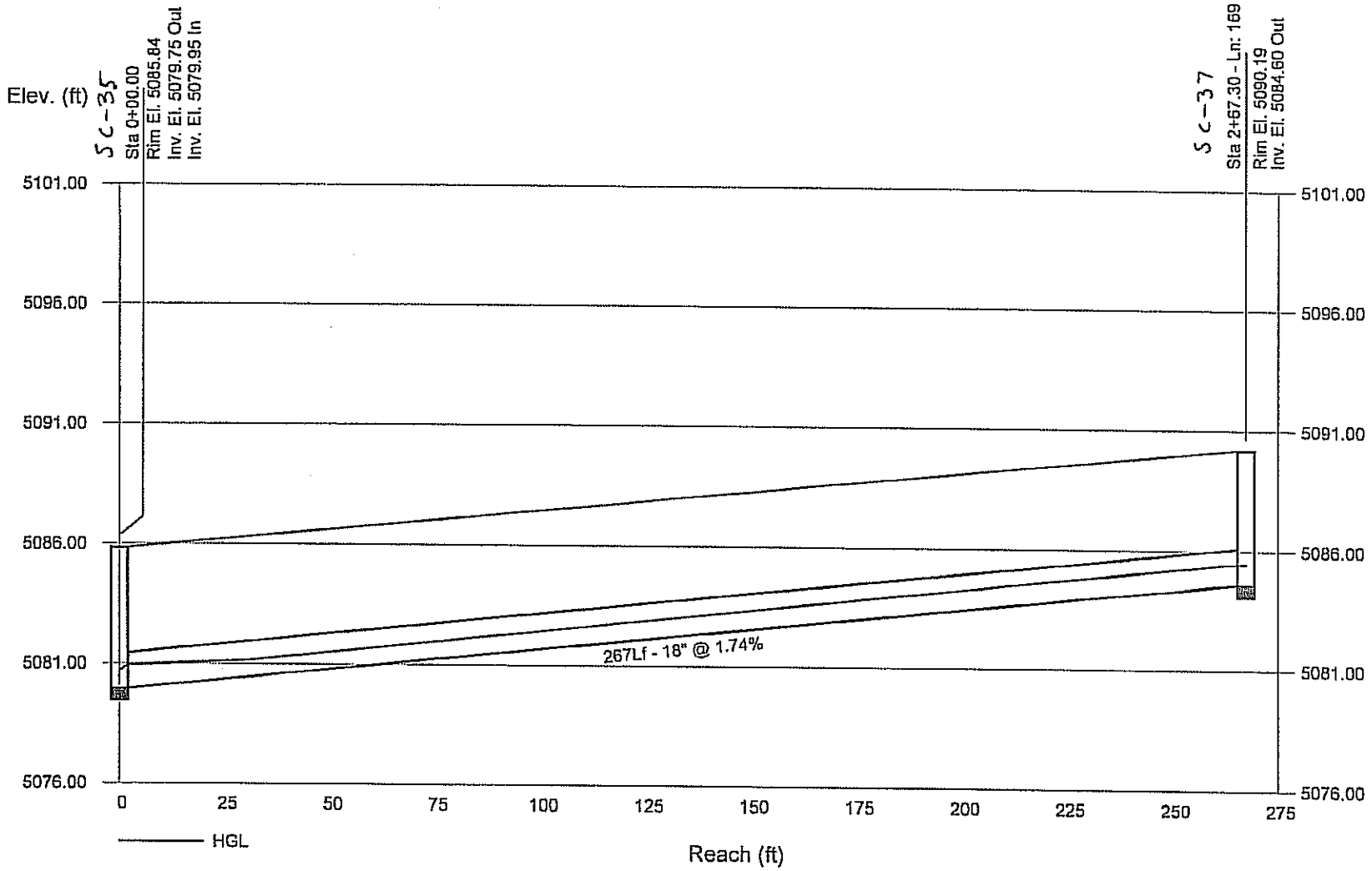


Hydraflow Storm Sewers 2008

Storm Sewer Profile

Proj. file: 202042-C3-2YR.stm



Storm Sewer Profile

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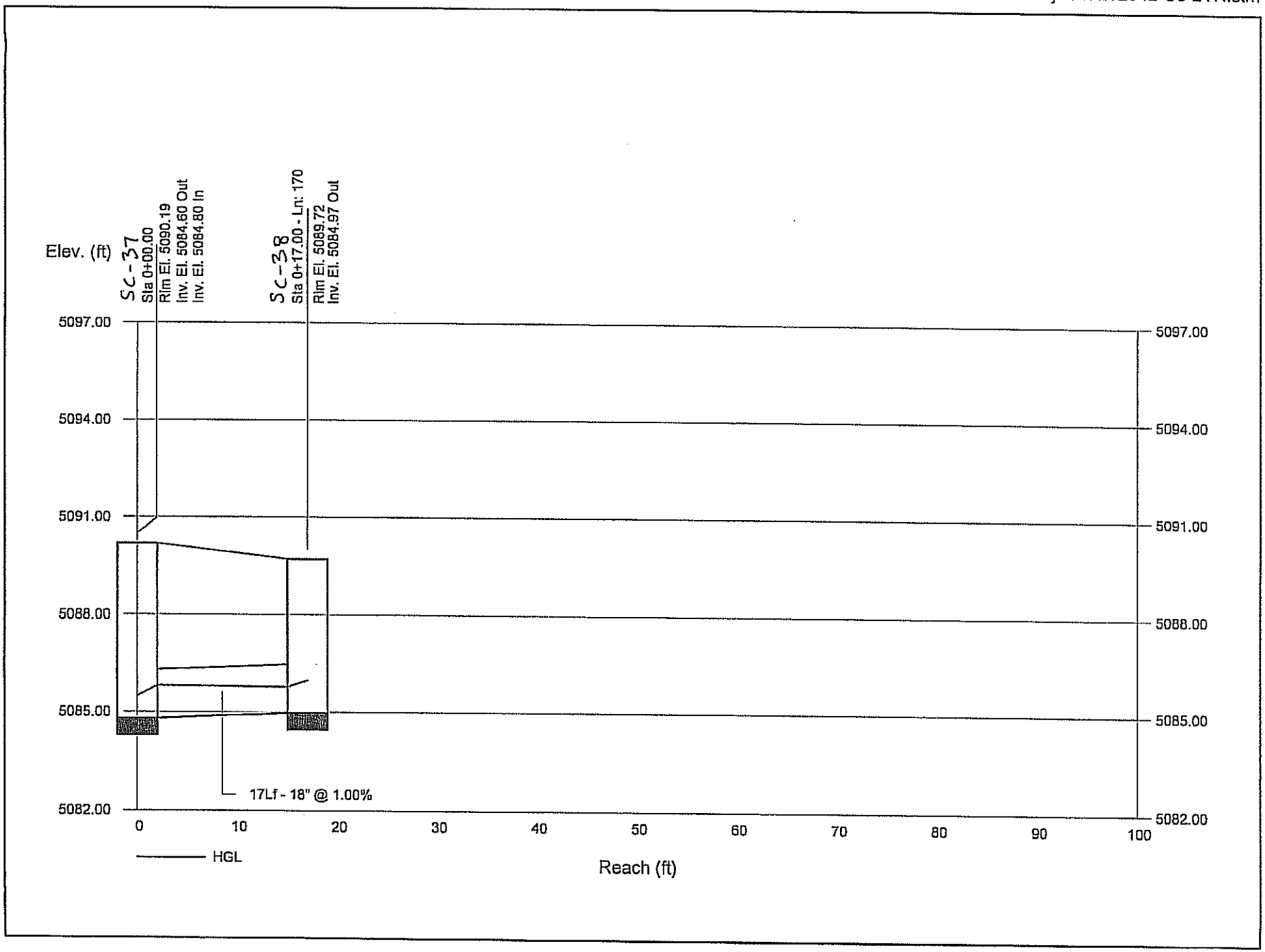

Storm Sewer Profile

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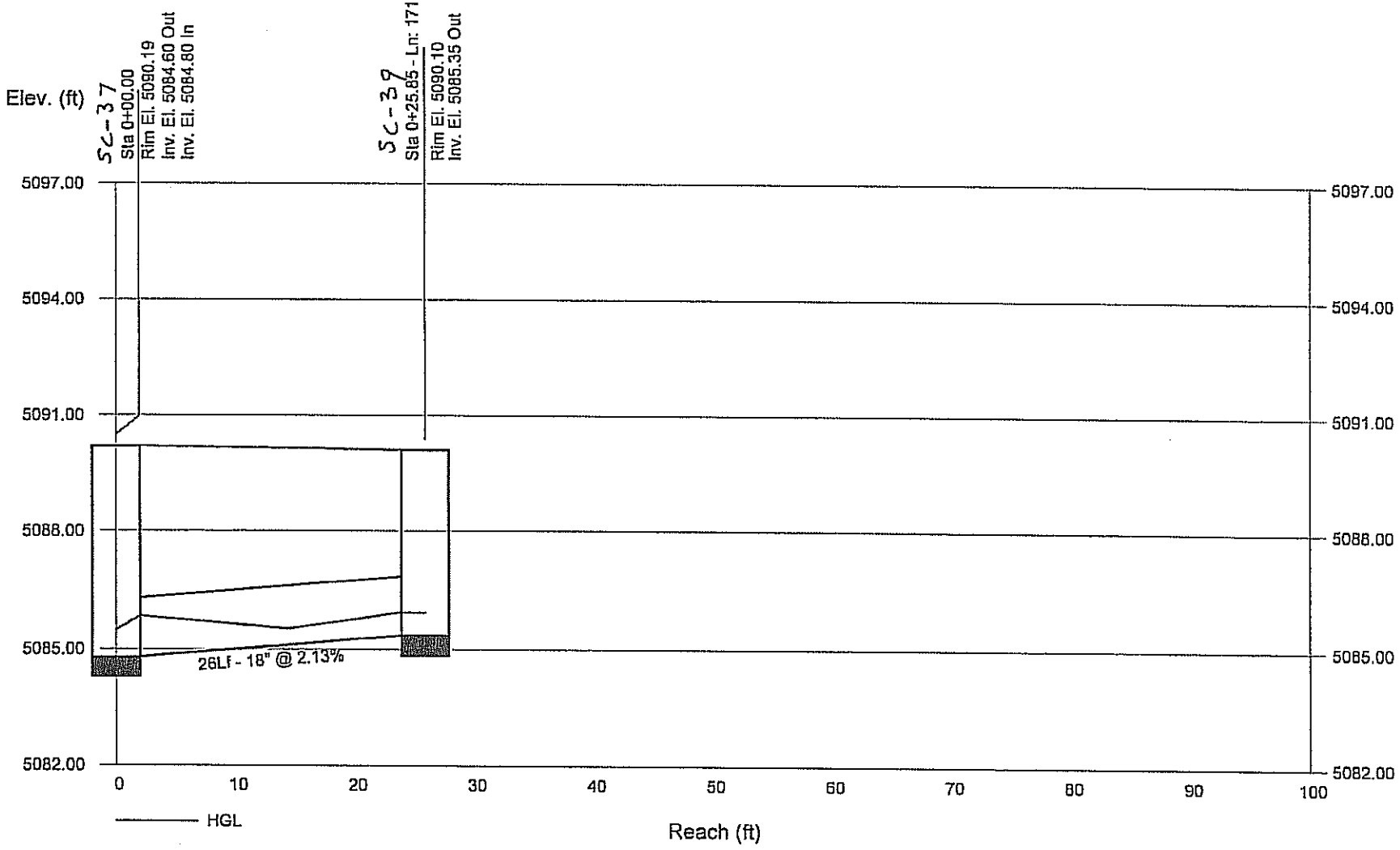

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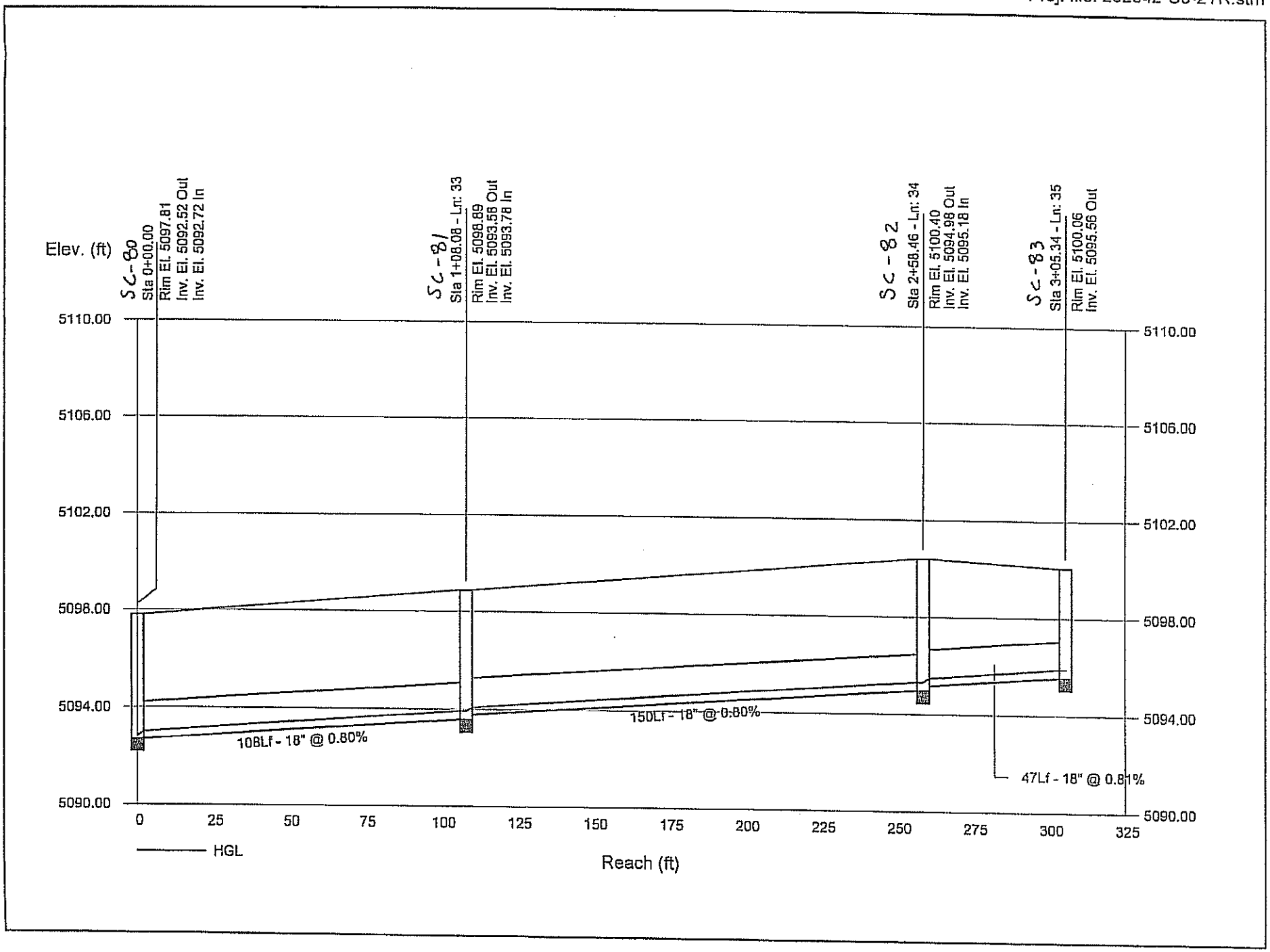

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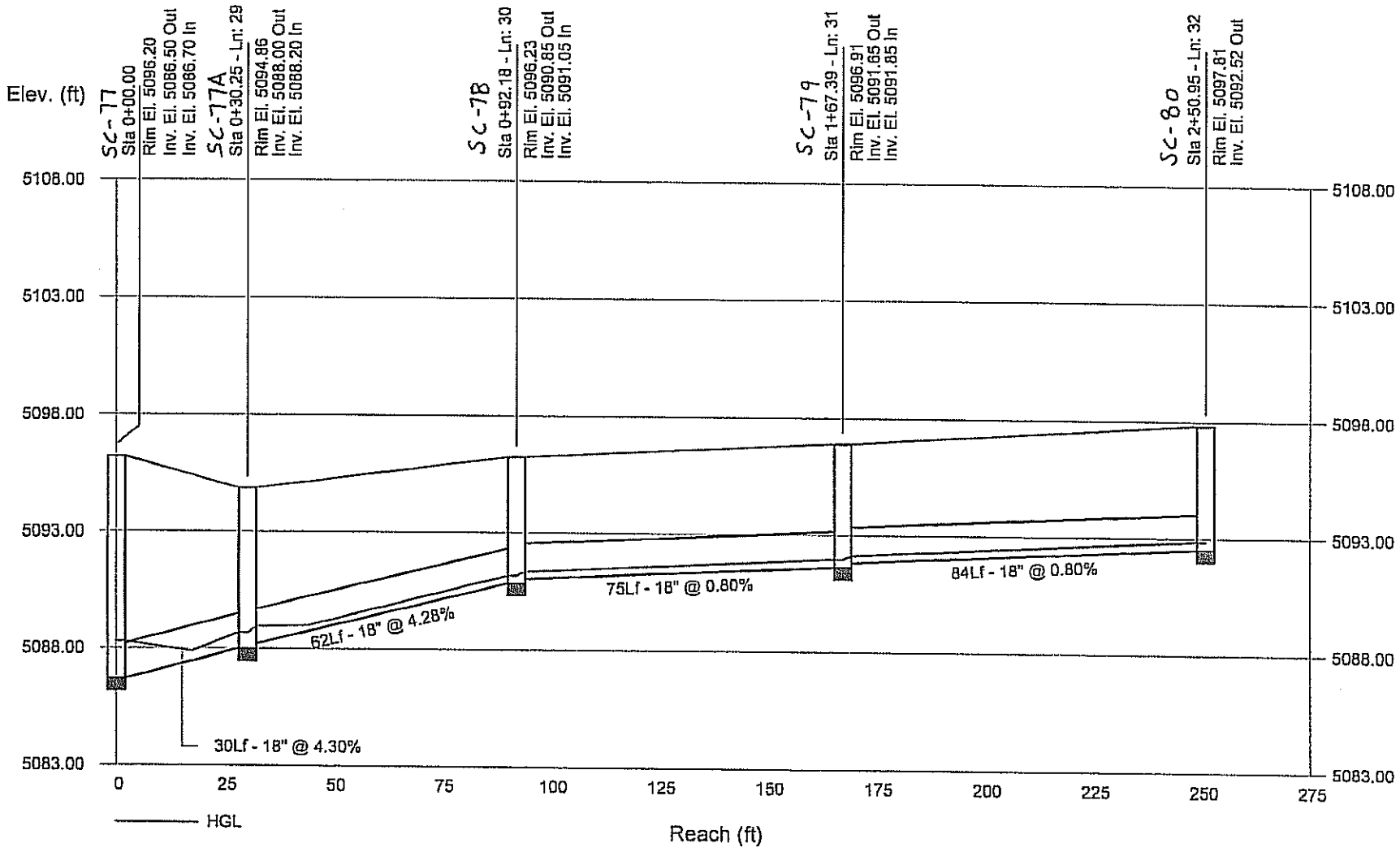

Storm Sewer Profile

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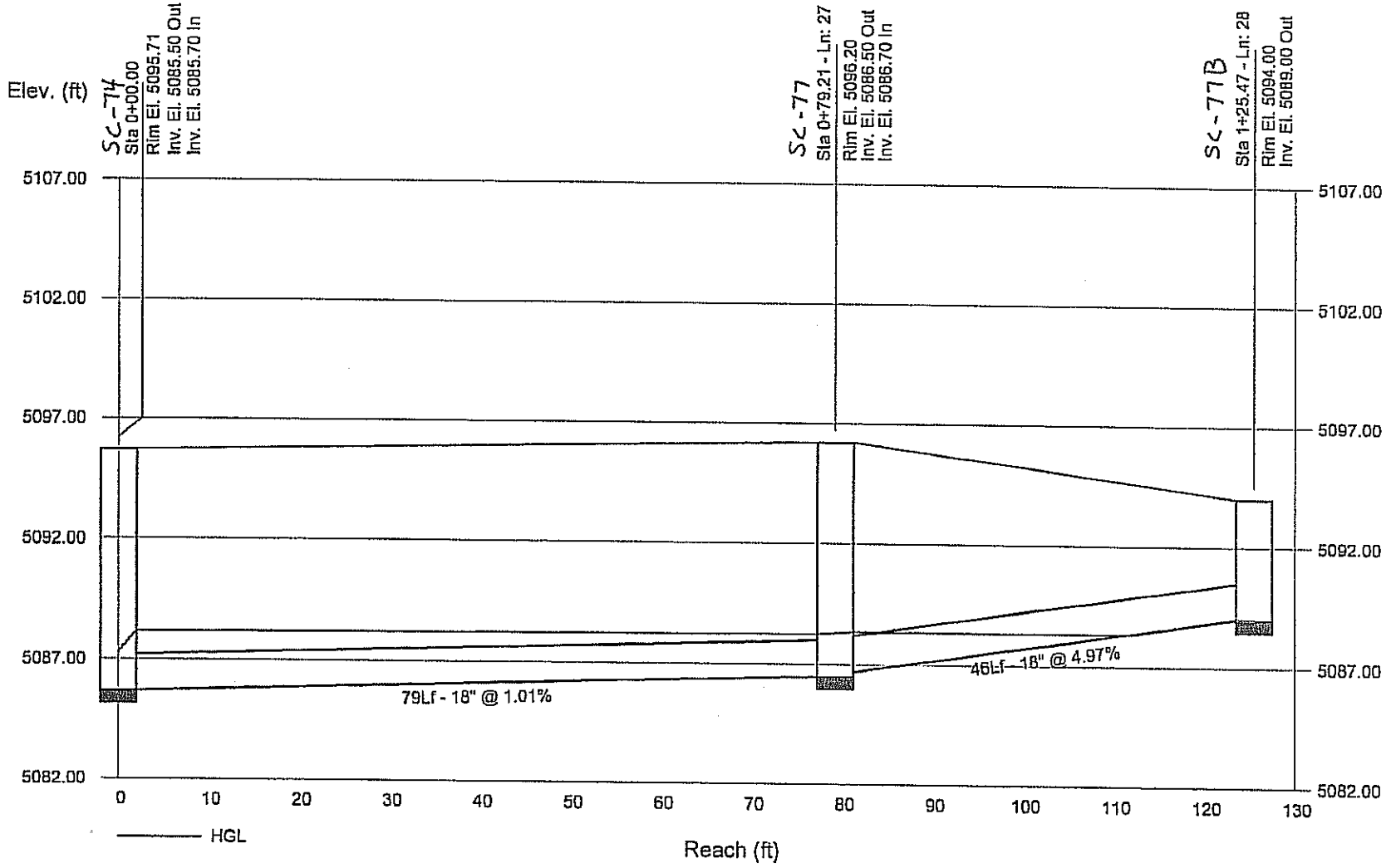


STORM PIPE SYSTEM C2
100-YEAR ANALYSIS

Storm Pipe Sizing - 100 Year Analysis

Job # 2020-42

Upstream & Downstream Design Points		OSP Basins 272 & 273 100-Year Runoff Rates (cfs)	Inlet Capcities		Pipe SC-54 to SC-53 Capacity (cfs)	Pipe SC-160 to SC-62 Capacity (cfs)	Pipe SC-31 to SC-30 Capacity (cfs)	100-Year Design Flow (cfs)	Slope (ft/ft)	Length (ft)	Pipe Size (in)
			SC-54	SC-49							
SC-56	SC-55	204	-	-	-	-	-	204.0	0.0262	65.00	54
SC-55	SC-54	204	-	-	-	-	-	204.0	0.0382	264.56	54
SC-54	SC-52	204	-	-	-	-	-	204.0	0.0081	47.07	54
SC-53	SC-52	-	4.5	-	-	-	-	4.5	0.0739	66.95	18
SC-52	SC-51	204	4.5	-	-	-	-	208.5	0.0080	140.69	54
SC-51	SC-50	204	4.5	-	-	-	-	208.5	0.0060	164.39	54
SC-50	SC-48	204	4.5	-	-	-	-	208.5	0.0060	133.49	54
SC-49	SC-48	-	-	4.2	-	-	-	4.2	0.0631	45.95	18
SC-48	SC-47	204	4.5	4.2	-	-	-	212.7	0.0144	173.52	54
SC-47	SC-46A	204	4.5	4.2	-	-	-	212.7	0.0800	170.00	54
SC-46A	SC-46	204	4.5	4.2	-	-	-	212.7	0.1186	118.88	54
SC-62	SC-46	-	-	-	114.9	68.3	-	183.3	0.0554	171.42	42
SC-46	SC-45A	204	4.5	4.2	114.9	68.3	-	396.0	0.0139	171.42	66
SC-30	SC-45A	-	-	-	-	-	17.80	17.8	0.0622	171.42	24
SC-45A	SC-45	204	4.5	4.2	114.9	68.3	17.80	413.8	0.0125	463.51	72

Note: Basins 272 & 273 are from the Erie OSP.

SC-51 to SC-50 Inlet Capacity Calculations

Orifice Equation: $Q = 0.60 * A * (2gh)^{1/2}$

It is assumed that the future detention pond servicing basins 272 and 273 will have 8.0 feet of head at the outfall structure.

Q_{100} = 204 cfs

Design Head (control for pipe size) = 8.0 ft

Min. Pipe Size = 52.4 Inches

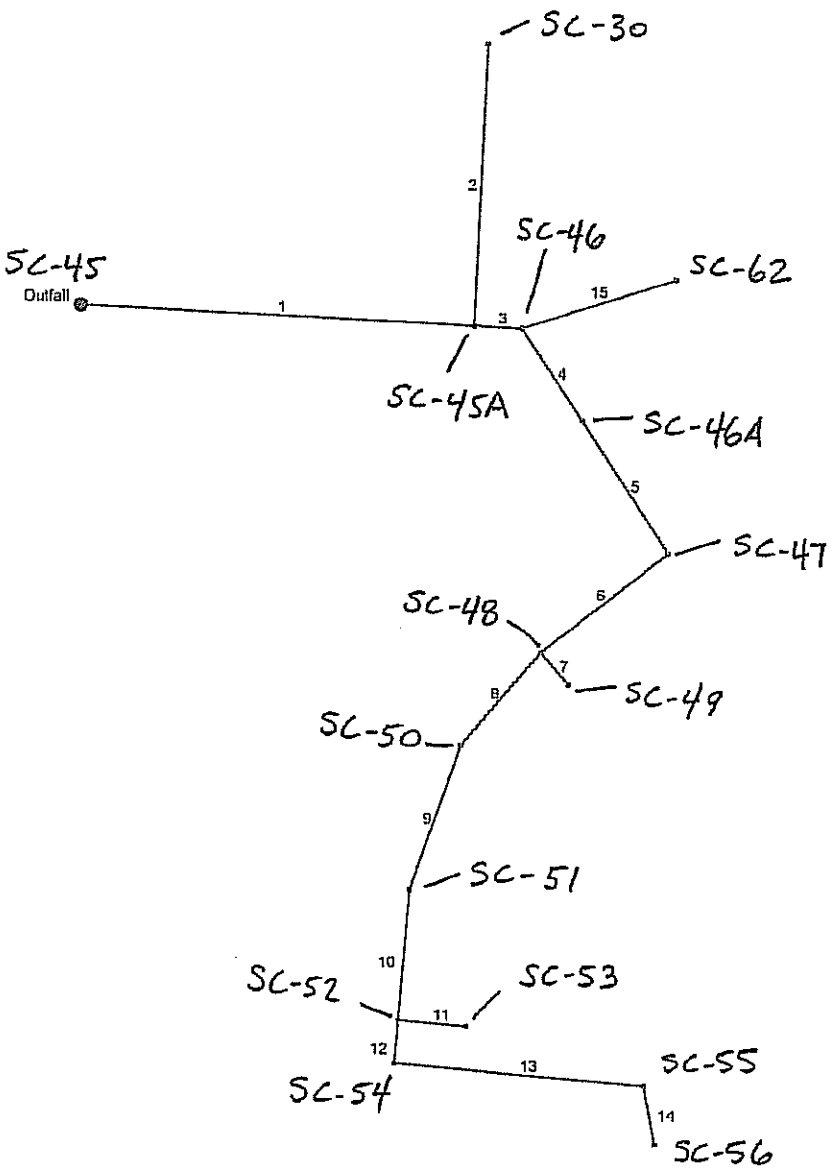
Min. Pipe Inlet Capacity = 204.0

Design Pipe Size = 54 Inches

Hydraflow Storm Sewers Plan

100-YEAR ANALYSIS

100-YR HGL STARTED @ 5053.70



Project File: 202042-C3-100YR.stm	Number of lines: 15	Date: 04-03-2013

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
1	End	417	3	MH	413.80	0.00	0.00	0.0	5045.00	1.25	5050.20	72	Cir	0.013	1.00	5065.70	SC-45 - SC-45A
2	1	308	-90	MH	17.80	0.00	0.00	0.0	5053.40	6.22	5072.55	18	Cir	0.013	1.00	5078.60	SC-45A - SC-30
3	1	50	0	MH	396.00	0.00	0.00	0.0	5050.60	1.39	5051.30	66	Cir	0.013	0.85	5066.60	SC-45A - SC-46
4	3	119	55	MH	212.70	0.00	0.00	0.0	5052.10	11.86	5066.20	54	Cir	0.013	0.15	5075.40	SC-46 - SC-46A
5	4	170	0	MH	212.70	0.00	0.00	0.0	5066.40	8.00	5080.00	54	Cir	0.013	0.99	5091.03	SC-46A - SC-47
6	5	174	83	MH	212.70	0.00	0.00	0.0	5080.20	1.44	5082.70	54	Cir	0.013	1.00	5093.26	SC-47 - SC-48
7	6	46	-90	Curb	4.20	0.00	0.00	0.0	5085.10	6.31	5088.00	18	Cir	0.013	1.00	5093.00	SC-48 - SC-49
8	6	133	-11	MH	208.50	0.00	0.00	0.0	5082.90	0.60	5083.70	54	Cir	0.013	0.40	5094.92	SC-48 - SC-50
9	8	164	-20	MH	208.50	0.00	0.00	0.0	5083.90	0.60	5084.89	54	Cir	0.013	0.29	5098.05	SC-50 - SC-51
10	9	141	-14	MH	208.50	0.00	0.00	0.0	5085.09	0.80	5086.22	54	Cir	0.013	1.00	5102.08	SC-51 - SC-52
11	10	72	-90	Curb	4.50	0.00	0.00	0.0	5091.05	4.10	5094.00	18	Cir	0.013	1.00	5104.04	SC-52 - SC-53
12	10	47	0	MH	204.00	0.00	0.00	0.0	5086.42	0.81	5086.80	54	Cir	0.013	1.00	5103.05	SC-52 - SC-54
13	12	265	-90	MH	204.00	0.00	0.00	0.0	5087.00	3.82	5097.10	54	Cir	0.013	0.97	5109.50	SC-54 - SC-55
14	13	65	75	MH	204.00	0.00	0.00	0.0	5097.30	2.62	5099.00	54	Cir	0.013	1.00	5104.00	SC-55 - SC-56
15	3	171	-21	MH	183.30	0.00	0.00	0.0	5052.50	5.54	5062.00	48	Cir	0.013	1.00	5069.60	SC-46 - SC-62

Project File: 202042-C3-100YR.stm | Number of lines: 15 | Date: 04-03-2013

Hydraulic Grade Line Computations

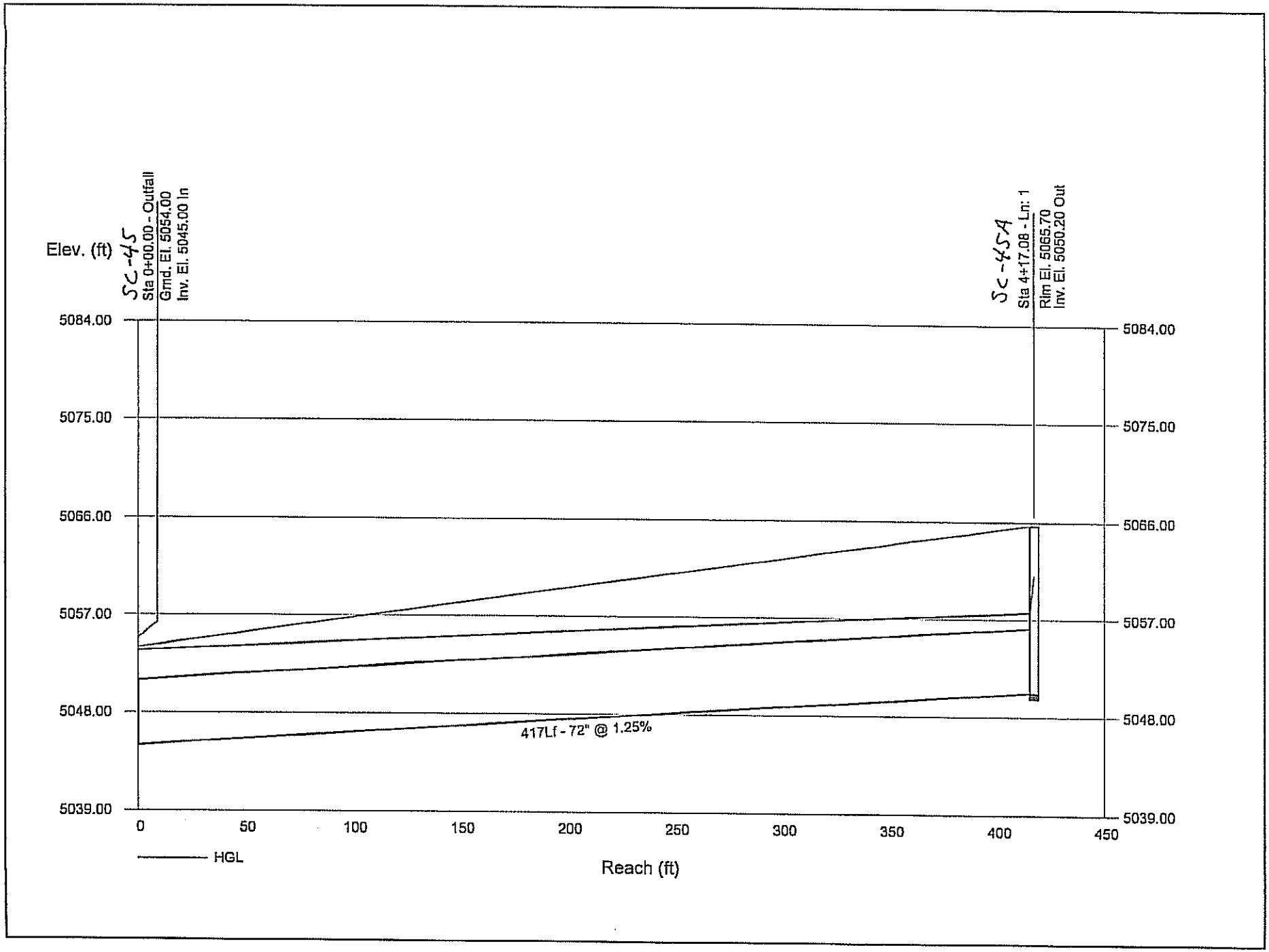
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
	(in)	(cfs)									(ft)											(K)	(ft)
1	72	413.8	5045.00	5053.70	6.00	28.27	14.64	3.33	5057.03	0.955	417	5050.20	5057.68	6.00	28.27	14.64	3.33	5061.01	0.954	0.955	3.981	1.00	3.33
2	18	17.80	5053.40	5062.77	1.50	1.75	10.07	1.58	5064.34	2.874	308	5072.55	5074.00 j	1.45**	1.75	10.18	1.61	5075.61	2.520	2.697	n/a	1.00	1.61
3	66	396.0	5050.60	5061.01	5.50	23.75	16.67	4.32	5065.33	1.391	50	5051.30	5061.72	5.50	23.76	16.67	4.32	5066.04	1.390	1.391	0.701	0.85	3.67
4	54	212.7	5052.10	5066.92	4.50	15.27	13.38	2.78	5069.71	1.170	119	5066.20	5070.32	4.12**	15.27	13.93	3.02	5073.34	1.017	1.094	n/a	0.15	0.45
5	54	212.7	5066.40	5070.56	4.16	15.27	13.85	2.98	5073.54	1.014	170	5080.00	5084.12	4.12**	15.27	13.93	3.02	5087.14	1.017	1.015	n/a	0.99	2.99
6	54	212.7	5080.20	5084.36	4.16	15.27	13.85	2.98	5087.34	1.014	174	5082.70	5086.82	4.12**	15.27	13.93	3.02	5089.84	1.017	1.015	n/a	1.00	3.02
7	18	4.20	5085.10	5089.75	1.50	1.77	2.38	0.09	5089.84	0.160	46	5088.00	5089.83	1.50	1.77	2.38	0.09	5089.92	0.160	0.160	0.074	1.00	0.09
8	54	208.5	5082.90	5087.40	4.50*	15.90	13.11	2.67	5090.07	1.124	133	5083.70	5088.90	4.50	15.90	13.11	2.67	5091.57	1.124	1.124	1.501	0.40	1.07
9	54	208.5	5083.90	5089.97	4.50	15.90	13.11	2.67	5092.64	1.124	164	5084.89	5091.82	4.50	15.90	13.11	2.67	5094.49	1.124	1.124	1.848	0.29	0.77
10	54	208.5	5085.09	5092.60	4.50	15.90	13.11	2.67	5095.27	1.124	141	5086.22	5094.18	4.50	15.90	13.11	2.67	5096.85	1.124	1.124	1.582	1.00	2.67
11	18	4.50	5091.05	5099.42	1.50	1.77	2.55	0.10	5099.52	0.184	72	5094.00	5099.55	1.50	1.77	2.55	0.10	5099.65	0.184	0.184	0.132	1.00	0.10
12	54	204.0	5086.42	5096.96	4.50	15.90	12.83	2.56	5099.52	1.076	47	5086.80	5097.47	4.50	15.90	12.83	2.56	5100.03	1.076	1.076	0.507	1.00	2.56
13	54	204.0	5087.00	5100.03	4.50	15.90	12.83	2.56	5102.59	1.076	265	5097.10	5102.88	4.50	15.90	12.83	2.56	5105.43	1.076	1.076	2.847	0.97	2.48
14	54	204.0	5097.30	5105.36	4.50	15.90	12.83	2.56	5107.92	1.076	65	5099.00	5106.06	4.50	15.90	12.83	2.56	5108.62	1.076	1.076	0.700	1.00	2.56
15	48	183.3	5052.50	5066.40	4.00	12.56	14.59	3.31	5069.71	1.629	171	5062.00	5069.19	4.00	12.57	14.59	3.31	5072.50	1.628	1.629	2.792	1.00	3.31

Project File: 202042-C3-100YR.stm | Number of lines: 15 | Run Date: 04-03-2013

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = clr e = ellip b = box

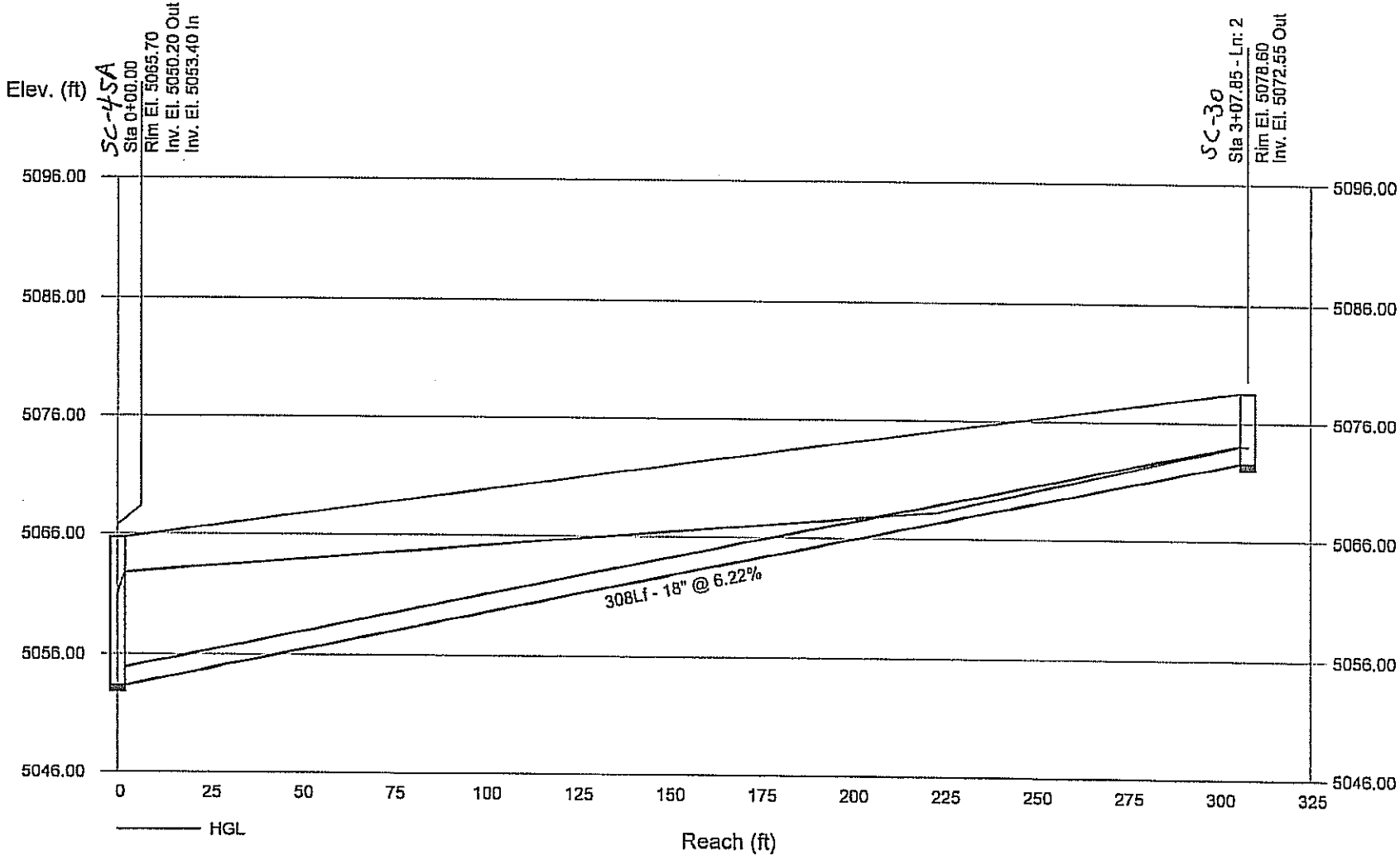
Storm Sewer Profile

Proj. file: 202042-C3-100YR.stm



Storm Sewer Profile

Proj. file: 202042-C3-100YR.stm



APPENDIX F
MAJOR STORM STREET ANALYSIS

Major Storm Street Analysis

Colliers Hill Filing 2A
Job # 2020-42

The proposed streets of Colliers Hill Phase 2A have adequate capacity to convey the 100-year flows. The critical cross-sections are analyzed below.

Analyzed Section : Downstream End of Basin C71
Street : Dawn Avenue (Local Street w/ Vertical Curbs)
Contributing Basins : C23, C71-C91, C93-C104

Area (ac)	C_{100}	T_c (min)	I_{100} (in/hr)	Q_{100} (cfs)	Q_2 (cfs)	Req'd Capacity (cfs)	Downstream Street Slope (ft/ft)	Street Capacity (cfs)
64.53	0.59	26.3	4.57	175.37	59.30	116.08	0.02118	609.92

100-Year One-Hour Rainfall Depth = 2.70 inches
Intensity = 28.5 * P_1 / ((10 + T_C)$^{0.786}$) RA-3, USDCM Vol. 1
Notes:
1. The above 2-year runoff rate is the summation of the contributing 2-year basin flow rates.
2. The above time of concentration is from the analyzed time of concentration for storm pipe SC-161 to SC-160.
3. Assumption: At least the summation of the upstream contributing 2-year basin runoff rates will be captured by the storm sewer during the 100-year storm event.

Analyzed Section : Downstream End of Basin C77
Street : Dawn Avenue (Local Street w/ Mountable Curbs)
Contributing Basins : C76, C77, C81-C91, C93-C104

Area (ac)	C_{100}	T_c (min)	I_{100} (in/hr)	Q_{100} (cfs)	Q_2 (cfs)	Req'd Capacity (cfs)	Downstream Street Slope (ft/ft)	Street Capacity (cfs)
46.59	0.59	25.0	4.71	130.27	40.19	90.08	0.02260	638.77

100-Year One-Hour Rainfall Depth = 2.70 inches
Intensity = 28.5 * P_1 / ((10 + T_C)$^{0.786}$) RA-3, USDCM Vol. 1
Notes:
1. The above 2-year runoff rate is the summation of the contributing 2-year basin flow rates.
2. The above time of concentration is from the analyzed time of concentration for storm pipe SC-166 to SC-165.
3. Assumption: At least the summation of the upstream contributing 2-year basin runoff rates will be captured by the storm sewer during the 100-year storm event.

Analyzed Section : Downstream End of Basins C21 & C23
Street : Colliers Boulevard (Collector Street)
Contributing Basins : C21, C23, C70-C106

Area (ac)	C_{100}	T_c (min)	I_{100} (in/hr)	Q_{100} (cfs)	Q_2 (cfs)	Req'd Capacity (cfs)	Downstream Street Slope (ft/ft)	Street Capacity (cfs)
74.45	0.58	26.3	4.57	197.01	70.46	126.55	0.01300	690.53

100-Year One-Hour Rainfall Depth = 2.70 inches
Intensity = 28.5 * P_1 / ((10 + T_C)$^{0.786}$) RA-3, USDCM Vol. 1
Notes:
1. The above 2-year runoff rate is the summation of the contributing 2-year basin flow rates.
2. The above time of concentration is from the analyzed time of concentration for storm pipe SC-161 to SC-160.
3. Assumption: At least the summation of the upstream contributing 2-year basin runoff rates will be captured by the storm sewer during the 100-year storm event.

Analyzed Section : Downstream End of Basins C20 & C22
Street : Colliers Boulevard (Collector Street)
Contributing Basins : C20, C22, C25, C30-C43, C45-C63

Area (ac)	C_{100}	T_c (min)	I_{100} (in/hr)	Q_{100} (cfs)	Q_2 (cfs)	Req'd Capacity (cfs)	Downstream Street Slope (ft/ft)	Street Capacity (cfs)
79.23	0.61	28.4	4.37	211.85	71.94	139.90	0.01140	646.64

100-Year One-Hour Rainfall Depth = 2.70 inches
Intensity = 28.5 * P_1 / ((10 + T_C)$^{0.786}$) RA-3, USDCM Vol. 1
Notes:
1. The above 2-year runoff rate is the summation of the contributing 2-year basin flow rates.
2. The above time of concentration is from the analyzed time of concentration for storm pipe SC-67 to SC-65.
3. Assumption: At least the summation of the upstream contributing 2-year basin runoff rates will be captured by the storm sewer during the 100-year storm event.

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CONSULTING ENGINEERS
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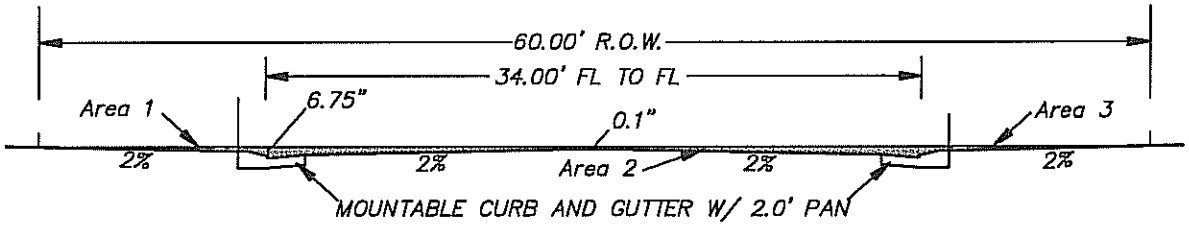
Boulder, Colorado 80301 (303) 449-9105

JOB 2020-42, COLLIERS HILL, FILING 2A
CALCULATED BY JR DATE 05/01/2017
CHECKED BY _____ DATE _____
SCALE: NTS SHEET NO. _____ OF _____

STREET CAPACITY ANALYSIS: MAJOR STORM EVENT

LOCAL STREEET: 60 FOOT R.O.W. (MOUNTABLE CURBS)



Allowable Depth at FL = 0.563'
Allowable Depth at CL = 0.1'

AREA 1:	0.918 S.F.
WET PERIMETER:	9.59 FEET
n:	0.035
SLOPE:	0.75%
AREA 1 CAPACITY:	0.706 CFS

$$Q_{allow.} = \frac{1.486}{n}(A)\left(\frac{A}{W.P.}\right)^{2/3} S^{1/2} * \text{Reduction Factor}$$

AREA 2:	10.26 S.F.
WET PERIMETER:	37.26 FEET
n:	0.016
SLOPE:	0.80%
AREA 2 CAPACITY:	36.07 CFS

AREA 3:	0.918 S.F.
WET PERIMETER:	9.59 FEET
n:	0.035
SLOPE:	0.75%
AREA 3 CAPACITY:	0.706 CFS

FULL STREET CAPACITY = 37.48 CFS AT 0.80%

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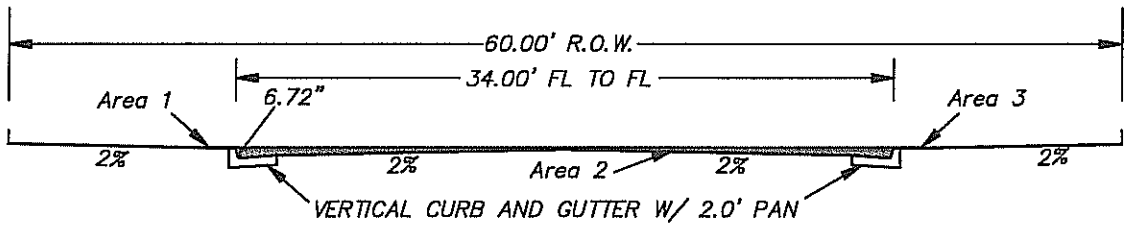
CALCULATED BY JR DATE 05/01/2017
CHECKED BY _____ DATE _____
SCALE: NTS SHEET NO. _____ OF _____

STREET CAPACITY ANALYSIS: MAJOR STORM EVENT

LOCAL STREEET: 60 FOOT R.O.W. (VERTICAL CURBS)



Allowable Depth at FL = 0.56'
Allowable Depth at CL = 0.10'

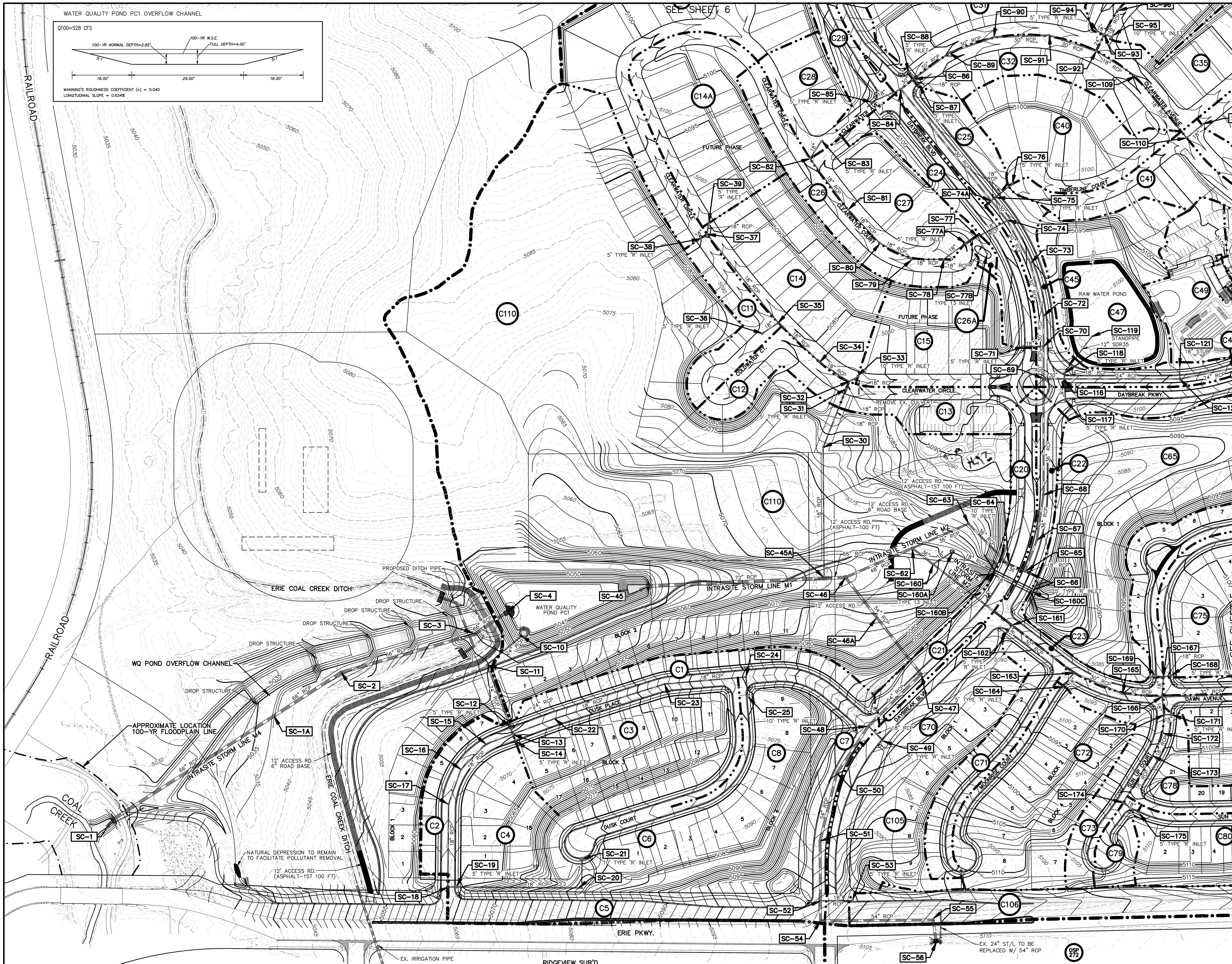
AREA 1:	0.085 S.F.
WET PERIMETER:	2.91 FEET
n:	0.035
SLOPE:	0.75%
AREA 1 CAPACITY:	0.03 CFS

$$Q_{allow.} = \frac{1.486}{n}(A)\left(\frac{A}{W.P.}\right)^{2/3} S^{1/2} * \text{Reduction Factor}$$

AREA 2:	9.56 S.F.
WET PERIMETER:	35.70 FEET
n:	0.016
SLOPE:	1.0%
AREA 2 CAPACITY:	36.89 CFS

AREA 3:	0.085 S.F.
WET PERIMETER:	2.91 FEET
n:	0.035
SLOPE:	0.75%
AREA 3 CAPACITY:	0.03 CFS

FULL STREET CAPACITY = 36.95 CFS AT 1.00%


WATER QUALITY POND PC1 OVERFLOW CHANNEL
Q100=528 CFS
100-YR NORMAL DEPTH=2.82'
100-YR W.S.E.
FULL DEPTH=4.00'
MANNING'S ROUGHNESS COEFFICIENT (n) = 0.040
LONGITUDINAL SLOPE = 0.634%
RAILROAD
SEE SHEET 6
SEE SHEET 5
ERIE COAL CREEK DITCH
WATER QUALITY POND PC1
WQ POND OVERFLOW CHANNEL
DROP STRUCTURE
PROPOSED DITCH PIPE
APPROXIMATE LOCATION 100-YR FLOODPLAIN LINE
INTRASITE STORM LINE M4
INTRASITE STORM LINE M1
INTRASITE STORM LINE M2
COAL CREEK
NATURAL DEPRESSION TO REMAIN TO FACILITATE POLLUTANT REMOVAL
12' ACCESS RD. (ASPHALT-1ST 100 FT)
12' ACCESS RD. 6" ROAD BASE
RAW WATER POND
FUTURE PHASE
CLEARWATER CIRCLE
CLEARWATER COURT
CLEARWATER AVENUE
COLDWATER CT.
TIMBERLINE COURT
DAYBREAK PKWY.
DAYBREAK BLVD
DUSK PLACE
DUSK COURT
DAWN AVENUE
SUN UP COURT
MOONRISE COURT
ERIE PKWY.
RIDGEVIEW SUB'D.
EX. IRRIGATION PIPE
EX. 24" ST/L TO BE REPLACED W/ 54" RCP
TEMPORARY BOX
REMOVE EX. CULVERT
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
C110
C14A
C28
C29
C32
C35
C40
C41
C25
C24
C26
C27
C14
C11
C12
C13
C15
C26A
C45
C47
C49
C46
C20
C22
C65
C75
C23
C21
C1
C3
C8
C7
C70
C71
C72
C73
C79
C78
C80
C105
C106
C2
C4
C5
C6
SC-1
SC-1A
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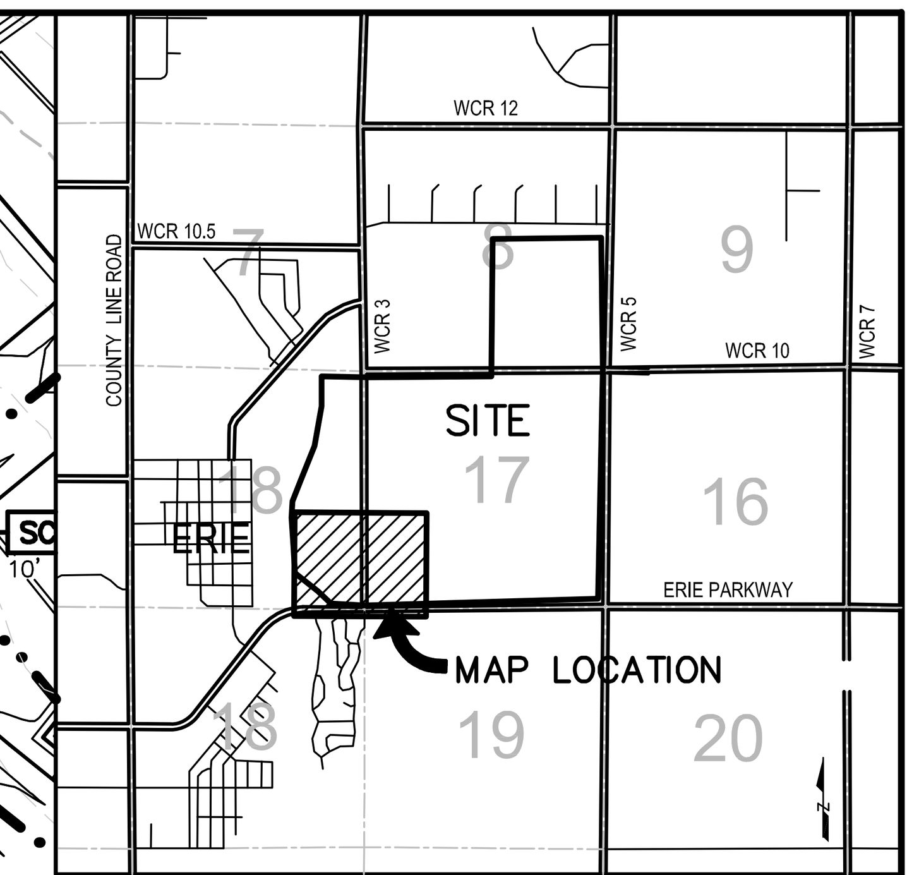
SC-170
SC-171
SC-172
SC-173
SC-174
SC-175
5' TYPE 'R' INLET
10' TYPE 'R' INLET
18" RCP
24" RCP
30" RCP
36" RCP
54" RCP
66" RCP
72" RCP
STANDPIPE
12" SDR35
18" STUB
OSP 272



VICINITY MAP

LEGEND

	Existing Contours
	Proposed Contours
	Flow Arrow
C52	Basin Designation
SC-121	Structure Number
	Basin Boundary
	Major Basin Boundary

COLORADO LICENSED
JOHN W. JORGENSON
22730
PROFESSIONAL ENGINEER

GRAPHIC SCALE
100 0 50 100
(IN FEET)
1 inch = 100 ft.

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DAYBREAK – METRO DISTRICT
ERIE, CO
PHASE 1 MASTER DRAINAGE PLAN
Sheet 1 of 3

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SHEET	04 OF 49

FILE G:\202042\CONST\METRO\04-06-202042-PH1-MD

SEE SHEET 6

SEE SHEET 4

BASIN LINE FOLLOWS DRAINAGE PATTERN OF FUTURE LOTS

TIMBERLINE ROAD

CLEARWATER AVENUE

BIG CREEK ROAD

DAYBREAK PKWY.

MAROON CREEK AVE.

MAROON CREEK COURT

MAROON CREEK COURT 2

MAROON CREEK WAY

CANNON COURT

LAURAL CREEK LANE

GREAT RIVER WAY

EQUINOX DRIVE

STARLIGHT CIRCLE

SUNBEAM COURT

DAWN AVENUE

SUNSHINE CIRCLE

SUN UP CIRCLE

SUN UP PLACE

SOLSTICE COURT

SOLSTICE WAY

DAWN AVENUE

SUMMER PLACE

DAWN AVENUE

ERIE PKWY.

TRACT D

FUTURE PHASE

BLOCK 1

BLOCK 2

BLOCK 3

BLOCK 5

BLOCK 6

BLOCK 7

BLOCK 8

SC-95 5' TYPE 'R' INLET

SC-96

SC-111 10' TYPE 'R' INLET

SC-121 18" STUB

SC-123A 18" STUB

SC-125 5' TYPE 'R' INLET

SC-126 10' TYPE 'R' INLET

SC-128

SC-129

SC-130

SC-131

SC-132 5' TYPE 'R' INLET

SC-133

SC-134

SC-135 5' TYPE 'R' INLET

SC-136

SC-137

SC-138 5' TYPE 'R' INLET

SC-139

SC-140

SC-141

SC-142

SC-143 5' TYPE 'R' INLET

SC-144

SC-145 5' TYPE 'R' INLET

SC-146

SC-147

SC-148

SC-149

SC-150

SC-151

SC-152

SC-153

SC-154

SC-155 5' TYPE 'R' INLET

SC-156 5' TYPE 'R' INLET

SC-167

SC-168 5' TYPE 'R' INLET

SC-171 5' TYPE 'R' INLET

SC-172

SC-173

SC-175 5' TYPE 'R' INLET

SC-176

SC-177

SC-178

SC-178A 5' TYPE 'R' INLET

SC-179 5' TYPE 'R' INLET

SC-180

SC-181 5' TYPE 'R' INLET

SC-182 5' TYPE 'R' INLET

SC-183

SC-184

SC-185

SC-186 5' TYPE 'R' INLET

SC-187

SC-188

SC-189

SC-190 5' TYPE 'R' INLET

SC-191

SC-192 5' TYPE 'R' INLET

SC-193

SC-194 5' TYPE 'R' INLET

SC-195

SC-196

SC-197 5' TYPE 'R' INLET

SC-198 5' TYPE 'R' INLET

SC-199

SC-200

SC-201 5' TYPE 'R' INLET

SC-202

SC-203

SC-204 5' TYPE 'R' INLET

SC-205 18" STUB

SC-206

SC-207 10' TYPE 'R' INLET

SC-208

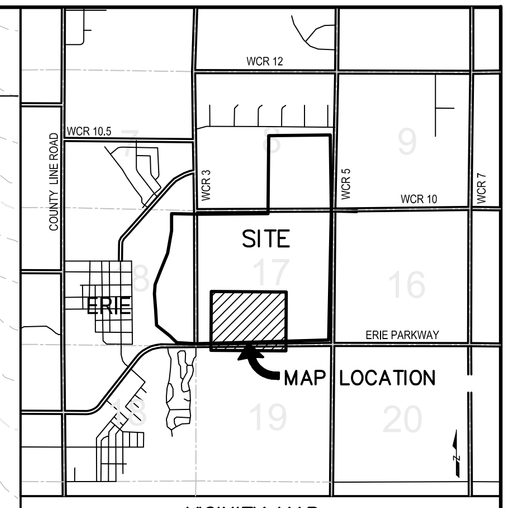
SC-209

SC-210 18" STUB

C35 C41 C42 C43 C46 C48 C49 C49A C50 C51 C52 C53 C54 C55 C56 C56A C57 C58 C59 C60 C61 C62 C63 C65 C74 C75 C76 C77 C78 C80 C81 C82 C83 C84 C85 C86 C87 C88 C89 C90 C91 C92 C93 C94 C95 C96 C97 C98 C99 C100 C101 C102 C103 C104

OSP 272

OSP 273



VICINITY MAP

LEGEND

- Existing Contours
- Proposed Contours
- Flow Arrow
- C52 — Basin Designation
- SC-121 — Structure Number
- Basin Boundary
- Major Basin Boundary

COLORADO LICENSED
JOHN W. JORGENSON
22730
PROFESSIONAL ENGINEER

GRAPHIC SCALE

100 0 50 100

(IN FEET)
1 inch = 100 ft.

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CEMETERY

FUTURE PHASE

BASIN LINE FOLLOWS DRAINAGE PATTERN OF FUTURE LOTS

CHAMPLAIN CIRCLE

TIMBERLINE ROAD

TENBRIDGE ROAD

CLEARWATER AVENUE

CLEARWATER CIRCLE

CLEARWATER COURT

DAYBREAK BLVD

TIMBERLINE COURT

BIG CREEK ROAD

MARSH CREEK AVE

DAYBREAK PKWY.

RAW WATER POND

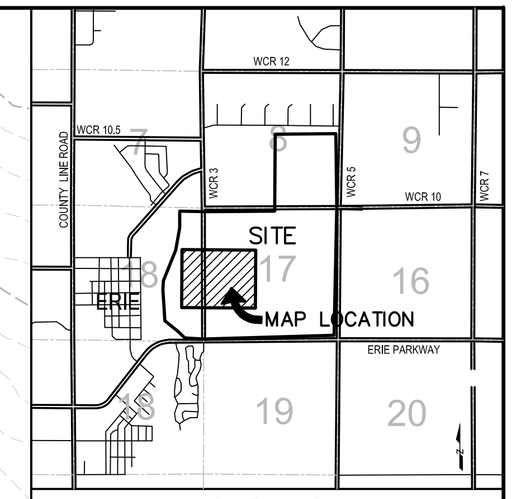
REMOVE EX. CULVERT

BLOCK 1

SEE SHEET 4

SEE SHEET 5

VICINITY MAP



LEGEND

- Existing Contours
- Proposed Contours
- Flow Arrow
- C52 — Basin Designation
- SC-121 — Structure Number
- Basin Boundary
- Major Basin Boundary

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JOHN W. JORGENSON
22730
PROFESSIONAL ENGINEER

GRAPHIC SCALE

100 0 50 100

(IN FEET)
1 inch = 100 ft.

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VERT.	n/a
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SHEET	06 OF 49

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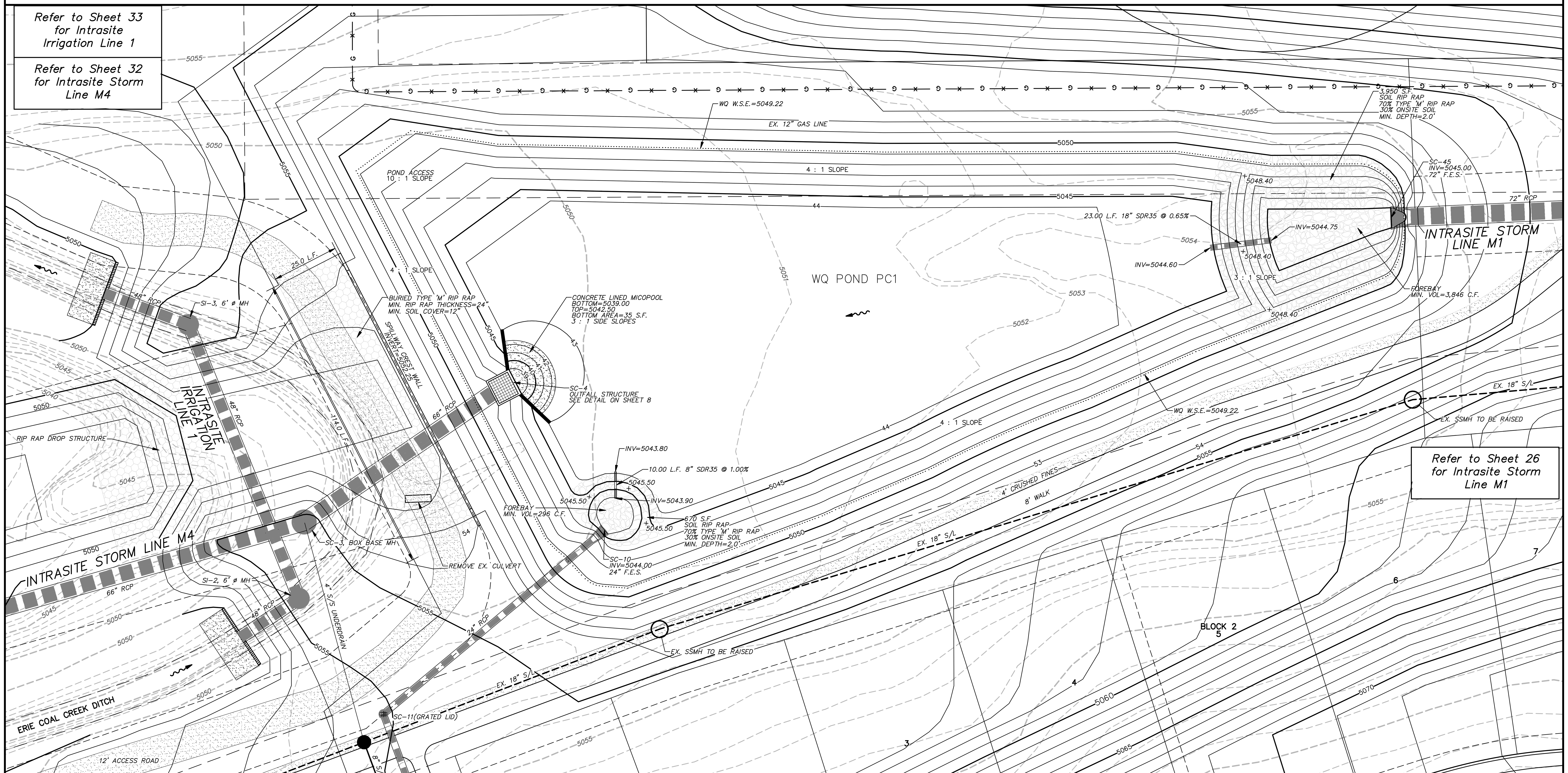

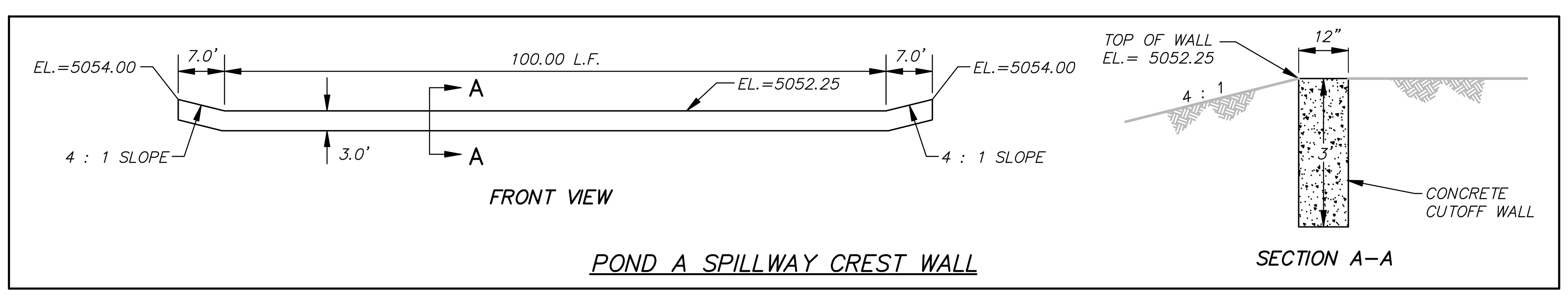

LEGEND

- Proposed Waterline
- Existing Waterline
- Proposed Sewerline
- Existing Sewerline
- Stormline
- Existing Gas line
- Water Service
- Sewer Service
- Fire Service
- Existing Underground Electric
- Existing Overhead Electric
- Thrust Block
- Water Valve
- Fire Hydrant
- Plug
- Manhole
- Type 'R' Inlet
- Existing Contours
- Proposed Contours
- Street Light

POND CHARACTERISTICS

WQ W.S.E. = 5049.22
WQ VOL = 3.86 AC–FT
Q10 = 345 CFS
Q100 = 873 CFS

COLORADO LICENSED PROFESSIONAL ENGINEER JOHN W. JORGENSON 22730

GRAPHIC SCALE
(IN FEET)
1 inch = 20 ft.

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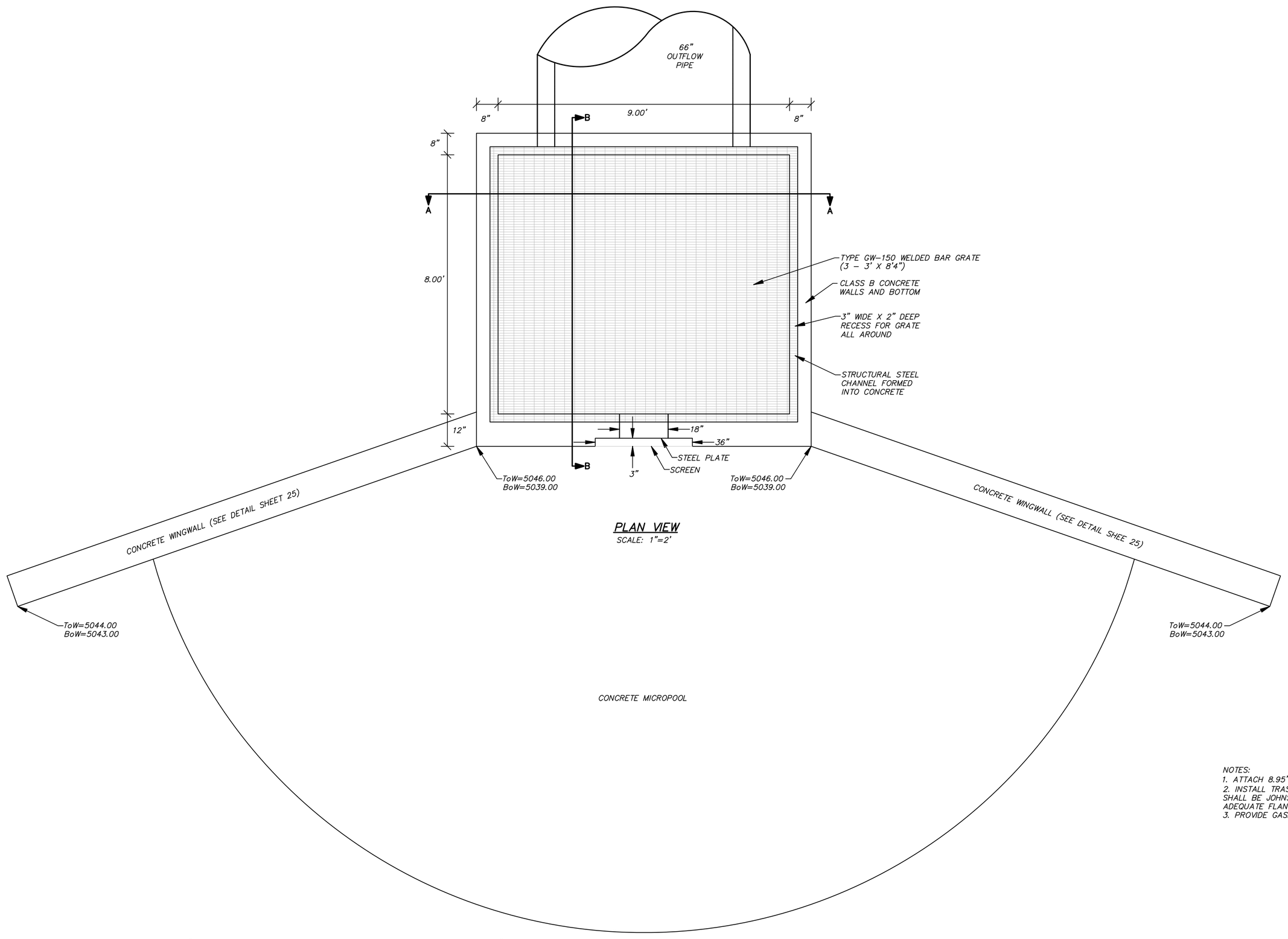
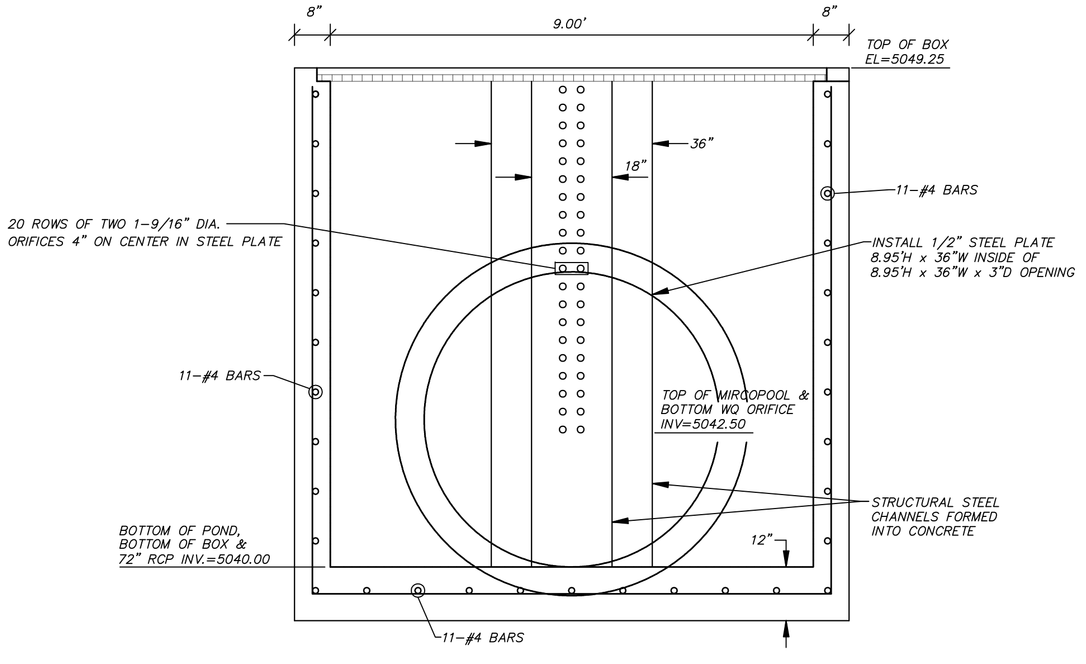
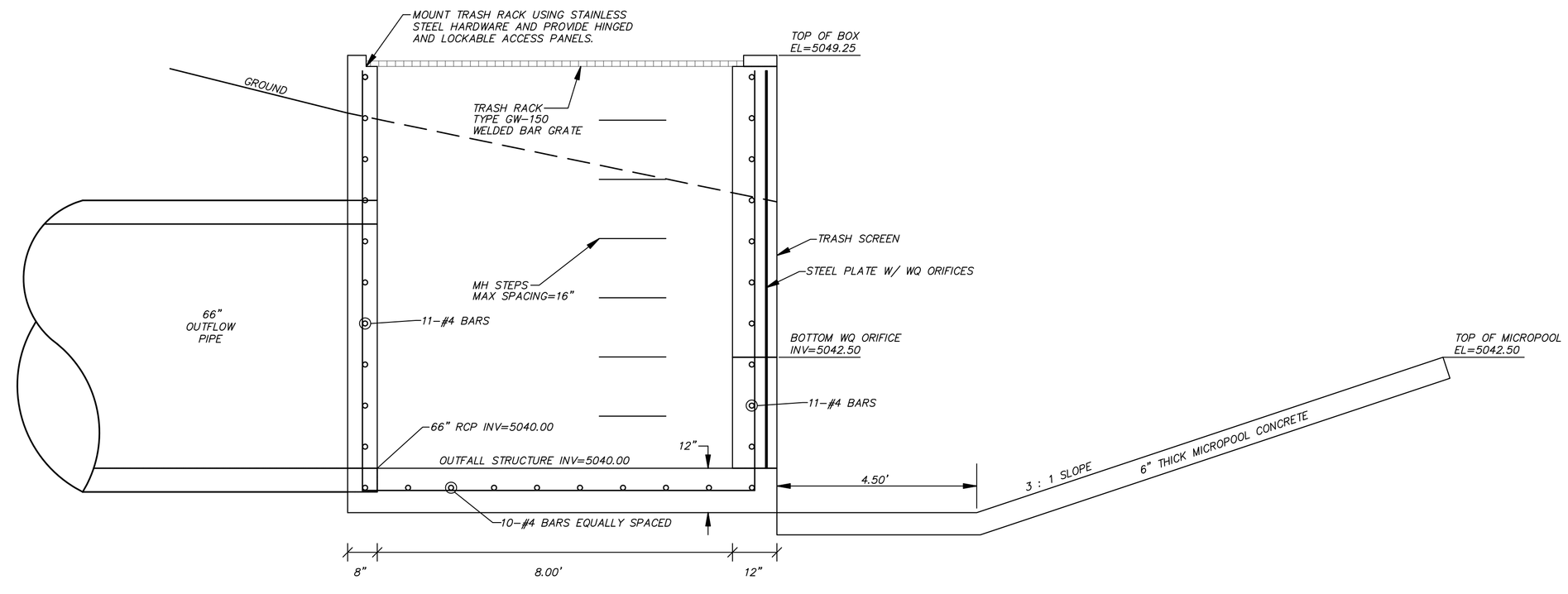


PLAN VIEW
SCALE: 1"=2'

NOTES:
1. ATTACH 8.95' H x 36" W STEEL PLATE WITH 1/2 INCH STEEL BOLTS ONE INCH LONG.
2. INSTALL TRASH SCREEN OVER 36" W BY 8.95' H OPENING. THE TRASH SCREEN SHALL BE JOHNSON VEE WIRETM STAINLESS STEEL SCREENT OR EQUIVALENT. PROVIDE ADEQUATE FLANGE WIDTH FOR INSTALLATION.
3. PROVIDE GASKET MATERIAL BETWEEN THE ORIFICE PLATE AND CONCRETE.



SECTION A-A
SCALE: 1"=2'



SECTION B-B
SCALE: 1"=2'

OUTFALL STRUCTURE

COLORADO LICENSED
JOHN W. JORGENSON
22730
PROFESSIONAL ENGINEER

72 HOURS BEFORE YOU DIG
CALL THE UTILITY NOTIFICATION CENTER OF COLORADO (U.N.C.C.)
811
GAS, ELECTRIC, TELEPHONE, CATV AND PANHANDLE EASTERN PIPELINE LOCATIONS

DAYBREAK - METRO DISTRICT
ERIE, CO
WATER QUALITY POND PC1
OUTFALL STRUCTURE DETAIL

HURST
CIVIL ENGINEERING
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2500 Broadway, Suite B
Boulder, CO 80304
303.449.9105
www.hurst-assoc.com

SCALE	HOR. n/a VERT. n/a
DESIGN/APPR.	JJ
DRAWN BY	TSA
DATE	04/03/13
SHEET	08 OF 49

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3799568 10/18/2011 12:26P Weld County, CO
1 of 46 R 236.00 D 0.00 Steve Moreno Clerk & Recorder

SURFACE USE AGREEMENT

THIS SURFACE USE AGREEMENT ("Agreement') is effective this 27th day of September, 2011, by and among ANADARKO E&P COMPANY LP, formerly known as Union Pacific Resources Company, and ANADARKO LAND CORP., formerly known as Union Pacific Land Resources Corporation (together the "Anadarko Entities"), both with an address of Post Office Box 1330, Houston, Texas 77251-1330; KERR-McGEE OIL & GAS ONSHORE LP ("Kerr-McGee") with an address of 1099 18th Street, Suite 1800, Denver, Colorado 80202; KERR-McGEE GATHERING LLC ("KMGG"), also with an address of 1099 18th Street, Denver, Colorado 80202; and ENCANA OIL & GAS (USA) INC. ("Encana") with an address of 370 17th Street, Suite 1700, Denver, Colorado 80202 (the Anadarko Entities, Kerr-McGee and Encana are sometimes referred to hereinafter separately as an "Oil Company" or collectively as the "Oil Companies") and TALLGRASS INVESTORS, LLC ("Surface Owner") with an address of 2500 Arapahoe Avenue, Suite 220, Boulder, Colorado 80302.

A. Surface Owner owns the surface estate for property located within the Town of Erie ("Erie") in Weld County, Colorado, described as the E/2 of Section 18, Township 1 North, Range 68 West, which is more specifically described in the attached Exhibit 1A and hereinafter referred to as the "Section 18 Property."

B. Surface Owner also owns the surface estate for property located in Erie described as the SE/4 of Section 8, Township 1 North, Range 68 West, which is more specifically described in the attached Exhibit 1B and hereinafter referred to as the "Section 8 Property."

C. The Section 18 Property and the Section 8 Property are hereinafter referred to together as the "Property."

D. The Anadarko Entities own all of the oil and gas that underlies the Property, and either the Anadarko Entities, or their predecessors, have granted oil and gas leasehold rights in the Property. Interests in such leasehold rights have been assigned to Encana and Kerr-McGee, among other parties.

E. Union Pacific Land Resources Corporation and Union Pacific Resources Company (together the "Union Pacific entities") entered into an agreement with Weld County Land Company, LLC dated November 14, 2000, entitled "Agreement for Compatible Development" ("Development Agreement") pursuant to which the parties set forth minimum standards with which Surface Owner is required to comply to protect existing oil and gas wells on the Property and for the location of future oil and gas wells on the Property, among other things.

F. The Development Agreement was recorded in the Weld County Clerk and Recorder's Office on November 17, 2000, at Reception No. 280715.

G. The Development Agreement contemplated that Surface Owner might enter into surface use agreements in the future with the parties which own oil and gas leasehold interests in the Property to which the Union Pacific entities were required to be signatory parties.

H. Encana owns certain oil and gas leasehold interests in the Section 18 Property that it derived through the Union Pacific entities and operates two oil and/or gas wells on the Section 18 Property, one identified as the Erie Champlin B Unit #1 well, generally in the center of the NE/4, and the other identified as the Erie Champlin B Unit #2 well, generally in the center of the SE/4.

I. Predecessors to Encana and Kerr-McGee entered into a joint operating agreement pursuant to which Encana, as operator, drilled and operates five oil and/or gas wells on the Section 8 Property identified as the Woolley #43-8 in the NE/4SE/4, the Woolley #33-8 in the NW/4SE/4, the Woolley #34-8 in the SW/4SE/4, and the Woolley K Unit #1 and Woolley #44-8 in the center of the SE/4.

J. The wells identified in Recitals H. and I. are hereinafter referred to alone or together as an "Existing Well" or the "Existing Wells."

K. Kerr-McGee owns certain oil and gas leasehold interests in both the Section 18 Property and the Section 8 Property that it derived through the Union Pacific entities.

L. Encana and Kerr-McGee have rights to drill additional wells on the Property.

M. KMGG is an affiliate of the Anadarko Entities and Kerr-McGee and signs this Agreement only in its capacity as a party which gathers or may gather gas produced from the Property.

N. KMGG and Surface Owner shall enter into a letter agreement that is effective the same date as this Agreement in which KMGG and Surface Owner shall agree upon certain amendments to existing pipeline easements and right-of-way grants that cover portions of the Property and property adjacent to the Property in Section 17 and within the proposed Bridgewater development and hereinafter referred to as the "Letter Agreement."

O. This Agreement provides for the compatible development of the surface estate and the oil and gas estate for the Property and, with respect to each of the Oil Companies, applies only to the oil and gas interests and/or the oil and gas leasehold interests that each owns.

NOW THEREFORE, in consideration of the covenants and mutual promises set forth in this Agreement, including in the recitals, the parties agree as follows:

1. Oil and Gas Operations Areas.

a. Existing, Proposed, and Future Wellsite Locations. With respect to the Section 18 Property, the Oil Companies agree to locate future oil and gas wells only within the two areas that are identified on Exhibit 2A as the Oil and Gas Operations Areas and located generally in the centers of the NE/4 and the SE/4 of Section 18. With respect to the Section 8 Property, the Oil Companies agree to locate future oil and gas wells only within the four areas that are identified on Exhibit 2B as the Oil and Gas Operations Areas and located generally in the centers of the SE/4, NE/4SE/4, NW/4SE/4 and SW/4SE/4. The locations identified on Exhibit 2A and Exhibit 2B are hereinafter referred to separately or together as an "Oil and Gas Operations Area"

or the "Oil and Gas Operations Areas." The Oil and Gas Operations Areas shall be made available to the Oil Companies and their designated gas gatherer by Surface Owner for their exclusive use in their present condition for their oil and gas operations and the location of wells and equipment, flowlines and pipeline easements, as specifically provided for herein.

b. The Oil and Gas Operations Areas in Section 18 and the NE/4SE/4 of Section 8. Each Oil and Gas Operations Area in Section 18 and the Oil and Gas Operations Area in the NE/4SE/4 of Section 8 includes the property specifically identified and depicted on Exhibit 2A and Exhibit 2B as the: (aa) Oil and Gas Operations Area; (bb) Oil and Gas Well Area; (cc) Facilities Location; and (dd) Temporary Easement Area adjacent to the Oil and Gas Operations Area. The Temporary Easement Area and the areas within Oil and Gas Operations Areas are for oil and gas operations and the location of wells and equipment as follows:

(i) The Oil Companies may use the Temporary Easement Area for operations related to the preparation, drilling and completion of horizontal wells to be drilled at locations within an Oil and Gas Well Area within the Oil and Gas Operations Area and for the temporary location of production facilities for horizontal wells up until and only prior to the time that construction begins on a building within a platted lot within the quarter section where the Oil and Gas Operations Area is located (NE/4 or SE/4 of Section 18 or SE/4 of Section 8, as the case may be). The Oil Companies may not locate wells or permanent production facilities within the Temporary Easement Area, but may use the Temporary Easement Area only for temporary uses relating to the drilling and completion of horizontal wells and the temporary location of production facilities. The Oil Companies shall not use the Temporary Easement Area (except as provided herein) after construction begins on a building within a platted lot within the quarter section for the particular Oil and Gas Operations Area.

(ii) The Oil and Gas Operations Areas shall be the locations for oil and gas operations, Existing Wells and future wells and production facilities and flowlines and pipeline easements.

(iii) The Oil and Gas Well Areas shall be the locations for Existing Wells and additional future wells.

(iv) The Facilities Locations shall be the locations for permanent productions facilities that service the wells described in section 1.e.

(v) For each Temporary Easement Area, Surface Owner shall give the Oil Companies ninety (90) days advance written notice that it will commence the construction of a building within the applicable quarter section for the particular Oil and Gas Operations Area. The Oil Companies shall relocate any production facilities that are located within the Temporary Easement Area within sixty (60) days from the date of the notice.

(vi) In consideration of the covenants and promises contained in this Agreement and without in any way limiting section 1.e, Surface Owner specifically agrees that wells may be drilled by the Oil Companies from the Oil and Gas Operations Area in the SE/4 of Section 18 to bottomhole locations in the SW/4 of Section 18 and production facilities to service such wells located within the Oil and Gas Operations Area in the SE/4 of Section 18.

c. The Oil and Gas Operations Areas in Section 8 Other than the NE/4SE/4 Location. Each Oil and Gas Operations Area in Section 8 other than the Oil and Gas Operations Area in the NE/4SE/4 of Section 8 shall be the size and configuration depicted on Exhibit 2B and shall be available for oil and gas operations and the location of wells and production facilities, flowlines and pipeline easements.

d. Surface Lot Line Requirements. Lot lines for surface development shall not be platted anywhere within the Oil and Gas Operations Areas, and Surface Owner shall not construct or install any permanent or temporary building, structure or other improvement within or under the Oil and Gas Operations Areas; provided, however, Surface Owner may install berms, screening, shrubs, perimeter fencing and irrigation systems adjacent to (but not within) the perimeter of the Oil and Gas Operations Areas; provided that, in the reasonable opinion of the Oil Company, such improvements do not in any way impede or interfere with present or future oil and gas operations; and, provided, further, that the Oil Companies shall not be liable for damage or injury to such berms, screening, shrubs, perimeter fencing or irrigation systems that in any way occurs because of or results from oil and gas operations on the Property. Further, upon prior notice from the Oil Company, Surface Owner shall cooperate with the applicable Oil Company to insure that improvements are restricted from public access during oil and gas operations within an Oil and Gas Operations Area that require the use of heavy equipment by the Oil Company.

e. Multiple Wells within Oil and Gas Operations Areas. The Oil Companies shall continue to have the right to operate and maintain the Existing Wells and to drill, complete, operate and maintain additional wells within the Oil and Gas Operations Areas (as described herein), including vertical, twinned, replacement, directional and horizontal wells (with bottomhole locations within and outside the Property) that produce from and drain the Property as well as lands other than the Property. The Oil Companies shall have the right to deepen, complete, recomplete, workover, fracture, refracture and plug and abandon the Existing Wells and any well that is drilled in the future; provided, however, Encana agrees to permanently plug and abandon the Existing Erie Champlin B Unit #2 Well on the Section 18 Property prior to commencing drilling operations for any future well within the Section 18 Property. The Oil and Gas Operations Areas shall be for the exclusive use of oil and gas drilling, exploration, completion, recompletion, production and maintenance operations and for the location of associated oil field exploration and production equipment and facilities (including pipelines and flowlines) necessary or convenient for the operation of a well or wells located within an Oil and Gas Operations Area. Surface Owner acknowledges and understands that: i) any wells shown on the exhibits are those existing or currently planned; ii) the Oil Companies shall not be limited or restricted to the drilling of only the depicted wells or types of wells; and (iii) the actual wells drilled, including the number and their type, may differ from those shown, as may be determined by the Oil Companies in their discretion.

f. Associated Drilling and Production Equipment. The Oil Companies shall have the right to construct, operate, locate, maintain and repair such associated drilling and production equipment, including tanks, separators, dehydrators, compressors, pipelines, flowlines and meters, and also any other associated oil field equipment necessary or convenient for the operation and production of the Existing Wells, proposed wells, and future wells within the Oil and Gas Operations Areas in the Section 8 Property and within the Facility Locations within the

Oil and Gas Operations Areas in the Section 18 Property and the NE/4SE/4 of the Section 8 Property. The Oil Companies agree to install low profile tanks for future operations; provided, however, Encana shall not be required to replace the equipment that is currently located on the Property that services the Existing Wells.

2. Access to Oil and Gas Operations Areas.

a. Access to Oil and Gas Operations Areas. Surface Owner acknowledges and understands that the Oil Companies have the right to continue to use the existing access routes that they are currently utilizing and the additional proposed access (when and if constructed) to access the Oil and Gas Operations Areas as identified on Exhibit 2A and Exhibit 2B. During surface construction by Surface Owner on pertinent portions of the Property, the parties may mutually agree upon different access routes to an Oil and Gas Operations Area and thereafter to permanent access routes; provided, however, all costs and expenses for a relocation to temporary access routes and permanent access routes shall be borne by Surface Owner; and provided, further, the Oil Companies shall at all times have access to the Oil and Gas Operations Areas and pipeline easements.

b. Relocation of Access. Access to an Oil and Gas Operations Area may be changed in the future by mutual agreement of the affected parties or their successors in interest; provided however, all costs and expenses for such relocations shall be borne by Surface Owner, if the relocation is requested by Surface Owner.

c. Maintenance and Use of Joint Access Roads. Surface Owner shall keep roads jointly used by both Surface Owner or its subdivision occupants and one or more of the Oil Companies in good condition and repair until they are dedicated to a local jurisdiction; provided, however, if an Oil Company causes damage to a road that is built to the specifications in section 2.d.(1), it agrees to promptly repair any damage that it causes that is a direct result of its use of the road. No party shall unreasonably interfere with the use by the other of an access road.

d. Construction and Width of Access Roads.

(1) Access roads that are jointly used by the Oil Companies and Surface Owner shall be thirty (30) feet or more in width, and Surface Owner shall construct or improve all paved or improved access roads so as to withstand the weight of oilfield equipment. Specifically, Surface Owner shall construct the roads so that they can be used to withstand the weight of 104,000 pounds and 26,000 pounds per axle.

(2) Access roads that are used exclusively by the Oil Companies shall be generally thirty (30) feet in width, and the Oil Companies shall install and maintain them to applicable standards of the Colorado Oil and Gas Conservation Commission ("COGCC"). The Oil Companies shall be solely responsible for the maintenance of those portions of access roads that are used exclusively by the Oil Companies.

e. Surface Owner agrees that it will obtain and pay the costs to obtain from the local jurisdiction, permits for curb cuts as deemed necessary by the Oil Companies. Said curb cuts shall be forty (40) feet in width.

3. Pipelines, Flowlines and Pipeline Easements.

a. Pipelines, Flowlines and Pipeline Easements for Existing Wells. Surface Owner acknowledges and understands that the Oil Companies and their affiliates have the right to continue to use the flowlines, pipelines and pipeline easements that they are currently utilizing to service the Existing Wells and to construct, repair, maintain and replace the flowlines and pipelines. The locations for pipelines and flowlines that service Existing Wells that are located outside Oil and Gas Operations Areas are depicted on Exhibit 2A and Exhibit 2B.

b. Relocation or Abandonment of Existing Pipelines within Section 18 Property. With respect to the Section 18 Property, KMGG agrees to abandon in place, in accordance with COGCC Rules and Regulations, the pipeline that currently gathers the gas from the Erie Champlin B Unit #1 Well ("Champlin #1 Well") in the NE/4 of Section 18 and labeled as "proposed NE/4 abandoned gathering line" on Exhibit 2A. The parties acknowledge and understand that the proposed NE/4 abandoned gathering line will not be abandoned until the pipeline is constructed and operational on the Section 18 Property in the west portion of the property and depicted on Exhibit 2A as the "Future Pipeline Easement." KMGG also agrees to abandon in place or to relocate, as provided herein, the pipeline that currently gathers gas from the Erie Champlin B Unit #2 Well ("Champlin #2 Well") in the SE/4 of Section 18 and labeled as "proposed SE/4 abandoned or relocated gathering line" on Exhibit 2A. The parties acknowledge and understand that the proposed SE/4 abandoned or relocated gathering line will not be abandoned or relocated until Encana plugs and abandons the Champlin #2 Well and the initial pipeline is constructed and in operation in the Future Pipeline Easement. The proposed abandoned gathering lines and any relocated pipeline shall be abandoned and installed by KMGG pursuant to a separate pipeline relocation agreement in the form attached hereto as Exhibit 3.

c. Pipelines, Flowlines and Pipeline Easements for Future Wells. Pipelines and pipeline easements and also flowlines (to the extent located outside Oil and Gas Operations Areas) that service future wells shall be at the locations identified on Exhibit 2A and Exhibit 2B, or as the parties may otherwise agree, and Surface Owner shall grant the Oil Companies, or KMGG, as directed by the Oil Companies, written pipeline easements for production from the Property and other lands upon the request of the Oil Companies and at no cost to them in the form of right-of-way grant attached hereto as Exhibit 4.

d. Relocation of Pipelines and Pipeline Easements. Locations of pipelines and pipeline easements may be changed by mutual agreement of Surface Owner and the appropriate Oil Company pursuant to a separate pipeline relocation agreement; provided, however, all costs and expenses of such relocations shall be borne by Surface Owner, if the relocation is requested by Surface Owner.

e. Width and Grant of Pipeline and Flowline Easements. Pipeline easements may be nonexclusive as provided in Section 3.f. For pipeline easements in Section 8, if pipelines are relocated, and for initial installation, pipeline easements shall in all cases be fifty (50) feet in width during construction activities and reduced to thirty (30) feet in width for all operations, maintenance and transportation activities. For pipeline easements in Section 18, if pipelines are relocated, and for initial installation, pipeline easements shall in all cases be seventy-five (75)

feet in width during construction activities and reduced to fifty (50) feet in width for all operations, maintenance and transportation activities.

f. Uses Within the Pipeline Easements. Pipeline easements shall be for the use of pipelines for oil and gas production and operations; provided, however, the Oil Companies may install one or more pipelines within the same easement, and provided further, Surface Owner shall be entitled to cross such easements at approximately right angles and to install and maintain access to such easements for: i) utility lines, including those for water, gas, sewer, electric, telephone, cable, television and fiber optic; and ii) other purposes with the permission of the applicable Oil Companies, which permission shall not be unreasonably withheld; provided, however, any new underground facilities which travel along or within a pipeline easement identified herein shall be located at a distance horizontally of at least ten (10) feet from parallel existing oil and gas pipelines and flowlines, and such facilities shall have at least twenty-four (24) inches of vertical clearance between the new facility and an oil and gas pipeline or flowline provided for herein, and any overhead power lines shall be at least twenty (20) feet above the ground.

g. Surface Uses Over Pipeline Easements. In all cases, Surface Owner may install grasses (no trees or shrubs) and non-permanent soft surface trails that meander over and across pipeline easements, and it may also install paved surface trails, but only that cross pipeline easements at generally right angles. In cases where pipeline easements are located on the Property and adjacent to Weld County Road 3 or Weld County Road 5 and for the pipeline easement that runs north and south to the Oil and Gas Operations Area in the center of the SE/4 of Section 8 as depicted on Exhibit 2B for the Section 8 Property, Erie may request that Surface Owner install trees or bushes within the pipeline easement. In the event of such a request, Surface Owner shall prepare a landscape plan for review and the consent of KMGG, such consent not to be unreasonably withheld; provided however: i) installation of bushes shall be preferred to trees; and ii) trees and bushes shall not be located on the surface of the pipeline easement area within ten (10) feet of a pipeline. It shall not be unreasonable for KMGG to withhold consent to the installation of trees and bushes on a case by case basis for safety reasons or for the convenient installation and maintenance by KMGG of a pipeline or a portion of the pipeline or because of the type of bush or tree proposed by Surface Owner or the practical width of the pipeline easement given the installation of other pipelines, utilities or improvements within the same easement or proposed to be installed within the same easement, among other considerations. In all cases the Oil Companies shall not be liable for damages to the trails (both hard and soft surface), grasses, bushes or trees that are caused in whole or in part by their oil and gas operations.

h. Use of Pipeline Easements. The Oil Companies shall have the right to limit or restrict use of pipeline easements by Surface Owner and its other grantees for safety or security reasons. Surface Owner shall pay the Oil Companies all costs and expenses they incur to encase or lower pipelines and flowlines, as they determine to be reasonably necessary, to the extent that such pipelines and flowlines intersect and underlie any improvement permitted under this section. Under no circumstances shall Surface Owner prohibit the Oil Companies from the use of the flowlines and pipelines at any time. In addition, the Oil Companies shall have no liability to Surface Owner or any other parties for damage to improvements, landscaping, utilities or

facilities permitted to be installed by Surface Owner or such other parties within or adjacent to pipeline easements for damage caused by the oil and gas operations of the Oil Companies.

i. Minimum Ground Cover to be Maintained. Surface Owner shall maintain a minimum ground cover of 48 inches and not more than 72 inches over pipelines and flowlines in the conduct of its operations and its construction activities on the Property.

j. Road and Pipeline Construction/Coordination. Surface Owner will provide the Oil Companies with at least fourteen (14) days advance written notice before it begins to pave current and future streets and access routes, as applicable, in order to allow the Oil Companies the opportunity to lay new flowlines or pipelines that cross underneath the streets or access routes. If Surface Owner does not give the notice required herein, the Oil Companies may bore underneath the paved streets and access routes, such costs and expenses for the boring to be paid by Surface Owner.

k. Pipeline Depth Investigation. If Surface Owner's development plans anticipate that roadways will or may in the future cross over existing pipelines, Surface Owner will pothole or request that the Oil Companies pothole the existing and future pipelines to check the depth of such pipelines. Prior to Surface Owner's installation of a new roadway, the Oil Companies will lower, as required, the affected pipelines to sufficient depth for the road elevations. Surface Owner agrees to pay the Oil Companies the reasonable cost of inspecting and lowering the pipelines, as well as the reasonable cost of any sub-grade work required to achieve the road construction specifications.

4. Notice of Commencement of Surface Construction and Drilling Activities.

a. Surface Owner Notice. Surface Owner shall give advance notice to and meet at the site with representatives of the appropriate Oil Companies to locate existing pipelines and flowlines and to coordinate proposed surface construction activities with current and prospective oil and gas operations.

b. Oil Company Notice. The applicable Oil Company shall give notice to Surface Owner of proposed drilling activities on the Property in accordance with the rules and regulations of the COGCC, but in no event less than ten (10) days advance notice.

5. Surface Construction Activities.

a. Shut-In Production Payments. Surface Owner shall notify the applicable Oil Company at least twenty (20) days before Surface Owner intends to commence construction activities where it will utilize heavy equipment or other equipment that crosses flowlines or pipelines or that will occur adjacent to an Oil and Gas Operations Area. An Oil Company may, in its reasonable discretion, for safety purposes, shut in any pipeline or flowline over which Surface Owner's heavy earth moving equipment is to be run. Further, Surface Owner may request, or an Oil Company may elect, in its reasonable discretion, to shut in one or more of its wells during Surface Owner's construction activity on the surface of the Property. During the period of shut-in of any well, pipeline or flowline (either at the request of Surface Owner or at the discretion of the Oil Company as herein provided), Surface Owner shall pay the applicable

Oil Company an amount for each day of the shut-in equal to the average daily production of the affected well for the preceding six months calculated on the basis of the days that the well actually produced during the six month period.

Surface Owner shall also pay the Oil Company any costs to rework the well in order to place the well in production status after the shut-in and costs to replace pipelines and flowlines that are damaged by the surface construction activities of Surface Owner.

b. Electrical Equipment. Surface Owner shall pay the applicable Oil Company all costs that the Oil Company incurs to change electrical equipment for an Oil and Gas Operations Area where the Oil Company is required to make the change because of actual surface development of the Property.

6. Subdivision Plat and Local Regulations. Surface Owner shall identify the Temporary Easement Areas and the Oil and Gas Operations Areas and all present and future access routes and pipeline easements on its subdivision plats and in all applications for development that it files with a local jurisdiction. Plats shall include restrictions that no property line, permanent or temporary building, structure or other improvement, landscaping or sprinkler systems shall be located, constructed or installed within the Oil and Gas Operations Areas and pipeline easements, except as otherwise expressly permitted in sections 1.d. and 3.g. Except as expressly permitted under this Agreement, Surface Owner shall not locate temporary or permanent buildings, structures, improvements or landscaping or sprinkler systems within the Oil and Gas Operations Areas or upon or within the pipeline easements, and it shall not locate structures, improvements and equipment under the surface of the Oil and Gas Operations Areas, including but not limited to, sewer lines, gas pipelines or water lines.

7. Waiver of Surface Damage Payments. Surface Owner hereby waives all surface damage payments or other such payments for the use of the Property or portions thereof pursuant to any current or future COGCC or local regulation, state statute, common law or prior agreement for each and every well and related wellsite that is drilled and constructed within an Oil and Gas Operations Area and for all production facilities and for the pipeline easements and access routes as depicted on Exhibit 2A and Exhibit 2B (or relocated area) and for the use of the Temporary Easement Area as provided for herein. The Oil Companies may provide a copy of this Agreement to the COGCC or to any local jurisdiction, person or entity or any court of law as evidence of this waiver. The term "surface damages" shall be given the meaning commonly used in the oil and gas industry, but is not intended to be a waiver of damages caused by the negligence of the Oil Companies or their unreasonable use of the surface.

8. Waiver of Setback and Other Requirements. Surface Owner understands and acknowledges that the COGCC has rules and regulations that apply to the distance between a wellhead and public roads, production facilities, building units and surface property lines, among other things. Surface Owner hereby waives all setback requirements in COGCC Rule 603 (including the high density setback rules), or any successor rule or amendment to the COGCC setback rules, and to any other state or local setback requirements that are or become inconsistent with this Agreement or that would prohibit or interfere with the rights of the Oil Companies to explore for and produce the oil and gas in accordance with this Agreement. Surface Owner understands (and shall notify parties who purchase all or portions of the Property from Surface

Owner) that the Oil Companies may cite the waiver in this section 8 in order to obtain a location requirement exception or variance under COGCC rules or from a local jurisdiction; provided, any such request for an exception location or variance is consistent with the terms of this Agreement.

9. Payment of Relocation Costs. Surface Owner shall give advance written notice to the applicable Oil Company at least thirty (30) days prior to the time that Surface Owner requests that an Oil Company relocate an access road or pipeline pursuant to sections 2.b. or 3.d. The applicable Oil Company shall thereafter provide Surface Owner with an estimate of the costs for the relocation within thirty (30) days after receipt of the notice. Surface Owner shall pay the full amount of the estimate of relocation costs to the Oil Company within ten (10) days from the date it receives the estimate. Upon receipt of the estimate of costs by Surface Owner and the execution of a separate relocation agreement, the Oil Company will within a reasonable time commence the relocation of the applicable access road or pipeline, install the same in a good and workmanlike manner, and diligently pursue such relocation work to completion within a reasonable time. Upon completion of the relocation, the Oil Company shall give Surface Owner an accounting of the costs and expenses of the relocation. If the amount of such costs exceeds the amount of the estimate, Surface Owner shall pay the Oil Company the amount of the shortfall within ten (10) days from the receipt of the accounting. If the amount of such costs is less than the amount of the estimate, the Oil Company shall reimburse the difference to Surface Owner at the time it provides the accounting to Surface Owner.

10. Governmental Proceedings.

a. Surface Owner Will Not Object. Surface Owner agrees that: i) it will not object in any forum to the use by the Oil Companies of the surface of the Property consistent with this Agreement and the Development Agreement, to the extent not inconsistent with this Agreement, and hereby waives any such right to object or to request a hearing; ii) it will provide such other written approvals and waivers which are requested and consistent with this Agreement, including, but not limited to, all approvals and waivers to drill a well or to conduct oil and gas operations on the Property because of any law or regulation, including any local ordinance and regulations of the COGCC, and including, for example, waivers to state and local setback requirements and to any setback requirement from a surface property line or for an exception location; iii) it waives any rights it has to require or request a surface inspection for wells proposed to be drilled on the Property for the purpose of requesting that conditions be attached to a permit to drill a well and waives its right to request such conditions; iv) it consents to the location of multiple wells within an Oil and Gas Operations Area (as provided herein) that are greater or less than fifty feet apart so long as all such wells are located within the Oil and Gas Operations Area (as provided herein); and v) it waives its rights to object, request a hearing before the COGCC or that conditions be attached to a COGCC permit to drill, and to allege noncompliance with COGCC rules or applicable statutes, or to allege potential adverse impacts to public health, safety, and welfare, including the environment and wildlife resources, that are within the jurisdiction of the COGCC with respect to COGCC Applications for Permit to Drill ("Form 2") and COGCC Oil and Gas Location Assessments ("Form 2A").

b. Oil Companies Will Not Object. Except as provided in section 28.c. with respect to the Anadarko Entities, the Oil Companies agree that they will not object in any forum to a

request by Surface Owner to zone, rezone, plat or replat all or any portion of the Property to the extent such request is consistent with this Agreement and the Development Agreement, to the extent not inconsistent with this Agreement.

11. Notice to Home Builders and Homeowners. Surface Owner shall furnish all persons or entities that have a contract to purchase or that purchase all or any portion of the Property from Surface Owner with an exhibit that shows the locations of all Oil and Gas Operations Areas, existing and future pipeline easements and existing and proposed access routes. In addition, Surface Owner shall provide written notice to all such purchasers that includes as follows:

i. such buyers are not purchasing and will not own any interest in the oil and gas mineral estate;

ii. there may be ongoing oil and gas operations and production on the surface of the Property within the Oil and Gas Operations Areas, pipeline easements and access routes;

iii. additional oil and gas wells are likely to be drilled and oil and gas operations and production will likely take place on the Property, including the construction of oil and gas facilities, pipelines and flowlines, which will affect the surface of the Property within the Oil and Gas Operations Areas, pipeline easement(s) and access road(s);

iv. heavy equipment will be used by the oil and gas interest owners from time to time for oil and gas drilling and production operations, and such operations may be conducted on a 24 hour basis;

v. future purchasers of all or a portion of the Property, as successors in interest, will be bound by the covenants and provisions in this Agreement and subject to the waivers and covenants (i) included in sections 1.d., 2.a., 3.c., 7, 8, 10 and 21, among others; (ii) prohibiting the location of any building, structure, or other improvement by the purchaser within the Oil and Gas Operations Areas and pipeline easement areas; (iii) waiving objections to the drilling of wells, the construction of facilities, and the conduct of oil and gas operations on the Property consistent with this Agreement; and iii) waiving objections to the setback requirements under the rules of the COGCC or any local jurisdiction.

12. Impact Mitigation.

a. Oil Company Mitigation. The Oil Companies agree that they shall install and maintain and repair at their sole cost and expense such fences, gates and locks around the wells and production facilities as are required by the COGCC or Erie or Weld County as a condition for a special use permit to drill wells. To the extent required by law or regulation, the Oil Companies shall bear the costs of impact mitigation measures, including environmental or hazardous materials cleanup, remediation or mitigation for their individual operations on the Property.

b. Surface Owner Mitigation. Except as provided in section 12.a., Surface Owner shall bear all costs and expenses to install such noise and visual impact mitigation measures it desires or Erie or Weld County or other applicable local jurisdiction requires at or around the Oil

shall be construed as if drafted jointly by the parties and no presumption or burden of proof shall arise favoring or disfavoring any party by virtue of authorship of any of the provisions of this Agreement. Any reference to any federal, state, local or foreign statute or law shall be deemed also to refer to all rules and regulations promulgated thereunder, unless the context requires otherwise. The word "including" shall mean including, without limitation.

23. Successors and Assigns. This Agreement and all of the covenants in it shall be binding upon the personal representatives, heirs, successors and assigns of all of the parties, and the benefits of this Agreement shall inure to their personal representatives, heirs, successors and assigns. This Agreement and all of the covenants in it shall be covenants running with the land.

24. Recording. The Oil Companies shall record this Agreement with the Clerk and Recorder of Weld County promptly after it is executed by all of the parties and provide evidence to the other parties of the recording.

25. Governing Law. The validity, interpretation and performance of this Agreement shall be governed and construed in accordance with the laws of the State of Colorado without reference to its conflicts of laws provisions.

26. Severability. If any part of this Agreement is found to be in conflict with applicable laws, such part shall be inoperative, null and void insofar as it conflicts with such laws; however, the remainder of this Agreement shall be in full force and effect. In the event that any part of this Agreement would otherwise be unenforceable or in conflict with applicable laws due to the term or period for which such part is in effect, the term or period for which such part of this Agreement shall be in effect shall be limited to the longest period allowable which does not cause such part to be unenforceable or in conflict with applicable laws.

27. Incorporation by Reference. Exhibits 1A, 1B, 2A, 2B, 3, 4 and 5 are incorporated into this Agreement by reference.

28. Entire Agreement and Conflicts in Agreements.

a. Entire Agreement. With respect to the matters included in them, this Agreement, the Development Agreement and the Letter Agreement set forth the entire understanding among the parties or the particular parties to the specific agreement and supersede any previous communications, representations or agreements, whether oral or written. No change of any of the terms or conditions herein shall be valid or binding on any party unless in writing and signed by an authorized representative of each party.

b. Conflicts Between Particular Agreements. In the event of a conflict between this Agreement and the Development Agreement for a matter specifically covered in this Agreement, this Agreement shall control. In the event of a conflict between this Agreement and the Letter Agreement for a matter specifically covered in the Letter Agreement, the Letter Agreement shall control.

c. Anadarko Entities Agreement Conditional. The agreement herein of the Anadarko Entities is conditioned upon the execution by Surface Owner of: i) the Letter

and Gas Operations Areas which are in excess of or in addition to those measures which are required by COGCC regulations for areas which are not high density and which are required at the time Surface Owner applies for surface development approvals; provided, however, the operator of the well within the particular Oil and Gas Operations Area shall have reasonable discretion to veto or protest the types and locations of impact mitigation measures in order to allow for safe oil and gas operations.

13. Limited Surface Use By Oil Companies. Except for the Oil and Gas Operations Areas and the access roads and easements associated with flowlines, gathering lines and pipelines as provided for in this Agreement, and the use of the Temporary Easement Areas as provided herein, the Oil Companies shall not occupy the surface of the Property except in the event of an emergency or for reasonable incidental, temporary and non-damaging activities, for which the particular Oil Company shall be strictly and solely responsible for any damages that may occur.

14. Compliance with Kerr-McGee's General Guidelines. Surface Owner acknowledges that it has received a copy of a document from Kerr-McGee titled "General Guidelines for Design and Construction Activities On or Near Kerr-McGee Gathering LLC and Kerr-McGee Rocky Mountain Corporation Pipelines and Related Facilities" (Revision 1/2010) with which Surface Owner agrees to comply and which is attached as Exhibit 5.

15. Individual Liability of Oil Companies. Nothing in this Agreement is intended to create a cause of action by any Oil Company against any other Oil Company or to enlarge or diminish any right or interest created by any agreement or lease or assignment of lease between or among the Oil Companies. The liability of the Oil Companies to perform any obligation or to comply with any agreement hereunder or to comply with any state or local rule or regulation is individual and several and not joint or collective. No Oil Company shall be liable or responsible for the acts, omissions, performance, obligations or duties of the other Oil Companies under this Agreement. Surface Owner shall look solely to the applicable Oil Company for the performance by such Oil Company of its obligations under this Agreement and compliance with applicable laws and regulations with respect to its respective oil and gas operations on the Property. The agreements herein of a particular Oil Company apply only to the extent of the oil and gas interests in the Property that are now owned or that may be owned in the future by that Oil Company. This Agreement does not create a joint venture or partnership between or among any of the Oil Companies or the Anadarko Entities. The Anadarko Entities shall in no event be liable for the acts or omissions of their lessees, assignees of such lessees or farmoutees or the contractors and subcontractors of any of them.

16. No Waiver of Rights. The Oil Companies do not waive the rights they have pursuant to each of their respective oil and gas interests to explore for, drill and produce the oil and gas for the Property or for ingress and egress to any Oil and Gas Operations Area, except as specifically provided in this Agreement.

17. Conflict in Agreements. In the event of a conflict between this Agreement and the Development Agreement, this Agreement shall control; provided, however, the terms of the Development Agreement shall continue to apply to the extent that they are not inconsistent with this Agreement.

18. Notice of Hearings. Surface Owner shall provide the Oil Companies with written notice not less than thirty (30) days before each hearing for approval of a plat application or other land use application for the Property that is to be held before Erie or Weld County.

19 Notices. Any notice or other communication required or permitted under this Agreement shall be given in writing by any of: i) personal delivery; ii) expedited delivery service with proof of delivery; iii) United States mail, postage prepaid, and registered or certified mail with return receipt requested; or iv) prepaid telecopy or fax, the receipt of which shall be acknowledged, addressed as follows:

Surface Owner:	Tallgrass Investors, LLC 2500 Arapahoe Avenue, Suite 220 Boulder, Colorado 80302 Attention: Jon Lee Fax: (303) 442-1241
Anadarko Entities Kerr-McGee and KMGG:	Anadarko Petroleum Corporation 1099 18th Street, Suite 1800 Denver, Colorado 80202
Encana:	Encana Oil & Gas (USA) Inc. 370 17th Street, Suite 1700 Denver, Colorado 80202 Attn: DJ Land Team Lead

Any party may, by written notice as provided in this section, change the address of the individual to whom delivery of notices shall be made thereafter.

20. Acknowledgment of Title to Oil and Gas. Surface Owner specifically acknowledges the title of Anadarko E&P and Anadarko Land to the oil and gas reserved for the Property and relinquishes all rights and claims thereto, and it also acknowledges the oil and gas leasehold rights that Kerr-McGee and Encana own for the Property and relinquishes all rights and claims thereto.

21. Compliance with Common Law and Statutory and Regulatory Requirements. Surface Owner expressly acknowledges that this Agreement satisfies the obligations and requirements of the Oil Companies pursuant to COGCC rules and regulations and Colorado statutes to consult in good faith with Surface Owner regarding existing and proposed oil and gas operations on the Property, including pursuant to COGCC Rules 305 and 306, as amended. Surface Owner further expressly acknowledges that this Agreement shall be deemed to be specifically applicable to, and to fully satisfy, the obligations of the Oil Companies to accommodate the use of the surface of the Property by Surface Owner, existing and future, and Surface Owner waives any statutory and common law claims to the contrary, including, but not limited to, any claims pursuant to C.R.S. 34-60-127.

22. Construction. The parties have participated jointly in the negotiating and drafting of this Agreement. In the event ambiguity or question of intent or interpretation arises, this Agreement

Agreement; and ii) a separate letter agreement among the Anadarko Entities, Noble Energy, Inc. and Surface Owner for property included in the Bridgewater development described as the N/2 of Section 17, Township 1 North, Range 68 West.

29. Counterpart Executions. This Agreement may be executed in counterparts, each of which shall be deemed an original, and all of which together shall constitute one and the same instrument.

IN WITNESS WHEREOF, the undersigned parties have caused this Agreement to be executed by duly authorized representatives on the dates set forth in the acknowledgements, but to be effective on the date first above written.

ANADARKO E&P COMPANY LP

By: _____
Name: David Bell
Its: Agent and Attorney-In-Fact

ENCANA OIL & GAS (USA) INC.

By: _____
Name: _____
Its: _____

ANADARKO LAND CORP.

By: _____
Name: David Bell
Its: Agent and Attorney-In-Fact

TALLGRASS INVESTORS, LLC

By: _____
Name: _____
Its: _____

KERR-McGEE OIL & GAS ONSHORE LP

By: _____
Name: David Bell
Its: Agent and Attorney-In-Fact

Kerr-McGee Gathering LLC signs this Agreement as the entity which gathers and may in the future gather gas from wells drilled on the Property or on lands near the Property and in no other capacity. KMGG is not otherwise bound by the obligations in this Agreement, but shall have the right to enforce the provisions in section 3.

KERR-McGEE GATHERING LLC

By: _____
Name: Ronald H. Olsen
Title: Agent + Attorney-in-Fact

Agreement; and ii) a separate letter agreement among the Anadarko Entities, Noble Energy, Inc. and Surface Owner for property included in the Bridgewater development described as the N/2 of Section 17, Township 1 North, Range 68 West.

29. Counterpart Executions. This Agreement may be executed in counterparts, each of which shall be deemed an original, and all of which together shall constitute one and the same instrument.

IN WITNESS WHEREOF, the undersigned parties have caused this Agreement to be executed by duly authorized representatives on the dates set forth in the acknowledgements, but to be effective on the date first above written.

ANADARKO E&P COMPANY LP

By: _____
Name: _____
Its: _____

ENCANA OIL & GAS (USA) INC.

By: _____
Name: Ricardo D. Gallegos
Its: Attorney In Fact

ANADARKO LAND CORP.

By: _____
Name: _____
Its: _____

TALLGRASS INVESTORS, LLC

By: _____
Name: _____
Its: _____

KERR-McGEE OIL & GAS ONSHORE LP

By: _____
Name: _____
Its: _____

Kerr-McGee Gathering LLC signs this Agreement as the entity which gathers and may in the future gather gas from wells drilled on the Property or on lands near the Property and in no other capacity. KMGG is not otherwise bound by the obligations in this Agreement, but shall have the right to enforce the provisions in section 3.

KERR-McGEE GATHERING LLC

By: _____
Name: _____
Title: _____

Agreement; and ii) a separate letter agreement among the Anadarko Entities, Noble Energy, Inc. and Surface Owner for property included in the Bridgewater development described as the N/2 of Section 17, Township 1 North, Range 68 West.

29. Counterpart Executions. This Agreement may be executed in counterparts, each of which shall be deemed an original, and all of which together shall constitute one and the same instrument.

IN WITNESS WHEREOF, the undersigned parties have caused this Agreement to be executed by duly authorized representatives on the dates set forth in the acknowledgements, but to be effective on the date first above written.

ANADARKO E&P COMPANY LP

By: _____
Name: _____
Its: _____

ENCANA OIL & GAS (USA) INC.

By: _____
Name: _____
Its: _____

ANADARKO LAND CORP.

By: _____
Name: _____
Its: _____

TALLGRASS INVESTORS, LLC

By: _____
Name: Jon RLEE
Its: AUTHORIZED REPRESENTATIVE

KERR-McGEE OIL & GAS ONSHORE LP

By: _____
Name: _____
Its: _____

Kerr-McGee Gathering LLC signs this Agreement as the entity which gathers and may in the future gather gas from wells drilled on the Property or on lands near the Property and in no other capacity. KMGG is not otherwise bound by the obligations in this Agreement, but shall have the right to enforce the provisions in section 3.

KERR-McGEE GATHERING LLC

By: _____
Name: _____
Title: _____

3799568 10/18/2011 12:26P Weld County, CO
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ACKNOWLEDGMENTS

STATE OF Colorado)
) ss.
COUNTY OF Adams)

The foregoing instrument was acknowledged before me this 10th day of October, 2011, by David Bell, as Agent and Attorney-In-Fact for ANADARKO E&P COMPANY LP.

My Commission expires: 9/27/2015:

Witness my hand and official seal.

Notary Public

M. HENCMANN NOTARY PUBLIC STATE OF COLORADO
My Commission Expires 9-27-2015

STATE OF Colorado)
) ss.
COUNTY OF Adams)

The foregoing instrument was acknowledged before me this 10th day of October, 2011, by David Bell, as Agent and Attorney-In-Fact for ANADARKO LAND CORP.

My Commission expires: 9/27/2015:

Witness my hand and official seal.

Notary Public

M. HENCMANN NOTARY PUBLIC STATE OF COLORADO
My Commission Expires 9-27-2015

STATE OF Colorado)
) ss.
COUNTY OF Adams)

The foregoing instrument was acknowledged before me this 10th day of October, 2011, by David Bell, as Agent and Attorney-In-Fact for KERR-McGEE OIL & GAS ONSHORE LP.

My Commission expires: 9/27/2015:

Witness my hand and official seal.

Notary Public

M. HENCMANN NOTARY PUBLIC STATE OF COLORADO
My Commission Expires 9-27-2015

3799568 10/18/2011 12:26P Weld County, CO
19 of 46 R 236.00 D 0.00 Steve Moreno Clerk & Recorder

STATE OF Colorado)
Denver) ss.
COUNTY OF ~~Adams~~)

The foregoing instrument was acknowledged before me this 11th day of October, 2011, by Ronald H. Olsen, as Agent and Attorney-In-Fact for KERR-McGEE GATHERING LLC.

My Commission expires: 9/27/2015:

Witness my hand and official seal.

Notary Public

M. HENGMANN NOTARY PUBLIC STATE OF COLORADO
My Commission Expires 9-27-2015

STATE OF COLORADO)
) ss.
City and County of Denver)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for ENCANA OIL & GAS (USA) INC.

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

STATE OF COLORADO)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for TALLGRASS INVESTORS, LLC

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

3799568 10/18/2011 12:26P Weld County, CO
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STATE OF _____)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for KERR-McGEE GATHERING LLC.

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

STATE OF COLORADO)
) ss.
City and County of Denver)

The foregoing instrument was acknowledged before me this 28th day of September 2011, by Rick Gallegar, as Attorney-in-Fact for ENCANA OIL & GAS (USA) INC.

My Commission expires: 11/30/2011:

Witness my hand and official seal.

Notary Public

EMILY CONRAD NOTARY PUBLIC STATE OF COLORADO
My Commission Expires 11/30/2011

STATE OF COLORADO)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for TALLGRASS INVESTORS, LLC

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

3799568 10/18/2011 12:26P Weld County, CO
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STATE OF _____)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for KERR-McGEE GATHERING LLC.

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

STATE OF COLORADO)
) ss.
City and County of Denver)

The foregoing instrument was acknowledged before me this _____ day of _____, 2011, by _____, as _____ for ENCANA OIL & GAS (USA) INC.

My Commission expires:_____:

Witness my hand and official seal.

_____
Notary Public

STATE OF COLORADO)
) ss.
COUNTY OF DENVER)

The foregoing instrument was acknowledged before me this 11th day of October, 2011, by Don R. Lee, as Authorized Representative for TALLGRASS INVESTORS, LLC

My Commission expires: 4/27/2013:

LORRI L. SIMPSON NOTARY PUBLIC STATE OF COLORADO My Commission Expires 4/27/13

Witness my hand and official seal.

Lorri L. Simpson
Notary Public

3799568 10/18/2011 12:26P Weld County, CO
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Exhibit 1A

to

Surface Use Agreement effective September 27, 2011 by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

Legal Description of the Section 18 Property

Township 1 North, Range 68 West
Section 18: metes and bounds description
Weld County, Colorado

See attached legal description consisting of two (2) pages.

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Exhibit 1B
to
Surface Use Agreement effective September 27, 2011
by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

Legal Description of the Section 8 Property

Township 1 North, Range 68 West
Section 8: metes and bounds description
Weld County, Colorado

See attached legal description consisting of two (2) pages.

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Section 18 Property

A parcel of land situate in the E1/2 of Section 18, Township 1 North, Range 68 West of th 6th P.M., Weld County, more particularly described as follows:

PARCEL D

Commencing at the Northeast corner of Section 18, Township 1 North, Range 68 West, 6th P.M., from whence the East 1/4 corner of said section lies S00°02'28" E, 2678.62 feet;
Thence N89°14'48" W, 30.07 feet to the point of beginning;
Thence S00°02'28" E, 1897.89 feet parallel with and 30.00 feet distant West of the East line of the NE1/4 of Section 18 to a point on the North line of the Erie Cemetery, partially described in a deed recorded on May 23, 1968, as Reception No. 1516751;
Thence N89°59'20" W, 640.42 feet to the Northwest corner of said cemetery;
Thence S00°03'40" W, 404.65 feet to the North line of a parcel recorded in Book 30, Page 483;
Thence N89°34'58" W, 163.67 feet to the Northwest corner of said parcel;
Thence S00°04'57" E, 417.42 feet to the Southwest corner of said parcel;
Thence S89°34'58" E, 804.84 feet to a point 30.00 feet westerly of the East line of the SE1/4 of Section 18;
Thence S00°25'10" E, 1450.65 feet parallel with and 30.00 feet distant westerly of the East line of said SE1/4 to a point on the North line of a parcel recorded as Reception No 1516751;

Thence along boundary of said parcel the following three courses:
1) S89°40'50" W, 658.56 feet,
2) S00°19'10" E, 253.00 feet,
3) N89°40'50" E, 659.00 feet to a point 30.00 feet westerly of the East line of the SE1, of Section 18;

Thence S00°25'10" E, 825.08 feet to a point 30.00 feet northerly of the South line of sai SE1/4 of Section 18, said point also being the northerly right-of-way line of Weld County Road 8;
Thence N89°31'17" W, 258.53 feet, along said northerly right of way, parallel with and 30.00 feet North of the South line of said SE1/4;
Thence N86°54'04" W, 1098.49 feet along the northerly line of Weld County Road 8, as described in Book 15551, Pages 39-43, Reception Nos. 2495437-41 to a point on the easterl line of property described in Book 754 at Reception No. 1676471;

Thence along said property the following three courses:
1) N00°29'16" E, 49.80 feet;
2) 453.09 feet along the arc of a tangent curve to the left, said arc subtended by a radius of 440.00 feet, a central angle of 59°00'00", and a chord bearing N29°00'44" W 433.33 feet;
3) N58°30'44" W, 204.67 feet to a point 50.00 feet distant southeasterly, measured at right angles, from the centerline of the main track of the Boulder branch of the Unic

(continued)

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Pacific Railroad Company as presently constructed and operated, said right of way conveyed to the Union Pacific Railroad by deed recorded in Book 359 at Page 418;
Thence northerly along a line drawn parallel and/or radially with said centerline of ma. track the following nine courses:

1) 629.21 feet along the arc of a non-tangent curve to the left, said arc subtended by radius of 1007.50 feet, a central angle of 35°46'57", and a chord bearing N07°31'37 E, 619.03 feet;
2) Thence N10°21'52" W, 694.70 feet;
3) 894.20 feet along the arc of a tangent curve to the right, said arc subtended by a radius of 1287.50 feet, a central angle of 39°47'36", and a chord bearing N09°31'57 E, 876.34 feet;
4) N29°25'45" E, 224.87 feet;
5) 463.85 feet along the arc of a tangent curve to the left, said arc subtended by a radius of 1673.50 feet, a central angle of 15°52'51", and a chord bearing N21°29'19 E, 462.36 feet;
6) N13°32'54" E, 421.72 feet;
7) 966.21 feet along the arc of a tangent curve to the left, said arc subtended by a radius of 2957.50 feet, a central angle of 18°43'06", and a chord bearing N04°11'21 E, 961.91 feet;
8) N05°10'12" W, 351.67 feet;
9) 165.08 feet along the arc of a tangent curve to the right, said arc subtended by a radius of 1575.00 feet, a central angle of 06°00'20", and a chord bearing N02°10'02 W, 165.01 feet to a point on the North line of the NE1/4 of Section 18;

Thence along said North line S89°14'48" E, 1206.77 feet to the point of beginning,
EXCEPTING THEREFROM a "road right of way 8 feet in width leading to said cemetery from Erie", so described in Book 30 at Page 483.

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Section 8 Property

Two parcels of land situate in the S21/4 of Section 8, Township 1 North, Range 68 West o the 6th P.M., Weld County, more particularly described as follows:

PARCEL B

Commencing at the Southeast corner of Section 8, Township 1 North, Range 68 West, 6th P.M., from whence the East 1/4 corner of said section lies N00°49'09" E, 2674.68 feet; Thence N45°04'48" W, 41.78 feet to the point of beginning, 30.00 feet North of the South line of said section;
Thence S89°01'14" W, 2618.83 feet parallel with and 30.00 feet North of the South line o said section to a point on the North-South centerline of Section 8;
Thence N00°01'31" E, 1579.23 feet along said North-South centerline to a point on the South right of way line of the Union Pacific Railroad, said right-of-way conveyed to the Union Pacific Railroad by a deed recorded June 13, 1912, in Book 359 at Page 418, said right-of-way line being 50.00 feet distant southerly as measured at right angles or radially from the existing main track centerline;
Thence along said right of way the following three courses:

1) N42°43'40" E, 467.34 feet,
2) 1735.43 feet along the arc of a tangent curve to the right, said arc subtended by a radius of 1858.50 feet, a central angle of 53°30'06", and a chord bearing N69°28'43" E, 1673.07 feet,
3) S83°46'14" E, 772.36 feet to a point 30.00 feet West of the East line of the S1/2 of the section;

Thence S00°49'09" W, 2380.71 feet parallel with and 30.00 feet West of the East line of the S1/2 to the point of beginning.

(continued)

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PARCEL B-1

Commencing at the East 1/4 corner of Section 8, Township 1 North, Range 68 West, 6th P.M. from whence the Southeast corner of said section lies S00°49'09" W, 2674.68 feet;
Thence along the East-West centerline S89°35'35" W, 30.00 feet to the point of beginning;
Thence S00°49'09" W, 163.81 feet parallel with and 30.00 feet West of the East line of th S1/2 of Section 8 to a point on the northerly right-of-way line of the Union Pacific Railroad, said right of way conveyed to the Union Pacific Railroad by a deed recorded Jur 13, 1912, in Book 359 at Page 418, said right-of-way line being 50.00 feet distant northerly as measured at right angles or radially from the existing main track centerline;
Thence following said northerly right of way the following three courses:

1) N83°46'14" W, 762.89 feet,
2) 1828.81 feet along the arc of a tangent curve to the left, said arc subtended by a radius of 1958.50 feet, a central angle of 53°30'06", and a chord bearing S69°28'43" W, 1763.09 feet;
3) S42°43'40" W, 358.98 feet to a point on the North-South centerline of Section 8;

Thence N00°01'31" E, 943.91 feet along said North-South centerline to a point on the East-West centerline of said Section 8;
Thence N89°35'35" E, 2655.15 feet along the East-West centerline to the point of beginning.

(continued)

3799568 10/18/2011 12:26P Weld County, CO
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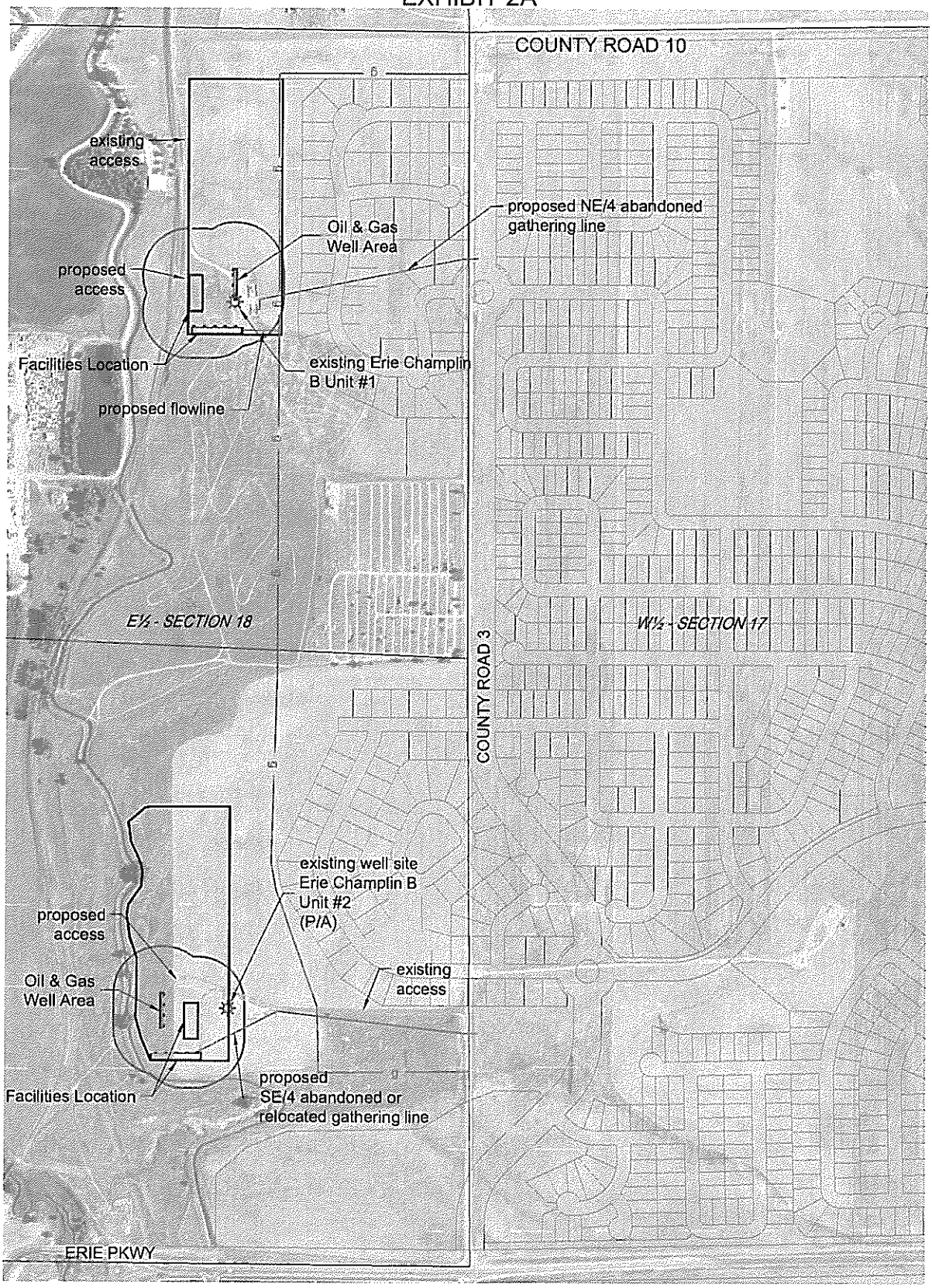
Exhibit 2A

to

Surface Use Agreement effective September 27, 2011 by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

See attached Plats consisting of three (3) pages for the Section 18 Property.

EXHIBIT 2A



PROPOSED ACCESS

FUTURE PIPELINE EASEMENT (75' TEMPORARY & 50' PERMANENT)

TEMPORARY EASEMENT AREA

OIL & GAS OPERATIONS AREA

encana

TOWNSHIP 1 NORTH, RANGE 68 WEST
A PORTION OF SECTIONS 17 & 18
WELD COUNTY, COLORADO

SCALE: 1" = 400' SEPTEMBER 26, 2011

EXHIBIT 2A.1

3799568 10/18/2011 12:26P Weld County, CO
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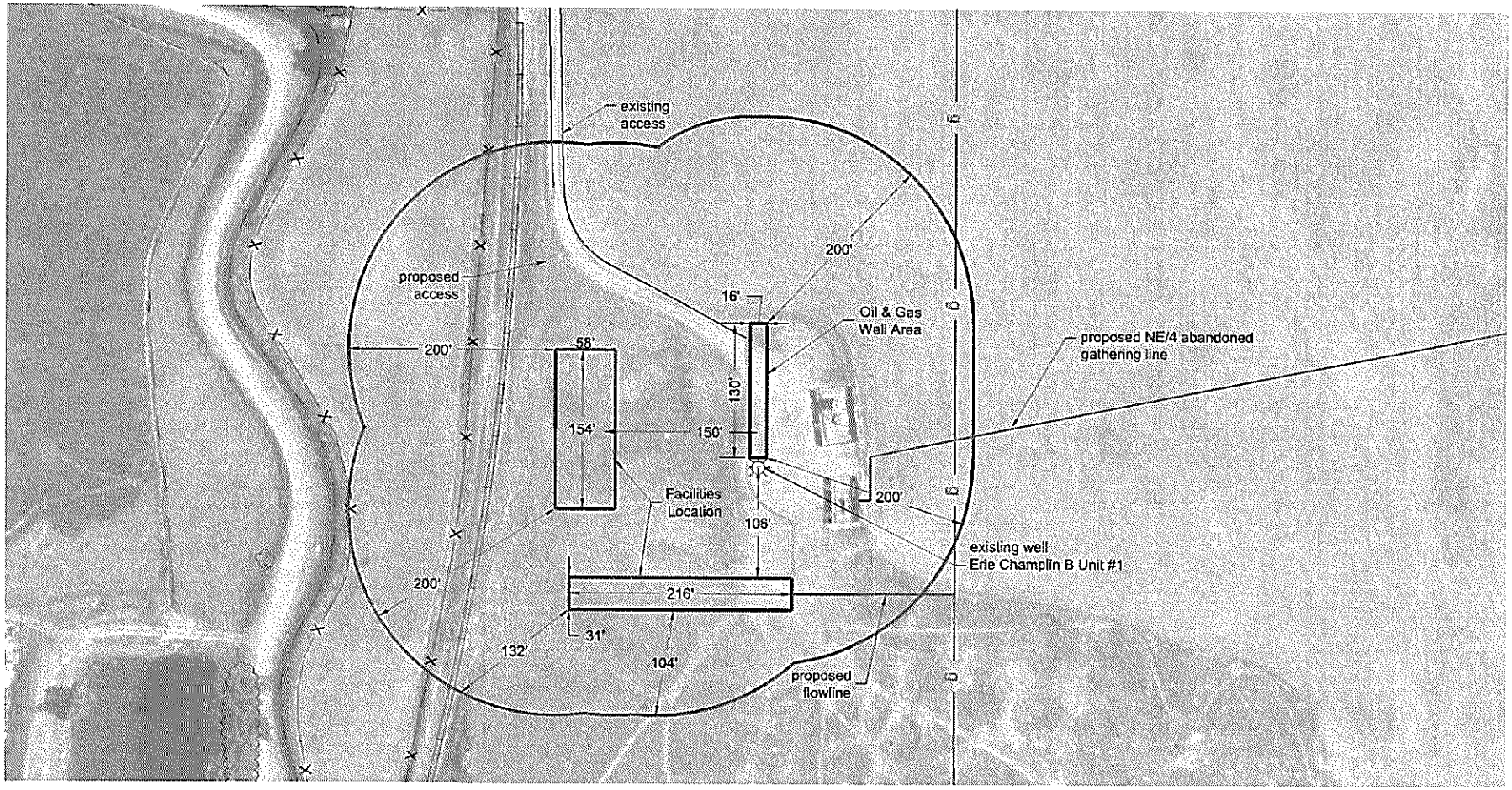

OIL & GAS OPERATIONS AREA

PROPOSED ACCESS

g — FUTURE PIPELINE EASEMENT
(75' TEMPORARY & 50' PERMANENT)

encana.

TOWNSHIP 1 NORTH, RANGE 68 WEST
SECTION 18: NE¼
WELD COUNTY, COLORADO

SCALE: 1" = 150' SEPTEMBER 26, 2011

EXHIBIT 2A.2

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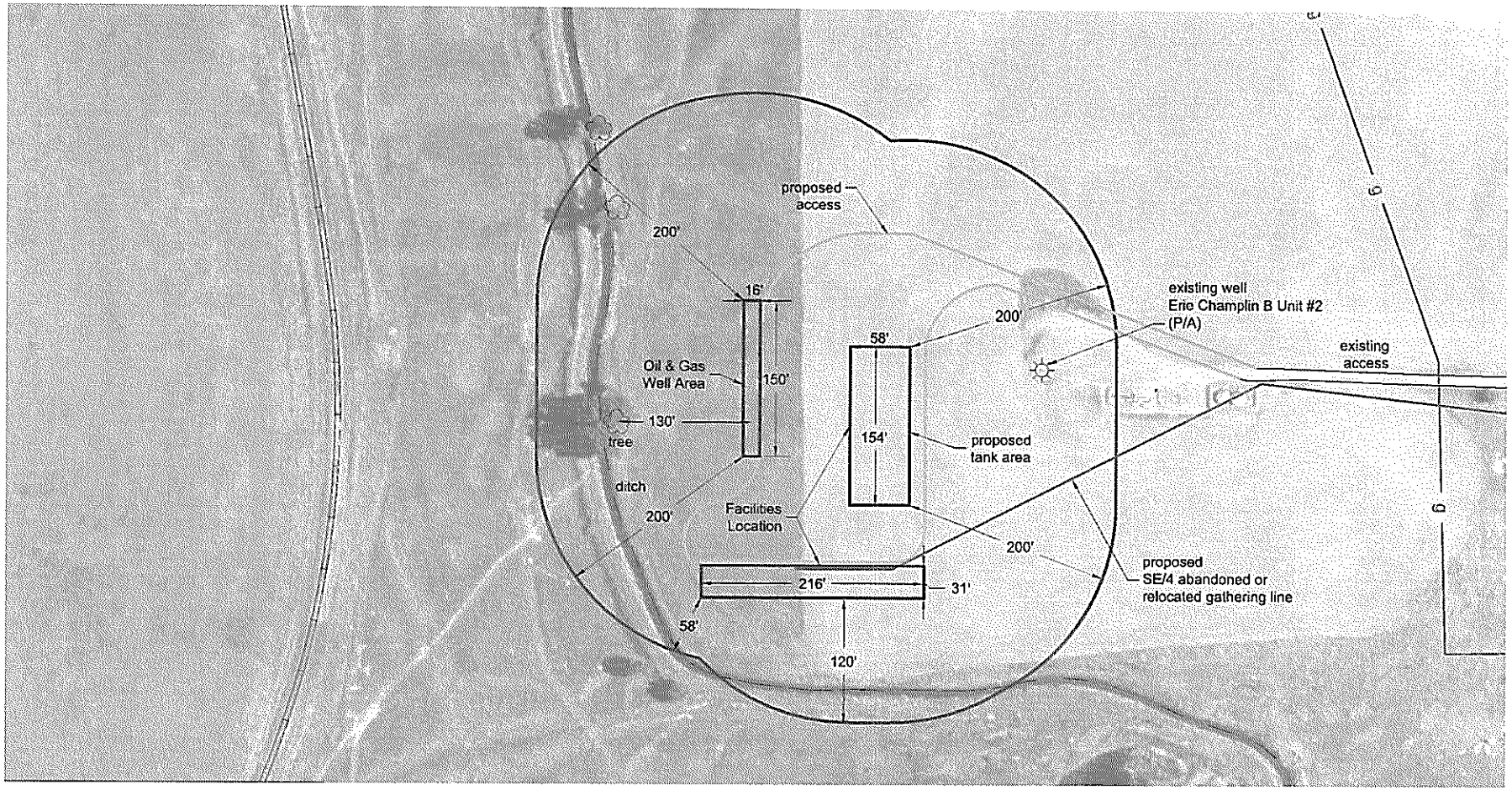

OIL & GAS OPERATIONS AREA

PROPOSED ACCESS

g — FUTURE PIPELINE EASEMENT
(75' TEMPORARY & 50' PERMANENT)

encana

TOWNSHIP 1 NORTH, RANGE 68 WEST
SECTION 18: SE¼
WELD COUNTY, COLORADO

SCALE: 1" = 150' SEPTEMBER 26, 2011

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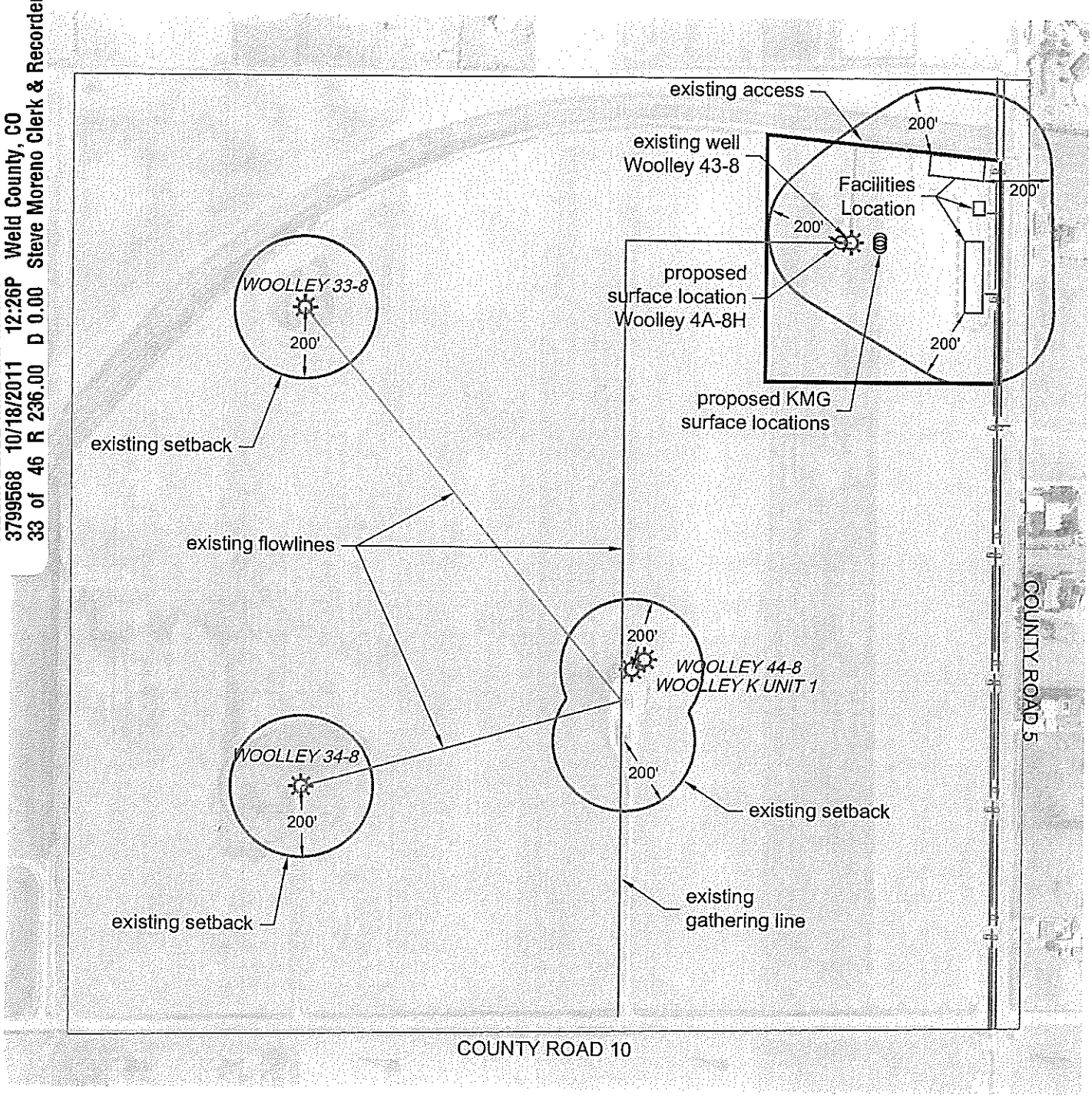
Exhibit 2B

to

Surface Use Agreement effective September 27, 2011 by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

See attached Plats consisting of two (2) pages for the Section 8 Property.

EXHIBIT 2B



TEMPORARY EASEMENT AREA

OIL & GAS OPERATIONS AREA

PROPOSED FUTURE PIPELINE EASEMENT
(50' TEMPORARY & 30' PERMANENT)

PROPOSED ACCESS

encana

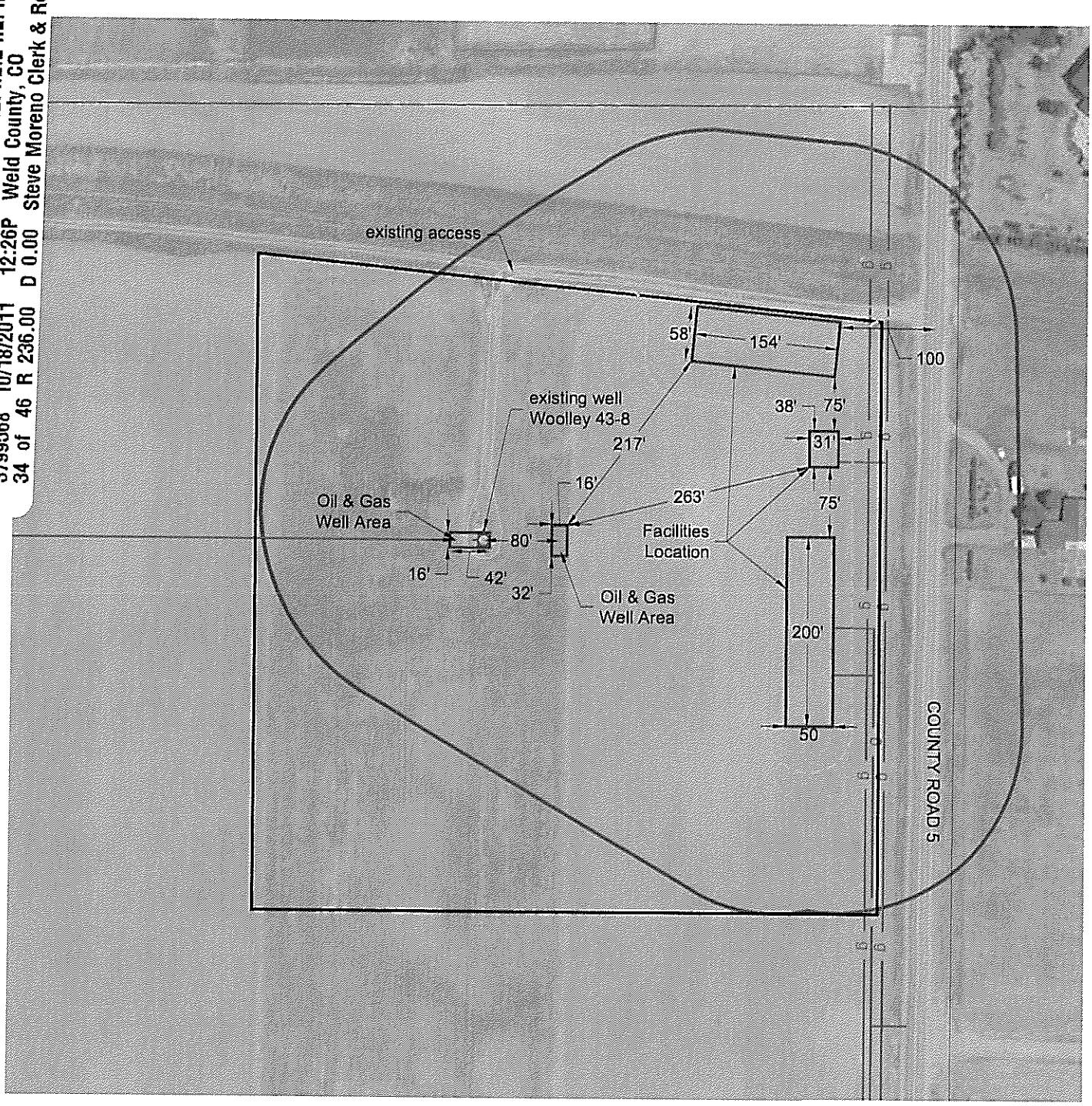
TOWNSHIP 1 NORTH, RANGE 68 WEST
SECTION 8: SE¼

WELD COUNTY, COLORADO

SCALE: 1" = 400'

OCTOBER 12, 2011

EXHIBIT 2B.1



TEMPORARY EASEMENT AREA

OIL & GAS OPERATIONS AREA

g PROPOSED FUTURE PIPELINE EASEMENT (50' TEMPORARY & 30' PERMANENT)

PROPOSED ACCESS

encana
natural gas

TOWNSHIP 1 NORTH, RANGE 68 WEST
SECTION 8: NE¼SE¼
WELD COUNTY, COLORADO

SCALE: 1" = 150'

OCTOBER 10, 2011

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Exhibit 3
to
Surface Use Agreement effective September 27, 2011
by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

AGREEMENT FOR RELOCATION OF PIPELINE AND RIGHT-OF-WAY

THIS AGREEMENT ("Agreement") is entered into this ____ day of _____, 20__, by and between **Tallgrass Investors, LLC** ("Tallgrass"), whose address is 2500 Arapahoe Avenue, Suite 220, Boulder, Colorado 80302 and **Kerr-McGee Gathering LLC** ("KMGG"), a Colorado limited liability company, whose address is 1099 18th Street, Denver, Colorado 80202.

RECITALS

A. KMGG is the successor in interest to a Right-of-Way Grant ("Easement") across a portion of the ____ of Section ____, Township 1 North, Range 68 West of the 6th P.M. in Weld County, Colorado. The Easement was originally conveyed to _____ for natural gas pipeline purposes by instrument recorded_____, reception #_____, of the records of the Weld County Clerk and Recorder.

B. Tallgrass is the current owner of a portion of the ___ of Section ___, Township 1 North, Range 68 West, 6th P.M., Weld County, Colorado (the "Property").

C. Tallgrass plans to develop the surface of the Property as a part of a residential development known as Bridgewater.

D. In order to accommodate the proposed development of the Property by Tallgrass, KMGG agrees to release a portion of the Easement lying within and across the Property and in consideration therefore, Tallgrass agrees to provide a Right-of-Way so that KMGG's pipeline(s) can be physically relocated and operated.

NOW, THEREFORE, in consideration of the covenants contained herein and the mutual benefits to be derived, KMGG and Tallgrass agree as follows:

1. Partial Release. KMGG shall execute and deliver a Partial Release of Easement (Exhibit "D") relinquishing and quitclaiming unto Tallgrass, the Easement, insofar, and only insofar, as it crosses or lies within the Property. Said Partial Release of Easement will be provided after delivery of the new Right-of-Way, as provided below, and after the physical relocation of the pipeline(s) and the tie-in of the relocated pipeline(s).

2. Amendment of Right-of-Way. Upon removal and rerouting of the existing pipelines from their current locations, KMGG shall execute and deliver an Amendment of Right-of-Way on the form attached hereto as Exhibit "A" and incorporated herein by this reference, amending permanently KMGG's pipeline Right-of-Way to the route(s) set forth and described in Exhibit "B" attached hereto which shall be attached to the Amendment as Exhibit "A". The Amendment will be provided after the physical relocation of the pipeline(s) and the tie-in of the relocated pipeline(s).

3. Conveyance of Right-of-Way. Tallgrass hereby agrees to provide and deliver to KMGG, prior to the actual placement and operation of new pipeline, an executed and recordable new Right-of-Way conveying unto KMGG, its successors and assigns, a perpetual right-of-way and easement for pipeline purposes on the form attached hereto as Exhibit "C". The new Right-of-Way shall be for the purposes of, and convey rights to survey, construct, install, maintain, inspect, operate, repair, replace, modify, change the size of, reconstruct, mark, monitor, abandon or remove, at KMGG's election, pipelines and all appurtenances, above or below ground, reasonably necessary or convenient for the transportation or transmission of oil, gas, petroleum products, water, hydrocarbons, and any other substances, whether fluid or gaseous, and any products, derivatives, combinations or mixtures of any of the foregoing. The width of the New Right-of-Way shall be _____ feet (___') during construction of the relocated portion of the pipeline(s) and any maintenance thereto, and subsequent to construction shall be _____ feet (___').

4. Title and Authority. Tallgrass represents and warrants to KMGG that Tallgrass is the sole owner in fee simple of the lands described in Exhibit "B" and Exhibit "C", being the route(s) of the Amended Right-of-Way and new Right-of-Way, respectively, and that Tallgrass has full power, right and authority to execute and deliver the Amendment of the Right-of-Way and new Rights-of-Way.

5. Senior Rights. KMGG acknowledges that all routes are non-exclusive and agrees that it will not object to the concurrent use of the routes by Tallgrass, utilities providers and other operators as Tallgrass may grant from time to time; provided, however, that such concurrent use does not in any way interfere with the use of the routes by KMGG. All pipes shall be placed with a minimum horizontal clearance of ten (10) feet from all other pipelines and utilities; and a minimum vertical clearance of eighteen (18) inches from all other pipelines and utilities. KMGG's "General Guidelines for Design and Construction Activities On or Near Kerr- McGee Gathering LLC and Kerr- McGee Oil & Gas Onshore LP Pipelines and Related Facilities" shall be strictly adhered to at all times. Said General Guidelines are attached hereto as Exhibit "F". Tallgrass further represents and warrants that it has full power, right and authority to enter into this Agreement and to make the covenants set forth herein.

6. Title Insurance. Tallgrass must deliver to KMGG a title commitment from an insurer acceptable to KMGG with any request for the relocation of any pipeline. If any of the exceptions contained in Schedule B-2 of said title commitment are (i) senior liens or encumbrances on the land upon which the right(s)-of-way to be granted to KMGG pursuant to this Agreement are to be located; or (ii) deemed by KMGG to infringe on its right of free use and enjoyment of new right(s)-of-way granted under this Agreement, the liens or encumbrances must be released or subordinated and any infringements must be cured by Tallgrass prior to the relocation of any pipelines. Prior to commencing any relocation activities, Tallgrass must furnish KMGG with a policy of title insurance insuring KMGG's title to its right(s)-of-way against any senior lien or encumbrance and against any interest that may interfere with KMGG's quiet enjoyment of the right(s)-of-way to be granted pursuant to this Agreement. KMGG will not be required to relocate any pipeline unless and until it has been furnished with a policy of title insurance that is satisfactory to it.

7. Pipeline Relocation Expense. KMGG has prepared a good faith estimate of the costs and expenses to be incurred in the pipeline relocation project and a summary of those costs and expenses is set forth on Exhibit "E" hereto. Costs include KMGG's corporate overhead of fifteen percent (15%) for the legal, engineering, and other administrative costs necessary to process and complete the relocation. Upon execution of this Agreement, Tallgrass will pay

KMGG the total estimated cost of pipeline relocation, which is $_____. It is understood that this amount is only an estimate and that Tallgrass shall be obligated to pay or reimburse KMGG for all actual costs and expenses related to the pipeline relocation. Upon conclusion of the relocation, the parties shall reconcile the costs incurred and payments made, with appropriate adjustments and reimbursements to Tallgrass or supplemental payments to KMGG being made within one-hundred twenty (120) days after the pipeline relocation is completed.

8. Amendments. This Agreement cannot be modified, except by a written agreement signed by both parties hereto.

9. Binding Effect. The rights granted herein may be assigned in whole or in part, and the terms, conditions, and provisions of this Agreement shall be a covenant running with the Property and shall extend to and be binding upon the heirs, executors, administrators, personal representatives, successors, and assigns of Tallgrass and KMGG.

IN WITNESS WHEREOF, the parties have executed this Agreement as of the date first above written.

TALLGRASS INVESTORS, LLC

By: _____

Title: _____

KERR-MCGEE GATHERING LLC
a Colorado limited liability company

By: _____
_____, Agent and Attorney-in-Fact

STATE OF COLORADO)
) ss.
COUNTY OF)

The foregoing instrument was acknowledged before me this _____ day of _____, 201_, by _____, as _____, on behalf of _____ .

Witness my hand and official Seal.

My Commission Expires:_____

_____
Notary Public

(SEAL)

STATE OF)
)ss.
COUNTY OF)

The foregoing instrument was acknowledged before me this _____ day of _____, 201_, by _____ as Agent and Attorney-in-Fact for Kerr-McGee Oil & Gas Onshore LP, a Delaware Limited Partnership, in its capacity as Manager of Kerr-McGee Gathering LLC, a Colorado limited liability company, on behalf of such company.

Witness my hand and official Seal.

My Commission Expires: _____

_____
Notary Public

(SEAL)

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Exhibit 4
to
Surface Use Agreement effective September 27, 2011
by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

RIGHT-OF-WAY GRANT

THIS RIGHT-OF-WAY GRANT ("Grant") is made this ____ day of _____, 20__, from TALLGRASS INVESTORS, LLC with an address of 2500 Arapahoe Avenue, Suite 220, Boulder, Colorado 80302 ("Grantor") to _____, with an address of _____ ("Grantee"). The parties agree as follows:

For and in consideration of Ten Dollars ($10.00) and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Grantor hereby grants, conveys and warrants unto Grantee, its successors and assigns, a perpetual right-of-way(s) and easement(s) to survey, construct, maintain, inspect, operate, repair, replace, modify, change the size of, reconstruct, mark, monitor, abandon or remove, at Grantee's election, pipelines and all appurtenances, below and/or above ground, including but not limited to, launchers and receivers, convenient for the transportation or transmission of oil, gas, petroleum products, water, hydrocarbons and any other substances, whether fluid, solid or gaseous, and any products, derivatives, combinations or mixtures of any of the foregoing, in, on, over, under, or through the lands situated in Weld County, State of Colorado, being generally described as follows and more specifically described on Exhibit "A" attached hereto and made a part hereof:

TOWNSHIP 1 NORTH, RANGE 68 WEST, 6TH PM
Section ___: ____

The specific route and course of the right-of-way(s) and easement(s) conveyed hereby ("Right-of-Way Lands") is more particularly described on Exhibit "B" attached hereto and made a part hereof. The width of the Right-of-Way Lands during construction shall be _____ feet (___') and subsequent to construction shall be _____ feet (___').*

Grantor represents and warrants to Grantee that Grantor is the sole owner in fee simple of the Right-of-Way Lands and has full right, power and authority to make this Grant.

Grantee shall lay all pipe at a depth of not less than 36 inches. Grantee shall repair and/or restore any fence on or adjacent to the Right-of-Way Lands removed or severed by Grantee in the course of the operations provided for in this Grant. If necessary to prevent the escape of Grantor's livestock, Grantee shall construct temporary gates or fences.

**Fifty (50) feet construction/thirty (30) feet permanent for Section 8 and Seventy-Five (75) feet construction/fifty (50) feet permanent for Section 18.*

Grantee shall have all rights, privileges and benefits necessary or convenient for the full use and enjoyment of this Grant, including but not limited to, the right of ingress and egress over and across Grantor's lands lying adjacent to the Right-of-Way Lands for any and all purposes necessary and incidental to exercising Grantee's rights hereunder. Grantor agrees not to build, create, construct or permit to be built, created or constructed, any obstruction, building, fence, landscaping, reservoir, engineering works or other structures or improvements over, under, on or across the Right-of-Way Lands without prior written consent of Grantee.

Grantee shall be obligated to pay for, repair, replace or otherwise compensate Grantor for any damages resulting from Grantee's activities and operations on the Right-of-Way Lands, and Grantor shall pay for, reimburse, indemnify and hold Grantee harmless from any and all claims or damages resulting from Grantor's activities on the Right-of-Way Lands. Grantor shall have the right to use and enjoy the Right-of Way Lands, subject to the rights herein granted.

This Grant cannot be modified, except in writing signed by Grantor and Grantee.

The rights granted herein may be assigned in whole or in part, and the terms, conditions, and provisions of this Grant are a covenant running with the land and shall extend to and be binding upon the successors and assigns of Grantor and Grantee.

Grantee agrees to level and restore any lands that may have excessive settling and sufficiently compact the soil within a reasonable period of time after completion of construction.

This Grant may be executed in counterparts each of which shall be considered one and the same agreement.

IN WITNESS WHEREOF, the parties have executed this Grant as of the date first above written.

Grantor:
Tallgrass Investors, LLC

By: _____
Name: _____
Its: _____

Grantee:
_____

By: _____
Name: _____
Agent & Attorney-in-Fact

STATE OF COLORADO)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 201__, by _____ as _____ of Tallgrass Investors, LLC.

Witness my hand and official Seal.

My Commission Expires:_____

_____

Notary Public

STATE OF _____)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of_____, 201_, by _____, as Agent and Attorney-in-Fact of _____, on behalf of such company.

Witness my hand and official Seal.

My Commission Expires:_____

_____

Notary Public

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Exhibit 5

to

Surface Use Agreement effective September 27, 2011 by and among Anadarko Land Corp., Anadarko E&P Company LP, Kerr-McGee Oil & Gas Onshore LP, Kerr-McGee Gathering LLC (for the limited purposes described herein), Encana Oil & Gas (USA) Inc. and Tallgrass Investors, LLC

See attached Guidelines consisting of four (4) pages.

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General Guidelines for Design and Construction Activities On or Near Kerr- McGee Gathering LLC Pipelines and Related Facilities

This list of design, construction and contractor requirements, including but not limited to the following, is for the design and installation of foreign utilities or improvements on Kerr McGee Gathering LLC (KMGG) right-of-way (ROW). These are not intended to, nor do they waive or modify any rights KMGG may have under existing easements or ROW agreements. For information regarding KMGG's rights and requirements as they pertain to the existing easements, please reference existing easements and amendments documents. This list of requirements is applicable for KMGG facilities on easements and in road rights of ways only. Encroachments on fee property should be referred to the Land & ROW Department. Any reference to KMGG in the below requirements is meant to include and apply to any Kerr McGee entity.

Design

- KMGG shall be provided sufficient prior notice of planned activities involving excavation, blasting, or any type of construction on KMGG's ROW or near its facilities. This is to determine and resolve any location, grade or encroachment problems and allow for the protection of KMGG's facilities and the general public. This prior notification is to be made **before** the actual work is to take place.

- The encroaching entity shall provide KMGG with a set of drawings for review and a set of final construction drawings showing all aspects of the proposed facilities in the vicinity of KMGG's ROW. The encroaching entity shall also provide a set of "as-built drawings" and submit to KMGG, showing the facilities in the vicinity of KMGG's ROW upon completion of the work.

- Only facilities shown on drawings reviewed by KMGG will be approved for installation on KMGG's ROW. All drawing revisions that affect facilities proposed to be placed on KMGG's ROW must be approved by KMGG in writing.

- KMGG shall approve the design of all permanent road crossings.

- Any repair to surface facilities following future pipeline maintenance or repair work by KMGG on its "prior rights" ROW will be at the expense of the developer or landowner. In addition, any repair to surface facilities following future pipeline maintenance or repair work by KMGG on replacement ROW granted to relocate KMGG facilities will also be done at the expense of the developer or landowner unless expressly addressed in surface use agreements and approved in writing by KMGG.

- The depth of cover over the KMGG pipelines shall not be increased or reduced nor surface modified for drainage without KMGG's written approval.

- Construction of any permanent structure within KMGG pipeline easement is **not** permitted without written approval by KMGG.

- Planting of shrubs and trees is not permitted on KMGG pipeline easement without written approval by KMGG.

- Irrigation equipment i.e. backflow prevent devices, meters, valves, valve boxes, etc. shall not be located on KMGG easement without written approval by KMGG.

- Foreign utility installations, i.e., distribution gas, oil and gas gathering, water, electric, telephone, cable and sewer lines, etc., may cross perpendicular to KMGG's pipeline within the ROW, provided that a minimum of eighteen inches (18") of vertical clearance is maintained between KMGG pipeline(s) and the foreign utility. Any installation by a foreign utility with less than 18" of vertical separation is not allowed without written approval by KMGG. In no case will vertical separation be less than 12". Constant line elevations must be maintained across KMGG's entire ROW width, gravity drain lines are the only exception and must be approved in writing. Foreign line crossings below the KMGG pipeline must be evaluated by KMGG to ensure that a significant length of the KMGG line is not exposed and unsupported during construction. Foreign line crossings above the KMGG pipeline with less than 18" of clearance must be evaluated by KMGG to ensure that additional support is not necessary to prevent settling on top of the KMGG natural gas pipeline. A KMGG representative must be on site during any crossing activities to verify clearance depths and to assure the integrity and support of the KMGG facility. All installations of foreign crossings done by boring and or jacking require the KMGG facility to be exposed to verify clearances.

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General Guidelines for Design and Construction Activities On or Near Kerr- McGee Gathering LLC Pipelines and Related Facilities

- Foreign utilities shall not run parallel to KMGG pipelines within the KMGG easement without written permission by KMGG. A minimum of 10 feet of horizontal separation must be maintained in parallel installations whether the foreign utility is placed within the KMGG easement or adjacent to the KMGG easement. Any deviation from the 10' horizontal requirement must be approved in writing by KMGG and an "as built survey" provided to KMGG after installation. In the instance that high voltage electric lines, greater than 20kV, are installed parallel to a KMGG pipeline a minimum horizontal distance of 15' must be maintained.

- The foreign utility should be advised that KMGG maintains cathodic protection on its pipelines and facilities. The foreign utility must coordinate their cathodic protection system with KMGG's. At the request of KMGG, foreign utilities shall install (or allow to be installed) cathodic protection test leads at all crossings for the purposes of monitoring cathodic protection interference. The KMGG CP technician and the foreign utility CP technician shall perform post construction CP interference testing. Interference issues shall be resolved by mutual agreement between foreign utility and KMGG. All costs associated with the correction of cathodic protection interference issues on KMGG pipelines as a result of the foreign utility crossing shall be borne by the foreign utility for a period of one year from date the foreign utility is put in service.

- The developer shall understand that KMGG, whether specifically required per federal law or by company standard, will mark the routing of its underground facilities with aboveground pipeline markers and test leads and maintain those markers and test leads. Markers will be installed at every point the pipeline route changes direction and adequate markers will be installed on straight sections of pipeline to insure, in the sole opinion of KMGG, the safety of the public, contractor, KMGG personnel and KMGG facilities.

- On all foreign utility crossings and / or encroachments, metallic foreign lines shall be coated with a suitable pipe coating for a distance of at least 10 feet on either side of the crossing.

- AC Electrical lines must be installed in conduit and properly insulated.

- On all foreign pipelines, DOT approved pipeline markers shall be installed so as to indicate the route of the foreign pipeline across the KMGG ROW.

- No power poles, light standards, etc. shall be installed in the KMGG easement without written approval by KMGG.

- KMGG installs above ground appurtenances at various locations that are used in the operation of its facilities. Kerr McGee will install protective enclosures at the above ground appurtenances to protect them from outside damage. The design and placement of these above ground appurtenances and protective enclosures is done at KMGG's sole discretion, and may exceed any regulatory requirements.

Construction

- If KMGG will be relocating KMGG facilities for any entity, grading in the new KMGG ROW shall be +/- 6 inches before KMGG will mobilize to complete the relocation. Final cover after the completion of the project will not be manipulated by the requesting entity to be less than 48" nor more than 72". All cover that exceeds 72" or less than 48" will be approved in writing by KMGG. This does not preclude KMGG from installing the pipeline at a minimum cover of 36" as provided for in CFR 49 Part 192. Cover during all construction activities will NEVER be less than 36" unless approved in writing and a KMGG representative is on site during the time cover is reduced.

- The entity requesting relocation shall survey top of pipe after installation but before backfill to determine proper final elevation of KMGG facilities. The entity requesting relocation is solely responsible for the final depth of cover over the relocated KMGG facility. Any deviation from cover requirements as outlined above will be corrected at the sole expense of the entity requesting relocation.

- Contractors shall be advised of KMGG's requirements and be contractually obligated to comply.

- The continued integrity of KMGG's pipelines and the safety of all individuals in the area of proposed work near KMGG's facilities are of the utmost importance. Therefore, contractor must meet with KMGG representatives prior to construction to provide and receive notification listings for appropriate area operations and emergency personnel. **KMGG's on-site representative will require discontinuation of any work that, in his or her opinion, endangers the operations or safety of personnel, pipelines or facilities.**

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General Guidelines for Design and Construction Activities On or Near Kerr- McGee Gathering LLC Pipelines and Related Facilities

- **The Contractor must expose all KMGG pipelines prior to crossing to determine the exact alignment and depth of the lines. A KMGG representative must be present.**

- The use of probing rods for pipeline locating shall be performed by KMGG representatives only, to prevent unnecessary damage to the pipeline coating. A KMGG representative shall do all line locating.

- Notification shall be given to KMGG at least 72 hours before start of construction. A schedule of activities for the duration of the project must be made available at that time to facilitate the scheduling of KMGG's work site representative. Any Contractor schedule changes shall be provided to KMGG immediately.

- Heavy equipment will not be allowed to operate directly over KMGG pipelines or in KMGG ROW unless written approval is obtained from KMGG. Heavy equipment shall only be allowed to cross KMGG pipelines at locations designated by KMGG. Haul roads will be constructed at all crossings. The haul roads will be constructed using lightweight equipment. The existing depth of cover over the pipeline must be verified. Cover will be added such that a total of 8' of fill exists over the pipeline and extends a minimum of 10' on each side of the pipeline. Depth of cover will then taper as required for equipment access. Steel plates may be used for load dissipation only if approved in writing by KMGG.

- Contractor shall comply with all precautionary measures required by KMGG, at its sole discretion to protect its pipelines. When inclement weather exists, provisions must be made to compensate for soil displacement due to subsidence of tires.

- Excavating or grading which might result in erosion or which could render the KMGG ROW inaccessible shall not be permitted unless the contractor agrees to restore the area to its original condition and provide protection to KMGG's facility. At no time will cover be reduced to less than 36" without written approval by KMGG and a KMGG representative on site.

- A KMGG representative shall be notified prior to construction activities within twenty-five (25) feet of a KMGG pipeline or above ground appurtenance. The contractor **shall not** be allowed to work within twenty-five (25) feet of KMGG facilities without approval from the KMGG representative. The KMGG representative may or may not remain on site during the entire construction activity. Contractor shall use extreme caution and take appropriate measures to protect KMGG facilities. The contractor shall call the KMGG representative prior to backfilling around the KMGG facility to allow for a final inspection of the KMGG facility.

- Ripping is only allowed when the position of the pipe is known and not within ten (10) feet of KMGG facility. KMGG personnel must be present.

- Temporary support of any exposed KMGG pipeline by Contractor may be necessary if required by KMGG's on-site representative. Backfill below the exposed lines and 12" above the lines shall be replaced with sand or other selected material as approved by KMGG's on-site representative and thoroughly compacted in 12" lifts to 95% of standard proctor dry density minimum or as approved by KMGG.'s on-site representative. This is to adequately protect against stresses that may be caused by the settling of the pipeline.

- No blasting shall be allowed within 1000 feet of KMGG's facilities unless blasting notification is given to KMGG Including complete Blasting Plan Data. A pre-blast meeting shall be conducted by the organization responsible for blasting.

- KMGG shall be indemnified and held harmless from any loss, cost of liability for personal injuries received, death caused or property damage suffered or sustained by any person resulting from any blasting operations undertaken within 500 feet of its facilities. The organization responsible for blasting shall be liable for any and all damages caused to KMGG's facilities as a result of their activities whether or not KMGG representatives are present. KMGG shall have a signed and executed Blasting Indemnification Agreement before authorized permission to blast can be given.

- No blasting shall be allowed within 200 feet of KMGG's facilities unless blasting notification is given to KMGG a minimum of one week before blasting. The organization responsible for blasting must complete Blasting Plan Data. KMGG shall review and analyze the blasting methods. A written blasting plan shall be provided by the organization responsible for blasting and agreed to in writing by KMGG. A written emergency plan shall be provided by the organization responsible for blasting.

- KMGG shall have a signed and executed Blasting Indemnification Agreement before authorized permission to blast can be given. A pre-blast meeting shall be conducted by the organization responsible for blasting.

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General Guidelines for Design and Construction Activities On or Near Kerr- McGee Gathering LLC Pipelines and Related Facilities

- Any contact with any KMGG facility, pipeline, valve set, etc. shall be reported immediately to KMGG. If repairs to the pipe are necessary, they will be made and inspected before the section is re-coated and the line is back-filled.
- KMGG personnel shall install all test leads on KMGG facilities.

Local Kerr-McGee Gathering LLC Representation:

Operations Manager	Kevin Osif, P.E.	Phone: (303) 655-4307
Staff Engineer:	Joseph E. Sanchez, P.E.	Phone: (303) 655-4319
Pipeline Foreman:	James Phillips	Phone: (303) 655-4343
Construction Foreman:	Jim McQuiston	Phone: (303) 655-4326
Construction Supervisor	Darrel Gentry	Phone: (303) 655-4326

Emergency Contacts:

On call supervisor	Phone: (303) 559-4001
Kerr McGee 24 hour emergency number	Phone: (303) 659-5922
One Call Emergency	Phone: 811