Preliminary Draft

US 6 Over Garrison Street

Hydrology and Hydraulics Report

Prepared For:

CDOT Region 1 Hydraulics
2000 South Holly Street
Denver, Colorado 80222

February 7, 2014

Prepared By:

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APPENDICES

I. INTRODUCTION

A. Background

The purpose of the 6th and Garrison Bridge Replacement Project, hereafter called "the project," is to replace a deteriorating bridge on 6th Avenue over Garrison Street.

This project includes the replacement of the bridge, addition of sidewalks along Garrison Street, and associated drainage and water quality improvements. Photographs of the bridge and various existing drainage features are included in Section III.

B. Location

1. Description

The project, CDOT Project No. FBR 0063-046, is located in the eastern portion of the City of Lakewood, in the west Denver metro area. Figure 1-1 shows the project location and limits. The Colorado Department of Transportation (CDOT), Federal Highway Administration (FHWA), and the City of Lakewood (The City) are the primary stakeholders in the project.

2. Streets, Highways, and Right-of-Way

The project site is located along approximately 2,500 linear feet of 6th Avenue (US 6) over Garrison Street in Lakewood, Colorado. The proposed right-of-way width of 6th Avenue just east of Garrison Street is 260', transitioning to 200' at the east end of the project limits. The proposed right of way width of 6th Avenue west of Garrison Street is generally 280'.

3. 1/4 Section, Section, Township, Range

The project site is located in Sections 3 and 10 of Township 4 South, Range 69 West.

4. Major Drainageways

There are no major drainageways within the site. Lakewood Gulch is located approximately 0.31 miles to the north and McIntyre Gulch is located approximately 0.35 miles to the south. Runoff from the project site drains north towards Lakewood Gulch.

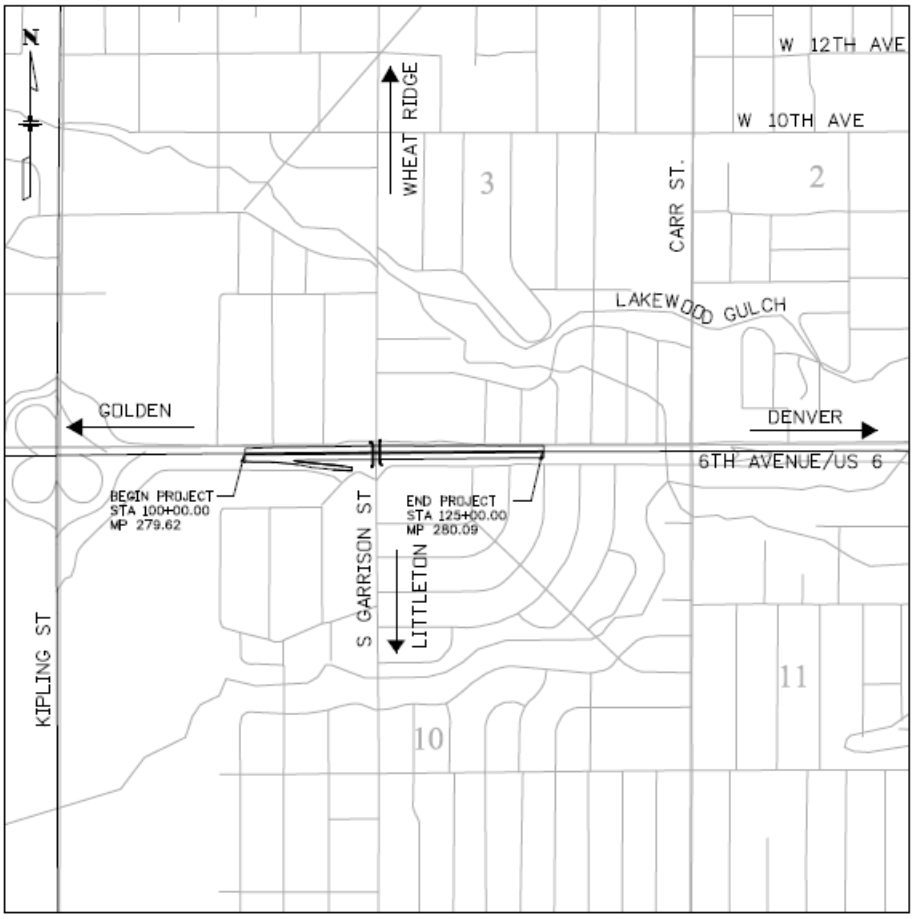


Figure 1-1: Project Site Map

C. Description of Property

1. Area in Acres

The area of disturbance for the project is approximately 10.33 acres. The area of disturbance beyond the original footprint of roadways is 2.99 acres.

2. Ground Cover

The area around the project is mostly developed with urban residential and commercial properties. Native grasses cover the existing roadway embankments, gore points and ditches of the intersection. Soils in the area are mostly within the Hydrologic Soils Group C. See **Appendix B** for Hydrologic Soils Group Map. The topography varies throughout the site with as little as 1% along the roadways to steeper than 50% along highway embankments.

3. General Project Description

The project includes the removal and replacement of the bridge on 6th Avenue over Garrison Street. A modified roadway profile will require new pavement along the approaches to the bridge. Sidewalks will be added under the bridge along Garrison Street. Associated work will be completed to meet drainage and water quality requirements.

4. Irrigation Facilities

There are no irrigation facilities within the project limits. The Rocky Mountain Ditch is located approximately 0.46 miles east of the bridge, but not within the project limits.

5. Land Use

Proposed land use is the same as existing: Roadway.

6. Wetlands

There are no wetlands within the project limits.

II. HYDROLOGY

A. Major Basin Description

1. Drainage Studies and Reports

Lakewood Gulch

Flood Hazard Area Delineation – Lakewood Gulch, for UDFCD, City of Lakewood, City and County of Denver and Jefferson County, prepared by Sellards & Grigg, Inc., dated February 1979

Lakewood Gulch Major Drainageway Planning Phase B Report, for UDFCD, City and County of Denver, City of Lakewood and Jefferson County, prepared by Sellards & Grigg, Inc., dated December 1979.

McIntyre Gulch

Flood Hazard Area Delineation – McIntyre Gulch, for UDFCD and City of Lakewood, prepared by Hydro-Triad, Ltd., dated October 1977

2. Major Drainage Basin Characteristics

Lakewood Gulch and McIntyre Gulch are located within FEMA-regulated floodplains, but the base flood elevation limits do not extend to the project area. The basins are generally made up of urban development.

3. Historic Drainage Patterns

Runoff from 6th Avenue in the vicinity of the Garrison Street Bridge drains to inlets and storm pipes that convey the flows north to Lakewood Gulch.

See Proposed Drainage Basin Map in **Appendix A.**

4. Identification of Lakes, Ponds, and Dams

There are no lakes, ponds, or dams within the project area.

B. Sub-Basin Description

1. Master Plan Improvements

There are no master planned drainage improvements within the project area.

2. Existing Drainage Patterns

6th Avenue – The bridge over Garrison Street is the high point in the area along 6th Avenue. Runoff flows east and west from the bridge to vane grate inlets along the side of 6th Avenue. The inlets are connected to a storm system that conveys the flows to Lakewood Gulch.

Garrison St. – Runoff on Garrison Street flows in a curb and gutter system to combination inlets in the vicinity of the bridge. The inlets are connected to a storm system that conveys the flows to Lakewood Gulch. Surface street flows are also directed northward to Lakewood Gulch.

3. Offsite Drainage Flow Patterns and Impacts

No offsite flows will be conveyed to the proposed storm and water quality systems. Offsite runoff on Garrison Street will continue to flow to the existing drainage system, bypassing the proposed water quality facilities.

C. Hydrologic Criteria

1. Design Rainfall

One Hour Point Rainfall

Frequency	**Rainfall (inches)**	
2-year	0.96	(minor storm)
5-year	1.35	
10-year	1.57	
50-year	2.27	
100-year	2.60	(major storm)

2. Runoff Calculation Method

The Rational Method will be used to calculate stormwater runoff from the project area. The maximum limit of application of the Rational Method is a tributary basin of approximately 160 acres. All basins tributary to the project area are less than 160 acres.

The rational formula is: $Q = CIA$

Where: Q = maximum rate of runoff in cubic feet per second

C = runoff coefficient

I = the average intensity of rainfall in inches per hour for a duration equal to the time of concentration. Minimum time of concentration of 5 minutes is used for calculation of intensity.

A = basin area in acres

D. Geology, Land Use, Soil Type

The land use for the project area was determined from existing aerial images for the project area. The project area consists of proposed roadway widening with offsite contributions to the roadway area from business and residential properties. See **Appendix B** for the soils data and map.

E. Design Frequency

The 5-year design storm was used to size the minor drainage system for the project. The 50-year storm event was used to size the pipes located in the roadway sag on the western side of the project. The 100-year storm will continue to flow overland along streets, as it currently does for existing conditions.

F. Hydrologic Discharge

The hydrologic discharge for the 5-year and 50-year storm events are summarized in **Appendix B**. 50-year storm events are shown to verify the spread width of the sag inlets at US 6.

G. Future Upstream Development

The basins tributary to the proposed water quality ponds are nearly fully developed. Redevelopment of the properties may occur, but will not impact the drainage and water quality facilities proposed for this project.

III. EXISTING DRAINAGE FACILITIES

A. Lakewood Drainage System

The drainage system on Garrison Street and frontage roads comprising of inlets, pipes and manholes, is owned and maintained by the City of Lakewood. No modifications or improvements to these systems are proposed for this project, with the exception of an inlet on the curb return at the northwest corner of the bridge will be replaced due to sidewalk and curb return improvements. See **Appendix F** for as-built drawings of the existing drainage system.

Looking west on north side of 6th Avenue

Looking east on south side of 6th Avenue

Looking east on north side of 6th Avenue

Looking north along Garrison Street

Looking east on north side of 6th Avenue

Looking southwest from intersection

B. CDOT Drainage System

Inlets, manholes, and pipes located on 6th Avenue are owned and maintained by CDOT. Inlets are located on both sides of 6th Avenue east and west of the bridge.

Looking east along 6th Avenue

Looking east along 6th Avenue

Looking west along 6th Avenue

Looking west along 6th Avenue

Inlet on 6th Avenue, west of bridge

Inlet on 6th Avenue, east of bridge

Inlet on 6th Avenue, west of bridge

Spillway southwest of bridge, looking west

IV. DESIGN DISCUSSION

A. General Concept

1. Proposed Drainage System and Drainage Patterns

a. The minor storm pipe system will convey the 5-year peak flow. The 50-year storm event was used to size the pipes located in the roadway sag on the western side of the project. Some pipes will convey the 100-year flow, but others will surcharge to the streets during the 100-year event.

b. There are no major storm systems proposed for this project.

2. Compliance with Offsite Runoff Considerations

a. Offsite flows will be conveyed as in existing conditions but will bypass proposed water quality facilities. Offsite flows will be conveyed through and around the project area in existing and proposed piped drainage systems.

b. Runoff from the new drainage systems will not impact off site properties.

3. Assumptions, Techniques, and Methodologies

The project will provide a cost effective design for the water quality ponds that meets the requirements for the Clean Water Act.

Inroads Storm and Sanitary was used to model the storm pipe and inlet system for the project. Its interface with Microstation allows for ease of modifications to the storm system design with changes to the roadway design. The minimum time of concentration used by Inroads Storm and Sanitary for this urban roadway project is 5 minutes. 5 minutes was used for all roadway basins on this project due to their small size.

B. Specific Details

1. Drainage Problems Encountered

a. No drainage problems were encountered

2. Pond Storage Requirements

Due to minimal increase in runoff, no detention ponds are required for this project as agreed upon by CDOT and the City of Lakewood. Water quality ponds will be designed to hold the water quality capture volume for 100% of the area tributary to the pond. The City of Lakewood agreed that the paved area east of the proposed easternmost inlets would not be required to be treated since the proposed paved area is the same as the existing paved area and the runoff could not feasibly be drained through the proposed ponds.

3. Maintenance and Access

The water quality ponds will be maintained by the City of Lakewood. The ponds will be accessed from the adjacent ramps.

4. Drainage Easements

All drainage facilities are located within the CDOT right-of-way or City of Lakewood-owned property. No easements are required.

5. Impacts on Downstream Properties

There are no adverse impacts to downstream properties.

6. Concerns by CDOT, Lakewood, and Property Owners

a. There are no known drainage concerns by CDOT, Lakewood, or property owners.

7. Design Details

a. Present and future land uses remain the same as a combination of residential and commercial properties.

b. The 100-year runoff from the project area will be conveyed overland to the adjacent streets where the flows will then be conveyed northeasterly to Lakewood Gulch.

c. This project complies with the requirements of Sections 402 NPDES and 404 of the Clean Water Act.

8. Structure Alternatives

a. Standard CDOT inlet structures are recommended for the project to simplify future maintenance and reduce construction cost. Type R inlets will be used on most curb applications. Vane Grate inlets will be used on 6th Avenue. An existing curb inlet will be replaced with a Type 13 grate inlet on the curb return north and west of the bridge.

C. Hydraulic Criteria

1. Capacity of the Downstream Drainage System

An analysis of the existing drainage system was not included in the scope of work for the project. There will be a slight increase in runoff due to the increase in bridge width at Garrison Street, but the initial flows will be attenuated through the water quality ponds.

2. Storm Sewer System Layout Including Inlets

The storm sewer system has been designed to convey runoff from the 5-year storm event. Inlets were sized and spaced to keep the maximum spread within the shoulder on Highways (US 6). The spread on the SW exit ramp slightly exceeds the shoulder width, but the single lane ramp width is approximately 22' in the vicinity of the affected inlets. The 50-year storm event was used to size the pipes and inlets located in the roadway sag on the western side of the project.

Inlets were placed within the approach slab on either side of the bridge to capture runoff from the bridge. A minimum pipe size of 18 inches was used for the bridge drainage system.

Vane grate inlets are used for the drainage on US 6. A 30% clogging factor is used for on-grade inlets and a 50% clogging factor is used in sump locations.

See drainage plans for the storm system layout.

3. Water Quality Pond Design

Water quality facilities have been designed to capture and detain the Water Quality Capture Volume (WQCV) in accordance with the CDOT MS4 permit with the exception of a section of newly paved area on 6th Avenue at the east end of the project and minor curb and sidewalk replacements on Garrison Street that could not feasibly be treated in the proposed water quality facilities. As underground water quality facilities would be expensive and are not preferred by the entities responsible for maintenance, this section of pavement remains untreated.

The ponds are designed as an Extended Detention Basin (EDB) with a forebay and a trickle channel and will drain within 40 hours. The northeast water quality pond and the southwest water quality pond will spill onto the adjacent ramps when the capacities of the ponds are exceeded.

D. Adaptations from Criteria

1. No detention required for this project as agreed upon by CDOT and the City of Lakewood.
2. No water quality treatment required for pavement replacement at east end of project or new sidewalk and curb replacement on Garrison Street as agreed upon by CDOT and the City of Lakewood.

V. RECOMMENDED DESIGN

A. Storm Drain Systems

Two new storm drain systems consisting of storm pipe, inlets, manholes, ditches, and ponds have been incorporated into the design discharging to the following water quality facilities:

NE WQ POND: Storm drain improvements for the project area located from Station 109+27 (crest of the bridge) to Station 119+55 drain to the proposed Northeast Water Quality Pond. The contributing basin area is approximately 3.36 acres.

SW WQ POND: Storm drain improvements for the project area located from station 100+00 (west end of the project limits) to Station 109+27 (crest of the bridge) drain to the proposed Southwest Water Quality Pond. The contributing basin area is approximately 3.58 acres.

B. Water Quality

Water quality ponds will be Extended Detention Basins (EDB) with forebays and trickle channels. They will be sized to store the Water Quality Capture Volume (WQCV), based on the impervious area in the basin tributary to the pond. The following are statistics for each pond:

NE WQ POND: Northeast WQ Pond will be located at the northeast corner of the intersection of 6th Avenue and Garrison Street. The drainage basin tributary to the pond extends from the crest of the bridge to the east end of the new inlets in 6th Avenue near the east end of the project.

SW WQ POND: Southwest WQ Pond will be located at the southwest corner of the intersection of 6th Avenue and Garrison Street. The drainage basin tributary to the pond extends from the west end of the project limits to the crest of the bridge.

See **Appendix D** for more detailed information on Water Quality.

C. Hydraulic Modeling

There are no large waterways within the project requiring hydraulic modeling.

VI. SUMMARY

A. Compliance with Criteria and Standards

Work is in compliance with the following:

- City of Lakewood Criteria
- CDOT Criteria
- UDFCD Drainage Criteria Manual

Due to minimal increase in runoff, it was agreed upon by CDOT and the City that no detention facilities would be incorporated into this project.

B. Drainage Concept

Damage Control of Drainage Design

The proposed drainage pipe system is designed to convey the minor storm event (5-year). There are no major event drainage systems for this project. The drainage design is effective in controlling erosion and flooding from the design storm runoff.

There are no adverse drainage impacts of the work on upstream or downstream properties.

C. Stormwater Management Plan

Refer to the Project Plan Sheets for a complete description of the Stormwater Management Plan. Stormwater erosion and sediment will be managed with temporary BMPs during construction and permanent BMPs after construction.

D. Water Quality

Water Quality will be improved on the site as follows:

- The water quality capture volume will be treated in water quality facilities, which meet the requirements of the CDOT MS4 permit, with the exception of a section of newly paved area on 6th Avenue at the east end of the project that could not feasibly be treated in the proposed water quality facilities. The water quality ponds will be maintained by the City of Lakewood.

E. Existing Drainage Facilities

Existing drainage facilities within the project limits will remain in place. New facilities will be connected to them.

There are no existing detention or water quality facilities that detain or treat stormwater runoff from the project area.

F. Proposed Drainage Facilities

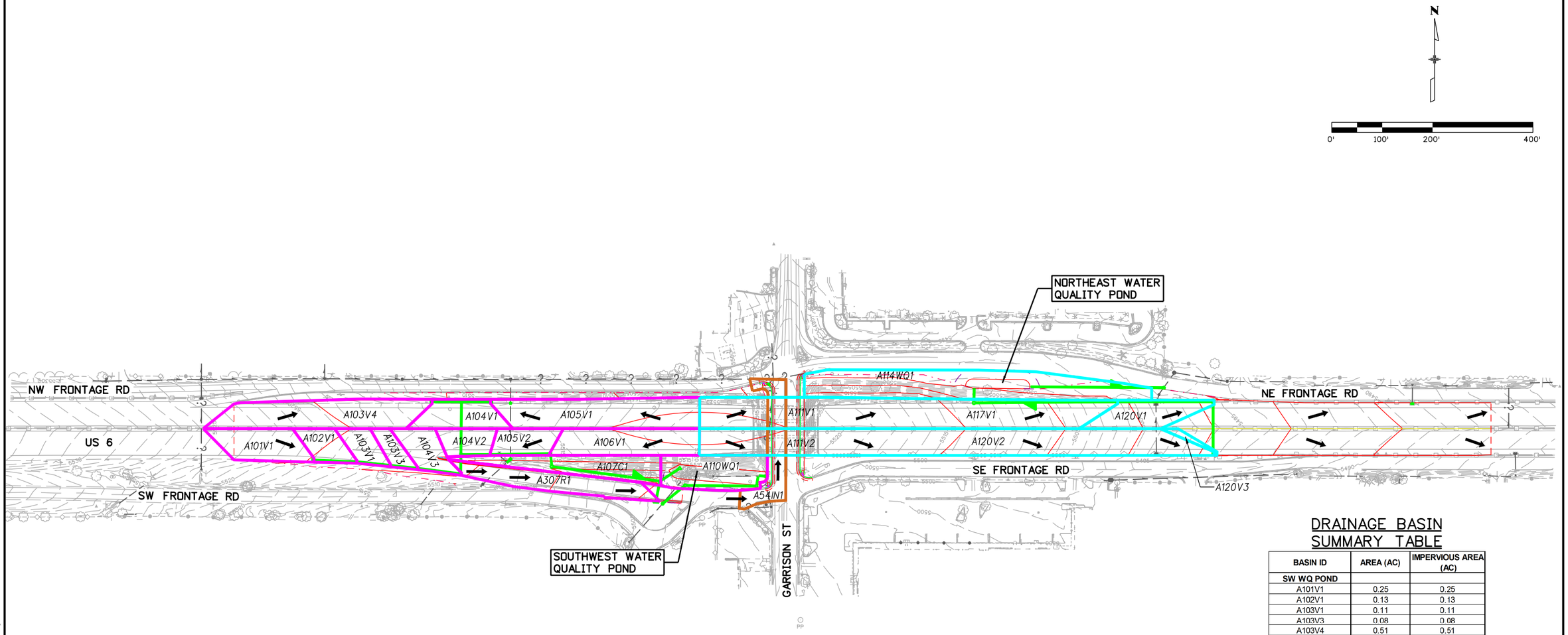
New storm drainage pipe systems were designed to collect and convey the 5-year flow from areas tributary to the project site. There will be no adverse drainage impacts either upstream or downstream of the project site due to the project improvements.

VII. REFERENCES

1. UDFCD Drainage Criteria Manual Volumes I, II, and III
2. City of Lakewood Storm Drainage Design Technical Criteria
3. Lakewood Gulch Major Drainageway Planning Phase B Report for UDFCD, City and County of Denver, City of Lakewood, and Jefferson County; by Sellards & Grigg, Inc.; Dated December 1979.
4. Major Drainageway Planning McIntyre Gulch Phase B for UDFCD and City of Lakewood; by Hydro-Triad, Ltd; Dated November 1977.
5. CDOT Drainage Design Manual
6. CDOT Erosion Control and Stormwater Quality Guide
7. Inroads Storm and Sanitary
8. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [12/27/2013].

Appendix A

Drainage Basin Map



DRAINAGE BASIN SUMMARY TABLE

BASIN ID	AREA (AC)	IMPERVIOUS AREA (AC)
SW WQ POND		
A101V1	0.25	0.25
A102V1	0.13	0.13
A103V1	0.11	0.11
A103V3	0.08	0.08
A103V4	0.51	0.51
A104V1	0.21	0.21
A104V2	0.13	0.13
A104V3	0.16	0.16
A105V1	0.54	0.54
A105V2	0.15	0.15
A106V1	0.35	0.35
A107C1	0.32	0.08
A307R1	0.32	0.32
A110WQ1	0.32	0.00
Totals	**3.58**	**3.02**
NE WQ POND		
A114WQ1	0.81	0.00
A117V1	1.10	1.10
A120V1	0.24	0.24
A120V2	1.19	1.19
A120V3	0.02	0.02
Totals	**3.36**	**2.55**
Garrison Street		
A54IN1	0.26	0.26
Totals	**0.26**	**0.26**
PROJECT TOTALS	**7.20**	**5.83**

LEGEND

- NORTHEAST WATER QUALITY POND
- SOUTHWEST WATER QUALITY POND
- EXISTING STORM DRAIN SYSTEM
- PROPOSED STORM DRAIN
- FLOW DIRECTION
- EXISTING PIPE

U.S. 6 OVER GARRISON STREET

Colorado Department of Transportation
DEPARTMENT OF TRANSPORTATION
425 B Corporate Circle
Golden, CO 80401
Phone: 720-497-6954 FAX: 720-497-6951
Region 1 KPB

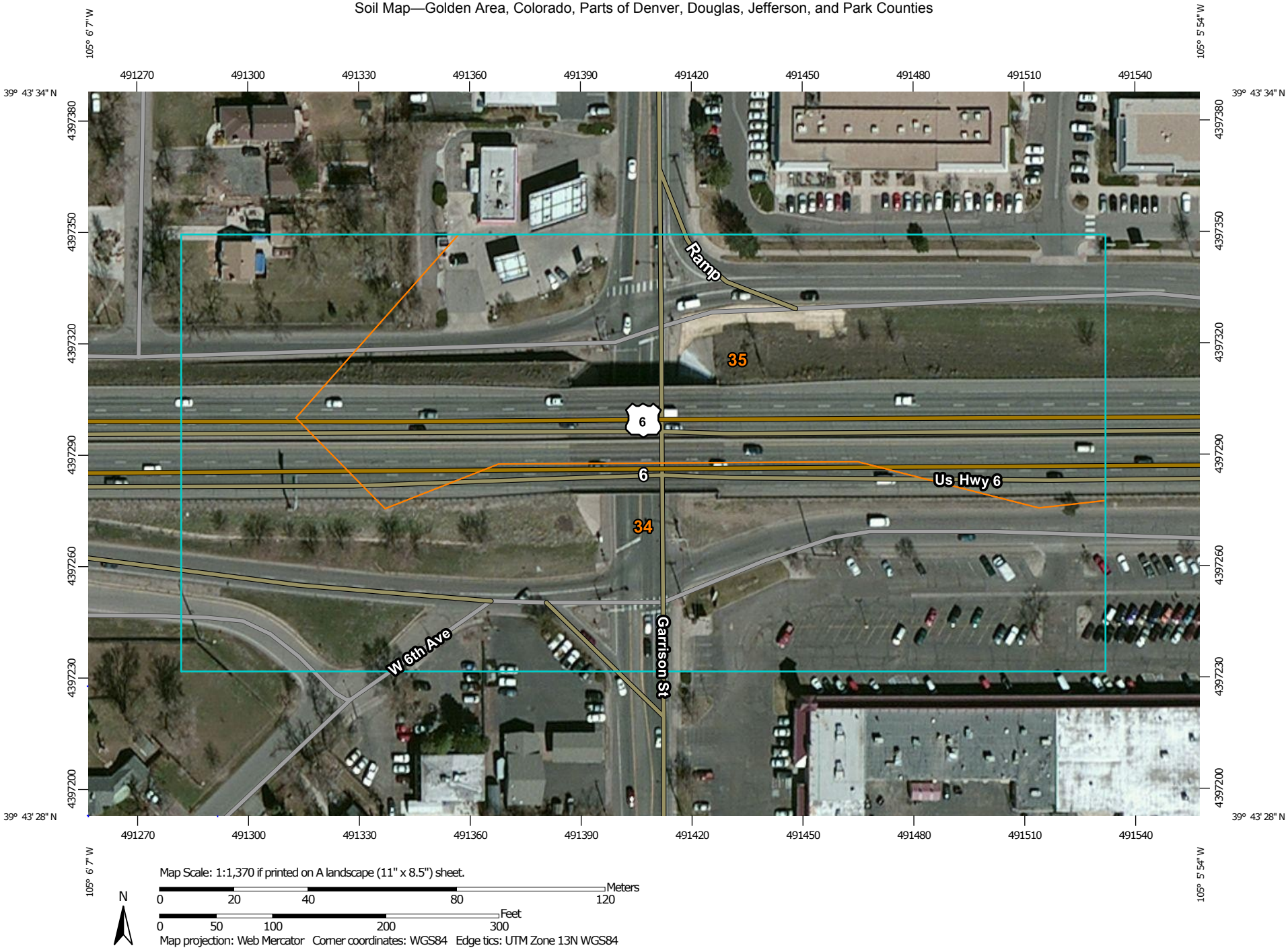
DRAINAGE BASIN MAP

Project No./Code
FBR 0063-046
19478
Figure Number 1

Appendix B

Hydrologic Data

Soils Map


105° 6' 7" W
105° 5' 54" W
491270
491300
491330
491360
491390
491420
491450
491480
491510
491540
39° 43' 34" N
39° 43' 28" N
4397380
4397350
4397320
4397290
4397260
4397230
4397200
Ramp
35
6
6
Us Hwy 6
34
W 6th Ave
Garrison St
Map Scale: 1:1,370 if printed on A landscape (11" x 8.5") sheet.
N
0 20 40 80 120 Meters
0 50 100 200 300 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties
Survey Area Data: Version 7, May 1, 2009

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

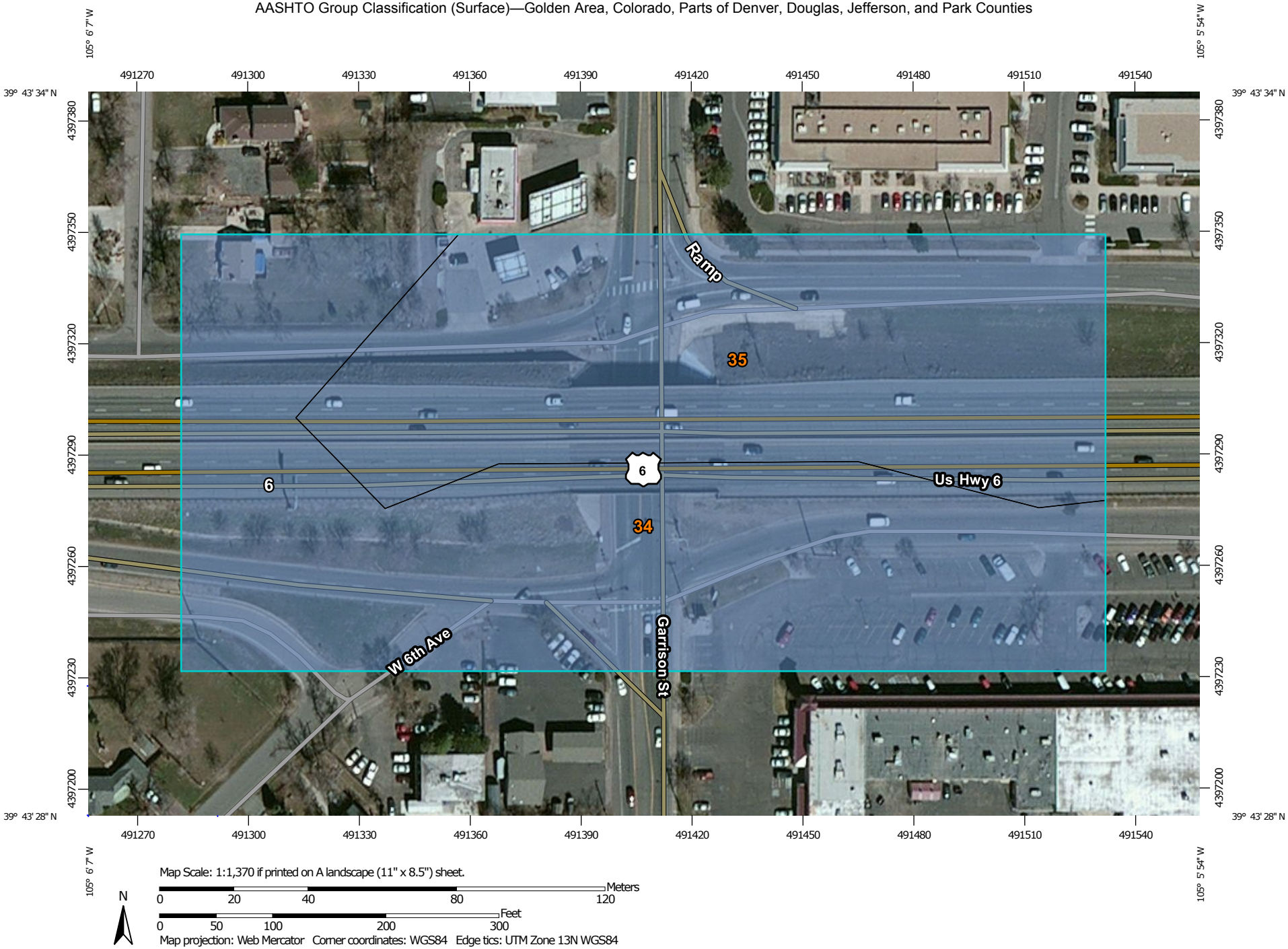
Date(s) aerial images were photographed: Apr 29, 2011—Apr 13, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties (CO641)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
34	Denver-Urban land complex, 0 to 2 percent slopes	4.1	55.6%
35	Denver-Urban land complex, 2 to 5 percent slopes	3.2	44.4%
Totals for Area of Interest		**7.3**	**100.0%**

AASHTO Group Classification (Surface)—Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A-1
- A-1-a
- A-1-b
- A-2
- A-2-4
- A-2-5
- A-2-6
- A-2-7
- A-3
- A-4
- A-5
- A-6
- A-7
- A-7-5
- A-7-6
- A-8
- Not rated or not available

Soil Rating Lines

- A-1
- A-1-a
- A-1-b
- A-2
- A-2-4
- A-2-5
- A-2-6
- A-2-7
- A-3
- A-4
- A-5
- A-6
- A-7
- A-7-5
- A-7-6
- A-8
- Not rated or not available

Soil Rating Points

- A-1
- A-1-a
- A-1-b
- A-2
- A-2-4
- A-2-5
- A-2-6
- A-2-7
- A-3
- A-4
- A-5
- A-6
- A-7
- A-7-5
- A-7-6
- A-8
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

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AASHTO Group Classification (Surface)

AASHTO Group Classification (Surface)— Summary by Map Unit — Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties (CO641)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
34	Denver-Urban land complex, 0 to 2 percent slopes	A-6	4.1	55.6%
35	Denver-Urban land complex, 2 to 5 percent slopes	A-6	3.2	44.4%
Totals for Area of Interest			**7.3**	**100.0%**

Description

AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in AASHTO Standard No. M 145-82. The classification is based on that portion of the soil that is smaller than 3 inches in diameter.

The AASHTO classification system has two general classifications: (i) granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and (ii) silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications, plus eight subgroups, for a total of fifteen for mineral soils. Another class for organic soils is used.

For each soil horizon in the database one or more AASHTO Group Classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

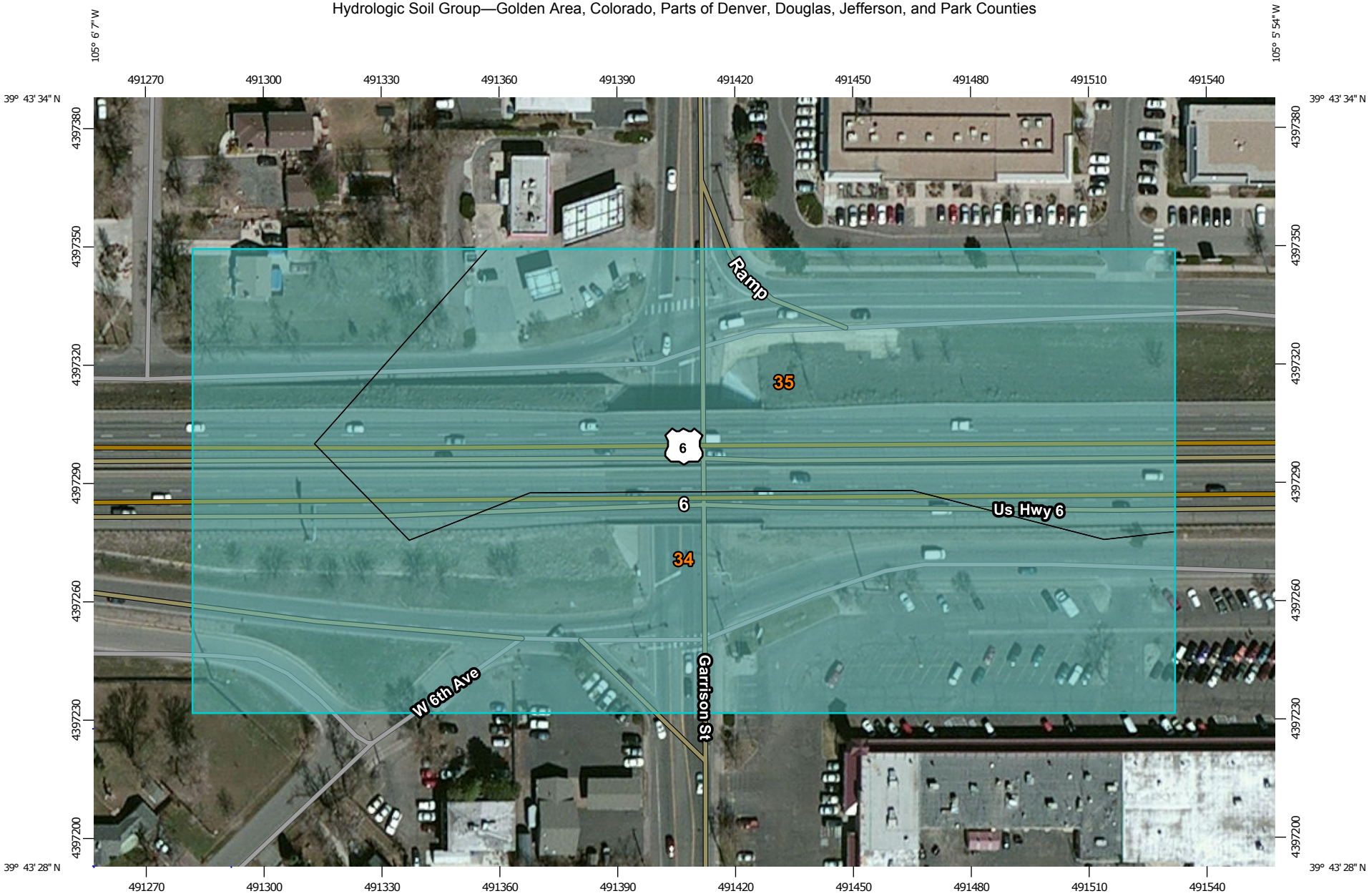
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Lower

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)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105° 5' 54" W
491270
491300
491330
491360
491390
491420
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491480
491510
491540
39° 43' 34" N
39° 43' 28" N
4397380
4397350
4397320
4397290
4397260
4397230
4397200
Ramp
35
6
6
Us Hwy 6
34
W 6th Ave
Garrison St
Map Scale: 1:1,370 if printed on A landscape (11" x 8.5") sheet.
N
0 20 40 80 120 Meters
0 50 100 200 300 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties
Survey Area Data: Version 7, May 1, 2009

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 29, 2011—Apr 13, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties (CO641)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
34	Denver-Urban land complex, 0 to 2 percent slopes	C	4.1	55.6%
35	Denver-Urban land complex, 2 to 5 percent slopes	C	3.2	44.4%
Totals for Area of Interest			**7.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Hydrologic Basin Calculations

Drainage Reports

Element Type: Area

Date: Monday, January 27, 2014 5:35:23 PM

Drainage Data File: 19478-DRAIN

ID	AttachedTo	Q (cfs)	Coef	Intensity (in/h)	TimeOfConc. (min)	Area (ac)
A101V1	101V1	1.00	0.88	4.55	5.00	0.25
A102V1	102V1	0.52	0.88	4.55	5.00	0.13
A103V1	103V1	0.44	0.88	4.55	5.00	0.11
A103V3	103V3	0.33	0.88	4.55	5.00	0.08
A103V4	103V4	2.06	0.88	4.55	5.00	0.51
A104V1	104V1	0.85	0.88	4.55	5.00	0.21
A104V2	104V2	0.52	0.88	4.55	5.00	0.13
A104V3	104V3	0.64	0.88	4.55	5.00	0.16
A105V1	105V1	2.18	0.88	4.55	5.00	0.54
A105V2	105V2	0.61	0.88	4.55	5.00	0.15
A106V1	106V1	1.39	0.88	4.55	5.00	0.35
A107C1	107C1	0.44	0.30	4.55	5.00	0.32
A110WQ1	110WQ1	0.73	0.50	4.55	5.00	0.32
A114WQ1	114WQ1	1.84	0.50	4.55	5.00	0.81
A117V1	117V1	4.41	0.88	4.55	5.00	1.10
A120V1	120V1	0.95	0.88	4.55	5.00	0.24
A120V2	120V2	4.76	0.88	4.55	5.00	1.19
A120V3	120V3	0.09	0.88	4.55	5.00	0.02
A307R1	307R1	1.28	0.88	4.55	5.00	0.32
A54IN1	54IN1	1.06	0.88	4.55	5.00	0.26

Number of items reported: 20

US 6 Over Garrison Street
Basin Calculations - Rational Method
Basin Descriptions

BY: GCS
DATE: 1/8/2014
REVISED BY: GCS
DATE: 1/27/2014

Basin Descriptions

On-site proposed roadway basins were calculated using the proposed profile for 6th Avenue and the SW off-ramp. Off-site basins were calculated from existing topography and field visits to verify existing drainage patterns. There are two major basins included in the design for 6th and Garrison.

Proposed SW Water Quality Pond

Begin Sta.	100+00	West Project Limits
Pond Sta.	109+62	Center of Pond
End Sta.	109+26.72	Crown of 6th Ave

Proposed NE Water Quality Pond

Begin Sta.	109+26.72	Crown of 6th Ave
Pond Sta.	115+18	Center of Pond
End Sta.	119+55	Furthest Inlets That Can Capture Project Runoff

Area not treated for Water Quality Pond

Begin Sta	119+55	Furthest Inlets That Can Capture Project Runoff
End Sta.	125+00	East Project Limits - Not able to be captured due to lower elevation than pond

Garrison Street

Existing Inlet Replaced

Time of Concentration

5 minute minimum Time Of Concentration used for urban conditions

US 6 Over Garrison Street
Basin Calculations - Rational Method
Basin Summary

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	DRAINS TO	AREA (AC)	IMPERVIOUS AREA (AC)	TOTAL ON SITE AREA (AC)	ONSITE IMPERVIOUS AREA (AC)	TOTAL OFF SITE AREA (AC)	OFFSITE IMPERVIOUS AREA (AC)
SW WQ POND							
A101V1	101V1	0.25	0.25	0.25	0.25		
A102V1	102V1	0.13	0.13	0.13	0.13		
A103V1	103V1	0.11	0.11	0.11	0.11		
A103V3	103V3	0.08	0.08	0.08	0.08		
A103V4	103V4	0.51	0.51	0.51	0.51		
A104V1	104V1	0.21	0.21	0.21	0.21		
A104V2	104V2	0.13	0.13	0.13	0.13		
A104V3	104V3	0.16	0.16	0.16	0.16		
A105V1	105V1	0.54	0.54	0.54	0.54		
A105V2	105V2	0.15	0.15	0.15	0.15		
A106V1	106V1	0.35	0.35	0.35	0.35		
A107C1	107C1	0.32	0.08	0.32	0.08		
A307R1	307R1	0.32	0.32	0.32	0.32		
A110WQ1	110WQ1	0.32	0.00	0.32	0.00		
Totals		**3.58**	**3.02**	**3.58**	**3.02**	**0.00**	**0.00**
NE WQ POND							
A114WQ1	114WQ1	0.81	0.00	0.81	0.00		
A117V1	117V1	1.1	1.10	1.10	1.10		
A120V1	120V1	0.24	0.24	0.24	0.24		
A120V2	120V2	1.19	1.19	1.19	1.19		
A120V3	120V3	0.02	0.02	0.02	0.02		
Totals		**3.36**	**2.55**	**3.36**	**2.55**	**0.00**	**0.00**
Garrison							
A54IN1	54IN1	0.26	0.26	0.26	0.26		
Totals		**0.26**	**0.26**	**0.26**	**0.26**	**0.00**	**0.00**
	PROJECT TOTALS	**7.20**	**5.83**	**7.20**	**5.83**	**0.00**	**0.00**

INPUT

US 6 Over Garrison Street
Basin Calculations - Rational Method
"C" Coefficients
5-Year

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	AREA (AC)	LAWNS, CLAYEY SOIL "C5" *	%	BUSINESS "C5" *	%	WATER "C5" *	%	RESIDENTIAL "C5" *	%	PAVED ROADS "C5" *	%	Composite "C5"	Composite "C" x Area
SW WQ POND		**0.10**		**0.87**		**1.0**		**0.45**		**0.88**			
A101V1	0.25	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.22
A102V1	0.13	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.11
A103V1	0.11	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.10
A103V3	0.08	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.07
A103V4	0.51	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.45
A104V1	0.21	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.18
A104V2	0.13	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.11
A104V3	0.16	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.14
A105V1	0.54	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.48
A105V2	0.15	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.13
A106V1	0.35	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.31
A107C1	0.32	0.10	75	0.87	0	0.98	0	0.45	0	0.88	25	**0.30**	0.09
A307R1	0.32	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.28
A110WQ1	0.32	0.10	55	0.87	0	0.98	45	0.45	0	0.88	0	**0.50**	0.16
Totals	**3.58**											**0.79**	2.84
NE WQ POND													
A114WQ1	0.81	0.10	55	0.87	0	0.98	45	0.45	0	0.88	0	**0.50**	0.40
A117V1	1.10	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.97
A120V1	0.24	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.21
A120V2	1.19	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	1.05
A120V3	0.02	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.02
Totals	**3.36**											**0.79**	2.65
Garrison													
A54IN1	0.26	0.10	0	0.87	0	0.98	0	0.45	0	0.88	100	**0.88**	0.23
Totals	**0.26**											**0.88**	0.23

*** Land use percentages obtained from aerial photo of existing area and survey information.**

INPUT

US 6 Over Garrison Street
Basin Calculations - Rational Method
"C" Coefficients
50-Year

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	AREA (AC)	LAWNS, CLAYEY SOIL "C50" *	%	BUSINESS "C50" *	%	WATER "C50" *	%	RESIDENTIAL "C50" *	%	PAVED ROADS "C50" *	%	Composite "C50"	Composite "C" x Area
SW WQ POND		**0.30**		**0.88**		**1.0**		**0.55**		**0.92**			
A101V1	0.25	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.23
A102V1	0.13	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.12
A103V1	0.11	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.10
A103V3	0.08	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.07
A103V4	0.51	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.47
A104V1	0.21	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.19
A104V2	0.13	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.12
A104V3	0.16	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.15
A105V1	0.54	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.50
A105V2	0.15	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.14
A106V1	0.35	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.32
A107C1	0.32	0.30	75	0.88	0	1.00	0	0.55	0	0.92	25	**0.46**	0.15
A307R1	0.32	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.29
A110WQ1	0.32	0.30	55	0.88	0	1.00	45	0.55	0	0.92	0	**0.62**	0.20
Totals	**3.58**											**0.85**	3.05
NE WQ POND													
A114WQ1	0.81	0.30	55	0.88	0	1.00	45	0.55	0	0.92	0	**0.62**	0.50
A117V1	1.10	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	1.01
A120V1	0.24	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.22
A120V2	1.19	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	1.09
A120V3	0.02	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.02
Totals	**3.36**											**0.85**	2.84
Garrison													
A54IN1	0.26	0.30	0	0.88	0	1.00	0	0.55	0	0.92	100	**0.92**	0.24
Totals	**0.26**											**0.92**	0.24

INPUT

*** Land Use obtained from aerial photo of existing area and survey information.**

US 6 Over Garrison Street
Basin Calculations - Rational Method
"C" Coefficients
100-Year

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	AREA (AC)	LAWNS, CLAYEY SOIL "C100" *	%	BUSINESS "C100" *	%	WATER "C100" *	%	RESIDENTIAL "C100" *	%	PAVED ROADS "C100" *	%	Composite "C100"	Composite "C" x Area
SW WQ POND		**0.40**		**0.89**		**1.0**		**0.60**		**0.93**			
A101V1	0.25	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.23
A102V1	0.13	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.12
A103V1	0.11	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.10
A103V3	0.08	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.07
A103V4	0.51	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.47
A104V1	0.21	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.20
A104V2	0.13	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.12
A104V3	0.16	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.15
A105V1	0.54	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.50
A105V2	0.15	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.14
A106V1	0.35	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.33
A107C1	0.32	0.40	75	0.89	0	1.00	0	0.60	0	0.93	25	**0.53**	0.17
A307R1	0.32	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.30
A110WQ1	0.32	0.40	55	0.89	0	1.00	45	0.60	0	0.93	0	**0.67**	0.21
Totals	**3.58**											**0.87**	3.12
NE WQ POND													
A114WQ1	0.81	0.40	55	0.89	0	1.00	45	0.60	0	0.93	0	**0.67**	0.54
A117V1	1.10	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	1.02
A120V1	0.24	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.22
A120V2	1.19	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	1.11
A120V3	0.02	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.02
Totals	**3.36**											**0.87**	2.91
Garrison													
A54IN1	0.26	0.40	0	0.89	0	1.00	0	0.60	0	0.93	100	**0.93**	0.24
Totals	**0.26**											**0.93**	0.24

INPUT

*** Land Use obtained from aerial photo of existing area and survey information.**

US 6 Over Garrison Street
Basin Calculations - Rational Method
Percent Impervious

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	AREA (AC)	LAWNS, CLAYEY SOIL 0%	%	BUSINESS 95%	%	WATER 0%	%	RESIDENTIAL 50%	%	PAVED ROADS 100%	%	Composite % Impervious	Area Impervious
SW WQ POND		**0**		**95**		**0**		**50**		**100**			
A101V1	0.25	0	0	95	0	0	0	50	0	100	100	100.0	0.25
A102V1	0.13	0	0	95	0	0	0	50	0	100	100	100.0	0.13
A103V1	0.11	0	0	95	0	0	0	50	0	100	100	100.0	0.11
A103V3	0.08	0	0	95	0	0	0	50	0	100	100	100.0	0.08
A103V4	0.51	0	0	95	0	0	0	50	0	100	100	100.0	0.51
A104V1	0.21	0	0	95	0	0	0	50	0	100	100	100.0	0.21
A104V2	0.13	0	0	95	0	0	0	50	0	100	100	100.0	0.13
A104V3	0.16	0	0	95	0	0	0	50	0	100	100	100.0	0.16
A105V1	0.54	0	0	95	0	0	0	50	0	100	100	100.0	0.54
A105V2	0.15	0	0	95	0	0	0	50	0	100	100	100.0	0.15
A106V1	0.35	0	0	95	0	0	0	50	0	100	100	100.0	0.35
A107C1	0.32	0	75	95	0	0	0	50	0	100	25	25.0	0.08
A307R1	0.32	0	0	95	0	0	0	50	0	100	100	100.0	0.32
A110WQ1	0.32	0	55	95	0	0	45	50	0	100	0	0.0	0.00
Totals	**3.58**											**84.4**	**3.02**
NE WQ POND													
A114WQ1	0.81	0	55	95	0	0	45	50	0	100	0	0.0	0.00
A117V1	1.10	0	0	95	0	0	0	50	0	100	100	100.0	1.10
A120V1	0.24	0	0	95	0	0	0	50	0	100	100	100.0	0.24
A120V2	1.19	0	0	95	0	0	0	50	0	100	100	100.0	1.19
A120V3	0.02	0	0	95	0	0	0	50	0	100	100	100.0	0.02
Totals	**3.36**											**75.9**	**2.55**
Garrison													
A54IN1	0.26	0	0	95	0	0	0	50	0	100	100	100.0	0.26
Totals	**0.26**											**100.0**	**0.26**

INPUT

Note: Land Use obtained from aerial photo of existing area and survey information.

US 6 Over Garrison Street
Basin Calculations - Rational Method
Calculated Runoff

BY: GCS
DATE: 1/8/2014
UPDATED: GCS
DATE: 1/27/2014

BASIN ID	AREA (acre)	C_5	C_{50}	C_{100}	I_5 $(in/hr)_1$	I_{50} $(in/hr)_1$	I_{100} $(in/hr)_1$	Q_5 (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	COMMENTS
SW WQ POND											
A101V1	0.25	0.88	0.92	0.93	4.58	7.80	8.75	1.0	1.8	2.0	
A102V1	0.13	0.88	0.92	0.93	4.58	7.80	8.75	0.5	0.9	1.1	
A103V1	0.11	0.88	0.92	0.93	4.58	7.80	8.75	0.4	0.8	0.9	
A103V3	0.08	0.88	0.92	0.93	4.58	7.80	8.75	0.3	0.6	0.7	
A103V4	0.51	0.88	0.92	0.93	4.58	7.80	8.75	2.1	3.7	4.2	
A104V1	0.21	0.88	0.92	0.93	4.58	7.80	8.75	0.8	1.5	1.7	
A104V2	0.13	0.88	0.92	0.93	4.58	7.80	8.75	0.5	0.9	1.1	
A104V3	0.16	0.88	0.92	0.93	4.58	7.80	8.75	0.6	1.1	1.3	
A105V1	0.54	0.88	0.92	0.93	4.58	7.80	8.75	2.2	3.9	4.4	
A105V2	0.15	0.88	0.92	0.93	4.58	7.80	8.75	0.6	1.1	1.2	
A106V1	0.35	0.88	0.92	0.93	6.30	10.73	12.04	1.9	3.5	3.9	
A107C1	0.32	0.30	0.46	0.53	6.30	10.73	12.04	0.6	1.6	2.1	
A307R1	0.32	0.88	0.92	0.93	6.30	10.73	12.04	1.8	3.2	3.6	
A110WQ1	0.32	0.50	0.62	0.67	4.58	7.80	8.75	0.7	1.5	1.9	
Totals	**3.58**	**0.79**	**0.85**	**0.87**	**4.58**	**7.80**	**8.75**	**13.0**	**23.8**	**27.3**	TC = 5 min.
NE WQ POND											
A114WQ1	0.81	0.50	0.62	0.67	4.58	7.80	8.75	1.8	3.9	4.7	
A117V1	1.10	0.88	0.92	0.93	4.58	7.80	8.75	4.4	7.9	9.0	
A120V1	0.24	0.88	0.92	0.93	4.58	7.80	8.75	1.0	1.7	2.0	
A120V2	1.19	0.88	0.92	0.93	4.58	7.80	8.75	4.8	8.5	9.7	
A120V3	0.02	0.88	0.92	0.93	4.58	7.80	8.75	0.1	0.1	0.2	
Totals	**3.36**	**0.79**	**0.85**	**0.87**	**4.58**	**7.80**	**8.75**	**12.1**	**22.2**	**25.5**	TC = 5 min.
Garrison											
A54IN1	0.26	0.88	0.92	0.93	4.58	7.80	8.75	1.0	1.9	2.1	
Totals	**0.26**	**0.88**	**0.92**	**0.93**	**4.58**	**7.80**	**8.75**	**1.0**	**1.9**	**2.1**	TC = 5 min.

[1] I = (28.5 x P1) / (10 +Tc)^0.786 , Eq. (RA-3) Urban Drainage, Where P1(2-yr)=0.96, P1(5-yr)=1.35, P1(10-yr)=1.57, P1(25-yr)=2.00, P1(50-yr)=2.30, P1(100-yr)=2.58

Input

Appendix C

Hydraulic Data

Inroads Storm and Sanitary Output

Drainage Reports

Element Type: Inlet

Date: Monday, January 27, 2014 5:33:04 PM

Drainage Data File: 19478-DRAIN

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)
101V1	Grate	2	1.00	0.95	0.05	30	0.13	6.51	5519.77	2	1.73	2.00
102V1	Grate	2	0.52	0.45	0.12	30	0.11	5.28	5518.25	2	1.70	2.00
103V1	Grate	2	0.44	0.44	0.12	30	0.11	5.38	5517.16	2	1.50	2.00
103V3	Grate	2	0.33	0.36	0.08	30	0.10	5.07	5516.43	2	1.30	2.00
103V4	Grate	2	2.06	1.62	0.44	30	0.22	11.23	5517.63	2	0.40	2.00
104V1	Grate	2	0.85	1.78	0.00	50	0.17	8.67	5517.52	2	0.00	2.00
104V2	Grate	2	0.52	0.67	0.00	50	0.09	4.52	5517.36	2	0.00	2.00
104V3	Grate	2	0.64	0.54	0.18	30	0.11	5.71	5515.18	2	1.80	2.00
105V1	Grate	2	2.18	1.68	0.49	30	0.24	11.88	5517.61	2	0.33	2.00
105V2	Grate	2	0.61	0.58	0.23	30	0.17	8.28	5517.60	2	0.31	2.00
106V1	Grate	2	1.39	1.19	0.20	30	0.18	9.06	5518.30	2	0.57	2.00
107C1	Grate	3	0.44	0.44	0.00	50	0.09	0.69	5503.50	3	0.00	25.00
110WQ1	Grate	6	0.73	3.75	8.09	30	0.39	13.35	5499.00	6	3.84	2.00
114WQ1	Grate	6	1.84	4.41	6.73	30	0.42	14.49	5497.28	6	2.29	2.00
117V1	Grate	2	4.41	3.43	0.98	30	0.20	10.02	5505.67	2	3.36	2.00
120V1	Grate	2	0.95	1.75	0.18	30	0.15	7.26	5498.91	2	3.57	2.00
120V2	Grate	2	4.76	3.66	1.09	30	0.20	10.19	5498.99	2	3.57	2.00
120V3	Grate	2	0.09	1.14	0.05	30	0.12	6.05	5498.78	2	3.56	2.00
307R1	Curb Opening	10	1.28	1.38	0.08	30	0.24	5.57	5504.35	10	2.00	2.00
54IN1	Grate	3	1.06	1.06	0.00	50	0.17	1.98	5497.51	3	0.00	1.10
EX118	Grate	3	0.00	0.00	0.00	30	0.00	0.00	5495.95	3	2.32	2.00
EXIN105	Grate	3	0.00	0.00	0.00	30	0.00	0.00	5507.93	3	24.32	2.00
EXIN1_CAP INLET	Grate	3	0.00	0.00	0.00	30	0.00	0.00	5517.89	3	0.50	2.00

Number of items reported: 23

Drainage Reports

Element Type: Manhole

Date: Tuesday, January 28, 2014 1:15:34 PM

Drainage Data File: 19478-DRAIN

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
105M1	Circular	4.00(SW)	5506.53 (N)	5504.78	5516.09	0.00
108M1	Circular	4.00(SW)	5497.65 (E)	5497.55	5502.40	2.00
110M1	Circular	4.00 (W)	5496.17 (N)	5496.07	5500.40	2.00
110M2	Circular	5.00 (W)	5495.65	0.00	5501.05	5.75
117M1	Circular	5.00 (E)	5493.13 (N)	5493.13	5513.92	9.71
118M1	Circular	4.00(SW)	5490.91(NE)	5490.80	5495.37	4.41
		(W)	5490.90			
305M1	Circular	5.00 (N)	5505.83 (E)	5504.24	5511.50	9.66
307M1	Circular	4.00(SW)	5500.59(NE)	5499.76	5504.40	2.00
EX118MH	Circular	4.00(SW)	5490.49	0.00	5494.69	4.41
EXMH54	Circular	4.00(SW)	5494.92	0.00	5497.81	1.06
		(W)	5494.97			

Number of items reported: 10

Drainage Reports

Element Type: Pipe

Date: Monday, January 27, 2014 5:33:34 PM

Drainage Data File: 19478-DRAIN

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P1	24	24	0.400	32	5493.13	5493.00	9.30	14.31	4.85	5494.68	5494.54	0.013
P2	24	24	3.858	44	5497.71	5496.00	11.15	44.43	11.77	5498.39	5496.68	0.013
P181	18	18	0.500	57	5512.97	5512.68	1.62	7.43	3.36	5513.95	5513.67	0.013
P182	18	18	0.500	57	5512.95	5512.66	1.68	7.43	3.40	5513.94	5513.65	0.013
P183	24	24	0.500	99	5512.18	5511.68	5.03	16.00	4.50	5512.95	5512.45	0.013
P185	18	18	0.500	85	5511.67	5511.24	2.16	7.43	3.64	5512.82	5512.37	0.013
P186	18	18	0.499	34	5511.18	5511.01	2.67	7.42	3.85	5512.23	5512.07	0.013
P187	24	24	0.500	57	5511.01	5510.72	8.09	16.00	5.11	5512.01	5512.27	0.013
P188	24	24	0.500	116	5510.72	5510.14	8.61	15.99	5.18	5512.24	5511.66	0.013
P190	18	18	2.905	83	5515.08	5512.66	0.95	17.90	5.35	5515.31	5513.00	0.013
P191	18	18	0.500	64	5512.56	5512.24	1.39	7.43	3.21	5513.00	5512.68	0.013
P192	18	18	0.719	52	5512.14	5511.77	1.81	8.90	3.95	5512.60	5512.84	0.013
P193	18	18	1.057	21	5496.07	5495.85	2.00	10.80	1.13	5497.82	5497.22	0.013
P194	24	24	1.112	15	5495.80	5495.64	5.75	23.85	6.24	5497.22	5497.06	0.013
P195	18	18	3.903	39	5499.52	5497.99	1.38	20.75	6.63	5499.79	5498.39	0.013
P196	18	18	1.000	138	5497.55	5496.17	2.00	10.50	4.57	5498.00	5497.84	0.013
P201	24	24	0.400	291	5494.29	5493.13	9.71	14.31	3.09	5495.69	5494.93	0.013
P202	24	24	0.410	269	5492.00	5490.90	4.41	14.48	4.04	5493.78	5492.44	0.013
P203	18	18	1.000	3	5495.56	5495.53	1.14	10.50	0.64	5496.99	5496.88	0.013
P204	18	18	0.500	97	5495.53	5495.04	4.80	7.43	2.72	5496.80	5496.50	0.013
P205	18	18	3.955	53	5499.76	5497.65	2.00	20.89	7.45	5500.08	5498.00	0.013
P206	18	18	0.400	189	5495.04	5494.29	6.48	6.64	3.67	5496.35	5495.70	0.013
P207	24	24	10.000	21	5507.88	5505.83	9.66	71.54	15.86	5508.38	5506.33	0.013
P208	24	24	2.669	213	5504.24	5498.56	9.65	36.96	9.88	5504.93	5499.26	0.013
PEX1	24	24	1.264	74	5507.47	5506.53	0.00	0.00	0.00	0.00	0.00	0.013
PEX2	24	24	0.805	108	5504.78	5503.91	0.00	0.00	0.00	0.00	0.00	0.013
PEX3	24	24	2.210	45	5503.91	5502.92	0.00	0.00	0.00	0.00	0.00	0.013
PEX6	12	12	0.500	10	5494.97	5494.92	1.06	2.52	3.06	5495.58	5495.63	0.013
PEX209	18	18	1.519	519	5502.85	5494.97	0.00	0.00	0.00	0.00	0.00	0.013
PEX4A	12	12	1.025	98	5501.60	5500.59	2.00	3.61	4.71	5502.13	5501.12	0.013
PEX5A	24	24	1.000	13	5491.04	5490.91	0.00	0.00	0.00	0.00	0.00	0.013
PEX5B	24	24	1.000	31	5490.80	5490.49	4.41	22.62	5.58	5492.16	5491.86	0.013

Number of items reported: 32

Network Outfall Report

Date: Monday, January 27, 2014 5:28:49 PM

Drainage Data File: 19478-DRAIN

Inlets: 101V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
101V1	Grate	2	1.00	0.95	0.05	30	0.13	6.51	5519.77	2	1.73	2.00	0.00 (E)	5515.08

Pipes: P190

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P190	18	18	2.905	83	5515.08	5512.66	0.95	17.90	5.35	5515.31	5513.00	0.013

Inlets: 102V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
102V1	Grate	2	0.52	0.45	0.12	30	0.11	5.28	5518.25	2	1.70	2.00 (W)	5512.66 (E)	5512.56

Pipes: P191

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P191	18	18	0.500	64	5512.56	5512.24	1.39	7.43	3.21	5513.00	5512.68	0.013

Inlets: 103V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V1	Grate	2	0.44	0.44	0.12	30	0.11	5.38	5517.16	2	1.50	2.00 (W)	5512.24 (E)	5512.14

Pipes: P192

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P192	18	18	0.719	52	5512.14	5511.77	1.81	8.90	3.95	5512.60	5512.84	0.013

Inlets: 103V3

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V3	Grate	2	0.33	0.36	0.08	30	0.10	5.07	5516.43	2	1.30	2.00 (W)	5511.77 (E)	5511.67

Pipes: P185

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P185	18	18	0.500	85	5511.67	5511.24	2.16	7.43	3.64	5512.82	5512.37	0.013

Inlets: 104V3

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V3	Grate	2	0.64	0.54	0.18	30	0.11	5.71	5515.18	2	1.80	2.00 (W)	5511.24 (N)	5511.18

Pipes: P186

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P186	18	18	0.499	34	5511.18	5511.01	2.67	7.42	3.85	5512.23	5512.07	0.013

Inlets: 103V4

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V4	Grate	2	2.06	1.62	0.44	30	0.22	11.23	5517.63	2	0.40	2.00	0.00 (E)	5512.97

Pipes: P181

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P181	18	18	0.500	57	5512.97	5512.68	1.62	7.43	3.36	5513.95	5513.67	0.013

Inlets: 105V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
105V1	Grate	2	2.18	1.68	0.49	30	0.24	11.88	5517.61	2	0.33	2.00	0.00 (W)	5512.95

Pipes: P182

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P182	18	18	0.500	57	5512.95	5512.66	1.68	7.43	3.40	5513.94	5513.65	0.013

Inlets: 104V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V1	Grate	2	0.85	1.78	0.00	50	0.17	8.67	5517.52	2	0.00	2.00	(E) 5512.66 (W) 5512.68	(S) 5512.18

Pipes: P183

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P183	24	24	0.500	99	5512.18	5511.68	5.03	16.00	4.50	5512.95	5512.45	0.013

Inlets: 104V2

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V2	Grate	2	0.52	0.67	0.00	50	0.09	4.52	5517.36	2	0.00	2.00	(N) 5511.68 (S) 5511.01	(E) 5511.01

Pipes: P187

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P187	24	24	0.500	57	5511.01	5510.72	8.09	16.00	5.11	5512.01	5512.27	0.013

Inlets: 105V2

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)

105V2	Grate	2	0.61	0.58	0.23	30	0.17	8.28	5517.60	2	0.31	2.00 (W)	5510.72 (E)	5510.72

Pipes: P188

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P188	24	24	0.500	116	5510.72	5510.14	8.61	15.99	5.18	5512.24	5511.66	0.013

Inlets: 106V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
106V1	Grate	2	1.39	1.19	0.20	30	0.18	9.06	5518.30	2	0.57	2.00 (W)	5510.14 (S)	5507.88

Pipes: P207

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P207	24	24	10.000	21	5507.88	5505.83	9.66	71.54	15.86	5508.38	5506.33	0.013

Manholes: 305M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
305M1	Circular	5.00 (N)	5505.83 (E)	5504.24	5511.50	9.66

Pipes: P208

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P208	24	24	2.669	213	5504.24	5498.56	9.65	36.96	9.88	5504.93	5499.26	0.013

Inlets: 307R1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
307R1	Curb Opening	10	1.28	1.38	0.08	30	0.24	5.57	5504.35	10	2.00	2.00	0.00 (N)	5499.52

Pipes: P195

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P195	18	18	3.903	39	5499.52	5497.99	1.38	20.75	6.63	5499.79	5498.39	0.013

Inlets: 107C1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
107C1	Grate	3	0.44	0.44	0.00	50	0.09	0.69	5503.50	3	0.00	25.00 (S) (W)	5497.99 (E) 5498.56	5497.71

Pipes: P2

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P2	24	24	3.858	44	5497.71	5496.00	11.15	44.43	11.77	5498.39	5496.68	0.013

Number of items reported: 28

Network Outfall Report

Date: Monday, January 27, 2014 5:34:23 PM

Drainage Data File: 19478-DRAIN

Inlets: 101V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
101V1	Grate	2	1.68	1.48	0.19	30	0.16	7.90	5519.77	2	1.73	2.00	0.00 (E)	5515.08

Pipes: P190

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P190	18	18	2.905	83	5515.08	5512.66	1.48	17.90	6.13	5515.37	5513.12	0.013

Inlets: 102V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
102V1	Grate	2	0.87	0.73	0.33	30	0.13	6.67	5518.25	2	1.70	2.00 (W)	5512.66 (E)	5512.56

Pipes: P191

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P191	18	18	0.500	64	5512.56	5512.24	2.20	7.43	3.66	5513.12	5513.45	0.013

Inlets: 103V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V1	Grate	2	0.74	0.73	0.34	30	0.14	6.85	5517.16	2	1.50	2.00 (W)	5512.24 (E)	5512.14

Pipes: P192

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P192	18	18	0.719	52	5512.14	5511.77	2.90	8.90	1.64	5513.45	5513.39	0.013

Inlets: 103V3

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V3	Grate	2	0.55	0.63	0.26	30	0.13	6.56	5516.43	2	1.30	2.00 (W)	5511.77 (E)	5511.67

Pipes: P185

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P185	18	18	0.500	85	5511.67	5511.24	3.51	7.43	1.99	5513.38	5513.26	0.013

Inlets: 104V3

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V3	Grate	2	1.07	0.87	0.46	30	0.14	7.18	5515.18	2	1.80	2.00 (W)	5511.24 (N)	5511.18

Pipes: P186

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P186	18	18	0.499	34	5511.18	5511.01	4.33	7.42	2.45	5513.17	5512.92	0.013

Inlets: 103V4

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
103V4	Grate	2	3.46	2.44	1.02	30	0.27	13.63	5517.63	2	0.40	2.00	0.00 (E)	5512.97

Pipes: P181

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P181	18	18	0.500	57	5512.97	5512.68	2.44	7.43	3.76	5514.21	5513.73	0.013

Inlets: 105V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
105V1	Grate	2	3.65	2.53	1.12	30	0.29	14.42	5517.61	2	0.33	2.00	0.00 (W)	5512.95

Pipes: P182

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P182	18	18	0.500	57	5512.95	5512.66	2.53	7.43	3.80	5514.19	5513.71	0.013

Inlets: 104V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V1	Grate	2	1.42	3.56	0.00	50	0.28	13.76	5517.52	2	0.00	2.00 (E) (W)	5512.66 (S) 5512.68	5512.18

Pipes: P183

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P183	24	24	0.500	99	5512.18	5511.68	8.44	16.00	5.16	5513.57	5513.20	0.013

Inlets: 104V2

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
104V2	Grate	2	0.88	1.20	0.00	50	0.13	6.66	5517.36	2	0.00	2.00 (N) (S)	5511.68 (E) 5511.01	5511.01

Pipes: P187

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P187	24	24	0.500	57	5511.01	5510.72	13.57	16.00	4.32	5512.87	5512.44	0.013

Inlets: 105V2

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)

105V2	Grate	2	1.02	0.96	0.58	30	0.21	10.53	5517.60	2	0.31	2.00 (W)	5510.72 (E)	5510.72	

Pipes: P188

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P188	24	24	0.500	116	5510.72	5510.14	14.43	15.99	5.76	5512.40	5511.82	0.013

Inlets: 106V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
106V1	Grate	2	2.33	1.82	0.51	30	0.22	11.00	5518.30	2	0.57	2.00 (W)	5510.14 (S)	5507.88	

Pipes: P207

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P207	24	24	10.000	21	5507.88	5505.83	16.04	71.54	18.35	5508.53	5506.47	0.013

Manholes: 305M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
305M1	Circular	5.00 (N)	5505.83 (E)	5504.24	5511.50	16.04

Pipes: P208

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P208	24	24	2.669	213	5504.24	5498.56	16.03	36.96	11.34	5505.16	5499.48	0.013

Inlets: 307R1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
307R1	Curb Opening	10	2.15	2.06	0.54	30	0.28	7.74	5504.35	10	2.00	2.00	0.00 (N)	5499.52	

Pipes: P195

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P195	18	18	3.903	39	5499.52	5497.99	2.06	20.75	7.48	5499.84	5498.61	0.013

Inlets: 107C1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
107C1	Grate	3	0.74	0.74	0.00	50	0.12	0.97	5503.50	3	0.00	25.00 (S)	5497.99 (E)	5497.71	(W) 5498.56

Pipes: P2

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P2	24	24	3.858	44	5497.71	5496.00	18.38	44.43	13.47	5498.61	5496.90	0.013

Number of items reported: 28

Network Outfall Report

Date: Monday, January 27, 2014 5:31:15 PM

Drainage Data File: 19478-DRAIN

Pipes: PEX4A

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
PEX4A	12	12	1.025	98	5501.60	5500.59	2.00	3.61	4.71	5502.13	5501.12	0.013

Manholes: 307M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
307M1	Circular	4.00(SW)	5500.59(NE)	5499.76	5504.40	2.00

Pipes: P205

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P205	18	18	3.955	53	5499.76	5497.65	2.00	20.89	7.45	5500.08	5498.00	0.013

Manholes: 108M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
108M1	Circular	4.00(SW)	5497.65 (E)	5497.55	5502.40	2.00

Pipes: P196

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P196	18	18	1.000	138	5497.55	5496.17	2.00	10.50	4.57	5498.00	5497.84	0.013

Manholes: 110M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
110M1	Circular	4.00 (W)	5496.17 (N)	5496.07	5500.40	2.00

Pipes: P193

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P193	18	18	1.057	21	5496.07	5495.85	2.00	10.80	1.13	5497.82	5497.22	0.013

Inlets: 110WQ1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
110WQ1	Grate	6	0.73	3.75	8.09	30	0.39	13.35	5499.00	6	3.84	2.00 (S)	5495.85 (E)	5495.80

Pipes: P194

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P194	24	24	1.112	15	5495.80	5495.64	5.75	23.85	6.24	5497.22	5497.06	0.013

Manholes: 110M2-NEW RIM_COVER

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
110M2-NEW RIM_COVER	Circular	4.00 (W)	5495.64	0.00	5501.05	5.75

Number of items reported: 10

Network Outfall Report

Date: Monday, January 27, 2014 5:32:16 PM

Drainage Data File: 19478-DRAIN

Inlets: 120V3

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
120V3	Grate	2	0.09	1.14	0.05	30	0.12	6.05	5498.78	2	3.56	2.00	0.00 (W)	5495.56

Pipes: P203

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P203	18	18	1.000	3	5495.56	5495.53	1.14	10.50	0.64	5496.99	5496.88	0.013

Inlets: 120V2

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
120V2	Grate	2	4.76	3.66	1.09	30	0.20	10.19	5498.99	2	3.57	2.00 (E)	5495.53 (N)	5495.53

Pipes: P204

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P204	18	18	0.500	97	5495.53	5495.04	4.80	7.43	2.72	5496.80	5496.50	0.013

Inlets: 120V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
120V1	Grate	2	0.95	1.75	0.18	30	0.15	7.26	5498.91	2	3.57	2.00 (S)	5495.04 (W)	5495.04

Pipes: P206

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P206	18	18	0.400	189	5495.04	5494.29	6.48	6.64	3.67	5496.35	5495.70	0.013

Inlets: 117V1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
117V1	Grate	2	4.41	3.43	0.98	30	0.20	10.02	5505.67	2	3.36	2.00 (E)	5494.29 (W)	5494.29

Pipes: P201

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P201	24	24	0.400	291	5494.29	5493.13	9.71	14.31	3.09	5495.69	5494.93	0.013

Manholes: 117M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
117M1	Circular	5.00 (E)	5493.13 (N)	5493.13	5513.92	9.71

Pipes: P1

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P1	24	24	0.400	32	5493.13	5493.00	9.30	14.31	4.85	5494.68	5494.54	0.013

Number of items reported: 10

Network Outfall Report

Date: Monday, January 27, 2014 5:32:50 PM

Drainage Data File: 19478-DRAIN

Inlets: EX118

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
EX118	Grate	3	0.00	0.00	0.00	30	0.00	0.00	5495.95	3	2.32	2.00	0.00 (N)	5491.04

Pipes: PEX5A

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
PEX5A	24	24	1.000	13	5491.04	5490.91	0.00	0.00	0.00	0.00	0.00	0.013

Inlets: 114WQ1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
114WQ1	Grate	6	1.84	4.41	6.73	30	0.42	14.49	5497.28	6	2.29	2.00	0.00 (E)	5492.00

Pipes: P202

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
P202	24	24	0.410	269	5492.00	5490.90	4.41	14.48	4.04	5493.78	5492.44	0.013

Manholes: 118M1

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
118M1	Circular	6.00(SW) (W)	5490.91(NE) 5490.90	5490.80	5495.37	4.41

Pipes: PEX5B

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
PEX5B	24	24	1.000	31	5490.80	5490.49	4.41	22.62	5.58	5492.16	5491.86	0.013

Manholes: EX118MH

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	RimElevation (ft)	TotalFlow (cfs)
EX118MH	Circular	4.00(SW)	5490.49	0.00	5494.69	4.41

Number of items reported: 7

Report Between Structures

Date: Monday, January 27, 2014 5:31:53 PM

Drainage Data File: 19478-DRAIN

Inlets: 54IN1

Inlet ID	Type	Length (ft)	Q (cfs)	Inlet Capacity (cfs)	Bypass Flow (cfs)	Clogging (%)	Flow Depth (ft)	Spread (ft)	Elevation (ft)	Length (ft)	Long. Slope (%)	Cross Slope (%)	InvertIn (ft)	InvertOut (ft)
54IN1	Grate	3	1.06	1.06	0.00	50	0.17	1.98	5497.51	3	0.00	1.10	0.00(NE)	5494.97

Pipes: PEX6

Pipe ID	Height (in)	Width (in)	Slope (%)	Length (ft)	InvertIn (ft)	InvertOut (ft)	TotalFlow (cfs)	Capacity (cfs)	Velocity (ft/s)	EntranceHGL (ft)	ExitHGL (ft)	Roughness
PEX6	12	12	0.500	10	5494.97	5494.92	1.06	2.52	3.06	5495.58	5495.63	0.013

Manholes: EXMH54

ID	Shape	Width (ft)	InvertIn (ft)	InvertOut (ft)	Rim Elevation (ft)	TotalFlow (cfs)
EXMH54	Circular	4.00(SW) (W)	5494.92 5494.97	0.00	5497.81	1.06

Number of items reported: 3

Appendix D

Water Quality Report

WATER QUALITY REPORT

US 6 OVER GARRISON STREET

LAKEWOOD, COLORADO

A Part of Sections 3 and 10, Township 4 South, Range 69 West of the 6th P.M.,
Jefferson County, CO

February 7, 2014

Prepared by:

CH2M HILL
9193 South Jamaica Street
Englewood, CO 80112
(303) 771-0900

Contact: Doug Stewart
doug.stewart@ch2m.com
http://www.ch2mhill.com

CH2M HILL Project No. 473244

CDOT Project Number: FBR 0063-046

TABLE OF CONTENTS

1. INTRODUCTION

This report presents the water quality analysis for roadway improvements along 6th Avenue (US 6) at Garrison Street between Milepost 279.62 and Milepost 280.09. Figure 1 shows the project location, which is located within the City of Lakewood, Colorado. The project area is located in a part of Sections 3 and 10, Township 4 South, Range 69 West of the 6th P.M., Jefferson County, Colorado. The project limits are entirely within CDOT right-of-way, CDOT-owned properties, and the City of Lakewood properties and easements within the City limits of Lakewood, Colorado.

The surrounding areas are a mixture of residential and commercial urban development. There are no existing water quality facilities in the vicinity of the project area. McIntyre Gulch crosses Garrison Street south of 6th Avenue between West 2nd Avenue and West 3rd PI and Lakewood Gulch crosses Garrison Street north of 6th Avenue between West 9th Avenue and Lakewood Village Dr. Stormwater runoff from the project site drains to the existing storm system in West 6th Avenue, which conveys the flows east and north to Lakewood Gulch. There are no irrigation laterals within the project area.

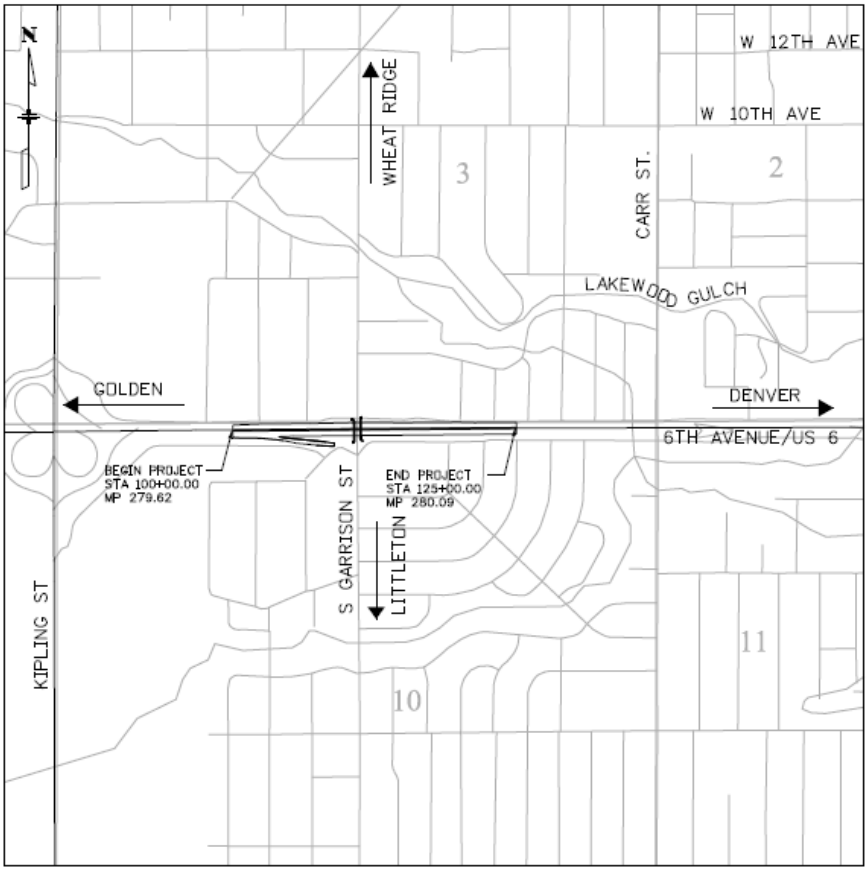


Figure 1 – Project Location

Lakewood Gulch ultimately discharges to the South Platte River approximately 4.5 miles east of the project. The majority of the runoff from newly paved areas discharges to water quality facilities through the newly designed storm sewer with the exception of pavement replacement at the east end of the project, which is noted in Section 3 of this report. The proposed southwest water quality facility discharges to the existing storm drain system in Garrison Street and the proposed northeast water quality facility discharges to the existing storm drain system in West 6th Avenue.

Figure 2 in Appendix A shows the project is within CDOT's municipal separate system (MS4) permit coverage area.

It is proposed to replace the existing Garrison Street Bridge with a new bridge. This will require roadway replacement improvements along each of the approaches to the bridge in addition to the new and replaced retaining walls on both sides of the 6th Avenue. Figure 3 is the Water Quality Plan showing the site location, proposed improvements, project limits and area of disturbance.

2. DISCUSSION OF CDOT MS4 / NDRD REQUIREMENTS

The purpose of this water quality report is to address Colorado Department of Health and Environment (CDPHE) permanent water quality requirements for MS4 compliance. CDOT's MS4 permit covers the project areas within the CDOT right-of-way, while project areas beyond the CDOT right-of-way are covered by the City of Lakewood's MS4 permit. The design includes ponds to provide the water quality capture volume (WQCV) in conformance with the MS4 permits. Technical and design details regarding the permanent water quality facilities are described in a separate drainage report. Some information between this water quality report and the drainage report is duplicated so each report can stand alone and address pertinent issues. The project drainage and water quality design are in accordance with CDOT and Urban Drainage and Flood Control District (UDFCD) criteria and guidelines.

3. PERMANENT WATER QUALITY BMPS

The BMPs recommended for this project are in accordance with the CDOT Erosion and Stormwater Quality Guide and Urban Drainage Flood Control District Best Management Practice Design Manual to ensure that permanent BMPs are adequate to protect the water quality as per the New Development and Redevelopment Planning Procedure.

This project constructs two water quality ponds to provide WQCV for the new paved surfaces within the project limits. The ponds are planned to be extended detention basins (EDBs) with concrete forebays. They are located at the northeast corner of 6th Avenue and Garrison Street and at the southwest corner of 6th Avenue and Garrison Street. Micropools will not be included within the outfall structures.

The EDB ponds are designed to empty within 40 hours after stormwater runoff ceases. A water quality pond uses a much smaller outlet than a flood control detention basin, which extends the emptying time for more frequently occurring runoff events to facilitate pollutant removal from the stormwater. A retaining wall is provided at one side of each of the ponds to achieve the desired water quality capture volume and to tie into the fill slope of 6th Avenue.

Northeast Water Quality Pond

The NE WQ pond was designed to include WQCV for a total contributing area of 3.36 acres, of which 2.55 acres is impervious. The WQCV for this area is 0.102 ac-ft.

Southwest Water Quality Pond

The SW WQ pond was designed to include WQCV for a total contributing area of 3.58 acres, of which 3.02 acres is impervious. The WQCV for this area is 0.128 ac-ft.

Area of disturbance

The total area of disturbance is approximately 10.33 acres. The area of disturbance outside the existing roadway footprint is 2.99 acres.

Disturbed area not treated

There is a pavement section on 6th Avenue at the east end of the project with an area of approximately 1.47 acres that will be removed, regraded, and replaced. The net pavement increase is zero. The runoff from this section of pavement cannot feasibly be conveyed to the Northeast water quality pond. Since there is no net

pavement increase in this area, CDOT and the City of Lakewood agreed that this area would not need to be treated for water quality.

Approximately 0.08 acres of modified areas on Garrison Street, including improvement of shoulders, curb/gutter and sidewalks are also not treated for water quality.

Overview

The proposed water quality facilities can fit within the proposed rights of way, can achieve the required water quality capture volume for the areas tributary to them, have maintenance access, meet CDOT and City of Lakewood MS4 requirements, and are the types of facilities that have been approved by CDOT, Lakewood, and the Urban Drainage and Flood Control District.

The design of the facilities was done according to Urban Drainage and Flood Control District criteria. The facilities will be maintained by CDOT.

See Appendix A for water quality capture volume (WQCV) calculations.

4. MAINTENANCE AND OPERATION

A. *Water Quality Pond including Forebay*

The Northeast and Southwest water quality ponds are located at the northeast and southwest corners of 6th Avenue and Garrison Street. They will have a single cell outlet structure with screen and orifice plate, which is designed for a 40-hour drain time. Two storm sewer lines drain into each pond at a concrete lined forebay. The forebay is designed to drain within 5 minutes and intercept sediment and large debris. Access to the northeast pond will be from the West 6th Avenue NE off ramp. Access to the southwest pond will be from the SW off ramp. 5:1 slopes were requested by the City in place of a formalized maintenance path to the forebay and pond outlet. The anticipated maintenance work that will be required to ensure continued effectiveness of the facility will be done by the City of Lakewood forces and will include:

- Mowing the native grass in the water quality basin, removing vegetation that may clog the outlet structures.
- Clean trash and debris from the trash rack and grates. Dispose of material off-site.
- Clear orifice holes so that water can continue to flow.

- Remove sediment from the basins when levels reach the lowest hole or the forebay outlet pipe is blocked. This can be done with hand shovels, bob-cats, or skid steers. Remove the material off-site to prevent re-polluting the pond.
- Reseed as necessary to prevent erosion.
- Add additional erosion control items to stabilize the site.
- Tighten or replace trash rack bolts and screens as necessary to keep the structure in working order.

The facilities will be owned by CDOT and maintained by the City of Lakewood maintenance staff.

5. REFERENCES

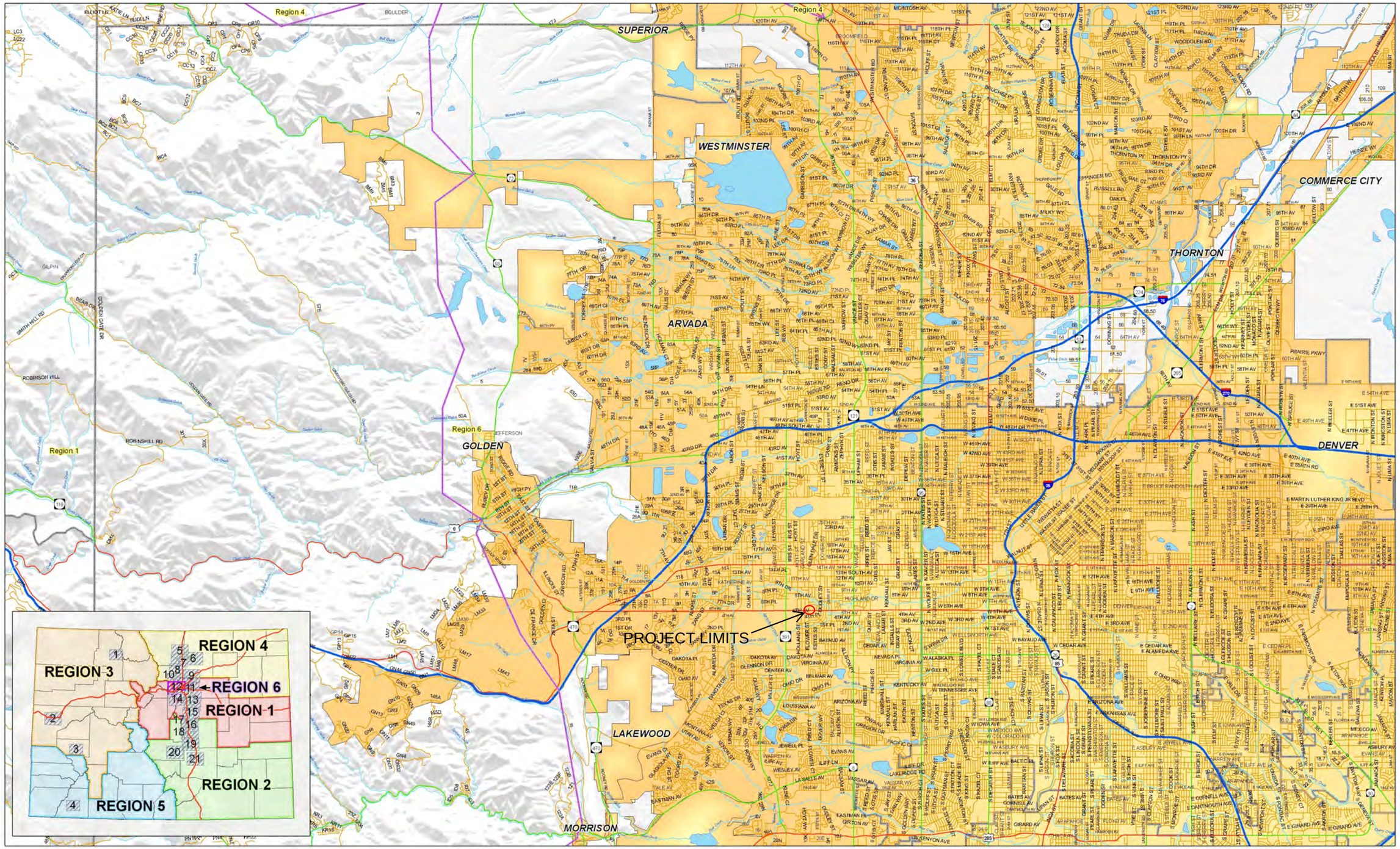
1. CH2M HILL site visits during 2013
2. Urban Drainage and Flood Control District, Urban Storm Drainage Criteria Manual, Volumes I, II, and III, current dates
3. Colorado Department of Transportation, Drainage Design Manual, 2004
4. CDOT MS4 Permit, New and Redevelopment Stormwater Management Program, February 2004
5. Stream Classifications and Water Quality Standards, Colorado Department of Public Health and Environment, 2004, (CDPHE, 2004a)
6. Regulation No. 31, Colorado Department of Public Health and Environment, November 8, 2004
7. Regulation No. 93, 2004 Section 303d List, Water-Quality-Limited Segments Requiring TMDL's, Colorado Department of Public Health and Environment, 2004
8. Colorado Department of Transportation Region 6 Permanent Water Quality Documentation, CDOT, April 6, 2011

APPENDIX A

SUPPLEMENTAL INFORMATION

CDOT MS4 Permit Coverage Area, Map 12 (Figure 2)
Water Quality Plan (Figure 3)
Water Quality Capture Volume (WQCV) Calculations
Project Meeting Minutes related to Water Quality

CDOT MS4 Permit Coverage Area, Map 12



Legend

- Rivers and Streams
- Interstate
- U.S. Hwy
- State Hwy
- Local Roads
- CDOT Regions
- Lakes
- County Boundary
- CDOT MS4 Coverage Area (after March 10, 2008)

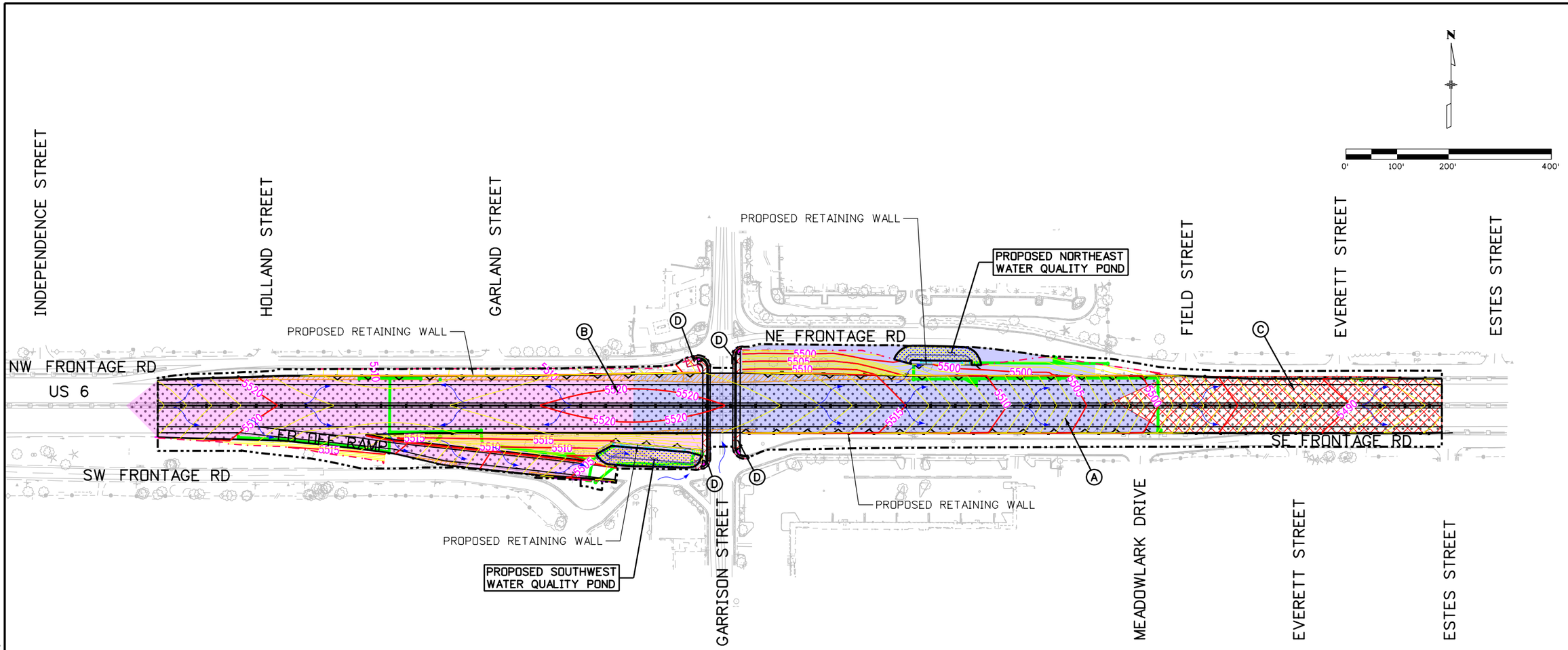
Phase I & II MS4 permit coverage areas as of November 2007.

Information sources:
urban area boundaries - 2000 census from CDOT GIS Section.
Jurisdictional boundaries from CDOT GIS Section Data Management Unit as of 12/31/2006.
Cherry Creek Basin used to delimit MS4 area from FHU.

0 2 4 8 Miles

N

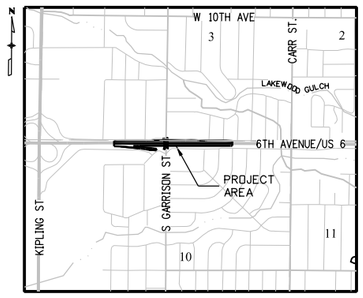
FIGURE 2: MS4 LOCATION MAP



AREA ID	BASIN	TYPE OF PERMANENT BMP	BASIN DESCRIPTION	TOTAL BASIN AREA (AC)	NEW IMPERVIOUS AREA (AC)	TOTAL IMPERVIOUS AREA (AC)	ACTUAL IMPERVIOUS AREA TREATED (AC)	COMMENTS
A		EXTENDED DETENTION BASIN	NE	3.36	0.21	2.55	2.55	NORTHEAST WATER QUALITY POND
B		EXTENDED DETENTION BASIN	SW	3.58	0.28	3.02	3.02	SOUTHWEST WATER QUALITY POND
C				1.47	0.04	1.47	0.00	IMPERVIOUS AREA NOT TREATED
D				0.08	0.00	0.08	0.00	IMPERVIOUS AREA NOT TREATED
			TOTALS	8.49	0.53	7.12	5.57	

LEGEND

- LIMITS OF DISTURBANCE
- PROPOSED STORM DRAIN
- IMPERVIOUS AREA NOT CAPTURED WITHIN LIMITS OF DISTURBANCE
- NEW/RECONSTRUCTED IMPERVIOUS AREA
- EXISTING IMPERVIOUS AREA
- PROPOSED POND SITE
- FLOW DIRECTION
- Ⓐ AREA ID



VICINITY MAP

U.S. 6 OVER GARRISON STREET

Colorado Department of Transportation
DOT DEPARTMENT OF TRANSPORTATION
425 B Corporate Circle
Golden, CO 80401
Phone: 720-497-6954 FAX: 720-497-6951
Region 1 KPB

WATER QUALITY PLAN

Project No./Code
FBR 0063-046
19478
Figure Number 3

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Southwest Water Quality Pond)
Location: Lakewood Colorado

1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a — I_a = 84.4 %

B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$) — i = 0.844

C) Contributing Watershed Area — Area = 3.580 ac

D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm — d_6 = _____ in

E) Design Concept (Select EURV when also designing for flood control)

Choose One
- (•) Water Quality Capture Volume (WQCV)
- ( ) Excess Urban Runoff Volume (EURV)

F) Design Volume (1.2 WQCV) Based on 40-hour Drain Time
($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area * 1.2)$) — V_{DESIGN} = 0.128 ac-ft

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
($V_{WQCV\ OTHER} = (d_6 * (V_{DESIGN} / 0.43))$) — $V_{DESIGN\ OTHER}$ = _____ ac-ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired) — $V_{DESIGN\ USER}$ = _____ ac-ft

I) Predominant Watershed NRCS Soil Group

Choose One
- ( ) A
- ( ) B
- (•) C / D

J) Excess Urban Runoff Volume (EURV) Design Volume
For HSG A: EURVA = (0.1878i - 0.0104)*Area
For HSG B: $EURV_B$ = (0.1178i - 0.0042)*Area
For HSG C/D: $EURV_{C/D}$ = (0.1043i - 0.0031)*Area

EURV = _____ ac-f t

2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.) — L : W = 4.0 : 1

3. Basin Side Slopes

A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred) — Z = 0.10 ft / ft **TOO STEEP (< 3)**

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations:

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Southwest Water Quality Pond)
Location: Lakewood Colorado

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 2% of the WQCV) — V_{FMIN} = 0.002 ac-ft

B) Actual Forebay Volume — V_F = ac-ft

C) Forebay Depth (D_F = 18 inch maximum) — D_F = 12.0 in

D) Forebay Discharge

i) Undetained 100-year Peak Discharge — Q_{100} = 19.11 cfs

ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$) — Q_F = 0.38 cfs

E) Forebay Discharge Design

Choose One
- ○ Berm With Pipe
- ◉ Wall with Rect. Notch
- ○ Wall with V-Notch Weir

(flow too small for berm w/ pipe)

F) Discharge Pipe Size (minimum 8-inches) — Calculated D_P = in

G) Rectangular Notch Width — Calculated W_N = 3.8 in

6. Trickle Channel

A) Type of Trickle Channel

Choose One
- ○ Concrete
- ○ Soft Bottom

F) Slope of Trickle Channel — S = ft / ft

7. Micropool and Outlet Structure

A) Depth of Micropool (2.5-feet minimum) — D_M = ft

B) Surface Area of Micropool (10 ft^2 minimum) — A_M = sq ft

C) Outlet Type

Choose One
- ○ Orifice Plate
- ○ Other (Describe):

D) Depth of Design Volume (EURV or 1.2 WQCV) Based on the Design Concept Chosen Under 1.E. — H = feet

E) Volume to Drain Over Prescribed Time — WQCV = 0.107 ac-ft

F) Drain Time (Min T_D for WQCV= 40 hours; Max T_D for EURV= 72 hours) — T_D = hours

G) Recommended Maximum Outlet Area per Row, (A_o) — A_o = square inches

H) Orifice Dimensions:
- i) Circular Orifice Diameter or — $D_{orifice}$ = inches
- ii) Width of 2" High Rectangular Orifice — $W_{orifice}$ = inches

I) Number of Columns — n_c = number

J) Actual Design Outlet Area per Row (A_o) — A_o = square inches

K) Number of Rows (nr) — n_r = number

L) Total Outlet Area (A_{ot}) — A_{ot} = square inches

M) Depth of WQCV (H_{WQCV}) (Estimate using actual stage-area-volume relationship and V_{WQCV}) — H_{WQCV} = feet

N) Ensure Minimum 40 Hour Drain Time for WQCV — $T_{D\,WQCV}$ = hours

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Southwest Water Quality Pond)
Location: Lakewood Colorado

8. Initial Surcharge Volume

A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches) — D_{IS} = _____ in

B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV) — V_{IS} = _____ cu ft

C) Initial Surcharge Provided Above Micropool — V_s = _____ cu ft

9. Trash Rack

A) Type of Water Quality Orifice Used

Choose One
- O Circular (up to 2" diameter)
- O Rectangular (2" high)

B) Water Quality Screen Open Area: $A_t = 38.5*(e^{-0.095D})*A_{ot}$ — A_t = _____ square inches

C) For 2", or Smaller, **Circular Opening** (See Fact Sheet T-12):

i) Width of Water Quality Screen and Concrete Opening ($W_{opening}$) — $W_{opening}$ = _____ inches

ii) Height of Water Quality Screen (H_{TR}) — H_{TR} = _____ inches

iii) Type of Screen, Describe if "Other"

Choose One
- O S.S. Well Screen with 60% Open Area*
- O Other (Describe):

D) For 2" High **Rectangular Opening**:

i) Width of Rectangular Opening ($W_{orifice}$) — W = _____ inches

ii) Width of Water Quality Screen Opening ($W_{opening}$) — $W_{opening}$ = _____ ft

iii) Height of Water Quality Screen (H_{TR}) — H_{TR} = _____ ft

iv) Type of Screen, Describe if "Other"

Choose One
- O Aluminum Amico-Klemp SR Series (or equal)
- O Other (Describe):

v) Cross-bar Spacing — _____ inches

vi) Minimum Bearing Bar Size

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Southwest Water Quality Pond)
Location: Lakewood Colorado

10. Overflow Embankment

A) Describe embankment protection for 100-year and greater overtopping:

B) Slope of Overflow Embankment
(Horizontal distance per unit vertical, 4:1 or flatter preferred)

Z_E = _____ ft / ft

11. Vegetation

Choose One
- ○ Irrigated
- ○ Not Irrigated

12. Access

A) Describe Sediment Removal Procedures

Notes:

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Northeast Water Quality Pond)
Location: Lakewood, Colorado

1. Basin Storage Volume	
A) Effective Imperviousness of Tributary Area, I_a	I_a = 75.9 %
B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i = 0.759
C) Contributing Watershed Area	Area = 3.360 ac
D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 = ____ in
E) Design Concept (Select EURV when also designing for flood control)	Choose One: (•) Water Quality Capture Volume (WQCV) ( ) Excess Urban Runoff Volume (EURV)
F) Design Volume (1.2 WQCV) Based on 40-hour Drain Time ($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area * 1.2)$	V_{DESIGN} = 0.102 ac-ft
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume ($V_{WQCV\ OTHER} = (d_6 * (V_{DESIGN} / 0.43))$	$V_{DESIGN\ OTHER}$ = ____ ac-ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{DESIGN\ USER}$ = ____ ac-ft
I) Predominant Watershed NRCS Soil Group	Choose One: ( ) A ( ) B (•) C / D
J) Excess Urban Runoff Volume (EURV) Design Volume For HSG A: EURVA = (0.1878i - 0.0104)*Area For HSG B: $EURV_B$ = (0.1178i - 0.0042)*Area For HSG C/D: $EURV_{C/D}$ = (0.1043i - 0.0031)*Area	EURV = ____ ac-f t
2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.)	L : W = 4.0 : 1
3. Basin Side Slopes	
A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Z = 0.01 ft / ft **TOO STEEP (< 3)**
4. Inlet	
A) Describe means of providing energy dissipation at concentrated inflow locations:	

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Northeast Water Quality Pond)
Location: Lakewood, Colorado

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 2% of the WQCV) — V_{FMIN} = 0.002 ac-ft

B) Actual Forebay Volume — V_F = ac-ft

C) Forebay Depth (D_F = 18 inch maximum) — D_F = 12.0 in

D) Forebay Discharge

i) Undetained 100-year Peak Discharge — Q_{100} = 27.27 cfs

ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$) — Q_F = 0.55 cfs

E) Forebay Discharge Design

Choose One
- ○ Berm With Pipe
- ◉ Wall with Rect. Notch
- ○ Wall with V-Notch Weir

(flow too small for berm w/ pipe)

F) Discharge Pipe Size (minimum 8-inches) — Calculated D_P = in

G) Rectangular Notch Width — Calculated W_N = 4.4 in

6. Trickle Channel

A) Type of Trickle Channel

Choose One
- ○ Concrete
- ○ Soft Bottom

F) Slope of Trickle Channel — S = ft / ft

7. Micropool and Outlet Structure

A) Depth of Micropool (2.5-feet minimum) — D_M = ft

B) Surface Area of Micropool (10 ft^2 minimum) — A_M = sq ft

C) Outlet Type

Choose One
- ○ Orifice Plate
- ○ Other (Describe):

D) Depth of Design Volume (EURV or 1.2 WQCV) Based on the Design Concept Chosen Under 1.E. — H = feet

E) Volume to Drain Over Prescribed Time — WQCV = 0.085 ac-ft

F) Drain Time (Min T_D for WQCV= 40 hours; Max T_D for EURV= 72 hours) — T_D = hours

G) Recommended Maximum Outlet Area per Row, (A_o) — A_o = square inches

H) Orifice Dimensions:
i) Circular Orifice Diameter or — $D_{orifice}$ = inches
ii) Width of 2" High Rectangular Orifice — $W_{orifice}$ = inches

I) Number of Columns — n_c = number

J) Actual Design Outlet Area per Row (A_o) — A_o = square inches

K) Number of Rows (nr) — n_r = number

L) Total Outlet Area (A_{ot}) — A_{ot} = square inches

M) Depth of WQCV (H_{WQCV}) (Estimate using actual stage-area-volume relationship and V_{WQCV}) — H_{WQCV} = feet

N) Ensure Minimum 40 Hour Drain Time for WQCV — $T_{D\,WQCV}$ = hours

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Northeast Water Quality Pond)
Location: Lakewood, Colorado

8. Initial Surcharge Volume

A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches) — D_{IS} = _____ in

B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV) — V_{IS} = _____ cu ft

C) Initial Surcharge Provided Above Micropool — V_s = _____ cu ft

9. Trash Rack

A) Type of Water Quality Orifice Used

Choose One
- O Circular (up to 2" diameter)
- O Rectangular (2" high)

B) Water Quality Screen Open Area: $A_t = 38.5*(e^{-0.095D})*A_{ot}$ — A_t = _____ square inches

C) For 2", or Smaller, **Circular Opening** (See Fact Sheet T-12):

i) Width of Water Quality Screen and Concrete Opening ($W_{opening}$) — $W_{opening}$ = _____ inches

ii) Height of Water Quality Screen (H_{TR}) — H_{TR} = _____ inches

iii) Type of Screen, Describe if "Other"

Choose One
- O S.S. Well Screen with 60% Open Area*
- O Other (Describe):

D) For 2" High **Rectangular Opening**:

i) Width of Rectangular Opening ($W_{orifice}$) — W = _____ inches

ii) Width of Water Quality Screen Opening ($W_{opening}$) — $W_{opening}$ = _____ ft

iii) Height of Water Quality Screen (H_{TR}) — H_{TR} = _____ ft

iv) Type of Screen, Describe if "Other"

Choose One
- O Aluminum Amico-Klemp SR Series (or equal)
- O Other (Describe):

v) Cross-bar Spacing — _____ inches

vi) Minimum Bearing Bar Size

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Douglas P. Stewart, PE
Company: CH2M HILL
Date: January 29, 2014
Project: US 6 Over Garrison Street (Northeast Water Quality Pond)
Location: Lakewood, Colorado

10. Overflow Embankment

A) Describe embankment protection for 100-year and greater overtopping:

B) Slope of Overflow Embankment
(Horizontal distance per unit vertical, 4:1 or flatter preferred)

Z_E = _____ ft / ft

11. Vegetation

Choose One
- ○ Irrigated
- ○ Not Irrigated

12. Access

A) Describe Sediment Removal Procedures

Notes:

CH2MHILL

US 6 Over Garrison

Preliminary and Final Engineering Design

Purpose:	**Technical Leadership Team (TLT) Meeting Minutes – No. 03** **Water Quality Pre-FIR Meeting**		
Day:	**Monday**	Date:	**November 25, 2013, 10:00 am**

Location:	**CDOT R1 – Corporate Circle** **Fossil Trace Conference Room**	**Golden, CO**

Participants:

Attendee	Representing	
Jana Spiker	CDOT	
Holly Huyck	CDOT	
Doug Stewart	CH2M HILL	

Attendee	Representing	

Discussion Items

The purpose of this Technical Leadership Team (TLT) meeting is to present a preliminary Permanent Water Quality design layout and discuss its issues and alternatives.

Action items are in **bold** type and key decisions are highlighted, both are summarized in tables at the end of this document.

Key agenda items are listed below:

Water Quality Design Discussion

Doug laid out a project area map delineating the drainage basins of concern for the project. The first area encompassed the disturbed area west of Garrison Avenue. There are two off-site flow storm drains that will bypass the project area to prevent offsite flows from overwhelming the water quality facility. Attempts were made to include treatment for offsite flows west of Garrison, but there is limited space for a surface BMP, without including walls. CDOT has stated in the past that they would prefer to not include walls in water quality ponds. Due to the raising of the roadway, a wall may be required along either the highway or one side of the water quality pond. An Extended Detention Basin (EDB) Water Quality pond is proposed for this basin between 6th Avenue and the SW Frontage Road. The pond would discharge to an existing drainage system along Garrison Street, which flows north to Lakewood Gulch. This will be called Basin No. 1 or the SW Basin

The next BMP basin is located east of Garrison, extending only as far along 6th Avenue as the area can be drained back to a water quality facility. An EDB is proposed between 6th Avenue and the NE Frontage Road. The pond would discharge to an existing drainage system just east of the pond, which discharges to a system of roadside ditches and culverts that flow to Lakewood Gulch. This will be called Basin No. 2 or the NE Basin.

The limits of disturbance for the project extend farther east than the NE Basin limits, but this area could not be drained back to an on-site pond. CDOT maintenance has stated that they would prefer not to use underground vaults for water quality, but they have been using them more frequently on other projects. Holly discussed a developing policy to apply funding dollars for meeting water quality requirements instead of multiple small permanent BMPs. In this way, project money that would have gone toward an on-site facility could go toward an off-site regional facility. Development of this process and guidelines is still underway. **Holly will coordinate further with Dave Baskett of City of Lakewood to discuss underground vaults, funding for off-site treatment and a maintenance agreement between the City and CDOT.**

Water Quality Report Discussion

The following discussion was in regard to the Sample Permanent Water Quality Report outline dated 7/25/13.

Section 1 – Disturbance vs. Project Limits. Both can be the same outline and area, but don't have to be. Disturbance usually occurs in grassed areas or where pavement is to be removed.

Section 2 – CDOT MS4 versus Local Jurisdiction MS4. CDOT MS4 is used when permanent water quality is located within the CDOT right-of-way or CDOT owned properties. If runoff from disturbed area within the CDOT property cannot be treated on CDOT property, then the local jurisdiction must be consulted to determine if their MS4 requirements should be followed.

Section 3.2 – Permanent WQ options considered. Only discuss those options that could be feasibly used on the project site. Do not need to discuss options that don't fit within the topography or have been excluded from selection by CDOT Maintenance or other jurisdictions who will maintain it.

Section 3.4 – Table added to Report Text. Holly would like to keep the table shown on the Water Quality Plan as it is with no modifications, but she would like to copy the Table from the WQ report to the report text and a column added for pervious areas.

Section 3.4 -6 – **Holly will review the text to clarify NEW imperious area versus ALL impervious area for area required for treatment.**

Seciton 3.4 -8 – **Holly will review the text to clarify REQUIRED versus ACTUAL areas treated and to define applicable exclusions.**

Other Items

Holly requested that we include Water Quality reports and maps, drainage plans and SWMP plans all together in the final ProjectWise directory so that her team does not have to search other directories for these references.

Holly and Doug discussed temporary BMPs for temporary Bridge detours. In Holly's opinion, she would connect any inlets along the detour route directly to the existing storm system, ASSUMING that there is only runoff from impervious roadway areas. If runoff from disturbed grass areas was directed to the detour, then temporary sediment traps should be considered. She recommended that Susie be included in this discussion.

Doug will provide Holly with an 11"x17" plan sheet showing the preliminary permanent water quality basins and systems layout.

DECISION LIST	
Decision	**Made by**
Copy the Table from the WQ report to the report text and a column added for pervious areas.	CDOT

ACTION ITEMS			
No.	**TLT Meeting #01**	**Responsibility**	**Status**
1	Holly will coordinate further with Dave Baskett of City of Lakewood to discuss underground vaults, funding for off-site treatment and a maintenance agreement between the City and CDOT.	Holly Huyck	
2	Holly will update the text to reference NEW imperious area instead of ALL impervious area for area required for treatment.	Holly Huyck	
3	Holly will update the text to clarify required versus actual areas treated and to define applicable exclusions.	Holly Huyck	
4	Doug will provide Holly with an 11"x17" plan sheet showing the preliminary permanent water quality basins and systems layout.	Doug Stewart	

Appendix E

Pipe Justification Report

Engineering Justification for Pipe Materials for

US 6 Over Garrison Street

To:	Scott Leiker, PE, CDOT Region 1 Hydraulics
Date:	February 7, 2014
From:	Douglas P. Stewart, PE, CH2M HILL
Project Number:	CDOT Federal Aid Project No.: FBR 0063-046 CH2M HILL: 473244.05.PD.HY

Introduction

This Pipe Materials Justification Report was prepared to document the research and process for selecting acceptable pipe materials for the US 6 Over Garrison Street Project, as outlined in the current CDOT Pipe Material Selection Policy.

Step 1: Application

This project specifies 18 inches to 24 inches reinforced concrete pipe for storm drain mains and laterals. The following justification supports this decision based on specific engineering requirements for the project.

Step 2: Abrasion Level

The abrasion level for the storm drain pipes is Abrasion Level 1, which applies to pipe with no bed load and low velocities.

Step 3: Corrosion Level

See attached excerpt from the Geotechnical Report by RockSol. See attached annotations on Table 1 of the CDOT Pipe Material Selection Policy.

CR Level 0 for Storm Drains.

Step 4: Selection of Pipe Material Type

See annotations on Figure 2 of the CDOT Pipe Material Selection Policy.

Acceptable pipe materials for CR 0 based on CDOT pipe selection criteria are RCP, PE, and PVC. The City of Lakewood has requested the use of only RCP due to their maintenance needs.

Step 5: Verify Fill Height

Fill for this project falls within the acceptable ranges as shown in the Standard Plans.

Step 6: Exceptions to CDOT Pipe Materials Selection Policy

The City of Lakewood has requested to use only RCP, which is an exception to the CDOT Pipe Materials Selection Policy.

Conclusion

RCP will be used on this project for the following reasons:

- Soil tests for water soluble sulfate concentrations were measured in samples obtained from the exploratory borings by RockSol. The RockSol test results indicate that the water soluble sulfate concentrations in soil were less than or equal to 0.10 percent by weight. This level of water soluble sulfate concentration is characterized by CDOT as a Class 0 (SP0) severity of sulfate exposure for concrete in contact with site soils. The water soluble sulfate concentrations encountered represent a "negligible" degree of sulfate attack on concrete according to the American Concrete Institute (ACI), which defines the degree of attack on concrete as negligible (0.0 to 0.1%). , moderate (0.1-0.2%)," severe (0.2-2.0%), and very severe (over 2.0%) as described in ACI, Section 318, Chapter 4. Groundwater will not be encountered during storm drain installations, therefore, its sulfate content was not considered in the pipe design.
- Section 603 of CDOT Standard Specifications for Road and Bridge Construction is used for the storm drain systems for this project.
- Only RCP pipe shall be used for the storm drains, as requested by the City of Lakewood.

RockSol
Consulting Group, Inc.

January 29, 2014

CH2M HILL
9193 South Jamaica Street
Englewood, Colorado 80112

Attention: Mr. Aaron Swafford, P.E.

Subject: Pavement Design Report, US 6 over Garrison Street Bridge Replacement Project, Lakewood, Colorado, Colorado Department of Transportation Project No. FBR 0063-046 (19478), RockSol Project Number 321.01

Dear Mr. Swafford:

RockSol Consulting Group, Inc. (RockSol) has performed a geotechnical investigation for the US 6 over Garrison Street Bridge Replacement Project.

This Pavement Design Report presents a brief discussion of the subsurface conditions encountered, a summary of the lab testing performed on recovered soil and bedrock samples, and pavement design recommendations to assist with design of pavements for the subject project.

Surface and groundwater hydrology, hydraulic engineering, and environmental studies including contaminant characterization were not included in RockSol's scope of work.

Project Description

The existing three-span bridge structure, identified as the US 6 over Garrison Bridge (Structure No. F-16-ER) is proposed to be replaced by a new single-span bridge over Garrison Street. The new structure may be slightly wider to accommodate wider shoulders within US 6 and lengthened to an approximate span length of 85 feet to allow for new 8-foot wide sidewalks and 4-foot wide bike lanes along northbound and southbound Garrison Street. Planned improvements will also include correcting the vertical curve deficiency on US 6 by raising the grade for US 6 to the east and west of Garrison Street and lowering the bridge over Garrison Street. The existing connection ramp configurations and tie in grades to US 6 are proposed to generally remain the same. The grade of the eastbound US 6 off-ramp to Garrison Street will be raised slightly for a portion of its length.

Proposed construction phasing will include the construction of a temporary bridge over Garrison Street to the south of the existing bridge structure and the construction of temporary retaining wall systems at the southwest and southeast quadrants of the overpass to allow westbound (WB) traffic to shift into the existing eastbound (EB) US 6 lanes while the WB bridge section is removed and replaced. During bridge construction the EB US 6 traffic will be shifted to the temporary bridge alignment. New pavement construction will be required for EB and WB US 6 within the project limits. Temporary (detour) pavement will also be required for EB US 6 as part of the construction phasing.

Project Site Conditions

The existing US 6 bridge over Garrison Street is a three span structure consisting of continuous welded girder center spans supported by two sets of six-concrete column piers. The existing bridge carries three lanes of traffic in each direction over Garrison Street and is approximately

90 feet in width. US 6 is presently surfaced with flexible pavement. The existing US 6 approach embankments (fill placement) are approximately 20 feet in height at the bridge abutments. Concrete slope paving (approximate 2H:1V slope) is present at each abutment with embankment side slopes of approximately 3H:1V to 4H:1V.

A mix of commercial and residential development borders the project area. Topography at the site generally consists of flat to mild slopes with a general trend of decreasing elevation to the north and east.

Subsurface Investigation

In August and September 2013, RockSol drilled 13 boreholes to evaluate the subsurface conditions for the US 6 over Garrison Bridge Replacement project. The borehole locations are identified as BR-1 through BR-6, RW-1 through RW-5 and PV-1 through PV-2, as shown on Figure 2, Borehole Location Plan. Boreholes BR-1 through BR-6 were drilled at the approximate location of the proposed bridge structure, Boreholes RW-1 through RW-5 were drilled to assist with retaining wall foundation recommendations, and Boreholes PV-1 and PV-2 were drilled to assist with pavement thickness recommendations. The boreholes were located by field survey provided by the project surveyor (HKS). Horizontal and vertical locations were then provided to RockSol for inclusion on the Borehole Location Plan and on the borehole logs. Pavement cores were obtained at Boreholes BR-1, BR-2, BR-5, RW-1, RW-2, RW-4, PV-1 and PV-2.

Truck mounted CME-45 and CME-55 drill rigs were used for drilling and sampling. The boreholes were advanced using 4-inch outside diameter solid stem augers and 8 inch outside diameter hollow stem augers to maximum depths ranging from approximately 10 feet to 80 feet below existing grades. The boreholes were logged in the field by a representative of RockSol with the depth to groundwater noted at the time of drilling. A monitoring well was drilled and installed near Borehole BR-4 for the project environmental team (Pinyon Environmental). Except for the monitoring well, the boreholes were backfilled at the completion of drilling and groundwater level checks. Boreholes drilled within existing pavement were patched with concrete and/or asphalt patch mixes.

Subsurface materials were sampled and resistance of the soil to penetration of the sampler was performed using modified California barrel and standard split spoon samplers. The modified California barrel sampler has an outside diameter of approximately 2.5 inches and an inside diameter of 2 inches. The standard split spoon sampler used had an outside diameter of 2 inches and an inside diameter of 1⅜-inches. Brass tube liners are used with the modified California barrel sampler to retain samples for density, swell, and unconfined compressive strength testing. Sample retaining liners are not used with the standard split spoon sampler.

Penetration Tests were performed at selected intervals using both a standard rope-cathead lift system and an automatic lift system. Both hammer lift systems used a hammer weighing 140 pounds and falling 30 inches. The standard split spoon sampling method is the Standard Penetration Test (SPT) described by ASTM Method D-1586. Penetration Tests were performed using the modified California barrel sampler with a standard hammer weighing 140 pounds falling 30 inches per ASTM D3550. The modified California Barrel sampling method is similar to the SPT test with the difference being the sampler dimensions and the number of 6-inch intervals driven with the hammer. Correlation of blow counts obtained from a modified California sampler to blow counts obtained from a standard split spoon sampler is not available. However, it is RockSol's experience that blow counts obtained with the modified California sampler tend to be slightly greater than a standard split spoon sampler. Penetration resistance

values (blow counts) were recorded for each sampling event. Blow counts, when properly evaluated, indicate the relative density or consistency of the soils. Depths at which the samples were taken, the type of sampler used, and the blow counts that were obtained are shown on the Boring Logs for each borehole. Individual Borehole Logs are included in Appendix A. Engineering Geology Sheets for the project are included in Figures 2A through 2D.

Subsurface Conditions

Roadway Pavement

Flexible pavement (asphalt) was encountered at the ground surface at eight borehole locations. Where flexible roadway pavement was encountered on US 6, the thickness generally ranged from 6.0 inches to 9.5 inches. At Boreholes BR-1, BR-2, BR-5, PV-1, and RW-2 approximately 4.0 inches to 8.5 inches of flexible asphalt pavement was noted overlying 7.5 inches to 10.5 inches of rigid pavement. Aggregate base course material was not noted below the pavement sections. A summary of the pavement section thicknesses encountered is presented in Table 1.

Table 1 – Existing Pavement Sections

Borehole	Location	HMA Thickness (inches)	PCCP Thickness (inches)	Total Pavement Thickness (inches)
BR-1	WB US 6 Shoulder	5	10¼	15¼
BR-2	EB US 6 Lane 1	7½	9½	17
BR-5	EB US 6 Lane 1	11½ (total) [2 distinct layers encountered]	8½	20
PV-1	WB US 6 Shoulder	7¼	7⅛	14⅜
PV-2	EB US 6 Shoulder	7½	Not Encountered	7½
RW-1	WB US 6 Shoulder	9¼	Not Encountered	9¼
RW-2	WB US 6 Shoulder	4	7½	11½
RW-4	EB US 6 Shoulder	7¾	Not Encountered	7¾
RW-5	US 6 Frontage Road (SE)	6	Not Encountered	6

The pavement section noted at Borehole RW-5 is based on field measurements made by RockSol during drilling operations. A pavement core was not recovered at Borehole RW-5. The pavement core recovered at Borehole BR-5 included a layer of asphalt pavement, 8¼ inches in thickness, over 8½ inches rigid pavement, which was over a layer of asphalt pavement approximately 3¼ inches in thickness. A summary of the recovered pavement cores is presented in Appendix B, Pavement Core Log Summary. Included in the core log summary are photographs of the recovered core sections and RockSol's general assessment of the condition of each core.

Topsoil

Topsoil was encountered at the ground surface at four borehole locations. The topsoil encountered was lightly organic sandy silt which supported a sparse covering of grasses and weeds. A topsoil thickness of approximately 3 inches to 6 inches was estimated based on field observations.

Fill Material

Beneath the pavement and topsoil, subsurface conditions encountered generally consisted of fill material to approximate depths ranging from 3 feet to 24 feet below existing grades and appears to be associated with the roadway embankment for US 6 over Garrison and the entrance and exit ramps for US 6. Fill material was not noted in Borehole BR-3. The fill material encountered generally consisted of medium stiff to very stiff sandy clay with gravel in parts. In Boreholes BR-2, BR-6, PV-1, and PV-2, fill material consisting of silty to clayey sand with gravel was encountered. Based on laboratory test results, the fill material encountered predominantly classified as A-6 soils by the American Association of State Highway and Transportation Officials (AASHTO) soil classification system. A-7-6 soils were also encountered. A summary of laboratory test results with soil classifications is presented in Appendix C.

Native Soils

Native soils encountered below the fill material or ground surface included stiff to hard sandy clay and medium dense to dense silty to clayey sand with gravel in parts. Sandy silt and gravelly sand were encountered at depths greater than 15 feet.

Bedrock

Sedimentary bedrock was encountered beneath the native soils in Boreholes BR-1 through BR-6 and RW-5 at elevations ranging from 5,455 feet to 5,461 feet during drilling operations. The bedrock generally consisted of very hard claystone. Very hard clayey sandstone and siltstone bedrock layers were also noted in Boreholes BR-1 through BR-6. Bedrock was not noted to the maximum depths drilled (approximately 10 feet to 50 feet) at Boreholes PV-1, PV-2 and RW-1 through RW-4.

Groundwater

Groundwater was encountered in 11 boreholes at elevations ranging from 5,479 feet to 5,493 feet (approximate depths ranging from 14 feet to 37 feet below existing grades) during drilling operations. Groundwater was not encountered to the maximum depths drilled (approximately 10 feet below existing grades) at Boreholes PV-1 and PV-2.

A summary of the bedrock and groundwater elevations encountered is presented in Table 2. The approximate groundwater and bedrock elevations are rounded to the nearest one-half foot and are based on the depth to groundwater and bedrock noted during drilling and sampling operations and the ground surface elevations provided by the project surveyor.

Based on the groundwater elevations presented in Table 2, there appears to be a decreasing gradient predominately to the east. Based on the bedrock elevations presented in Table 2, the bedrock surface elevation appears to be decreasing in the northeast direction.

Table 2 – Approximate Groundwater and Bedrock Elevations

Borehole	Ground Elevation (feet)	Groundwater Elevation (feet)	Bedrock Elevation (feet) Note 1
BR-1	5,520.8	5,487	5,459
BR-2	5,521.3	5,486	5,458
BR-3	5,501.2	5,485	5,458
BR-4	5497.8	5,483.5	5,455
BR-5	5,520.4	5,483	5,455
BR-6	5,501.1	5,483	5,460
RW-1	5,514.0	5,493	Not Encountered
RW-2	5,518.9	5,490	Not Encountered
RW-3	5,504.8	5,491	Not Encountered
RW-4	5,516.4	5,479	Not Encountered
RW-5	5,499.5	5,479.5	5,461

Expansive Soil Discussion

Swell potential in the subgrade soils obtained within the upper 5 feet below existing and proposed pavement grades ranged from 0.0 percent (swell) to 1.8 percent (swell), when tested with a 200 pound per square foot (psf) surcharge, with the average swell less than 1 percent.

Swell potentials ranging from -1.0 percent (consolidation) to 3.0 percent (swell) were obtained in subgrade soils deeper than 5 feet in the boreholes used for pavement recommendations and in Boreholes in areas where no new pavement is anticipated. For pavement recommendations swell potentials from tests in the upper 5 feet below existing and proposed pavement grades where new pavement is anticipated were used.

Based on the swell test data, the pavement subgrade soils appear to possess a low swell potential and low consolidation potential. Special earthwork requirements for mitigation of expansive soils are not considered necessary for this project. New embankment material placed for this project shall meet requirements of Section 203 (Excavation and Embankment) of the CDOT Standard Specifications for Road and Bridge Construction, dated 2011, with a minimum R-Value of 5 and a swell percentage less than 1 percent when tested with a 200-psf surcharge.

A summary of laboratory test results is presented in Appendix C.

Sulfate Exposure Category

Cementitious material requirements for concrete in contact with site soils or groundwater are based on the percentage of water soluble sulfate in either soil or groundwater that will be in contact with concrete constructed for this project. Mix design requirements for concrete exposed to water soluble sulfates in soils or water is considered by Colorado Department of Transportation (CDOT) as shown in Table 3 and in the Standard Specifications for Road and Bridge Construction, dated 2011 (CDOT Table 601-2).

Table 3
Requirements to Protect Against Damage to Concrete by Sulfate Attack from External Sources of Sulfate

Severity of sulfate exposure	Water-soluble sulfate (SO_4), in dry soil, percent	Sulfate (SO_4), in water, ppm	Water Cementitious Ratio, maximum	Cementitious Material Requirements
Class 0	0.00 to 0.10	0 to 150	0.45	Class 0
Class 1	0.11 to 0.20	151 to 1,500	0.45	Class 1
Class 2	0.21 to 2.0	1,500 to 10,000	0.45	Class 2
Class 3	2.01 or greater	10,001 or greater	0.40	Class 3

The concentration of water soluble sulfates measured in 21 soil samples obtained from RockSol's exploratory boreholes was less than 0.1 percent by weight. Based on the results of the water soluble sulfate testing, Exposure Class 0 is considered appropriate for concrete in contact with subgrade materials for the project.

Subgrade Support Testing

R-Value tests were performed on a sample of A-7-6 soil from Borehole PV-1 and on a sample of A-6 soil from Borehole PV-2. A summary of the R-Value test results is shown in Table 4. All samples tested were obtained within the upper 10 feet of the existing ground surface.

Table 4
Subgrade Soil R-Value Test Summary

Borehole	Approximate Location	AASHTO Classification	R-Value
PV-1	WB US 6, Station 104+30, Lane 3	A-7-6 (8)	5
PV-2	EB US 6, Station 118+45, Outside Shoulder	A-6 (19)	4

Based on the results of the R-Value testing and subgrade soil classification testing, RockSol considers a subgrade support R-Value of 5 appropriate for pavement design purposes.

Pavement Thickness Recommendations (New Construction – 20/30 Year Design Life)

18 Kip equivalent single axle loads (ESALs) for US 6 within the project limits and US 6 Eastbound off-ramp at Garrison Street were provided to RockSol by CH2M HILL. The average daily traffic for mainline US 6 was taken from the CDOT OTIS system and included 2012 (current) data, forecast data for the year 2035, and data for the year 2045 estimated by linear extrapolation. Percent trucks accounted for approximately 3.1 percent to 3.2 percent of the traffic volume with single unit trucks accounting for approximately 1.7 percent to 1.9 percent and combination trucks accounting for approximately 1.4 percent and 1.3 percent respectively. A summary of the traffic data used to develop the design life ESAL's for this project is included in Appendix D.

Design life ESAL's are based on a project completion year of 2015. For new construction a design life of twenty years was used for flexible pavement. A design life of thirty years was used for rigid pavement.

Pavement thicknesses were calculated using the AASHTO Pavement Design and Analysis System (DARWin) and the NCHRP rigid pavement design supplemental spreadsheet software, based on the 1998 AASHTO Supplemental Guide for rigid pavement. Structural coefficients of 0.15 and 0.44 were used for CDOT Class 6 aggregate base course and HMA, respectively, when developing flexible pavement thickness recommendations. Elastic modulus values of 25,000 psi and 3,400,000 psi were used for CDOT Class 6 aggregate base course and PCC,

respectively, when developing rigid pavement thickness recommendations. A Reliability Level of 95 percent was used.

All permanent (20/30 year design life) pavement thicknesses presented are to be placed on top of 6 inches of CDOT Class 6 Aggregate Base Course (ABC) since the design life ESAL values are greater than 500,000.

Pavement thickness recommendations for mainline US 6 and the Eastbound US 6 off-ramp at Garrison Street are presented in Table 5A.

Table 5A – Pavement Thickness Recommendations (New Construction)

Roadway	Pavement Type	Design Life (years)	Structural Number (in)	Design Lane 18k ESALs	Recommended Pavement Thickness (Note 1)
					Subgrade R-Value = 5
US 6 West of Garrison Street	Flexible	20	6.13	5,900,000	12.0 inches HMA over 6.0 inches ABC
	Rigid	30	-	13,500,000	11.0 PCC over 6.0 inches ABC
US 6 East of Garrison Street	Flexible	20	6.06	5,400,000	12.0 HMA over 6.0 inches ABC
	Rigid	30	-	12,400,000	10.5 PCC over 6.0 inches ABC
Eastbound Off-Ramp at Garrison Street	Flexible	20	5.11	1,500,000	10.0 HMA over 6.0 inches ABC
	Rigid	30	-	3,300,000	9.0 PCC over 6.0 inches ABC

Note 1) HMA = Hot Mix Asphalt, ABC = Aggregate Base Course, PCC = Portland Cement Concrete

The recommended flexible pavement thickness values presented in Table 5A are rounded up to the nearest ½-inch, per CDOT methodology. Recommended pavement thickness values for rigid pavement shown in Table 5A include a ¼-inch thickness added to the calculated thickness and then rounded up to the nearest ½-inch, per CDOT methodology. Pavement thickness calculation sheets for the pavement sections shown in Table 5A are included in Appendix E.

All flexible pavements will be Hot Mix Asphalt (HMA) using CDOT approved mix designs. RockSol recommends using Grade SX or SMA mix for the surface layer and Grade S mix for the lower (intermediate and base) layers. A gyratory design revolution (Ndes) of 100 is recommended. Performance Grade Binder of PG 76-28 is recommended for the surface layer (Grade SX or SMA mix). Performance Grade Binder of PG 64-22 is recommended for the intermediate and base layers (Grade S mix). A summary of the recommended pavement lift sections is presented in Tables 5B and 5C. Pavement design parameter sheets are presented in Appendix F.

Table 5B – Recommended Flexible Pavement Lift Summary (US 6 EB and WB)

Lift Description	Lift Thickness (inches)	Grading	Binder
Top Lift	2	SX or SMA	PG 76-28
Intermediate Lift 3	2.25	S	PG 64-22
Intermediate Lift 2	2.25	S	PG 64-22
Intermediate Lift 1	2.5	s	PG 64-22
Bottom Lift	3.0	S	PG 64-22

Table 5C – Recommended Flexible Pavement Lift Summary (US 6 EB Off-Ramp)

Lift Description	Lift Thickness (inches)	Grading	Binder
Top Lift	2	SX or SMA	PG 76-28
Intermediate Lift 2	2.5	S	PG 64-22
Intermediate Lift 1	2.5	s	PG 64-22
Bottom Lift	3.0	S	PG 64-22

The contractor may choose alternative layer thicknesses to those shown in Tables 5B and 5C, however, the layer thicknesses must conform to the minimum and maximum layer thickness requirements presented in Table 3.7 of the 2014 CDOT Pavement Design Manual, or the Manual designated at the time of bidding.

US 6 Detour Pavement Section Thickness Recommendations

Temporary detours will be required for Eastbound US 6 traffic while the bridge structure over Garrison is constructed. RockSol understands that the detours may be required for 6 months to 18 months and that flexible pavement will be used. ESAL values for 6, 9, 12, and 18 month detours were used to determine required pavement thicknesses for those time frames, based on 2012 ADT data obtained for US 6 from the CDOT OTIS site and projected to the year 2015. The 2012 ADT values for the section of US 6 within the project limits were 100,000 vehicles per day (both directions with 1.7 percent single unit trucks and 1.4 percent combination trucks.

Detour pavements were calculated utilizing a subgrade with an effective R-value of 5 for the existing condition. A summary of the recommended flexible pavement sections for detours of 6, 9, 12, and 18 months are presented in Table 6.

Table 6 – Minimum Detour Pavement Thickness

Roadway	Pavement Type	Design Life (months)	Design Lane 18k ESALs	Structural Number (in)	Minimum Pavement Thickness (Note 1) Subgrade R-Value = 5
Temporary Pavement US 6 EB Lanes	Flexible	6	160,000		6.5 inches HMA over 6.0 inches ABC
		9	250,000		7 inches HMA over 6.0 inches ABC
		12	325,000		7.5 inches HMA over 6.0 inches ABC
		18	485,000		8 inches HMA over 6.0 inches ABC
		6	160,000	3.71	7.25 inches HMA over 4.0 inches ABC
		9	250,000	3.96	7.75 inches HMA over 4.0 inches ABC
		12	325,000	4.12	8.0 inches HMA over 4.0 inches ABC
		18	485,000	4.37	8.75 inches HMA over 4.0 inches ABC

Note 1) HMA = Hot Mix Asphalt, ABC = Aggregate Base Course, PCC = Portland Cement Concrete

Pavement thickness calculation sheets for the detour pavement sections shown in Table 6 are presented in Appendix E. Pavement design parameter sheets for the detour pavement sections are included in Appendix F.

Subgrade Preparation (New Pavement)

For all new pavement areas, proof rolling with pneumatic tire equipment shall be performed using a minimum axle load of 18 kips per axle after specified subgrade compaction has been obtained. Areas found to be weak and those areas which exhibit soft spots, non-uniform deflection or excessive deflection as determined by the project engineer shall be ripped, scarified, wetted or dried if necessary, and re-compacted to the requirements for density and moisture. Complete coverage of the proof roller will be required.

All pavement subgrade preparation, pavement materials, and pavement construction shall conform to CDOT Standard Specifications for Road and Bridge Construction (2011). At a minimum, subgrade moisture conditioning and compaction should meet the compaction specifications outlined in Table 7.

Table 7 –Compaction Specifications

AASHTO Classification	Minimum Relative Compaction (Percentage of MDD), %	Moisture Content (Deviation from OMC)
A-1, A-2-4, A-2-5, A-3,	95% of AASHTO T99	-2 to +2
A-2-6, A-2-7, A-4, A-5 A-6 and A-7	95% of AASHTO T99	0 to +3

Based on swell test data, it is RockSol's opinion that moisture conditioning to a depth of 6 inches is appropriate for this project.

Limitations

This geotechnical investigation was conducted in general accordance with the scope of work. This report has been prepared for use by CH2M HILL and the Colorado Department of Transportation (CDOT) exclusively for the project described in this report. The report is based on information provided by CDOT, RockSol's observations, and exploratory boreholes and does not take into account variations in the subsurface conditions that may exist between boreholes. Additional investigation is required to address such variation. The nature and extent of subsurface variations across the project site may not become evident until the construction phase of the project and when excavations are performed.

The conclusions and recommendations submitted in this report are based upon the data obtained from the boreholes drilled at the locations indicated on the boring location sheets and our understanding of the proposed type of construction. If the proposed construction is different than described in this report, RockSol should be notified to re-evaluate, or supplement, the recommendations contained in this report. RockSol is not responsible for liability associated with interpretation of subsurface data by others.

Prepared by RockSol Consulting Group, Inc.:

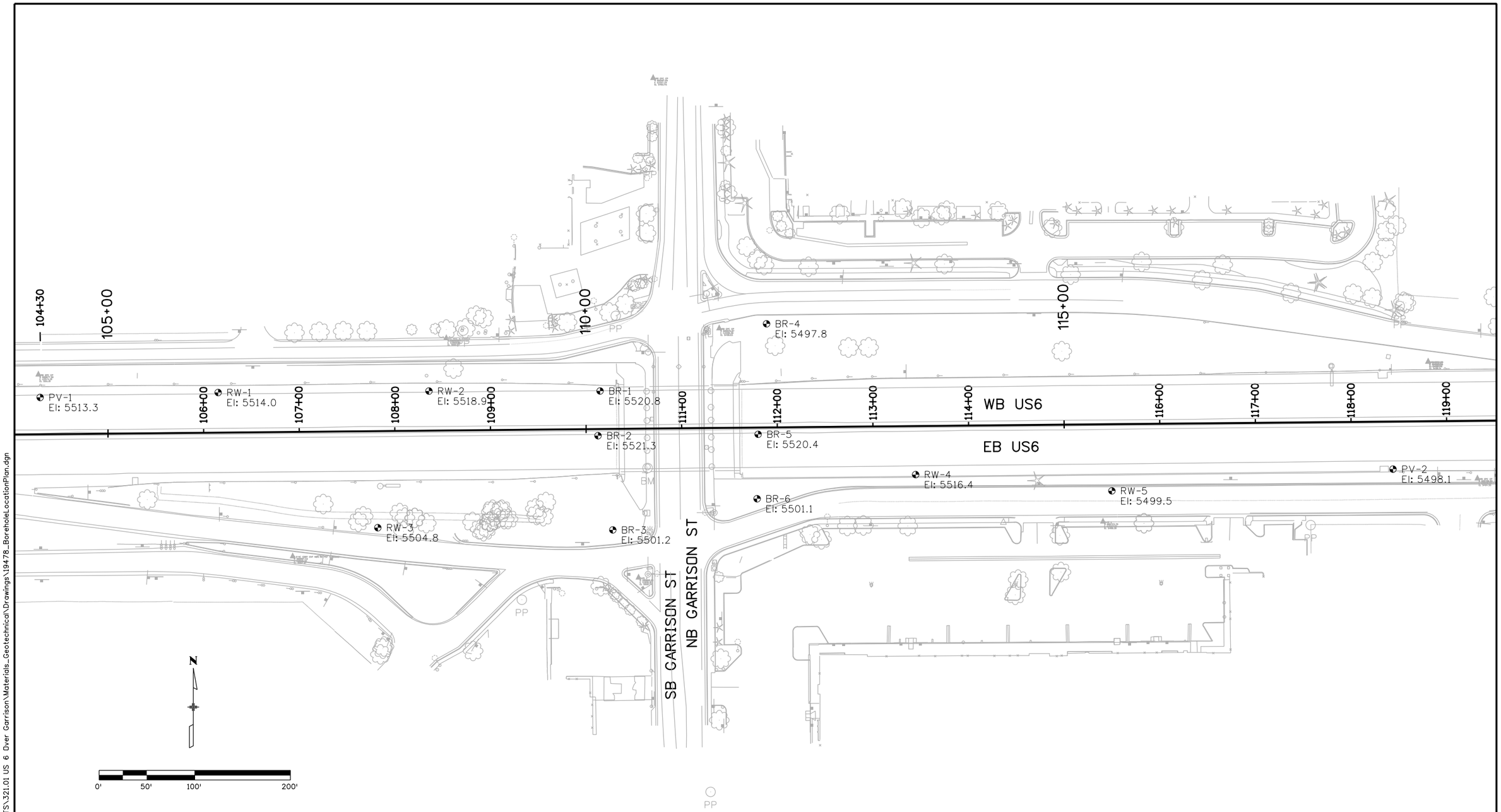
Jacob Biller, P.E.
Geotechnical Engineer

Donald G. Hunt, P.E.
Senior Geotechnical Engineer

Attachments:

Figure 1 - Site Vicinity Map
Figure 2 - Borehole Location Plan
Figures 2A – 2D: Engineering Geology Sheets

Appendix A – Legend and Individual Borehole Logs
Appendix B – Pavement Core Log Summary
Appendix C – Laboratory Test Results
Appendix D – Equivalent Single Axle Load Calculations (From CH2M HILL)
Appendix E – Flexible and Rigid Pavement Calculation Sheets (DARWin/AASHTO 98)
Appendix F – Pavement Design Parameter Sheets (New Construction and Detour)



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RockSol Project No. 321.01	Unit Leader _		

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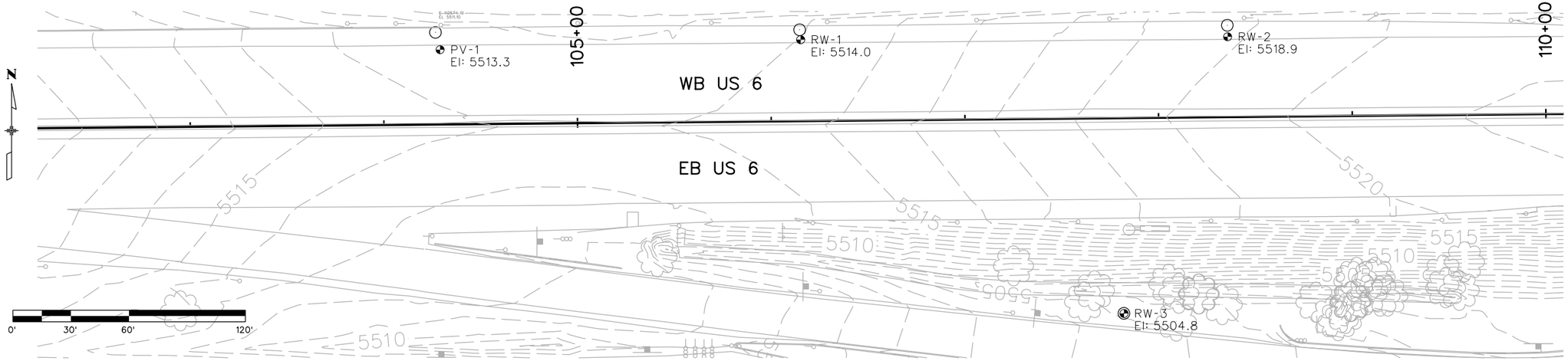
US 6 OVER GARRISON STREET
BOREHOLE LOCATION PLAN

Designer: R. LEPRO
Detailer: S. MCKANNA-KOON
Sheet Subset:
Structure Numbers
Subset Sheets: of

Project No./Code
19478
Figure 2

WORK IN PROGRESS



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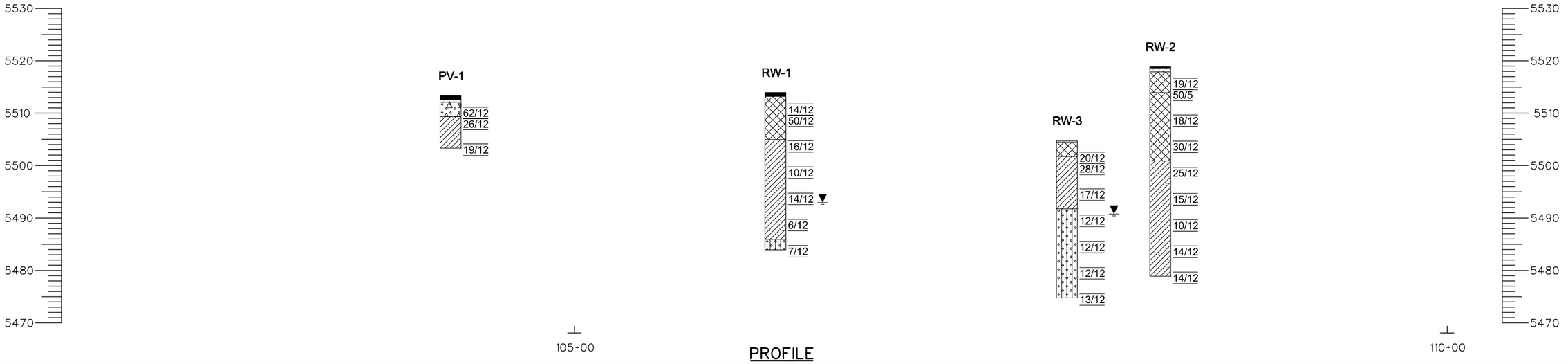


PROFILE

SUMMARY OF TEST RESULTS

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
PV-1	1.25-10	46	24	48	SC	A-7-6 (8)			0.00
PV-1	2						6.0	119.9	
PV-1	4						22.4	99.5	
PV-1	9						30.1	89.5	
RW-1	2						20.6	106.2	
RW-1	4						3.0	138.1	
RW-1	9						25.4	97.7	
RW-1	14						26.0	96.5	0.00
RW-1	19						29.1	92.3	
RW-1	24						37.4	85.1	
RW-1	29						30.2	90.3	
RW-2	1-5	38	18	44	SC	A-6 (4)			0.01
RW-2	2						18.6	108.9	
RW-2	4						17.3	110.7	
RW-2	9	31	16	30	SC	A-2-6 (1)	11.4	111.6	

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
RW-2	14						14.5	111.9	0.01
RW-2	19	47	27	76	CL	A-7-6 (20)	20.4	105.4	
RW-2	24						17.9	105.4	
RW-2	29						22.9	103.2	
RW-2	39						24.6	99.7	
RW-3	0-10	43	23	54	CL	A-7-6 (9)			0.00
RW-3	2	NP	NP	47	SM	A-4 (0)	10.1	117.8	0.00
RW-3	4						19.7	108.8	
RW-3	9						18.7	107.2	
RW-3	14	40	17	38	SC	A-6 (2)	25.9	97.7	
RW-3	19						27.3	97.2	
RW-3	24						30.7	96.0	

TYPE OF MATERIAL

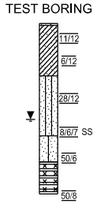
LITHOLOGY

- Asphalt Pavement
- Concrete
- Fill - CLAY
- Fill - SAND
- Native - TOPSOIL
- Native - SAND, silty
- Native - SAND, gravelly
- Native - SAND, clayey
- Native - CLAY
- Native - CLAY, sandy
- Native - SILT, sandy
- Bedrock - CLAYSTONE
- Bedrock - Interbedded SILTSTONE/CLAYSTONE
- Bedrock - SANDSTONE

SEE INDIVIDUAL LOG SHEETS FOR ADDITIONAL DESCRIPTION OF MATERIAL ENCOUNTERED

LEGEND

TEST BORING



B Bridge Borehole

Ground Water Level At Time of Drilling

3/12 9 Blows for 12 Inches

50/3 50 Blows for 3 Inches

8/6/7 SS Split Spoon Sampler
Required 8 Blows for 6 Inches
Required 6 Blows for 6 Inches
Required 7 Blows for 6 Inches

BORING ID NOTED AT THE TOP OF LOG
BLOW COUNTS OBTAINED WITH SPLIT SPOON SAMPLERS ARE NOTED WITH "SS". ALL OTHER BLOW COUNTS OBTAINED WITH A MODIFIED CALIFORNIA BARREL SAMPLER
SEE INDIVIDUAL LOG SHEETS FOR MORE DETAIL

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US 6 OVER GARRISON STREET
ENGINEERING GEOLOGY

Designer: J. Biller
Detailer: S. McKanna-Koon
Sheet Subset:
Structure Numbers
Subset Sheets: of

Project No./Code
19478
Figure 2A

WORK IN PROGRESS

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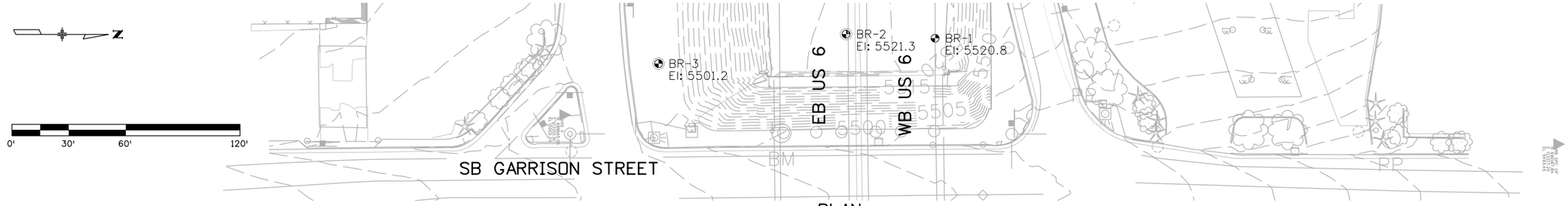

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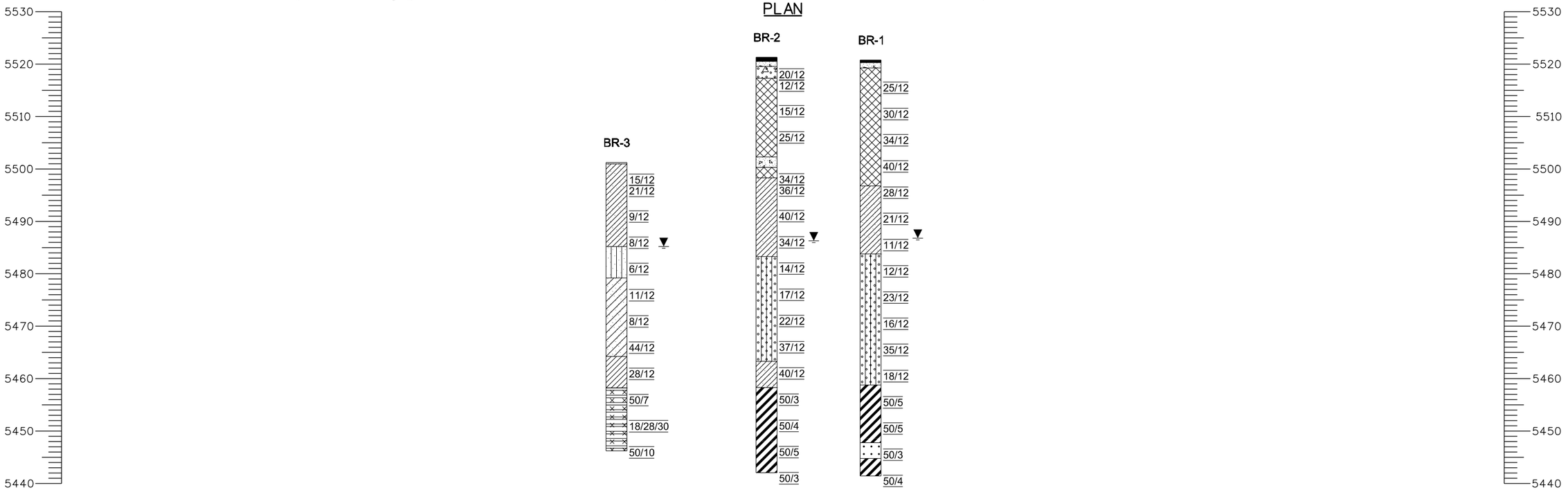


PROFILE

SUMMARY OF TEST RESULTS

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
BR-1	4						21.4	104.8	
BR-1	9	32	17	59	CL	A-6 (7)	18.1	108.5	
BR-1	14						19.1	109.8	
BR-1	19						21.8	101.7	0.00
BR-1	24						24.1	99.9	
BR-1	29	52	28	70	CH	A-7-6 (19)	25.9	97.6	
BR-1	34						31.2	91.5	
BR-1	44						25.5	100.8	
BR-1	54						31.3	91.0	
BR-1	59						21.5	109.5	
BR-1	69						33.2	86.7	
BR-1	74						21.0	102.9	
BR-1	79						20.9	107.7	
BR-2	1.4-10	40	21	48	SC	A-6 (6)			0.02
BR-2	2						15.4	103.2	
BR-2	4						24.9	98.2	
BR-2	9						23.9	97.0	
BR-2	14						19.6	109.9	
BR-2	21						24.7	99.0	
BR-2	24						20.6	104.8	
BR-2	29						19.2	109.3	
BR-2	34	38	20	56	CL	A-6 (8)	22.3	104.9	
BR-2	39						31.3	90.0	
BR-2	44						31.8	90.6	
BR-2	49						30.7	91.9	
BR-2	54	40	18	48	SC	A-6 (5)	25.8	97.8	
BR-2	59						21.0	106.9	
BR-2	64	46	22	52	CL	A-7-6 (8)	24.6	96.6	
BR-2	69						26.2	93.8	
BR-2	79						22.7	100.4	
BR-3	1.9-14	40	15	64	CL	A-6 (8)			0.00
BR-3	2						15.3	110.3	
BR-3	4						14.6	117.2	
BR-3	9						16.4	108.4	
BR-3	14						28.6	94.2	
BR-3	19	32	3	54	ML	A-4 (0)	33.1	90.9	
BR-3	24						27.3	97.6	
BR-3	34						25.5	102.1	
BR-3	39						29.8	93.4	0.01
BR-3	44						28.1	98.1	
BR-3	49	59	22	92	MH	A-7-5 (26)	31.5		0.01
BR-3	54						25.3	97.0	

TYPE OF MATERIAL

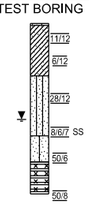
LITHOLOGY

- Asphalt Pavement
- Concrete
- Fill - CLAY
- Fill - SAND
- Native - TOPSOIL
- Native - SAND, silty
- Native - SAND, gravelly
- Native - SAND, clayey
- Native - CLAY
- Native - CLAY, sandy
- Native - SILT, sandy
- Bedrock - CLAYSTONE
- Bedrock - Interbedded SILTSTONE/CLAYSTONE
- Bedrock - SANDSTONE

SEE INDIVIDUAL LOG SHEETS FOR ADDITIONAL DESCRIPTION OF MATERIAL ENCOUNTERED

LEGEND

TEST BORING



- B — Bridge Borehole
- Ground Water Level At Time of Drilling
- 3/12 — 9 Blows for 12 Inches
- 50/3 — 50 Blows for 3 Inches
- 8/6?? SS — Split Spoon Sampler Required 8 Blows for 6 Inches Required 6 Blows for 6 Inches Required 7 Blows for 6 Inches

BORING ID NOTED AT THE TOP OF LOG
BLOW COUNTS OBTAINED WITH SPLIT SPOON SAMPLERS ARE NOTED WITH "SS". ALL OTHER BLOW COUNTS OBTAINED WITH A MODIFIED CALIFORNIA BARREL SAMPLER
SEE INDIVIDUAL LOG SHEETS FOR MORE DETAIL

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US 6 OVER GARRISON STREET
ENGINEERING GEOLOGY

Designer: J. Biller
Detailer: S. McKanna-Koon
Sheet Subset:
Structure Numbers
Subset Sheets: of

Project No./Code
19478
Figure 2B

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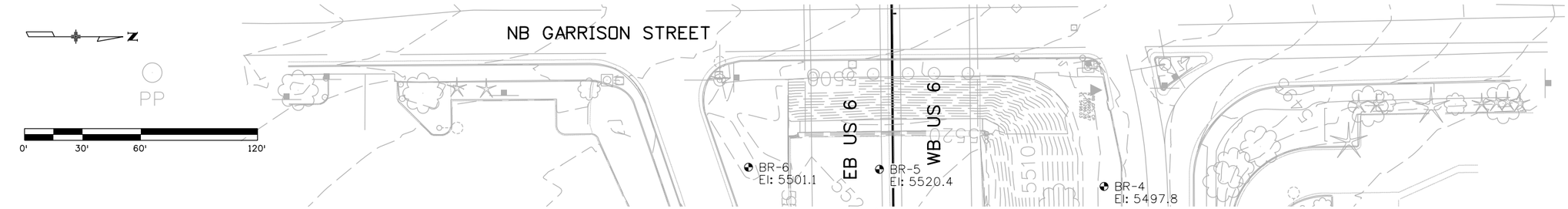

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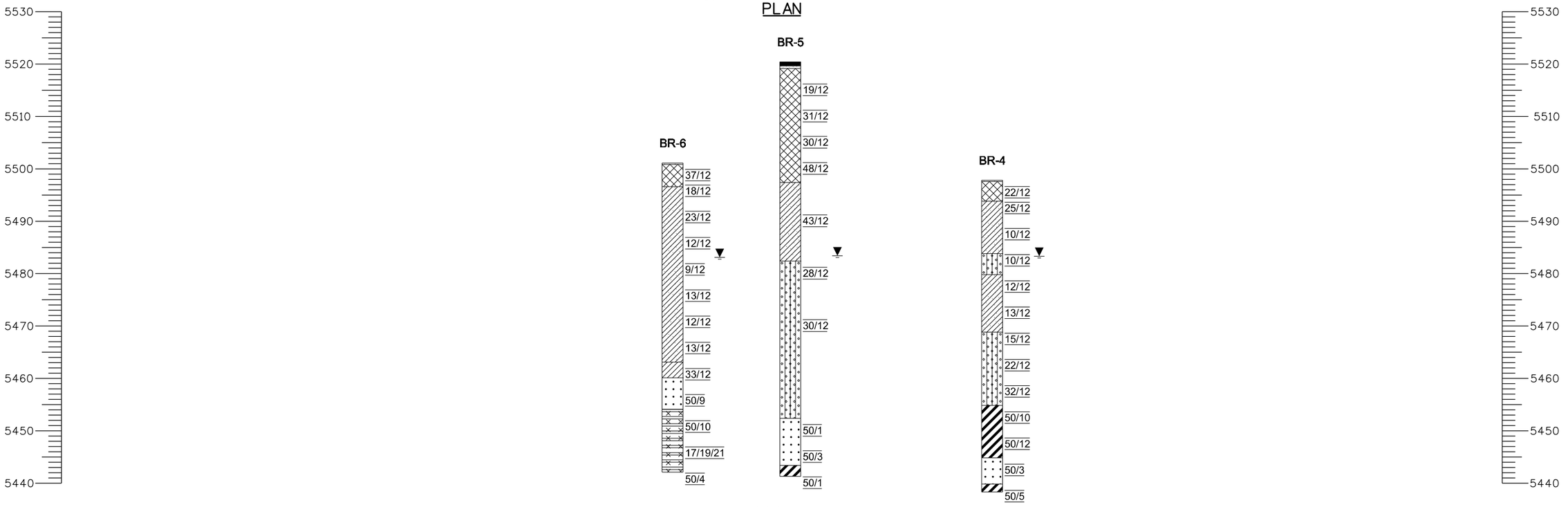


PROFILE

SUMMARY OF TEST RESULTS

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
BR-4	0-10	46	24	66	CL	A-7-6 (14)			0.02
BR-4	2						13.6	91.8	
BR-4	4						19.8	108.2	0.00
BR-4	9						21.5	100.7	
BR-4	14	39	14	44	SC	A-6 (3)	30.1	98.0	
BR-4	19						29.0	96.9	
BR-4	24						35.6	88.1	
BR-4	29	41	18	47	SC	A-7-6 (5)	29.6	95.6	
BR-4	34						24.0	104.1	
BR-4	39	26	2	20	SM	A-1-b (0)	19.9	110.1	
BR-4	44						22.1	108.8	
BR-4	49	61	32	98	CH	A-7-6 (37)	30.7	92.0	0.01
BR-4	54						22.6	103.1	
BR-4	59						18.2	108.1	
BR-4	74						26.9	96.5	

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
BR-5	1,25-10	46	27	52	CL	A-7-6 (10)			0.01
BR-5	4						26.7	97.3	
BR-5	9						22.6	103.5	
BR-5	~20								
BR-5	10-20	52	30	60	CH	A-7-6 (16)			0.01
BR-5	14						20.0	107.2	
BR-5	19						17.8	111.1	
BR-5	29						17.0	113.7	
BR-5	49						26.3	97.2	
BR-5	74						26.9	96.5	
BR-6	2	NP		14	SM	A-1-a (0)	3.2	132.6	
BR-6	4						19.2	109.5	0.01
BR-6	9						21.7	103.8	
BR-6	14						24.8	99.8	
BR-6	19						25.1	100.9	

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
BR-6	24						29.9	94.5	
BR-6	29						29.8	91.7	
BR-6	34						27.7	96.2	0.02
BR-6	39						28.4	94.9	
BR-6	44						21.0	106.0	
BR-6	49						25.4	94.0	
BR-6	54	60	21	93	MH	A-7-5 (26)	34.9		

TYPE OF MATERIAL

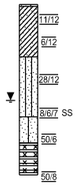
LITHOLOGY

- Asphalt Pavement
- Fill - CLAY
- Native - TOPSOIL
- Native - SAND, gravelly
- Native - CLAY
- Native - SILT, sandy
- Bedrock - Interbedded SILTSTONE/CLAYSTONE
- Concrete
- Fill - SAND
- Native - SAND, silty
- Native - SAND, clayey
- Native - CLAY, sandy
- Bedrock - CLAYSTONE
- Bedrock - SANDSTONE

SEE INDIVIDUAL LOG SHEETS FOR ADDITIONAL DESCRIPTION OF MATERIAL ENCOUNTERED

LEGEND

TEST BORING



- B — Bridge Borehole
- Ground Water Level At Time of Drilling
- 9/12 — 9 Blows for 12 Inches
- 50/3 — 50 Blows for 3 Inches
- 8/6/7 SS — Split Spoon Sampler Required 8 Blows for 6 Inches Required 6 Blows for 6 Inches Required 7 Blows for 6 Inches

BORING ID NOTED AT THE TOP OF LOG
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SEE INDIVIDUAL LOG SHEETS FOR MORE DETAIL

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No Revisions:
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US 6 OVER GARRISON STREET
ENGINEERING GEOLOGY

Designer: J. Biller
Detailer: S. McKanna-Koon
Sheet Subset:
Structure Numbers
Subset Sheets: of

Project No./Code
19478
Figure 2C

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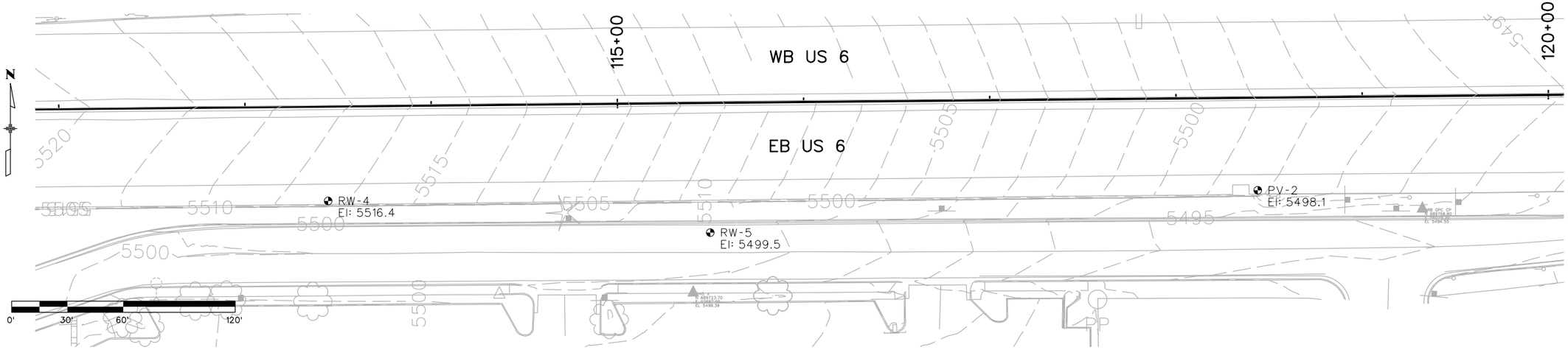

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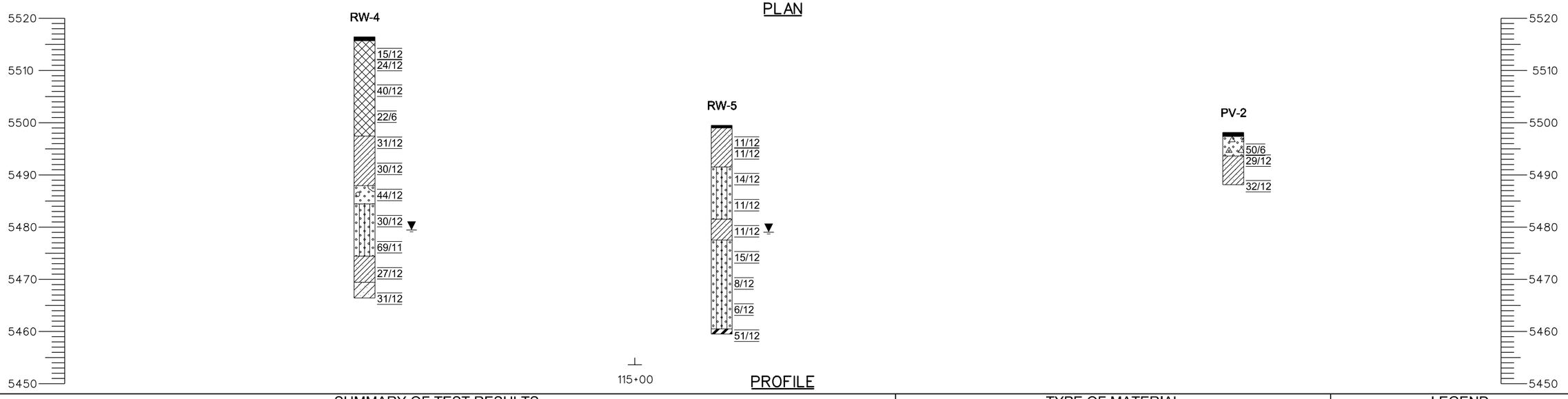

PROFILE

SUMMARY OF TEST RESULTS

Sample ID	Depth (ft)	Liquid Limit	Plasticity Index	%< #200 Sieve	Classification USCS	Classification AASHTO	Water Content (%)	Dry Density (%)	Sulfate (%)
RW-4	2						17.8	112.7	
RW-4	4	37	18	49	SC	A-6 (5)	19.6	107.5	
RW-4	9						9.4	112.6	
RW-4	14						18.6	100.7	
RW-4	19	34	9	27	SM	A-2-4 (0)	16.0	110.0	
RW-4	24						17.7	106.6	0.00
RW-4	29						7.7	116.5	
RW-4	34						28.4	95.8	
RW-4	24						17.7	106.6	0.00
RW-4	29						7.7	116.5	
RW-4	34						28.4	95.8	
RW-4	39						29.1	98.4	
RW-4	44						30.8	89.5	
RW-4	49						31.9	90.7	
RW-5	2						27.9	96.8	
RW-5	4						19.2	104.3	0.00
RW-5	9	36	8	54	ML	A-4 (3)	15.5	104.9	
RW-5	14						21.8	99.9	
RW-5	19						19.0	109.5	
RW-5	39						26.3	100.6	
PV-2	0.75-5	38	22	87	CL	A-6 (19)			0.00
PV-2	2						5.7	125.2	
PV-2	4						23.4	102.0	
PV-2	9						22.5	10.1	

TYPE OF MATERIAL

LITHOLOGY

- Asphalt Pavement
- Concrete
- Fill - CLAY
- Fill - SAND
- Native - TOPSOIL
- Native - SAND, silty
- Native - SAND, gravelly
- Native - SAND, clayey
- Native - CLAY
- Native - CLAY, sandy
- Native - SILT, sandy
- Bedrock - CLAYSTONE
- Bedrock - Interbedded SILTSTONE/CLAYSTONE
- Bedrock - SANDSTONE

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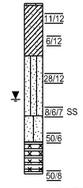
LEGEND

TEST BORING



- B — Bridge Borehole
- Ground Water Level At Time of Drilling
- 3/12 — 9 Blows for 12 Inches
- 50/3 — 50 Blows for 3 Inches
- 8/6/7 SS — Split Spoon Sampler Required 8 Blows for 6 Inches Required 6 Blows for 6 Inches Required 7 Blows for 6 Inches

BORING ID NOTED AT THE TOP OF LOG
BLOW COUNTS OBTAINED WITH SPLIT SPOON SAMPLERS ARE NOTED WITH "SS". ALL OTHER BLOW COUNTS OBTAINED WITH A MODIFIED CALIFORNIA BARREL SAMPLER
SEE INDIVIDUAL LOG SHEETS FOR MORE DETAIL

Print Date: 11/13/2013
File Name: 19478_Engineering_Geology_East_US6.dgn
Horiz. Scale: As Noted Vert. Scale: As Noted
RockSol Project No. 321.01 Unit Leader Initials

RockSol Consulting Group, Inc.
6510 W 91st Ave, Ste 130
Westminster, CO 80031
Ph: 303-962-9300
Fax: 303-962-9350

R-X

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
425 B Corporate Circle
Golden, CO 80401
Phone: 720-497-6954 FAX: 720-497-6951
Region 1 KPB

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER GARRISON STREET
ENGINEERING GEOLOGY

Designer: J. Biller
Detailer: S. McKanna-Koon
Sheet Subset:
Structure Numbers
Subset Sheets: of

Project No./Code
19478
Figure 2D

WORK IN PROGRESS

mckanna-koon 10:35:08 PM M:\PROJECTS\321.01 US 6 Over Garrison\Materials_Geotechnical\Drawings\19478_Engineering_Geology_East_US6.dgn

CDOT PIPE MATERIAL SELECTION POLICY

Implementation

The CDOT Pipe Material Selection Policy has been developed by the Project Development Branch for approval by the Chief Engineer

These Procedures for Pipe Material Selection supersede and replace all previous procedures, guidelines, and policies regarding the selection of pipe materials used by CDOT.

These procedures also replace the CDOT Chief Engineer memo dated February 8, 1984, *Pipe to be Used in Storm Drains*

The Colorado Department of Transportation will adopt the content of this policy:

Recommended for Approval

Scott McDaniel 8/13/2013

Scott McDaniel, Director of Staff Services Date

Tim Harris 9/9/13

Tim Harris, Chief Engineer Date

CDOT PIPE MATERIAL SELECTION POLICY

Introduction

This policy was originally developed to comply with the provisions of the Final Rule published in 23 CFR 635.411 (b) published in the Federal Register on November 15, 2006. On July 6, 2012 the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law, with the passage MAP-21 the federal requirement for this policy was nullified. The Colorado Department of Transportation (CDOT) has determined the additional performance criteria outlined in the original policy is beneficial to the state. Therefore this revised policy retains much of the original policy and is to be incorporated into all CDOT design projects. CDOT will follow its standard practices for the hydraulic and structural design of pipes. This policy replaces all previous policies regarding the selection of pipe material for Storm Drains, Cross Drains, and Side Drains. Under this policy, PMs will select the allowable pipe material options for each installation on a specific project. The Contractor will choose the final pipe material from the list of options provided in the Contract and as specified in applicable sections of the CDOT *Standard Specifications for Road and Bridge Construction.* Any pipe that meets the corrosion and abrasion criteria in this policy and is installed per the plans and specifications is assumed to have a 50-year service life.

Selection Considerations

CDOT will evaluate the risk associated with the performance of the pipe materials. Risk will be considered to the extent that it is influenced by the pipe, other materials, or installation techniques as they are used in construction. Project design and material selection are based on balancing engineering requirements with budget constraints.

The CDOT Pipe Material Selection Policy identifies the specific engineering and performance criteria used to evaluate the acceptability of alternative pipe materials. CDOT will allow alternative pipe materials where appropriate. A record of the determination of abrasion and corrosion levels will be documented and maintained in the project design files.

Subsurface Drains and Embankment Protector Type 3 (M-Standard 615) are not covered by this policy.

Definitions

Cross Drain –Pipes or culverts that convey flows from one side of the road to the other, and are typically open on each end. Also known as a Cross Culvert.

Side Drain – A pipe or culvert which is typically parallel to the roadway and under a driveway or a road approach to the mainline roadway.

Storm Drain – A network of pipes that connects inlets, manholes, and other drainage features to an outfall.

Subsurface Drain – A network of piping used to collect ground water, or relieve water pressure from a wall or structure, and transport it to a location where it will not harm the roadway features, or where it can be conveyed by another system, often a storm sewer. A common example is a French Drain.

Type III Embankment Protector – See M-Standard 615-1

Durability - A pipe or culverts ability to resist wear and tear or decay. Although structural condition is a very important element in the performance of pipes, durability problems are a common cause for replacement. Pipes are more likely to "wear away" than fail structurally. Durability is affected by two mechanisms: corrosion and abrasion. Each is discussed in the following sections.

CDOT PIPE MATERIAL SELECTION POLICY

Corrosion – Corrosion is the deterioration of material due to chemical or electrochemical reaction with the environment. Corrosion of pipe materials may occur in many different types of soils and waters. Corrosive soils and waters may contain acids, alkalis, dissolved salts, organics, industrial wastes or chemicals, mine drainage, sanitary effluents, and dissolved or free gases. Pipe corrosion is generally related to water and the chemicals that have reacted to, become dissolved in, or been transported by the water.

Abrasion – Abrasion is the process of wearing down or grinding away the surface material of pipes, as water laden with sand, gravel, or stones flow through a pipe. Abrasive forces increase as the velocity of the water flowing through a pipe increases.

Alternative Materials – Alternative materials are the various pipe materials that will meet the project requirements. The alternative materials will be identified in the Contract, and the Contractor may select any one of them for use on the project.

Selection Process/Responsibility – All decisions regarding pipe material type will be based on engineering practices and judgments. The Project Manager (PM) is responsible for all aspects of the design of the project and for ensuring timely completion of tasks associated with project advertisement. The PM will schedule work associated with this procedure to ensure compliance with the project schedule. The PM will consider such factors as durability, environmental considerations, soil conditions, fill heights, need for water tight joints, slopes of inverts, hydraulic characteristics of pipe material inside surfaces, and other factors relevant to the project and or specific pipe location.

The PM will specify on the plans or in the special provisions when water tight joints are required. Siphons, irrigation systems, and storm drain systems require water tight joints.

Pipe extensions of existing pipes or systems shall be completed using similar material and sizes. Exceptions to this may be made when conditions and engineering justifications merit otherwise.

Local agencies and other organizations that will own and maintain the new pipe should be consulted for guidance on pipe material type selection. Only pipe material types that have been evaluated and approved for use by CDOT shall be used. In the event a local agency or organization will own and maintain the new pipe and the guidance provided differs from this policy, the guidance from the local agency or organization shall govern.

In some cases the results of the material type section process may produce alternative materials types in differing pipe diameters. In such cases the PM may specify the appropriate diameter for each material type or specify only the larger pipe diameter in the plans. When a specific manning's "n" value is critical to the pipe's performance, the maximum/minimum value shall be shown on the plans. If the larger diameter will not meet the minimum cover requirements, or the material will not meet the Manning's "n" value range. That material type shall be disqualified at those location(s). Any Material type disqualified at a location during design should be stated as such on the plans.

Step I: Determine Application – The PM will use the latest version of CDOT's *Drainage Design Manual* and CDOT's *Project Development Manual.* The pipe selection process begins when the PM determines the location of the new pipe. The PM will then determine and document the specific use of the pipe:

- Cross Drain
- Side Drain
- Storm Drain

Step II: Determine Abrasion Level – An estimate of the potential for abrasion is required to determine acceptable pipe types and whether there is a need for invert protection. The PM shall select one of the following abrasion levels:

- Abrasion Level 1 – This level applies where the conditions are nonabrasive. Nonabrasive conditions exist in areas of no bed load and very low velocities. This is the level assumed for the soil side of drainage pipes. This is also the level assumed for the inverts of cross drains and side drains installed in typically dry drainages.
- Abrasion Level 2 – This level applies where low abrasive conditions exist. Low abrasive conditions exist in areas of minor bed loads of sand and velocities of 5 fps or less.
- Abrasion Level 3 – This level applies where moderately abrasive conditions exist. Moderately abrasive conditions exist in areas of moderate bed loads of sand and gravel and velocities between 5 fps and 15 fps.
- Abrasion Level 4 – This level applies where severely abrasive conditions exist. Severely abrasive conditions exist in areas of heavy bed loads of sand, gravel, and rock and velocities exceeding 15 fps.

Abrasion levels are intended to help the PM consider the impacts of bed-load wear on the invert of pipe materials. The PM will determine the expected level of abrasion through visual examination and documentation of the size of the materials in the stream bed and the average slope of the channel. In some case sampling of the streambed material may be required to assist the PM in determining the level of abrasion.

Where existing pipes are in place in the same drainage, the conditions of their inverts should be documented and used as guidance. The expected stream velocity should be based upon 2-year flow and less.

The PM will estimate and document the abrasive forces that will have an effect on the pipe material; and document the following items:

- Measure or calculate the velocity of the water based upon 2-year flow and less.
- Estimate the bed-loading as:
  - No bed load
  - Minor bed load – silt and sand
  - Moderate bed load – silt, sand, and gravel
  - Heavy bed load – silt, sand, gravel, and rock
- Determine whether the abrasion level is 1, 2, 3, or 4 as defined above.

Step III: Determine Corrosion Level – The station of each proposed pipe will be determined by the PM. The PM will schedule the soil and water testing to ensure compliance with the project advertisement date. Resistivity, PH and moisture levels will be determined in the field by the Region as these tests are most efficiently and effectively conducted at the time of sampling. The CDOT Materials and Geotechnical group is available to perform sulfate and chloride testing, however, the PM will schedule this work appropriately to avoid project delays. The Region should develop their ability to perform these simple tests in the Region to expedite project design. The resulting sample testing information will be used in flow charts (Figures 1 and 2) to select appropriate material.

The PM will document the following properties of the soil and water using the designated test procedure:

- Sulfate Levels - CPL 2103
- Chloride Levels - CPL 2104

- Resistivity - **ASTM G57**
- pH - **ASTM G51**
- Moisture Levels

This information will be obtained at all pipe locations supplied by the PM and documented in the project records by the PM. If the alluvium of the area is sufficiently homogeneous, a reduced sampling schedule will be acceptable. This determination should only be made with input from the Region Materials Engineers (or Staff Materials) and the Region Hydraulics Engineer.

Step IV: Selection of Pipe Material Type – Use the flowcharts in this document to identify acceptable pipe material types. Use Figure 1 to determine if metal pipe is an allowable material type, and then use, Table 2 to determine whether there are additional requirements for metal pipes.

Step V: Verify Fill Height – Check Fill Height tables in the Standard Plans. Determine if Project Special Provisions are required and/or if any other Standard Special Provisions are applicable.

Step VI: Address Exceptions to CDOT Pipe Materials Selection Policy – When sound engineering judgment justifies an exception to this policy, the PM shall document this in a justification letter. All justification letters shall be approved by the Region Program Engineer (PE III) or their designee prior to final design.

Step VII: Documentation – All design decisions regarding pipe material type selection must be documented and a letter placed in the project file. Copies of all selection letters are to be sent to the Region Program Engineer or their designee prior to final design decisions being made, for guidance and to verify consistency.

Table 1

Guidelines for selection of corrosion resistance levels

	SOIL			WATER		
CR Level	Sulfate (SO_4)	Chloride (Cl)	pH	Sulfate (SO_4)	Chloride (Cl)	pH
	% max	% max		ppm (max)	ppm (max)	
*CR 0	0.05	0.05	6.0-8.5	50	50	6.0-8.5
CR 1	0.10	0.10	6.0-8.5	150	150	6.0-8.5
CR 2	0.20	0.20	6.0-8.5	1,500	1,500	6.0-8.5
CR 3	0.50	0.50	6.0-8.5	5,000	5,000	6.0-8.5
CR 4	1.00	1.00	5.0-9.0	7,500	7,500	5.0-9.0
CR 5	2.00	2.00	5.0-9.0	10,000	10,000	5.0-9.0
CR 6	>2.00	>2.00	<5** or >9	>10,000	>10,000	<5** or >9

Project Pipe Locations

*No special corrosion protection recommended when values are within these limits. **Concrete pipe used when the pH of either the soil or water is less than 5 shall be coated in accordance with subsection 706.07. When needed, specify the coating in a special provision or plan note.

CDOT PIPE MATERIAL SELECTION POLICY

Table 2

Minimum Pipe Thickness For Metal Pipes Based On The Resistivity And pH Of The Adjacent Soil

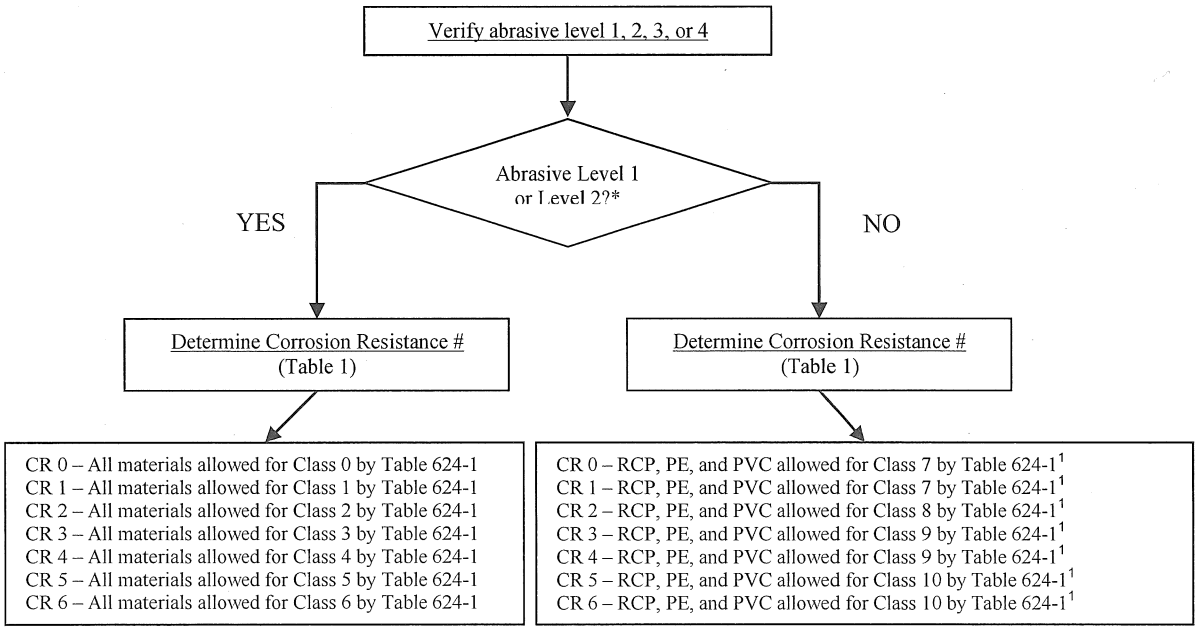
SOIL SIDE		MINIMUM REQUIRED GAUGE THICKNESS FOR METAL PIPE MATERIAL
Resistivity, R (Ohm – cm)	pH	
≥1,500	5.0-9.0	0.052 in (18 Gauge) Aluminized Type 2
≥250	3.0-12.0	0.052 in (18 Gauge) Polymer Coated

Use the latest versions of these specifications, found at:
http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs

For Storm Drains use Standard Specification 603, and write a Project Special Provision stating the required corrosion classification as determined by this policy. (i.e. sulfate class)

Use appropriate pay items in these cases.

Figure 1
CROSS – DRAINS and SIDE – DRAINS



*Aluminum alloy pipe not allowed in environments with an Abrasion Level higher than 1.

[1] When concrete pipe is selected the sulfate content dictates the CR level. Cementitious requirements for Sulfate Protection Classes are listed in 601.04. A higher level of protection may be used. Concrete shall have a minimum compressive strength of 4,500 psi and maximum water to cementitious ratio (w/cm) listed in 601.04. Concrete may be used when the pH and chlorides exceed the levels listed in Table 1

CDOT PIPE MATERIAL SELECTION POLICY

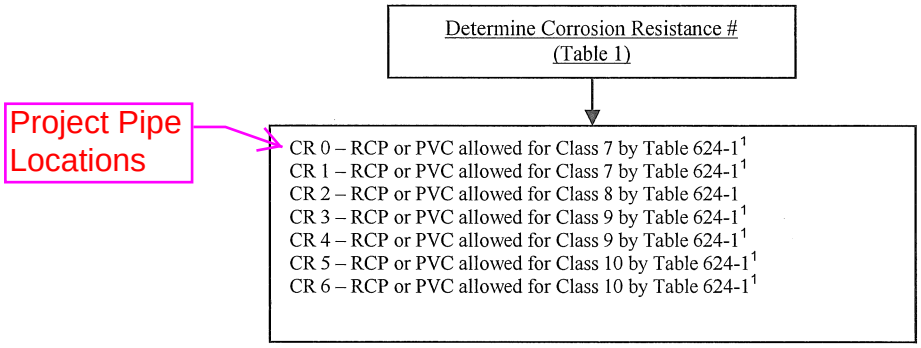
For Metal pipes, see "Minimum Pipe Thickness For Metal Pipes Based On The Resistivity And pH Of The Adjacent Soil" (Table 2) in this document.

When extending an existing pipe, the same size and type of material must be specified. If conditions are Abrasive level 1 or 2 **and** CR 0, specify material type from Section 603 pay items.

Figure 2

STORM-DRAINS

CDOT will only allow the use of reinforced concrete pipe (RCP) or Polyvinyl Chloride Pipe (PVC) in accordance with Standard Plans M-603-2 and M-603-5 for storm drains



[1] – If abrasion level is 3 or 4, concrete shall have a minimum compressive strength of 4,500 psi. Cementitious requirements for Sulfate Protection Classes are listed in 601.04. A higher level of protection may be used.

When extending an existing pipe, the same size and type of material must be specified. If conditions are Abrasive level 1 or 2 **and** CR 0, specify material type from Section 603 pay items.

TRIAL INSTALLATIONS & EVALUATION PROCESS

At any time, Manufacturers may request in writing to have materials not approved herein evaluated for a specific application. Requests for trial installations shall follow the requirements of P.D. 1401.1. Contact information for that procedure is given below:

Product Evaluation Coordinator
Colorado Department of Transportation
Materials and Geotechnical Branch
4670 Holly Street, Unit A
Denver, CO 80216
303-398-6500

- Manufacturers will provide all of the materials, equipment and labor required for the pipe material to be evaluated at no cost to CDOT.
- The pipe material to be evaluated must meet applicable AASHTO and ASTM design and material standards.
- Manufacturers will be responsible for all coordination with the Contractor, and any additional cost incurred by the Contractor as a result of the trial installation.
- CDOT will determine a suitable location for the trial installation.
- During installation, the manufacturer shall have a representative at the installation site. The manufacturer will provide documentation to CDOT that the pipe material was designed and

installed per all current and applicable AASHTO and CDOT design and installation standards.

- Trial installations shall perform satisfactorily for at least one year before conclusions regarding product performance are made.
- During the one year evaluation period, at a time chosen by CDOT, the manufacturer shall provide laser video inspection services on the trial installation utilizing an inspection contractor approved by CDOT.
- The results of the laser video inspection shall be used to evaluate trial installations. The results shall demonstrate compliance with CDOT and AASHTO deflection, joint separation, buckling, tearing, sagging and cracking standards.
- Monitoring may include research of the trial material in use in other states.
- If further evaluation is required beyond one year, the supplier will be notified of the justification for this evaluation extension.
- An independent evaluation performed by a local agency or other organization may be substituted for this trial installation and evaluation process if all of the following are true.
  - The local agency or other organization owns and maintains the material being evaluated.
  - A representative with the local agency or organization can be contacted to verify the information supplied.
  - The installation specifications are available for CDOT to review.
  - A trial installation was performed in Colorado on site applications similar to CDOT projects.
  - A laser video inspection was performed (or can be performed) a minimum of 1 year after installation that produced satisfactory results.
- Upon successful completion of the monitoring period, CDOT's Materials Advisory Committee (MAC) will review the performance and determine the acceptability of the material for future inclusion into the *CDOT Pipe Material Selection Policy*. The MAC will forward recommendations to the Chief Engineer.
- If changes to this policy, including the introduction of new materials or drainage products, are requested, they will be evaluated through the following process:
  - The MAC's Pipe Material Task Group (PMTG) will evaluate documentation concerning changes to the policy.
  - Documentation supporting the proposed change shall be submitted by the supplier to the Product Evaluation Coordinator (PEC) at the address above.
  - The PEC will compile all submitted documentation and submit it to the PMTG.
  - The PMTG will evaluate proposals as submitted and make recommendations to the MAC for voting.
  - The MAC will review the PMTG recommendations and determine the future acceptability of the material for inclusion into the CDOT Pipe Material Selection Policy. The MAC will forward recommendations to the Chief Engineer for signature.

REVISION OF SECTIONS 603, 624, 705, AND 712
DRAINAGE PIPE

In subsection 624.02 delete Table 624-1 and replace it with the following:

TABLE 624-1
Materials Allowed for Class of Pipe

Material Allowed**	Class of Pipe*										
	0	**1**	**2**	**3**	**4**	**5**	**6**[4]	**7**	**8**	**9**	**10**[4]
CSP	Y	N	N	N	N	N	N	N	N	N	N
Bit. Co. CSP	Y	Y[1]	N	N	N	N	N	N	N	N	N
A.F. Bo. CSP	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
CAP	Y	Y[2]	Y[2]	Y[2]	Y[2]	Y	N	N	N	N	N
PCSP - both sides	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
PVC[6]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PE[6]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PP[6]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
RCP (SP0)[3,5]	Y	Y	N	N	N	N	N	Y	N	N	N
RCP (SP1)[3,5]	Y	Y	Y	N	N	N	N	Y	Y	N	N
RCP (SP2)[3,5]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N
RCP (SP3)[3,5]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

* As determined by the Department in accordance with the CDOT *Pipe Selection Guide*. Determination is based on abrasion and corrosion resistance.

** Y=Yes; N=No.

[1] Coated Steel Structural Plate Pipe of equal or greater diameter, conforming to Section 510, may be substituted for Bit. Co. CSP at no additional cost to the project.

[2] Aluminum Alloy Structural Plate Pipe of equal or greater diameter, conforming to Section 510, may be substituted for CAP at no additional cost to the project.

[3] SP= Class of Sulfate Protection required in accordance with subsection 601.04 as revised for this project. RCP shall be manufactured using the cementitious material required to meet the SP class specified.

[4] For pipe classes 6 and 10, the RCP shall be coated in accordance with subsection 706.07 when the pH of either the soil or water is less than 5. The Contract will specify when RCP is to be coated.

[5] Concrete shall have a compressive strength of 4500 psi or greater.

[6] In accordance with subsection 712.13.

Appendix F

Miscellaneous Documents

PLAN SHEETS CREATED FROM SCANNING PROJECT CXFRU 11-0006-13

RIGHT OF WAY LINES SHOWN ARE FOR INFORMATION ONLY. THE CONTRACTOR SHALL FIELD VERIFY ACTUAL RIGHT OF WAY LINES IF REQUIRED.

N

APPROX. SCALE 1"=100'

HOLLAND ST.

~STA. 243+25, ~50' LT
REQ. REMOVE INLET
REQ. VANE GRATE INLET (DOUBLE)(10')
RIM ELEV.= 5510.24'

GARLAND ST.

STA. 241+97 TO STA.247+97, LT.
Remove 600 LF of Guardrail Type 3
Req. 587.5 LF of Guardrail Type 3
End Anchorage Type 3D
End Anchorage Type 3H

CARRISON ST.

EQ = 249+29.18 BK / 249+28.06 AH
Anchorage Type 3G

STA. 249+29 TO STA. 257+64 LT.
Remove 150 LF of Guardrail Type 4 (Temp.)
Remove 685 LF of Guardrail Type 3
Req. 775 LF of Guardrail Type 3
Req. 670 LF of Curb Type 6 (Section M)
End Anchorage Type 3G
End Anchorage (Nonflared Terminal)

12" San. Sewer

12" San. Sewer

N.E. FRONTAGE ROAD

FRONTAGE ROAD

N.W. FRONTAGE ROAD

TYPICAL SECTION 2 — TYPICAL SECTION 1

24' (CAPPED)

245

SH 6

250

TYPICAL SECTION 2 — TYPICAL SECTION 1

24'

Existing 535' of guardrail type 3

STR. NO. F-16-ER

Existing guardrail type 3 located on the top of the retaining

PAVING LIMIT

S.W. RAMP

S.E. FRONTAGE ROAD

STA. 248+63.35 US 6 =
STA. 5+00 Garrison St.

~STA. 242+50
REQ. CAP MEDIAN INLET

~STA. 242+75 TO STA 243+10, RT
REQ. 45 LF OF GUTTER
TYPE 2 (5 FOOT)

STA. 243+25, RT
REQ. Repair Embankment Protector
To be paid for as HBP (Patching)

STA. 242+62 TO STA.247+97, RT
Remove 535 LF of Guardrail Type 3
Req. 475 LF of Guardrail Type 3
Req. 498 LF of Curb Type 6 (Section M)
End Anchorage Type 3G
End Anchorage (Nonflared)

STA. 243+25, 50' RT
REQ. VANE GRATE INLET (SINGLE)(5')
RIM ELEV. = 5509.56
Connect to existing 24" pipe

THIS SECTION
INTERPOLATED FROM AERIAL PHOTOGRAPH

CALL UTILITY NOTIFICATION CENTER OF COLORADO
1-800-922-1987
CALL 2-BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

Computer File Information			
Creation Date:	03/15/99	Initials:	AS
Last Modification Date:	11/08/99	Initials:	AK
Full Path:	C:\PROJECTS\12023		
Drawing File Name:	FINAL_MASTR13.DWG\SHEET6		
Acad Ver. R14	Scale:~1"=100'	Units: ENGLISH	

Sheet Revisions		

Colorado Department of Transportation
2000 SOUTH HOLLY ST.
ROOM 185
DENVER, CO 80222
Phone: (303) 984-5260 FAX: (303) 984-5299
Region 6 DEW

As Constructed
No Revisions: 11/9/01
Revised:
Void:

PLAN SHEET 6

Designer:
Detailer:
Sheet Subset:
Structure Numbers
Subset Sheets: 6 of 10

Project No./Code
NH 0062-011
12023
Sheet Number 44

U 006-6(2) 43

DRAINAGE, FENCING AND UTILITIES

AS CONSTRUCTED
WORK REVISION 7/14/72

N

INDEPENDENCE ST.

HOLLAND ST. (DENVER)

GARLAND ST.

ST. S 0°23' W

2358
20.05

SMH 235

237B
18.22

20' Transition

237C

18" (Capped)

242C
20.93

CENTERLINE
N 89°44' E

N. W. FR. RD.

N.W. SLIP RAMP

SECTION LINE = N 89°40' E

N. E. FR. RD.

N 89°53' E

N 89°41' E

S. W. SLIP RAMP

S. E. FR. RD.

S.W. FR. RD.

GARRISON
S 0°10' E

CONC. RET. WALL

(CONS MUTUAL)

W.O. #03456-F

235 240 245 250

5530
5520
5510
5630
5520
5510

-2.70%
+3.00%
WESTBOUND

-2.70%
+3.00%
EASTBOUND

STR. NO. F-16-EQ

STR. NO. F-16-ER

235 240 245 250

STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS STATE OF COLORADO
DENVER 34
JULY 1948

U 005-6(2) 44

DRAINAGE, FENCING AND UTILITIES

CONSTRUCTED 7/14/72
REVISIONS

PLAN
DATE
REVISED
AS CONSTRUCTED
NOTE BOOK
BY OF WAY CHECKED
No.

PROFILE
GRADES
NOTE BOOK
No.

N

W.O. #03456-F

N. E. FR. RD.

S. E. FR. RD.

CONC. RET. WALL

SECTION LINE
N 89°55' E

CENTERLINE
N 89°41' E

MH 256
87.91

257B
87.13

256B
88.97

256C

263B
79.13

263C

SM257

SM262

FIELD ST.

EVERETT ST.

ESTES ST.

MEADOWLARK ST.

DUDLEY ST.

CONS MUTUAL

DENVER SAN.

LAKEWOOD SAN.

CAPPSO

FL 86.28
FL 83.94
FL 83.28
FL 78.85
FL 76.37
FL 77.84

250
255
260
265

5520
5510
5500
5490
5480
5470

4.00%
WESTBOUND

4.00%
EASTBOUND

FED. ROAD REG. NO.	DIVISION	PROJ. NO.	SHEET NO.	TOTAL SHEETS
9	COLO	F012-2 (8)	52	

ROADWAY DRAINAGE, LIGHTING & FENCING PLANS

LEGEND

SANITARY SEWERS

- Existing sanitary sewer
- Existing sewers to be abandoned
- Existing sewer to be plugged
- Existing manhole requiring new work
- New sewers and manholes

STORM SEWERS

- Existing lines, manholes and inlets
- Existing lines to be used
- Existing lines to be plugged and/or inlets to be abandoned
- New lines, manholes and inlets
- Drop inlet Adjustment

UTILITY LINES

- Power lines (underground)
- Tel. & Tel. lines (underground)
- Gas lines
- Water lines

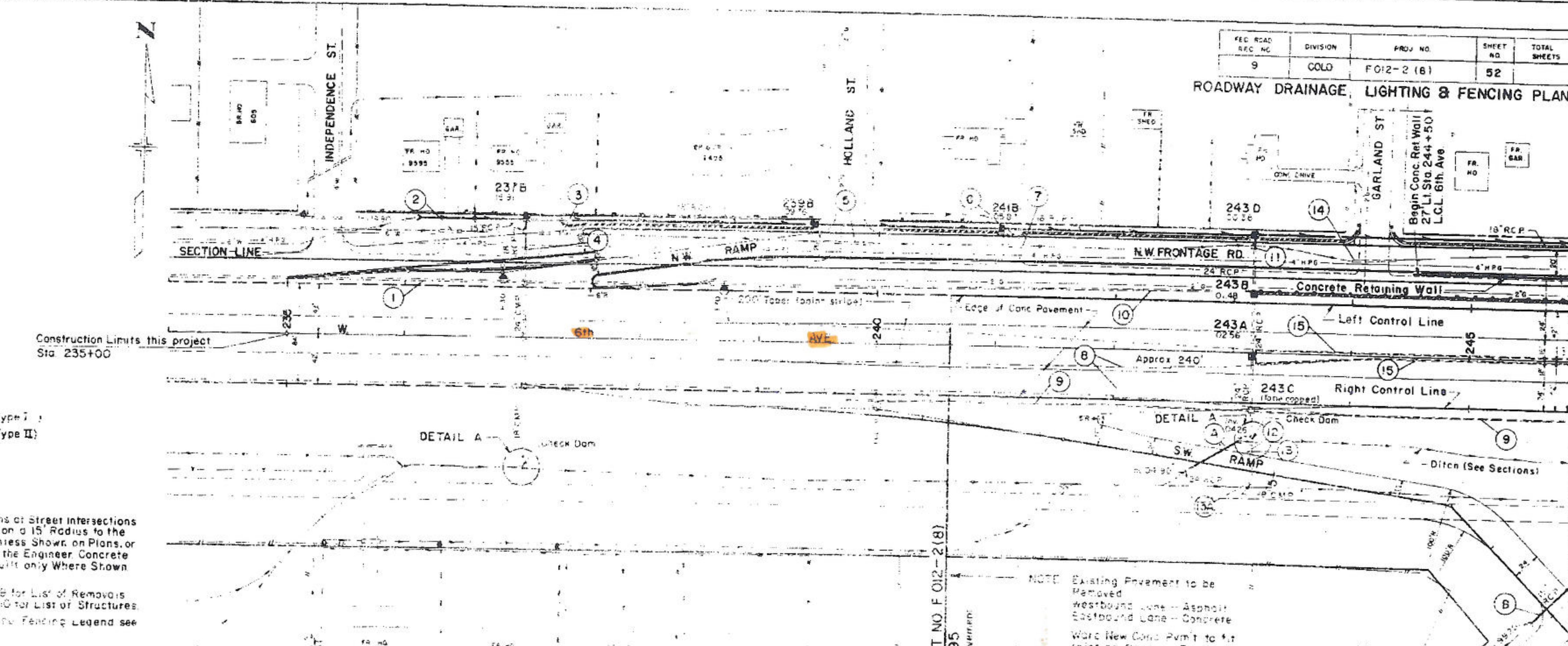
CURBS

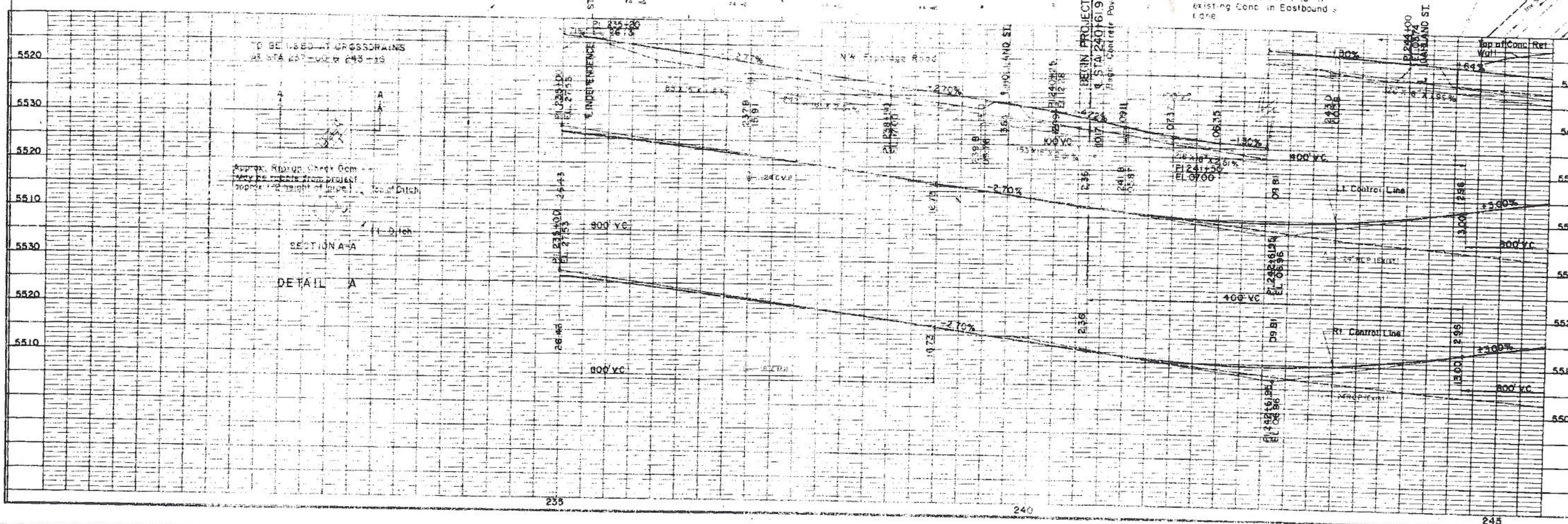
- Concrete Combination Curb & Gutter (Type I)
- Concrete Combination Curb & Gutter (Type II)
- Asphaltic Shoulder Roll
- Concrete Gutter
- Combination Curb & Gutter Sidewalk
- Concrete Barrier Curb

NOTE: All Curb Returns of Street Intersections shall be Built on a 15' Radius to the Face of Curb unless Shown on Plans, or as Directed by the Engineer. Concrete Gutter to be Built only Where Shown on Plans.

NOTE: See Sheet No. 8 for List of Removals. See Sheet No. 10 for List of Structures.

NOTE: For Lighting and Fencing Legend see Sheet No. 51





FED ROAD REG NO.	DIVISION	PROJ NO.	SHEET NO.	TOTAL SHEETS
9	COLO	FOI2-2(8)	53	

ROADWAY DRAINAGE, LIGHTING & FENCING PLANS

NOTE: See Typical Section 3 for Sprinkler System Details, Sheet No. 5
See Sheet No. 52 for Sewer, Utility, Curb and Gutter Legend
See Sheet No 9 for List of Removals
See Sheet No. 10 for List of Structures
See Sheet No. 51 for Lighting and Fencing Legend

* NOTE 255A is a Double Type A Inlet

NOTE: Existing Pavement to be Removed
Westbound Lane – Asphalt
Eastbound Lane – Concrete
Warp New Concrete Pavement to fit existing Concrete in Eastbound Lane

MEADOWLARK SHOPPING CENTER

Begin Concrete Retaining Wall 27' Lt. Sta. 244+50 L.C.L. 6th Ave.

Reqd. 475' Metal Plate Beam Guard Fence Sta. 243+25 – Sta. 248+00 (Lt. L.C.L.)

Reqd. 100' Metal Plate Beam Guard Fence Sta. 247+00 – Sta. 248+00 (Lt. R.C.L.)

End Conc. Ret Wall 27' Lt. Sta. 248+18 L.C.L. 6th Ave.

Reqd. 100' Metal Plate Beam Guard Fence Sta. 249+30 – Sta. 250+30 (Lt. L.C.L.)

End Concrete Ret Wall Sta. 258+33 24' Lt.

Begin Concrete Retaing Wall 10' Rt. Sta. 248+95 R.C.L. 6th Ave.

End Concrete Retaining Wall 10' Rt. Sta. 256+10 R.C.L. 6th Ave.

Sta. 258 + 26.88 End Proj. No. FOI2-2(8) ℄ Sta. 258+20.52 End Conc. Pavement Rt.

Eq. 260+00 Bk. = 259+989 Ah.

Top of Conc. Ret Wall Pl 247+50 EL. 98.00

Sta. 248+63.63 N.W. Fr. Rd. POT 4+40.56 ℄ Garr. St. EL. 96.58

POT 0+00 N.E. Fr. Rd. = POT 5+60 Garrison St. EL. 94.90

Pl 248+63.35 EL. 95.00

Pl 0+50 EL. 93.90

Pl 4+25 EL. 93.40

Pl 8+25 EL. 92.05

Pl 10+30 EL. 89.00

POT 10+90 N.E. Fr. Rd. EL. 88.00

STR. NO. F-16-EQ

Pl 248+13.36 EL. 94.59

Conc. Slope Paving

Lt. Control Line

STR. NO. F-16-ER

Rt. Control Line

Pl 248+63.35 EL. 95.00

POT 248+63.93 S.E. Fr. Rd. = POT 5+93.16 ℄ Garrison St. EL. 98.39

Top of Conc. Ret Wall

Pl 248+20 EL. 97.26

Pl 2+31.40 EL. 98.83

Pl 256+83.24 EL. 92.20

Pl 256+70.52 EL. 92.71

Pl 258+50 EL. 89.75

POT 260+50 S.E. Fr. Rd. (EL. 85.60)

Existing Ditch

Open Ditch (See X-Sections)

Concrete Retaining Wall

Sprinkling System

Approx 240'

200' Taper (paint stripe)

Approx 150'

Begin Concrete Retaing Wall 10' Rt. Sta. 248+95 R.C.L. 6th Ave.

PLEASE DO NOT TRIM

FED. ROAD AGS NO.	DIVISION	PROJ. NO.	SHEET NO.	TOTAL SHEETS
9	COLO.	FOI2-2(8)	54	

ROADWAY DRAINAGE, LIGHTING & FENCING PLANS

Req'd.
100' Flexibeam Guard Rail
Sta. 249+32 - Sta. 250+32
(Rt. L.C.L.)

N.E. FRONTAGE RD.

STR NO. F-16-EQ

Left Control Line

Concrete Retaining Wall

MEADOWLARK SHOPPING CENTER

Begin Conc. Ret. Wall 10' Rt
Sta 248+95 R.C.L. 6th Ave

W. 5th Place

GARRISON

N. 0° 23' E

S 0°10' E

ST

Inv 8854
End Conc. Ret. Wall 27' Lt.
Sta. 248+18 L.C.L. 6th Ave.

STANDARD OIL SERVICE STA.

Req'd.
100' Flexibeam Guard Rail
Sta. 247+00 - Sta. 248+00 (Lt. R.C.L.)

Req'd.
480' Flexibeam Guard Rail
Sta 243+20 - Sta. 248+00 (Lt. L.C.L.)

N.W. FRONTAGE RD.

Concrete Retaining Wall

STR NO. F-16-EB

6th

UH6

NOTE See Sheet No. 3 for Sprinkler System Details
See Sheet No. 52 for Sewer, Utility, Curb & Gutter Legend
See Sheet No. 9 for List of Removals
See Sheet No. 10 for List of Structures
See Sheet No. 51 for Lighting & Fencing Legend

See X-Sections

STR NO. F-16-EQ

STR NO. F-16-EB

Future Grade

Existing Grade

+1.50%

-2.80%

+1.50%

-1.51%

5520

5510

5500

5490

5480

0

5

10