SOUTH WASHINGTON WATERSHED DISTRICT
CENTRAL DRAW STORAGE FACILITY (CDSF)
BASIS OF DESIGN REPORT

October 2013

HDR Engineering

701 Xenia Ave S Suite 600

Minneapolis, MN 55416

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 PREAMBLE

This is a Basis of Design Report (BoDR) for construction of the South Washington Watershed District's (SWWD's) Central Draw Storage Facility (CDSF) and associated outlet pipe system which are located in the City of Cottage Grove. This is a living document that will be progressively updated as the design and permitting phase continues and will only be finalized when construction of the Project is complete. This BoDR serves as a summary of the design documentation and of the design and construction process.

2.0 DEFININITION OF TERMS

For purposes of this report, the following terms and acronyms are defined:

2030 CP	2030 Comprehensive Plan
AUAR	Alternative Urban Areawide Review
BoDR	Basis of Design Report
CDSF	Central Draw Storage Facility
Design Storm	6.3-inch depth, 24-hour duration storm event under a SCS Type II Rainfall Distribution
NPDES	National Pollutant Discharge Elimination System
Project	Design, Permit, and Construction of the CDSF and corresponding outlet/overflow pipe system
SWMP	Surface Water Management Plan
SWWD	South Washington Watershed District
SWPPP	Soil and Water Pollution Prevention Plan

3.0 PROJECT OVERVIEW

3.1 PROJECT DRIVERS AND NEED

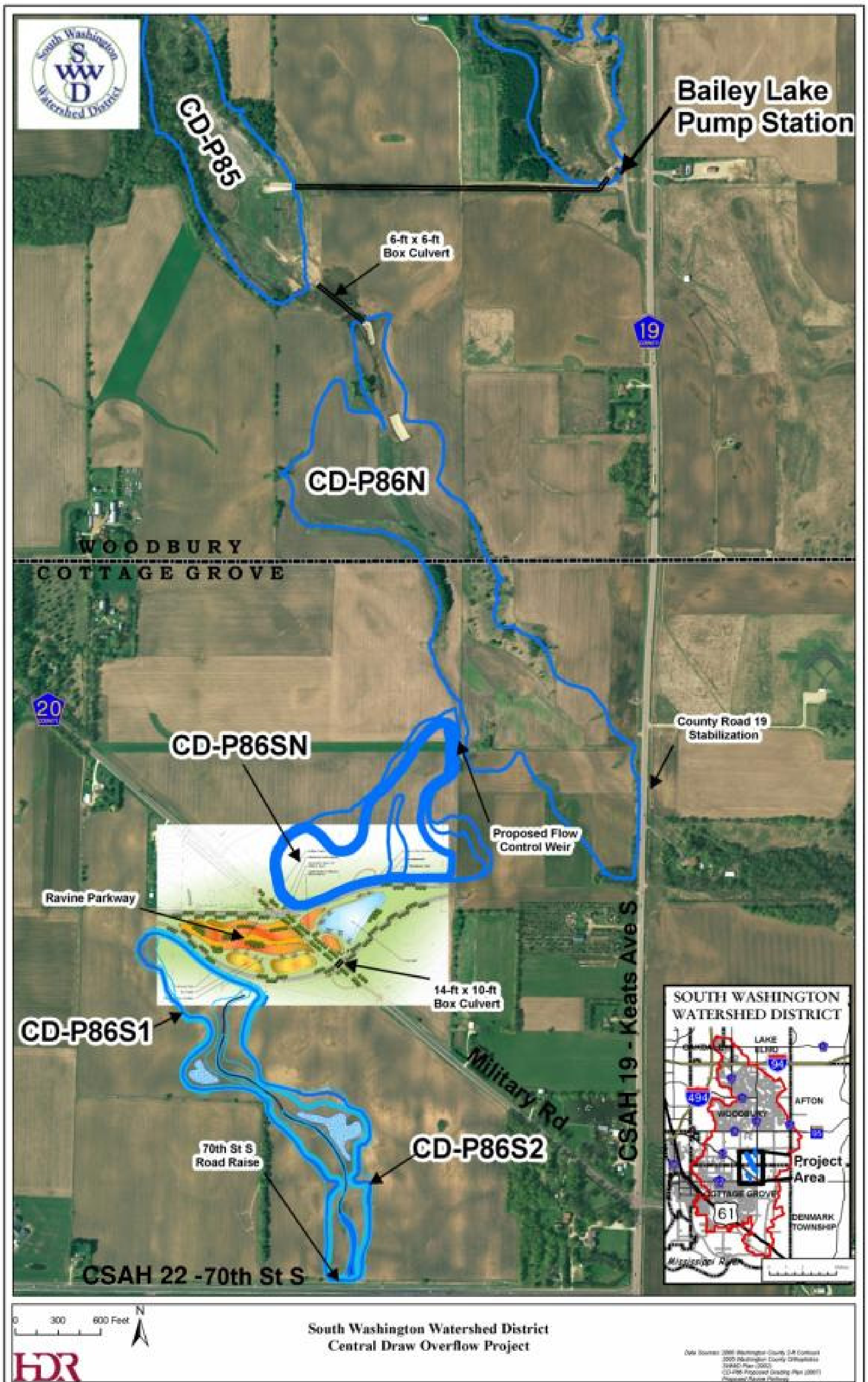
The Northern Watershed consists of approximately 23 of the 81 square miles that make up the South Washington Watershed District. From north to south, the Northern Watershed includes the drainage areas of Armstrong, Markgrafs, Wilmes, Powers, Colby, and Bailey Lakes. The entire Northern Watershed, which includes portions of Lake Elmo, Oakdale, Afton, and the City of Woodbury, eventually drains to Bailey Lake, a water body that would be landlocked if not for the pump station located at its southern most lobe. Under existing conditions, any water pumped out of Bailey Lake would flow south until it ponds in a low area on the north side of the CSAH-22 (70th Street) roadway embankment. There are no outlets from this low area adjacent to CSAH-22 that would allow the area to drain.

The Bailey Lake Lift Station was designed in order to maintain water levels at or below a Bailey Lake pool elevation of 877 feet. Outflows from Bailey Lake are restricted by the DNR (through operational pump rate restrictions) so that the existing storage volumes upstream of the CSAH-19 embankment will not be exceeded under 100-year design storm conditions. Exceedance of storage volumes adjacent to CSAH-22 would result in flooding of the areas upstream of the CSAH 22 roadway embankment, and could result in water overtopping the CSAH-22 embankment and flowing through residential neighborhoods to the south.

Future development upstream of Bailey Lake and in the areas between Bailey Lake and CSAH-22 would result in increased stormwater volumes and peak flow rates. The greater stormwater volumes and peak flow rates would increase flooding risks in areas upstream of the Bailey Lake pump station. Furthermore, the lack of an outlet from the area upstream of CSAH-22 would increase the likelihood of CSAH-22 overtopping and would increase flooding risks in downstream residential areas.

The CDSF Overflow project proposes adding the "CDSF" storage area in between Bailey Lake and CSAH-22, and providing an outlet for flow out of the "CDSF" storage area. The CDSF storage area would consist of multiple connected lobes. The pump station would discharge water to CDP-85, a pond which is located within and owned by the City of Woodbury. Water would then flow into CDP-86, a pond which is split between Woodbury and Cottage Grove jurisdictional limits (Figure 1). The CDP-86 basin is further separated into the CDP-86N (north lobe), CDP-86SN (north part of the south lobe), and CDP-86S1 and S2 (the south part of the south lobe past present Military Road). An outlet pipe would be provided from the southern-most lobe of the system,

FIGURE 1
CDSF OVERALL LAYOUT



which would convey flows to the East Ravine. CDSF flows in the East Ravine would then flow overland in an existing open channel to the Mississippi River.

If development were to occur without construction of the CDSF Overflow project, there would be increased flood risks in areas upstream of the Bailey Lake pump station and downstream of CSAH-22. Water surface elevations on the north side of CSAH-22 would also exceed the design water surface elevation of 902 feet identified in the City of Cottage Grove Surface Water Management Plan.

Engineering analysis indicates that the existing storage area between the Bailey Lake pump station and CSAH-22 is insufficient for containing future conditions flows. Analysis indicates that the lift station and other upstream properties would be inundated during future conditions design events. If the existing lift station is to be fully utilized, then it is critical that sufficient pump and outlet capacity is provided. Due to the limited flood storage capacity in the CDSF and subsequent limited pumping allowed from the lift station as constrained by the DNR permit, the lift station can only be operated for 6½ days before storage capacity is used up during the 100-year 24-hour conditions.

Construction of the CDSF is critical to allowing future development and to the overall watershed functioning both as the primary outlet to the Northern Watershed and as a local storm water facility within the City of Cottage Grove. The outlet/overflow is needed to provide safe conveyance of excess runoff from the CDSF to the Mississippi River and to provide an adequate level of flood protection for the watershed.

3.2 Project Background

3.2.1 Detailed Background Information

The Central Draw Storage Facility (CDSF) Overflow Project ('Project') has been in development for over 30 years for the purposes of flood control and the protection of life and property. Beginning in the late 1970s the Cities of Woodbury and Cottage Grove contemplated a connected storm sewer system between the northern and southern watersheds through Cottage Grove to the Mississippi River. The general approach used in the Woodbury (1979) and Cottage Grove (1984) plans was to provide outlets for landlocked basins, once urbanization occurs, to control water levels in the basins. The connection of several landlocked areas within the northern portion of the watershed necessitated planning for a central drainage system. The drainage systems presented in the plans accounted for full development of the cities.

The 1979 City of Woodbury Storm Drainage Plan was the first drainage plan designed for the entire City of Woodbury and indicated the need for a future outlet to the Mississippi River. The plan described storm sewer, open channels, major natural drainage-ways, and ponding areas that were necessary to provide an adequate and economical means of conveying stormwater runoff through Woodbury. The 1979 Plan developed the methods and general layout that became the City's current stormwater system; showing the central drainage system as carrying runoff water from the northern portion of the watershed to its southern border. It would then need to be transported downstream to the Mississippi River. The central drainage system shown consisted of a gravity system connecting the lakes that lie in the center of the watershed.

The 1984 City of Cottage Grove plan showed the upstream central drainage flow from Woodbury being carried through the eastern portion of the city to the Mississippi River. The planned stormwater system consisted of gravity connections between landlocked basins and a natural drainage channel to the Mississippi River. The planned intercommunity stormwater connection is intended to provide relief for excess stormwater runoff from the northern watershed area. This connection was and remains a focal point of the watershed management organizations charged with managing the watershed. The other areas in Cottage Grove in the western and central portions of the city were shown to be conveyed to the Mississippi River through pipes, man-made channels, and natural channels and include outlets for landlocked areas in the city.

In 1984 the Cottage Grove Ravine Watershed Management Organization (WMO) was formed to manage the water resources of the area that is now the SWWD. The boundaries of the two organizations were virtually the same except that the WMO included the eastern half of Grey Cloud Island which was not included in the new SWWD boundary. The Cottage Grove Ravine WMO prepared a draft Watershed Management Plan (WMP) in 1988. The WMO draft WMP included a drainage system generally consistent with the city plans. The central drainage system shown was a series of landlocked basins interconnected and an outlet system to the Mississippi River. The Cottage Grove Ravine WMO draft WMP showed additional ponding north of I-94 not shown in the 1986 Lake Elmo Plan. The Cottage Grove Ravine WMO draft WMP stressed cooperative efforts by the member cities. The WMO outlined a process where implementation and enforcement of controls would be carried out by the cities once they adopted their Local Municipal Management Plans. The WMO draft WMP was never adopted since the WMO could not obtain a four-fifths majority to adopt the WMP as was required in the joint powers agreement. As a result the WMO was dissolved, which led to the formation of a watershed district in 1993 known as the Cottage Grove Ravine Watershed District. The Cottage Grove Ravine Watershed District decided in 1995 to change its name to the South Washington Watershed District (SWWD) to prevent confusion with the City of Cottage Grove.

Since the establishment of the SWWD and the creation of the first watershed management plan in 1997, the SWWD has been evaluating and planning for the construction of a watershed overflow.

Between 2000 and 2004 the SWWD contemplated a combined project with the Metropolitan Council during the construction of the South Washington County Sanitary Sewer Interceptor. At that time the SWWD determined that other partnerships would be available in the future for the SWWD to pursue a combined project and decided not to enter into a partnership with the Metropolitan Council.

By the late 1990s many flood management alternatives had been evaluated by the SWWD, including complete storage concepts and various drainage concepts. Any number of the proposed alternatives may have been considered feasible, but were not considered practical due to political, cost, environmental or other considerations given the complex regulatory and political climate that existed regarding this project. In general, the alternative that satisfies the flood storage management objectives, maximizes the use of natural storage areas and storm water conveyance systems, creates greenway opportunities, coordinates to the extent practical with proposed land use development projects, minimizes project costs, accommodates future growth and minimizes overall environmental impacts which will result in the most attractive project alternative. The selected alternative may not be the least expensive alternative, but the one that results in addressing the most concerns and maximizing overall public benefits.

The SWWD considered thirteen different overflow routes and options for storm water conveyance; a listing of the various reports and memorandums that address these considerations can be found in Appendix B of HDR (2002a). These reports are on file with the SWWD. Because an overflow route from Bailey Lake to Gables Lake was not feasible, the Bailey Lake Pump Station to the CDSF was chosen to accommodate any excess Northern Watershed stormwater. However, when Woodbury's Phase I AUAR area is fully developed in the future, under extreme precipitation events the maximum designed CDSF stormwater volume capacity would likely be reached. Upon careful consideration of the various alternatives and review of the relevant facts, the SWWD determined that the CDSF overflow to the East Ravine was the best overall alternative.

In 2000 the SWWD released its Greenway Corridor Plan (SWWD 2000), which presented a greenway corridor encompassing the major drainage route from the Mississippi River north to Lake Elmo Regional Park linking important natural areas while providing stormwater conveyance to the Mississippi River. This Plan described recreational opportunities, rare species habitats, groundwater recharge areas, water quality protection, and environmental education opportunities. The Plan highlighted the restoration opportunities for historic prairie and oak savanna forest, and gave details about the missing links that have been identified in the corridor as well as the three protection areas of ecological significance that are in danger of loss or further degradation.

In 2002 the 1997 SWWD Watershed Management Plan was amended to conduct additional planning studies and implement projects related to the Central Draw Overflow Project, and was based on two reports addressing the Project. The first report was the SWWD Central Draw Overflow Project; Minor Plan Amendment Report (HDR 2001), which summarized engineering and technical activities related to the Central Draw Overflow Project. The report provided a basis for the SWWD Board to amend the 1997 Plan in order to conduct additional planning studies and implement projects related to the Central Draw Overflow Project. Hydrologic and hydraulic modeling was used to assess existing and future conditions of the watershed's stormwater system. The report recommended that the amendment develop a comprehensive watershed approach that included: flood damage reduction; flood storage volumes/floodplain; emergency response planning; watershed overflow.

The second report forming the basis for the 2002 amended SWWD Watershed Management Plan was the SWWD Engineer's Report - Central Draw Project and Flood Storage Area Maps – Final (HDR 2002), which presented a project to correct existing flooding conditions and identify associated flood storage areas in the communities upstream of Bailey Lake. Hydrologic and hydraulic modeling was used to assess existing conditions of the stormwater system. The proposed Project provides a principal outlet capable of managing the excess runoff associated with a 100-year 24-hour event under existing conditions. The design was intended to provide overflow capacity for this landlocked area up through completion of Woodbury's Phase I AUAR development area. The report also noted that Woodbury intended to apply for a permit to alter the rate, volume and location of stormwater discharge from the Bailey Lake Pump Station. The permit, at the time of the study, limited flow rate to 75 cfs where water could not be discharged beyond CD-P86 North lobe (Figure 1 of EAW, north central area of CDSF). The Project was designed to accommodate flows up to 150 cfs and discharge stormwater to CD-P86 South Lobe and Gables Lake.

The CD-P86 Natural Resources Management Plan (SWWD 2002b) developed an ecologically based management approach that improves, protects and maintains the ecological functions of CDP-86. This natural depression is a link in the Greenway Corridor. The CDP-86 area was shown to provide the critical connection between the City of Woodbury's trunk stormwater system and a natural drainage-way through Cottage Grove that discharges into the Mississippi River. The plan established a framework for future restoration efforts on portions of the site including areas both inside and outside of the conservation easement.

The Woodbury East AUAR plan encompassed 1,832 acres in eastern Woodbury (City of Woodbury 2002), and is relevant to the current Project because it proposed the areas of future development that would contribute stormwater to Bailey Lake. The area was mostly undeveloped farmland and the AUAR boundary generally followed the hydrologic boundary between Valley Branch Watershed

District (VBWD) and SWWD. Major residential developments that have occurred within the 2002 AUAR area include Dancing Waters, Turnberry, Stonemill Farms, and Bailey's Arbor. As required by State law, the AUAR identified potential environmental impacts of the proposed land uses and included a mitigation plan that identified how the potential impacts would be avoided or mitigated.

In 2004 the SWWD published a Flood Mitigation Plan and Emergency Response Evaluation (SWWD 2004), which was intended to serve as the foundation for flood mitigation activities and actions within the SWWD. A model was constructed to evaluate flooding and flood damages for the areas surrounding Bailey, Wilmes, and Powers Lake and for the City of Cottage Grove. Maps delineated at-risk flood areas based on the nearest 2-foot contour to the predicted water surface elevation, as well as the estimated flood damage for various flood depths above estimated walkout elevations. The document discussed watershed plan solutions, including: - Inventory, Acquisition, and Relocation of Repetitive Loss Structures; - Flood proofing and retrofitting of structures; and - Additional Drainage Infrastructure (Flood Damage Mitigation Program to utilize storage, infiltration and routing to provide an overflow to the Mississippi River in extreme flooding events). The Draft Plan also described the components and steps to prepare an Emergency Preparedness Plan, which the report noted will be required by the SWWD as a future action item. The document also provided an Emergency Action Plan for the cities of Woodbury and Cottage Grove (which the SWWD is to help facilitate) in the form of Public Service Announcements which explain what to do in conditions of a Flood Watch, Flood Warning, and after a flood event. Portions of this plan were incorporated into the Washington County's Emergency Preparedness Plan and provided the basis for the FEMA mapping update.

In 2005 Cottage Grove released a draft Alternative Urban Areawide Review (AUAR) and Mitigation Plan for the East Ravine (City of Cottage Grove 2005) for public comment; the East Ravine is an area that contributes stormwater to the East Ravine. The Cottage Grove East Ravine AUAR is based on a master planning project that evaluated land use and development patterns for an area of roughly 3,800 acres in a future Metropolitan Urban Services Area (MUSA) expansion area as identified in the City's Comprehensive Plan. The planning area was generally bound by Highway 61 on the south, Keats Avenue on the west, the municipal boundary on the north and Kimbro Avenue on the east. The AUAR evaluated a base scenario consistent with the Comprehensive Plan and an alternative development scenario derived through the East Ravine Pre-Design master planning process. The project included residential (roughly 6,550 units) and commercial development (roughly 850,000 square feet) and included associated public infrastructure improvements including sanitary sewer, storm sewer, public water supply and roadway/traffic improvements to serve the development. The project is expected to occur over a 20+ year time frame.

Revisions to the previous document were incorporated into the City of Cottage Grove East Ravine Master Plan Final AUAR Adopted (City of Cottage Grove 2006), which identified the 4000-acre eastern portion of the community as a future phase for development. Two scenarios were evaluated: a base scenario using the current comprehensive plan (generally a low density residential land use pattern with limited commercial areas along T.H. 10/ T.H. 61); and the East Ravine Pre-design Master Plan (large areas of single family residences interspersed with medium and higher density residences and two commercial areas). The focus of this AUAR's evaluation was on the second scenario. The development of the AUAR project area could have impacts on the environment and existing development. The Mitigation Plan identified existing tools and policies that the City has in place, as well as additional methods to mitigate potential impacts. Infiltration and ponding techniques are mitigation measures to protect downstream resources.

In October 2005 Woodbury received several inches of rain in a short time period. While the City's storm drainage system performed well, certain areas did experience high water conditions. However, flood damage to homes and infrastructure was limited. The City subsequently analyzed these areas and found that flood damage occurred due to deficiencies in parts of the City's system and also due to deficiencies created by homeowners, builders and developers (City of Woodbury 2006). The final report identified numerous improvements, some of which the City has already constructed.

The SWWD Watershed Management Plan (2007) presently provides guidance for the SWWD to manage the water and natural resources of the watershed. The SWWD plan inventoried resources, assessed resource quality, and established regulatory controls or physical improvements to maintain environmental quality of the watershed. The SWWD's updated plan included policies and related information critical to managing urban development and growth. Infiltration is not considered as a flood control measure as this provides an appropriate, conservative assumption for stormwater rate and volume control in terms of infrastructure planning; however, infiltration is considered for water quality aspects in relation to the Plan. Post-project or development conditions cannot exceed existing stormwater runoff rates and volume control is required by the Plan. The Plan also established regional assessment points at several locations to provide a performance measure.

The Cottage Grove Storm Water Management Plan (City of Cottage Grove 2008) established stormwater design events and peak flow rates for development and redevelopment in line with those of the SWWD, and also discussed the input of Woodbury stormwater as paraphrased here:

In addition to the direct drainage area from the City of Cottage Grove, approximately 14,500 acres from the City of Woodbury will ultimately be routed into the East Ravine District via the Bailey Lake lift station. Discharge from the Bailey Lake lift station is routed into two basins; CD-P85 owned and maintained by the City of Woodbury and CD-P86 owned and maintained by the

SWWD. The ultimate discharge rate from the Bailey Lake lift station, as it is routed through CD-P85 into CD-P86 is included in the regional stormwater design of the East Ravine. Connection of CD-P86 north and south was completed in 2003 with installation of a box culvert under Military Road in 2003. A conveyance system was constructed between CD-P85 and CD-P86 in 2004. Both projects were completed under the 2002 SWWD Watershed Plan Amendment to efficiently utilize available storage downstream of the Bailey Lake lift station. The City of Cottage Grove anticipates that the SWWD will provide an outlet for CD-P86 with the capacity to handle a peak lift station discharge from Bailey Lake of 150 cfs, as previously discussed. The City assumes that this pipe will be financed by the SWWD. The regional stormwater system for this district builds off of the stormwater ponding layout proposed in the AUAR for the East Ravine. The AUAR document identifies an entire stormwater system of interconnected basins and natural drainage-ways designed to promote infiltration and protect downstream key water resources. From the design proposed in the AUAR, a number of key ponding basins within the AUAR study area have been incorporated into the regional stormwater system for the East Ravine District. As development occurs within the East Ravine District, the regional stormwater system identified in this SWMP should be implemented.

The CDSF will provide two things: flood storage capacity and infiltration capacity. Immediately to the south of the CDSF, the Central Ravine Connection (refer to Section 6d) will allow localized drainage in the area west of CSAH 19 to be directed to the Central Ravine drainage system. The Central Ravine Connection will also provide some degree of operational flexibility in that it will be able to accept some amount of storm water from the CDSF. A large stormwater pond (CP4-3; location shown in Figure 13 of this report) will provide storage capacity and infiltration capacity below the 100-year design event for the Cottage Grove East AUAR local drainage system east of CSAH 19 that will flow to the pond. Cottage Grove East AUAR local drainage south of CP4-3 will be managed locally up to the 100-year design event prior to entering the Project pipe. However, for the purposes of flood control and public safety, stormwater generated at or above the 100-year design event for the Cottage Grove East AUAR drainage east of CSAH 19 may enter the Project pipe in overflow situations.

The City of Woodbury adopted its 2030 Comprehensive Plan in 2010 (City of Woodbury 2010a). The City's Surface Water Management Plan (SWMP) is contained in Chapter 12 of that document (City of Woodbury 2010b). Woodbury's central drainage system flows to Bailey Lake. The pump station at Bailey Lake discharges into CD-P85. If CD-P85 overflows, it flows southeast into CD-P86. Without an overflow pipe (current Project), CD-P86 could overflow into Cottage Grove (and Gables Lake) under extreme conditions. CD-P85 and CD-P86 do have potential for infiltration; however, the present and long-term firm capacity to infiltrate are not quantified and, therefore, infiltration capacity is not factored into the overall stormwater handling capacity of the CD-P85 and

CD-P86 system (CDSF) in terms of the storm water system design. The Woodbury Plan states that its "Central Draw stormwater will continue through a stormwater drainage system constructed by SWWD to the Mississippi River through the City of Cottage Grove in the future."

The 2030 Regional Development Framework (Metropolitan Council 2006) was written to guide the Council's regional policy plans, and was intended to help ensure the orderly, economical development of the seven-county area and the efficient use of four regional systems: transportation, aviation, water resources (including wastewater collection and treatment) and regional parks and open space. The Council's strategies were organized around four policies: accommodating growth in a flexible, connected and efficient manner; slowing the growth in traffic congestion and improving mobility; encouraging expanded choices in housing locations and types; and conserving, protecting and enhancing the region's vital natural resources. Population forecasts by community have been recently updated by the Metropolitan Council (2012), projecting significant growth in both Cottage Grove (2010: 36,000; 2020: 45,400; 2030: 53,000) and Woodbury (2010: 60,000; 2020: 73,500; 2030: 84,000).

The Washington County 2030 Comprehensive Plan (Washington County 2010) echoed many of the strategies employed by the Metropolitan Council (2006). The Natural Resources and Environmental Protection Plan (contained within the comprehensive plan) set the framework to continue economic growth while protecting natural resources and supporting a high quality of life. Major goals included: utilization of land in a manner that minimizes the impact on the county's natural resources; protection of groundwater and surface water resources through coordination and collaboration with state and local water resources organizations; and preservation, management, and utilization of resources to promote a healthy environment for present and future generations.

The City of Cottage Grove 2030 Comprehensive Plan (2011) set the course for future growth in Cottage Grove and included goals and policies intended to guide decisions on development and redevelopment in the city. The plan also brought together in a single document plans for land use, transportation, utilities, and parks. The primary goals with respect to surface water management included: managing surface and groundwater resources using approaches that meet or exceed regulatory requirements; providing adequate flood protection for residents and structures to protect the integrity of conveyance channels and stormwater detention areas; pursuing the reduction of total phosphorus (TP) and total suspended solids (TSS) loading to water bodies by compliance, municipal management activities, and public education; classifying and effectively managing water bodies in the community to achieve watershed management organization, state, and federal regulatory agency standards; classifying and managing wetlands in the community; and regulating new development and redevelopment activities.

3.2.2 SUMMARY OF BACKGROUND INFORMATION

The Northern Watershed is essentially land-locked (no surface water outlet), with its surface water drainage system terminating at Bailey Lake. For storm events smaller than the 100 year event, Woodbury can accommodate the storm water in its drainage system. However, during larger events the Northern Watershed's lack of a surface water outlet would likely cause large-scale flooding in Woodbury. This reality necessitated installation of a pump station at Bailey Lake to address such low frequency storm events. When operated, the pumped water is conveyed into the CDSF area. The CDSF has been designed to accommodate localized sub-watershed runoff up to the 100-year storm event (24 hour 6.3 inch Type II event).

However, when the Northern Watershed in Woodbury experiences full build-out in the near future, the quantity of stormwater generated will increase the likelihood that the Bailey Lake Pump Station will be operated. Modeling has demonstrated that under extreme precipitation conditions, particularly a series of low-probability precipitation events, several days of pumping from the Bailey Lake lift station to the CDSF would result in water overflowing the CDSF that may cause flooding in areas of Cottage Grove's Central Ravine. There is a need to safely convey overflow from extreme potential runoff events through Cottage Grove. The SWWD, as part of its and its member communities plans, is essentially providing downstream overflow capacity for the Northern Watershed (which also includes a small portion of northern Cottage Grove). A CDSF overflow through the East Ravine was chosen as the preferred of several alternatives.

3.3 PROJECT FEATURE DESCRIPTION

The project is proposed to be constructed in multiple phases. Portions of the project within the CDSF will be completed by developers in coordination with the South Washington Watershed District and the City of Cottage Grove. The upper portion of the overflow pipe built in conjunction with the CSAH 19-20-22 roadway project (referred to as Phase 1 in this document) will be completed in the summer of 2013. Subsequent phases of the project will connect the end of the Phase 1 overflow pipe to the East Ravine. Phase 2 will be completed at an undetermined date subsequent to the CSAH 19-20-22 project. The following sections describe the components of the Project starting from the Bailey Lake Lift Station to the Mississippi River.

3.3.1 PROJECT DESIGN FEATURES

3.3.1.1 Bailey Lake Lift Station Improvements (Completed)

Improvements were made to the Bailey Lake Lift Station by the City of Woodbury. These improvements extended as far north as Bailey Road. The first portion of the improvements included a second storm sewer pipe beneath Bailey Road, connecting a pond at the south end of the

Prestwick Golf Course with the north end of Bailey Lake on the south side of Bailey Road. The pipe allows greater control of the elevation of the water in the Prestwick Golf Course pond. Another element of the project included an additional pipe beneath Dale Road at the south end of Bailey Lake. Additional grading was also done around some of the segments of the panel between Dale Road and the Bailey Lake Lift Station for additional stream capacity. The original Bailey Lake Lift Station, built about 1993, included three large storm water pumps. With the improvement, three additional storm water pumps were installed to increase pump capacity to 150 cfs. In addition, the Bailey Lake Lift Station was improved by flood proofing the building, grading around the building, and adding additional outlets for portable generators. Finally, an additional force main was added in parallel to the existing force main between the Bailey Lake Lift Station and CD-P85.

3.3.1.2 CD-P85 Outlet Structure (Completed)

A controlled overflow structure has been constructed that conveys storm water from CD-P85 into CD-P86N. The area contains poorly graded sands that are susceptible to erosion. Given these soil conditions, it was necessary to construct a culvert, energy dissipater and protected waterway down to the bottom elevation of CD-P86N in order to avoid back cutting and scour. This project provided 356 ac-ft of storage in CD-P85.

3.3.1.3 CD-P86N Grading, CSAH 19 Stabilization and Flow Control Weir (Pending)

The CD-P86 North Lobe (CD-P86N) will contain 600 ac-ft of effective flood storage and offers the potential for additional storm water infiltration capacity. The storage capacity of the basin was created through construction of CSAH-19 roadway embankment across a topographic low area. The following activities may be completed in the future to suit CD-P86N as a storm water facility:

- Modifications to the County Road 19 embankment to make it better suited to detain stormwater *(assessment required at a future date)*
- Creation of an earthen berm between CD-P86N and CD-P86SN. This berm will contain a lined spillway and channel to direct water flow towards the CDSF north and south lobes.

3.3.1.4 CD-P86SN, CD-P86S1, and CD-P86S2 Grading (Pending)

The final configuration of the CD-P86 basins will be determined in coordination with developers. As of August 2013, developers have begun basin grading to meet the storage requirements provided by SWWD while also meeting anticipated development layout needs. The CD-P86 South Lobe will contain approximately 410 ac-ft of effective flood storage in excess of local runoff. The damming of the topographic low by CSAH-22 creates the flood storage capacity of the basin. For storm water to reach the CD-P86 South Lobe, flow must pass underneath Military Road. In 2004, Military Road was raised approximately 3.5 feet to elevation 908.5 to provide cover over the box culvert. This raise was intended to also provide adequate freeboard for wave runup. A 14-foot wide by 10-foot high box culvert was installed through the road to convey floodwater as well as serve as a bike path underpass. There are plans for Cottage Grove to realign Military Road into Ravine Parkway in the future. The preliminary concept for this realignment is shown on Figure 1 (labeled "Ravine Parkway"). All modifications to Military Road will need to account for its embankment to be used as the walls of a detention basin and the associated hydraulic structure will need to pass water freely between the CD-P86SN to CD-P86S1. Grading and scour protection will also be required to ensure that water can flow between the lobes as designed without causing soil erosion. A culvert connection will be provided (by developers) between the CD-P86S1 and S2 basins to allow a bike path to proceed across the CDSF. See Section 5.3 for a more detailed discussion on grading that is to occur in the CDSF.

3.3.2 OVERFLOW PIPE (PHASE 1) PROJECT FEATURES (IN CONSTRUCTION)

3.3.2.1 CSAH 22 Roadway Embankment

The CSAH 22 (70th Street) roadway embankment will be modified as part of the CSAH 19-20-22 reconstruction project. This construction will alter the roadway profile and roadway cross section. The profile is increasing in elevation across the low area which would provide additional freeboard for CDSF storage. The roadway cross section is being widened to accommodate additional lanes. The widening will also have the benefit of improving stability of the embankment for CDSF storage. See Section 5.2.2 for discussion on the suitability of the CSAH 22 roadway embankment for impoundment of water.

3.3.2.2 CSAH 20 Roadway Embankment

CSAH 22 will be extended east of CSAH 19 as a new roadway alignment (CSAH 20). This new alignment will provide a connection to the existing 70th Street alignment to the east after crossing an agricultural field. Local roadway drainage from CSAH 20 will not be drained to the overflow pipe (they are independent systems).

3.3.2.3 CDSF Overflow Pipe

Construction plans for the CDSF Overflow Pipe project are included in Appendix A. From the flared end section inlet on the north side of the CSAH 22 (70th Street) embankment, the pipe will proceed east approximately 600 feet, before crossing to a control structure on the south side of the embankment. The control structure contains gates which will regulate flows from the CDSF basin. When the gates are in the normal closed position, water would pond in the CDSF. Opening of the control structure gates would allow water to flow through the overflow pipe system to the East Ravine. From the control structure, the overflow pipe alignment proceeds east along the south edge of the new CSAH 22 roadway alignment, crosses CSAH 19, proceeds further east along the south side of the new CSAH 20, and eventually turns to the south into the East Ravine.

Phase 1 of the pipe alignment is to be established from the southern end of the CDSF to a location approximately 30 feet north of the southern property line for the "Goebel, Thomas A & Mary Ann" parcel. The Phase 1 pipe will be temporarily bulkheaded rather than outletted to the surface. Accordingly, the gates in the overflow pipe control structure will not be opened until after Phase 2 is constructed. Phase 2 of the project will involve removing the temporary bulkhead, and continuing the overflow pipe alignment so that it connects to the East Ravine. Due to the bulkhead and incomplete routing of the overflow pipe during Phase 1, there will be no outflow of stormwater to the East Ravine until after Phase 2 of the project is completed.

The Phase 1 overflow pipe alignment is approximately 5,780 feet long. The 72" RCP alignment will have cover depths ranging from 4 feet to 38 feet. Due to the presence of utilities, there will be two locations where the pipe will need to be jack and bored.

Phase 2 of the overflow pipe alignment will be approximately 5,690 feet long and would be the final phase of construction which would allow water to flow through East Ravine to the Mississippi River.

3.3.2.4 Control Structure

The 72" RCP leading from the CDSF to the control structure will be installed so that the invert of the 72" RCP at the control structure is at an elevation higher than the inlet of the 72" RCP at the flared end section in the CDSF. Under low flow conditions, ditch flows along the south side of CSAH 22 will enter the control structure and flow back to the CDSF for infiltration. Under high flows in the northern watershed, the CDSF will fill with water, and water will flow through the reverse-grade 72" RCP leading to the control structure where the position of gates in the open or closed position will determine if additional water will be stored in the CDSF or if the water will be diverted to the East Ravine. See Sections 5.4.1 and 5.6.2 for additional discussion on the control structure.

4.0 PERTINENT DATA

4.1 PAST STUDIES USED IN SUPPORT OF THE CURRENT PROJECT

There have been numerous studies, investigations, and preliminary designs related to this project. A summary of the most pertinent documents are listed in Table 1. The first report listed, "SWWD Engineer's Report: Central Draw Project and Flood Storage Area Maps", contains references to additional engineering documents.

TABLE 1 PREVIOUS STUDIES, INVESTIGATIONS AND DESIGN PERTINENT TO THE CDSF AND ASSOCIATED OUTLET

Document Title	Document Type	Author	Date Issued	Description
Central Draw Project and Flood Storage Area Maps	SWWD Engineer's Report	HDR Engineering	June 2002	The Engineers Report that presents the Central Draw Project to correct existing flooding conditions with associated flood storage areas identified. This information was used as a minor plan amendment by the SWWD plan to allow for project implementation.
City of Woodbury Bailey Lake Discharge Facility Operating Plan	Operating Plan	Bonestroo, Rosene, Anderlik and Associates	April 18, 2005-DRAFT	Draft operating plan for the Bailey Lake Lift Station
Cottage Grove East Ravine Alternative Urban Areawide Review (AUAR) and Mitigation Plan	AUAR	Hoisington Koegler Group	March 6, 2006-Final Draft Document	Plan for City of Cottage Grove
Coordination of the Proposed Ravine Parkway with the Central Draw Overflow Project	SWWD Memorandum	HDR Engineering	April 30, 2007	Evaluation of Central Ravine impacts to Central Draw Overflow Project.
Central Draw project grading update	SWWD Memorandum	HDR Engineering	May 29, 2007	Updated CDSF grading plans.
Model Update and Analysis Report: Central Draw and Bailey Lake Watersheds	SWWD Report	HDR Engineering	November 2007	Modeling evaluation for Central Draw.

Document Title	Document Type	Author	Date Issued	Description
City of Cottage Grove Storm Water Management Plan	Storm Water Plan		2008	Plan for the City of Cottage Grove that addresses future storm water infrastructure.
City of Woodbury Surface Water Management Plan	Surface Water Management Plan	Bonestroo	April 2009	Surface Water Management Plan for the City of Woodbury that addresses the future storm water infrastructure.
City of Woodbury 2030 Comprehensive Plan	Comprehensive Plan		May 2009	Comprehensive plan for the City of Woodbury that addresses the land use anticipated for by the year 2030.
Central Draw Storage Facility Outlet Pipe Design Phase I, Model Updates and Results	SWWD Memorandum	HDR Engineering	July 2, 2009	Discusses the updates completed to the Central Draw Storage Facility model. These updates were Phase 1 of the two-part project to develop preliminary plans for the outflow from the Central Draw Storage Facility (CDSF) to the East Ravine. The model updates were necessary to size the outflow infrastructure and ensure that local runoff impacts are accurately considered in the outflow rate and volume.

Document Title	Document Type	Author	Date Issued	Description
Outlet Pipe Design for Central Draw Storage Facility (CDSF) Phase II - Alignment, Profile and Size Selection and Evaluation of the Impacts to East Ravine	SWWD Memorandum	HDR Engineering	August 5, 2009	Discusses Phase II of the two-part project to develop preliminary plans for the outflow from the Central Draw Storage Facility (CDSF) to the East Ravine. It contains the preliminary selection and evaluation of the capacity, alignment, and profile for the CDSF outlet and its subsequent downstream impacts to the East Ravine.
City of Cottage Grove 2030 Comprehensive Plan	Comprehensive Plan		February 2011	Comprehensive plan for the City of Cottage Grove that lays out the land use anticipated for by the year 2030.
Data Report of Geotechnical Exploration, CSAH 19-20-22 and SWWD Overflow Outlet	Geotechnical Report	American Engineering Testing, Inc.	December 28, 2011	Contains information related to soil borings taken for overflow pipe project.
Seepage Analysis of Temporary Flood Condition	SWWD Memorandum	HDR Engineering	September 24, 2012	Describes seepage analysis performed for CSAH 22 roadway embankment.
CDSF Outlet Configuration Memorandum	SWWD Memorandum	HDR Engineering	September 28, 2012	Explains the alternatives evaluation performed for the control structure.

Document Title	Document Type	Author	Date Issued	Description
Report of Geotechnical Exploration, Added Borings 1A to 4A	Geotechnical Report Supplement	American Engineering Testing, Inc.	January 18, 2013	This is a supplement to the December 28, 2011 document.
Supplemental update to the Central Draw Storage Facility outlet design and impacts to the East Ravine in the City of Cottage Grove	SWWD Memorandum	HDR Engineering	August 9, 2013	Provides discussion on impacts to the East Ravine due to the CDSF and local inflows from anticipated development

4.1.1 Central Draw Project and Flood Storage Area Maps

The Central Draw Project and Flood Storage Area Maps "Engineer's Report" was developed by HDR Engineering for the SWWD in June, 2002. It proposed the Central Draw Project as a solution to correct existing flooding conditions and identifies flood storage areas. This information was used as a minor plan amendment by the SWWD plan to allow for project implementation. It contains the plan set "Implementation of Central Draw Overflow – Phase I CD-P86 Outlets and Embankment Improvements". This plan set has the original grading plan concept for the CDSF.

4.1.2 City of Woodbury Bailey Lake Discharge Facility Operating Plan

The 2005 Draft Bailey Lake Discharge Facility Operating Plan (Operating Plan) was developed for the City of Woodbury by Bonestroo, Rosene, Anderlik and Associates on April 18, 2005. This Operating Plan lays out operating routines for activation of the pumps in series, starting with single pump operation up to a five pump scenario. Since design of the CDSF is based on an extreme events (the Design Storm), the focus of this report is on the five pump operating routine.

This Operating Plan provides a pump plan interim to the construction of the CDSF outlet. This plan assumes a storage capacity with the CDSF of 1,510 ac-ft and provides fill times for various pump rates from Bailey Lake.

4.1.3 COTTAGE GROVE EAST RAVINE ALTERNATIVE URBAN AREAWIDE REVIEW (AUAR) AND MITIGATION PLAN

This is the Cottage Grove AUAR that lays out the proposed development in the CDSF and East Ravine. It provides both the anticipated year 2030 land use and associated storm water infrastructure. It is a basis for determining the design for the CDSF.

4.1.4 COORDINATION OF THE PROPOSED RAVINE PARKWAY WITH THE CENTRAL DRAW OVERFLOW PROJECT

This Memorandum was developed by HDR Engineering for the SWWD in April, 2007. It presents a review of the impacts the proposed Ravine Parkway would have on the grading plan and subsequent storage potential of the CDSF. This memorandum contains a draft grading plan within the SWWD ownership boundaries that account for the Ravine Parkway.

4.1.5 CENTRAL DRAW PROJECT GRADING UPDATE

This Memorandum was developed by HDR Engineering for the SWWD in May, 2007. It presents the revised grading plan (revised from the 2002 Engineer's report) for the CDSF based on SWWD property boundaries. It also presents the water surface elevations for the Design Storm consequent to this update.

4.1.6 MODEL UPDATE AND ANALYSIS REPORT: CENTRAL DRAW AND BAILEY LAKE WATERSHEDS

This report was developed by HDR Engineering for the SWWD in November, 2007. It addresses five primary concerns:

1) Confirmation of a need for an overflow from the CDSF system to the East Ravine or Central Ravine
2) When does the overflow need to be constructed?
3) What is the minimum required capacity for the overflow from the CDSF?
4) What are the impacts the surface water management plans for Cities of Woodbury and Cottage Grove on the CDSF?
5) Can the CDSF function as a local storm water management facility?

To answer these questions, multiple modeling scenarios were executed. The following were carefully analyzed to help with interim management of storm runoff: volume allocation, volume optimization, and pumping rules. Several modeling scenarios were constructed according to the following:

- The revised CDSF storage volume within the SWWD property boundary is 1350 ac-ft
- The total permitted volume that can be pumped from Bailey Lake is approximately 1500 ac-ft
- The Bailey Lake pump station permit document lists elevation 878-ft as the peak stage at Bailey Lake for the design event
- The pump station is flood proofed to an elevation of 885-ft
- Available storage volume within the CDSF is 1810 ac-ft when CDP-86 is allowed to bounce to an elevation of 906
- The storage volume within Bailey Lake between elevation 873 and 878 is approximately 500 ac-ft
- The storage volume within Bailey Lake between elevation 878 and 880 is approximately 750 ac-ft
- The anticipated land use and infrastructure for future development is represented by the SWMPs for their respective cities

The main points discussed within this report were:

- The rate and volume of runoff from the Bailey Lake watershed moderately increased for the proposed conditions reflected in the surface water management plan. The outlet structure planned for the Danner gravel pit in the surface water management plan leaves excess, unused storage that can be maximized by installing a revised outlet structure design
- The Bailey Lake pump station, when operated without any flow restrictions, forces approximately 2200-ac-ft of volume into CDP-85, spread over a fourteen day period during a 6.3-inch 24-hour design rain event. This volume results in uncontrolled overflows across 70th Street in Cottage Grove
- The available storage volume at Bailey Lake can be used by optimizing the operations at the pump station during a 6.3-inch, 24-hour event. When pumping is controlled, the water surface elevations in the CDSF system would stay below the maximum overflow elevations without uncontrolled overflows. However, the water surface elevations would exceed target elevations and ponded areas would encroach onto current flowage easements. The current configuration and the proposed grading plan configuration for the CDP-86 basins can accommodate a 6.3-inch, 24-hour event with no expected uncontrolled overflows if the Bailey Lake pump station has optimized operating rules
- Storm runoff volumes for the 6.3- and 7.8-inch, 24-hour events from the direct drainage areas affecting the CDSF, without pumping from Bailey Lake, is contained within the

CDSF without uncontrolled overflows. In this scenario, the basins work to manage the local runoff. Base flood elevations are contained below the target elevations for the basins under the proposed grading plan

- Uncontrolled overflows across 70th Street would result under a 7.8-inch, 24-hour event or back to back 100-year 6.3-inch, 24-hour events even when pumping is controlled at Bailey Lake. In light of the probabilities of these events occurring, the construction of an overflow does not present an immediate or emergency need. However, it is strongly recommended that an implementation plan for an overflow be compiled so that one can be funded, planned, designed, and constructed within a reasonable time span such as the next 3 to 5 years
- The proposed concept plan for the Ravine Parkway will have significant impacts to CDSF storage volumes and the manner in which the CDSF functions. These impacts were discussed in a separate memorandum that is included in Appendix B of the 2007 report.

The report presented the following:

- The Central Draw Storage Facility needs an overflow pipe to provide an adequate level of protection for the watershed. Present modeling indicates a 48-inch diameter pipe capacity, at a minimum, is required to adequately convey the overflow
- It is recommended that an implementation plan for overflow be compiled so that one can be funded, planned, designed, and constructed within the next 3 to 5 years
- The surface water management plans for both Cities of Woodbury and Cottage Grove maintain peak flow rates within the exiting values but, result in moderate increases in runoff volume from the contributing watersheds. Controlled and managed pumping from Bailey Lake can increase the functionality of the Central Draw Storage Facility
- The Central Draw Storage Facility can contain the 100-year runoff from the immediate watershed. Hence, the CDSF can function as a local storm water management facility within the immediate CDSF contribution drainage areas

4.1.7 City of Cottage Grove Storm Water Management Plan

This document discusses the practices and municipal programs that the City of Cottage Grove is implementing in order to promote healthy watersheds. This document discusses planning, management, engineering, and regulation of the stormwater utility for areas within jurisdictional limits.

4.1.8 CITY OF COTTAGE GROVE 2030 COMPREHENSIVE PLAN

This 2030 Comprehensive Plan (2030CP) for the City of Cottage Grove lays out the land use anticipated by the year 2030. It is a basis for design of the CDSF.

4.1.9 CITY OF WOODBURY 2030 COMPREHENSIVE PLAN

This 2030 Comprehensive Plan (2030CP) for the City of Woodbury lays out the land use anticipated by the year 2030. It is the basis of reason for the predicted future operation of the Bailey Lake Lift Station and therefore a basis for design of the CDSF.

4.1.10 CENTRAL DRAW STORAGE FACILITY OUTLET PIPE DESIGN PHASE I, MODEL UPDATES AND RESULTS

This memorandum was developed by HDR Engineering for the SWWD in July 2009 and discusses the updates completed to the Central Draw Storage Facility model. These updates were Phase 1 of the two-part project to develop preliminary plans for the outflow from the Central Draw Storage Facility (CDSF) to the East Ravine. The model updates were necessary to size the outflow infrastructure and to accurately consider local runoff impacts in the outflow rate and volume. Phase 1 consisted of updates to the CDSF model, documentation of the results and impacts to the CDSF system, and revisions to finalize assessment point flow rates for inflows to the CDSF. This portion of the project increased the reliability of the CDSF model which is important to design the outlet structure to the East Ravine.

The geometry was modified for the majority of links and nodes in the model, which created flow rate and water surface elevation variations from the Cottage Grove SWMP model. There were some impacts to local storage facilities and infrastructure, as noted in the memorandum. The inflow volume from Cottage Grove to the CDSF increased by approximately 6 acre-feet and is currently accommodated within the available storage. It was recommended that these changes be considered for the planned/proposed infrastructure and future developments in the area.

4.1.11 OUTLET PIPE DESIGN FOR CENTRAL DRAW STORAGE FACILITY (CDSF) PHASE II - ALIGNMENT, PROFILE AND SIZE SELECTION AND EVALUATION OF THE IMPACTS TO EAST RAVINE

This Memorandum was developed by HDR Engineering for the SWWD in August, 2009, and discussed Phase II of the two-part project to develop preliminary plans for the outflow from the Central Draw Storage Facility (CDSF) to the East Ravine. It contains the preliminary selection and evaluation of the capacity, alignment, and profile for the CDSF outlet and its subsequent downstream impacts to the East Ravine.

This memorandum discussed the modeling and analysis completed in support of determining the elevation of and the pipe size for the outlet. Potential impacts to the East Ravine resulting from connecting the CDSF were analyzed during this project. Further analysis of potential impacts will be required during the detailed design phase of the outlet pipe project. Tasks completed during this effort and presented in sequence are:

1. Develop profiles for the outlet pipe based on the previously selected alignment
2. Setting the outlet elevation and pipe size for the outlet from the CDSF and modeling analysis
3. Determine the impacts of 7.8-inch rainfall event and a back-to-back design event at the CDSF through modeling analysis
4. Update the existing conditions model for the East Ravine to reflect the land use and infrastructure presented in the AUAR modeling analysis.
5. Evaluate potential impacts of connecting the CDSF to the East Ravine through modeling analysis

The results generated by the tasks listed above suggested the following conclusions:

- The Central Draw Storage Facility needs an outlet pipe to provide an adequate level of protection for the watershed.
- It was recommended that an implementation plan for an outlet be compiled so that one can be funded, planned, designed, and constructed within the next 3 to 5 years.
- An outlet pipe with a 4-foot diameter and an invert elevation of 896 feet at the CDSF will meet the design requirements for the design event.
- Local storm events up to a 5-year return period level can be contained within the CDSF.
- A 5-foot diameter pipe will provide an added factor of safety during extreme precipitation conditions such as 7.8-inch and back-to-back events. The 4-foot diameter pipe size is sufficient to maintain peak stage at the CDSF without exceeding the BFE and over topping elevation at 70th street.
- The incremental cost difference between installing a 4-ft pipe and a 5-ft pipe is 5% or approximately $750,000.
- Planned land use and stormwater infrastructure changes represented in the AUAR for the East ravine result in significant increased to peak flow rates.
- Impacts of outflow from the CDSF on the peak flow rates through the East Ravine are minimal. This is due to the approximate six day delay in outflow from the CDSF.
- Though the flow rate is lower than the peak flows caused by local runoff, outflow from the CDSF can continue for over seven days.

- When modeling back-to-back storms over the CDSF and East Ravine drainage areas, the peak flow rates discharging from the CDSF into the East Ravine do not coincide with the peak flow rates generated within the East Ravine drainage area due to the much faster hydrologic response of the East Ravine watershed.
- A combination of high flow rates and subsequent extended duration flow could have adverse impacts along the East Ravine Park.

4.1.12 DATA REPORT OF GEOTECHNICAL EXPLORATION, CSAH 19-20-22 AND SWWD OVERFLOW OUTLET

This is a geotechnical report provided by American Engineering Testing. The report provides soil boring data along the overflow pipe alignment.

4.1.13 REPORT OF GEOTECHNICAL EXPLORATION, ADDED BORINGS 1A TO 4A

This is a supplement to the original geotechnical report provided by American Engineering Testing. The supplement provides a summary of the findings from four supplemental soil borings. The purpose of the four new borings was to better define the elevation of sandstone in the vicinity of the Northern Natural Gas crossing. It was determined that the sandstone was deep enough that the jack and bore operation that would be required underneath the Northern Natural Gas crossing will likely not encounter sandstone.

5.0 ENGINEERING STUDIES, INVESTIGATIONS AND DESIGN

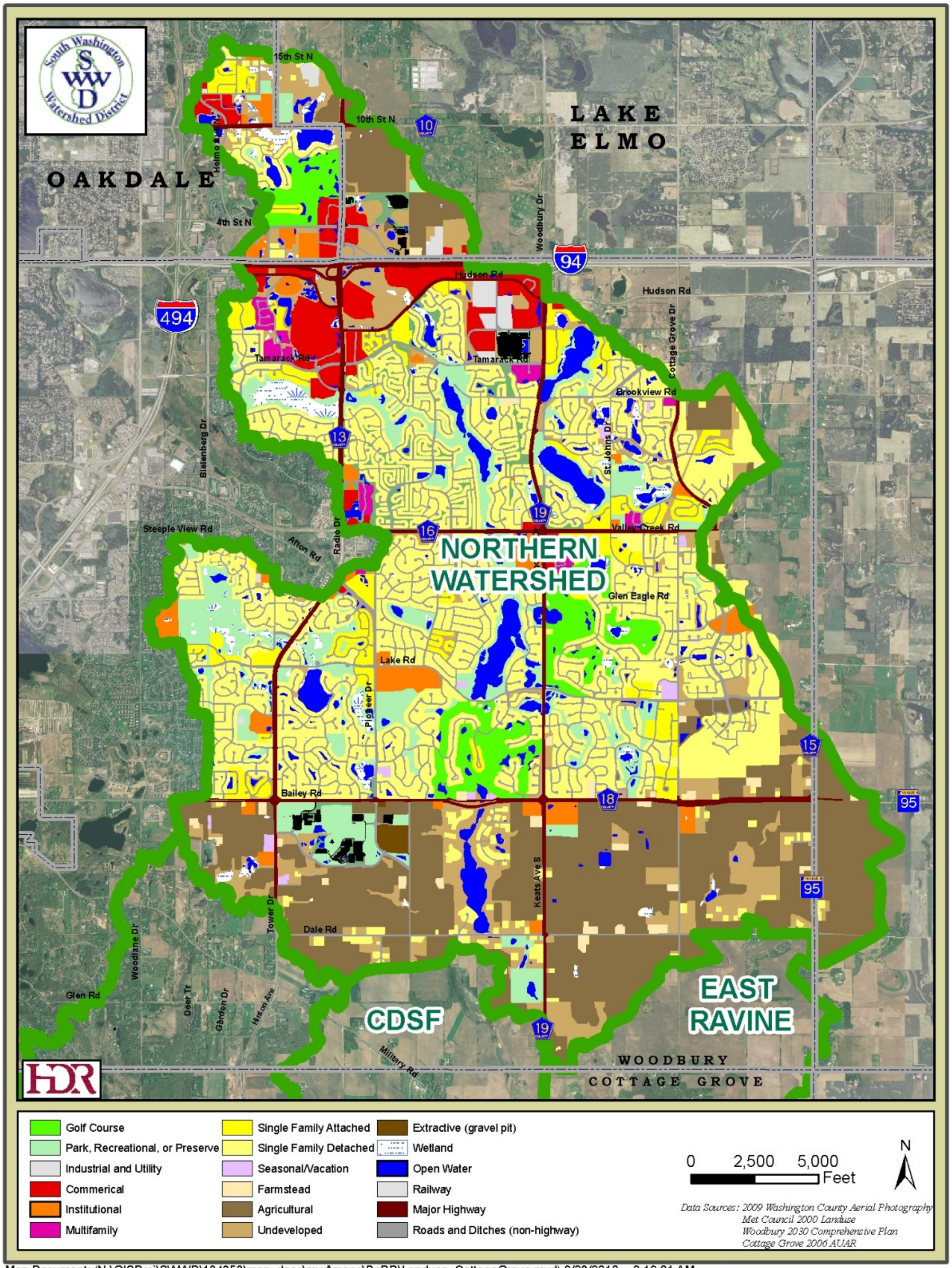
5.1 PROPOSED OUTFLOW FROM THE BAILEY LAKE LIFT STATION

A critical aspect of designing the CDSF and the associated overflow pipe outlet is determining the design storm conditions for outflow from the Bailey Lake Lift Station. This outflow is dependent on estimates of future flows to Bailey Lake under ultimate development conditions. The hydrologic evaluation used to estimate future flows is described below.

5.1.1 FUTURE LAND USE AND STORM WATER INFRASTRUCTURE IN THE NORTHERN WATERSHED

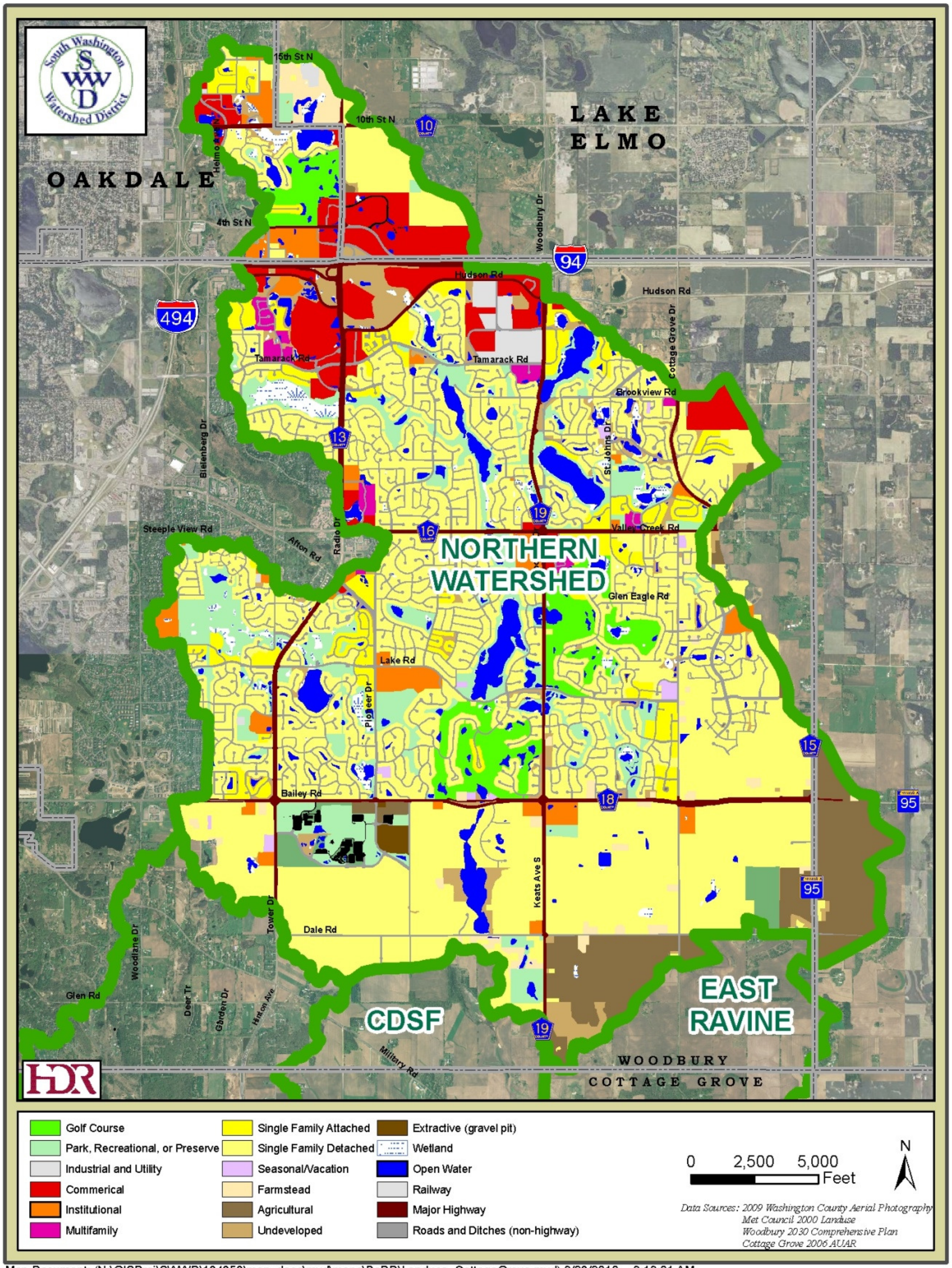
Although a significant portion of the City of Woodbury is developed, the area draining directly to Bailey Lake is still predominantly agricultural (Figure 2). The Woodbury 2030 Comprehensive Plan (2009) and Surface Water Management Plan (2009) indicate that the Bailey Lake watershed will be developed (Figure 3) and for currently land locked internal depressions and watersheds to become hydraulically connected to Bailey Lake (Figure 4). The connection of landlocked areas will add approximately 2,150 acres from the area which lies generally south of Bailey Road to the Cottage Grove border and extends from west of Radio Drive to east of Woodbury Drive. The proposed development is all residential except for the community-scale commercial area at the southwest corner of Radio Drive and Bailey Road, across from the Bielenberg Sports Center and a small neighborhood commercial center at the northeast corner of Dale Road and Woodbury Drive. This anticipated development involves enough land planned for residential use to accommodate an average annual growth rate of approximately 600 units per year over the ten-year period from 2010 to 2020. This accounts for a significant increase in surface water runoff volume from storms in the Northern Watershed.

FIGURE 2 EXISTING LAND USE FOR THE NORTHERN WATERSHED



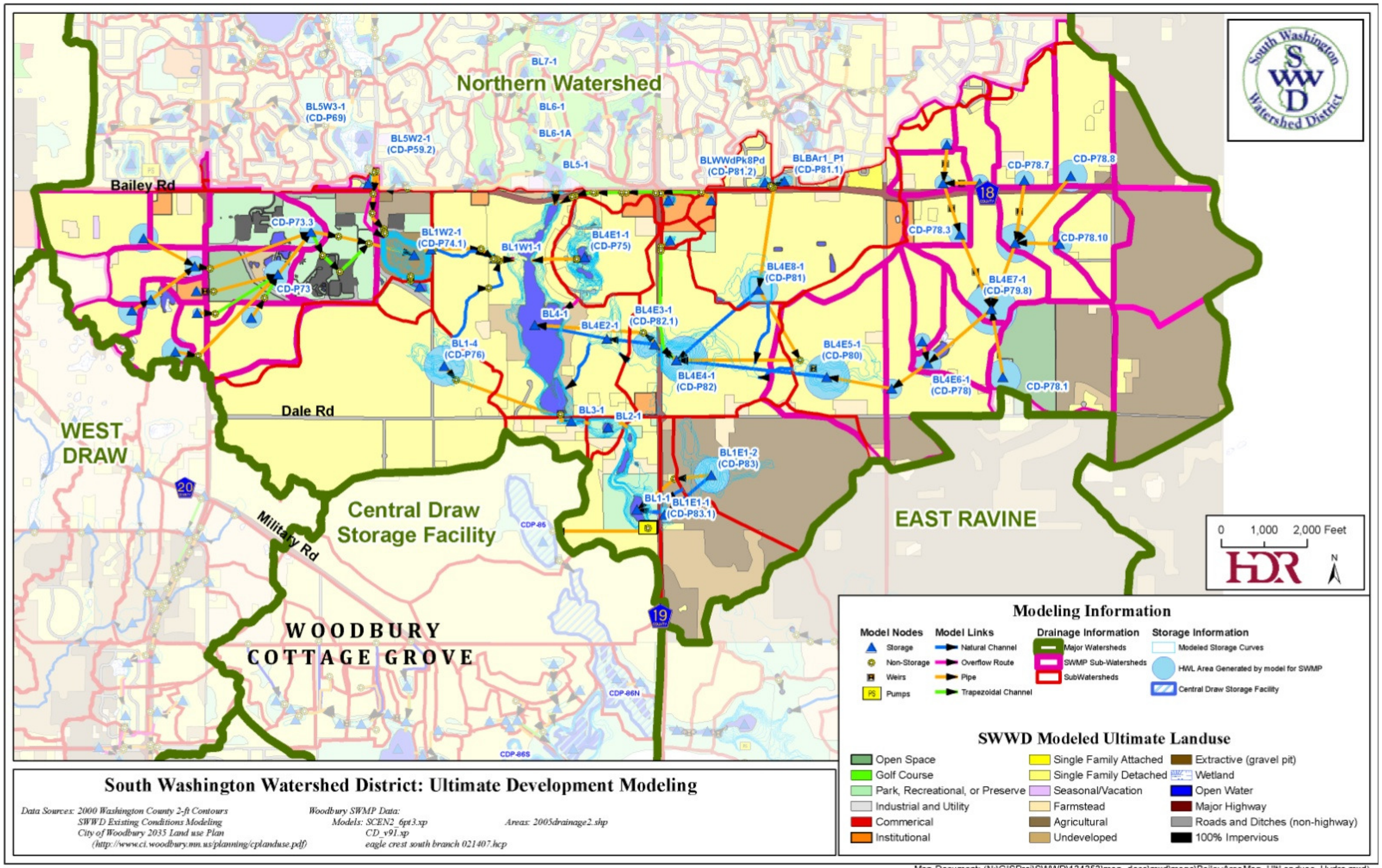
Map Document: (N:\GISProj\SWWD\134353\map_docs\mxd\maps\BoDR\Landuse_CottageGrove.mxd) 9/23/2010 – 9:19:01 AM

FIGURE 3 ULTIMATE BUILD OUT LAND USE FOR THE NORTHERN WATERSHED



Map Document: (N:\GISProj\SWWD\134353\map_docs\mxd\maps\BoDR\Landuse_CottageGrove.mxd) 9/23/2010 – 9:19:01 AM

FIGURE 4 PROPOSED INFRASTRUTURE DRAINING INTO BAILEY LAKE ACCORDING TO THE 2009 WOODBURY SURFACE WATER MANAGEMENT PLAN



5.1.2 Flow from the Bailey Lake Lift Station

The method for estimating future flows to the Bailey Lake lift station is to represent future land use and storm water infrastructure conditions in an ultimate build-out XP-SWMM model entitled ***NWS_030109Ult_BLModelelPmp_CDBaileyinflowDivON.xp.*** This model was developed based on the following:

- The model used to develop the Bailey Lake Lift Station hydrograph represents the Ultimate build-out conditions for Northern Watershed of the South Washington Watershed District.
- The model is a modification of the SWWD Existing Conditions watershed model with a date tag of March 3, 2009. The existing conditions model reflects the best available information provided to the SWWD by the Cities of Woodbury, Oakdale and Lake Elmo prior to March 3, 2009.
- The model incorporates the projected ultimate land use conditions in the Northern Watershed as presented on the Woodbury 2030 Comprehensive Plan (May 2009) and the Metropolitan Council Regional Planned Land use GIS file (October 2003).
- The model contains the planned infrastructure changes to the Bailey Lake Sub-watersheds as presented in the Woodbury Surface Water Management Plan models provided by the City of Woodbury. These models and the date in which they were received are listed in Table 2.

TABLE 2 LIST OF MODEL SOURCES FROM THE CITY OF WOODBURY USED BY HDR ENGINEERING TO DEVELOP THE ULTIMATE BUILD-OUT MODEL

Model Name	Model Platform	Impact Area	Date Provided
eagle crest south branch 021407.hcp	HydroCAD	Eagle Crest area to the east of Bailey Lake	June 13, 2007
SCEN2_6pt3.xp	XP-SWMM	East Ridge High School	June 13, 2007
CD_v91.xp	XP-SWMM	Connections to Bailey Lake south of Bailey Road	June 9, 2010

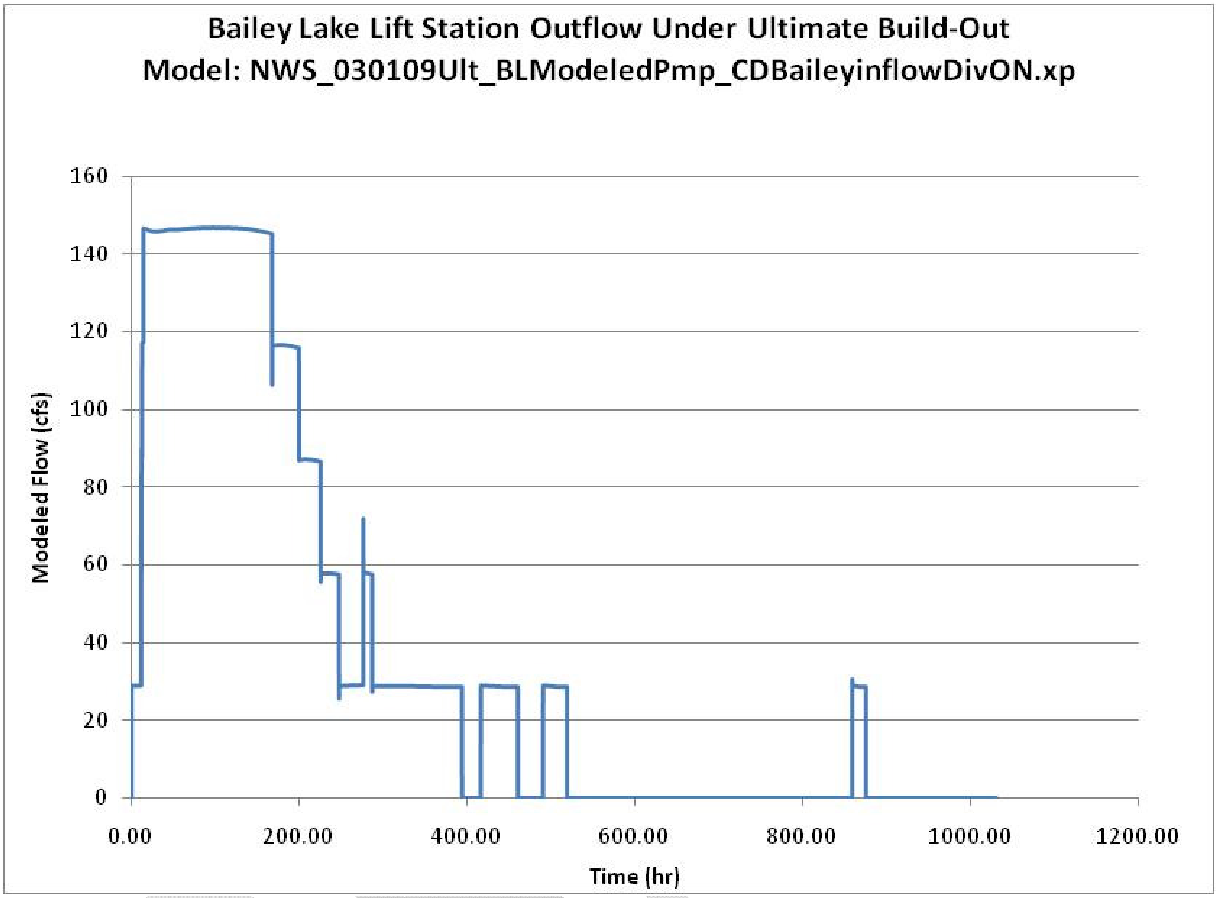
The Bailey Lake Lift Station is permitted to pump 1,510 acre-feet of water, which is equivalent to about a constant rate of 30 cfs over 25 days or 150 cfs over 5 days. Under ultimate build-out conditions, the Bailey Lake Lift Station would pump a volume of 3,100 acre-feet. The ultimate build-out model is used to generate the pump hydrograph shown in Figure 5 and defines the upstream boundary condition for designing the CDSF and its outlet. Since the Bailey Lake Lift Station is limited to 150 cfs, the increased volume is reflected in duration of pumping rather than peak flow. It is foreseen under the 2030 plan that the Bailey Lake Lift Station could discharge for a period in excess of 20 days under the current operating routine without any restrictions.

The increase of water volume that will require pumping from Bailey Lake is in excess of the storage capacity of the CDSF. Two possible scenarios exist under future conditions should an outlet to the CDSF not be constructed:

1. If pumping continues to be restricted under the current Operating Plan, there is a risk of flooding in the Northern Watershed.
2. If the Bailey Lake Lift Station is allowed to pump Bailey Lake down to its Ordinary Water Level, the CDSF will flood.

Construction of the CDSF outlet is therefore necessitated by the City of Woodbury's 2030 Comprehensive Plan. Timing of the Bailey Lake area development is contingent on the construction of the CDSF outlet and overflow.

FIGURE 5 OUTFLOW HYDROGRAPH FROM THE BAILEY LAKE LIFT STATION UNDER ULTIMATE BUILD-OUT CONDITIONS



5.2 THE FUTURE LAND USE, STORM WATER INFRASTRUCTURE, DESIGN AND OPERATIONS IN THE CDSF

The Cottage Grove 2030 comprehensive plan provides guidance for future development within its jurisdictional boundary. This land use and infrastructure development has significant impact due to the use of the CDSF as a facility for local development and runoff.

5.2.1 FUTURE LAND USE AND STORM WATER INFRASTRUCTURE IN THE CDSF

The area downstream of Bailey Lake that drains to the CDSF is predominantly agricultural (Figure 6). Development of the area immediately north of CSAH 22 into residential lots is underway at the time of this writing. The Woodbury 2030 Comprehensive Plan (2009), the Cottage Grove AUAR (2006), and the Cottage Grove 2030 Comprehensive Plan (2008) propose that the CDSF become predominantly single family residential housing with a small mix of commercial property (Figure 7) that drains both directly into the CDSF basins (CD-P85 and CD-P86N) and into the proposed storm water infrastructure in the City of Cottage Grove.

The implication of the Cottage Grove AUAR (2006) and Comprehensive (2008) plans, along with the Woodbury Comprehensive plan (2009), is that the function of the CDSF becomes one of storing local runoff and not just an overflow as was called for in the original 2002 SWWD plan. The Woodbury and Cottage Grove plans also affect the timing of the CDSF construction. The CDSF watershed cannot undergo its planned development until an outlet and overflow to the CDSF has been constructed.

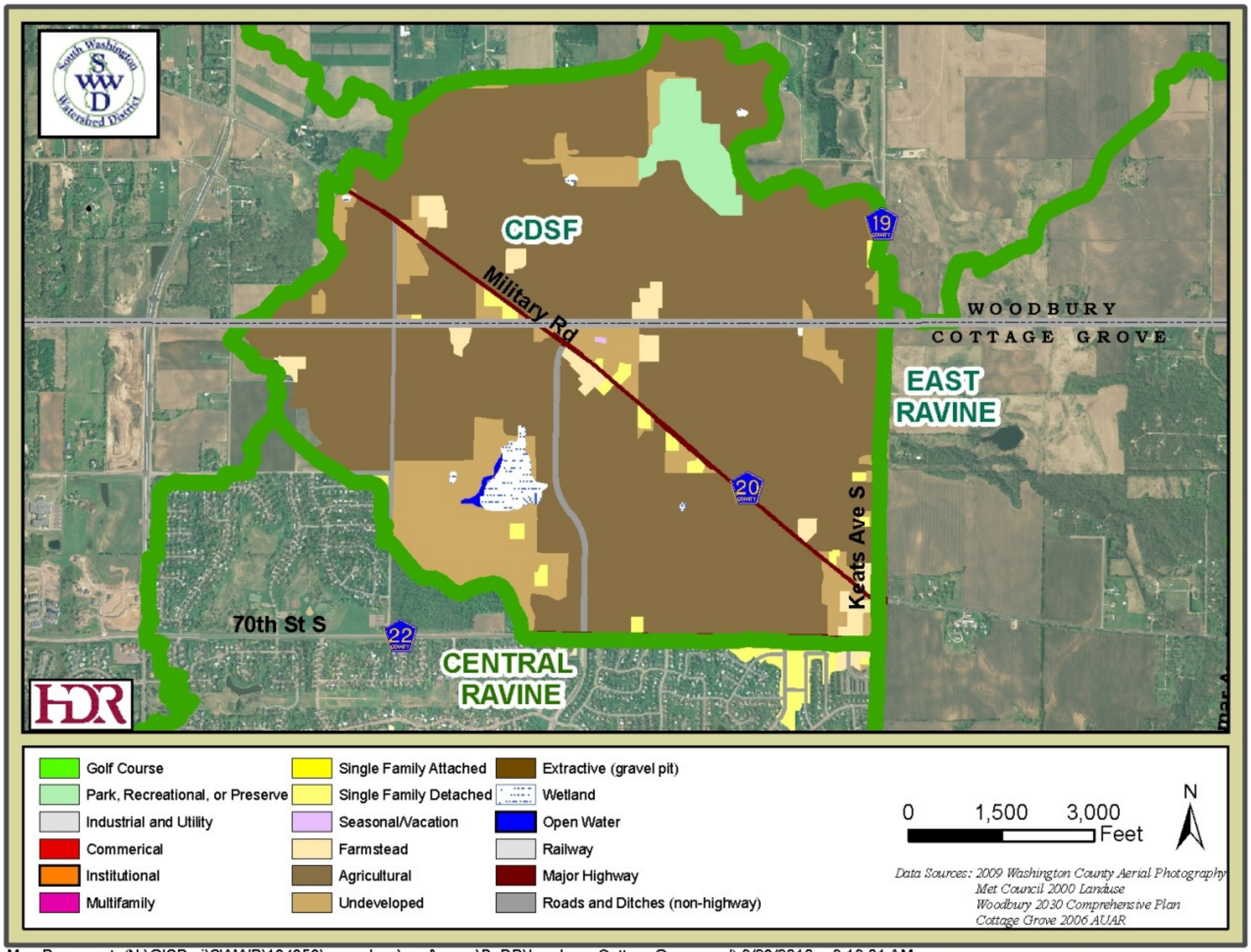
5.2.2 IMPOUNDMENT OF WATER BY ROADWAY EMBANKMENTS

Water within the CDSF will temporarily pond against CSAH 19 and CSAH 22. The portion of CSAH 22 roadway embankment detaining water was evaluated as part of the Phase 1 overflow pipe project. It was determined that the proposed roadway embankment (with standard roadway cross section) would be sufficient for temporarily detaining water in the CDSF. The analysis confirmed that a clay liner is not required on the upstream side of the embankment. The plans do, however, require removal of an abandoned culvert that is located beneath the roadway fill. Removal of this pipe will eliminate a potential seepage path. A summary of the roadway embankment analysis for CSAH 22 is provided in Appendix B.

The granular bedding around the overflow pipe was evaluated as a potential seepage path since the overflow pipe crosses through the CSAH 22 roadway embankment. It was determined that due to the ponding elevations in the CDSF and the relatively high ground elevation at the control structure (where the overflow pipe crosses the CSAH 22 roadway embankment), there would not be a significant risk of embankment failure due to seepage along the overflow pipe.

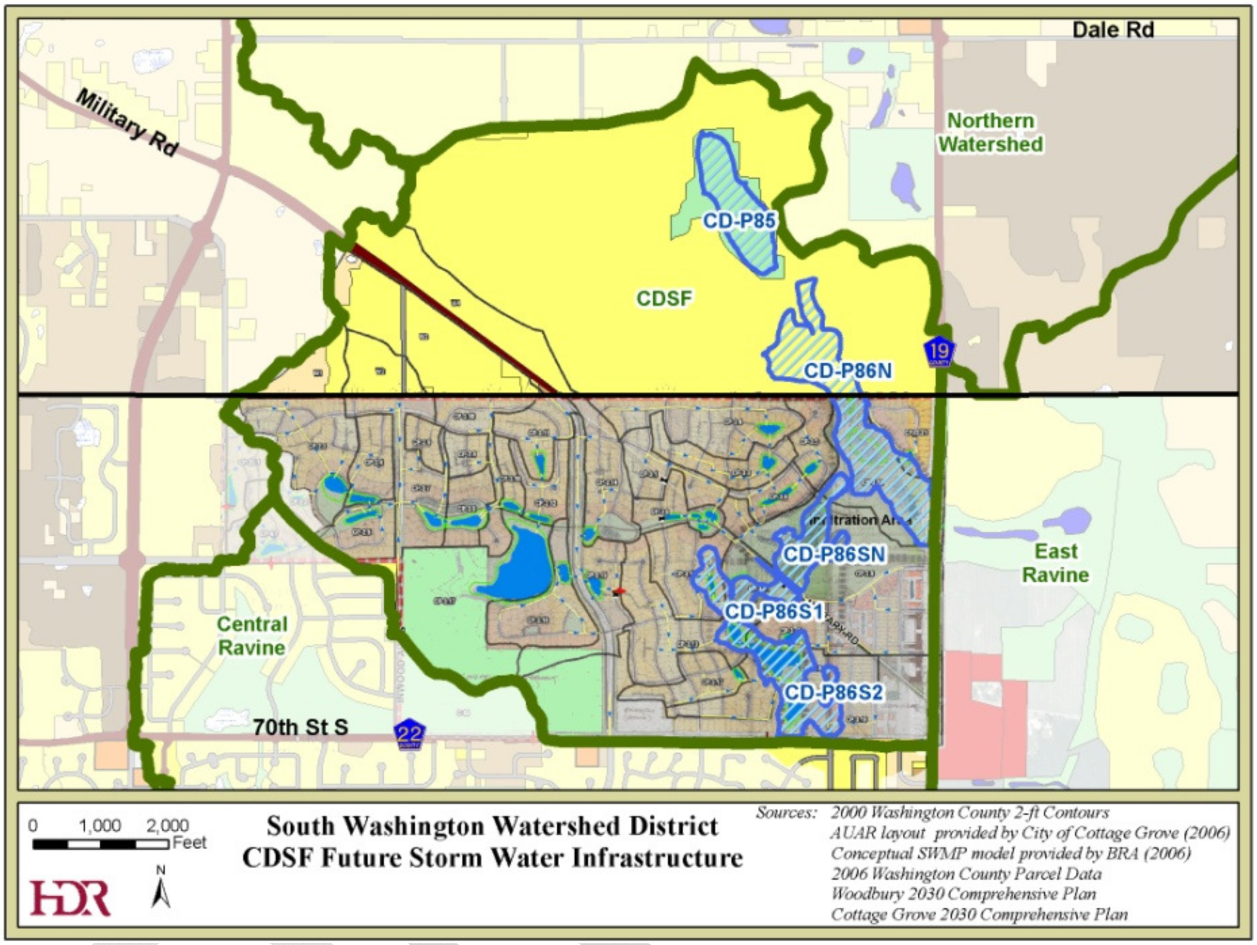
Evaluation of the CSAH 19 embankment has not yet been completed.

FIGURE 6 EXISTING LAND USE FOR THE CENTRAL DRAW STORAGE FACILITY



Map Document: (N:\GISProj\SWWD\134353\map_docs\mxd\maps\BoDR\Landuse_CottageGrove.mxd) 9/23/2010 – 9:19:01 AM

FIGURE 7 PROPOSED LAND USE AND INFRASTRUCTURE FOR THE CENTRAL DRAW STORAGE FACILITY



5.3 CDSF GRADING PLAN

The current basins north of CSAH 22 exist as natural depressions connected via overflows are and bounded by both the natural landscape and existing roads. The boundaries of the natural basins do not conform to property lines and do not maximize storage potential. It is therefor necessary to grade the CDSF to both maximize this storage and to contain water within the property boundaries of the SWWD. The City of Cottage Grove has conceptual plans for construction of a new Ravine Parkway at the location of the present day Military Road separating CD-86SN from CD-P86S1 (Figure 1, labeled "Ravine Parkway"). This Parkway is not in the Cottage Grove AUAR but is mentioned in the Cottage Grove Comprehensive Plan. Two separate grading plans and associated storage curves were therefore generated both with and without construction of Ravine Parkway.

A first iteration of preliminary CDSF grading plans was generated for the 2002 Engineering Report (Section 4.1.1). A second iteration of the grading plan was then generated in 2007 (Sections 4.1.4 and 4.1.5) to conform to SWWD property boundaries. The 2007 draft grading plan for the condition without construction of Ravine Parkway is shown in Figure 8 and Figure 9. The 2007 draft grading plan that includes construction of Ravine Parkway is shown in Figure 10 and Figure 11. Grading plans were not generated for the other CDSF basins on the assumption that existing topography and subsequent storage potential will be maintained. With the 2007 grading plans, a significant amount of storage was lost. This loss of storage means that the CDSF require an outlet and overflow, not just an emergency overflow.

Table 3 provides a breakdown of the target storage elevations and storage volumes for the five sub-basins that comprise the CDSF storage basins for both grading plans. Generally, the maximum target stage that keeps the stored water within the property boundaries is at an approximate elevation of 902-ft for storage areas CDP-86SN, CDP-86S1, and CDP-86S2 (southern areas of the CDP-86 basin). Based on these target elevations, the total storage volume available within the project after implementation of the grading plan is approximately 1,366 ac-ft without the Ravine Parkway and 1,232 ac-ft with the Ravine Parkway (under the 2007 grading concepts). Currently the City of Woodbury is allowed to pump 1,500 ac-ft of water, supporting the need to develop interim pumping scenarios at Bailey Lake (for use by the City of Woodbury), and update the operational parameters for the proposed CDSF basin overflow.

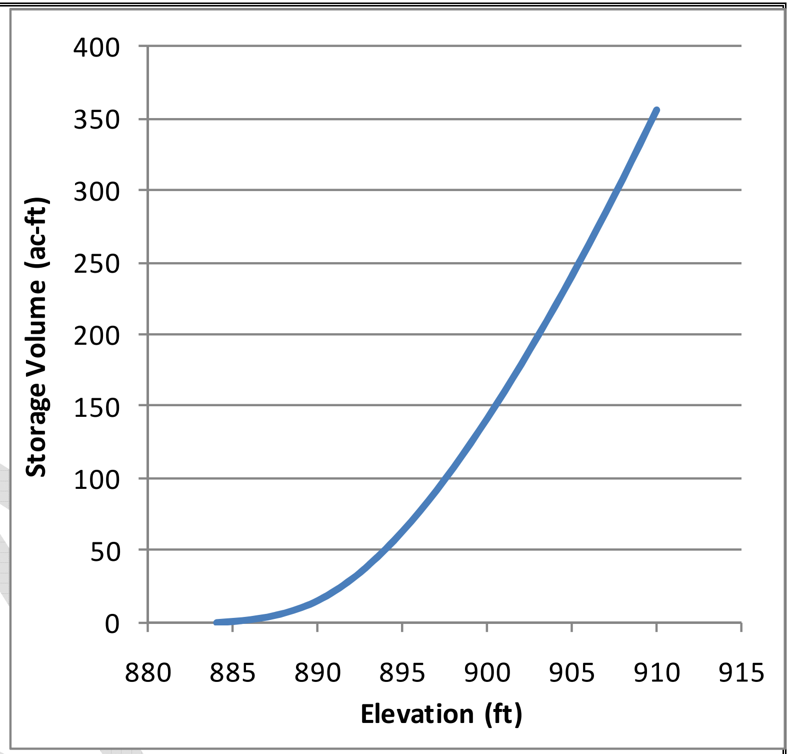
TABLE 3 CDSF STORAGE VOLUMES (GRADING PLANS INCORPORATED)

Basin	Target Flood Storage Elevation	Storage Volume without Ravine Parkway (ac-ft)	Storage Volume-with Ravine Parkway (ac-ft)
CDP-85	910	356	356
CDP-86N	904	600	600
CDP-86SN	902	174	99
CDP-86S1	902	130	71
CDP-86S2	902	107	106
TOTAL		1366	1232

Table 4 and Table 5 present the existing storage curves for CD-P85 and CD-P86N, respectively. These storage curves are based on the year 2000 Washington County 2-foot contours and are not expected to change under future conditions.

TABLE 4 STORAGE CURVE FOR CD-P85 (EXISTING AND PROPOSED)

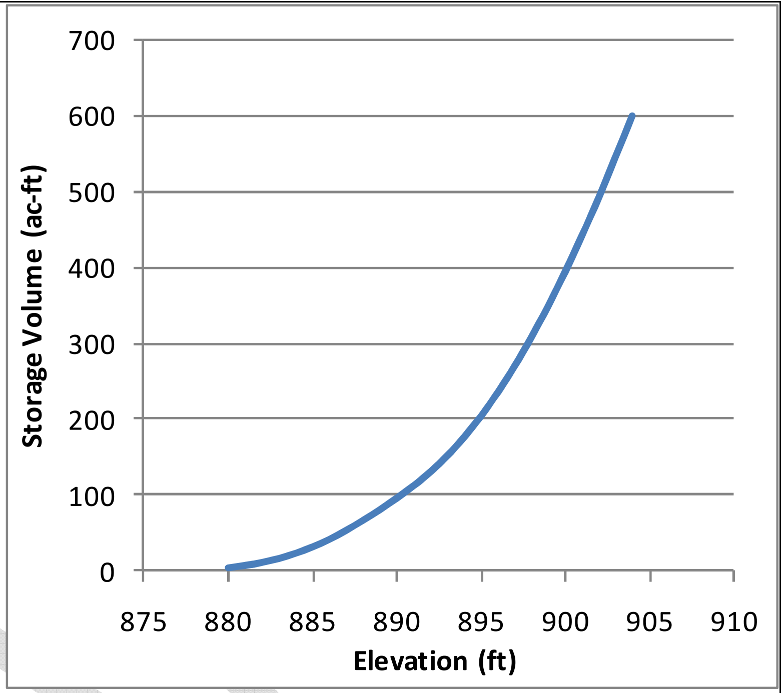
CDSF Storage Basin:		CD-P85	
Outlet Elevation:			
Overflow Elevation:		910	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	884	0.5	0.0
2	886	1.6	2.1
4	888	3.0	6.7
6	890	5.8	15.5
8	892	9.1	30.4
10	894	11.8	51.3
12	896	14.2	77.3
14	898	16.3	107.7
16	900	18.0	142.0
18	902	19.5	179.4
20	904	20.8	219.8
22	906	22.1	262.7
24	908	23.3	308.2
26	910	24.5	356.0
Storage Volume from the basin bottom to the overflow (ac-ft):		356	



Storage Curve developed from Washington County Contours (2000).

TABLE 5 STORAGE CURVE FOR CD-P86N (EXISTING AND PROPOSED)

CDSF Storage Basin:		CD-P86N	
Outlet Elevation:		904	
Overflow Elevation:		904	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
2	880	2.6	4.0
4	882	4.5	11.1
6	884	7.5	23.2
8	886	10.9	41.6
10	888	14.1	66.6
12	890	15.2	95.9
14	892	19.1	130.2
16	894	26.5	175.8
18	896	32.6	234.8
20	898	40.0	307.4
22	900	46.1	393.4
24	902	51.6	491.1
26	904	56.7	599.4
Storage Volume from the basin bottom to the overflow (ac-ft):		600	

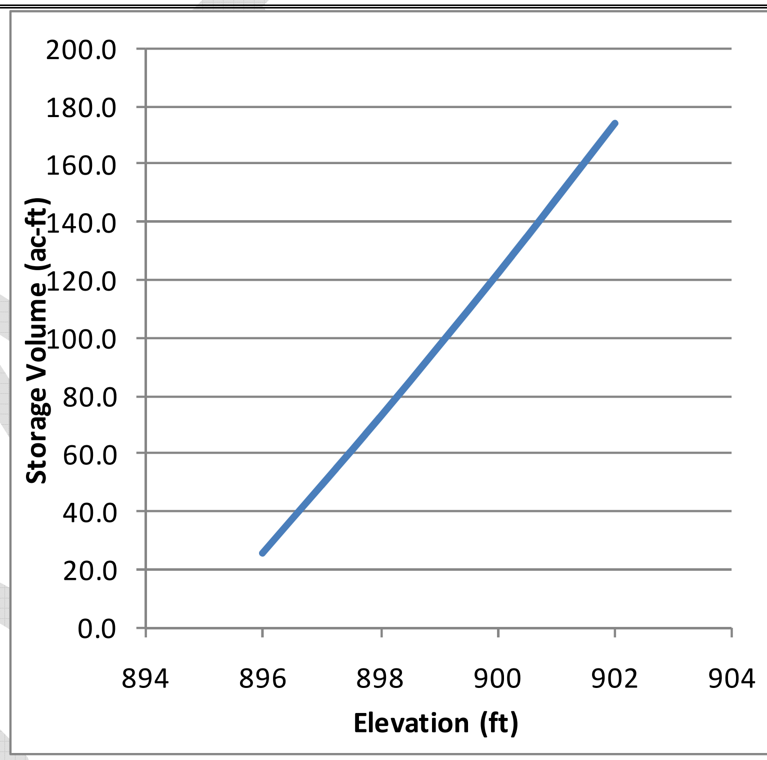


Storage Curve developed from Washington County Contours (2000).

Table 6, Table 7, and Table 8 present the proposed storage curves for CD-P86SN, CD-P86S1 and CD-P86S2, respectively, without construction of the proposed Ravine Parkway. These storage curves are based on maximizing storage capacity within the SWWD ownership boundaries. Generally the maximum target stage that keeps the stored water within the property boundaries is at an approximate elevation of 902 for storage areas CDP-86SN, CDP-86S1, and CDP-86S2. Therefore elevation 902 is the upper extent presented for their respective storage curves.

TABLE 6 STORAGE CURVE FOR CD-P86SN (PROPOSED) WITHOUT RAVINE PARKWAY

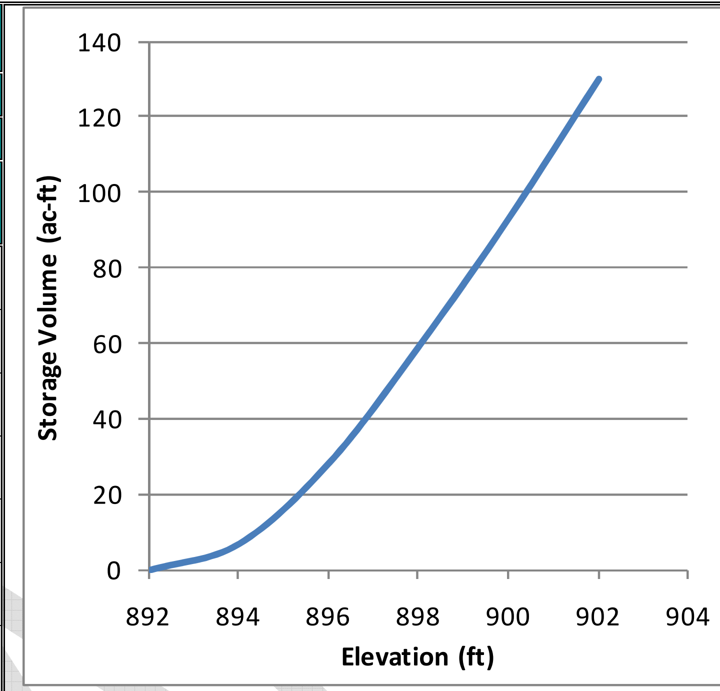
CDSF Storage Basin:		CD-P86SN	
Outlet Elevation:		894.2	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
2	896	22.9	25.6
4	898	24.1	72.6
6	900	25.3	122.0
8	902	26.6	173.9
Storage Volume from the basin bottom to the overflow (ac-ft):		174	



Storage Curve developed from the SWWD grading plan without Ravine Parkway.

TABLE 7 STORAGE CURVE FOR CD-P86S1 (PROPOSED) WITHOUT RAVINE PARKWAY

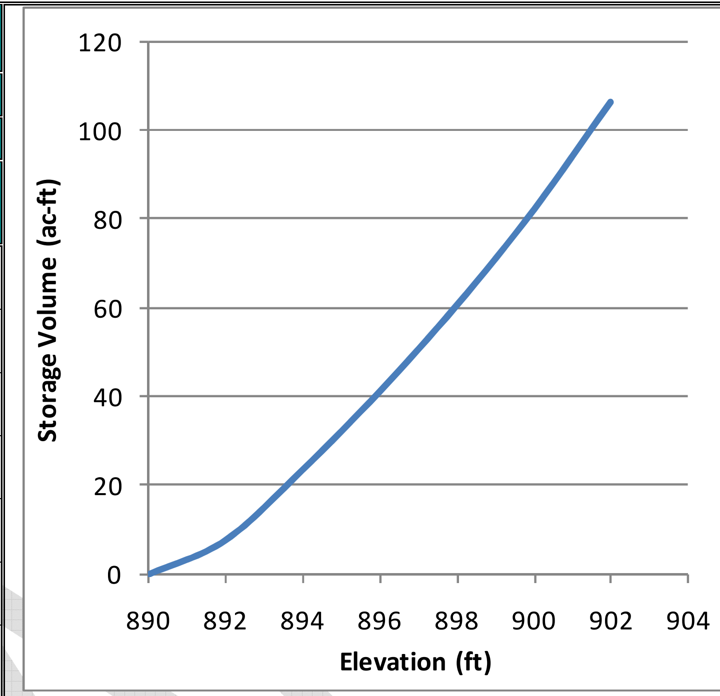
CDSF Storage Basin:		CDP86-S1	
Outlet Elevation:		892	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	892	0.3	0
2	894	6.7	7.0
4	896	14.7	28.4
6	898	16.3	59.4
8	900	17.7	93.4
10	902	19.2	130.3
Storage Volume from the basin bottom to the overflow (ac-ft):		130	



Storage Curve developed from the SWWD grading plan without Ravine Parkway.

TABLE 8 STORAGE CURVE FOR CD-P86S2 (PROPOSED) WITHOUT RAVINE PARKWAY

CDSF Storage Basin:		CDP86-S2	
Outlet Elevation:		Unknown	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	890	0.2	0
2	892	7.5	7.7
4	894	8.4	23.6
6	896	9.3	41.2
8	898	10.1	60.6
10	900	11.4	82.2
12	902	12.9	106.6
Storage Volume from the basin bottom to the overflow (ac-ft):		107	

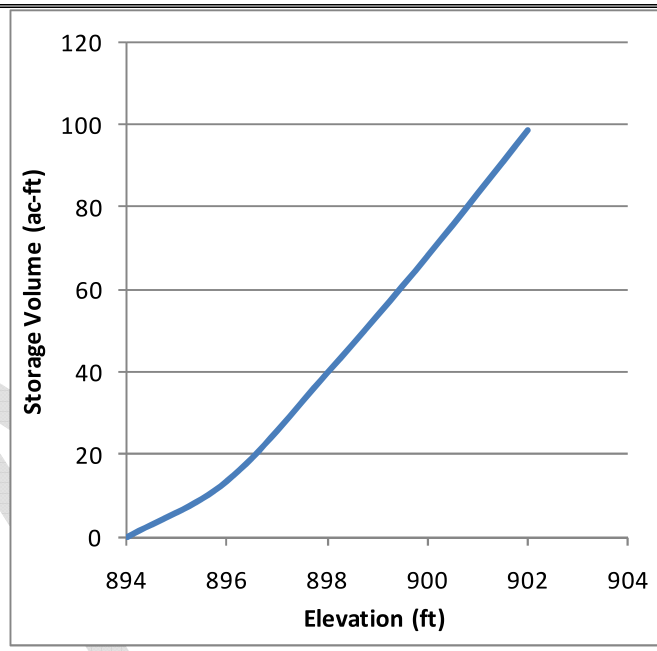


Storage Curve developed from the SWWD grading plan without Ravine Parkway.

Table 9, Table 10, and Table 11 present the proposed storage curves for CD-P86SN, CD-P86S1 and CD-P86S2, respectively, with construction of the proposed Ravine Parkway. These storage curves are also based on obtaining the greatest storage capacity possible within the SWWD ownership boundaries. As with the grading plans without Ravine Parkway, the maximum target stage that keeps the stored water within the property boundaries is at an approximate elevation of 902 feet.

TABLE 9 STORAGE CURVE FOR CD-P86SN (PROPOSED) WITH RAVINE PARKWAY

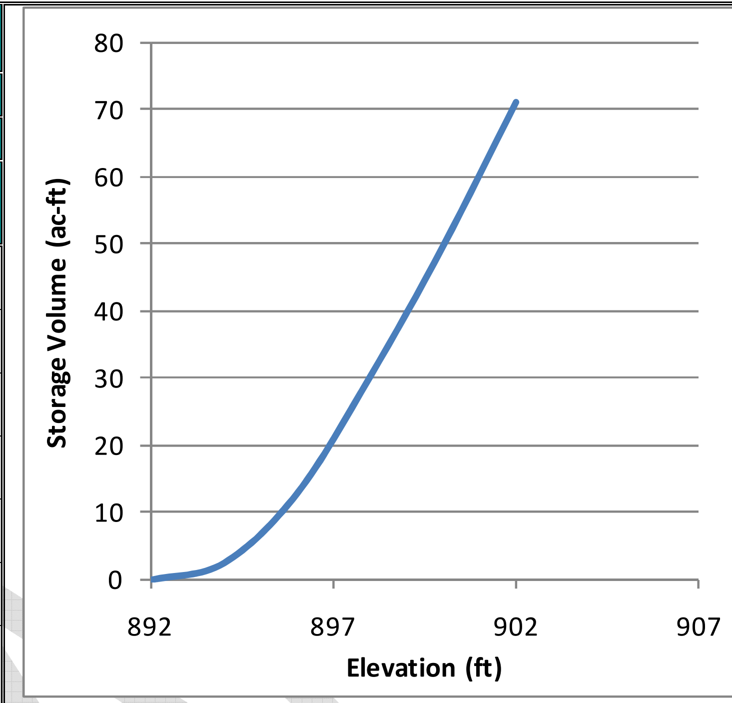
CDSF Storage Basin:		CD-P86SN	
Outlet Elevation:		894.2	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	894	1.1	0
2	896	12.6	13.6
4	898	13.6	39.8
6	900	14.7	68.1
8	902	15.8	98.6
Storage Volume from the basin bottom to the overflow (ac-ft):		99	



Storage Curve developed from the SWWD grading plan with Ravine Parkway.

TABLE 10 STORAGE CURVE FOR CD-P86S1 (PROPOSED) WITH RAVINE PARKWAY

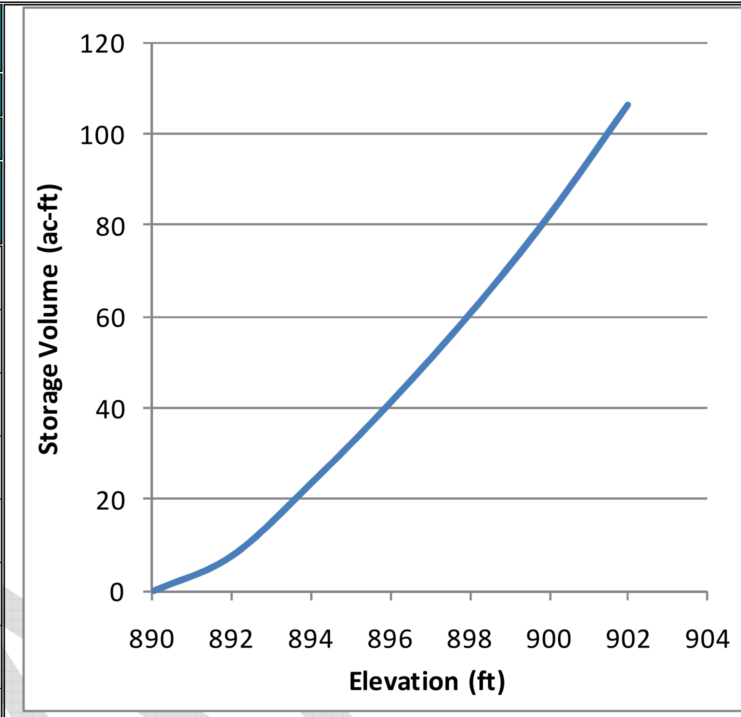
CDSF Storage Basin:		CDP86-S1	
Outlet Elevation:		892	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	892	0.3	0
2	894	2.2	2.5
4	896	8.2	12.9
6	898	9.2	30.3
8	900	10.2	49.7
10	902	11.2	71.1
Storage Volume from the basin bottom to the overflow (ac-ft):		71	



Storage Curve developed from the SWWD grading plan with Ravine Parkway.

TABLE 11 STORAGE CURVE FOR CD-P86S2 (PROPOSED) WITH RAVINE PARKWAY

CDSF Storage Basin:		CDP86-S2	
Outlet Elevation:		Unknown	
Overflow Elevation:		902	
Depth (ft)	Elevation	Area (ac)	Volume (ac-ft)
0	890	0.2	0
2	892	7.5	7.7
4	894	8.4	23.6
6	896	9.3	41.2
8	898	10.1	60.6
10	900	11.4	82.2
12	902	12.9	106.6
Storage Volume from the basin bottom to the overflow (ac-ft):		107	



Storage Curve developed from the SWWD grading plan with Ravine Parkway.

FIGURE 8 CDSF GRADING PLAN FOR CD-86SN (WITHOUT THE COTTAGE GROVE RAVINE PARKWAY)

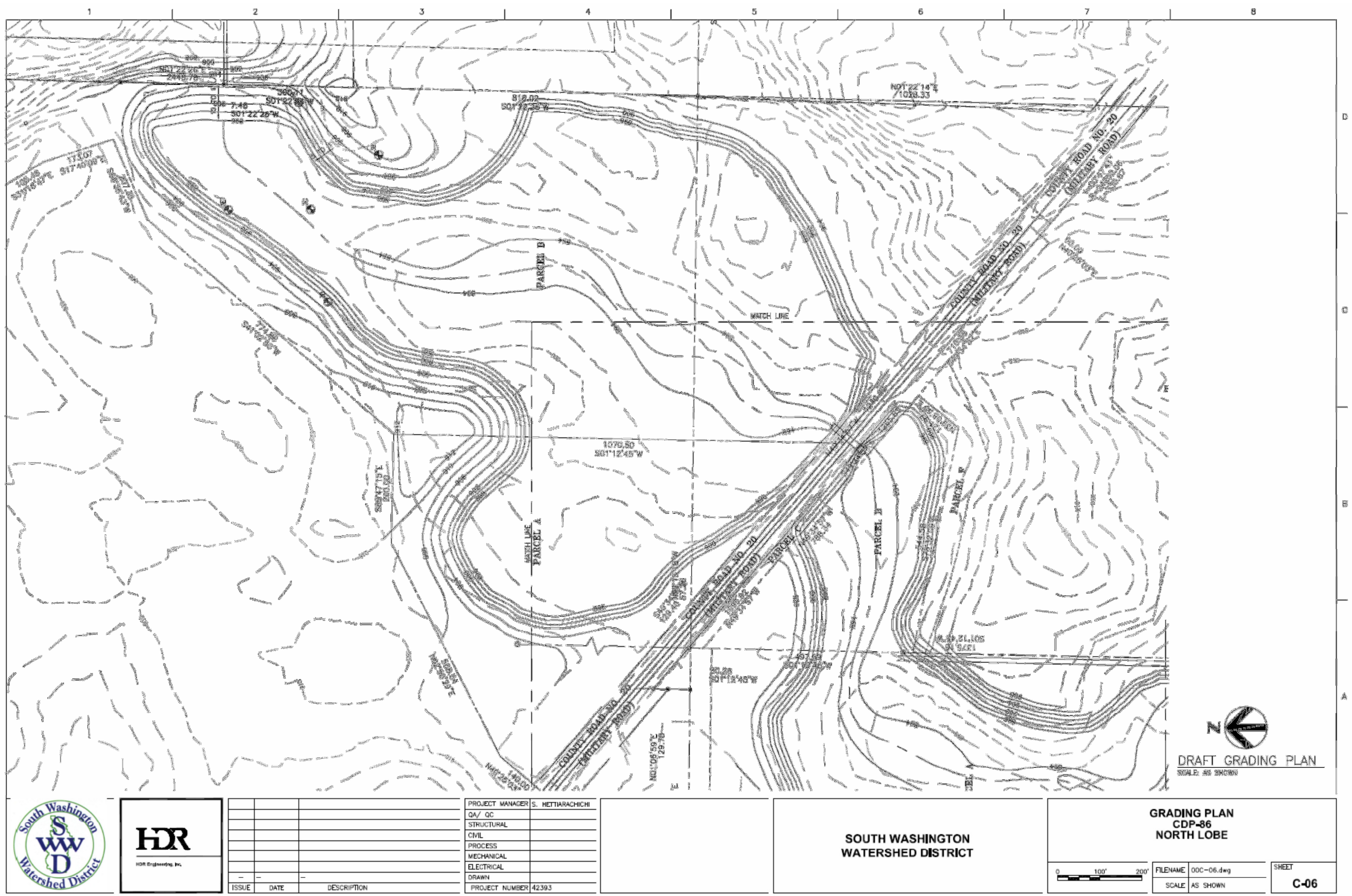


FIGURE 9 CDSF GRADING PLAN FOR CD-P86S1 AND CD-PS2 (WITH THE COTTAGE GROVE RAVINE PARKWAY)

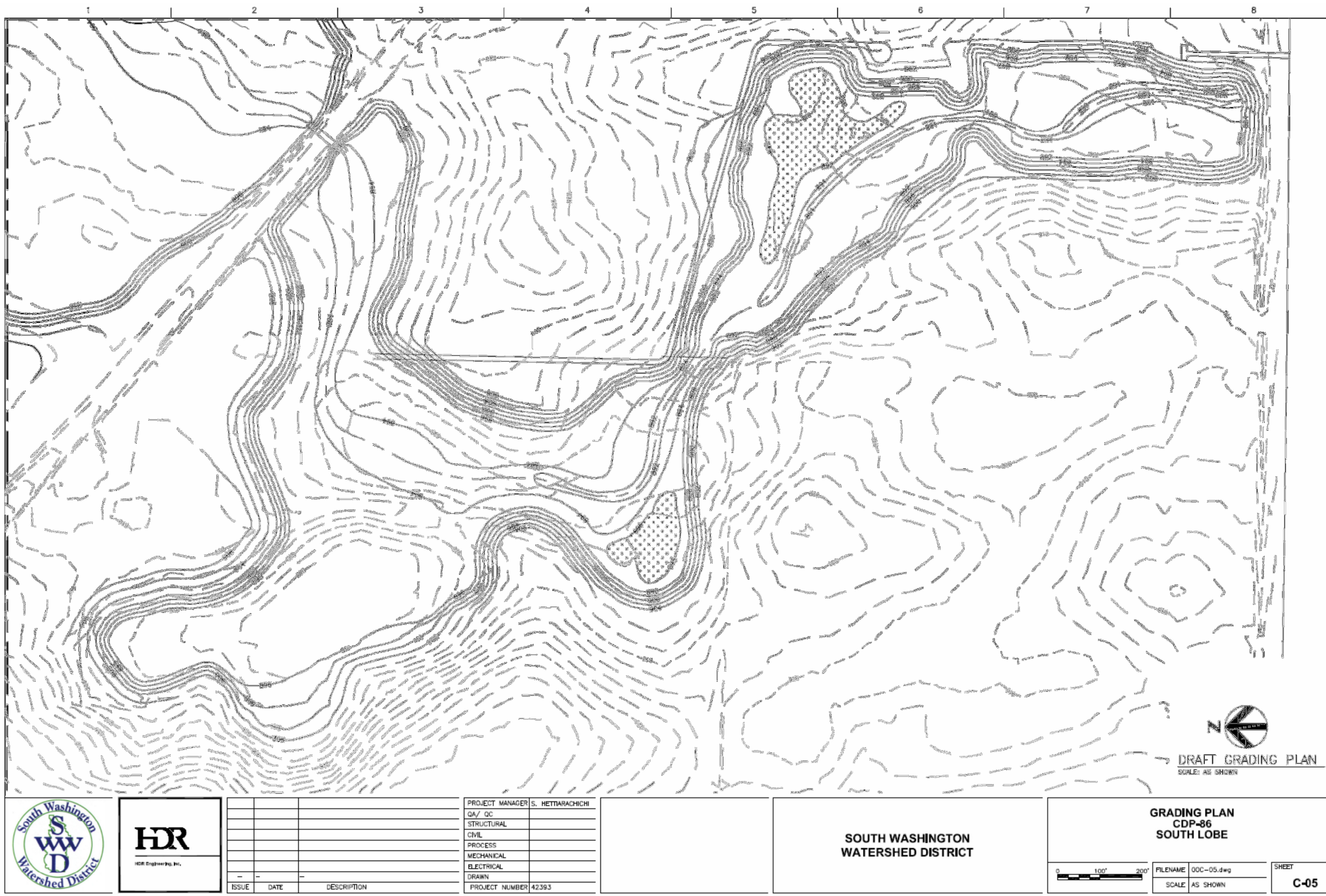


FIGURE 10 CDSF GRADING PLAN FOR CD-86SN (WITH THE COTTAGE GROVE RAVINE PARKWAY)

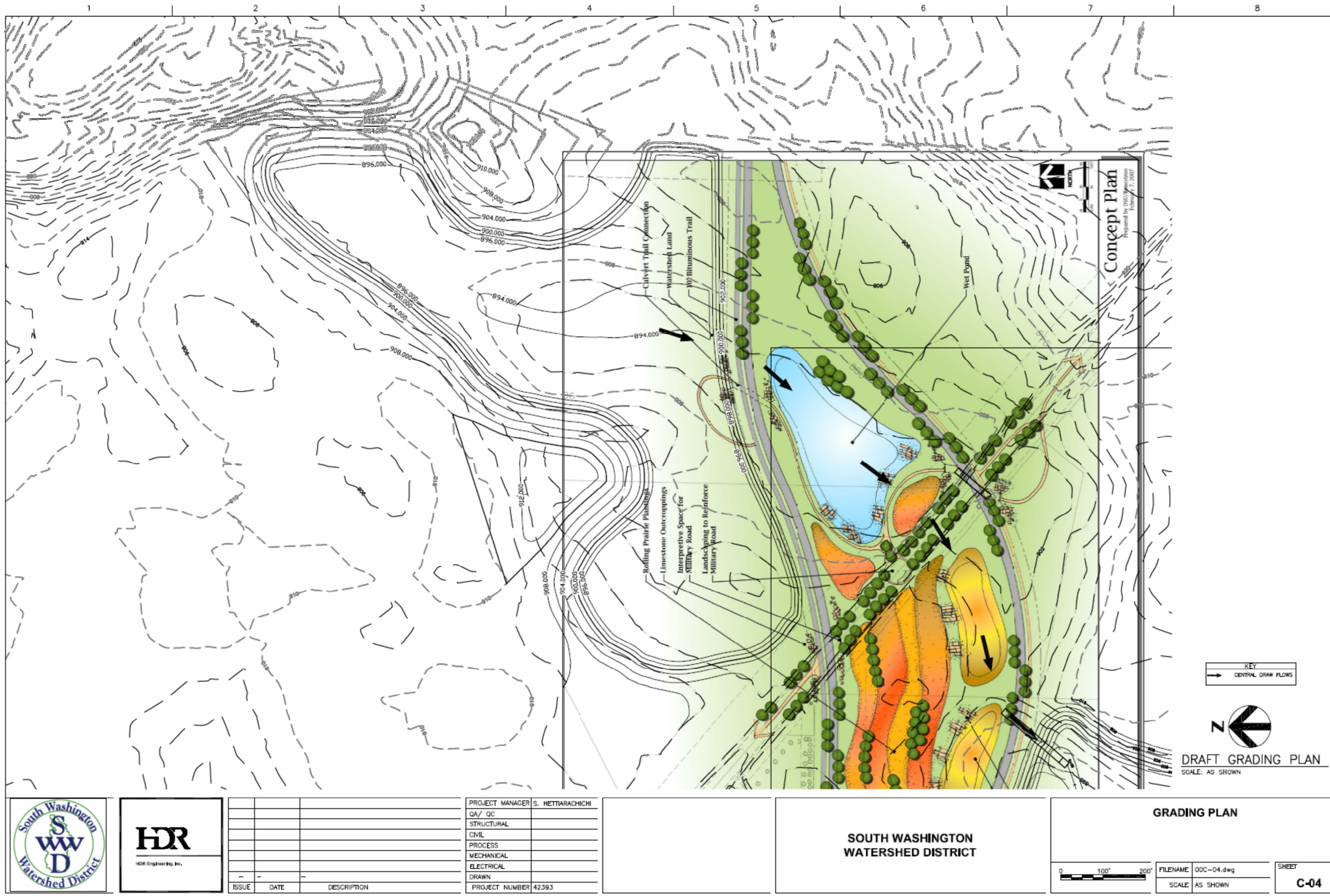
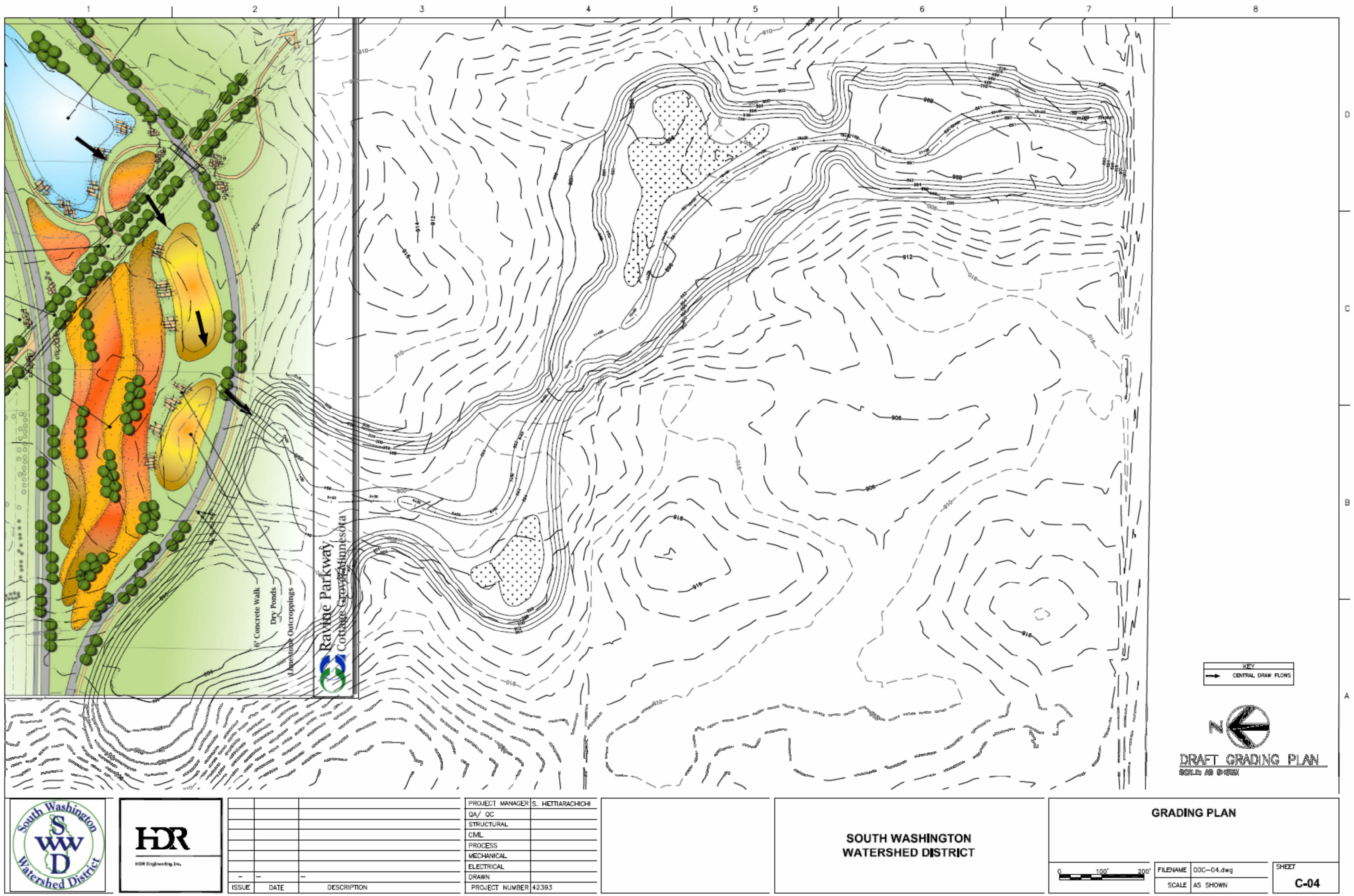


FIGURE 11 CDSF GRADING PLAN FOR CD-P86S1 AND CD-PS2 (WITHOUT THE COTTAGE GROVE RAVINE PARKWAY)



5.4 CDSF Options and Design Features

5.4.1 Central Draw Connection

Various outlet configurations from the CDSF to the Central Draw were considered during project design. As discussed below, configurations that relied on the Central Draw to serve as a primary outlet for CDSF discharge were eliminated from consideration. It was determined, however, that CDSF operations and local stormwater system benefits justified providing a connection between the CDSF and the Central Draw.

5.4.1.1 Central Draw as a Primary Outlet

In order for all CDSF flows to go to the Central Draw, additional piping and use of existing drainage ways would be required through the Central Draw. This potential alignment is shown in Figure 12. It was determined through modeling that this configuration would result in increased future conditions flooding risks and damages in the areas downstream in the Central Draw. For this reason, using the Central Draw as a primary outlet was deemed to be an unacceptable alternative.

Use of a smaller diameter pipe to direct only a portion of CDSF flows down the Central Draw was also evaluated. Modeling showed that discharging of regular (frequent) flows to the Central Draw was not a cost effective or reasonable alternative for reducing storage requirements in the CDSF or reducing outflows to the East Ravine.

5.4.1.2 Central Draw Connection for Operations and Local Stormwater Benefit

Connection of the Central Draw to the CDSF provides some benefits that are mutually beneficial to the City of Cottage Grove and the South Washington Watershed District. The connection is accomplished through use of stormwater pipes and a control structure. The presence of a gate in the CDSF control structure would allow moderation of flows into and out of the CDSF. The memorandum "CDSF Outlet Configuration Memorandum", dated September 28, 2012, details how this control structure and associated piping will function. Details of the control structure and piping are shown in the construction plans included in Appendix A.

Connection of the CDSF to the Central Ravine provides the following benefits:

- This connection will accommodate construction of the overflow pipe in multiple stages. The storm sewer connection will provide a way for limited flows to be discharged into the Central Draw. Although this connection will not allow the CDSF to function per design, it would allow limited outflow from the CDSF prior to completion of the overflow pipe.
- After construction of Phase 1 and 2, the connection would provide an emergency overflow. Although the 72" RCP overflow pipe will provide sufficient capacity for anticipated design

events, an alternate outlet would provide system redundancy in the event of extreme flooding conditions which exceed design events or unanticipated operational deficiencies or failures such as improper gate operation, pipe or outlet structure clogging, or gate failures.

The Central Draw connection also provides local benefits as follows:

- The proposed CDSF-Central Draw connection would divert local drainage into CDSF for temporary storage or infiltration.
- The existing storm sewer pipe draining into the ponding area south of 70^{th} Street and west of Joliet Avenue South (ED-P 81.1) could be abandoned.
- The diverted flows would provide relief to the storm sewer along Jocelyn Avenue which is undersized.
- The depth of ponding in ED-P 81.1 would be reduced by 3.5 feet under 100-year design storm conditions.

FIGURE 12 LOW FLOW OUTLET ROUTE FROM THE CDSF TO THE MISSISSIPPI RIVER

Map Document: (N:\GISProj\SWWD\134353\map_docs\mxd\maps\BoDR\EastRavine_OverflowToMississippiRiver.mxd) 9/22/2010 – 12:11:49 PM

5.4.2 PIPE ALIGNMENT TO EAST RAVINE

The East Ravine will serve as the primary outlet for the CDSF. The memorandum "Supplemental Update to the Central Draw Storage Facility Outlet Design and Evaluation of Impacts to the East Ravine in the City of Cottage Grove", dated October 3, 2013, provides details on the analysis that was performed to evaluate the potential for impacts to the hydrology and hydraulics in the East Ravine. The entire overflow route from the CDSF to the Mississippi River is shown in Figure 13.

Several overflow pipe profiles have been considered over the years to discharge the CDSF into the Ravine Regional Park (See "Outlet Pipe Design for Central Draw Storage Facility (CDSF) Phase II - Alignment, Profile and Size Selection and Evaluation of the Impacts to East Ravine"). The alignment options for the East Ravine overflow options are described in Table 12 and presented in Figure 14.

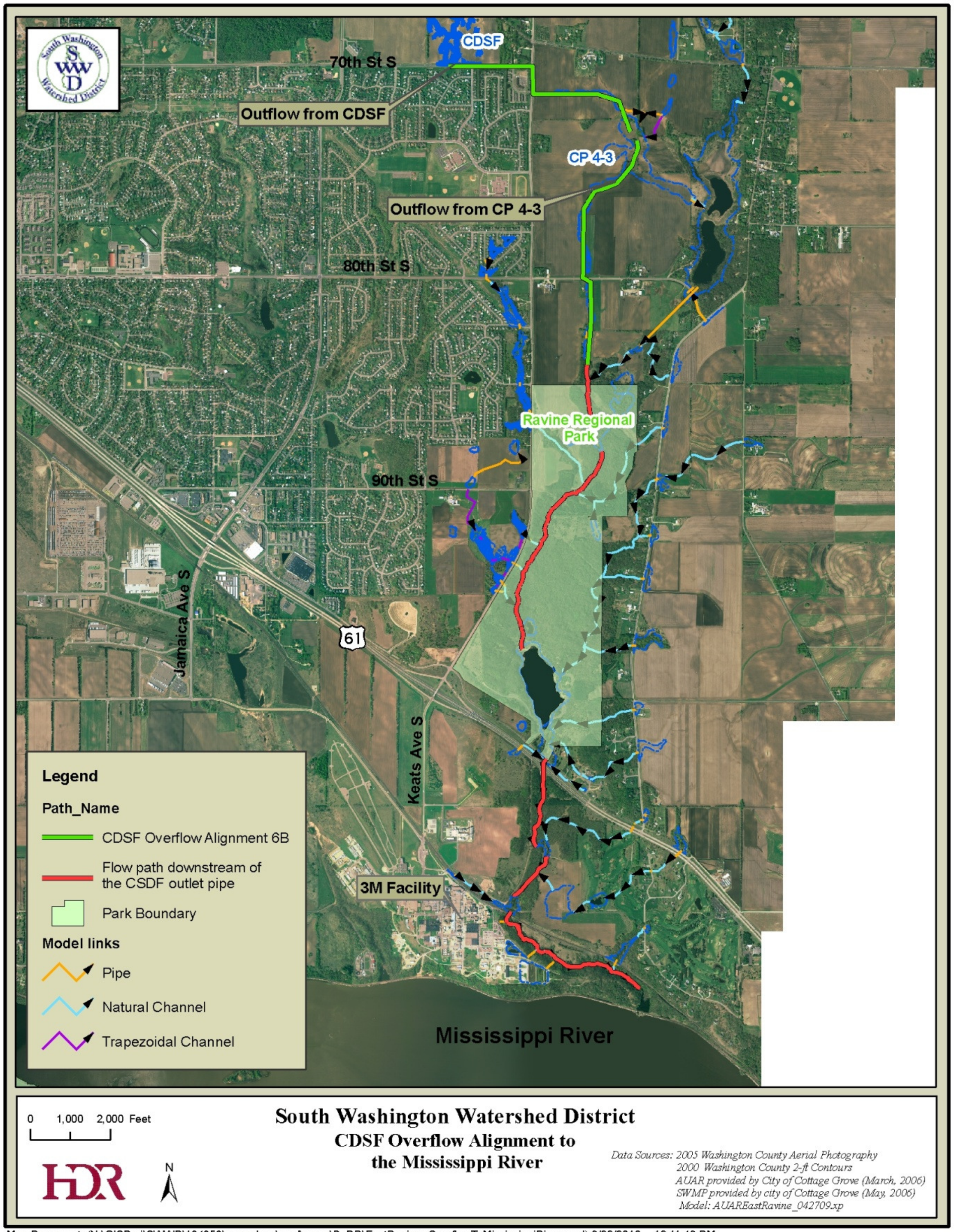
TABLE 12 DESCRIPTIONS OF CONCEPTUAL ALIGNMENT OPITONS FOR THE EAST RAVINE OVERFLOW FROM THE CDSF

Alignment Name	Alignment Description
ALIGNMENT 6A:	Alignment 6A runs along Keats Avenue South (Figure 3).
ALIGNMENT 6B:	Alignment 6B runs through farm land and has an additional storage area (CP 4-3)
70TH STREET ALIGNMENT:	The 70th Street Alignment extends straight east of 70th Street, outlets to CP 4

The SWWD evaluated the various alignment options for the overflow pipe, and selected Alignment 6B as the preferred route. This alignment initially would follow CSAH-22 (70^{th} Street) before going south along Keats Ave S. It then would pass through agricultural fields before discharging into an existing depression that is called CP-4.3. This depression would then outlet to another pipe before discharging into Ravine Regional Park.

The 6B alignment initially approved by the SWWD was refined by SWWD in 2012 once it became apparent that additional right of way would be acquired by Washington County as part of the CSAH-19-20-22 roadway project. The ROW to be acquired would provide a logical corridor for the overflow pipe. The 6B revised alignment is shown in Figure 15.

FIGURE 13 ENTIRE OVERFLOW ROUTE FROM THE CDSF TO THE MISSISSIPPI RIVER



Map Document: (N:\GISProj\SWWD\134353\map_docs\mxd\maps\BoDR\EastRavine_OverflowToMississippiRiver.mxd) 9/22/2010 – 12:11:49 PM

FIGURE 14 ALIGNMENTS FOR THE OVERFLOW FROM THE CDSF TO THE EAST RAVINE

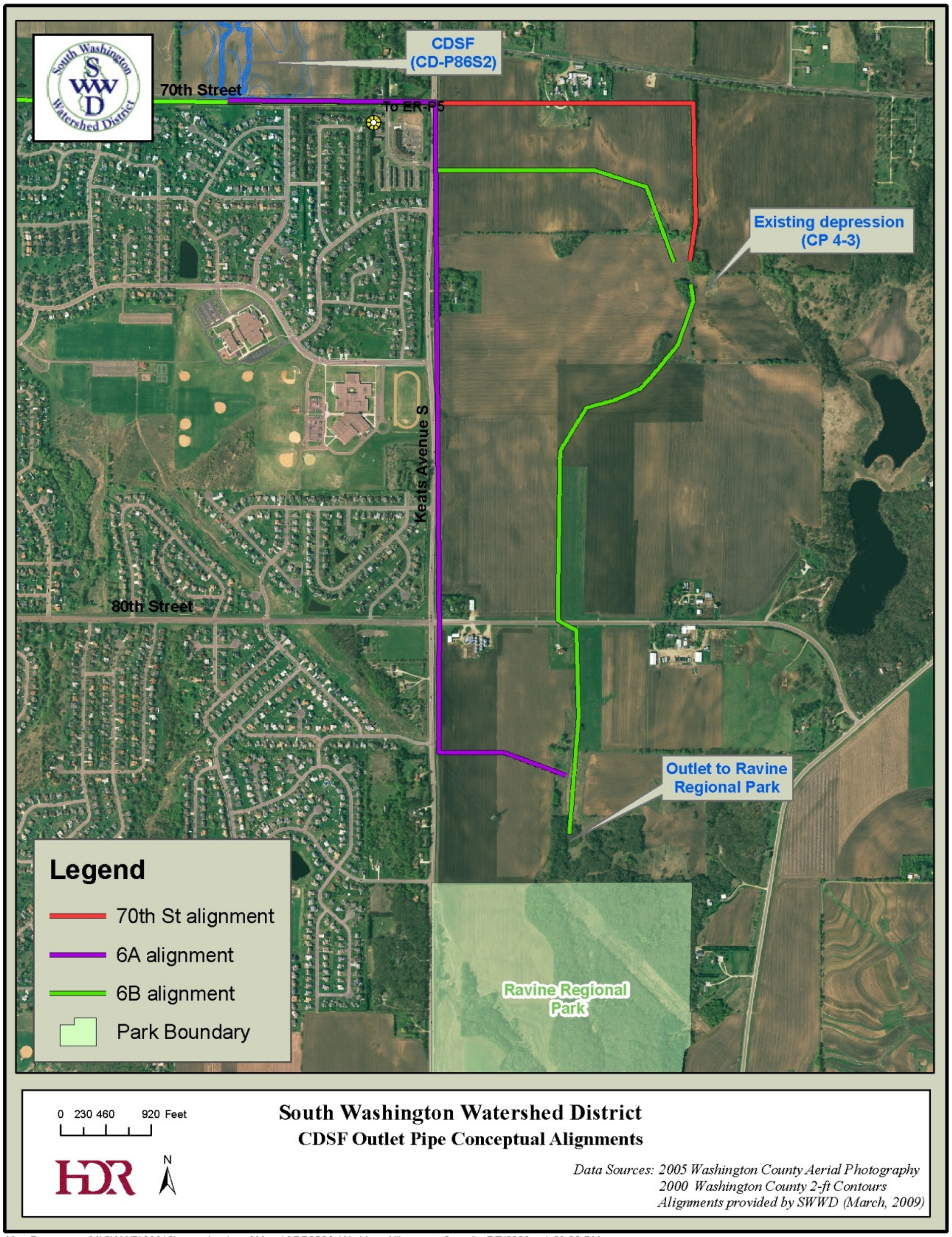


FIGURE 15 REVISED 6B ALIGNMENT

Map Document: (Y:\SWWD\96612\map_docs\mxd\Maps\CDP8586_Working_Allignments2.mxd) 7/7/2009 -- 1:29:28 PM

5.4.2.1 Outlet Size and Elevation

Modeling analysis shows that a 6-foot outlet pipe diameter is sufficient for discharging flows from the CDSF during the design event. The outlet of the CDSF control structure is set at an elevation of 894 feet. Hydraulic modeling indicates that the water surface elevation immediately upstream of the CDSF outlet (the elevation of the south lobe of the CDSF) will be 901.4 feet during the design storm event. This is below the target design water surface elevation of 902.0 feet and provides 6.6 feet of freeboard to the sag point of the proposed CSAH 22 embankment which has a centerline elevation of 908.0 feet.

5.4.3 MANHOLE STRUCTURES

Workers will have to enter the overflow pipe on a periodic basis for inspection and maintenance. As a safety feature, no steps are provided at any of the mainline overflow pipe manholes. Manholes will be located generally every 200 feet along the overflow pipe alignment in order to accommodate access. This spacing is based on an assumption that any personnel in the pipe would be tethered in accordance with confined space safety practices. The distance between manholes will be 390 feet near CSAH 19, and 240 feet near the Northern Natural Gas lines due to construction limitations. Safety precautions will need to be taken to ensure sufficient tether length at these two locations when maintaining the pipe system. Due to the fact that the manhole structures will be precast units, the special provisions for the overflow project require that the design be certified by the precast concrete manufacturer.

5.4.4 PIPE JACKING

Jack and bore operations will be completed in order to cross the Northern Natural Gas pipelines located at approximately station 53+00, and to cross the 3M wastewater line, gas lines, and water line located between stations 30+00 and 31+00.

The Northern Natural Gas lines are 24" and 30" high pressure mains located adjacent to each other. Discussions were held with Northern Natural Gas to determine if there were alternatives to jacking and boring. They indicated that a jack and bore operation would be the best way to proceed given the size of the trench excavation required to place the overflow pipe. The jacking length was estimated based on starting at the existing grade 10 feet away from each pipe centerline, and projecting a line downward at a 1:5H to 1V slope to the required overflow pipe trench invert. The length indicated in the construction plans for jacking is 130 feet. Specially manufactured class V pipe is required for this installation in order to accommodate the forces associated with pushing the pipe, and to allow for grout ports in the perimeter of the pipe.

Open trench excavation was initially considered for crossing the utilities between 30+00 and 31+00. The concern over the consequences associated with a rupture of the 3M line, and the logistical difficulties associated with staging and temporary traffic routing in this location, ultimately led to the decision to pursue a jack and bore operation at this location as well.

5.5 Instrumentation Plans

It is anticipated that the gates would be operated based on visual observation of water levels. No instrumentation related to seepage or stability is anticipated to be necessary. Monitoring of project feature performance would occur through regular inspections and through observation during flooding events. Although the need for instrumentation is not anticipated at this time, the use of instrumentation will need to be coordinated with the Operations and Maintenance Plan as the procedures supporting that document are finalized.

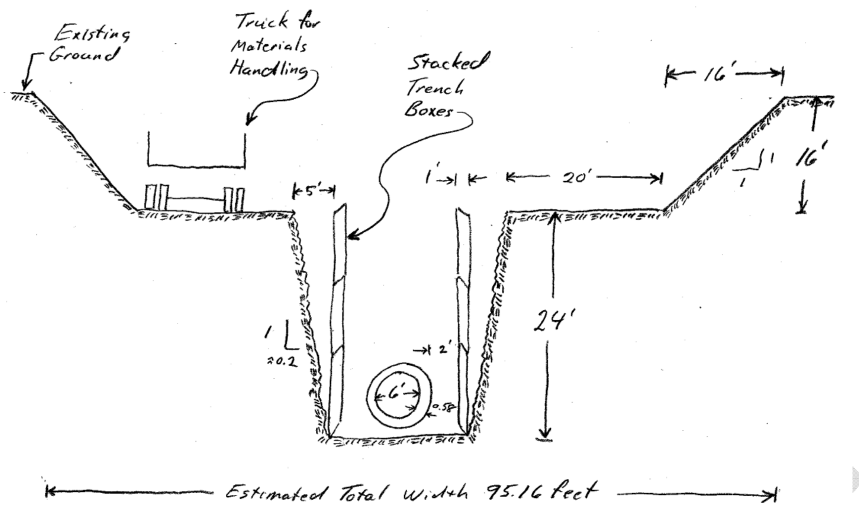
5.6 Structural Evaluations

5.6.1 Pipe Design

Due to the large depth of excavation on this project the bedding and pipe design was based on the constructability of this project. In performing the pipe class and bedding evaluation, it was assumed that the low bidder's approach to this project would be to use trench boxes. The limit of stacking trench boxes was assumed to be three 8-foot tall units. As a result the total height of the stacked trench boxes would be 24 feet. It was assumed that the trench cross section would look similar to Figure 16.

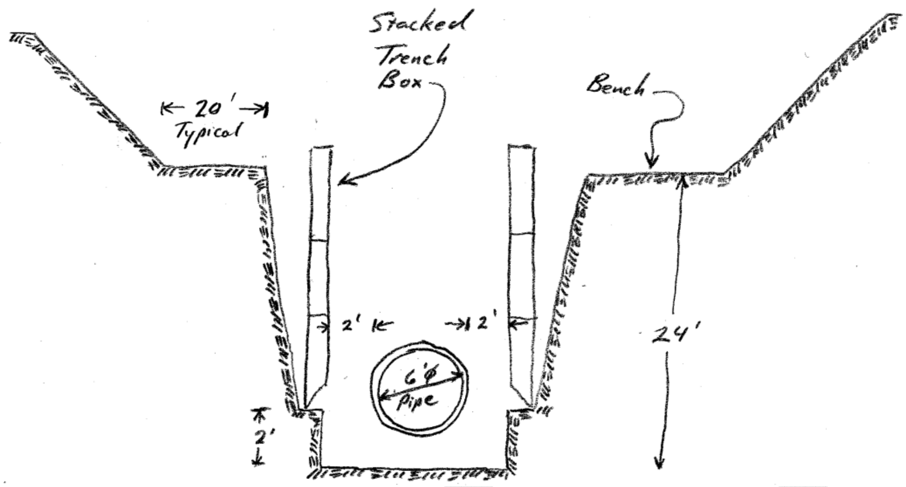
.

FIGURE 16 POTENTIAL TRENCH CONFIGURATION



Trench boxes are used to protect the workers rather than to protect the slope, and as such are not installed tight against the sidewall of the trench. This gap also allows the trench box to be moved forward as the trench excavation progresses. A difficulty with the use of a trench box system is that pipe bedding materials can be disturbed when the trench boxes are moved forward. In order to avoid this, the bottom of the trench excavation should be below the bottom of the trench shields (as much as 2 feet below). One typical configuration that would accomplish this is shown in Figure 17. Use of this configuration would mean that the bottom 2 feet of pipe bedding would remain undisturbed as the trench box is moved forward,.

FIGURE 17 TRENCH BOX INSTALLED 2-FEET ABOVE TRENCH BOTTOM

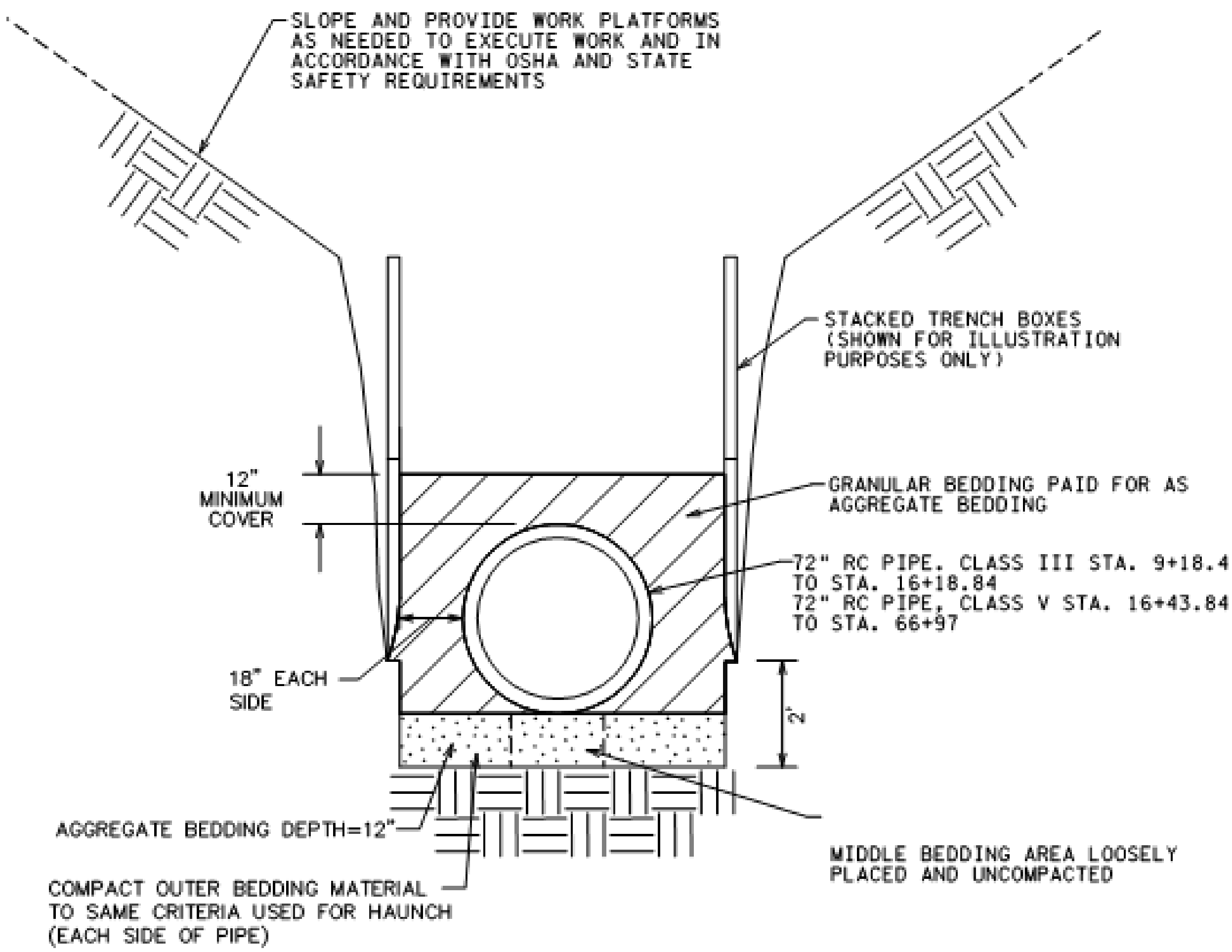


An analysis of the probable pipe loading conditions for this project was undertaken in order to confirm the appropriate class of concrete pipe and aggregate bedding. The results of the loading calculations for alternate bedding conditions are provided in Appendix C.

The deepest location for the pipe alignment occurs at approximately station 50+00. At this location the ground to invert distance is approximately 45.5 feet (approximately 39 feet of cover). For the pipe depths on this project, the tables show that a Class V concrete pipe would be appropriate with use of either a Type 1 or Type 2 bedding condition. Type 1 bedding was selected in order to provide a margin of safety due to variable construction and materials conditions, and to account for the possibility that additional soil loads could be placed on the pipe alignment in the future. An engineering evaluation should be completed in the future, however, if it is desired to place additional fill over the pipe alignment.

Information in the American Concrete Pipe Association Design Manual (2011) was used as the basis for developing the standard detail used in the overflow project construction plans. The standard detail developed for the project is provided in Figure 18. Compacted granular bedding should be installed below the bottom elevation of the trench box. The pipe bedding material shown in the center of the trench will need to be loosely placed backfill in order to achieve proper bedding conditions.

FIGURE 18 TRENCH BOX INSTALLED 2-FEET ABOVE TRENCH BOTTOM



The trench box should be moved forward by the Contractor after installing the pipe bedding, the pipe, and fill under the pipe haunches. After the trench box is moved forward, the remainder of the trench backfill material could be installed without the use of the trench box.

It should be noted that alternative laying methods could be used. The calculations confirming pipe class and bedding condition used conservative assumptions, however, the work plan to be submitted by the contractor will need to be reviewed by the Engineer to confirm that a suitable bedding condition can be achieved.

5.6.2 CONTROL STRUCTURE DESIGN

The control structure will be made from steel reinforced concrete. The design is based on ASCE-7 and ACI 318 provisions. The structure is classified as a simple reinforced concrete structure with conventional orthogonal reinforcement. The structure consists of a base slab, top slab, perimeter walls with RCP penetrations, and an interior wall with two drop-gate openings and a full length weir opening (above both gates). The portion of concrete between the gates is loaded in both axial compression and lateral bending. This lateral bending consists of the hydrostatic pressure from the base slab to the top of the weir slot. The top slab is designed for AASHTO HS20 loading. All horizontal wall reinforcement is for loading due to temperature and shrinkage. There is a non-structural, non-reinforced concrete slab placed on the base slab to accommodate the various invert heights and gate installation. Structural design was performed by modeling with Staad Software. A summary of the calculations output is provided in Appendix D.

5.7 WATER QUALITY

A 3 foot deep sump has been provided at manhole 1051 in order to allow settlement of soils prior to entry of storm water flows into the CDSF. No other specific accommodations to water quality have been made as a part of the overflow pipe project. An NPDES permit will be acquired for the highway/overflow pipe construction project in order to comply with MPCA requirements. Some water quality features such as use of erosion control BMPs, and grass swales will likely be incorporated into the roadway design plans and SWPPP.

5.8 DISPOSAL AREAS

No disposal areas are anticipated to be needed for this project.

5.9 OPERATIONS AND MAINTENANCE MANUAL

An Operations and Maintenance (O&M) Manual will be completed at a future date. This manual will provide information on timing of gate operation, and guidance on maintenance of project features.

5.10 ENVIRONMENTAL ASSESSMENT WORKSHEET

A discretionary EAW was performed for this project. See "Environmental Assessment Worksheet, Central Draw Storage Facility Overflow Project".

APPENDIX A

OVERFLOW PIPE CONSTRUCTION PLANS

SEE SHEET 2 FOR PLAN AND UTILITIES SYMBOLS

MINNESOTA DEPARTMENT OF TRANSPORTATION

WASHINGTON COUNTY DEPARTMENT OF TRANSPORTATION & PHYSICAL DEVELOPMENT

CONSTRUCTION PLAN FOR GRADING, AGGREGATE BASE, BITUMINOUS PAVING, STORM SEWER, WATERMAIN, CONCRETE CURB & GUTTER, BITUMINOUS PATH, ADA IMPROVEMENTS, SIGNING & STRIPING, LIGHTING, LANDSCAPING.

S.A.P. 082-622-010, 180-020-006

C.S.A.H. 22 (70TH ST. S.)

GROSS LENGTH 4058.81 FEET 0.77 MILES
BRIDGES-LENGTH 0.00 FEET 0.00 MILES
EXCEPTIONS-LENGTH 0.00 FEET 0.00 MILES
NET LENGTH 4058.81 FEET 0.77 MILES
NOTE: LENGTH BASED ON CR22 AND EB22 ALIGNMENTS

LOCATION

REF. POINT 178+59.00 TO REF. POINT 219+17.81
LOCATED ON C.S.A.H. 22 (70TH ST. S.) FROM 650' WEST OF JENSEN AVE. S. TO C.S.A.H. 19.

LEGAL DESCRIPTION

FROM A POINT APPROX. 1198' E. OF THE NE CORNER OF SEC. 9, T27N, R21W, TO A POINT APPROX. AT THE NE CORNER OF SEC. 10, T27N, R21W.

DESIGN DESIGNATION

FUNCTIONAL CLASS = MINOR ARTERIAL
NO. OF TRAFFIC LANES = 2
NO. OF PARKING LANES = 0
SHOULDER WIDTH = 10
DESIGN ESALS = 2,577,000
AADT (CURRENT YEAR) 2013 = 4,355
AADT (FUTURE YEAR) 2033 = 5,301
T (HEAVY COMMERCIAL) = 4.0 %
R VALUE = 30
TON DESIGN = 10
DESIGN SPEED 55 MPH
BASED ON STOPPING SIGHT DISTANCE
HEIGHT OF EYE 3.5' HEIGHT OF OBJECT 2.0'
DESIGN SPEED NOT ACHIEVED AT ROUNDABOUT APPROACHES.

S.A.P. 082-620-009, 180-020-006

C.S.A.H. 20 (70TH ST. S.)

GROSS LENGTH 4552.03 FEET 0.86 MILES
BRIDGES-LENGTH 0.00 FEET 0.00 MILES
EXCEPTIONS-LENGTH 0.00 FEET 0.00 MILES
NET LENGTH 4552.03 FEET 0.86 MILES
NOTE: LENGTH BASED ON EB20 AND CR20 ALIGNMENTS

LOCATION

REF. POINT 300+00.00 TO REF. POINT 345+50.00
LOCATED ON C.S.A.H. 20 (70TH ST. S.) FROM C.S.A.H. 19 TO 810' EAST OF KIRKWOOD AVE. S.

LEGAL DESCRIPTION

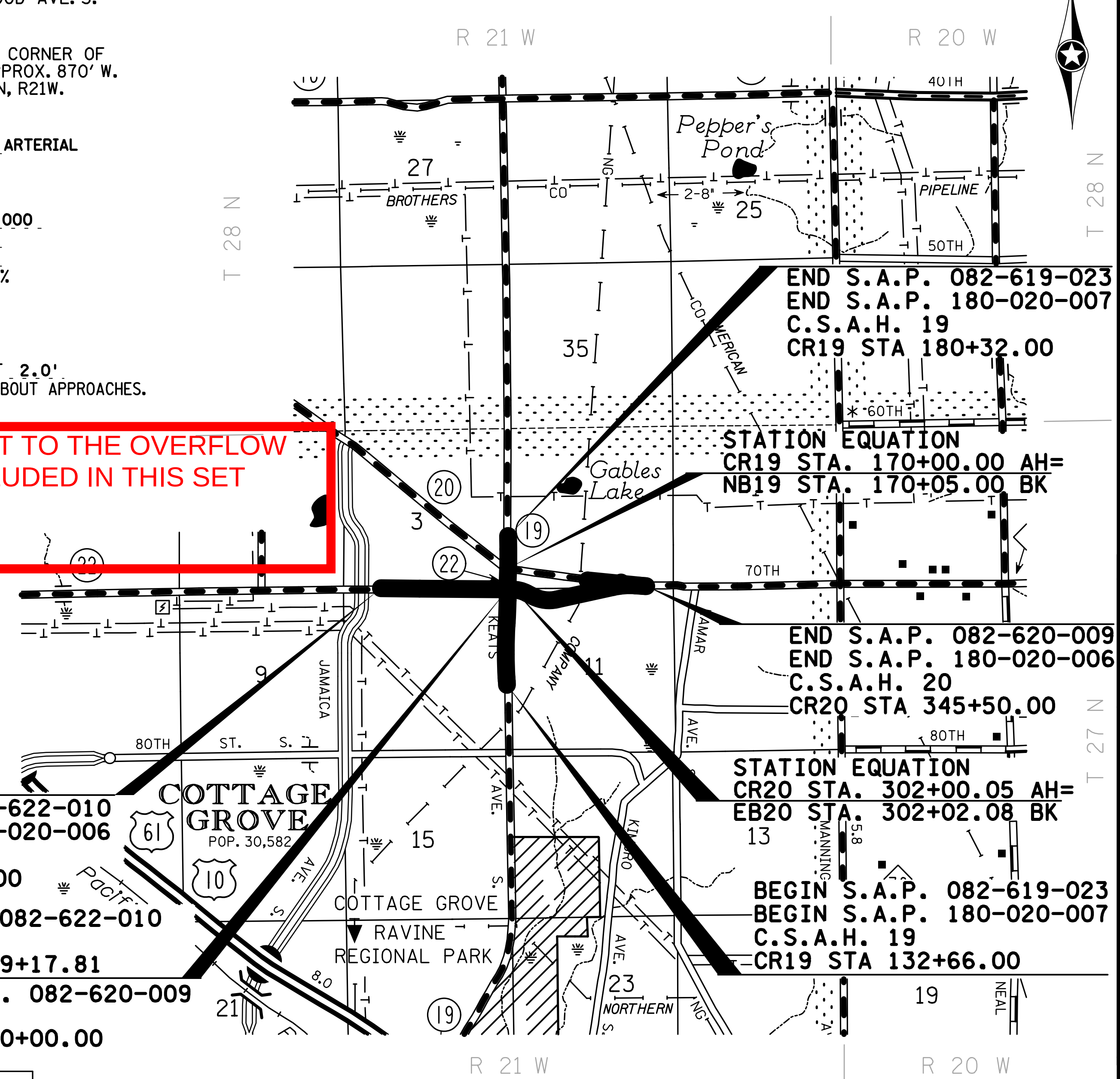
FROM A POINT APPROX. AT THE NE CORNER OF SEC. 10, T27N, R21W, TO A POINT APPROX. 870' W. OF THE NE CORNER OF SEC. 11, T27N, R21W.

DESIGN DESIGNATION

FUNCTIONAL CLASS = MINOR ARTERIAL
NO. OF TRAFFIC LANES = 2
NO. OF PARKING LANES = 0
SHOULDER WIDTH = 10
Design ESALS = 1,656,000
AADT (CURRENT YEAR) 2013 = 4,200
AADT (FUTURE YEAR) 2033 = 5,595
T (HEAVY COMMERCIAL) = 4.0 %
R VALUE = 30
TON DESIGN = 10
DESIGN SPEED 55 MPH
BASED ON STOPPING SIGHT DISTANCE
HEIGHT OF EYE 3.5' HEIGHT OF OBJECT 2.0'
DESIGN SPEED NOT ACHIEVED AT ROUNDABOUT APPROACHES.

WARNING! HIGH PRESSURE GAS PIPELINE CROSSINGS.
WARNING! 3M SANITARY FORCEMAIN CROSSING.

ONLY SHEETS RELEVANT TO THE OVERFLOW PIPE PROJECT ARE INCLUDED IN THIS SET



S.A.P. 082-619-023, 180-020-007

C.S.A.H. 19 (KEATS AVE. S.)

GROSS LENGTH 4766.00 FEET 0.90 MILES
BRIDGES-LENGTH 0.00 FEET 0.00 MILES
EXCEPTIONS-LENGTH 0.00 FEET 0.00 MILES
NET LENGTH 4766.00 FEET 0.90 MILES
NOTE: LENGTH BASED ON CR19 AND NB19 ALIGNMENTS

LOCATION

REF. POINT 132+66.00 TO REF. POINT 180+32.00
LOCATED ON C.S.A.H. 19 (KEATS AVE. S.) FROM 420' SOUTH OF INDIAN BLVD. S. TO 1050' NORTH OF MILITARY RD.

LEGAL DESCRIPTION

FROM A POINT APPROX. 2179' N. OF THE NE CORNER OF SEC. 15, T27N, R21W, TO A POINT APPROX. 1696' N. OF THE NE CORNER OF SEC. 10, T27N, R21W.

DESIGN DESIGNATION

FUNCTIONAL CLASS = MINOR ARTERIAL
NO. OF TRAFFIC LANES = 2
NO. OF PARKING LANES = 0
SHOULDER WIDTH = 10
DESIGN ESALS = 2,953,000
AADT (CURRENT YEAR) 2013 = 7,239
AADT (FUTURE YEAR) 2033 = 9,571
T (HEAVY COMMERCIAL) = 4.0 %
R VALUE = 30
TON DESIGN = 10
DESIGN SPEED 60 MPH
BASED ON STOPPING SIGHT DISTANCE
HEIGHT OF EYE 3.5' HEIGHT OF OBJECT 2.0'
DESIGN SPEED NOT ACHIEVED AT ROUNDABOUT APPROACHES.

SCALE
INDEX MAP 1 MI

PLAN REVISIONS

DATE	SHEET NO.	APPROVED BY

PROJECT LOCATION
COUNTY : WASHINGTON
DISTRICT : METRO

S.A.P. 082-619-023, S.A.P. 082-620-009, S.A.P. 082-622-010 (COUNTY)
S.A.P. 180-020-006, S.A.P. 180-020-007 (CITY)

5:52:22 PM
2/27/2013
c:\pwworking\oma\d0788781\CD174267_TSH.dgn

GOVERNING SPECIFICATIONS

THE 2005 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN.

ALL TRAFFIC CONTROL DEVICES SHALL CONFORM TO THE MINNESOTA MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES, INCLUDING THE MOST CURRENT "FIELD MANUAL FOR TEMPORARY TRAFFIC CONTROL ZONE LAYOUTS."

INDEX

THIS PLAN CONTAINS 308 SHEETS

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME: DAX W. KUHFUSS LICENSE # 46620
DATE: 2/28/2013 SIGNATURE: Dax W. Kuhfuss

HDR Engineering, Inc.

APPROVED ______ 2013
CITY OF COTTAGE GROVE

APPROVED ______ 2013
SOUTH WASHINGTON WATERSHED DISTRICT

APPROVED ______ 2013
WASHINGTON COUNTY

RECOMMENDED FOR APPROVAL ______ 2013
DISTRICT TRANSPORTATION ENGINEER

REVIEWED FOR COMPLIANCE WITH STATE AID RULES/POLICY ______ 2013
DISTRICT STATE AID ENGINEER

APPROVED FOR STATE AID FUNDING ______ 2013
STATE AID ENGINEER

I HEREBY CERTIFY THAT THE FINAL FIELD REVISIONS, IF ANY, WERE PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME: ______ LICENSE # ______
DATE: ______ SIGNATURE: ______

PLAN SYMBOLS

- PROPOSED RIGHT OF WAY
- EXISTING RIGHT OF WAY
- PERMANENT EASEMENT
- TEMPORARY EASEMENT
- CONTROL OF ACCESS LINE
- PROPERTY LINE
- CORPORATE OR CITY LIMITS
- RETAINING WALL
- RAILROAD
- RAILROAD RIGHT-OF-WAY LINE
- RIVER OR CREEK — NAME
- DRY RUN
- DRAINAGE DITCH — SIZE
- DRAIN TILE
- CULVERT
- DROP INLET — DI
- GUARD RAIL — P P
- BARBED WIRE FENCE
- WOVEN WIRE FENCE — XW
- CHAIN LINK FENCE — XC
- WOODEN FENCE
- STONE WALL OR FENCE
- HEDGE
- RAILROAD CROSSING SIGNAL
- RR CROSSING SIGNAL WITH GATE
- ELECTRIC WARNING SIGN
- MEANDER CORNER
- SPRINGS
- MARSH
- TIMBER / ORCHARD / BRUSH / NURSERY — (TIMBER)
- TREE - LEAF BEARING
- TREE - EVERGREEN
- VALVE
- VENT
- CATCH BASIN — CB
- FIRE HYDRANT

BUILDING (One Story Frame) — 1-S-F

F-FRAME	C-CONCRETE
S-STONE	T-TILE
B-BRICK	ST-STUCCO

- IRON PIPE OR ROD — ROD
- MONUMENT (STONE, CONCRETE, OR METAL)
- WOODEN HUB
- GRAVEL PIT — G
- SAND PIT — S
- BORROW PIT — B
- ROCK QUARRY — Q

UTILITY SYMBOLS

- POWER POLE
- TELEPHONE/TELEGRAPH POLE — T
- ANCHOR
- STEEL TOWER
- UTILITY PEDESTAL
- LIGHT POLE
- GAS MAIN — G G
- WATER MAIN
- CONDUIT
- TELE. CABLE IN CONDUIT — T
- ELECT. CABLE IN CONDUIT — P
- BURIED RAILROAD WIRES — RR-BUR
- BURIED FIBER OPTIC — F/O-BUR
- BURIED COMM. CABLE
- BURIED TELEPHONE CABLE — TV-BUR
- BURIED ELECTRIC CABLE — P-BUR
- SEWER, (SANITARY) — >>
- SEWER, (STORM) — >
- MANHOLE — MH M
- HANDHOLE — H
- OVERHEAD UTILITY — OHU OHU

CD174267_SY01.dgn
5:52:34 PM
2/27/2013
CD174267_Pen_Table.tbl

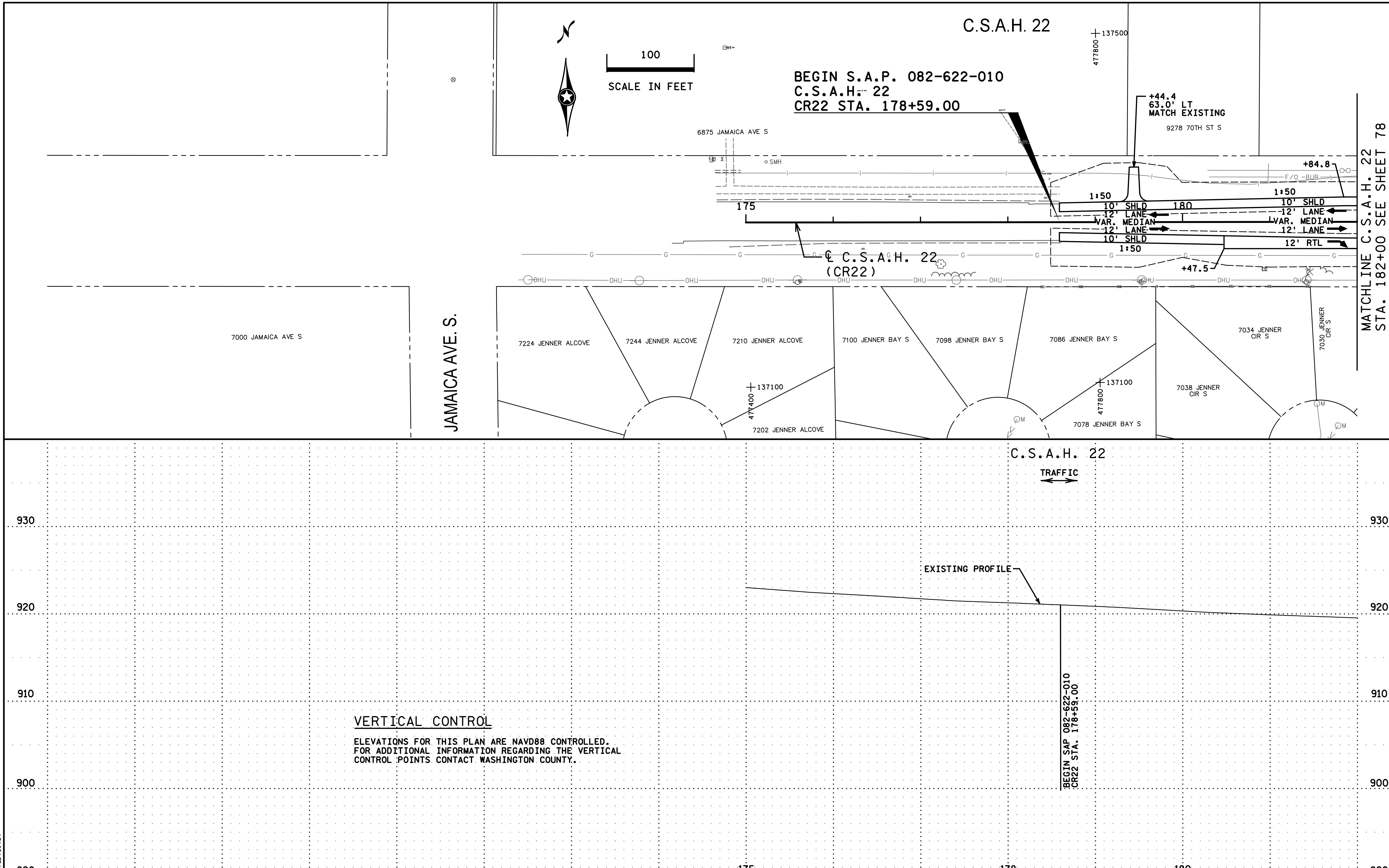
DRAWN BY: DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER	01/31/2013 DATE
DESIGNED BY: DWK		NAME: DAX W. KUHFUSS	LIC. NO. 46620
CHECKED BY: SCB			

HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

SYMBOLS LEGEND (1 OF 1)



VERTICAL CONTROL

ELEVATIONS FOR THIS PLAN ARE NAVD88 CONTROLLED.
FOR ADDITIONAL INFORMATION REGARDING THE VERTICAL CONTROL POINTS CONTACT WASHINGTON COUNTY.

CD174267_CP00.dgn
6:04:28 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	DWK
DESIGNED BY:	DWK
CHECKED BY:	SCB

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: Dax W. Kuhfuss — LICENSED PROFESSIONAL ENGINEER — 01/31/2013 DATE

NAME: DAX W. KUHFUSS LIC. NO. 46620

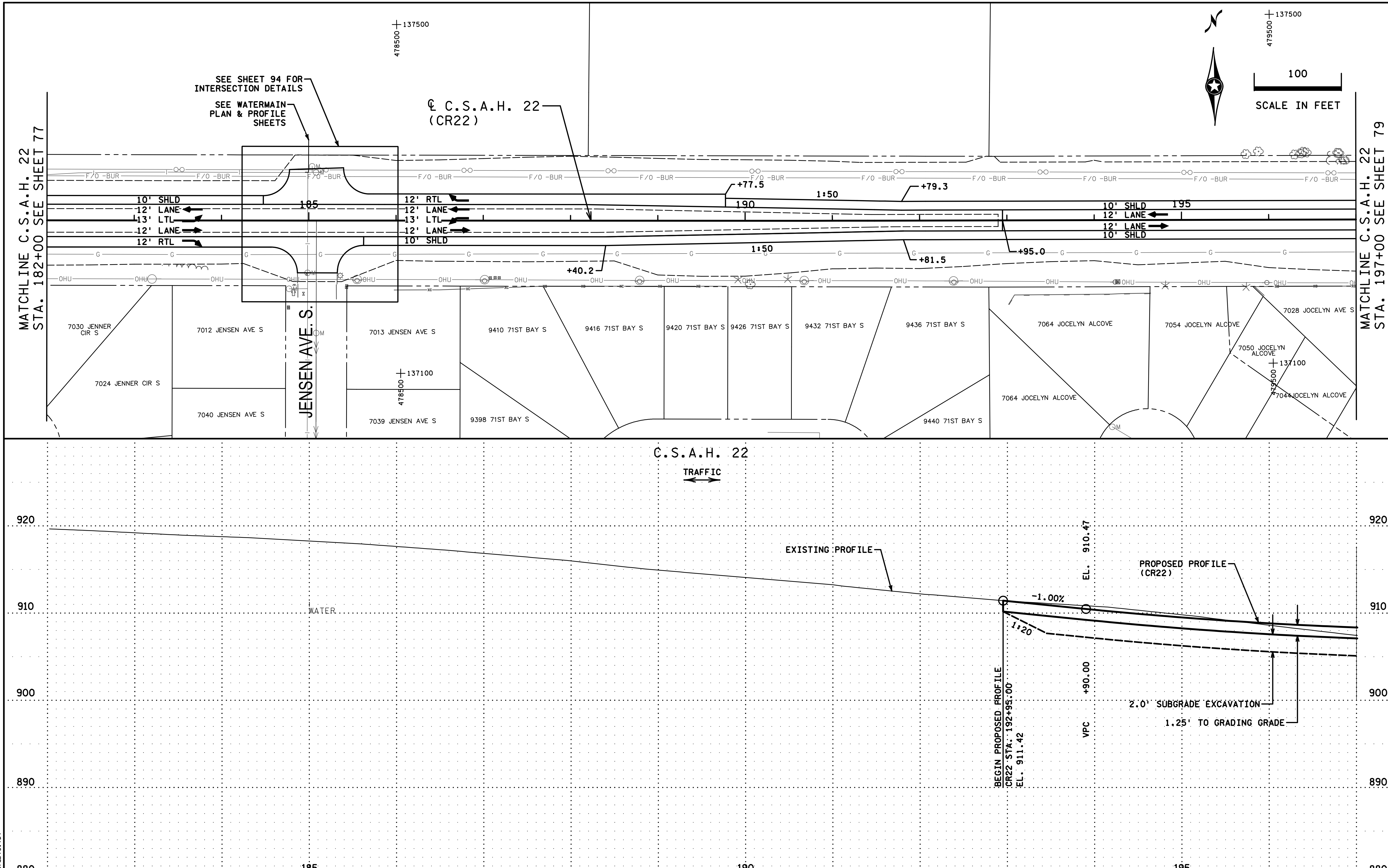
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (1 OF 11)

C.S.A.H. 22



CD174267_CP01.dgn
6:04:43 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER — 01/31/2013 DATE
DESIGNED BY:	DWK		NAME: DAX W. KUHFUSS — LIC. NO. 46620
CHECKED BY:	SCB		

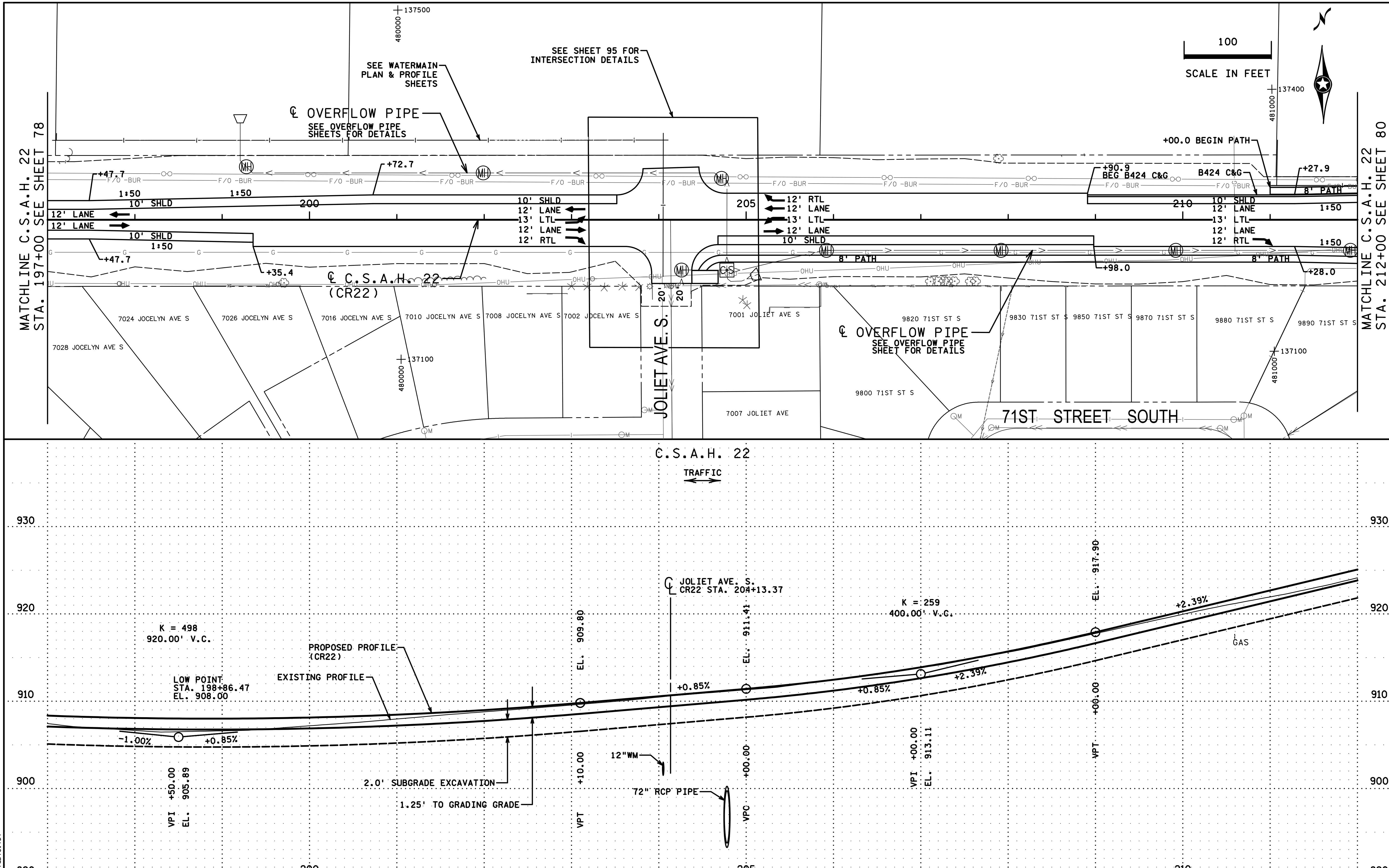
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (2 OF 11)

C.S.A.H. 22



DRAWN BY:	DWK
DESIGNED BY:	DWK
CHECKED BY:	SCB

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

NAME: DAX W. KUHFUSS — LIC. NO. 46620

HDR Engineering, Inc.

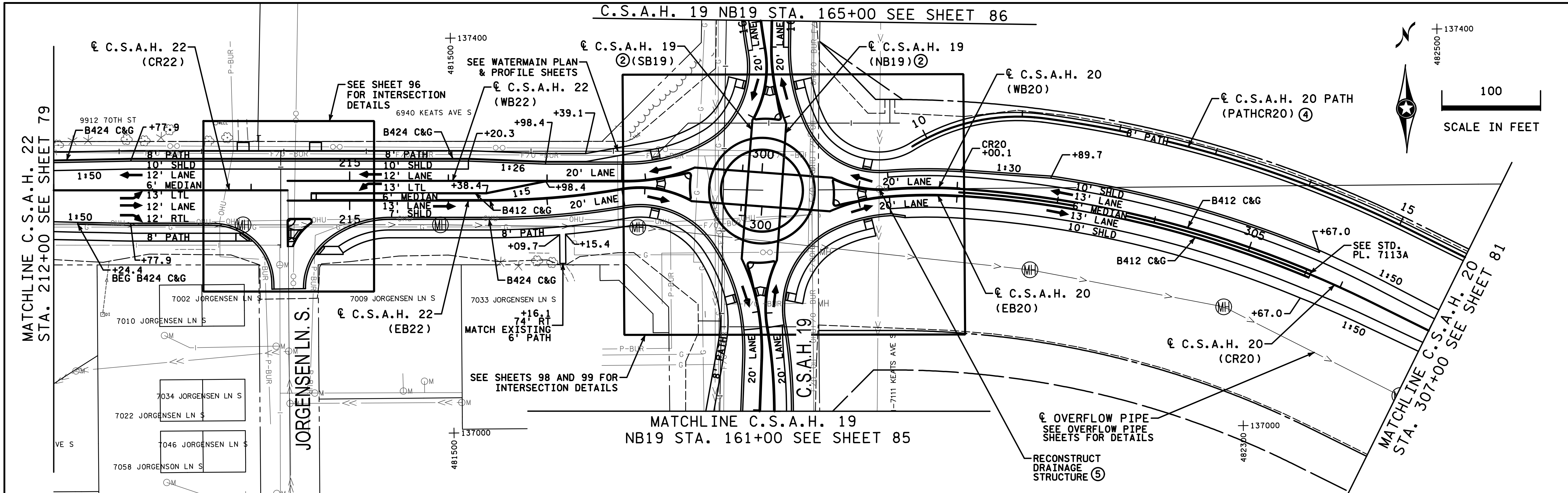
Washington County

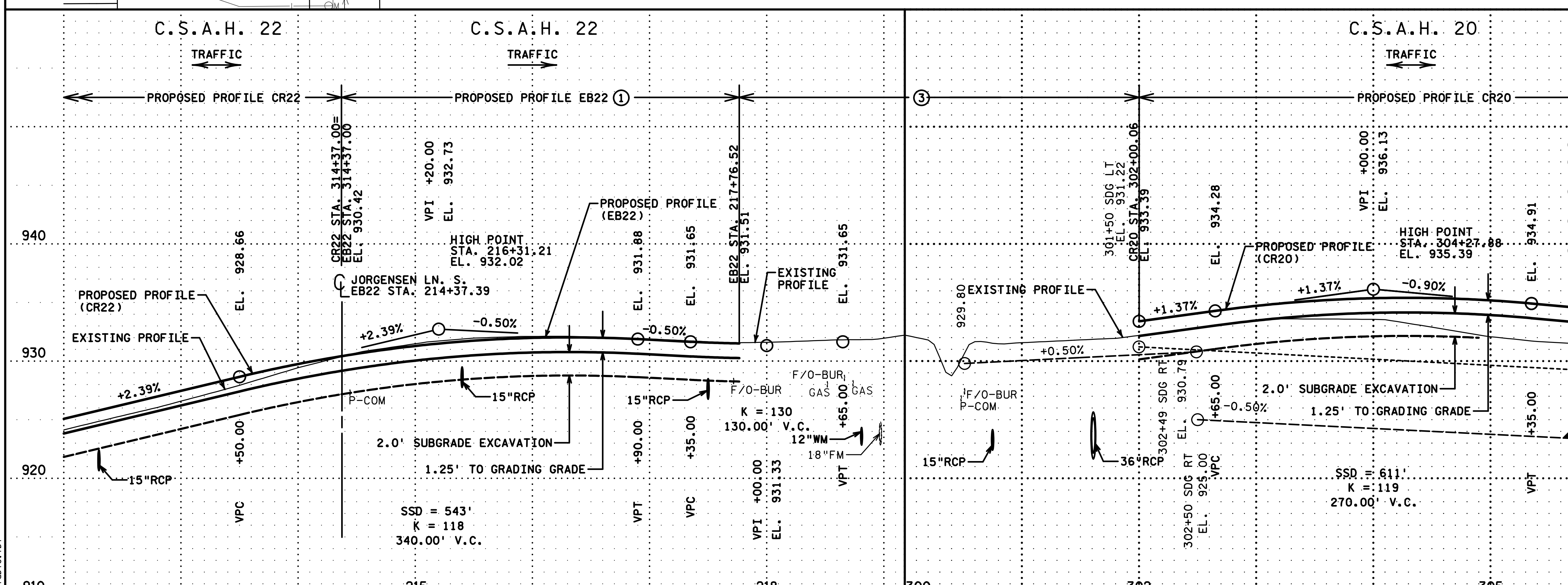
WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (3 OF 11)

C.S.A.H. 22 — SHEET NO. 79 OF 308 SHEETS

CD174267_CP02.dgn 6:04:56 PM 2/27/2013 CD174267_Pen_Table.tbl





SPECIFIC NOTES

1. SEE SHEET 88 FOR WB22 PROFILE.
2. SEE SHEET 86 FOR C.S.A.H. 19 PLAN AND PROFILE DETAILS.
3. SEE SHEET 98 AND 99 FOR INTERSECTION DETAILS.
4. SEE SHEET 92 AND 93 FOR PROFILES.
5. SEE SHEET 124 FOR DETAILS.

GENERAL NOTES

SPECIAL DITCH GRADE ELEVATIONS SHOWN TO TOP OF GRADING.

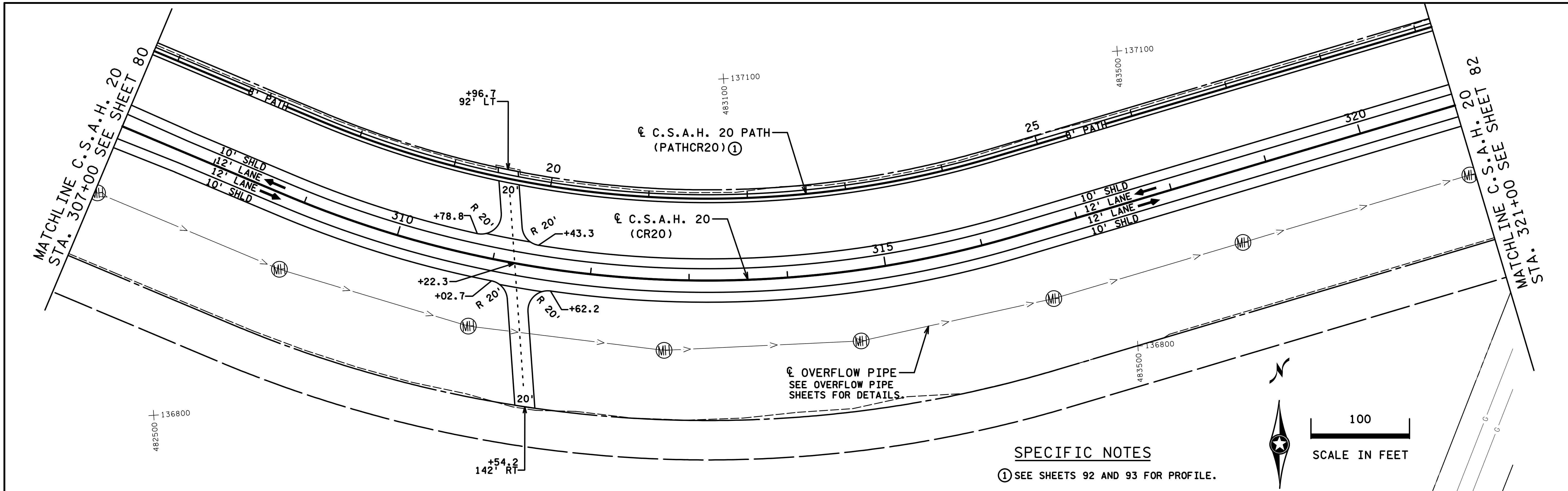
CD174267_CP03.dgn
6:05:10 PM
2/27/2013
CD174267_Pen_Table.tbl

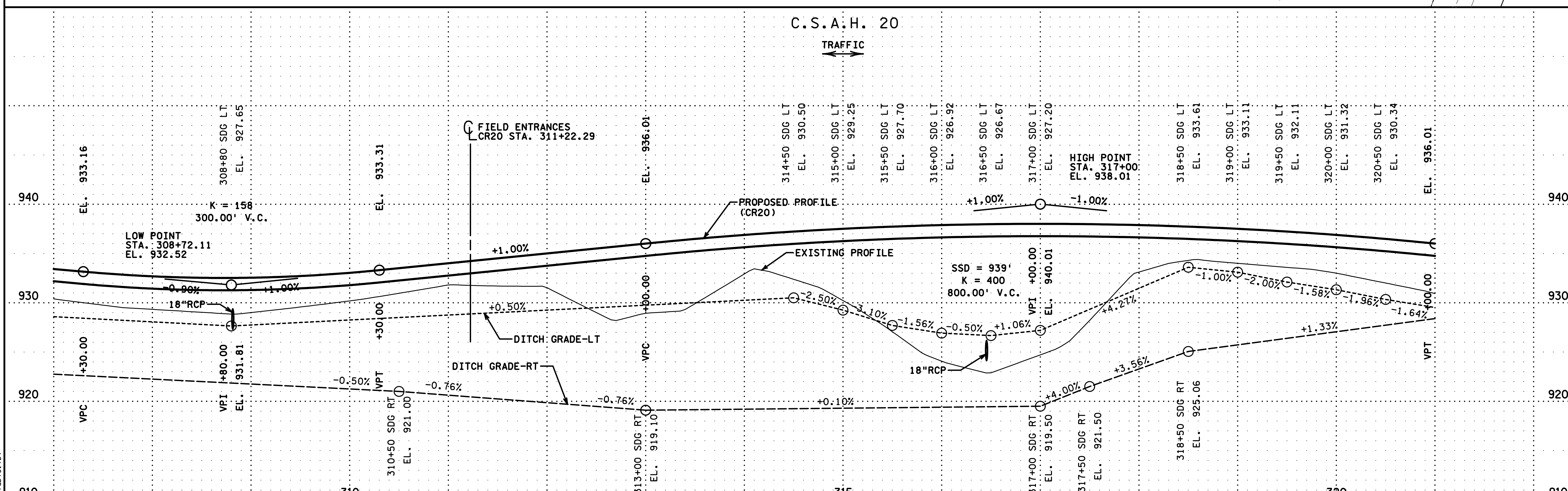
DRAWN BY: DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER	01/31/2013 DATE	HDR Engineering, Inc.
DESIGNED BY: DWK		NAME: DAX W. KUHFUSS	LIC. NO. 46620	Washington County
CHECKED BY: SCB				

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (4 OF 11)

ROUNDABOUT





CD174267_CP04.dgn
6:05:28 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.
DESIGNED BY:	DWK	
CHECKED BY:	SCB	

CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER — DATE: 01/31/2013

NAME: DAX W. KUHFUSS — LIC. NO. 46620

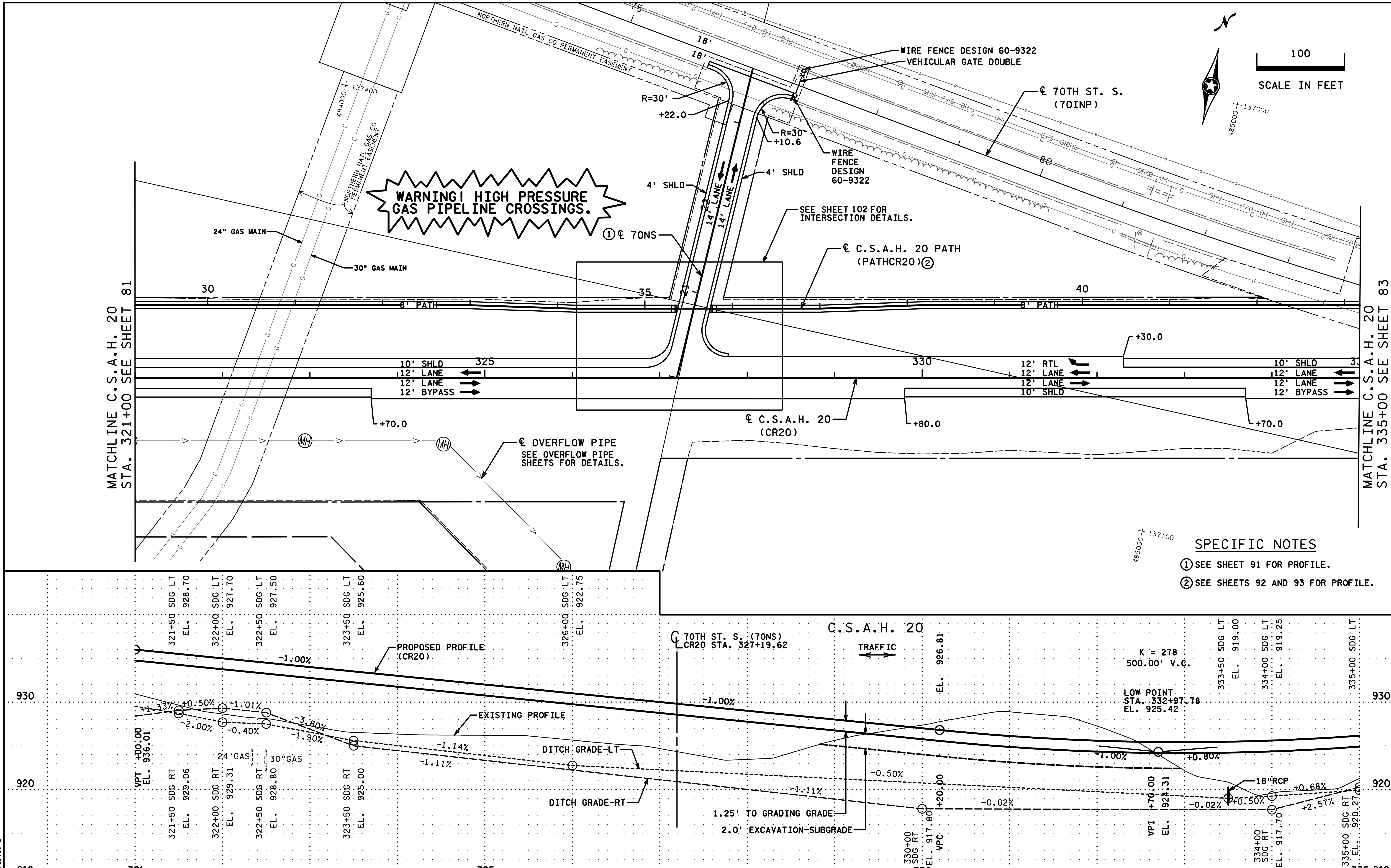
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

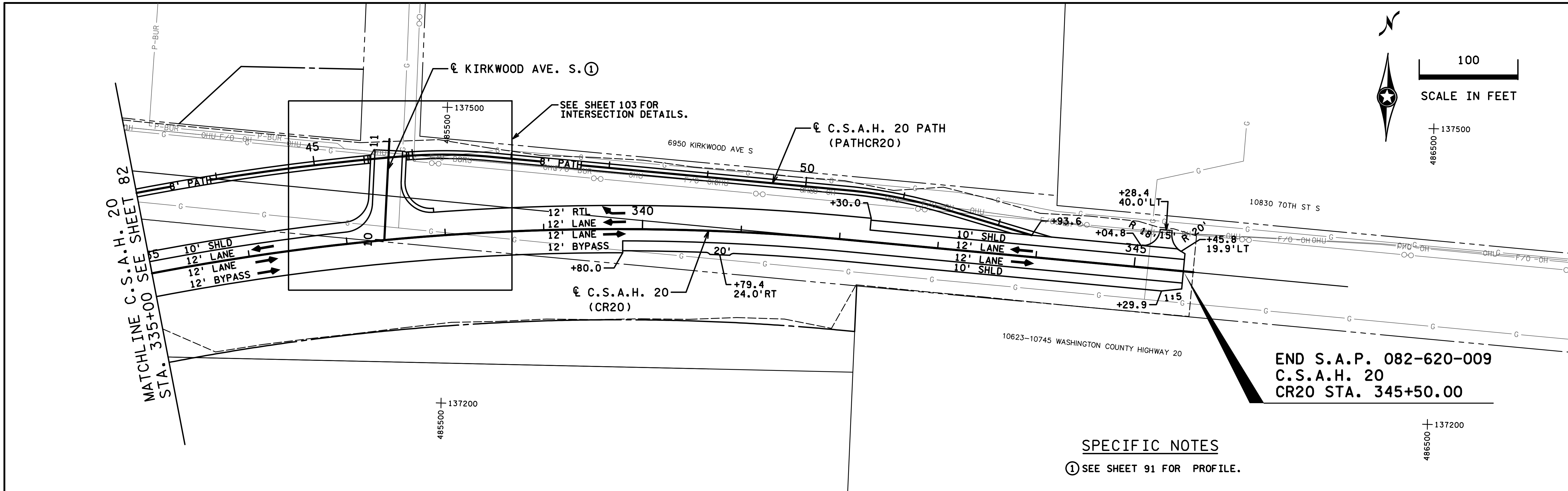
CONSTRUCTION PLANS & PROFILES (5 OF 11)

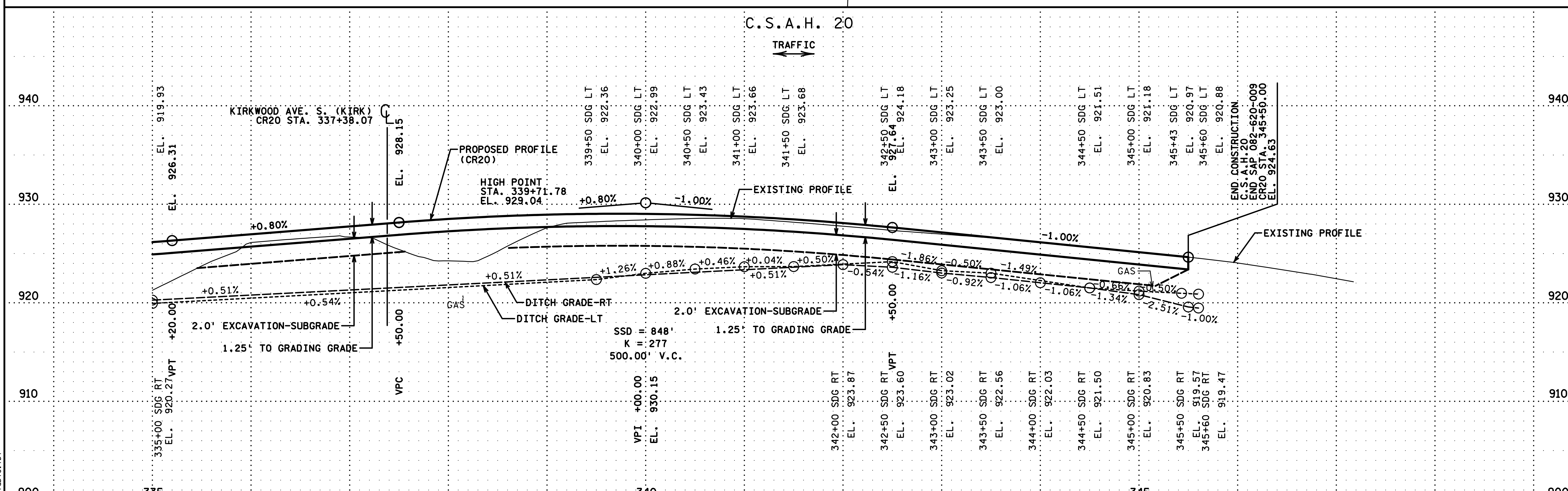
C.S.A.H. 20



DRAWN BY: DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER	01/31/2013 DATE	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023; C.S.A.H. 20 S.A.P. 082-620-009; C.S.A.H. 22 S.A.P. 082-622-010; CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007; C.S.A.H. 20 & 22 S.A.P. 180-020-006	CONSTRUCTION PLANS & PROFILES (6 OF 11)
DESIGNED BY: DWK		NAME: DAX W. KUHFUSS	LIC. NO. 46620				
CHECKED BY: SCB							C.S.A.H. 20 — SHEET NO. 82 OF 308 SHEETS

CD174267_CP05.dgn 6:05:43 PM 2/27/2013 CD174267_Pen_Table.tbl





DRAWN BY: DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER	01/31/2013 DATE
DESIGNED BY: DWK		NAME: DAX W. KUHFUSS	LIC. NO. 46620
CHECKED BY: SCB			

HDR Engineering, Inc.

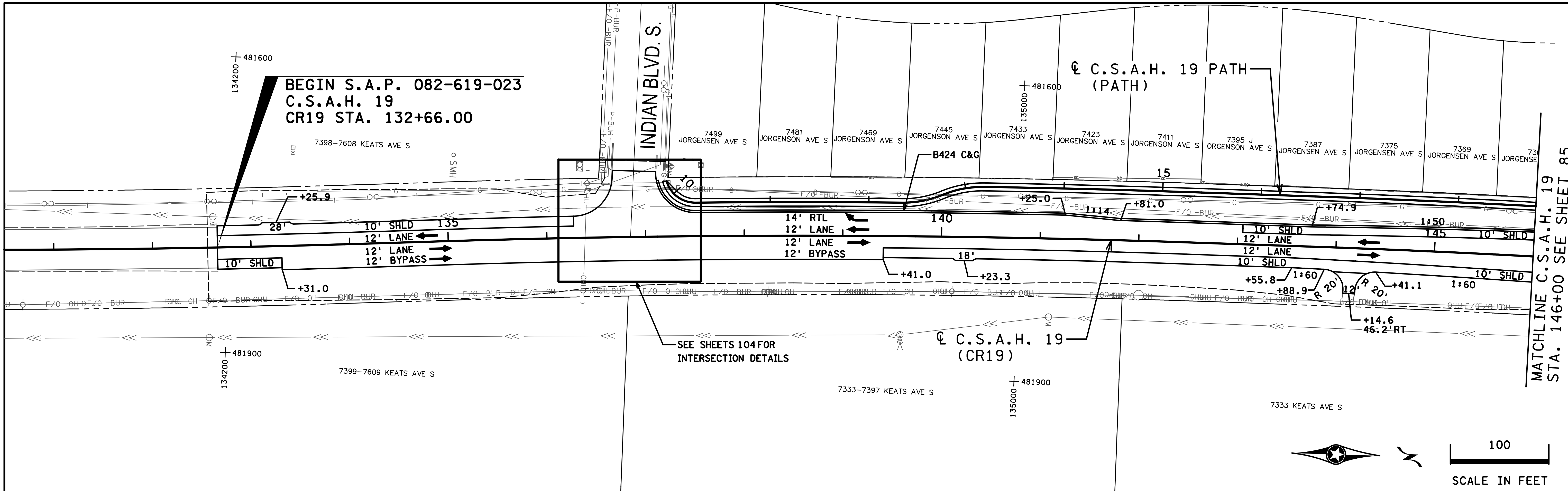
Washington County

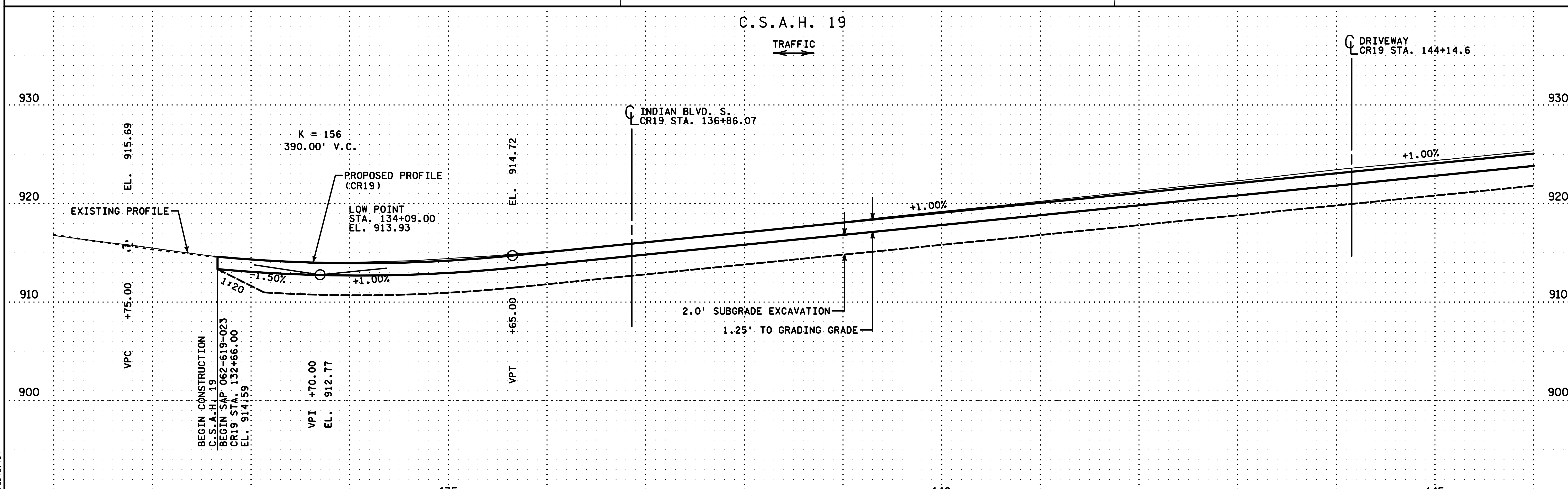
WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (7 OF 11)

C.S.A.H. 20 SHEET NO. 83 OF 308 SHEETS

CD174267_CP06.dgn 6:05:57 PM 2/27/2013 CD174267_Pen_Table.tbl





DRAWN BY:	DWK	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.
DESIGNED BY:	DWK	
CHECKED BY:	SCB	

CERTIFIED BY: [signature] — LICENSED PROFESSIONAL ENGINEER — 01/31/2013 DATE

NAME: DAX W. KUHFUSS LIC. NO. 46620

HDR Engineering, Inc.

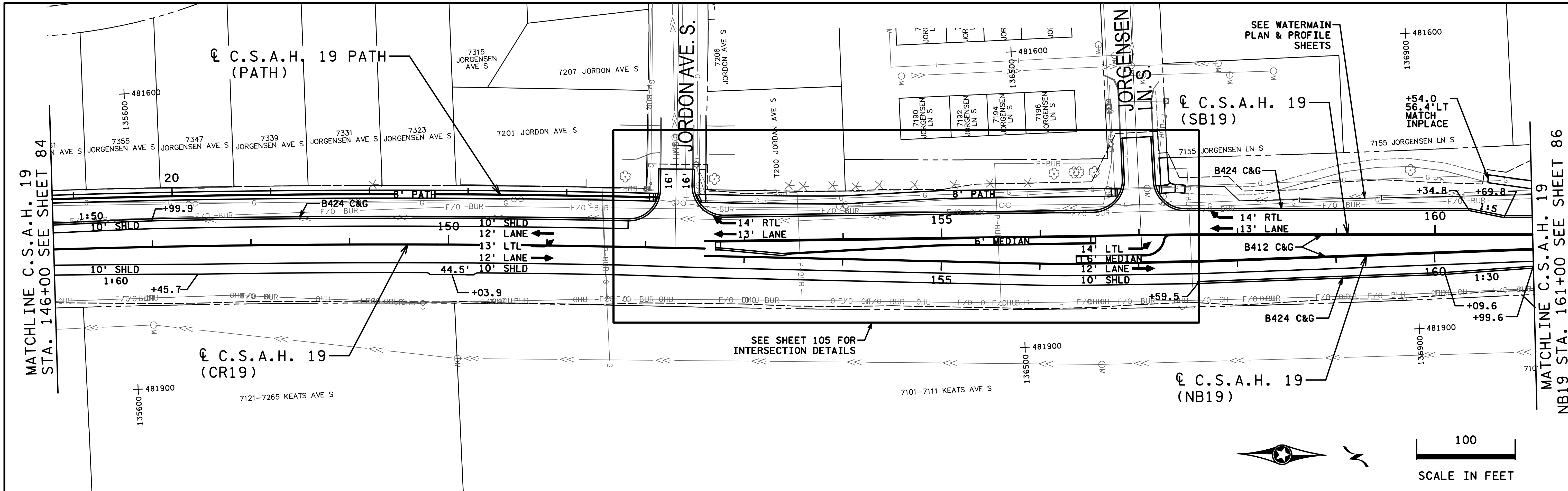
Washington County

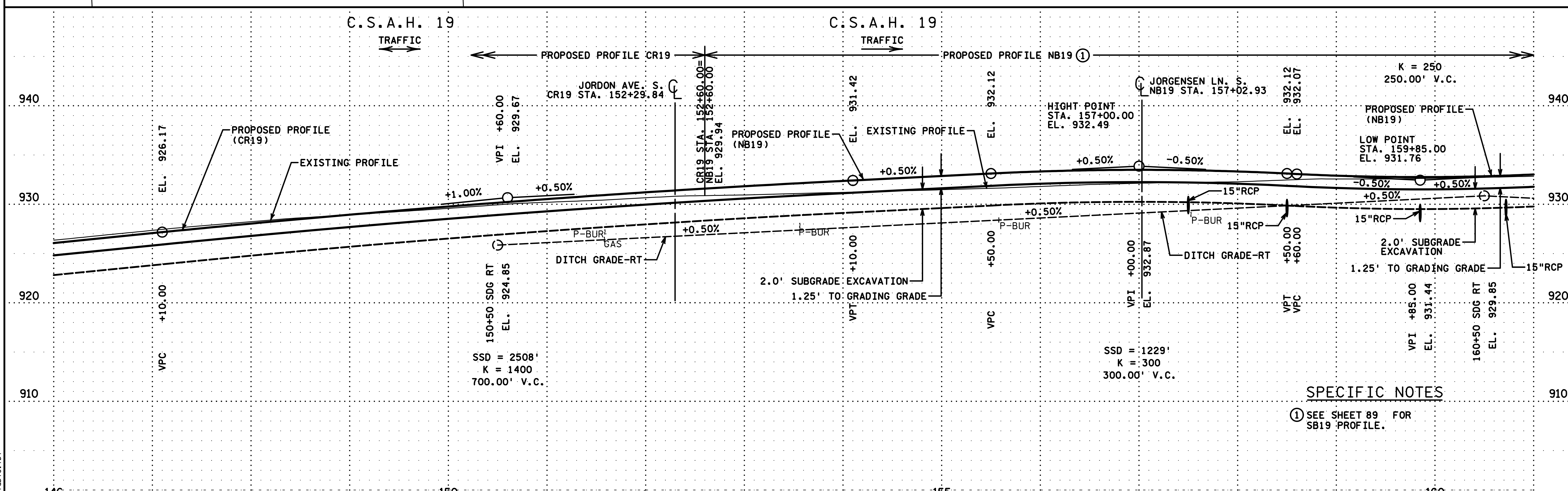
WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (8 OF 11)

C.S.A.H. 19 SHEET NO. 84 OF 308 SHEETS

CD174267_CP07.dgn
6:06:11 PM
2/27/2013
CD174267_Pen_Table.tbl





SPECIFIC NOTES

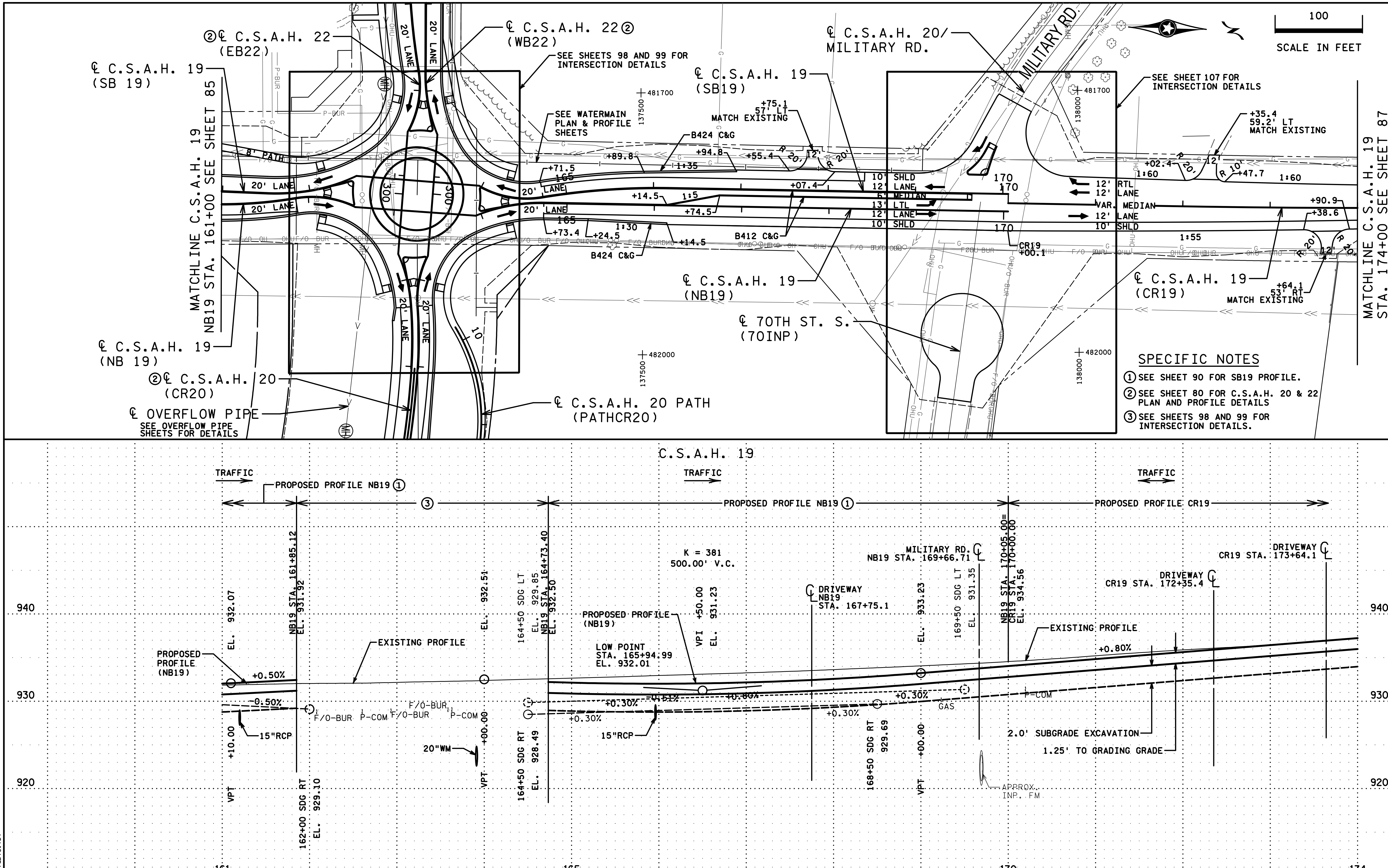
① SEE SHEET 89 FOR SB19 PROFILE.

DRAWN BY: DWK DESIGNED BY: DWK CHECKED BY: SCB	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: DAX W. KUHFUSS LIC. NO. 46620	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (9 OF 11)

C.S.A.H. 19 SHEET NO. 85 OF 308 SHEETS

CD174267_CP08.dgn
6:06:26 PM
2/27/2013
CD174267_Pen_Table.tbl



DRAWN BY:	DWK
DESIGNED BY:	DWK
CHECKED BY:	SCB

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: Dax W. Kuhfuss — LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

NAME: DAX W. KUHFUSS — LIC. NO. 46620

HDR Engineering, Inc.

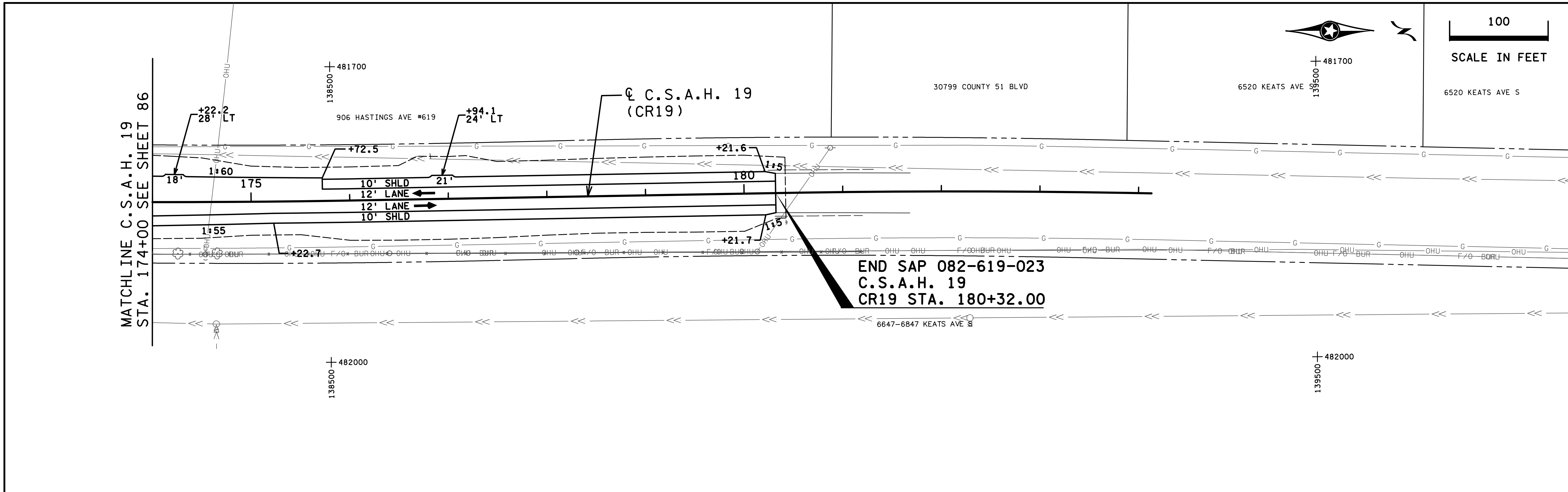
Washington County

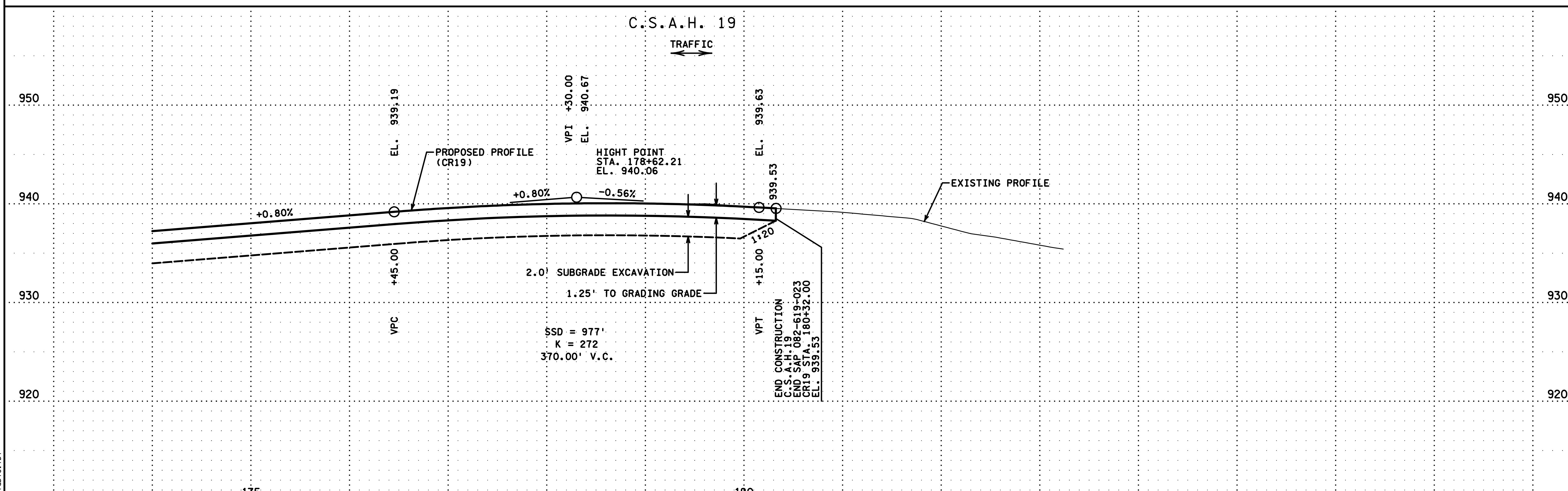
WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (10 OF 11)

C.S.A.H. 19

CD174267_CP09.dgn 6:06:40 PM 2/27/2013 CD174267_Pen_Table.tbl





CD174267_CP10.dgn
6:06:54 PM
2/27/2013
CD174267_Pen_Table.tbl

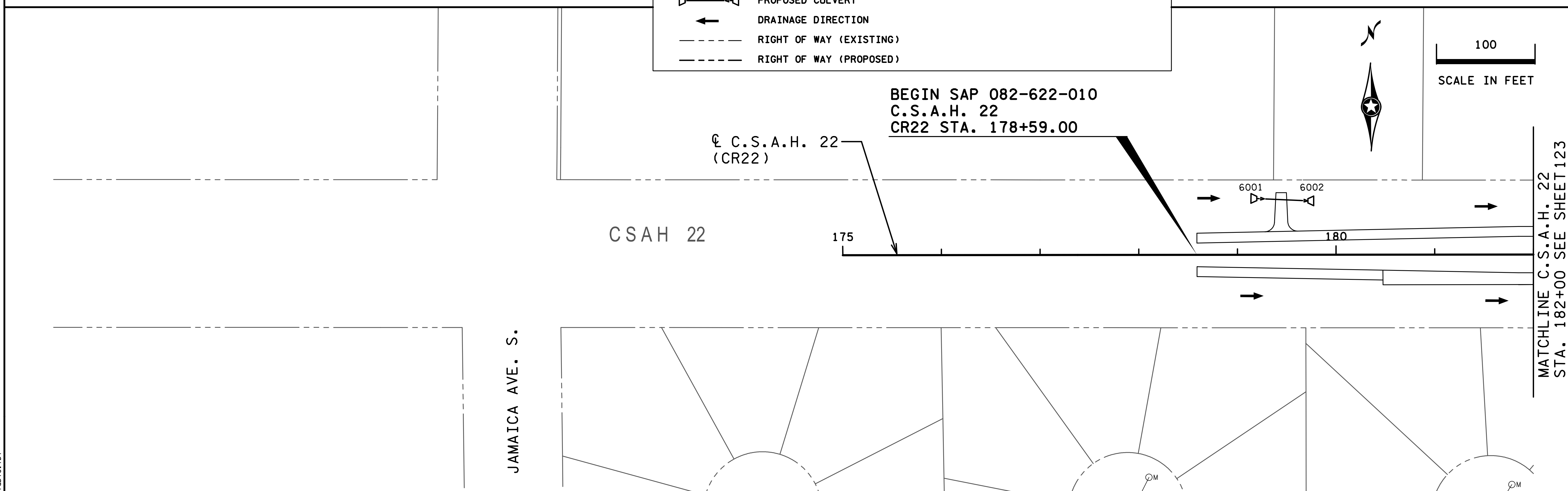
DRAWN BY: DWK DESIGNED BY: DWK CHECKED BY: SCB	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER NAME: DAX W. KUHFUSS	01/31/2013 DATE LIC. NO. 46620	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

CONSTRUCTION PLANS & PROFILES (11 OF 11)

C.S.A.H. 19 — SHEET NO. 87 OF 308 SHEETS

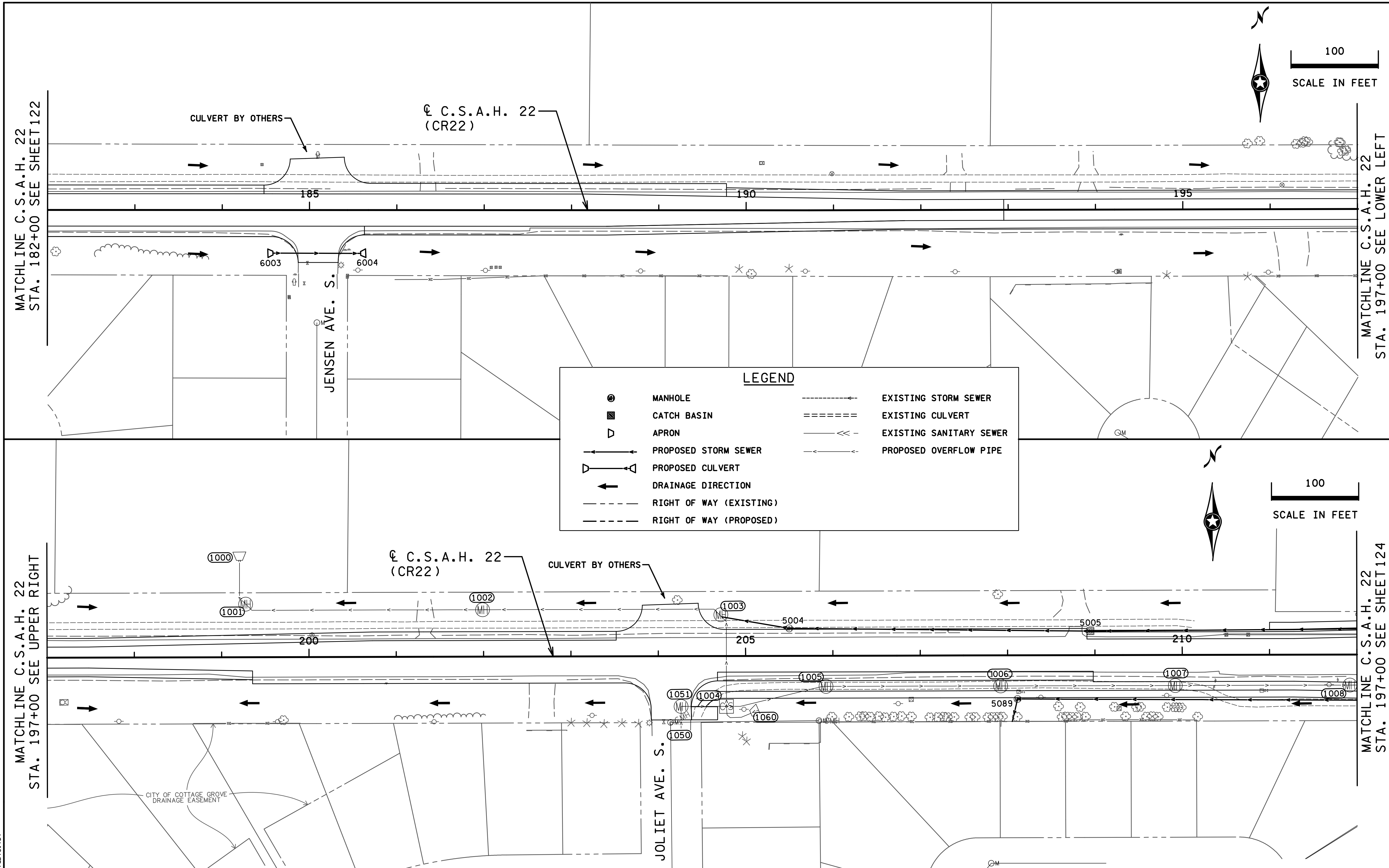
LEGEND

Symbol	Description	Symbol	Description
⊕	MANHOLE	----------<--	EXISTING STORM SEWER
▨	CATCH BASIN	=======	EXISTING CULVERT
▷	APRON	——<< -	EXISTING SANITARY SEWER
←——←	PROPOSED STORM SEWER	—<———<-	PROPOSED OVERFLOW PIPE
▷——◁	PROPOSED CULVERT		
←	DRAINAGE DIRECTION		
— — — —	RIGHT OF WAY (EXISTING)		
— - - -	RIGHT OF WAY (PROPOSED)		



DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: MATTHEW K. REDINGTON LIC. NO. 44737	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (1 OF 8)

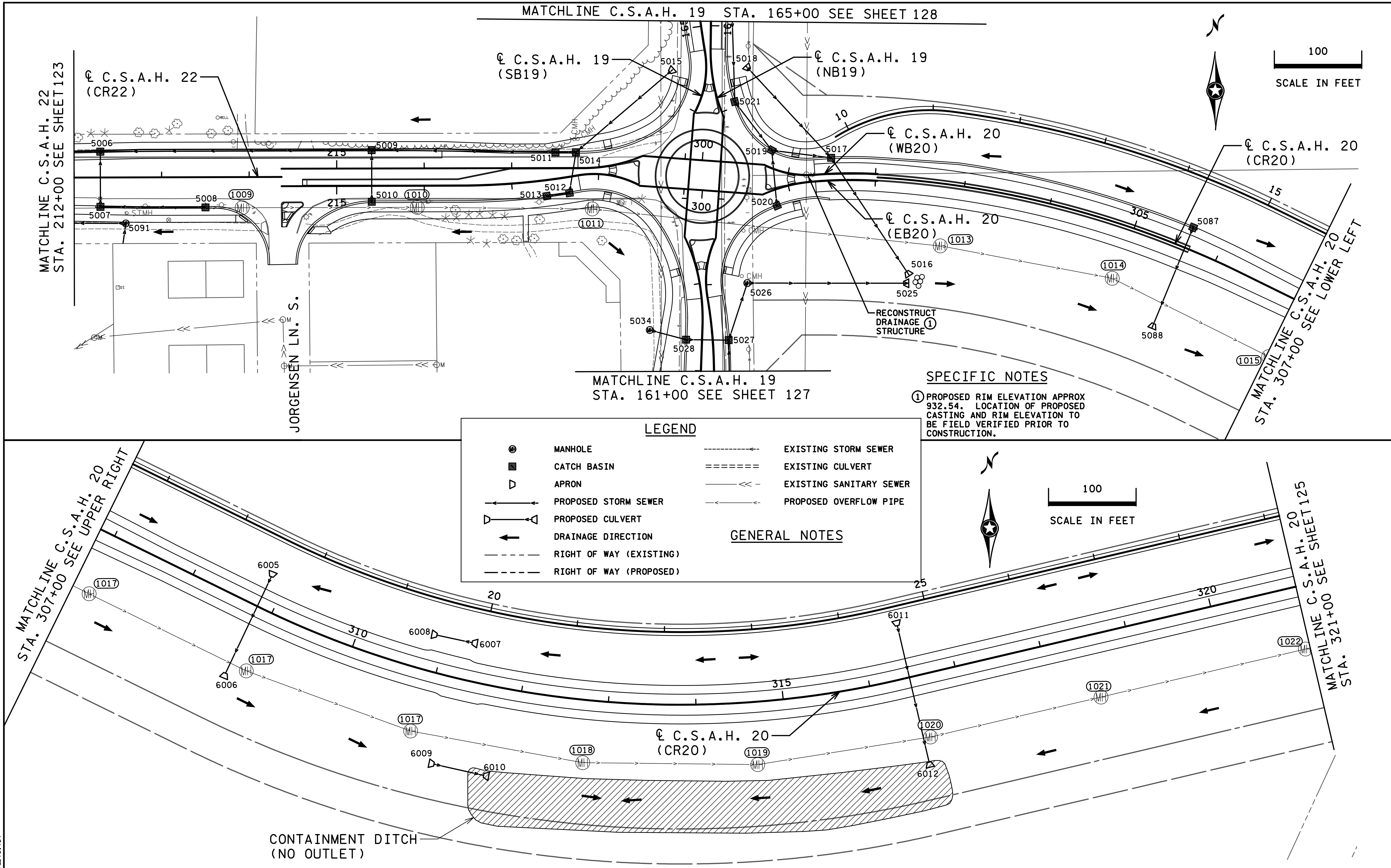


CD174267_DR01.dgn
6:13:34 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: ____ LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: MATTHEW K. REDINGTON LIC. NO. 44737	HDR HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

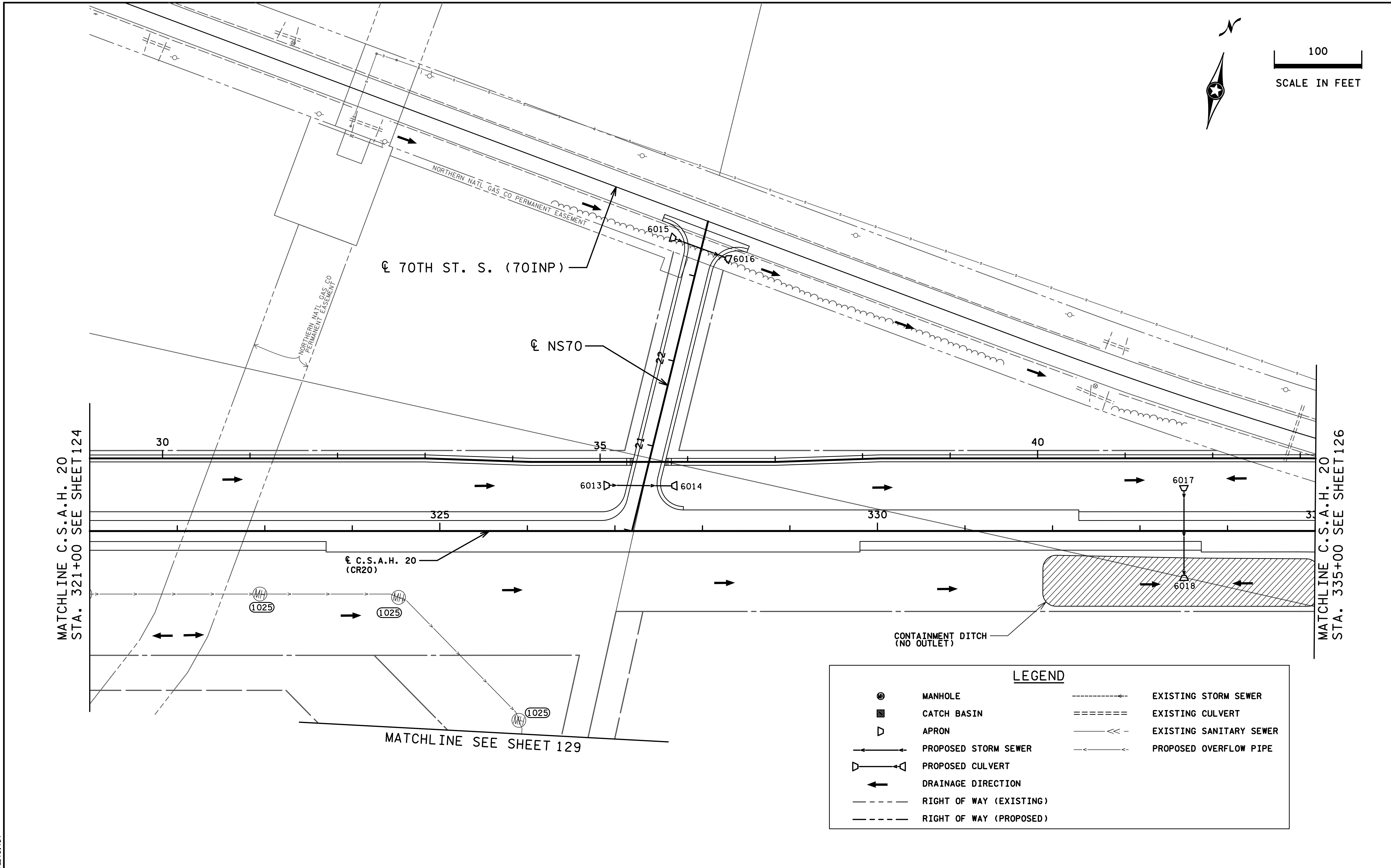
DRAINAGE PLANS (2 OF 8)

SHEET NO. 123 OF 308 SHEETS



CD174267_DR02.dgn
6:13:47 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: MATTHEW K. REDINGTON LIC. NO. 44737	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006	DRAINAGE PLANS (3 OF 8) SHEET NO. 124 OF 308 SHEETS



CD174267_DR03.dgn
6:13:59 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	NF
DESIGNED BY:	NF
CHECKED BY:	MR

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

NAME: MATTHEW K. REDINGTON — LIC. NO. 44737

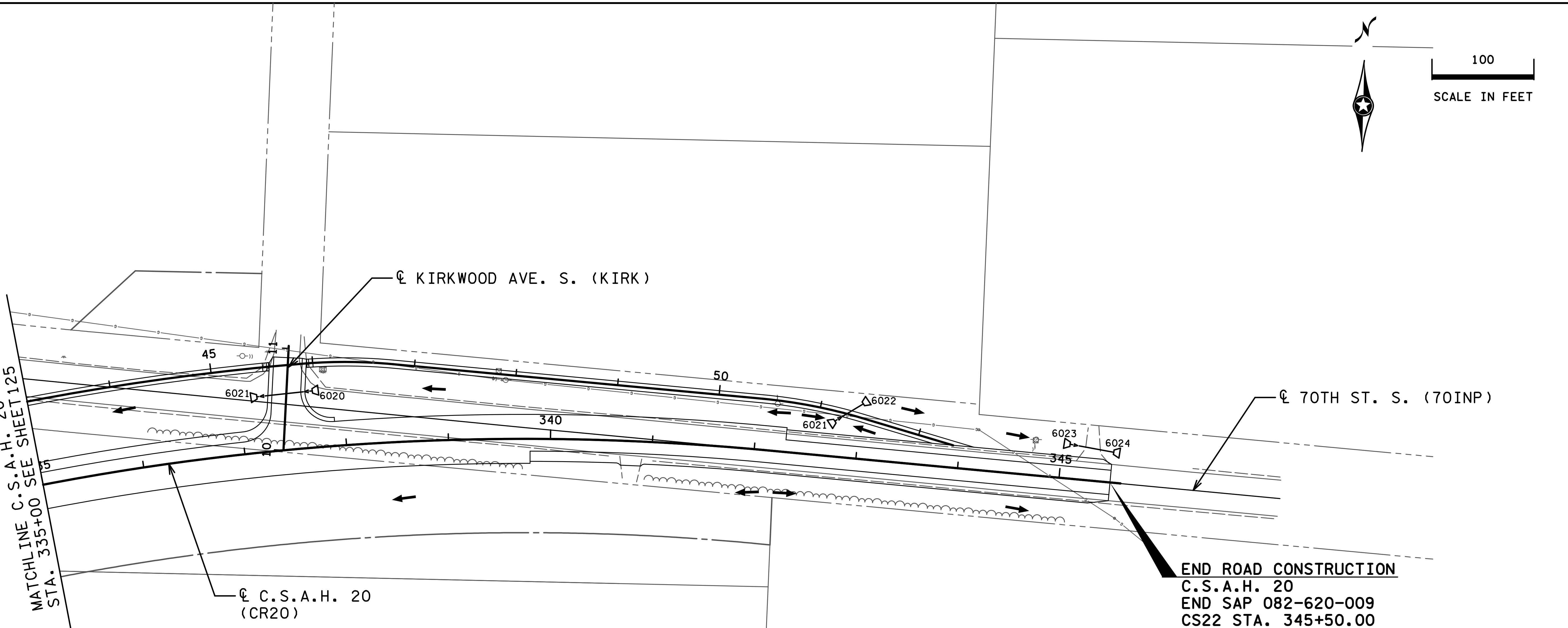
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (4 OF 8)

SHEET NO. 125 OF 308 SHEETS



LEGEND

MANHOLE	EXISTING STORM SEWER
CATCH BASIN	EXISTING CULVERT
APRON	EXISTING SANITARY SEWER
PROPOSED STORM SEWER	PROPOSED OVERFLOW PIPE
PROPOSED CULVERT	
DRAINAGE DIRECTION	
RIGHT OF WAY (EXISTING)	
RIGHT OF WAY (PROPOSED)	

CD174267_DR04.dgn
6:14:10 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	NF
DESIGNED BY:	NF
CHECKED BY:	MR

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE

NAME: MATTHEW K. REDINGTON LIC. NO. 44737

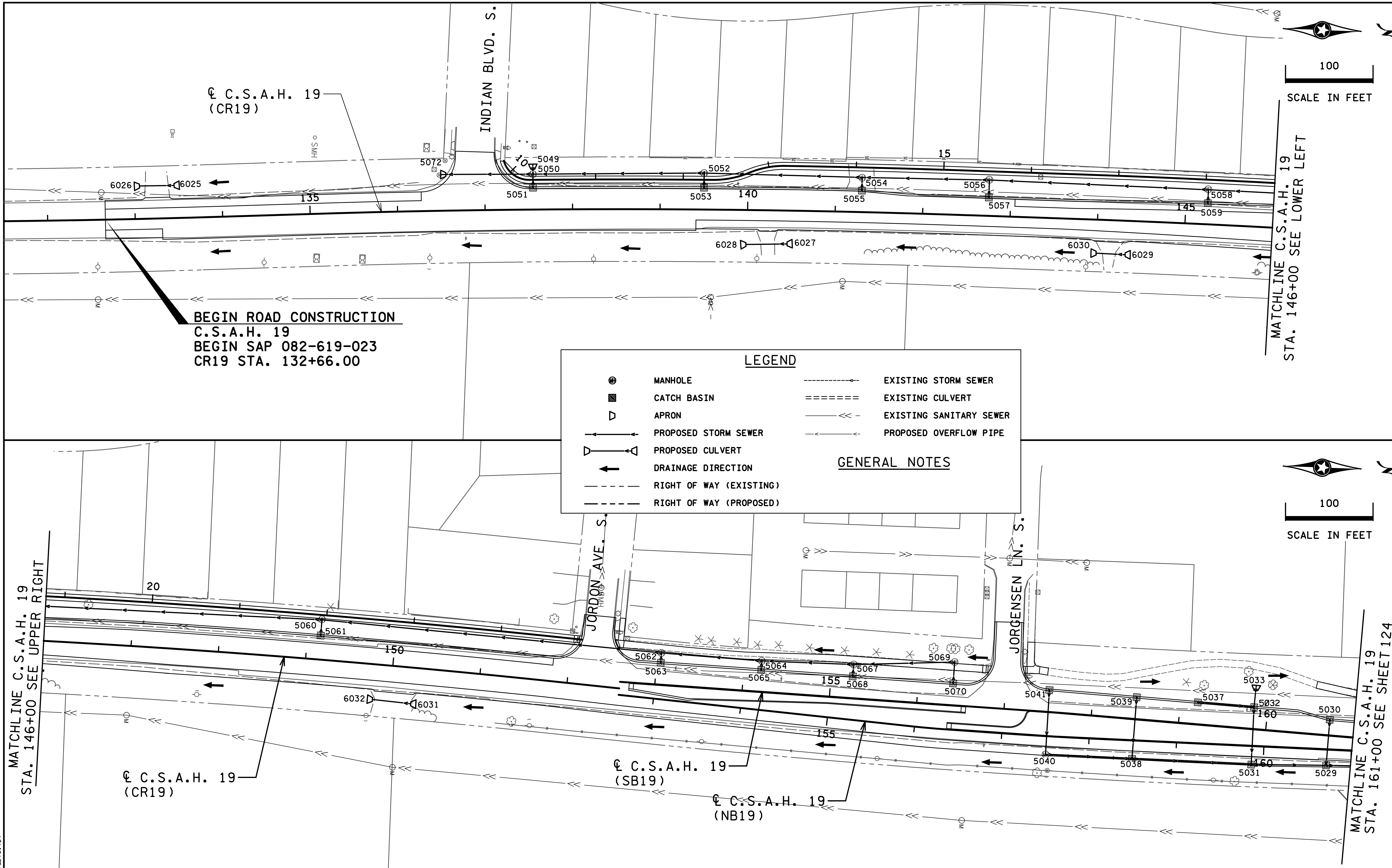
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (5 OF 8)

SHEET NO. 126 OF 308 SHEETS



DRAWN BY: NF	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER	01/31/2013 DATE
DESIGNED BY: NF		NAME: MATTHEW K. REDINGTON	LIC. NO. 44737
CHECKED BY: MR			

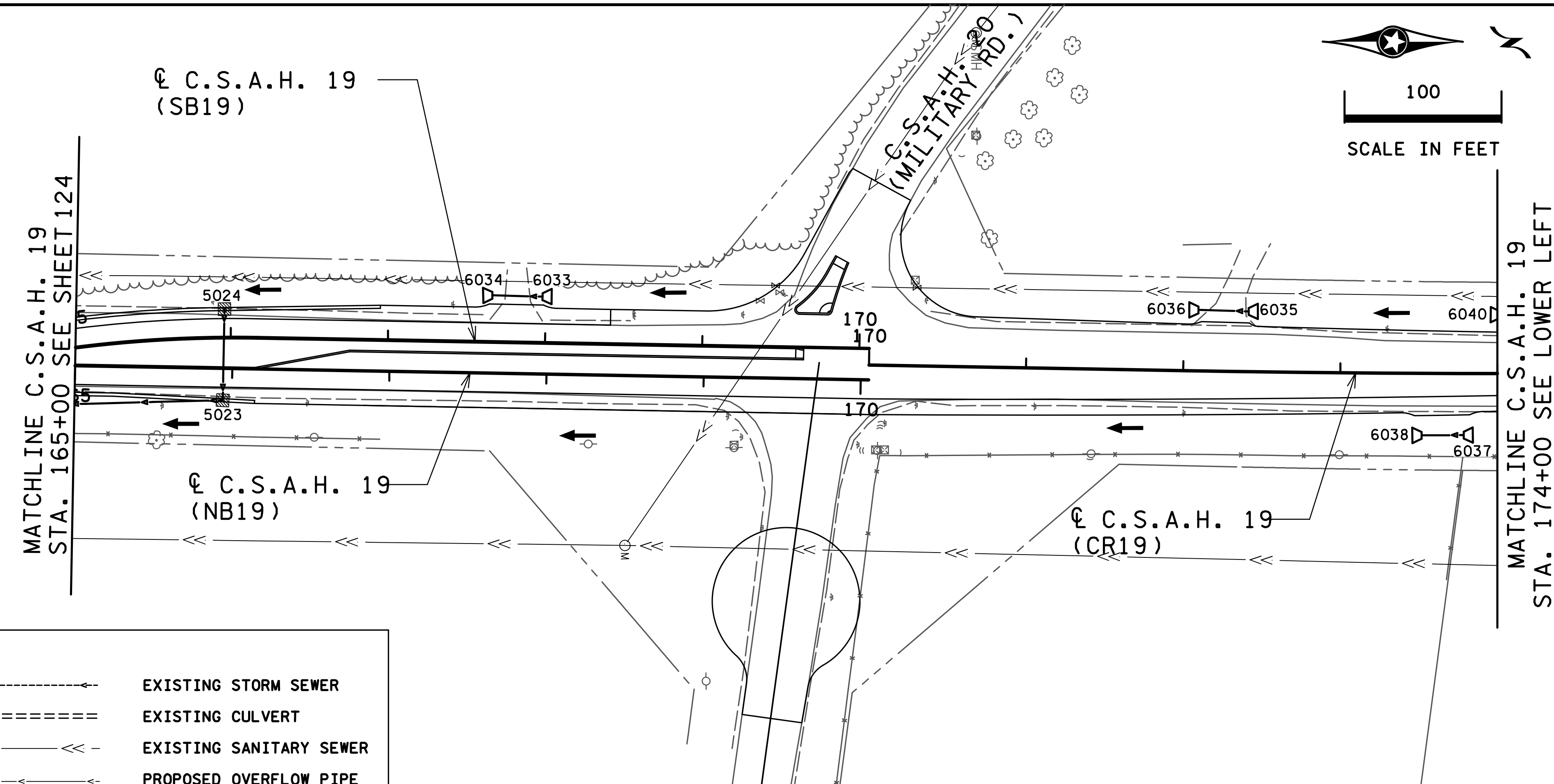
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (6 OF 8)

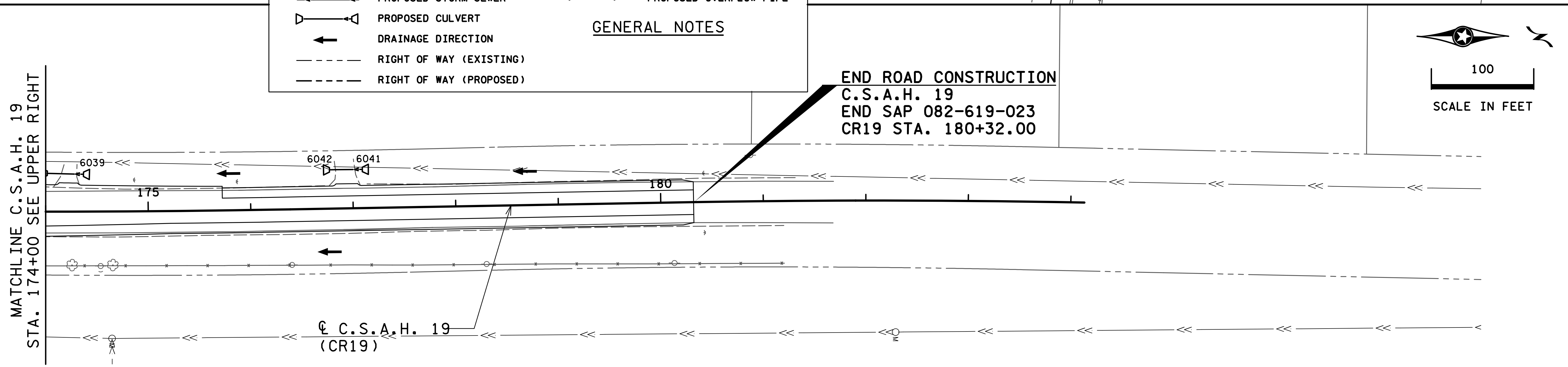
CD174267_DR05.dgn 6:14:22 PM 2/27/2013 CD174267_Pen_Table.tbl



LEGEND

MANHOLE	EXISTING STORM SEWER
CATCH BASIN	EXISTING CULVERT
APRON	EXISTING SANITARY SEWER
PROPOSED STORM SEWER	PROPOSED OVERFLOW PIPE
PROPOSED CULVERT	
DRAINAGE DIRECTION	
RIGHT OF WAY (EXISTING)	
RIGHT OF WAY (PROPOSED)	

GENERAL NOTES



CD174267_DR06.dgn
6:14:35 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	NF
DESIGNED BY:	NF
CHECKED BY:	MR

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: [signature] LICENSED PROFESSIONAL ENGINEER — DATE: 01/31/2013

NAME: MATTHEW K. REDINGTON — LIC. NO. 44737

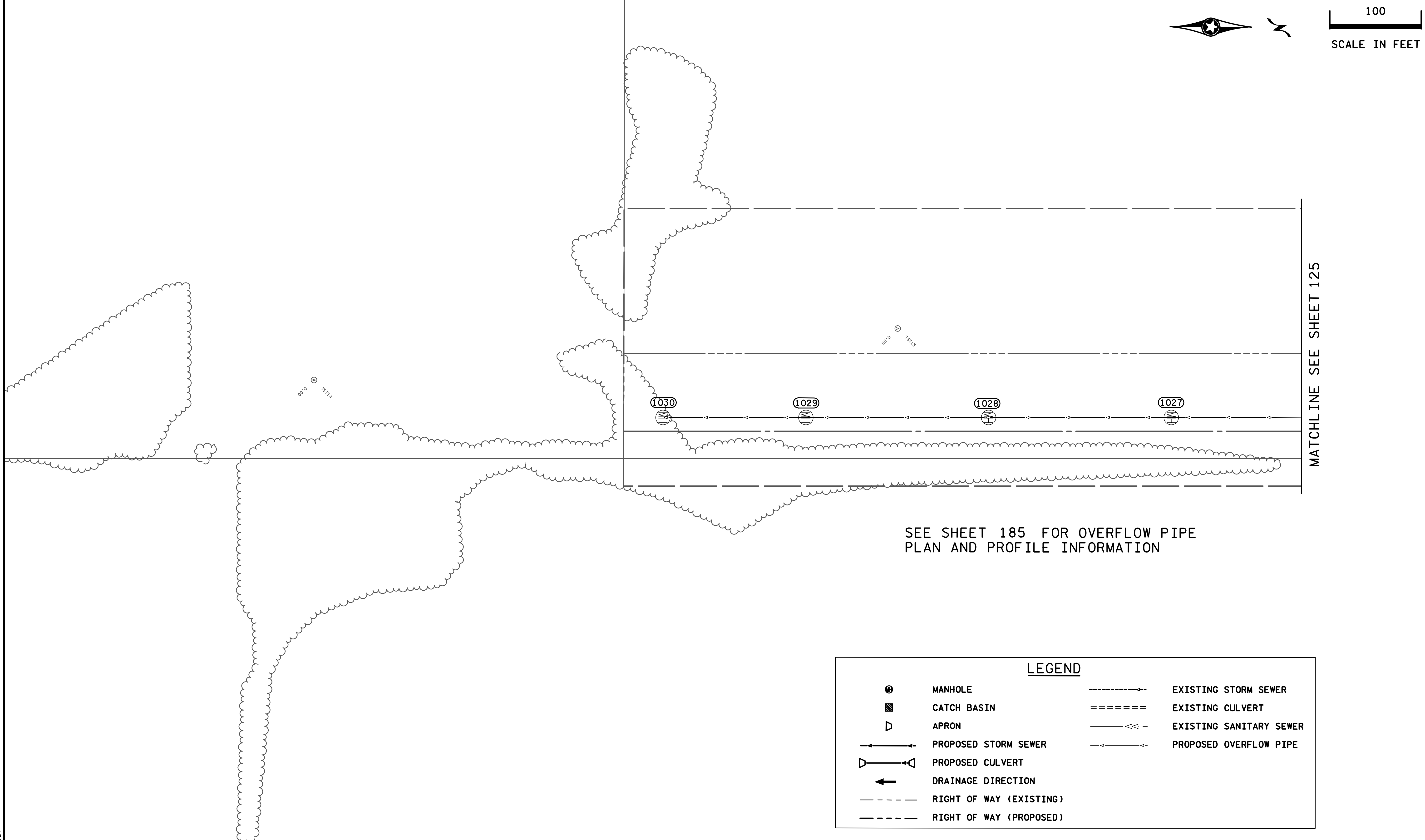
HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (7 OF 8)

SHEET NO. 128 OF 308 SHEETS



LEGEND

Symbol	Description	Symbol	Description
	MANHOLE		EXISTING STORM SEWER
	CATCH BASIN		EXISTING CULVERT
	APRON		EXISTING SANITARY SEWER
	PROPOSED STORM SEWER		PROPOSED OVERFLOW PIPE
	PROPOSED CULVERT		
	DRAINAGE DIRECTION		
	RIGHT OF WAY (EXISTING)		
	RIGHT OF WAY (PROPOSED)		

CD174267_DR07.dgn
6:14:47 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:
DESIGNED BY:
CHECKED BY:

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE

NAME: MATTHEW K. REDINGTON LIC. NO. 44737

HDR Engineering, Inc.

Washington County

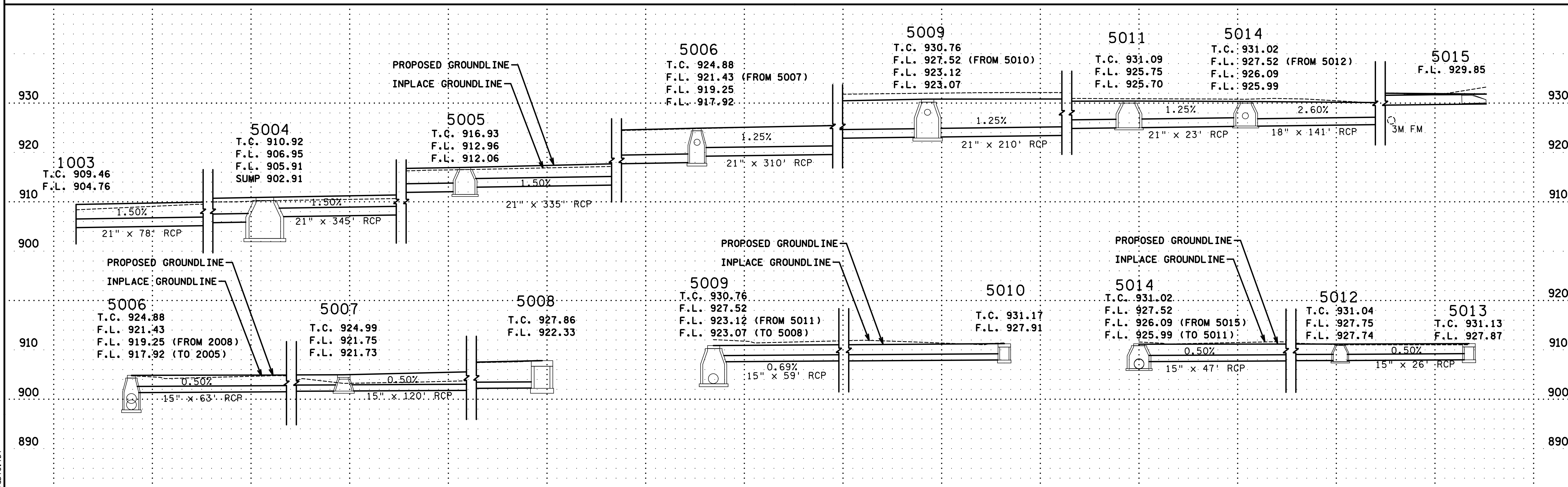
WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PLANS (8 OF 8)

DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO.		STRUCTURE LOCATION			DRAINAGE STRUCTURES											15" RCP CL II	18" RCP CL II	21" RCP CL II	21" RCP CL III	APRON	APRON TYPE	2" INSULATION	GUIDE POSTS TYPE B	REMARKS
FLOWS FROM	FLOWS TO	ALIGN.	STATION	OFFSET	TYPE	DESIGN	EST LIN FT	PAY HEIGHT A or F LIN FT	PAY HEIGHT N LIN FT	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D	TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	LIN FT	LIN FT	LIN FT	LIN FT	EACH		SQ YD	EACH	
5015	5014	SB19	164+50.00	37.0' LT										929.85	926.09		141			1	18" RC	3.6	1	
5014	5011	WB22	217+73.40	18.0' LT	CB	F	4.9	4.9		B - 9	C		931.02	925.99	925.75			23						
5011	5009	CR22	217+50.00	27.5' LT	CB	F	5.3	5.3		B - 9	C		931.09	925.70	923.12			210						
5009	5006	CR22	215+40.00	30.5' LT	CB	F	7.6	7.6		B - 9	A		930.76	923.07	919.25				310					
5006	5005	CR22	212+30.00	29.5' LT	CB	F	6.9	6.9		B - 9	A		924.88	917.92	912.96				335					
5005	5004	CR22	208+95.00	27.5' LT	CB	F	4.8	4.8		B - 9	C		916.93	912.06	906.95			345						
5004	1003	CR22	205+50.00	31.5' LT	MH	F	8.1	8.1		A - 7D	C		910.92	905.91	904.76			78						
5013	5012	CR22	217+40.00	22.5' RT	CB	N	3.2		3.2	B - 9			931.13	927.87	927.75	26								
5012	5014	EB22	217+63.61	18.0' RT	CB	N	3.2		3.2	B - 9			931.04	927.74	927.52	47								
5010	5009	CR22	215+40.00	28.5' RT	CB	N	3.2		3.2	B - 9			931.17	927.91	927.52	59								
5008	5007	CR22	213+50.00	34.5' RT	CB	N	5.5		5.5	B - 9			927.86	922.33	921.75	120								
5007	5006	CR22	212+30.00	33.6' RT	CB	N	3.2		3.2	B - 9			924.99	921.73	921.43	63								
TOTALS								37.6	18.3	11						315	141	656	645	1		3.6	1	

NOTES:
(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.



CD174267_DPR01.dgn
6:15:05 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	NF
DESIGNED BY:	NF
CHECKED BY:	MR

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

NAME: MATTHEW K. REDINGTON — LIC. NO. 44737

HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

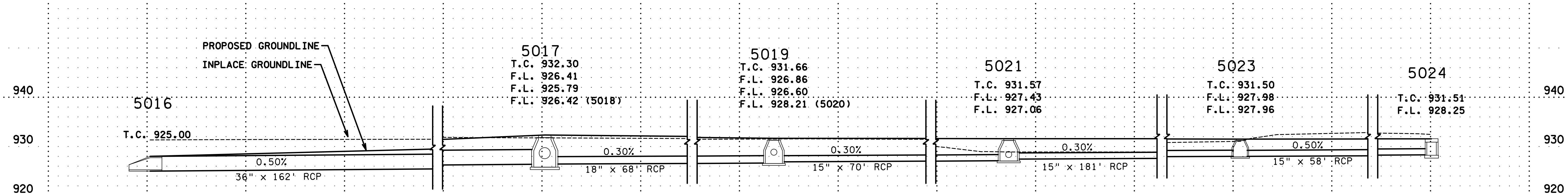
DRAINAGE PROFILES & TABULATIONS (1 OF 6)

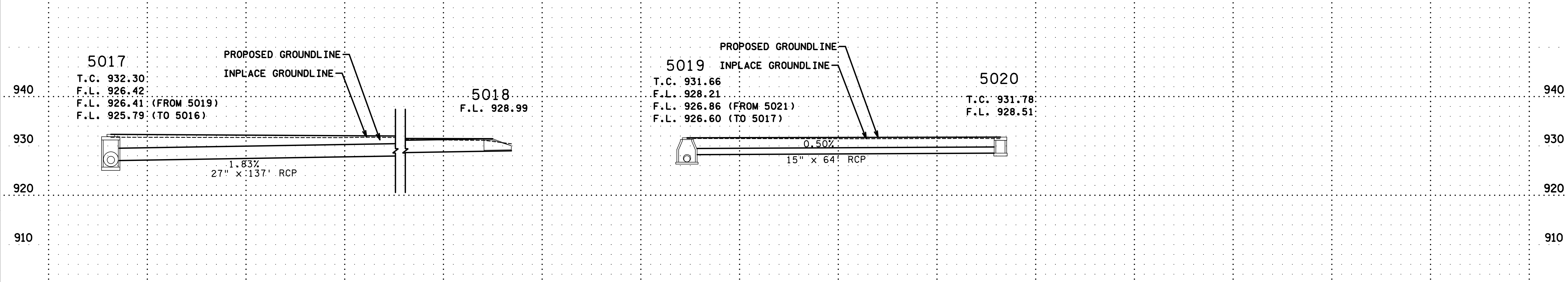
DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO. FLOWS FROM	STRUCTURE NO. FLOWS TO	STRUCTURE LOCATION ALIGN.	STRUCTURE LOCATION STATION	STRUCTURE LOCATION OFFSET	DRAINAGE STRUCTURE TYPE	DESIGN	EST LIN FT	PAY HEIGHT A or F LIN FT	PAY HEIGHT N LIN FT	PAY HEIGHT 84-1020 LIN FT	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D	TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	15" RCP CLII LIN FT	18" RCP CLII LIN FT	27" RCP CL III LIN FT	36" RCP CL IV LIN FT	APRON EACH	APRON TYPE	RANDOM RIPRAP CLASS III CU YD	GUIDE POSTS TYPE B EACH	REMARKS
5024	5023	SB19	165+96.10	18.0' LT	CB	N	3.2		3.2		B - 9			931.51	928.25	927.98	58								
5023	5021	NB19	165+94.30	20.3' RT	CB	F	3.5	3.5			B - 9	C		931.50	927.96	927.43	181								
5021	5019	NB19	164+06.25	18.0' RT	CB	F	4.4	4.4			B - 9	C		931.57	927.06	926.86	70								
5019	5017	WB20	300+71.20	18.5' LT	CB	F	5.0	5.0			B - 9	C		931.66	926.60	926.41		68							
5017	5016	WB20	301+50.00	18.0' LT	CB	84-4020	6.4			6.4	B - 9	C		932.30	925.79	925.00				162					
5016		EB20	302+50.00	105.0' RT											925.00						1	36" RC	13.80	1	
5020	5019	EB20	300+79.75	18.0' RT	CB	N	3.2		3.2		B - 9			931.78	928.51	928.21	64								
5018	5017	NB19	164+50.00	39.0' RT											928.99	926.42			137		1	27" RC		1	
TOTALS								12.9	6.4	6.4	6						373	68	137	162	2		14	2	

NOTES:

(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.

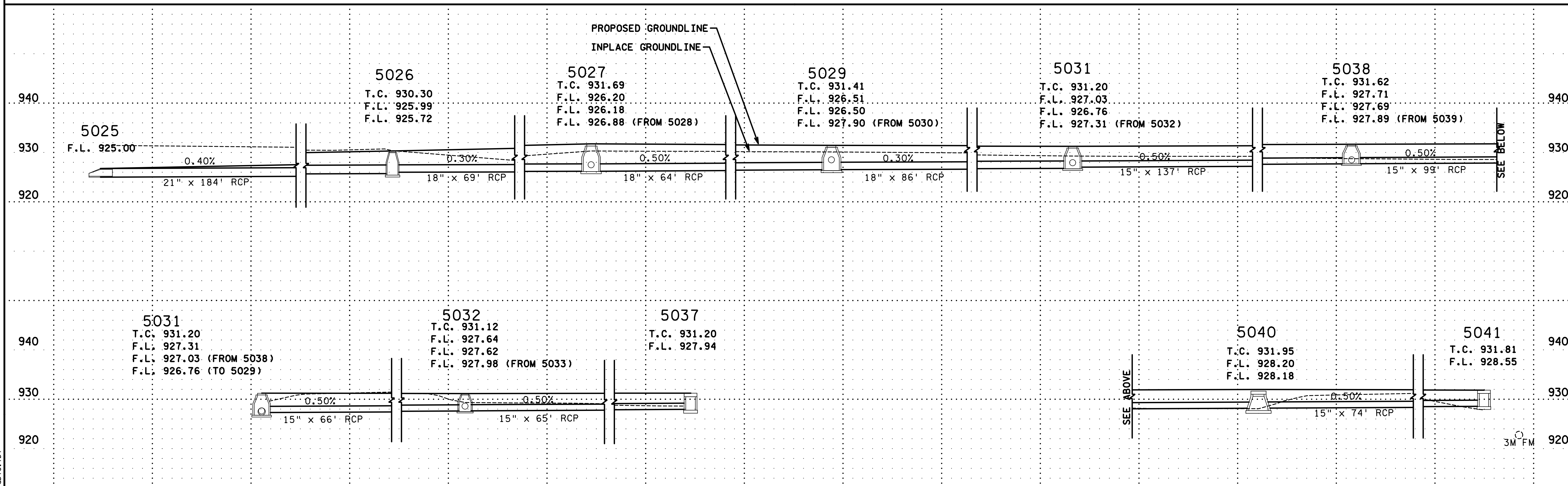




DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO. FLOWS FROM	STRUCTURE NO. FLOWS TO	STRUCTURE LOCATION ALIGN.	STATION	OFFSET	DRAINAGE STRUCTURES TYPE	DESIGN	EST LIN FT	PAY HEIGHT A or F LIN FT	PAY HEIGHT N LIN FT	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D	TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	15" RCP CL II LIN FT	18" RCP CL II LIN FT	21" RCP CL III LIN FT	APRON EACH	APRON TYPE	RANDOM RIPRAP CLASS III CU YD	GUIDE POSTS TYPE B EACH	REMARKS
5041	5040	SB19	157+50.00	25.0' LT	CB	N	3.2		3.2	B - 9			931.81	928.55	928.20	74							
5040	5038	NB19	157+51.40	21.0' RT	MH	F	3.9	3.9		A - 7D	C		931.95	928.18	927.71	99							
5038	5031	NB19	158+50.00	21.0' RT	CB	F	3.9	3.9		B - 9	C		931.62	927.69	927.03	137							
5031	5029	NB19	159+86.50	21.2' RT	CB	F	4.4	4.4		B - 9	C		931.20	926.76	926.51		86						
5029	5027	NB19	160+72.00	18.0' RT	CB	F	4.8	4.8		B - 9	C		931.41	926.50	926.20		64						
5027	5026	NB19	161+35.00	18.0' RT	CB	F	5.4	5.4		B - 9	C		931.69	926.18	925.99		69						
5026	5025	NB19	162+00.00	47.0' RT	MH	F	4.7	4.7		A - 7D	C		930.30	925.72	925.00			184					Beehive
5025		NB19	162+55.28	226.5' RT										925.00					1	21" RC	6.30	1	
5037	5032	SB19	159+20.00	25.0' LT	CB	N	3.2		3.2	B - 9			931.20	927.94	927.64	65							
5032	5031	SB19	159+84.50	25.0' LT	CB	F	3.4	3.4		B - 9	C		931.12	927.62	927.31	66							
TOTALS								30.5	6.4	9						441	219	184	1		6	1	

NOTES:
(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.



DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: MATTHEW K. REDINGTON LIC. NO. 44737	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

DRAINAGE PROFILES & TABULATIONS (3 OF 6)

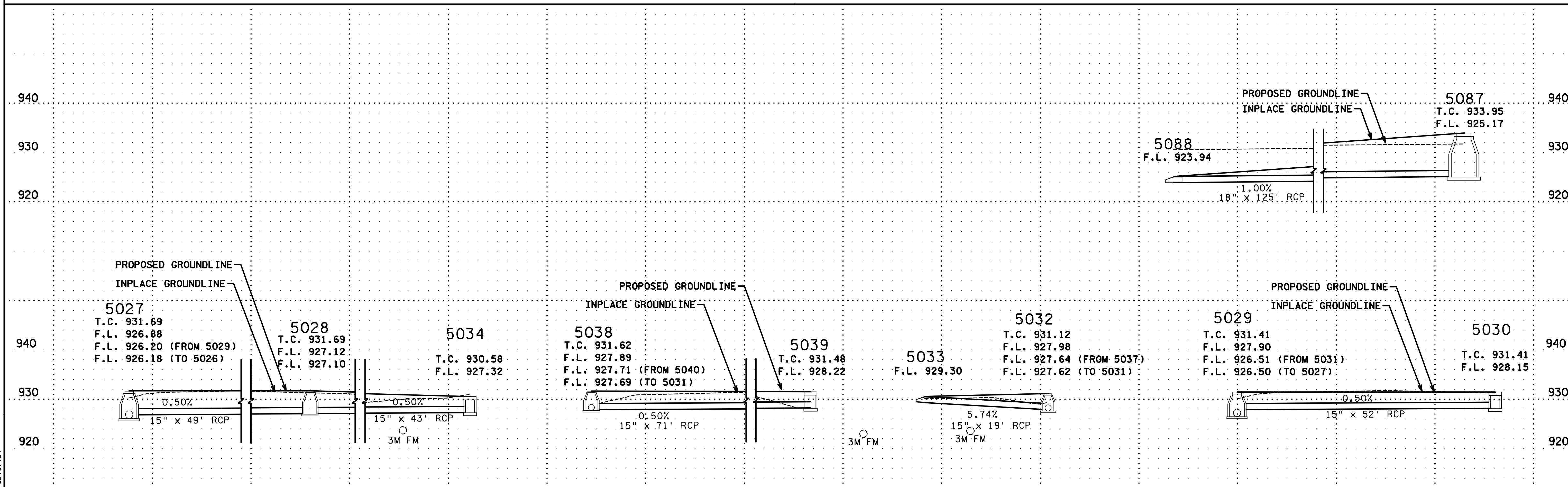
SHEET NO. 132 OF 308 SHEETS

CD174267_DPR03.dgn
6:15:41 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO.		STRUCTURE LOCATION			DRAINAGE STRUCTURES								TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	15" RCP CL II	18" RCP CL IV	APRON	APRON TYPE	2" INSULATION	GUIDE POSTS TYPE B	REMARKS
FLOWS FROM	FLOWS TO	ALIGN.	STATION	OFFSET	TYPE	DESIGN	PAY HEIGHT EST	PAY HEIGHT A or F	PAY HEIGHT N	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D										
							LIN FT	LIN FT	LIN FT							LIN FT	LIN FT	EACH		SQ YD	EACH	
5030	5029	SB19	160+72.00	18.0' LT	CB	N	3.2		3.2	B - 9			931.41	928.15	927.90	52						
5033	5032	SB19	159+85.00	50.0' LT										929.30	927.98	19		1	15" RC	3.6	1	
5039	5038	SB19	158+50.00	25.0' LT	CB	N	3.2		3.2	B - 9			931.48	928.22	927.89	71						
5034	5028	SB19	161+44.56	59.9' LT	MH	N	3.4		3.4	A - 7D			930.58	927.32	927.12	43				3.6		Beehive
5028	5027	SB19	161+35.00	18.0' LT	CB	F	4.5	4.5		B - 9	C		931.69	927.10	926.88	49						
5087	5088	CR20	305+62.00	25.0' LT	CB	F	8.7	8.7		B-9	A		933.95	925.17	923.94		125					
5088		CR20	305+62.00	99.6' RT										923.94				1	18" RC		1	
TOTALS								13.2	9.8	5						234	125	2		7.2	2	

NOTES:
(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.



DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER 01/31/2013 DATE NAME: MATTHEW K. REDINGTON LIC. NO. 44737	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006	DRAINAGE PROFILES & TABULATIONS (4 OF 6) SHEET NO. 133 OF 308 SHEETS

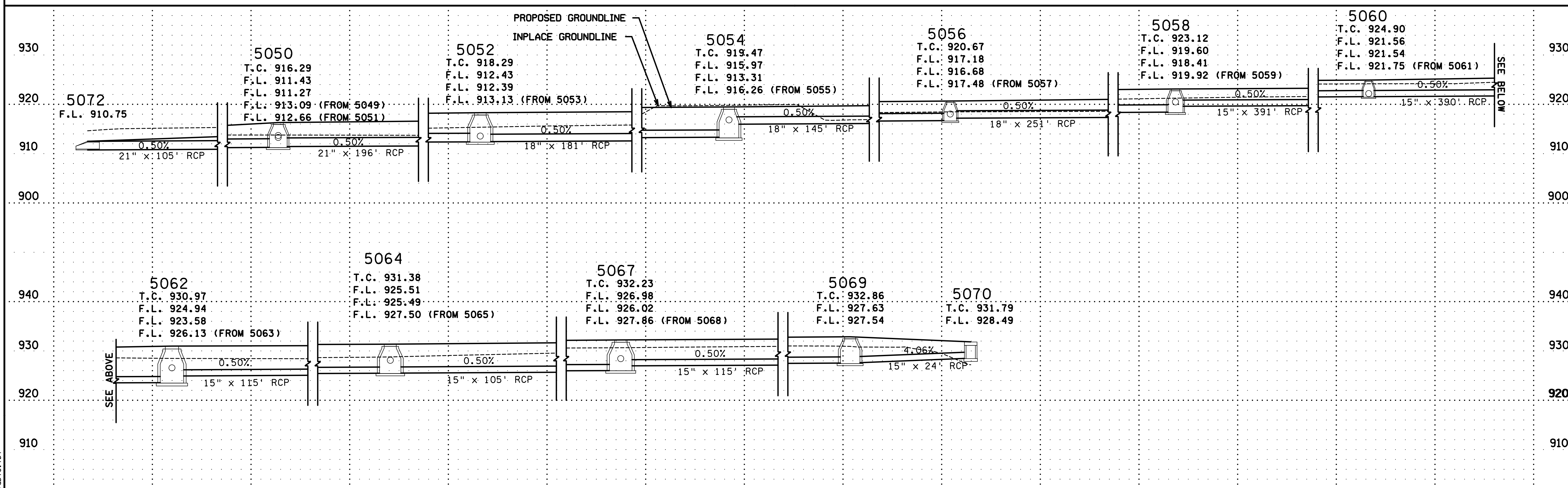
CD174267_DPR04.dgn
6:16:01 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO.		STRUCTURE LOCATION			DRAINAGE STRUCTURES								TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	15" RCP CL II	18" RCP CL II	21" RCP CL II	APRON	APRON TYPE	2" INSULATION	GUIDE POSTS TYPE B	REMARKS
FLOWS FROM	FLOWS TO	ALIGN.	STATION	OFFSET	TYPE	DESIGN	PAY HEIGHT EST LIN FT	PAY HEIGHT A or F LIN FT	PAY HEIGHT N LIN FT	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D				LIN FT	LIN FT	LIN FT	EACH		SQ YD	EACH	
5070	5069	SB19	156+40.00	25.0' LT	CB	N	3.2		3.2	B - 9			931.79	928.49	927.63	24					3.6		
5069	5067	SB19	156+40.00	49.4' LT	MH	F	3.4	5.4		A - 7D	C		932.86	927.54	926.98	115							
5067	5064	SB19	155+25.00	38.5' LT	MH	F	6.6	6.3		A - 7D	C		932.23	926.02	925.51	105							
5064	5062	SB19	154+20.00	35.3' LT	MH	F	5.5	6.0		A - 7D	C		931.38	925.49	924.94	115							
5062	5060	SB19	153+05.00	36.3' LT	MH	F	7.4	7.5		A - 7D	C		930.97	923.58	921.56	390							
5060	5058	CR19	149+15.00	45.5' LT	MH	F	3.4	3.5		A - 7D	C		924.90	921.54	919.60	391							
5058	5056	CR19	145+25.00	39.5' LT	MH	F	4.8	4.8		A - 7D	C		923.12	918.41	917.18		251						Beehive
5056	5054	CR19	142+75.00	41.0' LT	MH	F	4.0	4.1		A - 7D	C		920.67	916.68	915.97		145						Beehive
5054	5052	CR19	141+30.00	39.6' LT	MH	F	6.1	6.3		A - 7D	C		919.47	913.31	912.43		181						Beehive
5052	5050	CR19	139+50.00	41.7' LT	MH	F	5.5	6.0		A - 7D	C		918.29	912.39	911.43			196					
5050	5072	CR19	137+55.00	40.5' LT	MH	F	4.4	5.1		A - 7D	C		916.29	911.27	910.75			105					
5072		CR19	136+50.00	41.5' LT										910.75					1	21" RC		1	
TOTALS								55.0	3.2	12						1140	577	301	1		3.6	1	

NOTES:

(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.



DRAWN BY: NF DESIGNED BY: NF CHECKED BY: MR	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER NAME: MATTHEW K. REDINGTON LIC. NO. 44737 DATE 01/31/2013	HDR Engineering, Inc.	Washington County	WASHINGTON COUNTY C.S.A.H. 19 S.A.P. 082-619-023 C.S.A.H. 20 S.A.P. 082-620-009 C.S.A.H. 22 S.A.P. 082-622-010 CITY OF COTTAGE GROVE C.S.A.H. 19 S.A.P. 180-020-007 C.S.A.H. 20 & 22 S.A.P. 180-020-006

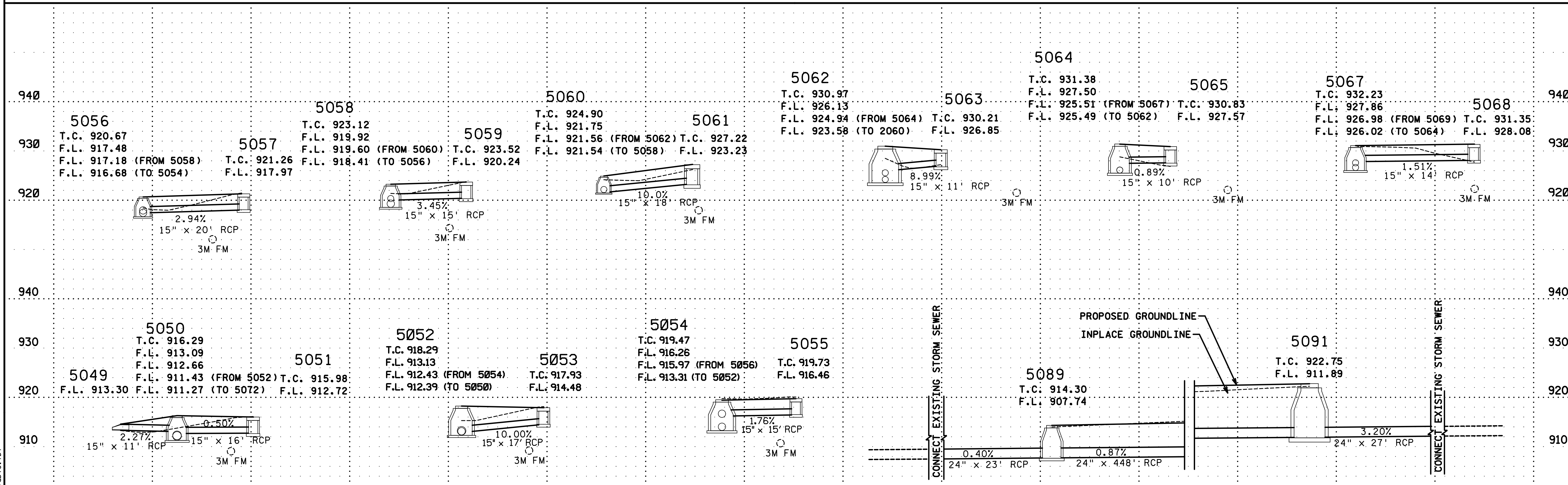
DRAINAGE PROFILES & TABULATIONS (5 OF 6)

DRAINAGE TABULATION (THIS SHEET ONLY)

STRUCTURE NO.		STRUCTURE LOCATION			DRAINAGE STRUCTURES								TOP OF CASTING ELEV	OUTLET ELEV.	INLET ELEV. (1)	15" RCP CL II	24" RCP CL IV	APRON	APRON TYPE	2" INSULATION	GUIDE POSTS TYPE B	REMARKS
FLOWS FROM	FLOWS TO	ALIGN.	STATION	OFFSET	TYPE	DESIGN	PAY HEIGHT EST LIN FT	PAY HEIGHT A or F LIN FT	PAY HEIGHT N LIN FT	CASTING ASSEMBLY TYPE	CONE TYPE	STEPS REQ'D				LIN FT	LIN FT	EACH		SQ YD	EACH	
5068	5067	SB19	155+25.00	25.0' LT	CB	N	3.2		3.2	B - 9		N	931.35	928.08	927.86	14				3.6		
5065	5064	SB19	154+20.00	25.0' LT	CB	N	3.2		3.2	B - 9		N	930.83	927.57	927.50	10						
5063	5062	SB19	153+05.00	25.0' LT	CB	N	3.3		3.2	B - 9		N	930.21	926.85	926.13	11						
5061	5060	CR19	149+15.00	27.5' LT	CB	N	3.9		3.8	B - 9		N	927.22	923.23	921.75	18						
5059	5058	CR19	145+25.00	24.2' LT	CB	N	3.2		3.2	B - 9		N	923.52	920.24	919.92	15				3.6		
5057	5056	CR19	142+75.00	21.0' LT	CB	N	3.2		3.2	B - 9		N	921.26	917.97	917.48	20				3.6		
5055	5054	CR19	141+30.00	24.6' LT	CB	N	3.2		3.2	B - 9		N	919.73	916.46	916.26	15				3.6		
5053	5052	CR19	139+50.00	25.0' LT	CB	N	3.4		3.4	B - 9		N	917.93	914.48	913.13	17				3.6		
5051	5050	CR19	137+55.00	25.0' LT	CB	F	3.2	3.2		B - 9		N	915.98	912.72	912.66	16				3.6		
5049	5050	CR19	137+55.00	51.9' LT										913.30	913.09	11		1	15" RC		1	
EX	5091													912.74	911.89		27					
5091	5089	CR22	212+58.91	52.6' RT	CB	F	10.9	10.9		A-7D		Y	922.75	911.89	907.74		448					
5089	EX	CR22	208+11.26	50.0' RT	CB	F	6.6	6.6		A-7D		Y	914.30	907.74	907.65		23					
TOTALS								20.7	26.4	11						147	498	1		21.6	1	

NOTES:

(1) INLET ELEVATION AT DOWNSTREAM STRUCTURE.



CD174267_DPR06.dgn
6:16:35 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	NF
DESIGNED BY:	NF
CHECKED BY:	MR

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

NAME: MATTHEW K. REDINGTON — LIC. NO. 44737

HDR Engineering, Inc.

Washington County

WASHINGTON COUNTY
C.S.A.H. 19 S.A.P. 082-619-023
C.S.A.H. 20 S.A.P. 082-620-009
C.S.A.H. 22 S.A.P. 082-622-010
CITY OF COTTAGE GROVE
C.S.A.H. 19 S.A.P. 180-020-007
C.S.A.H. 20 & 22 S.A.P. 180-020-006

(6 OF 6)

ALIGNMENT TABULATION

STRUCTURE ID	STATION	DISTANCE	BEARING	COORDINATES	
				X	Y
72" OVERFLOW PIPE ALIGNMENT					
APRON1000	9+18.47			479,818.36	137,372.48
.		43.09	S 0°38'07.70" W		
PI	9+61.56			479,817.85	137,329.39
.		10.00	S 44°21'58.22" E		
CB1001	9+71.56			479,824.84	137,322.23
.		10.00	S 44°21'58.22" E		
PI	9+81.56			479,831.84	137,315.09
.		264.23	S 89°28'02.21" E		
CB1002	12+45.79			480,096.06	137,312.63
.		265.00	S 89°28'02.21" E		
PI	15+10.79			480,361.05	137,310.17
.		10.00	S 44°28'02.21" E		
CB1003	15+20.79			480,368.05	137,303.03
.		10.00	S 44°28'02.21" E		
PI	15+30.79			480,375.06	137,295.90
.		97.21	S 0°37'03.76" W		
CB1004	16+28.01			480,374.01	137,198.69
.		15.83	S 89°21'58.22" E		
PI	16+43.84			480,389.84	137,198.51
.		97.21	N 77°01'51.88" E		
CB1005	17+41.05			480,484.57	137,220.33
.		203.68	S 89°27'57.57" E		
CB1006	19+44.73			480,688.25	137,218.43
.		200.00	S 89°28'02.21" E		
CB1007	21+44.73			480,888.24	137,216.57
.		200.00	S 89°28'02.21" E		
CB1008	23+44.73			481,088.23	137,214.71
.		200.00	S 89°28'02.21" E		
CB1009	25+44.73			481,288.22	137,212.85
.		200.00	S 89°28'02.21" E		
CB1010	27+44.73			481,488.21	137,210.99
.		199.99	S 88°47'51.18" E		
CB1011	29+44.73			481,688.16	137,206.80
.		399.86	S 83°15'58.98" E		
CB1013	33+44.67			482,085.27	137,159.91
.		199.91	S 78°38'59.06" E		
CB1014	35+44.58			482,281.27	137,120.57
.		199.92	S 62°43'37.57" E		
CB1015	37+44.50			482,458.97	137,028.96
.		200.00	S 63°11'32.72" E		
CB1016	39+44.50			482,637.47	136,938.76
.		199.97	S 69°13'19.35" E		
CB1017	41+44.47			482,824.44	136,867.82
.		199.94	S 78°54'50.22" E		
CB1018	43+44.41			483,020.65	136,829.37
.		199.94	S 88°42'10.57" E		

ALIGNMENT TABULATION

STRUCTURE ID	STATION	DISTANCE	BEARING	COORDINATES	
				X	Y
72" OVERFLOW PIPE ALIGNMENT (CONT.)					
CB1019	45+44.36				
.		199.97	N 81°35'57.48" E		
CB1020	47+44.32				
.		199.99	N 77°29'20.06" E		
CB1021	49+44.32				
.		240.00	N 77°26'52.76" E		
CB1022	51+84.32				
.		200.00	N 77°26'52.76" E		
CB1023	53+84.32				
.		149.15	N 77°26'52.76" E		
PI	55+33.47				
.		10.00	S 79°46'11.13" E		
CB1024	55+43.47				
.		10.00	S 79°46'11.13" E		
PI	55+53.47				
.		178.23	S 56°59'15.02" E		
PI	57+31.70				
.		9.98	S 33°13'48.21" E		
CB1025	57+41.70				
.		9.98	S 33°13'48.21" E		
PI	57+51.65				
.		189.09	S 9°22'43.98" E		
CB1026	59+40.74				
.		199.97	S 0°09'02.10" E		
CB1027	61+40.72				
.		200.00	S 0°03'24.61" E		
CB1028	63+40.72				
.		200.00	S 0°03'24.61" E		
CB1029	65+40.72				
.		156.46	S 0°03'24.61" E		
CB1030	66+97.18				

ALIGNMENT TABULATION

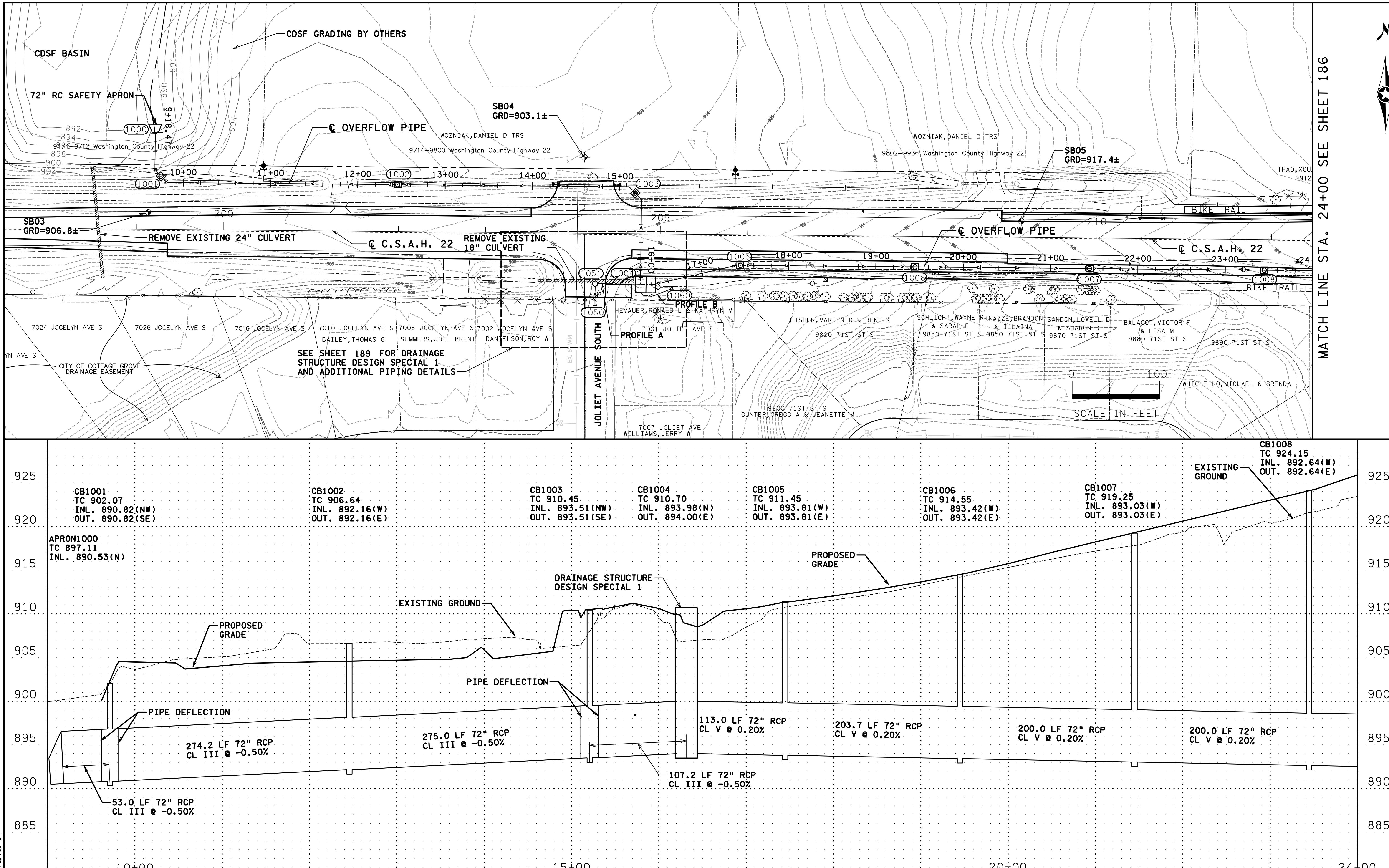
STRUCTURE ID	STATION	DISTANCE	BEARING	COORDINATES	
				X	Y
PROFILE A ALIGNMENT - 42" JOLIET AVENUE SOUTH CONNECTION					
CB1050	0+00.00			480,321.79	137,174.26
.		25.00	N 1°10'18.13" E		
CB1051	0+25.00			480,322.07	137,199.26
.		45.78	S 89°21'58.29" E		
CB1004	1+04.87			480,374.01	137,198.69

ALIGNMENT TABULATION

STRUCTURE ID	STATION	DISTANCE	BEARING	COORDINATES	
				X	Y
PROFILE B ALIGNMENT - 18" RCP TO CONTROL STRUCTURE					
CB1004	0+00.00			480,410.68	137,194.02
.		22.61	S 68°08'01.78" W		
PI	0+22.61			480,389.70	137,185.60
.		12.08	N 89°21'58.22" W		
PI	0+34.69			480,377.62	137,185.73
		5.30	N 44°21'58.22" W		
APRON1060	0+40.00			480,373.91	137,189.52

HORIZONTAL CONTROL

THE HORIZONTAL CONTROL FOR THIS PLAN IS NAD83 (1996 ADJUSTMENT) WASHINGTON COUNTY COORDINATES. FOR THE INFORMATION ON THE HORIZONTAL CONTROL POINTS CONTACT WASHINGTON COUNTY.



DRAWN BY: KAH	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — NAME: MATTHEW K. REDINGTON	DATE: 01/31/2013 — LIC. NO. 44737
DESIGNED BY: MKR			
CHECKED BY: MWJ			

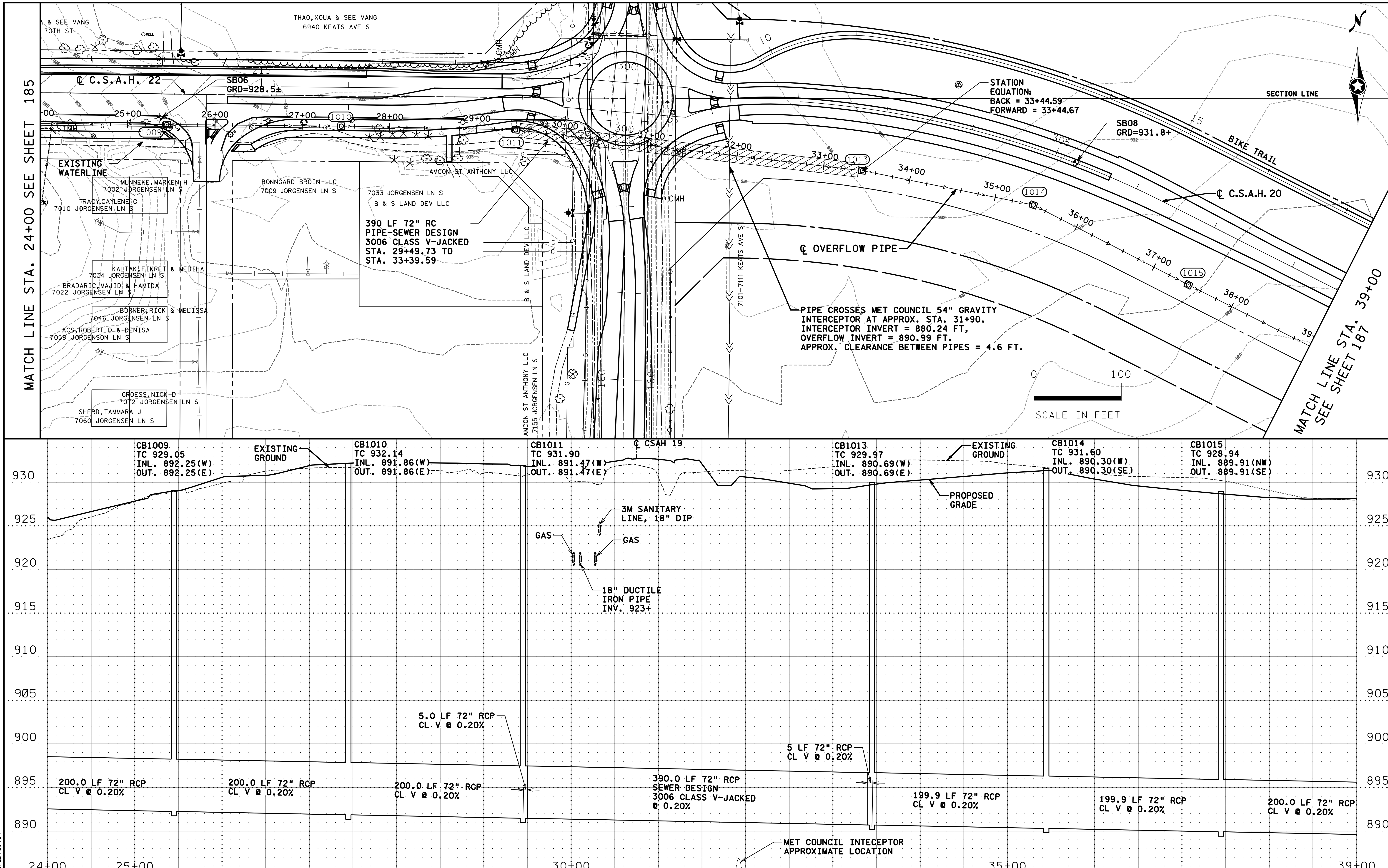
HDR Engineering, Inc.

South Washington WATERSHED District

OVERFLOW PIPE PLAN AND PROFILE (1 OF 4)

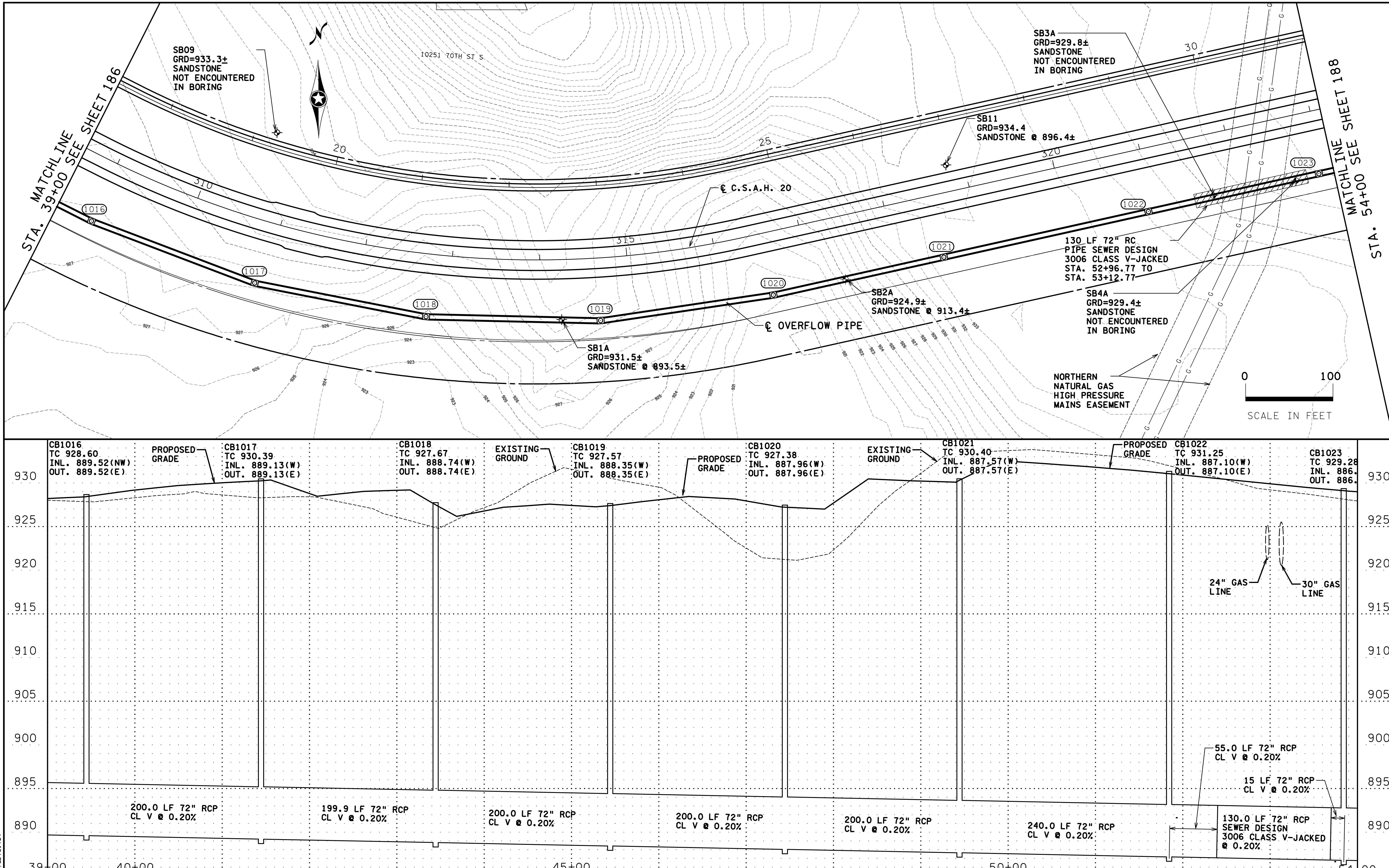
SHEET NO. 185 OF 308 SHEETS

CD174267_ST_PP1.dgn
6:24:56 PM
2/27/2013
CD174267_Pen_Table.tbl



CD174267_ST_PP2.dgn
6:25:08 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY: KAH	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — 01/31/2013 DATE	HDR Engineering, Inc.	OVERFLOW PIPE PLAN AND PROFILE (2 OF 4)
DESIGNED BY: MKR		NAME: MATTHEW K. REDINGTON — LIC. NO. 44737	South Washington WATERSHED District	SHEET NO. 186 OF 308 SHEETS
CHECKED BY: MWJ				

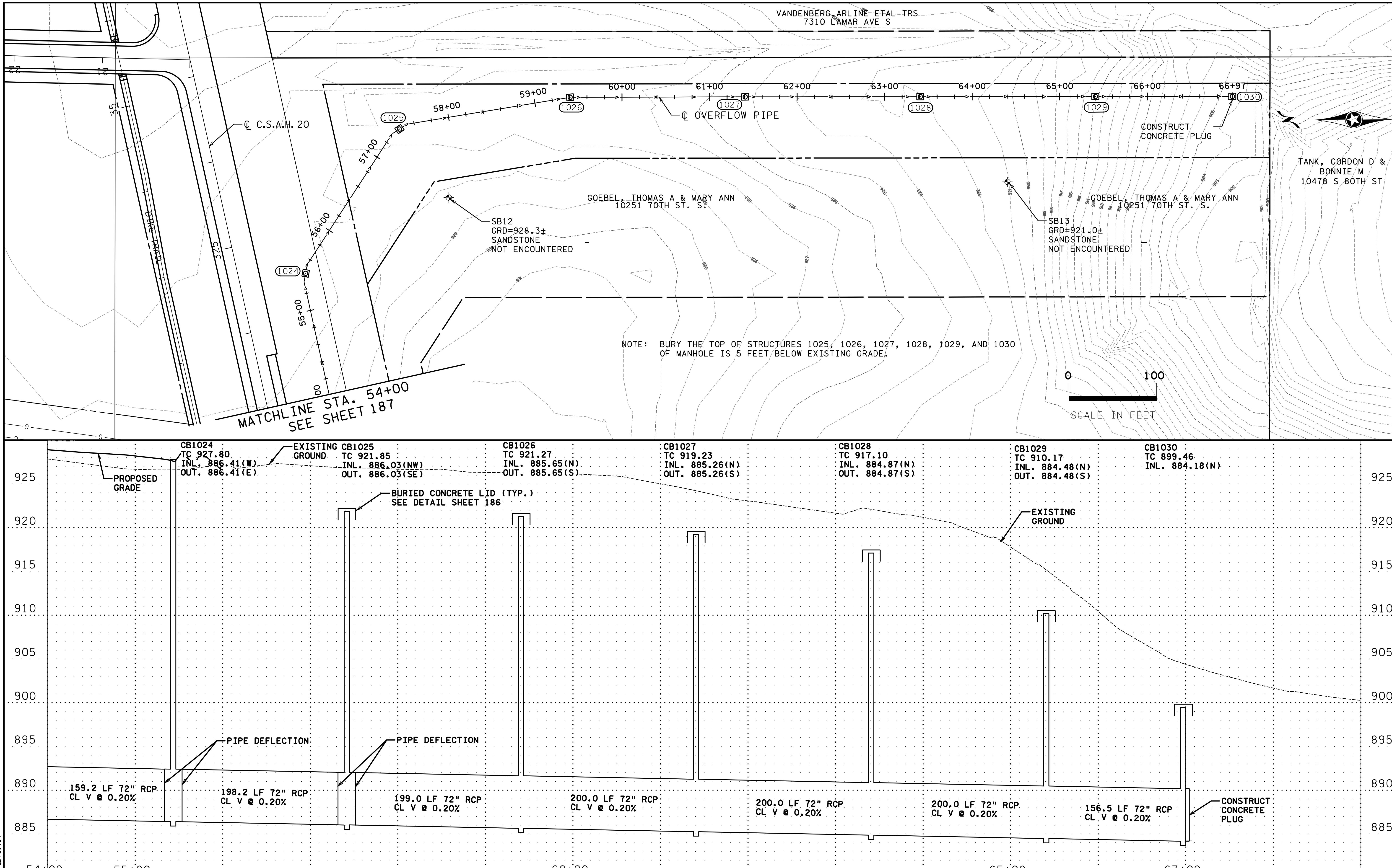


CD174267_ST_PP3.dgn
6:25:22 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY: KAH	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER; DATE 01/31/2013	HDR Engineering, Inc.
DESIGNED BY: MKR		NAME: MATTHEW K. REDINGTON; LIC. NO. 44737	South Washington WATERSHED District
CHECKED BY: MWJ			

OVERFLOW PIPE PLAN AND PROFILE (3 OF 4)

SHEET NO. 187 OF 308 SHEETS



CD174267_ST_PP4.dgn 6:25:39 PM 2/27/2013 CD174267_Pen_Table.tbl

DRAWN BY:	KAH	
DESIGNED BY:	MKR	
CHECKED BY:	MWJ	

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER — DATE 01/31/2013

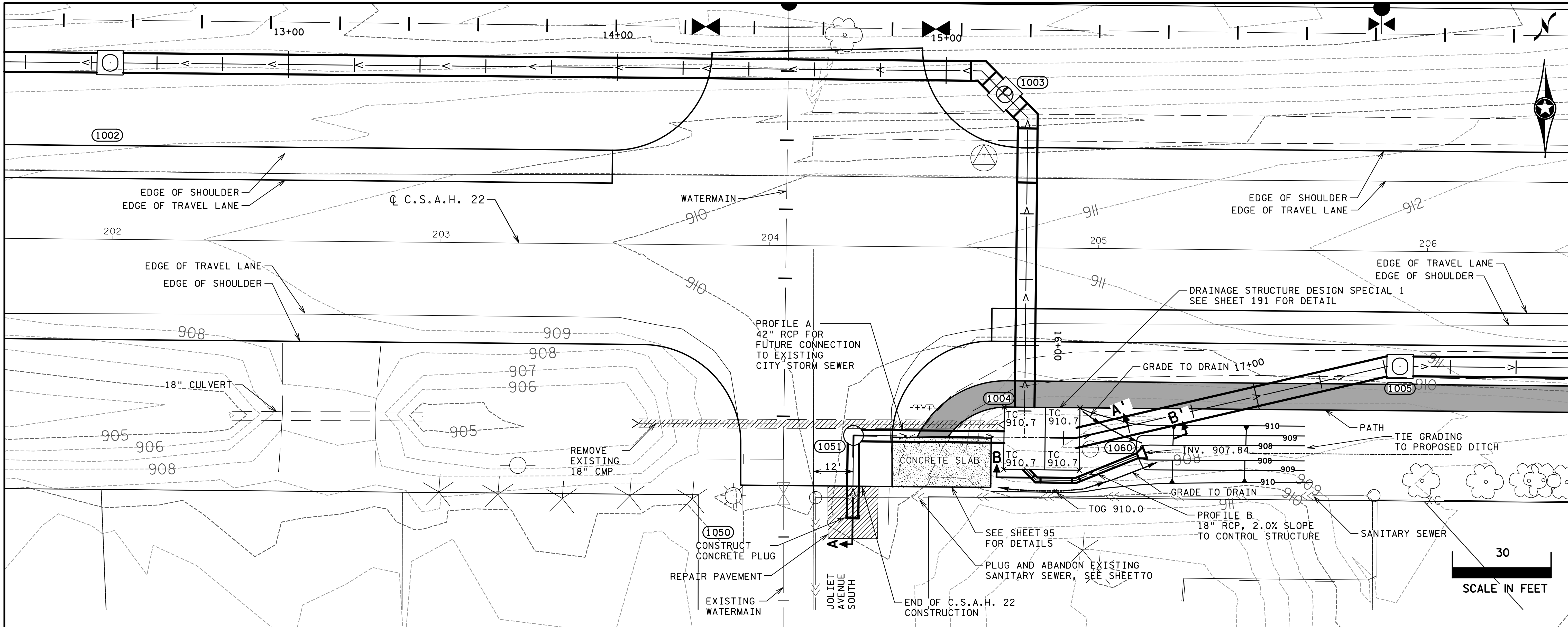
NAME: MATTHEW K. REDINGTON — LIC. NO. 44737

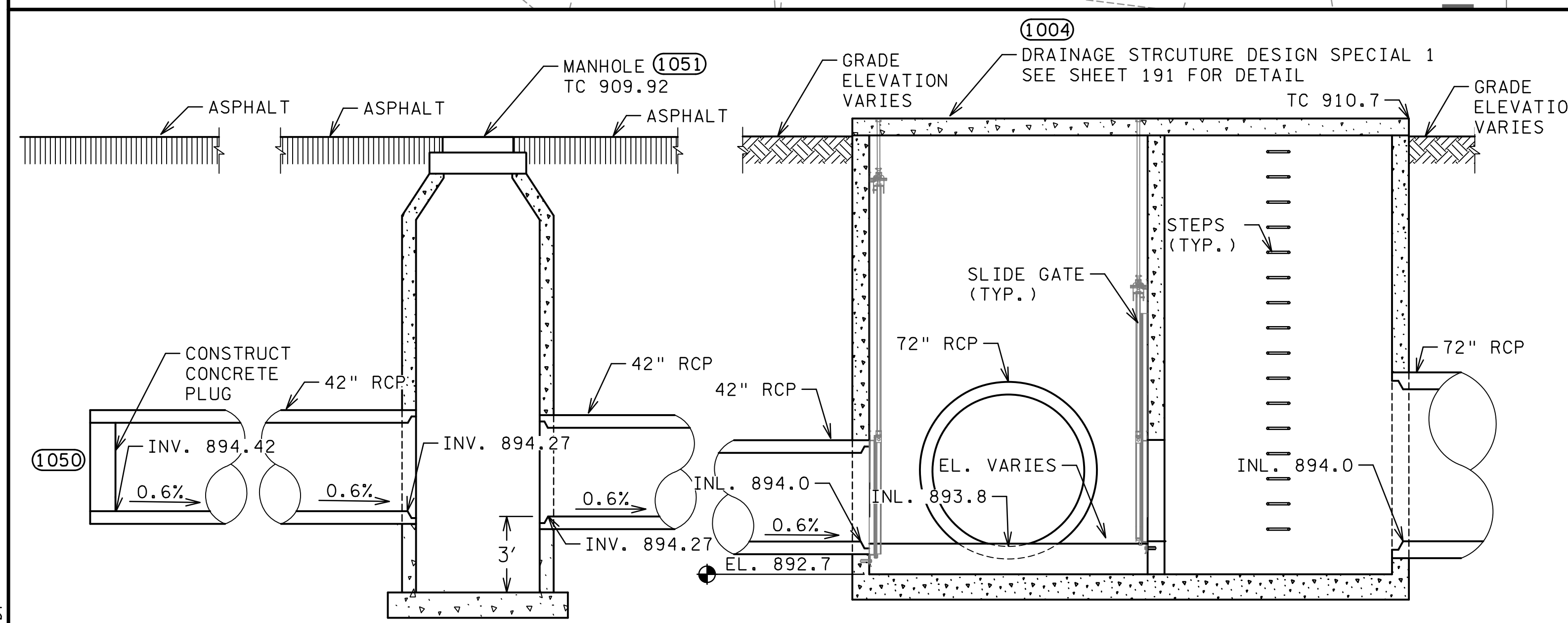
HDR Engineering, Inc.

South Washington WATERSHED District

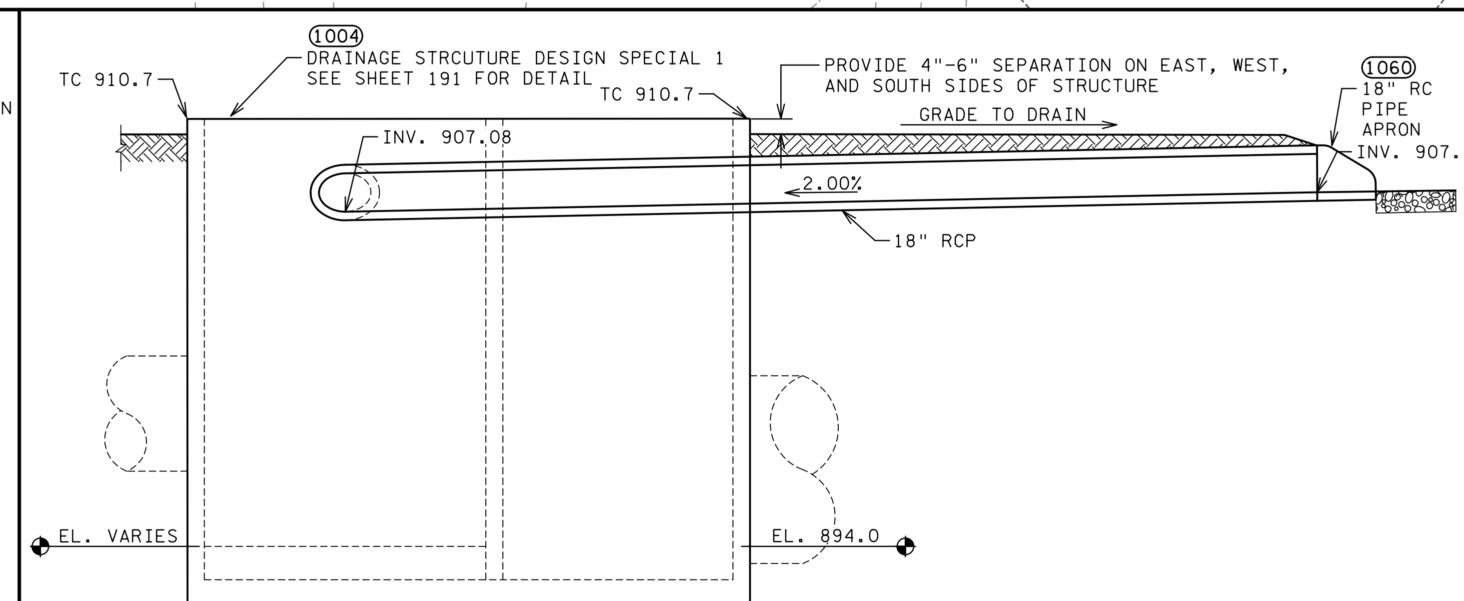
OVERFLOW PIPE PLAN AND PROFILE (4 OF 4)

SHEET NO. 188 OF 308 SHEETS





PROFILE A - 42" RCP



PROFILE B - 18" RCP

CD174267_GR_SHT1.dgn
6:25:55 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY: KAH DESIGNED BY: MKR CHECKED BY: MWJ	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER NAME: MATTHEW K. REDINGTON	01/31/2013 DATE LIC. NO. 44737	HDR HDR Engineering, Inc.	South Washington WATERSHED District

DRAINAGE STRUCTURE DESIGN SPECIAL 1 GRADING PLAN & PROFILES (1 OF 1)

SHEET NO. 189 OF 308 SHEETS

AP

OVERFLOW PIPE TABULATIONS

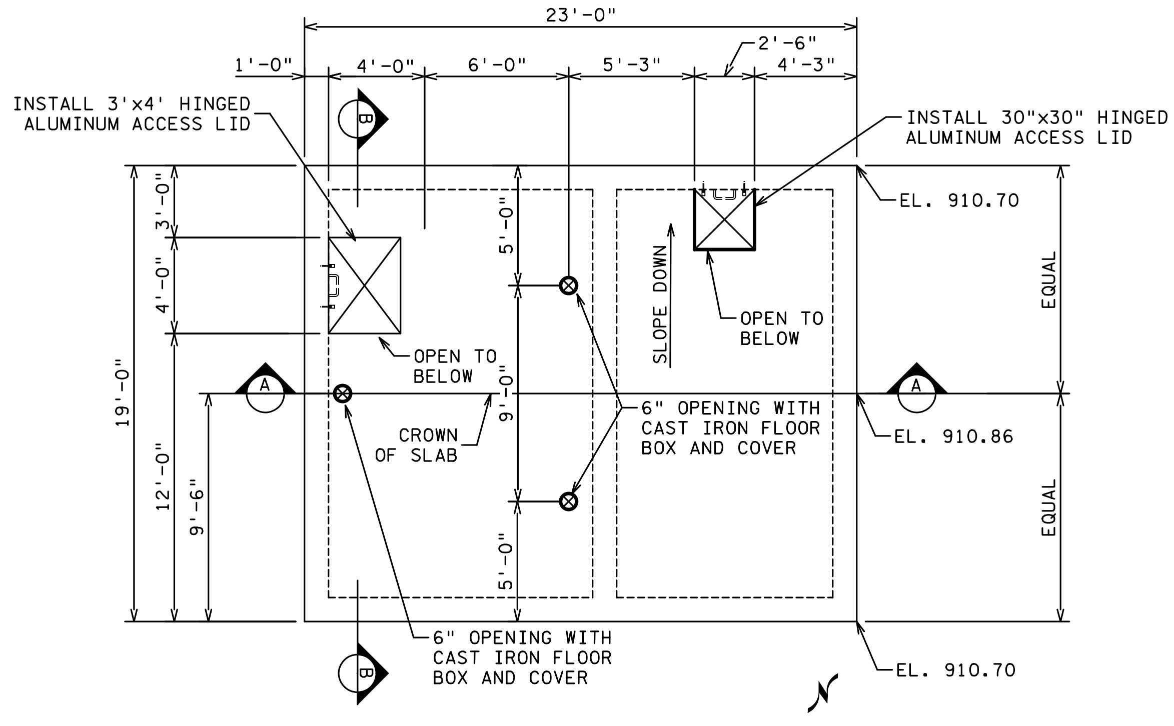
STRUCTURE NO.		STRUCTURE LOCATION		NEW STRUCTURE CONSTRUCTION (SPEC. 2506)							NEW PIPE CONSTRUCTION									NOTES
				CONST DRAINAGE STRUCTURE			CASTING ASSEMBLY (A-7D)	CONE TYPE	STEPS REQ'D	PRECAST CONC MANHOLE COVER	RC PIPE SEWER DES 3006 (SPEC. 2503)					RC SAFETY APRON & GRATE (SPEC. 2501)		CONSTRUCT CONCRETE OR MASONRY PLUG (SPEC. 2411)	AGGREGATE BEDDING (CV) (SPEC. 2451)	
FLOWS FROM	FLOWS TO	ALIGNMENT NAME	STATION	DESIGN SPECIAL	DESIGN A OR F	DESIGN SPEC 1					18" CL III	42" CL III	72" CL III	72" CL V	72" CL V JACKED	18" DES 3128	72" DES 3132			
				LIN FT	LIN FT	EACH	EACH			EACH	LIN FT	LIN FT	LIN FT	LIN FT	LIN FT	EACH	EACH	EACH	CU YD	
1000	1001	OVERFLOW PIPE	9+18.47										53				1		104	
1001	1002	OVERFLOW PIPE	9+71.56	10.7			1	A					274						536	
1002	1003	OVERFLOW PIPE	12+45.79	13.9			1	A					275						538	
1003	1004	OVERFLOW PIPE	15+20.79	16.4			1	B					107						209	1
1004	1005	OVERFLOW PIPE	16+28.01	16.1		1								113					221	2
1005	1006	OVERFLOW PIPE	17+41.05	17.1			1	A						204					399	
1006	1007	OVERFLOW PIPE	19+44.73	20.5			1	A						200					392	
1007	1008	OVERFLOW PIPE	21+44.73	25.6			1	A						200					392	
1008	1009	OVERFLOW PIPE	23+44.73	30.9			1	A						200					392	
1009	1010	OVERFLOW PIPE	25+44.73	36.2			1	A						200					392	
1010	1011	OVERFLOW PIPE	27+44.73	39.7			1	A						200					392	
1011	1013	OVERFLOW PIPE	29+44.73	39.8			1	A						10	390				20	
1013	1014	OVERFLOW PIPE	33+44.67	38.7			1	A						200					392	
1014	1015	OVERFLOW PIPE	35+44.58	40.7			1	A						200					392	
1015	1016	OVERFLOW PIPE	37+44.50	38.4			1	A						200					392	
1016	1017	OVERFLOW PIPE	39+44.50	38.5			1	A						200					392	
1017	1018	OVERFLOW PIPE	41+44.47	40.7			1	A						200					392	
1018	1019	OVERFLOW PIPE	43+44.41	38.3			1	A						200					392	
1019	1020	OVERFLOW PIPE	45+44.36	38.6			1	A						200					392	
1020	1021	OVERFLOW PIPE	47+44.32	38.8			1	A						200					392	
1021	1022	OVERFLOW PIPE	49+44.32	42.2			1	A						240					470	
1022	1023	OVERFLOW PIPE	51+84.32	43.6			1	A						70	130				137	
1023	1024	OVERFLOW PIPE	53+84.32	42.0			1	A						159					311	
1024	1025	OVERFLOW PIPE	55+43.47	40.8			1	A						198					388	
1025	1026	OVERFLOW PIPE	57+41.70	35.2						1				199					390	3
1026	1027	OVERFLOW PIPE	59+40.74	35.0						1				200					392	3
1027	1028	OVERFLOW PIPE	61+40.72	33.4						1				200					392	3
1028	1029	OVERFLOW PIPE	63+40.72	31.6						1				200					392	3
1029	1030	OVERFLOW PIPE	65+40.72	25.1						1				156					305	3
1030		OVERFLOW PIPE	66+97.18	14.7						1								1		3
1050	1051	PROFILE A	0+00.00									25						1	29	
1051	1004	PROFILE A	0+25.00		18		1	A	YES			45							53	
1060	1004	PROFILE B	0+40.00								40					1			13	
TOTAL				924	18	1	23			6	40	70	709	4549	520	1	1	2	10395	

NOTES:

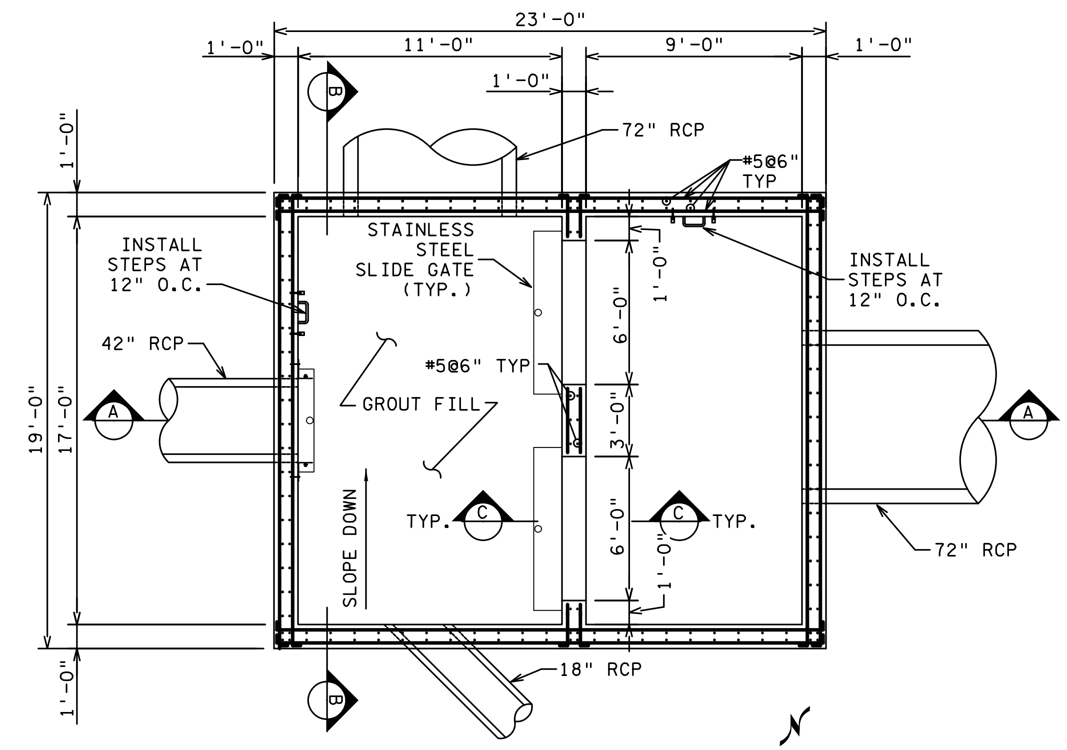
1 CASTING TO BE LOCATED OUTSIDE OF SHOULDER PAVEMENT.

2 CDSF CONTROL STRUCTURE.

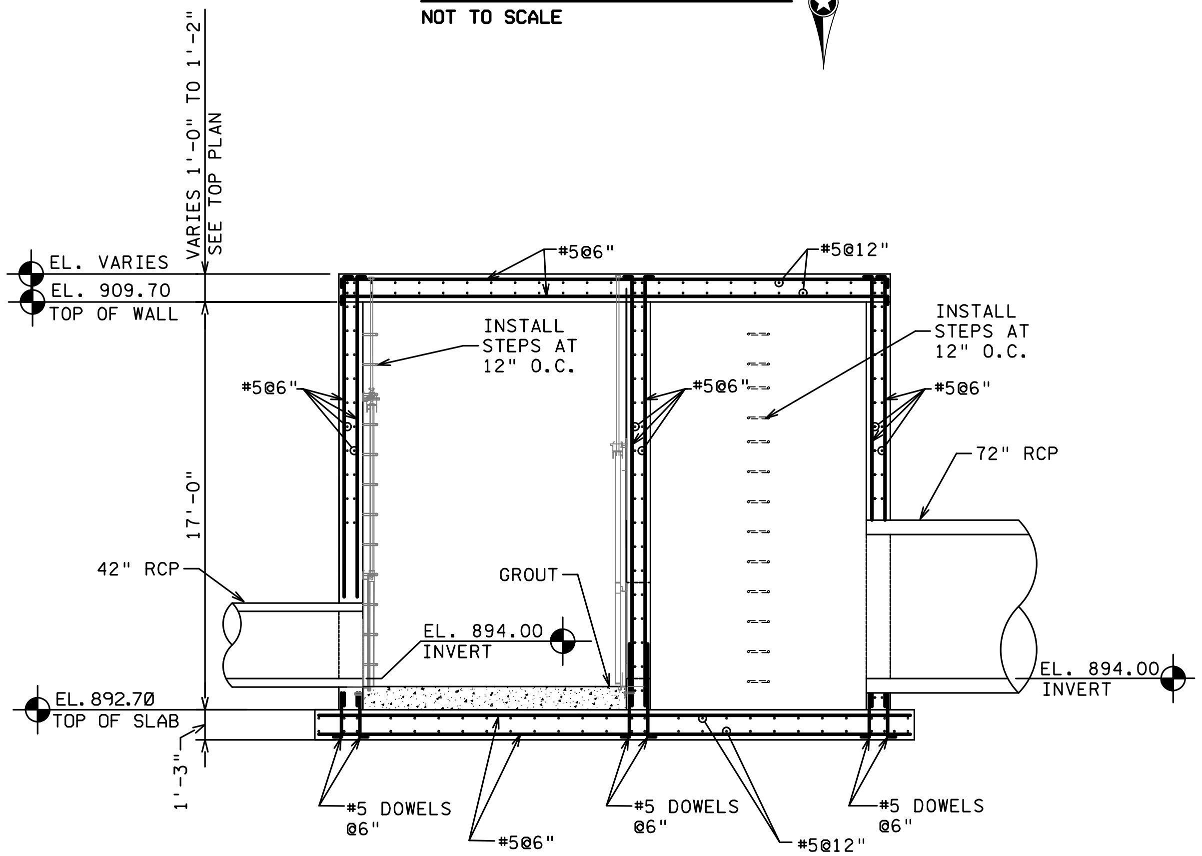
3 MANHOLE LID 5' BELOW FINISHED GRADE.



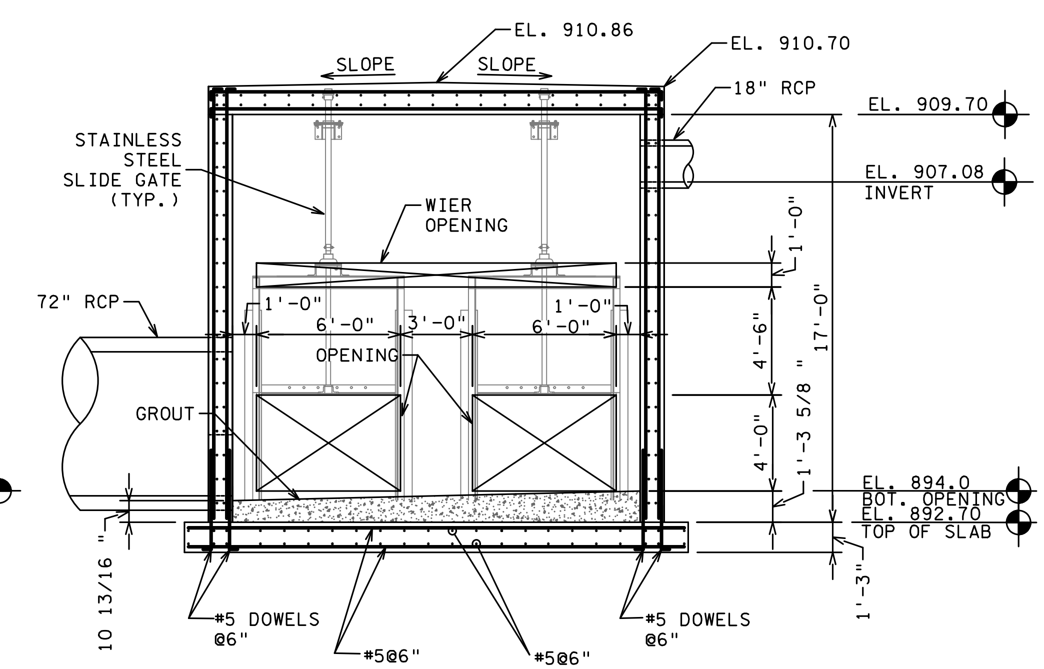
TOP PLAN
NOT TO SCALE



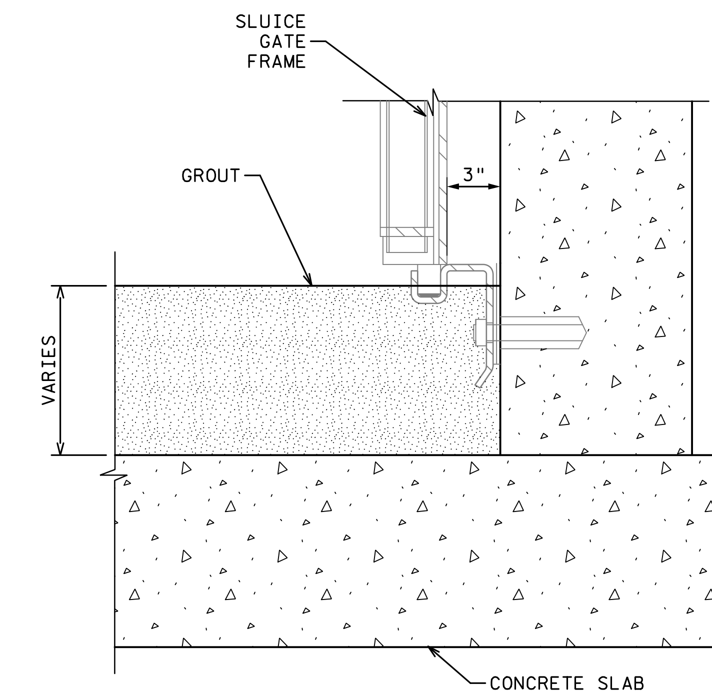
SECTIONAL PLAN
NOT TO SCALE



SECTION
NOT TO SCALE
A
-



SECTION
NOT TO SCALE
B
-



SECTION
NOT TO SCALE
C
-

CD174267_DD03.dgn
6:26:18 PM
2/27/2013
CD174267_Pen_Table.tbl

DRAWN BY:	KAH
DESIGNED BY:	MKR
CHECKED BY:	MWJ

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER

01/31/2013
DATE

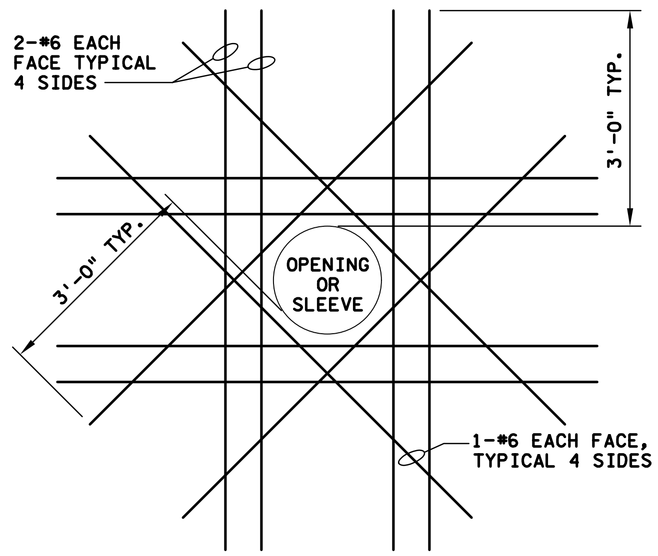
NAME: MATTHEW K. REDINGTON LIC. NO. 44737

HDR Engineering, Inc.

South Washington WATERSHED District

GATE STRUCTURE STRUCTURAL DETAILS (1 OF 2)

SHEET NO. 191 OF 308 SHEETS



REINFORCING DETAIL (1)

SCALE: NOT TO SCALE

NOTE:
1. REINFORCING IS SIMILAR AT RECTANGULAR OPENINGS.

2. PROVIDE STANDARD MATCHING DOWELS FOR VERTICAL REINFORCEMENT.

STRUCTURAL NOTES

PRODUCTS

1 CONCRETE PIPE — MnDOT MIX 3Y46

2 REINFORCEMENT — ASTM A615, GRADE 60

3 STRUCTURAL STEEL
- BEAMS AND TEES — ASTM A992, GRADE 50 KSI
- STEEL PIPE — ASTM A53, GRADE 35 KSI
- OTHER SHAPES — ASTM A36, GRADE 36 KSI

EXECUTION

1 SPECIAL STRUCTURAL INSPECTIONS
- A. SPECIAL STRUCTURAL INSPECTIONS IN ACCORDANCE WITH IBC CHAPTER 17 SHALL BE PERFORMED.
- B. SPECIAL STRUCTURAL INSPECTION FORM WILL BE SUPPLIED BY OWNER.

2 CONCRETE
- A. PROVIDE ALL CONCRETE STANDARDS DETAILS SHOWN ON THIS SHEET UNLESS NOTED OTHERWISE.
- B. LAP SPLICES AND 90 DEGREE END HOOKS SHALL BE AS SHOWN UNLESS NOTED OTHERWISE.

REINF. BAR SIZE	ALL CONCRETE BAR LAP	ALL CONCRETE *TOP BAR	90 DEGREE END HOOK
#3	19 IN	24 IN	6 IN
#4	25 IN	32 IN	8 IN
#5	31 IN	40 IN	10 IN
#6	37 IN	48 IN	12 IN
#7	54 IN	70 IN	14 IN

* DENOTES TOP BAR SPLICES ARE HORIZONTAL REINFORCEMENT PLACED SUCH THAT MORE THAN 12-INCHES OF CONCRETE IS CAST IN THE MEMBER BELOW THE SPLICE.

A. REINFORCING BARS SHALL HAVE THE FOLLOWING CONCRETE COVER UNLESS NOTED OTHERWISE.
1) CONCRETE CAST AGAINST EARTH 3"
2) ALL OTHER CONCRETE 2"

B. HORIZONTAL REINFORCEMENT SHALL HAVE STANDARD HOOKS ON EACH END UNLESS NOTED OTHERWISE.

C. BEVEL ALL EXPOSED CORNERS OF CONCRETE 3/4" X 3/4".

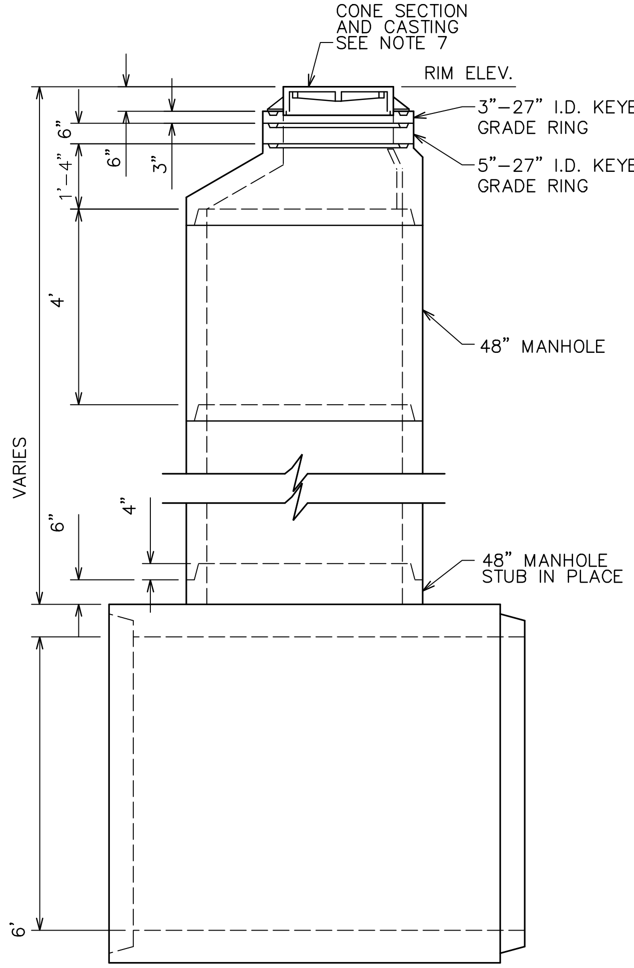
REQUIRED STRUCTURAL TESTS AND SPECIAL INSPECTIONS

STRUCTURAL TESTING AND SPECIAL INSPECTIONS ARE IN ACCORDANCE OF IBC CHAPTER 17.

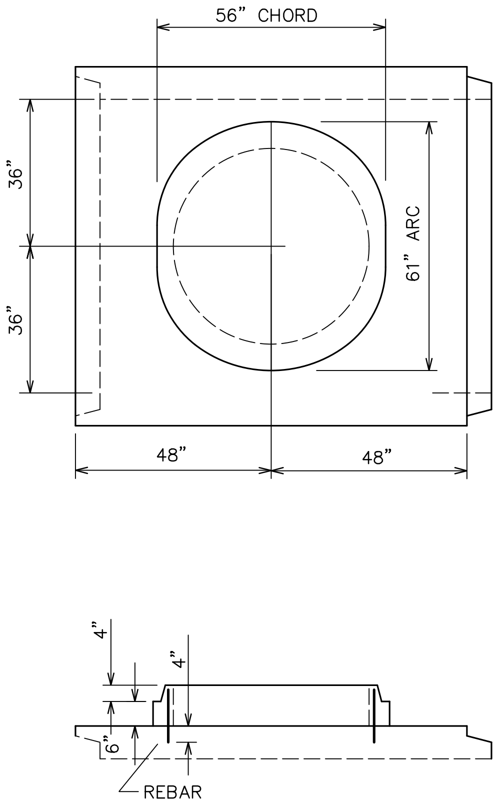
DESCRIPTION	TESTING YES	TESTING NO	INSPECTION YES	INSPECTION NO		N/A COMMENTS
1 STEEL CONSTRUCTION						
WELDING					•	UNLESS VISUAL FAILURE
DETAILS: BRACING, LOCATIONS, ETC.					•	
HIGH-STRENGTH BOLTING					•	
2 CONCRETE CONSTRUCTION						
CONCRETE	•		•			
REINFORCEMENT: SIZE AND SPACING		•	•			
BOLTS INSTALLED IN CONCRETE		•	•			UNLESS VISUAL FAILURE
DUCTILE MOMENT FRAMES					•	
3 MASONRY CONSTRUCTION						
REINFORCEMENT: SIZE AND SPACING					•	
PRISMS					•	
DETAILS: GROUTING, LINTELS, ETC.					•	
4 WOOD CONSTRUCTION					•	
5 GRADING, EXCAVATION AND FILLING					•	
6 PILING, PIERS AND CAISSONS					•	TEST AND PRODUCTION PILES
7 SPRAY-APPLIED FIREPROOFING					•	
8 EXTERIOR INSULATION AND FINISH SYSTEM					•	
9 SPECIAL CASES					•	

NOTES:

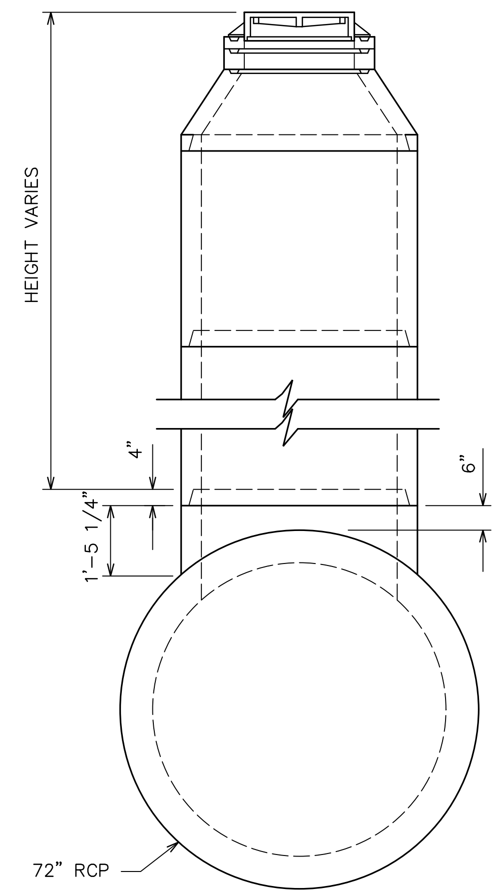
1. ALL BUILDING PERMITS AND OTHER SPECIAL PERMITS TO BE OBTAINED BY OWNER.
2. VERIFY ALL DIMENSIONS AND GATE MANUFACTURER'S REQUIREMENTS PRIOR TO CONSTRUCTION.
3. PROVIDE CONSTRUCTION JOINTS FOR CONCRETE EXTENDING MORE THN 12'-0" EITHER DIRECTION. INDICATE CONSTRUCTION JOINTS ON REIMFORCEMENT SHOP DRAWINGS.
4. PROVIDE ADDITIONAL REINFORCEMENT AT ALL OPENINGS UNLESS NOTED OTHERWISE. SEE DETAIL 1.
5. PROVIDE SLOPE GROUT FILL AS SHOWN ON PLANS AFTER GATE AND GATE FRAME IS SECURED.



SIDE VIEW



PLAN VIEW



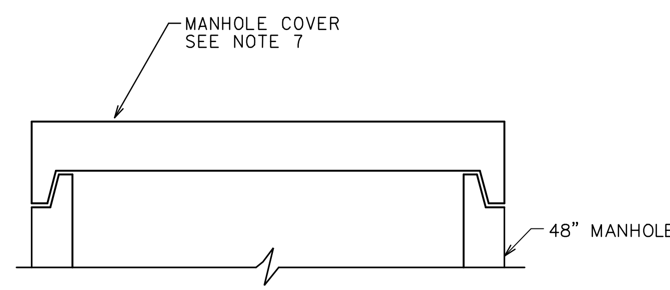
END VIEW

DESIGN DRAINAGE STRUCTURE SPECIAL MANHOLE DETAIL

NOT TO SCALE

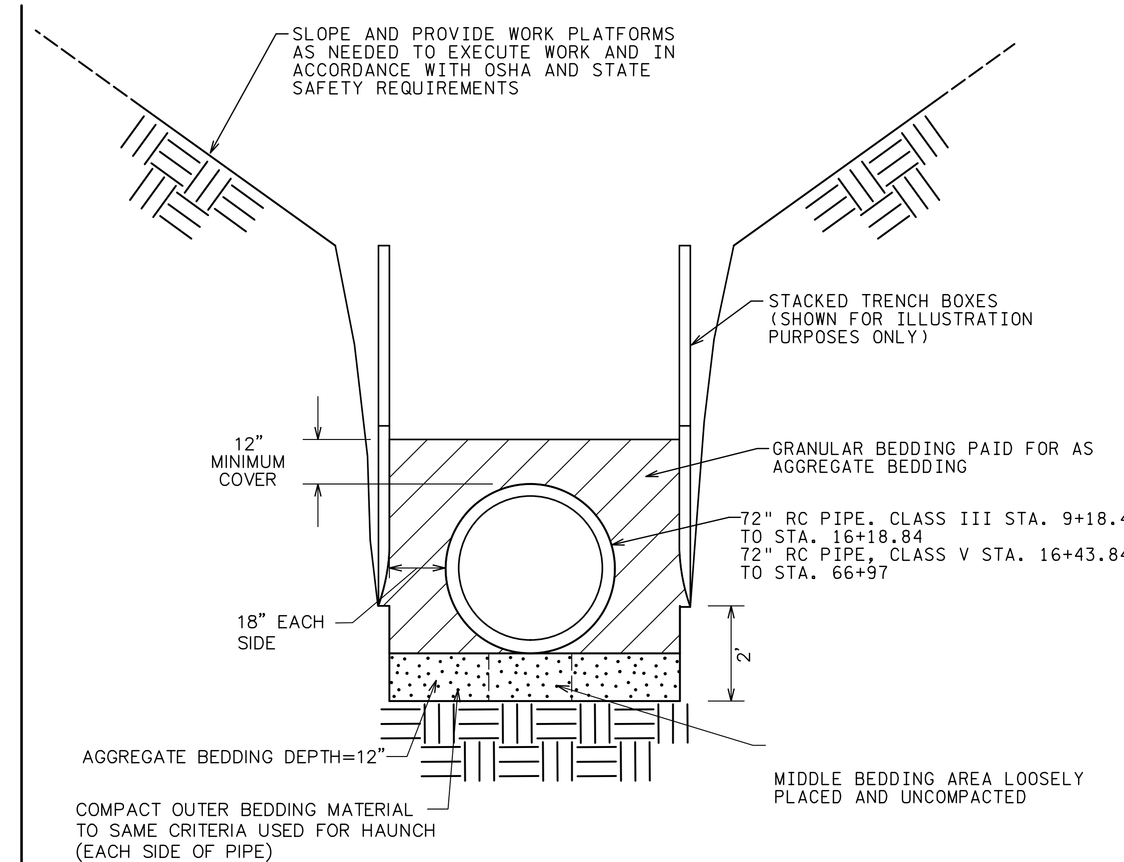
NOTES:

1. SHOP DRAWINGS AND CALCULATIONS SHALL BE SIGNED AND SEALED BY A REGISTERED MINNESOTA PROFESSIONAL ENGINEER, AND SHALL BE SUBMITTED BY THE CONTRACTOR TO THE ENGINEER FOR REVIEW.
2. ALL MANHOLES SHALL BE DESIGNED FOR A COVER DEPTH OF AT LEAST 50 FEET AND HS-20 LOADING.
3. IN LOCATIONS WHERE THERE IS A DEFLECTION LESS THAN 20 DEGREES TO THE OVERFLOW PIPE ALIGNMENT, THE ALIGNMENT SHALL TURN DIRECTION BY USE OF MITERED BEND SECTIONS ADJACENT TO THE MANHOLE STRUCTURE OR BY PROVIDING AN ANGLED END TO THE MANHOLE STRUCTURE.
4. IN LOCATIONS WHERE THERE IS A DEFLECTION GREATER THAN 20 DEGREES TO THE OVERFLOW PIPE ALIGNMENT, THE ALIGNMENT SHALL TURN DIRECTION BY USE OF MITERED BEND SECTIONS ADJACENT TO THE MANHOLE STRUCTURE. THE DEFLECTION SHALL BE SPLIT APPROXIMATELY EQUALLY ON EACH SIDE OF THE MANHOLE STRUCTURES.
5. SHOP DRAWINGS OF THE MITERED BEND SECTIONS SHALL BE SUBMITTED BY THE CONTRACTOR TO THE ENGINEER FOR REVIEW.
6. THE SAME BEDDING, TRENCHING, AND GASKET REQUIREMENTS THAT APPLY TO THE OVERFLOW PIPE SHALL APPLY TO THE MANHOLE STRUCTURE.
7. SEE BID TABULATIONS FOR CONE AND CASTING TYPE. FOR MANHOLES 1025–1030 REPLACE CONE AND CASTING WITH PRECAST CONCRETE MANHOLE COVER (NO OPENING FOR ACCESS). PRECAST CONCRETE MANHOLE COVER SHALL BE DESIGNED FOR DIRECT HS-20 LOADING, OR A COMBINATION OF 5' BURY DEPTH AND HS-20 LOADING AT THE SURFACE, WHICHEVER IS MORE RESTRICTIVE. PROVIDE LIFTING EYES TO ALLOW THE COVER TO BE REMOVED IN THE FUTURE. PROVIDE SHOP DRAWING SIGNED AND SEALED BY A REGISTERED MINNESOTA PROFESSIONAL ENGINEER TO THE ENGINEER FOR REVIEW.



BURIED CONCRETE LID

NOT TO SCALE



OVERFLOW PIPE TRENCH DETAIL

NOT TO SCALE

NOTES:

1. TRENCH BOXES MAY BE USED TO MINIMIZE EXCAVATION QUANTITIES AND FOOTPRINT OF WORKSPACE. CONFIGURATION AND USE OF TRENCH BOXES SHOWN IN DETAIL ARE FOR ILLUSTRATION PURPOSES ONLY.
2. CONTRACTOR SHALL COMPLY WITH ALL OSHA, STATE, AND LOCAL REGULATIONS IN REGARDS TO TRENCH DESIGN AND USE OF TRENCH BOXES.
3. IN LOCATIONS WHERE CONTRACTOR ELECTS TO NOT USE TRENCH BOXES, THE MINIMUM DISTANCE BETWEEN EXCAVATED PIPE TRENCH AND OUTER WALL OF PIPE SHALL BE 18" AND MINIMUM COVER SHALL BE MAINTAINED AT 12".
4. TRENCH BOXES, IF USED, SHALL BE PLACED NO LOWER THAN 2 FEET ABOVE THE BOTTOM OF TRENCH AS SHOWN IN THE DETAIL IN ORDER TO AVOID DISTURBANCE OF COMPACTED AGGREGATE BEDDING WHEN THE TRENCH BOXES ARE MOVED. TRENCH BOXES SHALL BE LIFTED AS INSTALLATION PROCEEDS, SUCH THAT COMPACTION OF AGGREGATE BEDDING ALWAYS OCCURS BELOW THE ELEVATION OF THE WALLS OF THE TRENCH BOX. MOVEMENT OF TRENCH BOXES MUST BE ACCOMPLISHED IN A MANNER AS TO AVOID DISTURBING COMPACTED AGGREGATE BEDDING.
5. AGGREGATE BEDDING SHALL BE COMPACTED TO AT LEAST 95% OF MAXIMUM STANDARD PROCTOR DENSITY.
6. AGGREGATE BEDDING SHALL MEET ALL REQUIREMENTS OF A TYPE 1 INSTALLATION AS DEFINED IN THE AMERICAN CONCRETE PIPE ASSOCIATION (ACPA) 2007 DESIGN MANUAL.
7. PIPE SHALL BE MNDOT C-WALL PIPE WITH NO FLARED BELLS AT FEMALE END OF PIPE.
8. PIPE SHALL HAVE RUBBER GASKETED SEALS THAT MEET THE REQUIREMENTS OF AASHTO M 198.
9. PIPE SHALL BE LAID WITH THE BELL END UPGRADE. PIPE LAYING SHALL PROCEED FROM DOWNSTREAM TO UPSTREAM.

DRAWN BY: KAH	I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.	CERTIFIED BY: LICENSED PROFESSIONAL ENGINEER	DATE: 01/31/2013	HDR Engineering, Inc. / South Washington WATERSHED District
DESIGNED BY: MKR		NAME: MATTHEW K. REDINGTON	LIC. NO. 44737	
CHECKED BY: MWJ				

OVERFLOW PIPE STORMWATER DETAILS (1 OF 1)

APPENDIX B

SEEPAGE ANALYSIS OF TEMPORARY FLOOD CONDITION

HDR | ONE COMPANY *Many Solutions*℠

Technical Memorandum

To:	File		
From:	Steve Olson	Project:	SWWD Overflow Outlet Cottage Grove, MN
cc:	Matt Redington , Justin Anderson, Pat Poepsel		
Date:	9/24/12	Job No:	164-161580

Re: Seepage Analysis of Temporary Flood Condition
County State Aid Highway (CSAH) 22
Cottage Grove, Minnesota

Introduction

This technical memorandum was prepared to discuss the results of a seepage analysis modeling the temporary flood condition near the low point of the planned County State Aid Highway (CSAH) 22 in Cottage Grove, Minnesota. The site is located in Washington County on County Road 22, west of County Road 19 as shown on sheet 1 of the 30% Plan document. The low point of the road is located near Station 198+50. A cross section of the road is shown on sheet X5 of the 30% plan document. The 100 year or more design water surface elevation (DWSE) is 902 feet. The analysis includes a model with flood elevation at top of roadway at 909 feet. A profile of the model is included in Appendix C.

Geotechnical Exploration

The subsurface conditions were investigated by 18 subsurface exploration borings performed for the CSAH 19-20-22 and Southwest Watershed District (SWWD) Overflow Outlet projects. The field work was performed by American Engineering Testing, Inc. (AET) during December, 2011. The work also included a laboratory test program. A copy of the report is included in Appendix A.

Subsurface Conditions

Boring No. 3 was located near the low point of existing CSAH 22 and was used to develop the existing soil profile. Laboratory test results of composite sample 1 & 2 were utilized to develop the embankment soil conditions, including estimated hydraulic conductivity. The deeper boring logs were used to aid in developing the assumed conditions at depth beneath the embankment.

The subsurface conditions at Boring No. 3 suggest the embankment fill consists of a mixture of silt and clay with a little sand and gravel. Overall the embankment soil was classified as CL based on procedures in general accordance with ASTM D2487-11, "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)." The native foundation soil supporting the embankment fill is primarily fine to medium grained alluvial sands, classified as SP. The sands are underlain by relatively less permeable sandy lean clay glacial till (found at Boring No. 9), and sandstone bedrock (found at Boring No. 11).

Groundwater was documented on the log of Boring No. 12 at a depth of 46.5 feet below the ground surface. Groundwater was not encountered within the depth of exploration at other locations.

Seepage Analysis

Underseepage analysis was conducted to evaluate the stability of the existing roadway embankment in a temporary flood condition. Analysis of underseepage was performed in general accordance with U.S. Army Corps of Engineers (USACE) Technical Letter No. 1110-2-569, "Design Guidance for Levee Underseepage" (USACE, 2005) and Urban Levee Design Criteria (ULDC, 2012).

The analysis of underseepage was performed based on the existing embankment height and permeability of embankment soils, the thickness and permeability of the native sand foundation, and the maximum head at the top of embankment (elevation 909 feet) at the lowest section of the existing roadway (near Station 188+50 ft).

According to the USACE guidance document, the following criteria for underseepage have been established.

- The average vertical exit gradient through the foundation sands at the landside toe of embankment should be less than 0.8 for water at the top of embankment, elevation 909 feet.
- The average vertical exit gradient through the foundation sands at the landside toe of embankment should be less than 0.5 for water at the DWSE, elevation 902 feet.
- The localized exit gradient should be less than 0.5 for DWSE, elevation 902 feet.

The seepage analysis was performed using SEEP/W software (GeoStudio, 2007). Soil input parameters were developed based on the subsurface exploration and laboratory test results. The hydraulic conductivity of the embankment soil and underlying native sands were developed based on the results of grain size and hydrometer analyses and published empirical correlations (JAS, 2007). Appendix B contains a sheet with specific details pertaining to the development of the hydraulic conductivity input values.

The seepage model profile is an embankment of nine feet in height overlying native alluvial sands. The embankment is composed of a mixture of predominately cohesive soils similar to those at the ground surface (upper 2 to 4 feet) described on the soil boring logs. Flood water level was modeled at the existing road surface at elevation 909 feet. The modeled profile and seepage analysis results are included in Appendix C.

Findings and Conclusions

The results of the seepage analysis at flood elevation 909 feet indicate the maximum vertical exit gradient at the landside embankment toe surface is about 0.47, suggesting a safety factor of about 1.8 against potential piping at the toe of the slope. The safety factor is based on an estimated critical gradient of 0.84 for the surficial alluvial soils. The computed average vertical exit gradient at the ground surface of the landside ditch is 0.18 and suggests a safety factor of 4.7 against piping at the ditch bottom.

Table 1 – Summary of Computed Seepage Gradients

Water Elevation	Average Vertical Exit Gradient (i_v)	Localized Exit Gradient (i_{xy})	Comments
DWSE – 902 ft	0.06	0.08	Ok, $i_v < 0.5$ and $i_{xy} < 0.5$
Top of Levee – 909 ft	0.47	N/A	Ok, $i_v < 0.8$

The average gradients at the toe are well below allowable and therefore no remediation of the embankment is required according to USACE guidance document (USACE, 2005).

Limitations

This report presents the findings, conclusions and analysis results for the geotechnical aspects of the proposed SWWD Outflow/Outlet project. It has been prepared in accordance with generally accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographic area. No warranty, expressed or implied, is made.

The conclusions and recommendations presented herein are based on research and available literature, the results of field exploration and laboratory materials testing, and the results of engineering analyses. Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, partly on our general experience, and on the state-of-the-practice at the time of this writing.

References

GeoStudio (2007). SEEP/W software, GeoStudio 2007, version 7.19, developed by Geo-Slope, International, Inc., dated 2007.

JAS (2007). "Evaluation of Empirical Formulae for Determination of Hydraulic Conductivity based on Grain-Size Analysis", prepared by Justine Odong, published by Journal of American Science (JAS), dated 2007.

ULDC (2012). "Urban Levee Design Criteria", State of California, The Natural Resources Agency, Department of Water Resources, dated May, 2012.

USACE (2000). "Design and Construction of Levees", EM 1110-2-1913, prepared by U.S. Army Corps of Engineers, dated April, 2000.

USACE (2005). "Design Guidance for Levee Underseepage", Technical Letter No. 1110-2-569, prepared by U.S. Army Corps of Engineers, dated May, 2005.

APPENDIX A

GEOTECHNICAL EXPLORATION REPORT

AMERICAN
ENGINEERING
TESTING, INC.

CONSULTANTS
• ENVIRONMENTAL
• GEOTECHNICAL
• MATERIALS
• FORENSICS

December 28, 2011

HDR Engineering, Inc.
701 Xenia Avenue South, Suite 600
Minneapolis, MN 55416

Attn: Steve Olson, PE

RE: Data Report of Geotechnical Exploration
CSAH 19-20-22 and SWWD Overflow Outlet
Cottage Grove, Minnesota
AET Nos. 01-05289 and 01-05290

Dear Mr. Olson:

This letter report presents the results of the soil borings and laboratory testing performed for the CSAH 19-20-22 and SWWD Overflow Outlet projects in Cottage Grove, Minnesota. The work was performed per our proposals to you for each of the projects.

The borings were conducted at the site from December 1 to 7, 2011. The logs of the test borings are attached. The boring locations were pre-selected by HDR, and then measured in the field by AET using GPS (submeter accuracy, but not surveyor quality). These locations graphically appear on attached Figure 1. The Washington County coordinates appear on the boring logs. Note that Borings 13 and 14 were shifted to the north from the originally planned location due to a property access issue. The boring surface elevations were not measured.

The boring logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted, which is based on the standard penetration resistance (N-value).

We refer you to the standard sheet entitled "Exploration/Classification Methods" for details on the drilling and sampling methods, the classification methods, and the water level measurement methods. Data sheets concerning the Unified Soil Classification System, the AASHTO Soil Classification System, the descriptive terminology, and the symbols used on the boring logs are also attached.

550 Cleveland Avenue North | St. Paul, MN 55114
Phone 651-659-9001 | Toll Free 800-972-6364 | Fax 651-659-1379 | www.amengtest.com | AA/EEO

The laboratory test program included the following:

- Three sieve analysis tests, including hydrometer analysis
- Four sieve analysis tests, without hydrometer analysis
- Five Atterberg Limits tests
- Water content tests on cohesive soils retrieved

The laboratory test results appear on the individual boring logs adjacent to the samples upon which they were performed, or on the data sheets following the boring logs.

Sincerely,
American Engineering Testing, Inc.

Jeffery K. Voyen, PE
Vice President/Principal Engineer
MN License #15928
Phone: (651) 659-1305
jvoyen@amengtest.com

Attachments

Figure 1 – Boring Locations
Subsurface Boring Logs
Results of Sieve Analysis Tests
Gradation Curves (tests with hydrometer analysis)
Exploration/Classification Methods
Boring Log Notes
Unified Soil Classification System
AASHTO Soil Classification System

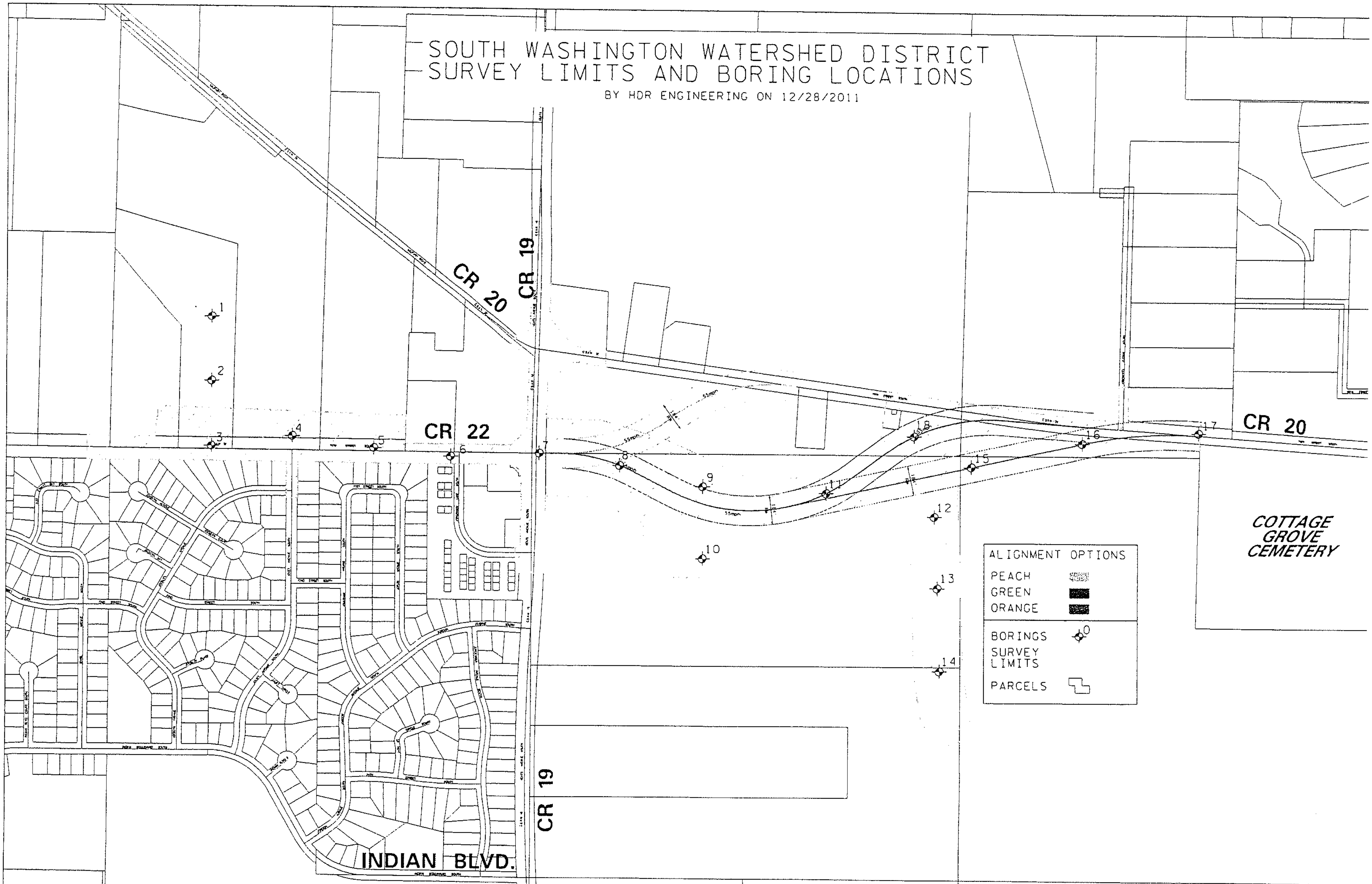


Figure 1 – Boring Locations
AET No. 01-05289, 01-05290

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-05290 LOG OF BORING NO. 1 (p. 1 of 1)

PROJECT: CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

SURFACE ELEVATION: ______ COUNTY COORDINATES: N 138081 E 479810

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly lean clay with sand, slightly organic, trace roots, dark brown (A-7-6)	FILL OR TILLED TOPSOIL	6	M	SS	6	17		*	*	
2–3	LEAN CLAY, trace roots, dark brown to brown, firm (CL) (A-7-6)	FINE ALLUVIUM	5	M	SS	10	18		*	*	
3–4.5	SAND, a little gravel, medium grained, brown, moist, loose (SP) (A-1-b)	COARSE ALLUVIUM									
4.5–7	SAND WITH GRAVEL, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		18	M	SS	14					
7–9	SAND, a little gravel, fine grained, light brown, moist, dense (SP) (A-3)		31	M	SS	16					
9–14	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-1-b)		20	M	SS	12					
			22	M	SS	13					
14–16	SAND WITH GRAVEL, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b)		15	M	SS	12					
16	**END OF BORING**										

*Composite sample from Borings 1 and 2: LL=42%, PL=23%, PI=19%, -#200=86% (61% silt, 25% clay)

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	3.25" HSA							
		12/2/11	10:06	16.0	14.5	14.7		None
		12/2/11	10:11	16.0	14.5	14.5		None

WATER LEVEL MEASUREMENTS

BORING COMPLETED: 12/2/11

DR: DS LG: EW Rig: 33C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **2 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137681** E **479810**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
1	FILL, mostly lean clay, slightly organic, trace roots, dark brown (A-7-6)	FILL OR TILLED TOPSOIL	5	M	SS	6	24		*	*	
2–3	LEAN CLAY, slightly organic, trace roots, dark brown, stiff (CL) (A-7-6)	TOPSOIL	11	M	SS	15	36 22		*	*	
3–4	SANDY LEAN CLAY, trace roots, dark brown to brown, stiff (CL) (A-6)	FINE ALLUVIUM									
5–6	GRAVEL WITH SAND, brown, moist, medium dense (GP) (A-1-a)	COARSE ALLUVIUM	12	M	SS	2					
7–8	CLAYEY SAND, a little gravel, brown, very stiff (SC) (A-6)	TILL OR MIXED ALLUVIUM	16	M	SS	16	12				
8–9	SILTY SAND, a little gravel, brown, medium dense, laminations of clayey sand (SM) (A-2-4)										
10–11	SILTY SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SM) (A-2-4)	COARSE ALLUVIUM	18	M	SS	13					
12–13	SAND WITH GRAVEL, fine grained, light brown, moist, medium dense (SP) (A-1-b)		19	M	SS	7					
14–15	SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SP) (A-1-b)		20	M	SS	13					
16	**END OF BORING**										

*Composite sample from Borings 1 and 2: LL=42%, PL=23%, PI=19%, -#200=86% (61% silt, 25% clay)

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	**3.25" HSA**							
		12/2/11	**10:30**	**16.0**	**14.5**	**14.8**		**None**
		12/2/11	**10:35**	**16.0**	**14.5**	**14.5**		**None**

(Water Level Measurements)

BORING COMPLETED: **12/2/11**

DR: **DS** LG: **EW** Rig: **33C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **3 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137281** E **479810**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	5" Bituminous pavement	FILL		M	SU						
1–2	10.5" FILL, mostly silty sand, a little gravel, brown (A-2-4)		16	M	SS	16	13				
2–6	FILL, mixture of sandy lean clay, lean clay with sand, slightly organic lean clay and clayey sand, a little silty sand, gray, dark gray and brown (A-6)		11	M	SS	18	22 21				78
			9	M	SS	8	11				61
6.5–10.5	LEAN CLAY, slightly organic, dark brown to brown, firm to stiff (CL) (A-6) (possible fill)	FINE ALLUVIUM OR FILL	8	M	SS	10	27		40	20	
			13	M	SS	11					
10.5–12	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM) (A-3)	COARSE ALLUVIUM									
12–16	SAND, fine grained, brown, moist, medium dense (SP) (A-3)		20	M	SS	14					2
			18	M	SS	13					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/1/11	10:34	16.0	14.5	15.2		None
12/1/11	10:39	16.0	14.5	15.0		None

BORING COMPLETED: **12/1/11**

DR: **DS** LG: **EW** Rig: **33C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **4 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137344** E **480310**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly lean clay with sand, slightly organic, trace roots, dark brown (A-7-6)	FILL OR TILLED TOPSOIL	10	M	SS	10	23				
2–4.5	LEAN CLAY, trace roots, dark brown to brown, stiff (CL) (A-7-6)	FINE ALLUVIUM	9	M	SS	10	16		42	22	
4.5–6.5	SILTY SAND, a little gravel, fine grained, brown, moist, medium dense (SM) (A-2-4)	COARSE ALLUVIUM	20	M	SS	6					
6.5–11.5	SAND WITH SILT, fine to medium grained, brown, moist, medium dense (SP-SM) (A-3)		20	M	SS	6					
			14	M	SS	10					
11.5–18	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		12	M	SS	12					
			14	M	SS	12					
18–21	SAND WITH SILT, a little gravel, fine to medium grained, brown, moist, medium dense (SP-SM) (A-1-b)		20	M	SS	10					
21	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-19½'	**3.25" HSA**	**12/2/11**	**11:10**	**21.0**	**19.5**	**19.7**		**None**
		12/2/11	**11:15**	**21.0**	**19.5**	**19.5**		**None**

BORING COMPLETED: **12/2/11**

DR: **DS** LG: **EW** Rig: **33C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **5 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137271** E **480810**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0	2" Bituminous pavement	FILL			SU						
1–2	12" FILL, mostly silty sand, a little gravel and clayey sand, brown (A-2-4)		12	M	SS	14	15				
2–3.5	FILL, mostly lean clay with sand, a little gravel, dark brown and brown (A-6)	COARSE ALLUVIUM OR FILL	24	M	SS	6					
3.5–6.5	SAND WITH GRAVEL, fine to medium grained, brown, moist, medium dense to loose (SP) (A-1-b) (possible fill)		7	M	SS	12					
6.5–9	SILTY SAND, fine grained, light brown, moist, loose, lenses and laminations of silt (SM) (A-2-4)	COARSE ALLUVIUM	9	M	SS	13					
9–11.5	GRAVEL WITH SAND, brown, moist, medium dense (GP) (A-1-a)		19	M	SS	6					
11.5–18	GRAVELLY SAND, medium grained, brown, moist, medium dense (SP) (A-1-b)		11	M	SS	4					
			18	M	SS	6					
18–24	SAND WITH GRAVEL, medium grained, brown, moist, medium dense (SP) (A-1-b)		19	M	SS	12					
24–28	SAND WITH GRAVEL, fine to medium grained, light brown, moist, medium dense (SP) (A-1-b)		24	M	SS	13					
28–31	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		18	M	SS	12					
31	**END OF BORING**										

FIELD & LABORATORY TESTS: WC, DEN, LL, PL, %-#200

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-29½'	**3.25" HSA**	**12/1/11**	**11:35**	**31.0**	**29.5**	**29.5**		**None**
		12/1/11	**11;40**	**31.0**	**29.5**	**29.5**		**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **12/1/11**

DR: **DS** LG: **EW** Rig: **33C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/13/11

12

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **6 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137220** E **481280**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–0.6	7.5" Bituminous pavement	FILL		M	SU						
1	FILL, mostly sand with silt and gravel, brown (A-1-b)		22	M	SS	13					
2–3	FILL, mixture of clayey sand and sand with silt, a little gravel, pieces of bituminous, dark brown and gray (A-6)		10	M	SS	13	12				
4–5	FILL, mostly silty sand, a little gravel and clayey sand, brown (A-2-4)	COARSE ALLUVIUM	18	M	SS	12					
6	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM) (A-3/A-2-4)										
7–11	SAND WITH SILT, fine grained, light brown, moist, medium dense (SP-SM) (A-3)		16	M	SS	14					
10			15	M	SS	14					
12–13	SAND, fine grained, light brown, moist, medium dense (SP) (A-3)		12	M	SS	13					
14–15	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP)		21	M	SS	13					
20			25	M	SS	4					
23–25	SAND, a little gravel, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b)		17	M	SS	13					
30			18	M	SS	13					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-29½'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/1/11	12:33	31.0	29.5	29.9		None
12/1/11	12:37	31.0	29.5	29.8		None

BORING COMPLETED: **12/1/11**

DR: **DS** LG: **EW** Rig: **33C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **7 (p. 1 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137243** E **481830**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	7" Bituminous pavement	FILL			SU						
1	6" FILL, mixture of silty sand and lean clay, a little gravel, dark brown and brown (A-2-4)		17	M	SS	13	6				
2	FILL, mostly sand with silt, a little gravel and clayey sand, brown (A-3)										
3		FINE ALLUVIUM OR FILL	13	M	SS	16	20				
4	FILL, mostly sand, a little gravel, brown (A-1-b)										
5	LEAN CLAY, brown, a little dark brown, stiff, laminations of silt (CL) (A-6) (possible fill)	TILL	14	M	SS	16	16				
6	SANDY LEAN CLAY, a little gravel, brown, stiff (CL) (A-6)	COARSE ALLUVIUM									
7											
8	SILTY SAND, a little gravel, fine grained, brown, moist, medium dense (SM) (A-2-4)		14	M	SS	12					
9	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)										
10			16	M	SS	11					
11	SAND, a little gravel, fine to medium grained, brown, moist, medium dense to loose (SP) (A-3)										
12											
13			12	M	SS	15					
14											
15			9	M	SS	13					
16											
17											
18											
19	SAND, a little gravel, medium to fine grained, brown, moist, loose to medium dense (SP) (A-1-b)										
20			10	M	SS	13					
21											
22											
23											
24											
25			12	M	SS	12					
26											
27											
28											
29	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)										
30			16	M	SS	13					
31											

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-39½' 3.25" HSA							
	12/1/11	**1:40**	**41.0**	**39.5**	**39.7**		**None**
	12/1/11	**1:45**	**41.0**	**39.5**	**39.5**		**None**
BORING COMPLETED: **12/1/11**							
DR: **DS** LG: **EW** Rig: **33C**							

WATER LEVEL MEASUREMENTS

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **7 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **137243** E **481830**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33	SAND, a little gravel, medium to fine grained, light brown, moist, medium dense (SP)	COARSE ALLUVIUM *(continued)*									
34											
35			15	M	SS	13					
36											
37											
38											
39											
40			19	M	SS	12					
41	**END OF BORING**										

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-05290 LOG OF BORING NO. 8 (p. 1 of 2)

PROJECT: CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

SURFACE ELEVATION: ______ COUNTY COORDINATES: N 137169 E 482330

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
1	FILL, mostly lean clay with sand, trace roots, dark brown (A-6)	FILL OR TILLED TOPSOIL	7	M	SS	5	20				
2–4	LEAN CLAY WITH SAND, trace roots, brown, stiff (CL) (A-6)	FINE ALLUVIUM	11	M	SS	4	21				
4–6	SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SP) (A-3)	COARSE ALLUVIUM	14	M	SS	12					
6–9	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		17	M	SS	6					
9–14	SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SP) (A-3)		20	M	SS	7					
			12	M	SS	13					
14–23	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		12	M	SS	13					
			20	M	SS	12					
23–31	SAND, a little gravel, fine grained, light brown, moist, medium dense (SP) (A-3)		29	M	SS	13					
			13	M	SS	12					

FIELD & LABORATORY TESTS: WC, DEN, LL, PL, %-#200

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-39½' 3.25" HSA	12/2/11	1:10	41.0	39.5	39.7		None
	12/2/11	1:15	41.0	39.5	39.5		None
BORING COMPLETED: 12/2/11							
DR: DS LG: EW Rig: 33C							

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

03/2011 01-DHR-060

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **8 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **137169** E **482330**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33											
34	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)										
35			28	M	SS	13					
36											
37											
38	SILTY SAND, a little gravel, fine grained, brown, moist, medium dense, lenses and laminations of clayey sand (SM) (A-2-4)										
39											
40			20	M	SS	14					
41	**END OF BORING**										

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **9 (p. 1 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137040** E **482850**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	LEAN CLAY, trace roots, dark brown, stiff (CL) (A-6)	TOPSOIL	12	M	SS	12	15				
2–4	LEAN CLAY, trace roots, light brown, firm (CL)	FINE ALLUVIUM	6	M	SS	12	7				
4–6.5	SILTY SAND, a little gravel, fine grained, brown, moist, medium dense (SM) (A-2-4)	COARSE ALLUVIUM	17	M	SS	12					
6.5–14	SAND, a little gravel, fine to medium grained, light brown, moist, loose (SP) (A-3)		8	M	SS	12					
			7	M	SS	12					
			6	M	SS	12					
14–18	SAND, a little gravel, fine to medium grained, light brown, moist, loose (SP) (A-3)		10	M	SS	12					
18–23	SAND, a little gravel, fine grained, light brown, moist, loose (SP) (A-3)		9	M	SS	12					
23–28	SAND WITH SILT AND GRAVEL, fine grained, brown, moist, dense (SP-SM) (A-1-b)		37	M	SS	14					
28–	CLAYEY SAND, a little gravel, brown, stiff (SC) (A-6)	TILL	13	M	SS	16	11				

FIELD & LABORATORY TESTS: WC, DEN, LL, PL, %-#200

DEPTH	DRILLING METHOD
0-49½'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/6/11	2:02	51.0	49.5	51.0		None

BORING COMPLETED: **12/6/11**

DR: **JM** LG: **JMM** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **9 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **137040** E **482850**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
		TILL *(continued)*									
33	SANDY LEAN CLAY, a little gravel, brown and gray mottled, very stiff, laminations of sandy silt (CL) (A-6)										
35			17	M	SS	20	15				
38	LEAN CLAY WITH SAND, a little gravel, gray, a little brown, very stiff, laminations of sandy silt (CL) (A-6)										
40			16	M	SS	20	17				
45			18	M	SS	20	18				
48	SANDY LEAN CLAY, a little gravel, dark gray, hard (CL) (A-6)										
50			44	M	SS	18	16				
51	**END OF BORING**										

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-05290 LOG OF BORING NO. 10 (p. 1 of 1)

PROJECT: CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

SURFACE ELEVATION: ________ COUNTY COORDINATES: N 136590 E 482850

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	FILL, mostly lean clay, slightly organic, trace roots, dark brown (A-6)	FILL OR TILLED TOPSOIL	11	M	SS	6	20		*	*	*
1–3	LEAN CLAY, trace roots, brown, stiff (CL) (A-6)	FINE ALLUVIUM	9	M	SS	17	13		*	*	*
3–4.5	SILTY SAND, a little gravel, fine grained, brown, moist, loose (SM) (A-2-4)	COARSE ALLUVIUM									
4.5–6	SAND, a little gravel, fine to medium grained, brown, moist (SP) (A-3)		19	M	SS	17					
6–8	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		22	M	SS	16					
8–11.5	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		12	M	SS	13					
11.5–14	SAND, a little gravel, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b)		19	M	SS	10					
14–16	SAND, a little gravel, fine grained, light brown, moist, medium dense (SP) (A-3)		16	M	SS	12					
16	**END OF BORING**										

*Composite sample:
LL=36%, PL=20%, PI=16%, -#200=87% (62% silt, 25% clay)

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	3.25" HSA	12/2/11	1:55	16.0	14.5	15.1		None
		12/2/11	2:00	16.0	14.5	14.7		None

(WATER LEVEL MEASUREMENTS)

BORING COMPLETED: 12/2/11

DR: DS LG: EW Rig: 33C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **11 (p. 1 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ________ COUNTY COORDINATES: N **137003** E **483616**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	LEAN CLAY WITH SAND, trace roots, brown, firm to stiff (A-6) (CL)	FINE ALLUVIUM	7	M	SS	16	15				
			9	M	SS	8	12				
4–9	SAND WITH GRAVEL, fine to medium grained, brown, moist, medium dense (SP) (A-1-b)	COARSE ALLUVIUM	17	M	SS	10					
			16	M	SS	12					
9–11½	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		14	M	SS	12					
11½–14	SAND, a little gravel, medium grained, brown, moist, loose (SP) (A-1-b)		9	M	SS	12					
14–23	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		15	M	SS	12					
			14	M	SS	12					
23–28	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		20	M	SS	12					
28–	FAT CLAY, gray, a little light gray and brown, stiff, laminations of silt and sandy silt (CH) (A-7-6)	FINE ALLUVIUM	14	M	SS	16	24		68	20	

DEPTH:	DRILLING METHOD
0-49½'	3.25" HSA

BORING COMPLETED: 12/6/11

DR: JM LG: JMM Rig: 68C

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/6/11	11:35	50.0	49.5	50.0		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **11 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **137003** E **483616**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33	SANDY LEAN CLAY, a little gravel, brown, a little light brown, very stiff, laminations of sandy silt (CL) (A-6)	TILL									
35			19	M	SS	18	14				
38	SANDSTONE, fresh, light grayish tan, a little light brown	ST. PETER SANDSTONE									
40			100/.5	M	SS	6					
45			100/.4	M	SS	6					
50			100/.5	M	SS	6					
	END OF BORING										

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **12 (p. 1 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **136860** E **484285**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	LEAN CLAY WITH SAND, slightly organic, trace roots, dark brown, firm (CL) (A-6)	TOPSOIL	8	M	SS	8	20				
2–4	LEAN CLAY WITH SAND, brown, firm (CL) (A-6)	FINE ALLUVIUM	5	M	SS	12	16				
4–6.5	SAND WITH GRAVEL, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)	COARSE ALLUVIUM	12	M	SS	12					
6.5–11.5	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense to loose (SP) (A-3)		13	M	SS	14					
			8	M	SS	16					
11.5–18	SAND, a little gravel, medium to fine grained, light brown, moist, loose to medium dense (SP) (A-1-b)		10	M	SS	12					
			11	M	SS	16					
18–28	SAND WITH GRAVEL, fine to medium grained, light brown, moist, medium dense (SP) (A-1-b)		24	M	SS	10					
			19	M	SS	14					
28–	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense to dense (SP) (A-3)		16	M	SS	12					

FIELD & LABORATORY TESTS: WC, DEN, LL, PL, %-#200

DEPTH:	DRILLING METHOD
0-49½'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/5/11	2:15	51.0	49.5	49.5		48.0
12/6/11	8:12	51.0	49.5	49.5		46.5

BORING COMPLETED: **12/5/11**

DR: **JM** LG: **JMM** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **12 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **136860** E **484285**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33–38	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense to dense (SP) (A-3) *(continued)*		32	M	SS	14					
38–43	SAND, fine grained, light brown, moist, medium dense (SP) (A-3)		27	M	SS	16					
43–51	SAND WITH SILT, fine grained, light brown, moist to waterbearing, medium dense to dense (SP-SM) (A-3)		22	M/W ▼	SS	18					
			32	W	SS	24					
51	**END OF BORING**										

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

24

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **13 (p. 1 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **136411** E **484304**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	LEAN CLAY, slightly organic, trace roots, dark brown, firm (CL) (A-6)	TOPSOIL	5	M	SS	6	21				
2–4	LEAN CLAY WITH SAND, trace roots, brown, firm (CL) (A-6)	FINE ALLUVIUM	6	M	SS	4	15				
4–6.5	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)	COARSE ALLUVIUM	18	M	SS	10					
6.5–23	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		11	M	SS	16					
			11	M	SS	16					
			21	M	SS	16					
			16	M	SS	14					
			27	M	SS	16					
23–28	SAND WITH GRAVEL, fine to medium grained, light brown, moist, medium dense (SP) (A-1-b)		18	M	SS	18					
28–	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		18	M	SS	16					

DEPTH:	DRILLING METHOD
0-39½'	3.25" HSA

BORING COMPLETED: 12/7/11

DR: JMM LG: JM Rig: 68C

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/7/11	11:56	41.0	39.5	41.0		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **13 (p. 2 of 2)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

COUNTY COORDINATES: N **136411** E **484304**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33–38	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3) *(continued)*										
35			25	M	SS	16					
38–41	SAND, fine grained, light brown, moist, dense (SP) (A-3)										
40			34	M	SS	18					
41	**END OF BORING**										

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **14 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ________ COUNTY COORDINATES: N **135950** E **484319**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	LEAN CLAY WITH SAND, trace roots, dark brown, firm (CL) (A-6)	TOPSOIL	6	M	SS	6	21				
2–4	SILTY SAND, a little gravel, trace roots, fine grained, brown, moist, loose (SM) (A-2-4)	COARSE ALLUVIUM	10	M	SS	8					
4–11.5	SAND, a little gravel, fine to medium grained, brown, moist, loose (SP) (A-3)		10	M	SS	8					
			7	M	SS	12					
			7	M	SS	10					
11.5–18	SAND WITH GRAVEL, fine to medium grained, light brown, moist, medium dense to loose (SP) (A-1-b)		15	M	SS	8					
			10	M	SS	10					
18–31	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		16	M	SS	12					1
			18	M	SS	10					
			17	M	SS	12					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-29½'	3.25" HSA	12/7/11	9:20	31.0	29.5	30.9		None

BORING COMPLETED: **12/7/11**

DR: **JM** LG: **JMM** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **15 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ________ COUNTY COORDINATES: N **137171** E **484510**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	LEAN CLAY, brown, stiff (CL) (A-6)	FINE ALLUVIUM	9	M	SS	18	14				
2–6	SAND, a little gravel, fine to medium grained, brown, moist, loose to medium dense, a lens of silty sand at about 5.5' (SP) (A-3)	COARSE ALLUVIUM	9	M	SS	10					
			14	M	SS	10					
6–13.5	SAND, a little gravel, medium to fine grained, light brown, moist, loose (SP) (A-1-b)		6	M	SS	12					
			6	M	SS	10					
			9	M	SS	12					
13.5–16	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)		12	M	SS	12					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14½'	3.25" HSA

BORING COMPLETED: **12/5/11**

DR: **JM** LG: **JMM** Rig: **68C**

WATER LEVEL MEASUREMENTS						
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/5/11	12:30	16.0	14.5	15.7		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **16 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137322** E **485190**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	LEAN CLAY WITH SAND, trace roots, dark brown to brown, stiff to firm (CL) (A-6)	FINE ALLUVIUM	9	M	SS	18	15				
			8	M	SS	13	24				
4–6	LEAN CLAY, a little gravel, gray, a little light brown, firm, laminations of silt (CL) (A-4)		6	M	SS	16	12				
6–8	SAND, a little gravel, fine to medium grained, light brown, moist, medium dense (SP) (A-3)	COARSE ALLUVIUM	12	M	SS	10					
8–16	SAND, a little gravel, medium to fine grained, light brown, moist, loose (SP) (A-1-b)		6	M	SS	10					
			7	M	SS	10					
			6	M	SS	10					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/5/11	**11:40**	**16.0**	**14.5**	**16.0**		**None**

BORING COMPLETED: **12/5/11**

DR: **JM** LG: **JMM** Rig: **68C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05289** LOG OF BORING NO. **17 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ______ COUNTY COORDINATES: N **137391** E **485910**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	3.75" Bituminous pavement	FILL			SU		15				
1	14" FILL, mostly sand with silt, a little gravel, brown (A-2-4)		13	M	SS	14	4				11
2–4	FILL, mixture of lean clay and sandy lean clay, a little silty sand and gravel, dark brown and brown (A-6)		7	M	SS	6	19				
4–6	SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SP) (A-3)	COARSE ALLUVIUM	11	M	SS	10					
7–16	SAND, a little gravel, medium to fine grained, brown, moist, loose to very dense (SP) (A-1-b)		23	M	SS	6					
			8	M	SS	10					
			9	M	SS	11					
			62	M	SS	3					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14½'	3.25" HSA

BORING COMPLETED: 12/2/11

DR: **DS** LG: **EW** Rig: **33C**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/2/11		16.0	14.5	15.1		None
12/2/11		16.0	14.5	14.8		None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05289.GPJ AET+CPT+WELL.GDT 12/27/11

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **01-05290** LOG OF BORING NO. **18 (p. 1 of 1)**

PROJECT: **CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN**

SURFACE ELEVATION: ________ COUNTY COORDINATES: N **137361** E **484160**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	SANDY LEAN CLAY, trace roots, dark brown to brown, firm (CL) (A-6)	TOPSOIL	6	M	SS	18	16				
2–4	CLAYEY SAND, brown, firm (SC) (A-6)	TILL OR MIXED ALLUVIUM	7	M	SS	8	13				
4–9	SAND, a little gravel, fine to medium grained, brown, moist, loose to medium dense (SP) (A-3)	COARSE ALLUVIUM	9	M	SS	10					
			11	M	SS	14					
9–16	SAND, a little gravel, medium to fine grained, brown, moist, medium dense (SP) (A-1-b)		13	M	SS	12					
			14	M	SS	12					
			15	M	SS	16					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14½'	**3.25" HSA**

BORING COMPLETED: **12/6/11**

DR: **JM** LG: **JMM** Rig: **68C**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
12/6/11	**9:45**	**16.0**	**14.5**	**15.9**		**None**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-COORDINATES 01-05290.GPJ AET+CPT+WELL.GDT 12/13/11

SIEVE/HYDROMETER ANALYSIS TEST RESULTS

PROJECT:
CSAH 19-20-22
SWWD Overflow Outlet
Cottage Grove, Minnesota

AET NO.: 01-05289
01-05290

DATE: December 27, 2011

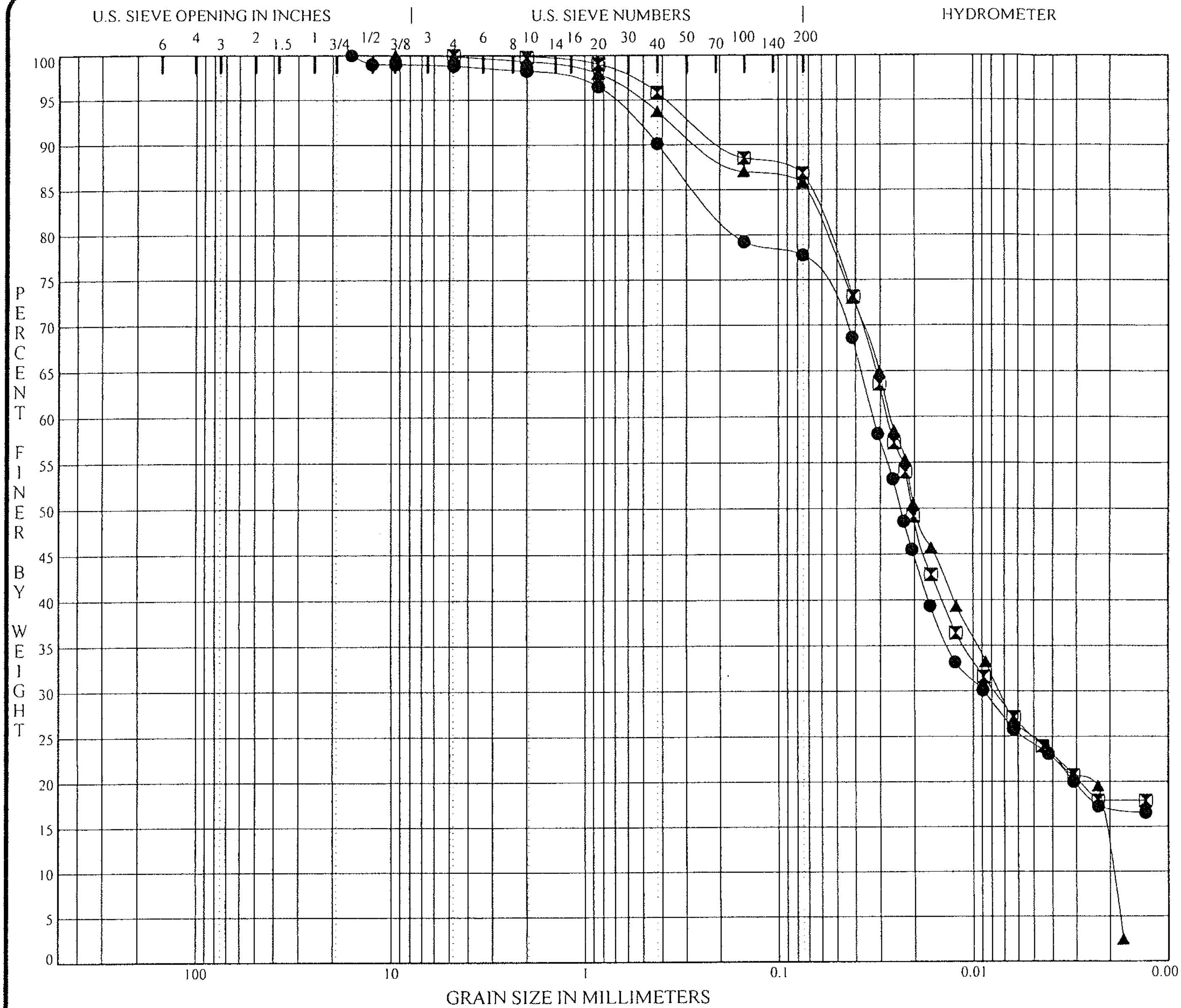
TEST METHODS: Sieve Analysis: General conformance with ASTM:D6913, Method A
Sieve Analysis with Hydrometer: General conformance with ASTM:D422

RESULTS:

Boring Number	1 and 2 composite	3	3	3	10	14	17
Sample Depth	0'-3'	2'-3½'	4½'-6'	12'-13½'	0'-3'	19½'-21'	3.75"-17.75"
Dry Sample Weight (gms)	297.61	318.07	156.91	186.13	202.21	229.84	219.56
Sieve Size or Number							
5/8"	100	100	100	100	100	100	100
1/2"	100	98	100	100	100	97	98
3/8"	100	98	100	100	100	97	98
#4	100	98	98	100	100	96	90
#10	99	98	95	99	100	93	76
#20	98	96	90	93	99	83	59
#40	94	90	81	69	96	55	38
#100	87	79	64	4.7	89	3.4	14
#200	86	78	61	1.7	87	1.4	11.4
Silt %/Clay %	61/25	54/24	*	*	62/25	*	*

**Hydrometer test not performed.*

Note: The small sample size limits the accuracy of the test, and the sample may not necessarily be representative of the entire layer shown on the boring log.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	MC%	LL	PL	PI	Cc	Cu
●	3	3.0'							
⌛	10	1.5'	LEAN CLAY		36	20	16		
▲	1&2	1.5'	LEAN CLAY		42	23	19	1.05	13.6

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	3	3.0'	16.00	0.03	0.009		1.2	21.1	53.5	24.3
⌛	10	1.5'	4.75	0.03	0.008		0.0	13.2	61.9	24.9
▲	1&2	1.5'	9.50	0.03	0.007	0.0019	0.2	14.0	60.7	25.1

PROJECT CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

AET JOB NO. 01-05290 and 01-05289 Labs

DATE

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
B,H,N:	Size of flush-joint casing
CA:	Crew Assistant (initials)
CAS:	Pipe casing, number indicates nominal diameter in inches
CC:	Crew Chief (initials)
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RD:	Rotary drilling with fluid and roller or drag bit
REC:	In split-spoon (see notes) and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
REV:	Revert drilling fluid
SS:	Standard split-spoon sampler (steel; 1⅜" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
∇:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RCS:	Rock Compressive Strength, ksi
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remoulded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

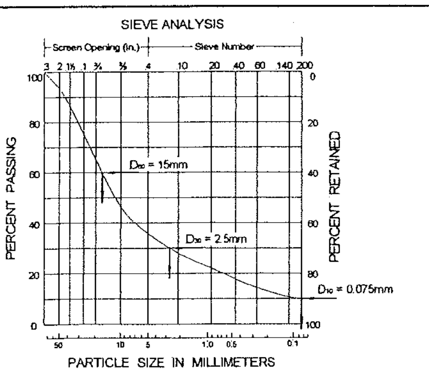
The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM:D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM:D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

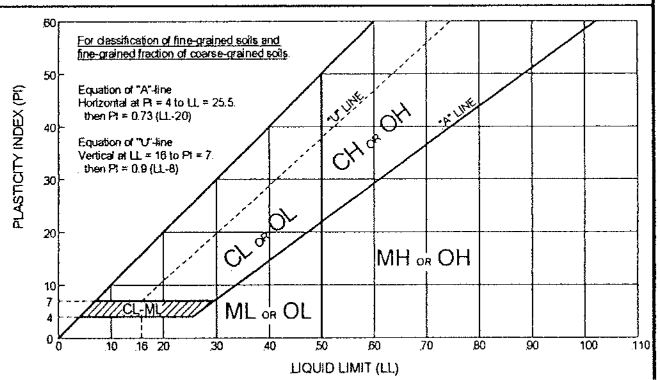
UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly-graded sand[I]
		Sands with Fines more than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	<u>Liquid limit–oven dried</u> / Liquid limit – not dried <0.75	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	<u>Liquid limit–oven dried</u> / Liquid limit – not dried <0.75	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $\quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{2.5^2}{0.075 \times 15} = 5.6$



Plasticity Chart

Notes

[A]Based on the material passing the 3-in (75-mm) sieve.

[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C]Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D]Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E]$Cu = D_{60}/D_{10}$, $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F]If soil contains ≥15% sand, add "with sand" to group name.

[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H]If fines are organic, add "with organic fines" to group name.

[I]If soil contains ≥15% gravel, add "with gravel" to group name.

[J]If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.

[K]If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.

[L]If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

[M]If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N]PI≥4 and plots on or above "A" line.

[O]PI<4 or plots below "A" line.

[P]PI plots on or above "A" line.

[Q]PI plots below "A" line.

[R]Fiber Content description shown below.

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition
(MC Column)

D (Dry):	Absence of moisture, dusty, dry to touch.
M (Moist):	Damp, although free water not visible. Soil may still have a high water content (over "optimum").
W (Wet/ Waterbearing):	Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
F (Frozen):	Soil frozen

Layering Notes

Laminations:	Layers less than ½" thick of differing material or color.
Lenses:	Pockets or layers greater than ½" thick of differing material or color.

Peat Description

Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

With roots:	Judged to have sufficient quantity of roots to influence the soil properties.
Trace roots:	Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.

AASHTO SOIL CLASSIFICATION SYSTEM

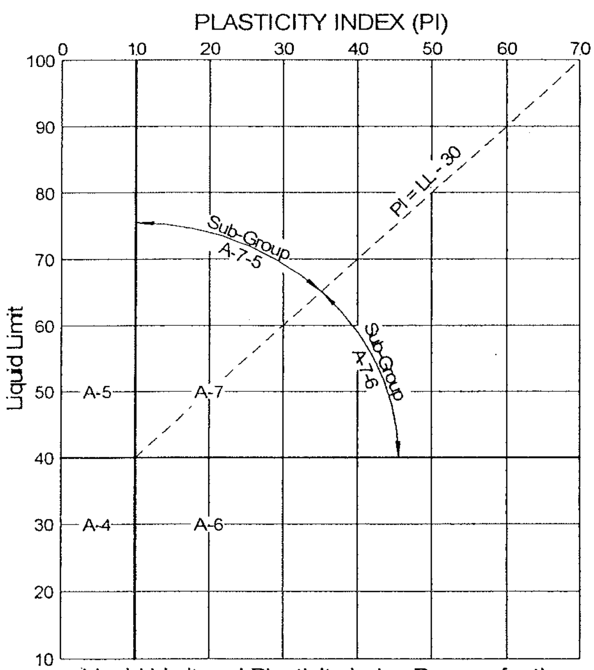
AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

Classification of Soils and Soil-Aggregate Mixtures

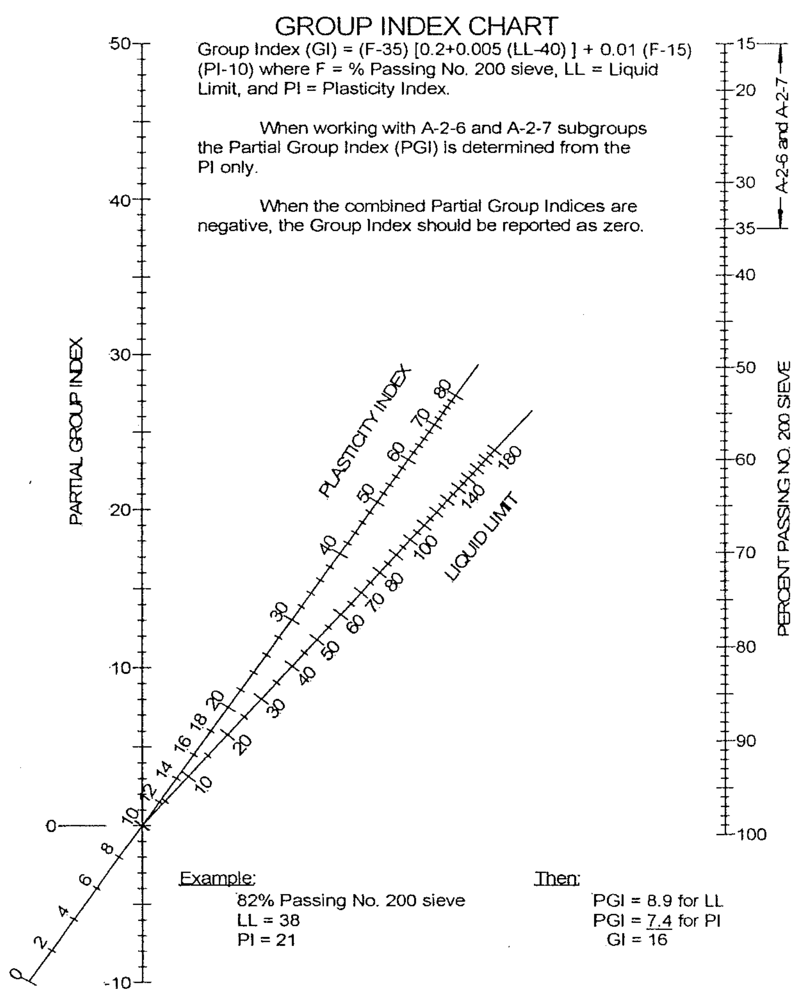
General Classification	Granular Materials (35% or less passing No. 200 sieve)							Silt-Clay Materials (More than 35% passing No. 200 sieve)			
Group Classification	A-1			A-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis, Percent passing:											
No. 10 (2.00 mm)	50 max.	....	....	....	....	....	....	....	....	....	....
No. 40 (0.425 mm)	30 max.	50 max.	51 min.	....	....	....	....	....	....	....	....
No. 200 (0.075 mm)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of Fraction Passing No. 40 (0.425 mm)											
Liquid limit	....		....	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Ratings as Subgrade	Excellent to Good							Fair to Poor			

The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.



Liquid Limit and Plasticity Index Ranges for the A-4, A-5, A-6 and A-7 Subgroups



Definitions of Gravel, Sand and Silt-Clay

The terms "gravel", "coarse sand", "fine sand" and "silt-clay", as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions are defined as follows:

GRAVEL - Material passing sieve with 3-in. square openings and retained on the No. 10 sieve.

COARSE SAND - Material passing the No. 10 sieve and retained on the No. 40 sieve.

FINE SAND - Material passing the No. 40 sieve and retained on the No. 200 sieve.

COMBINED SILT AND CLAY - Material passing the No. 200 sieve

BOULDERS (retained on 3-in. sieve) should be excluded from the portion of the sample to which the classificaiton is applied, but the percentage of such material, if any, in the sample should be recorded.

The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.

APPENDIX B

HYDRAULIC CONDUCTIVITY DEVELOPMENT

Project Information

This portion of the project includes a temporary storage basin north of CSAH 22. Assuming the outflow is not working, CSAH may in affect be a temporary dam. The low point of CSAH 22 is near Station 198+50. Subsurface exploration and laboratory test results were performed by AET (Report No. 01-05290). Nearest boring is No. 3.

Embankment Cross Section

Upstream toe elevation =	892.0	ft
Upstream slope ratio (H / V) =	4	
Top of road elevation =	909.0	ft
Embankment top (road) width =	65.0	ft
Downstream slope ratio (H / V) =	4	
Downstream toe elevation =	901.0	ft

Hydraulic Gradient (i)

Potential head differential (H) =	8.0	ft
Approx Ave length of drainage path (L) =	131.0	ft
Hydraulic gradient (i) =	H / L	
=	0.0611	

Embankment Soil Properties

A summary of the laboratory test results performed by AET are as follows. The embankment soil is fill consisting of primarily silt size material based on the grain size and hydrometer analyses and shown in the table below. The Atterberg Limit results indicate the soils have a Liquid Limit (LL) of 42, a Plastic Limit (PL) of 23, and Plasticity Index (PI) of 19. The sieve size of which 10 percent of material is finer than (i.e., D_{10}) is 0.0019mm. C_c is 1.05 and C_u is 13.6. The soil is classified as Lean Clay (CL).

Particle Size	**Percentage**	Properties	
Silt	60.7	LL =	42
Clay	25.1	PI =	19
Sand	14.0	C_u =	13.6
Gravel	0.2	D_{10} =	0.0019

Estimated Hydraulic Conduvtivity (K) - Breyer

Better for heterogeneous soils with $1 < C_u < 20$ (embankment)

Hydraulic Conductivity (K) = $g/v \times 6.45 \times 10^{-4} \text{ Log } [500 / C_u] \, d_{10}^2$

D_{10} =	0.0019	mm	Effective diameter
C_u =	13.6		Porosity
g =	981	cm / sec^2	Acceleration of gravity
v=	0.0100	cm^2 / sec	Kinematic viscosity (ν) = dynamic viscosity (μ) / fluid density (ρ)
K =	0.00000332	cm / sec	dynamic viscosity (μ) = 0.01 g / cm-sec @ 20° C
=	**0.00000011**	**ft / sec**	fluid density (ρ) = 0.9982 g / cm^3 @ 20° C
=	0.002869	m / day	

Embankment

Estimated Hydraulic Conduvtivity (K) - Hazen

Typically for sand. However, in this case correlates well with Breyer for silt/clay embankment.

Permeability (K) = $C * (D_{10})^2$

D_{10} = 0.0019 mm — Effective diameter

C = 0.92 — Coefficient usually 1.00, ranges from 0.40 (fine) to 1.50 (coarse)

K = 0.00000332 cm / sec

= **0.00000011 ft / sec**

= 0.002870 m / day

Native Sand (foundation) Soil Properties

Laboratory tests performed by AET indicate foundation soils consist of fine and fine to medium grained sands (SP), based on grain size analyses. The effective diameter (D_{10}) was extrapolated from the grain size distribution curves and judged to be about 0.18 mm.

Estimated Hydraulic Conductivity (K) - Kozeny-Carman

General use, especially sands

Hydraulic Conductivity (K) = $g/v \times 8.3 \times 10^{-3} [n^3 / (1 - n)^2] D_{10}^2$

D_{10} = 0.1800 mm — Estimated effective diameter

n = 0.32 — Porosity

g = 981 cm / sec^2 — Acceleration of gravity

v = 0.010018032 cm^2 / sec — Kinematic viscosity (v) = dynamic viscosity (μ) / fluid density (ρ)

K = 0.01866130 cm / sec — dynamic viscosity (μ) = 0.01 g / cm-sec @ 20° C

Foundation = **0.00061225 ft / sec** — fluid density (ρ) = 0.9982 g / cm^3 @ 20° C

= 16.12335913 m / day

Hazen (K) Comparison

Compares well to Kozeny-Carman, assuming fine grained sand

Hydraulic Conductivity (K) = $C * (D_{10})^2$

D_{10} = 0.1800 mm — Estimated effective diameter

C = 0.60 — Fine grained sand, C = 0.40 to 0.80

K = 0.01944000 cm / sec

= **0.00063780 ft / sec**

= 16.796160 m / day

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-05289 LOG OF BORING NO. 3 (p. 1 of 1)

PROJECT: CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

SURFACE ELEVATION: 906.07 COUNTY COORDINATES: N 137281 E 479810

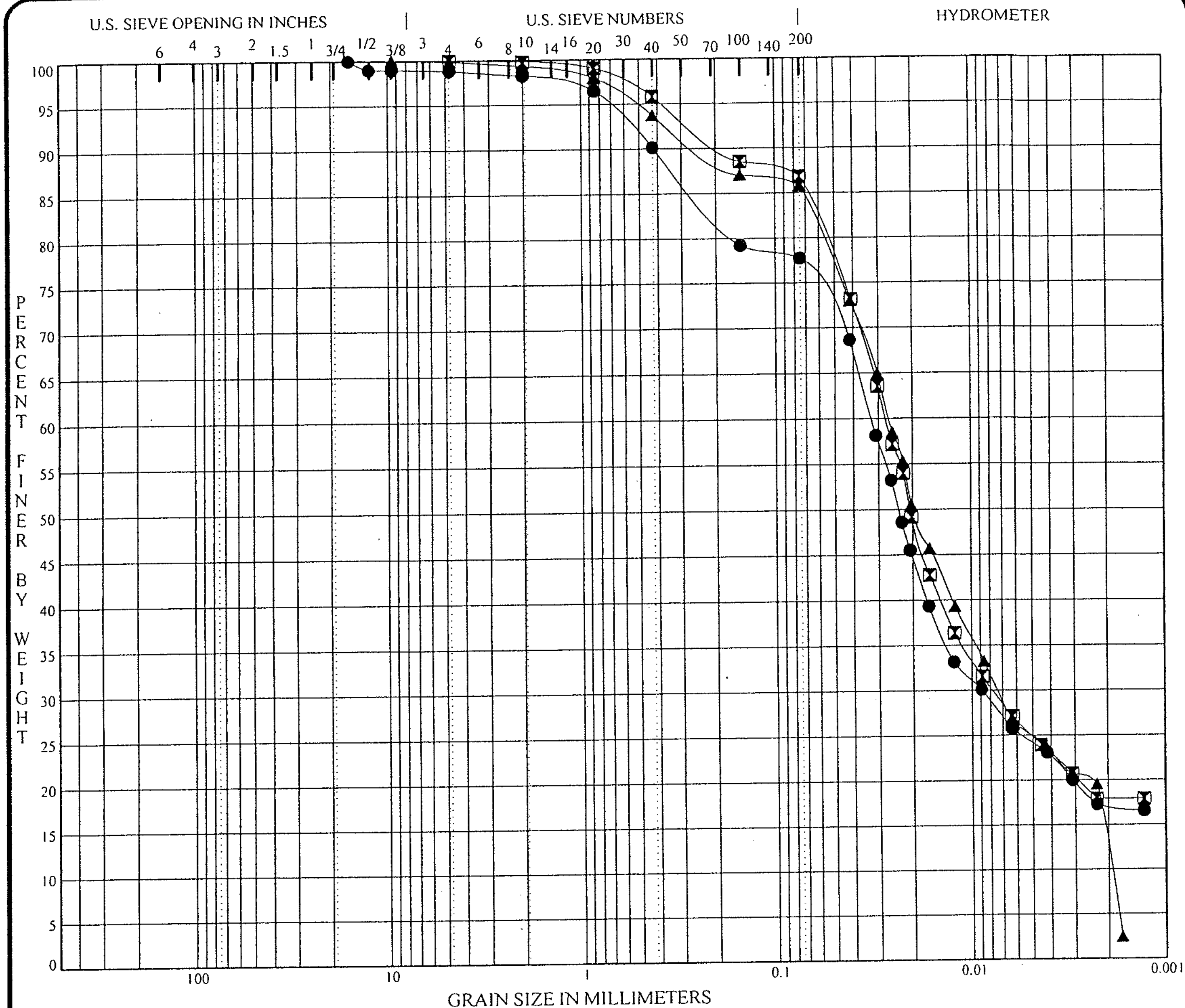
DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	5" Bituminous pavement	FILL		M	SU						
1	10.5" FILL, mostly silty sand, a little gravel, brown (A-2-4)		16	M	SS	16	13				
2–6	FILL, mixture of sandy lean clay, lean clay with sand, slightly organic lean clay and clayey sand, a little silty sand, gray, dark gray and brown (A-6)		11	M	SS	18	22 21				78
			9	M	SS	8	11				61
7–10	LEAN CLAY, slightly organic, dark brown to brown, firm to stiff (CL) (A-6) (possible fill)	FINE ALLUVIUM OR FILL	8	M	SS	10	27		40	20	
			13	M	SS	11					
11	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM) (A-3)	COARSE ALLUVIUM									
12–16	SAND, fine grained, brown, moist, medium dense (SP) (A-3)		20	M	SS	14					2
			18	M	SS	13					
16	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	3.25" HSA	12/1/11	10:34	16.0	14.5	15.2		None
		12/1/11	10:39	16.0	14.5	15.0		None

BORING COMPLETED: 12/1/11

DR: DS LG: EW Rig: 33C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	3	3.0'	Embankment Soil						
⊠	10	1.5'	LEAN CLAY		36	20	16		
▲	1&2	1.5'	LEAN CLAY		42	23	19	1.05	13.6

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	3	3.0'	16.00	0.03	0.009		1.2	21.1	53.5	24.3
⊠	10	1.5'	4.75	0.03	0.008		0.0	13.2	61.9	24.9
▲	1&2	1.5'	9.50	0.03	0.007	0.0019	0.2	14.0	60.7	25.1

PROJECT CSAH 19-20-22 and SWWD Overflow Outlet; Cottage Grove, MN

AET JOB NO. 01-05290 and 01-05289 Labs
DATE

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES

SIEVE/HYDROMETER ANALYSIS TEST RESULTS

PROJECT:
CSAH 19-20-22
SWWD Overflow Outlet
Cottage Grove, Minnesota

AET NO.: 01-05289
01-05290

DATE: December 27, 2011

TEST METHODS: Sieve Analysis: General conformance with ASTM:D6913, Method A
Sieve Analysis with Hydrometer: General conformance with ASTM:D422

RESULTS:

Boring Number	1 and 2 composite	3	3	3	10	14	17
Sample Depth	0'-3'	2'-3½'	4½'-6'	12'-13½'	0'-3'	19½'-21'	3.75"-17.75"
Dry Sample Weight (gms)	297.61	318.07	156.91	186.13	202.21	229.84	219.56
Sieve Size or Number							
5/8"	100	100	100	100	100	100	100
1/2"	100	98	100	100	100	97	98
3/8"	100	98	100	100	100	97	98
#4	100	98	98	100	100	96	90
#10	99	98	95	99	100	93	76
#20	98	96	90	93	99	83	59
#40	94	90	81	69	96	55	38
#100	87	79	64	4.7	89	3.4	14
#200	86	78	61	1.7	87	1.4	11.4
Silt %/Clay %	61/25	54/24	*	*	62/25	*	*

**Hydrometer test not performed.*

Note: The small sample size limits the accuracy of the test, and the sample may not necessarily be representative of the entire layer shown on the boring log.

Foundation Soil

APPENDIX C

SEEPAGE ANALYSIS

Steady-State Seepage - water at 909 ft

File Information

Title: Temporary Dam - Co Rd 22, Cottage Grove, MN
Created By: Olson, Steve
Revision Number: 82
Last Edited By: Olson, Steve
Date: 9/20/2012
Time: 11:32:37 AM
File Name: SWWD Outflow_seepage_120917.gsz
Directory: C:\Users\stolson\Documents\Geotech\SWWD-CottageGrove\
Last Solved Date: 9/20/2012
Last Solved Time: 11:32:45 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Mass(M) Units: lbs
Mass Flux Units: lbs/sec
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Steady-State Seepage - water at 909 ft

Kind: SEEP/W
Method: Steady-State
Settings
- Include Air Flow: No

Control
- Apply Runoff: Yes

Convergence
- Convergence Type: Gauss Point K
- Convergence Settings
  - Maximum Number of Iterations: 500
  - Tolerance: 0.01
  - Maximum Change in K: 0.1
  - Rate of Change in K: 1.02
  - Minimum Change in K: 0.0001

Equation Solver: Parallel Direct
Potential Seepage Max # of Reviews: 10

Time

Starting Time: 0 sec
Duration: 0 sec
Ending Time: 0 sec

Materials

Embankment Fill (Breyer)

Model: Saturated Only

Hydraulic

K-Sat: 1.1e-007 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

Native sands (Kozeny-Carman)

Model: Saturated Only

Hydraulic

K-Sat: 0.00061 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

CL Till

Model: Saturated Only

Hydraulic

K-Sat: 1e-008 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

St Peter Sandstone

Model: (none)

Boundary Conditions

Reservoir Head

Type: Head (H) 909

Potential Seepage Face

Review: true
Type: Total Flux (Q) 0

Regions

	Material	Points	Area (ft^2)
Region 1	CL Till	13,12,14,15	2950
Region 2	St Peter Sandstone	15,14,10,11	8850
Region 3	Native sands (Kozeny-Carman)	17,16,18,30,19,12,13	11314
Region 4	Native sands (Kozeny-Carman)	9,20,21,19	15
Region 5	Native sands (Kozeny-Carman)	19,21,22,12	200
Region 6	CL Till	22,12,14,23	50
Region 7		23,14,10,24	150
Region 8		11,25,26,15	150
Region 9	CL Till	15,13,27,26	50
Region 10	Native sands (Kozeny-Carman)	13,17,28,27	155
Region 11	Native sands (Kozeny-Carman)	5,29,28,17	5
Region 12	Embankment Fill (Breyer)	31,1,2,3,4,30,18	918
Region 13	Native sands (Kozeny-Carman)	31,18,16,17,5,6	78
Region 14	Native sands (Kozeny-Carman)	4,7,8,9,19,30	230

Lines

	Start Point	End Point	Hydraulic Boundary
Line 1	12	13	
Line 2	12	14	
Line 3	14	15	
Line 4	15	13	
Line 5	14	10	
Line 6	10	11	
Line 7	11	15	
Line 8	9	19	
Line 9	18	16	
Line 10	16	17	
Line 11	17	5	
Line 12	19	12	

Line 13	13	17	
Line 14	9	20	
Line 15	20	21	
Line 16	21	19	
Line 17	21	22	
Line 18	22	12	
Line 19	14	23	
Line 20	23	22	
Line 21	10	24	
Line 22	24	23	
Line 23	11	25	
Line 24	25	26	
Line 25	26	15	
Line 26	13	27	
Line 27	27	26	
Line 28	17	28	
Line 29	28	27	
Line 30	5	29	
Line 31	29	28	
Line 32	19	30	
Line 33	30	18	
Line 34	31	1	
Line 35	1	2	Reservoir Head
Line 36	2	3	
Line 37	3	4	Potential Seepage Face
Line 38	4	30	
Line 39	18	31	
Line 40	5	6	Reservoir Head
Line 41	6	31	Reservoir Head
Line 42	4	7	Potential Seepage Face
Line 43	7	8	Potential Seepage Face
Line 44	8	9	Potential Seepage Face

Points

	X (ft)	Y (ft)

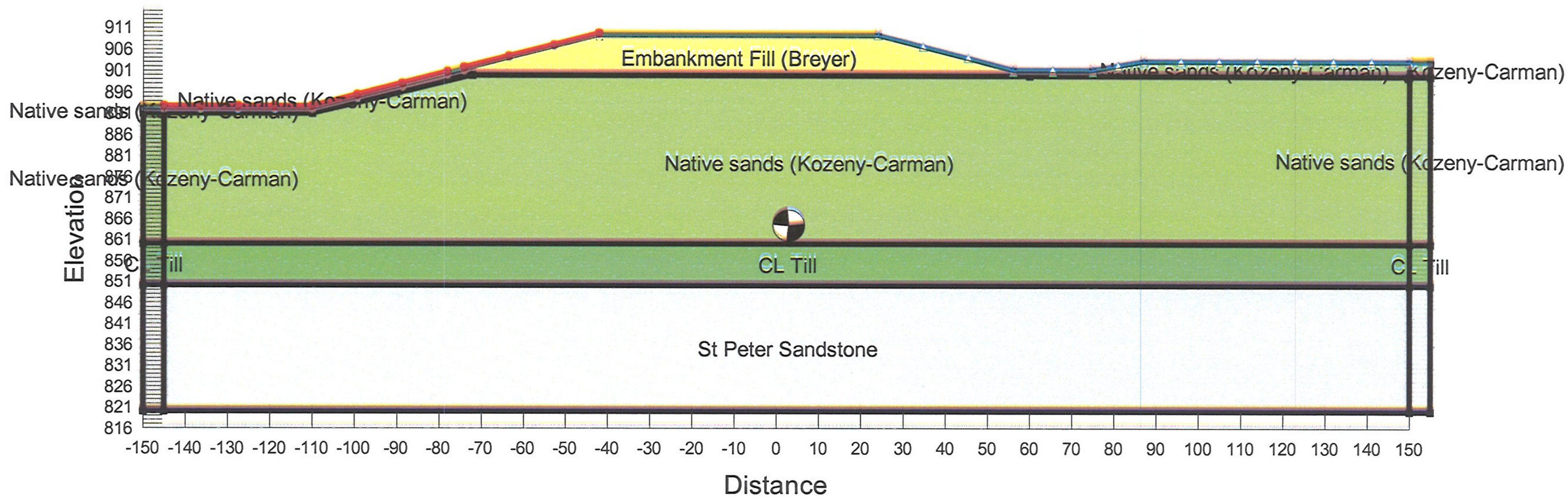
Point 1	-74	901
Point 2	-42	909
Point 3	24	909
Point 4	56	901
Point 5	-145	892
Point 6	-110	892
Point 7	75	901
Point 8	87	903
Point 9	-150	903
Point 10	150	820
Point 11	-145	820
Point 12	150	860
Point 13	-145	860
Point 14	150	850
Point 15	-145	850
Point 16	-110	891
Point 17	-145	891
Point 18	-72	900
Point 19	150	900
Point 20	155	903
Point 21	155	900
Point 22	155	860
Point 23	155	850
Point 24	155	820
Point 25	-150	820
Point 26	-150	850
Point 27	-150	860
Point 28	-150	891
Point 29	-150	892
Point 30	60	900
Point 31	-78	900

Name: Embankment Fill (Breyer)
K-Sat: 1.1e-007 ft/sec
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

Name: Native sands (Kozeny-Carman)
K-Sat: 0.00061 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: CL Till
K-Sat: 1e-008 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: St Peter Sandstone



Name: Embankment Fill (Breyer)
K-Sat: 1.1e-007 ft/sec
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

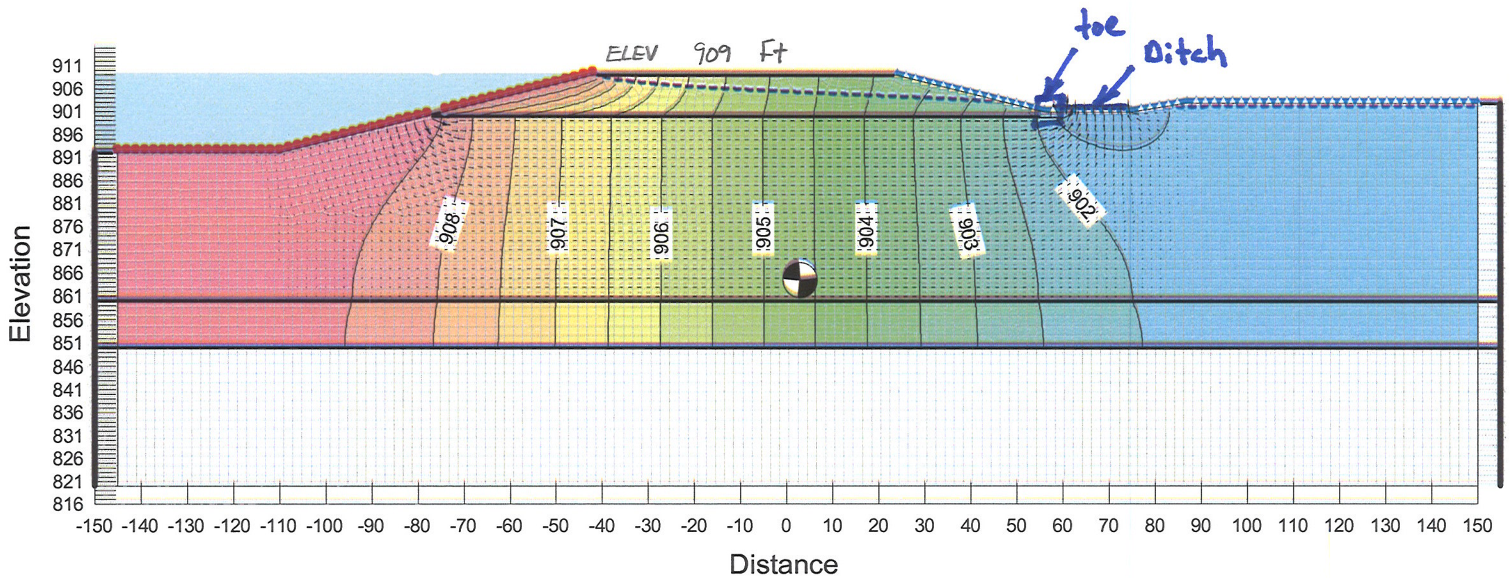
Name: Native sands (Kozeny-Carman)
K-Sat: 0.00061 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: CL Till
K-Sat: 1e-008 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: St Peter Sandstone

Results

Vertical exit gradient at toe = 0.47 < 0.84
∴ ok



Steady-State Seepage - DWSE = 902 ft

File Information

Title: Temporary Dam - Co Rd 22, Cottage Grove, MN
Created By: Olson, Steve
Revision Number: 83
Last Edited By: Olson, Steve
Date: 9/26/2012
Time: 10:30:54 AM
File Name: SWWD Outflow_seepage_120926.gsz
Directory: C:\Users\stolson\Documents\Geotech\SWWD-CottageGrove\
Last Solved Date: 9/26/2012
Last Solved Time: 10:31:02 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Mass(M) Units: lbs
Mass Flux Units: lbs/sec
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Steady-State Seepage - DSWE = 902 ft

Kind: SEEP/W
Method: Steady-State
Settings
Include Air Flow: No
Control
Apply Runoff: Yes
Convergence
Convergence Type: Gauss Point K
Convergence Settings
Maximum Number of Iterations: 500
Tolerance: 0.01
Maximum Change in K: 0.1
Rate of Change in K: 1.02
Minimum Change in K: 0.0001

Equation Solver: Parallel Direct
Potential Seepage Max # of Reviews: 10

Time

Starting Time: 0 sec
Duration: 0 sec
Ending Time: 0 sec

Materials

Embankment Fill (Breyer)

Model: Saturated Only

Hydraulic

K-Sat: 1.1e-007 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

Native sands (Kozeny-Carman)

Model: Saturated Only

Hydraulic

K-Sat: 0.00061 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

CL Till

Model: Saturated Only

Hydraulic

K-Sat: 1e-008 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

St Peter Sandstone

Model: (none)

Boundary Conditions

Reservoir Head

Type: Head (H) 902

Potential Seepage Face

Review: true
Type: Total Flux (Q) 0

Regions

	Material	Points	Area (ft²)
Region 1	CL Till	13,12,14,15	2950
Region 2	St Peter Sandstone	15,14,10,11	8850
Region 3	Native sands (Kozeny-Carman)	17,16,18,30,19,12,13	11314
Region 4	Native sands (Kozeny-Carman)	9,20,21,19	15
Region 5	Native sands (Kozeny-Carman)	19,21,22,12	200
Region 6	CL Till	22,12,14,23	50
Region 7		23,14,10,24	150
Region 8		11,25,26,15	150
Region 9	CL Till	15,13,27,26	50
Region 10	Native sands (Kozeny-Carman)	13,17,28,27	155
Region 11	Native sands (Kozeny-Carman)	5,29,28,17	5
Region 12	Embankment Fill (Breyer)	31,1,2,3,4,30,18	918
Region 13	Native sands (Kozeny-Carman)	31,18,16,17,5,6	78
Region 14	Native sands (Kozeny-Carman)	4,7,8,9,19,30	230

Lines

	Start Point	End Point	Hydraulic Boundary
Line 1	12	13	
Line 2	12	14	
Line 3	14	15	
Line 4	15	13	
Line 5	14	10	
Line 6	10	11	
Line 7	11	15	
Line 8	9	19	
Line 9	18	16	
Line 10	16	17	
Line 11	17	5	
Line 12	19	12	

Line 13	13	17	
Line 14	9	20	
Line 15	20	21	
Line 16	21	19	
Line 17	21	22	
Line 18	22	12	
Line 19	14	23	
Line 20	23	22	
Line 21	10	24	
Line 22	24	23	
Line 23	11	25	
Line 24	25	26	
Line 25	26	15	
Line 26	13	27	
Line 27	27	26	
Line 28	17	28	
Line 29	28	27	
Line 30	5	29	
Line 31	29	28	
Line 32	19	30	
Line 33	30	18	
Line 34	31	1	
Line 35	1	2	Reservoir Head
Line 36	2	3	
Line 37	3	4	Potential Seepage Face
Line 38	4	30	
Line 39	18	31	
Line 40	5	6	Reservoir Head
Line 41	6	31	Reservoir Head
Line 42	4	7	Potential Seepage Face
Line 43	7	8	Potential Seepage Face
Line 44	8	9	Potential Seepage Face

Points

	X (ft)	Y (ft)

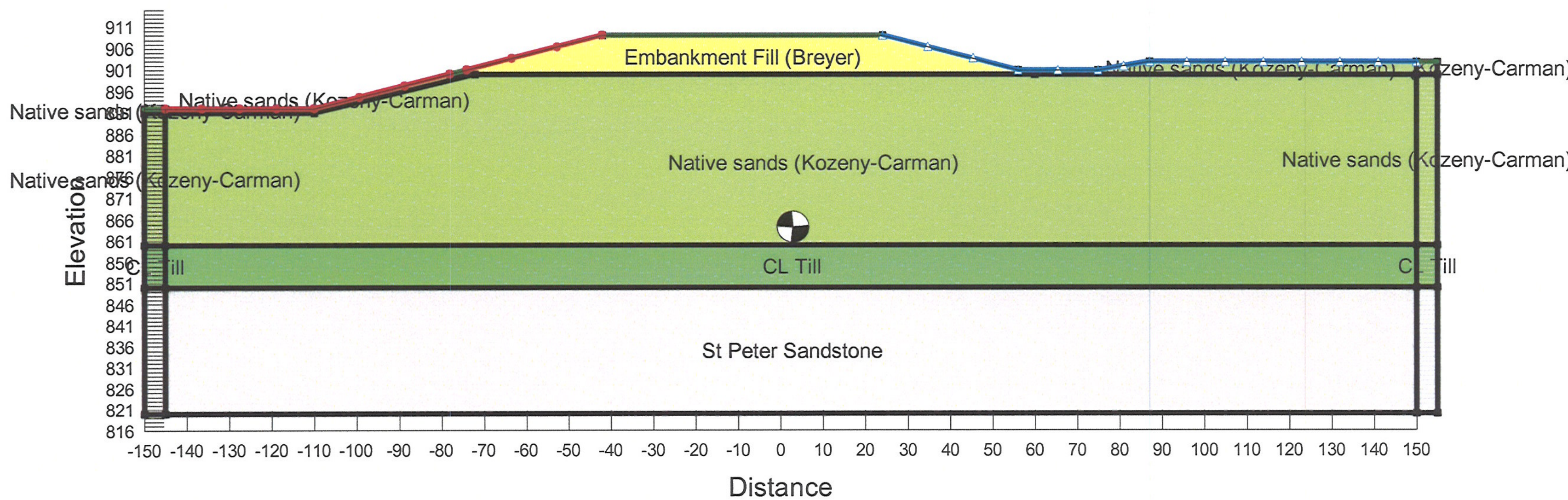
Point 1	-74	901
Point 2	-42	909
Point 3	24	909
Point 4	56	901
Point 5	-145	892
Point 6	-110	892
Point 7	75	901
Point 8	87	903
Point 9	150	903
Point 10	150	820
Point 11	-145	820
Point 12	150	860
Point 13	-145	860
Point 14	150	850
Point 15	-145	850
Point 16	-110	891
Point 17	-145	891
Point 18	-72	900
Point 19	150	900
Point 20	155	903
Point 21	155	900
Point 22	155	860
Point 23	155	850
Point 24	155	820
Point 25	-150	820
Point 26	-150	850
Point 27	-150	860
Point 28	-150	891
Point 29	-150	892
Point 30	60	900
Point 31	-78	900

Name: Embankment Fill (Breyer)
K-Sat: 1.1e-007 ft/sec
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

Name: Native sands (Kozeny-Carman)
K-Sat: 0.00061 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: CL Till
K-Sat: 1e-008 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: St Peter Sandstone



Name: Embankment Fill (Breyer)
K-Sat: 1.1e-007 ft/sec
Mv: 0 /psf
K-Ratio: 0.25
K-Direction: 0 °

Name: Native sands (Kozeny-Carman)
K-Sat: 0.00061 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

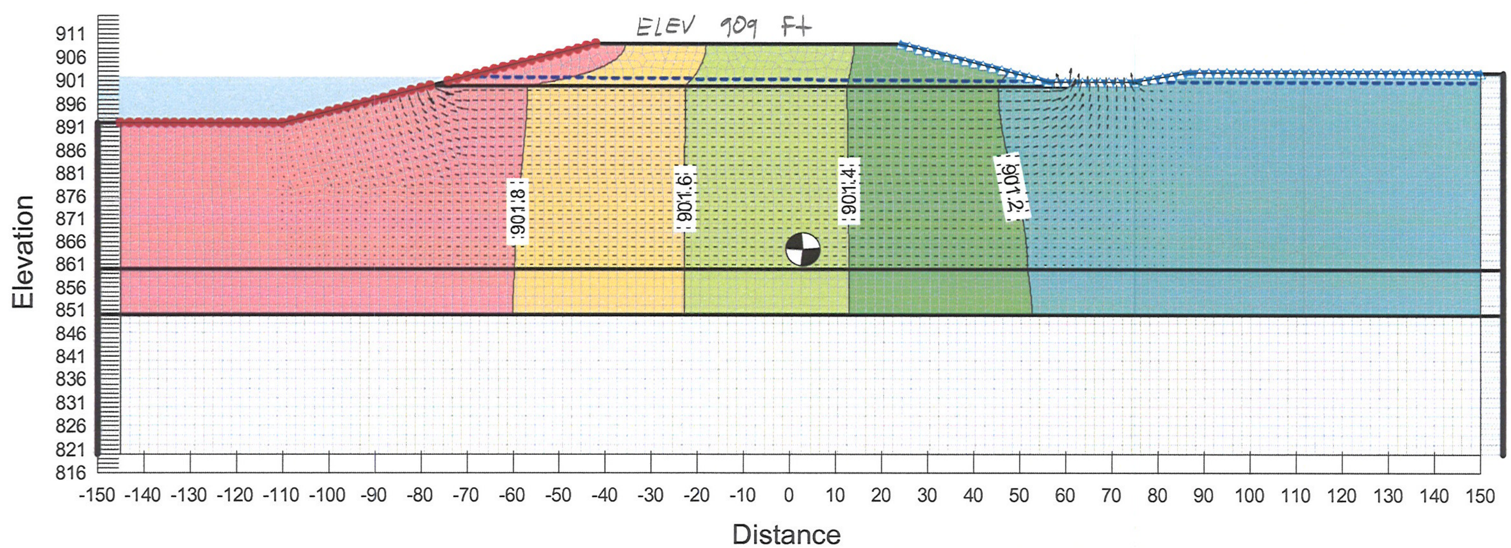
Name: CL Till
K-Sat: 1e-008 ft/sec
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: St Peter Sandstone

Results

Vertical exit gradient at toe = 0.06 < 0.5
Localized exit gradient at toe = 0.08 < 0.5

∴ ok



APPENDIX C

PIPE CALCULATIONS

Concrete Pipe Design With Surcharge Load Using the D-Load Method

(Spreadsheet prepared by Steve McKelvie using methods taken from the "Concrete Pipe Design Manual" 19th Printing April 2007)

South Washington Water District

Rigid Pipe Earth Load Calculations

Bedding Reference Data Taken From "Concrete Pipe Design Manual"

Illustration 4.3 Standard Trench/Embankment Installation

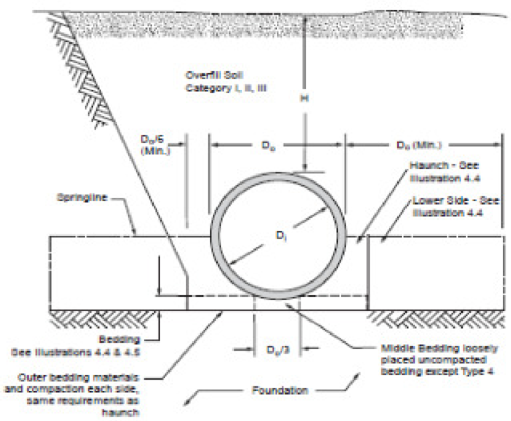


Illustration 4.4 Standard Installations Soil and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	$D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150 mm (6").	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	$D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150 mm (6").	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	$D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150 mm (6").	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use $D_o/12$ minimum, not less than 150 mm (6").	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Illustration 4.7 Vertical Arching Factor (VAF)

Standard Installation	Minimum Bedding Factor, B_{fo}
Type 1	1.35
Type 2	1.40
Type 3	1.40
Type 4	1.45

ASTM Pipe Class	D-Load 0.01 Crack ›/ln ft/ ft di	D-Load Ultimate lb/ln ft/ ft dia.)
1	800	1200
2	1000	1500
3	1350	2000
4	2000	3000
5	3000	3750

Illustration 4.21 Bedding Factors, Embankment Conditions, B_{fe}

Pipe Diameter	Standard Installation Type 1	Type 2	Type 3	Type 4
12 in.	4.4	3.2	2.5	1.7
24 in.	4.2	3.0	2.4	1.7
36 in.	4.0	2.9	2.3	1.7
72 in.	3.8	2.8	2.2	1.7
144 in.	3.6	2.8	2.2	1.7

Notes:

1. *For pipe diameters other than listed in Illustration 4.21, embankment condition factors, B_{fe} can be obtained by interpolation.*
2. *Bedding factors are based on the soils being placed with the minimum compaction specified in Illustration 4.4 for each standard installation.*

Condition - Scrape Away Near Surface Soil and Trench The Deeper Portions

Assumed Trench Depth, ft. 20 feet

Remainder of Cover removed by scrappers and replaced after pipe installed

Use Type 1 Bedding Condition

Total Depth of Cover (feet)	Inside Pipe Diameter (feet)	Pipe Wall Thickness (feet)	Pipe Outside Diameter (feet)	Bedding Depth (feet)	Total Excavation Depth (feet)	Bedding Width Beyond Pipe (feet)	Allowance for Shoring Width (feet)	Top of Pipe Trench Width (feet)	Soil Density (lb/cu. ft.)	Conjugate Ratio K	Sliding Friction u'	Total Trench Depth (feet)	Ku'	Trench Load Coefficient Cd	Trench Cover on Pipe (feet)	Trench Cover/ Pipe Width (H/Bc)	Transition Width (feet)	Loading Condition	Prism Load (lb/ft)	Type 1 Bedding Vertical Arching Factor	Earth Load W (lb/ft.)	Bedding Factor Type 1	Required D-Load (lb/ln ft/ ft dia.)	Required Pipe Class	Class D-Load (lb/ln ft/ ft dia.)
5	6	0.58	7.16	0.66	12.82	2	1	13.16	125	0.33	0.5	12.82	0.165	0.357	5.000	0.698	10.894	Embankment	5162.6	1.35	6970	3.8	305.7	1	800
10	6	0.58	7.16	0.66	17.82	2	1	13.16	125	0.33	0.5	17.82	0.165	1.092	10.000	1.397	11.470	Embankment	9637.6	1.35	13011	3.8	570.6	1	800
15	6	0.58	7.16	0.66	22.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	14112.6	1.35	19052	3.8	835.6	2	1000
16	6	0.58	7.16	0.66	23.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	15007.6	1.35	20260	3.8	888.6	2	1000
17	6	0.58	7.16	0.66	24.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	15902.6	1.35	21469	3.8	941.6	2	1000
18	6	0.58	7.16	0.66	25.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	16797.6	1.35	22677	3.8	994.6	2	1000
19	6	0.58	7.16	0.66	26.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	17692.6	1.35	23885	3.8	1047.6	3	1350
20	6	0.58	7.16	0.66	27.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	18587.6	1.35	25093	3.8	1100.6	3	1350
21	6	0.58	7.16	0.66	28.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	19482.6	1.35	26302	3.8	1153.6	3	1350
22	6	0.58	7.16	0.66	29.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	20377.6	1.35	27510	3.8	1206.6	3	1350
23	6	0.58	7.16	0.66	30.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	21272.6	1.35	28718	3.8	1259.6	3	1350
24	6	0.58	7.16	0.66	31.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	22167.6	1.35	29926	3.8	1312.6	3	1350
25	6	0.58	7.16	0.66	32.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	23062.6	1.35	31135	3.8	1365.5	4	2000
26	6	0.58	7.16	0.66	33.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	23957.6	1.35	32343	3.8	1418.5	4	2000
27	6	0.58	7.16	0.66	34.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	24852.6	1.35	33551	3.8	1471.5	4	2000
28	6	0.58	7.16	0.66	35.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	25747.6	1.35	34759	3.8	1524.5	4	2000
29	6	0.58	7.16	0.66	36.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	26642.6	1.35	35968	3.8	1577.5	4	2000
30	6	0.58	7.16	0.66	37.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	27537.6	1.35	37176	3.8	1630.5	4	2000
31	6	0.58	7.16	0.66	38.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	28432.6	1.35	38384	3.8	1683.5	4	2000
32	6	0.58	7.16	0.66	39.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	29327.6	1.35	39592	3.8	1736.5	4	2000
33	6	0.58	7.16	0.66	40.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	30222.6	1.35	40801	3.8	1789.5	4	2000
34	6	0.58	7.16	0.66	41.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	31117.6	1.35	42009	3.8	1842.5	4	2000
35	6	0.58	7.16	0.66	42.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	32012.6	1.35	43217	3.8	1895.5	4	2000
36	6	0.58	7.16	0.66	43.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	32907.6	1.35	44425	3.8	1948.5	4	2000
37	6	0.58	7.16	0.66	44.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	33802.6	1.35	45634	3.8	2001.5	5	3000
38	6	0.58	7.16	0.66	45.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	34697.6	1.35	46842	3.8	2054.5	5	3000
39	6	0.58	7.16	0.66	46.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	35592.6	1.35	48050	3.8	2107.5	5	3000
40	6	0.58	7.16	0.66	47.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	36487.6	1.35	49258	3.8	2160.5	5	3000
41	6	0.58	7.16	0.66	48.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	37382.6	1.35	50467	3.8	2213.4	5	3000
42	6	0.58	7.16	0.66	49.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	38277.6	1.35	51675	3.8	2266.4	5	3000
43	6	0.58	7.16	0.66	50.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	39172.6	1.35	52883	3.8	2319.4	5	3000
44	6	0.58	7.16	0.66	51.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	40067.6	1.35	54091	3.8	2372.4	5	3000
45	6	0.58	7.16	0.66	52.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	40962.6	1.35	55300	3.8	2425.4	5	3000
46	6	0.58	7.16	0.66	53.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	41857.6	1.35	56508	3.8	2478.4	5	3000
47	6	0.58	7.16	0.66	54.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	42752.6	1.35	57716	3.8	2531.4	5	3000
48	6	0.58	7.16	0.66	55.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	43647.6	1.35	58924	3.8	2584.4	5	3000
49	6	0.58	7.16	0.66	56.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	44542.6	1.35	60133	3.8	2637.4	5	3000
50	6	0.58	7.16	0.66	57.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	11.722	Embankment	45437.6	1.35	61341	3.8	2690.4	5	3000

Condition - Scrape Away Near Surface Soil and Trench The Deeper Portions

Assumed Trench Depth, ft. 20 feet
Remainder of Cover removed by scrappers and replaced after pipe installed
Use Type 2 Bedding Condition

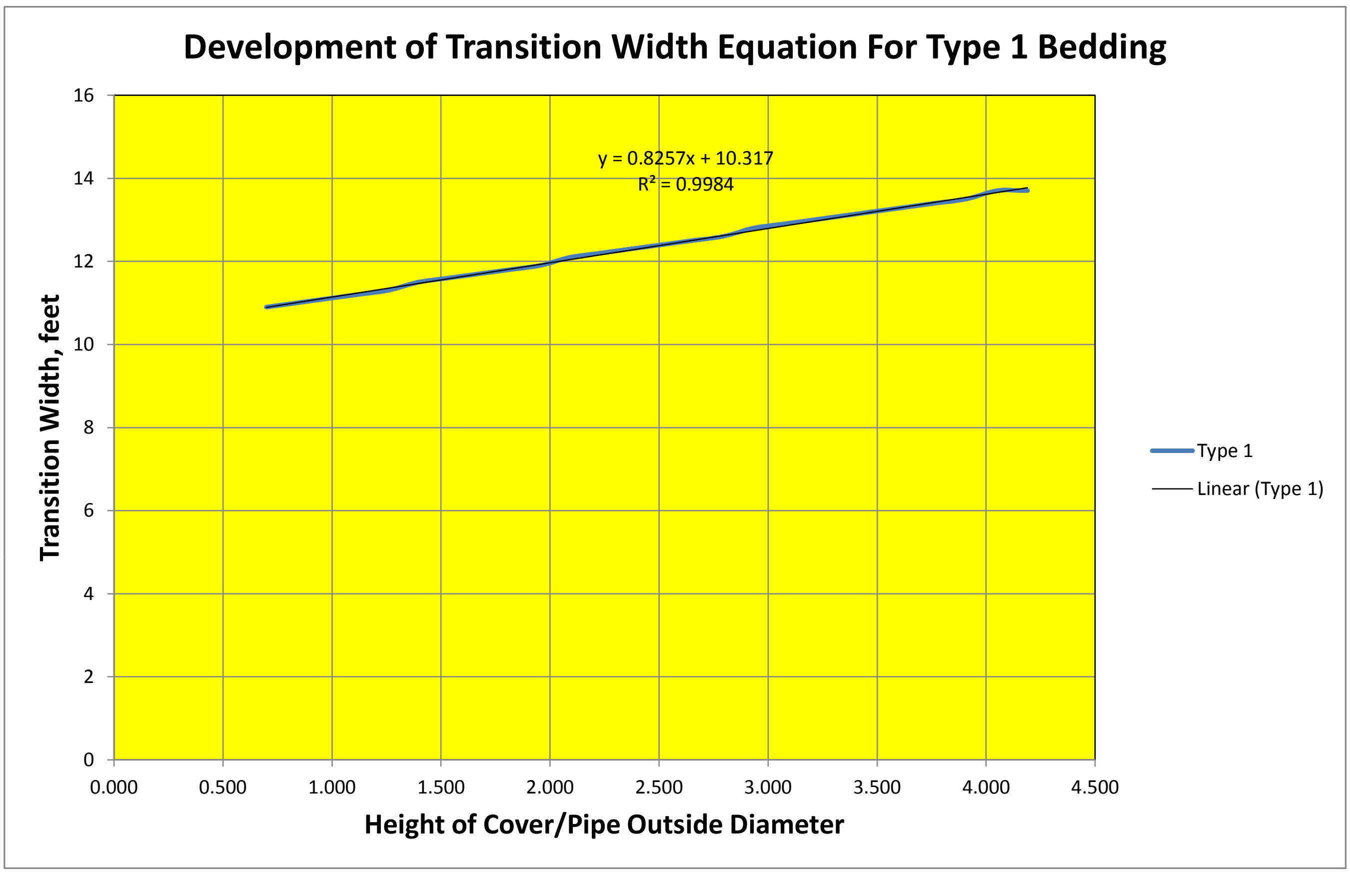
Total Depth of Cover (feet)	Inside Pipe Diameter (feet)	Pipe Wall Thickness (feet)	Pipe Outside Diameter (feet)	Bedding Depth (feet)	Total Excavation Depth (feet)	Bedding Width Beyond Pipe (feet)	Allowance for Shoring Width (feet)	Top of Pipe Trench Width (feet)	Soil Density (lb/cu. ft.)	Conjugate Ratio K	Sliding Friction u'	Total Trench Depth (feet)	Ku'	Trench Load Coefficient Cd	Trench Cover on Pipe (feet)	Trench Cover/ Pipe Width (H/Bc)	Transition Width (feet)	Loading Condition	Prism Load (lb/ft)	Type 2 Bedding Vertical Arching Factor	Earth Load W (lb/ft.)	Bedding Factor Type 2	Required D-Load (lb/ln ft/ ft dia.)	Required Pipe Class	Class D-Load (lb/ln ft/ ft dia.)
5	6	0.58	7.16	0.66	12.82	2	1	13.16	125	0.33	0.5	12.82	0.165	0.357	5.000	0.698	11.289	Embankment	5162.6	1.40	7228	2.8	430.2	1	800
10	6	0.58	7.16	0.66	17.82	2	1	13.16	125	0.33	0.5	17.82	0.165	1.092	10.000	1.397	11.859	Embankment	9637.6	1.40	13493	2.8	803.1	2	1000
15	6	0.58	7.16	0.66	22.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	14112.6	1.40	19758	2.8	1176.1	3	1350
16	6	0.58	7.16	0.66	23.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	15007.6	1.40	21011	2.8	1250.6	3	1350
17	6	0.58	7.16	0.66	24.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	15902.6	1.40	22264	2.8	1325.2	3	1350
18	6	0.58	7.16	0.66	25.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	16797.6	1.40	23517	2.8	1399.8	4	2000
19	6	0.58	7.16	0.66	26.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	17692.6	1.40	24770	2.8	1474.4	4	2000
20	6	0.58	7.16	0.66	27.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	18587.6	1.40	26023	2.8	1549.0	4	2000
21	6	0.58	7.16	0.66	28.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	19482.6	1.40	27276	2.8	1623.6	4	2000
22	6	0.58	7.16	0.66	29.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	20377.6	1.40	28529	2.8	1698.1	4	2000
23	6	0.58	7.16	0.66	30.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	21272.6	1.40	29782	2.8	1772.7	4	2000
24	6	0.58	7.16	0.66	31.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	22167.6	1.40	31035	2.8	1847.3	4	2000
25	6	0.58	7.16	0.66	32.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	23062.6	1.40	32288	2.8	1921.9	4	2000
26	6	0.58	7.16	0.66	33.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	23957.6	1.40	33541	2.8	1996.5	4	2000
27	6	0.58	7.16	0.66	34.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	24852.6	1.40	34794	2.8	2071.1	5	3000
28	6	0.58	7.16	0.66	35.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	25747.6	1.40	36047	2.8	2145.6	5	3000
29	6	0.58	7.16	0.66	36.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	26642.6	1.40	37300	2.8	2220.2	5	3000
30	6	0.58	7.16	0.66	37.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	27537.6	1.40	38553	2.8	2294.8	5	3000
31	6	0.58	7.16	0.66	38.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	28432.6	1.40	39806	2.8	2369.4	5	3000
32	6	0.58	7.16	0.66	39.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	29327.6	1.40	41059	2.8	2444.0	5	3000
33	6	0.58	7.16	0.66	40.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	30222.6	1.40	42312	2.8	2518.6	5	3000
34	6	0.58	7.16	0.66	41.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	31117.6	1.40	43565	2.8	2593.1	5	3000
35	6	0.58	7.16	0.66	42.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	32012.6	1.40	44818	2.8	2667.7	5	3000
36	6	0.58	7.16	0.66	43.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	32907.6	1.40	46071	2.8	2742.3	5	3000
37	6	0.58	7.16	0.66	44.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	33802.6	1.40	47324	2.8	2816.9	5	3000
38	6	0.58	7.16	0.66	45.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	34697.6	1.40	48577	2.8	2891.5	5	3000
39	6	0.58	7.16	0.66	46.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	35592.6	1.40	49830	2.8	2966.1	5	3000
40	6	0.58	7.16	0.66	47.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	36487.6	1.40	51083	2.8	3040.6	Special	
41	6	0.58	7.16	0.66	48.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	37382.6	1.40	52336	2.8	3115.2	Special	
42	6	0.58	7.16	0.66	49.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	38277.6	1.40	53589	2.8	3189.8	Special	
43	6	0.58	7.16	0.66	50.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	39172.6	1.40	54842	2.8	3264.4	Special	
44	6	0.58	7.16	0.66	51.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	40067.6	1.40	56095	2.8	3339.0	Special	
45	6	0.58	7.16	0.66	52.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	40962.6	1.40	57348	2.8	3413.6	Special	
46	6	0.58	7.16	0.66	53.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	41857.6	1.40	58601	2.8	3488.1	Special	
47	6	0.58	7.16	0.66	54.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	42752.6	1.40	59854	2.8	3562.7	Special	
48	6	0.58	7.16	0.66	55.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	43647.6	1.40	61107	2.8	3637.3	Special	
49	6	0.58	7.16	0.66	56.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	44542.6	1.40	62360	2.8	3711.9	Special	
50	6	0.58	7.16	0.66	57.82	2	1	13.16	125	0.33	0.5	20	0.165	1.195	12.180	1.701	12.108	Embankment	45437.6	1.40	63613	2.8	3786.5	Special	

Transition Width Calcs

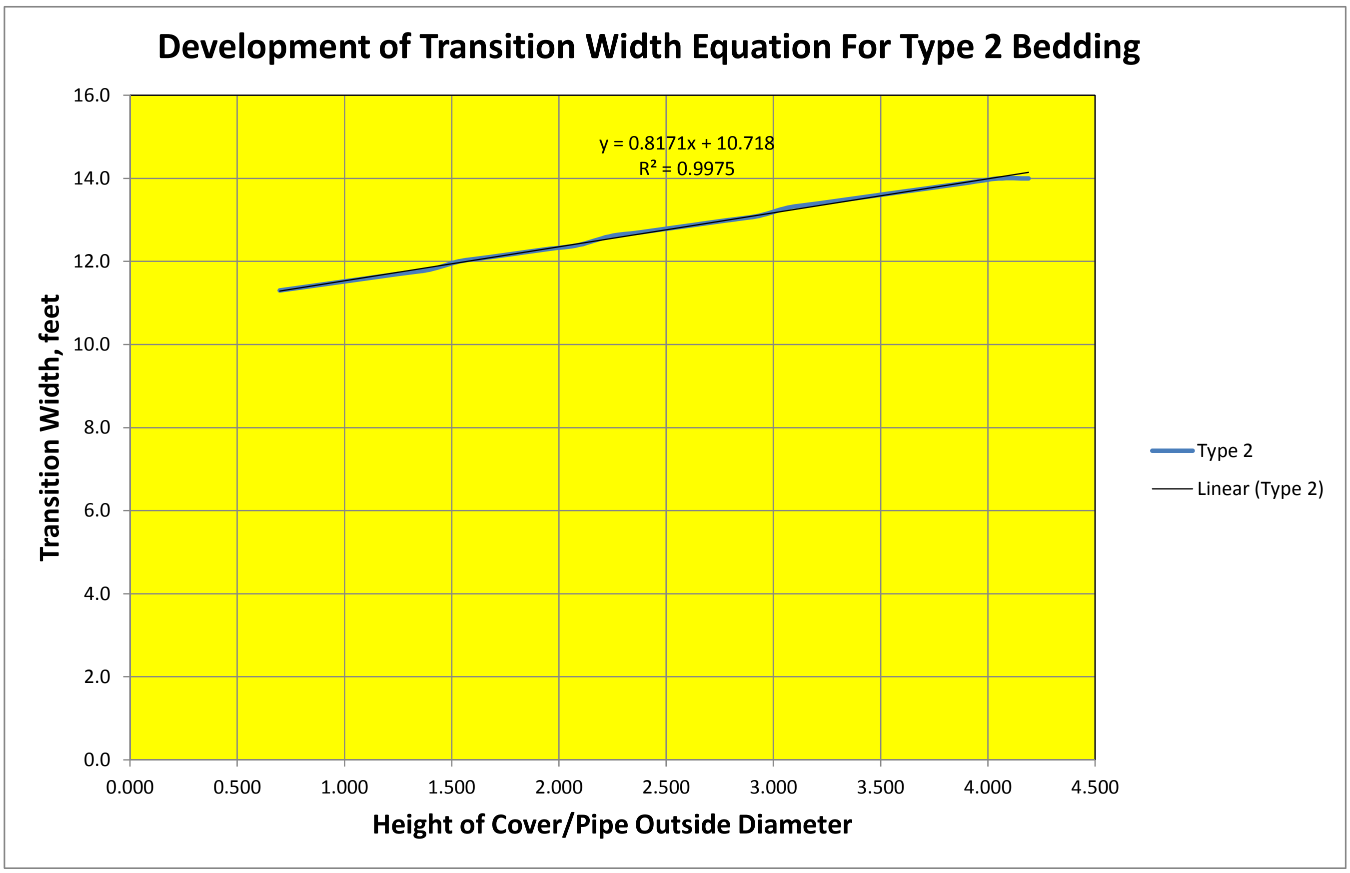
(based on values in Concrete Pipe Manual, Page 134 for Ku = 0.165 and 72-inch pipe)

Bc : 7.16 feet

Height of Cover (feet)	Type 1 Bedding Transition Width, (feet)	H/Bc	Type 2 Bedding Transition Width, (feet)
5	10.9	0.698	11.3
6	11	0.838	11.4
7	11.1	0.978	11.5
8	11.2	1.117	11.6
9	11.3	1.257	11.7
10	11.5	1.397	11.8
11	11.6	1.536	12.0
12	11.7	1.676	12.1
13	11.8	1.816	12.2
14	11.9	1.955	12.3
15	12.1	2.095	12.4
16	12.2	2.235	12.6
17	12.3	2.374	12.7
18	12.4	2.514	12.8
19	12.5	2.654	12.9
20	12.6	2.793	13.0
21	12.8	2.933	13.1
22	12.9	3.073	13.3
23	13	3.212	13.4
24	13.1	3.352	13.5
25	13.2	3.492	13.6
26	13.3	3.631	13.7
27	13.4	3.771	13.8
28	13.5	3.911	13.9
29	13.7	4.050	14.0
30	13.7	4.190	14.0



Development of Transition Width Equation For Type 1 Bedding
y = 0.8257x + 10.317
R² = 0.9984
Transition Width, feet
16
14
12
10
8
6
4
2
0
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
Height of Cover/Pipe Outside Diameter
Type 1
Linear (Type 1)



Development of Transition Width Equation For Type 2 Bedding
y = 0.8171x + 10.718
R² = 0.9975
Transition Width, feet
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
Height of Cover/Pipe Outside Diameter
Type 2
Linear (Type 2)

APPENDIX D

CONTROL STRUCTURE CALCULATIONS

HDR

Project: SWWD		Computed: E.T.	Date: 01/20/2012
Subject: Drainage structure 1004		Checked:	Date:
Task: Analysis and calculations		Page:	of:
Job #: 161580		No:	

1. Basic Data

① soil weight $W_s = (22\times26-19\times23)(910.7-894+0.75)\times0.115 = (135\times17.45)\times0.115$
$= 270.91$ kips

② Concrete-slab $W_{cs} = 22\times26\times1.25\times0.15 = 107.25$ kips

③ concrete - plain concrete $W_{cp} = 17(21-1.5)\times0.75\times0.15 = 37.29$ kips

④ concrete - walls $W_{wall} = (17\times1\times3+23\times1\times2)\times16.45\times0.15 = 239.34$ kips

⑤ concrete - cover $W_{cover} = 19\times21\times1\times0.15 = 59.85$ kips

Holes in the walls are neglected.

⑥ Water-full

$W_{water} = (19\times23-17\times1\times3-23\times1\times2)\times16.45\times0.0624 = 349$ kips

⑦ suppose the live load is $LL = 250psf = 0.25$ ksf

2. Bearing pressure check

$$p = \frac{W_s+W_{cs}+W_{wall}+W_{cover}+W_{cover}+W_{water}}{22\times26}+0.25$$

$$= \frac{270.91+107.25+37.29+239.34+59.85+349}{22\times26}+0.25$$

$= 1.86+0.25$

$= 2.11\ ksf < P_{allowable} = 3ksf$

O.K.

3. Buoyancy check

Although no groundwater was found at the time of boring, we still assume a groundwater level which is 5ft below the ground surface. Then

$$F_B = [(17.45-5)\times 19\times 23 + 22\times 26\times 1.25]\times 0.0624$$
$$= 384.11 \text{ kips}$$

$$W = W_{cs} + W_{wall} + W_{cover} + 270.91\times\frac{0.115-0.0624}{0.115} + W_{cp}$$
$$= 107.25 + 37.29 + 239.34 + 59.85 + 270.91\times\frac{0.115-0.0624}{0.115}$$
$$= 443.73 + 123.9$$
$$= 567.64$$

$$K_B = \frac{W}{F_B} = 567.64/384.11 = 1.48 > 1.25 \quad \text{O.K.}$$

4. Concrete reinforcement Design.

$P_{soil\_overburden} = -17.4167 \times 0.115 = -2 ksf$

$P_{LL} = 0.25 ksf$

$P_{react\_weight} = \frac{107.25 + 37.29 + 239.34 + 59.85 + 270.91}{22 \times 26} = 1.249 ksf$

$P_{react\_LL} = 0.25 ksf$

① Bottom slab design.

Loads: soil bearing pressure, soil bearing pressure due to Live load, Self weight

② Cover:

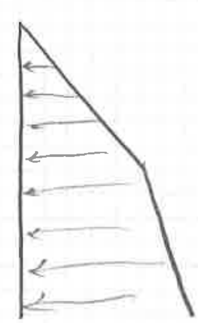
Self weight & Live load

③ Lateral soil pressure on outside walls

$P_{LL-lateral} = K_0 P_{LL} = (1 - \sin 31°) \times 0.25 = 0.485 \times 0.25$
$= 0.12125 ksf$

$P_{soil\_lateral} = K_0 \gamma h = 0.485 \times 0.115 \times h = 0.055775 h$ (h<5)

$P_{soil\_lateral} = K_0 \times 5 \times 0.115) + K_0 \times 0.0624 (h-5)$
$= K_0 [0.575 - 0.312 + h \times 0.0624]$
$= 0.127555 + 0.030264 h$ (h≥5ft)



HDR

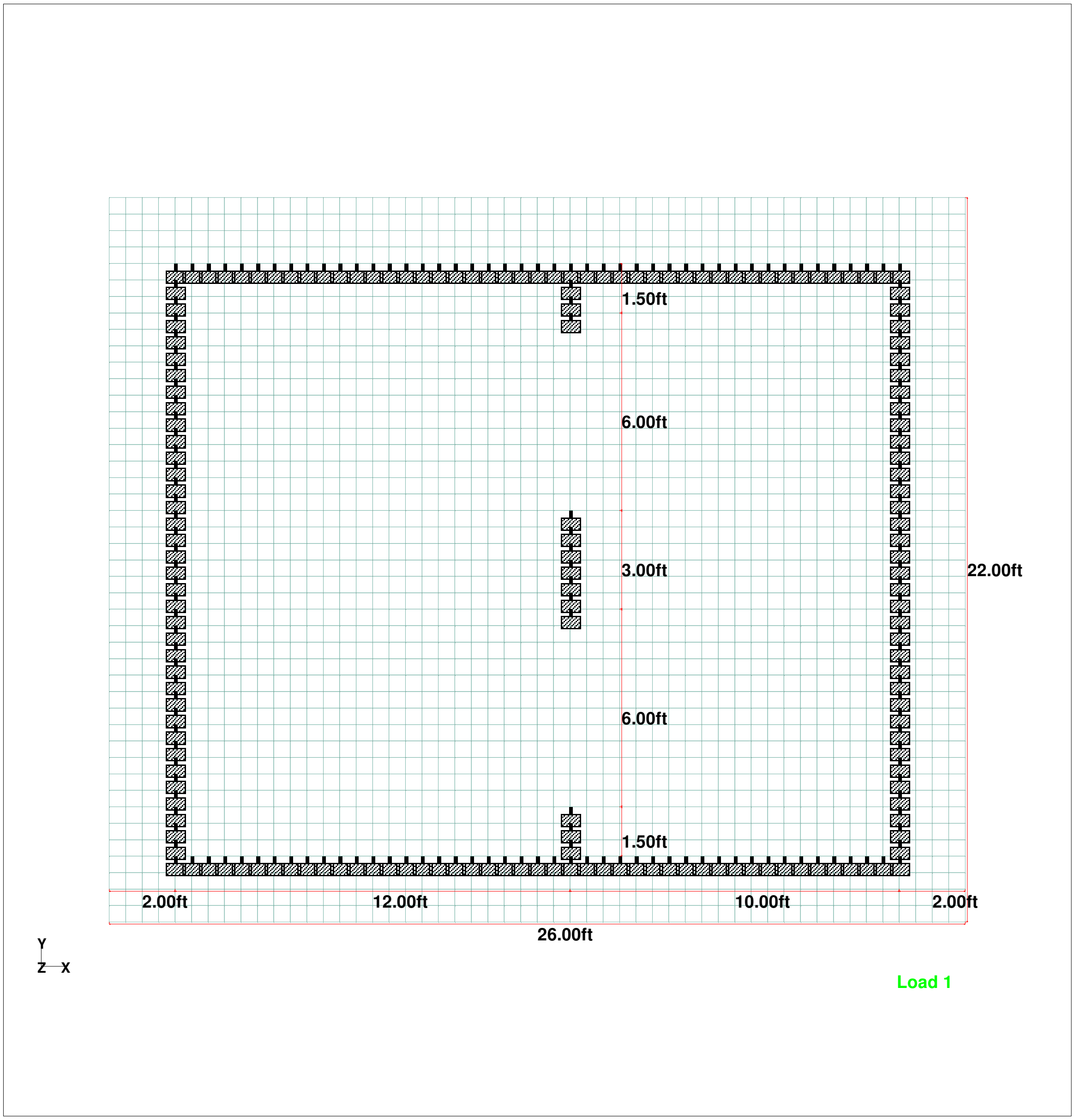
Project:	Computed:	Date:
Subject:	Checked:	Date:
Task:	Page:	of: 4
Job #:	No:	

$$P_{water\_lateral} = \gamma_{water}(h-5)$$
$$= 0.0624h - 5\times 0.0624$$
$$= 0.0624h - 0.312 \qquad (h \geq 5ft)$$

2. Models and results

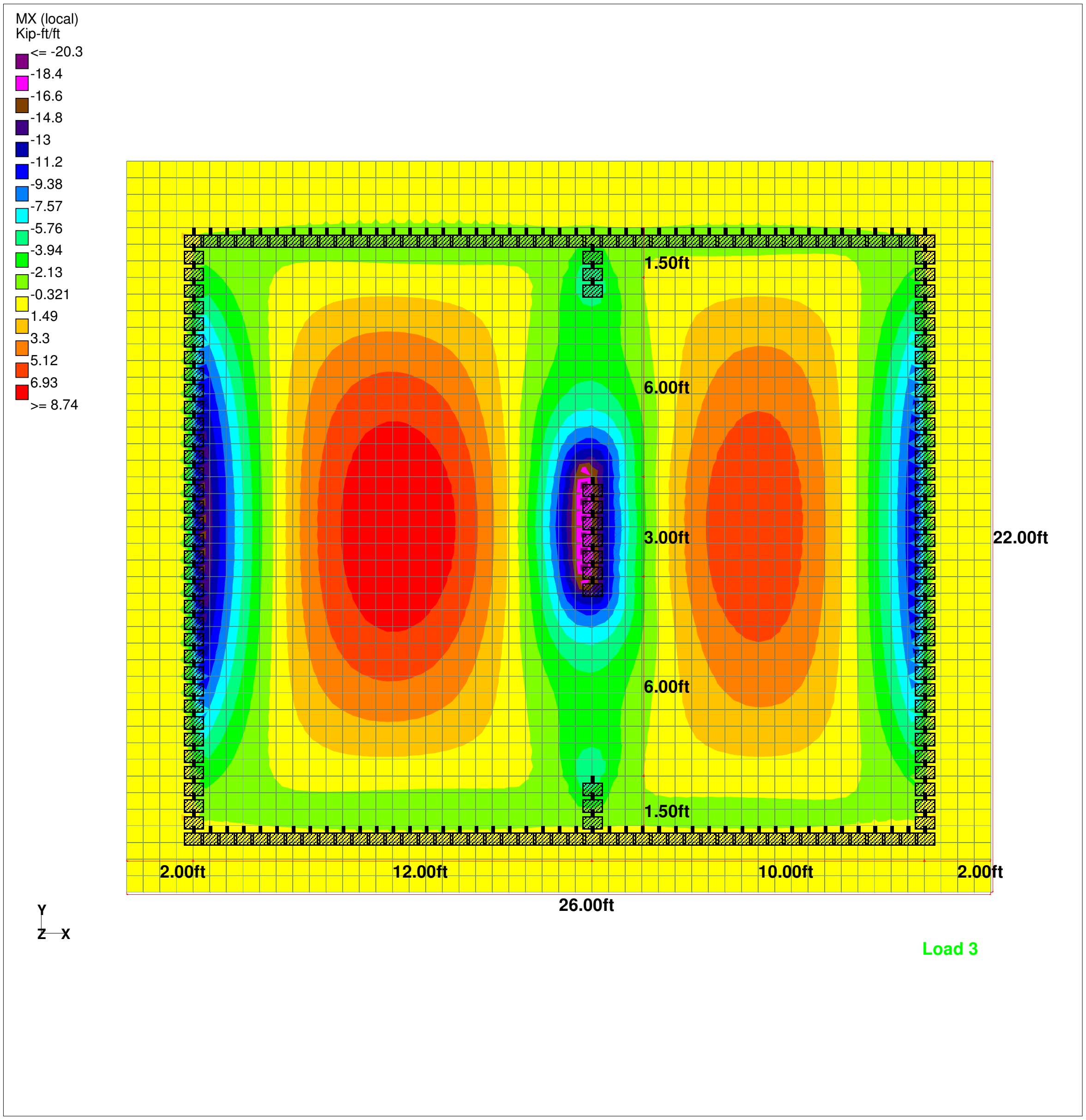
The staad model and results are shown in the following pages.

Software licensed to HDR	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 1_Slab.std	Date/Time 21-Jan-2013 15:08	

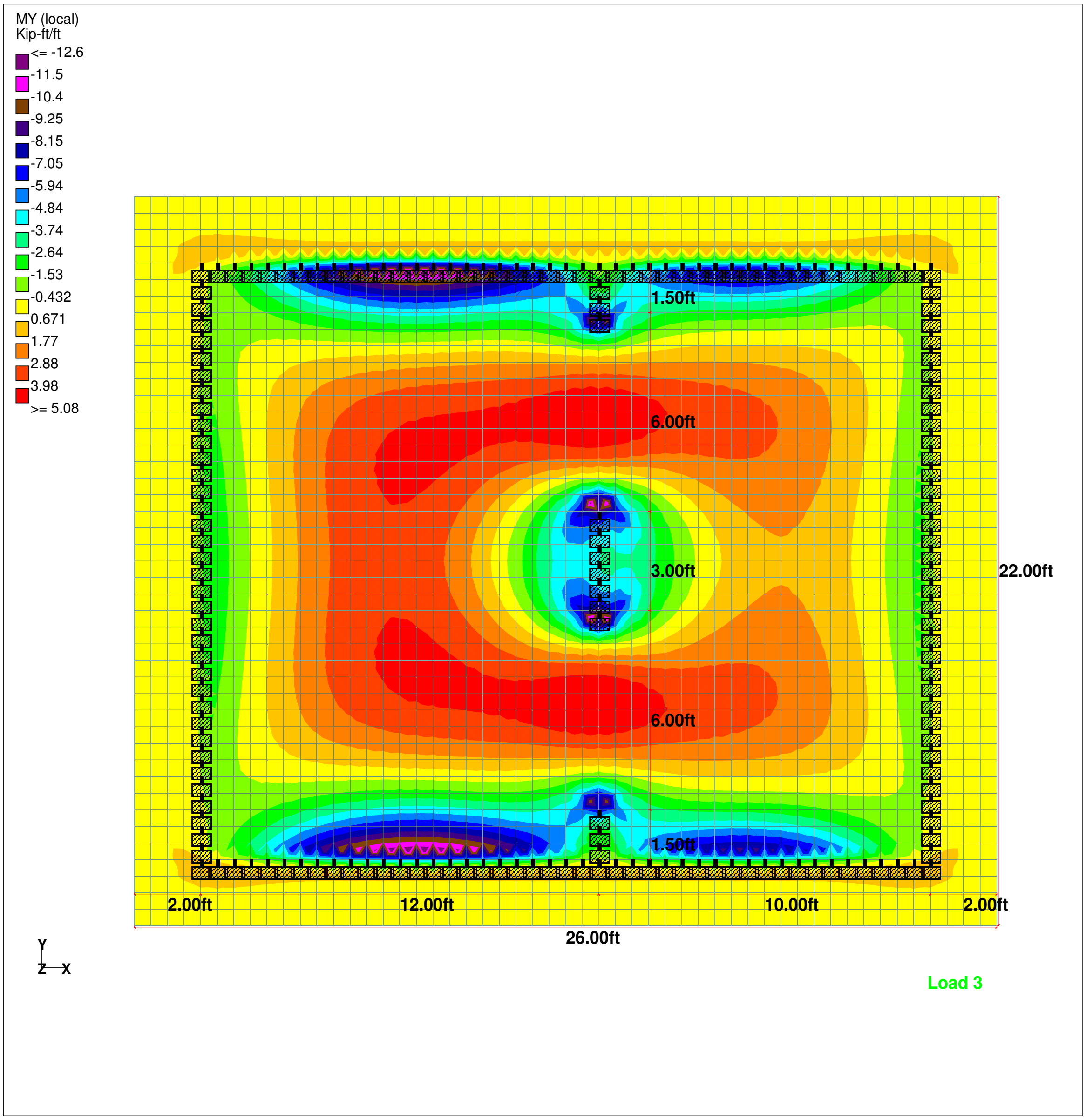


Bottom Slab (1.25ft thick)

Software licensed to HDR	Job No	Sheet No 2	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 1_Slab.std	Date/Time 21-Jan-2013 15:08	

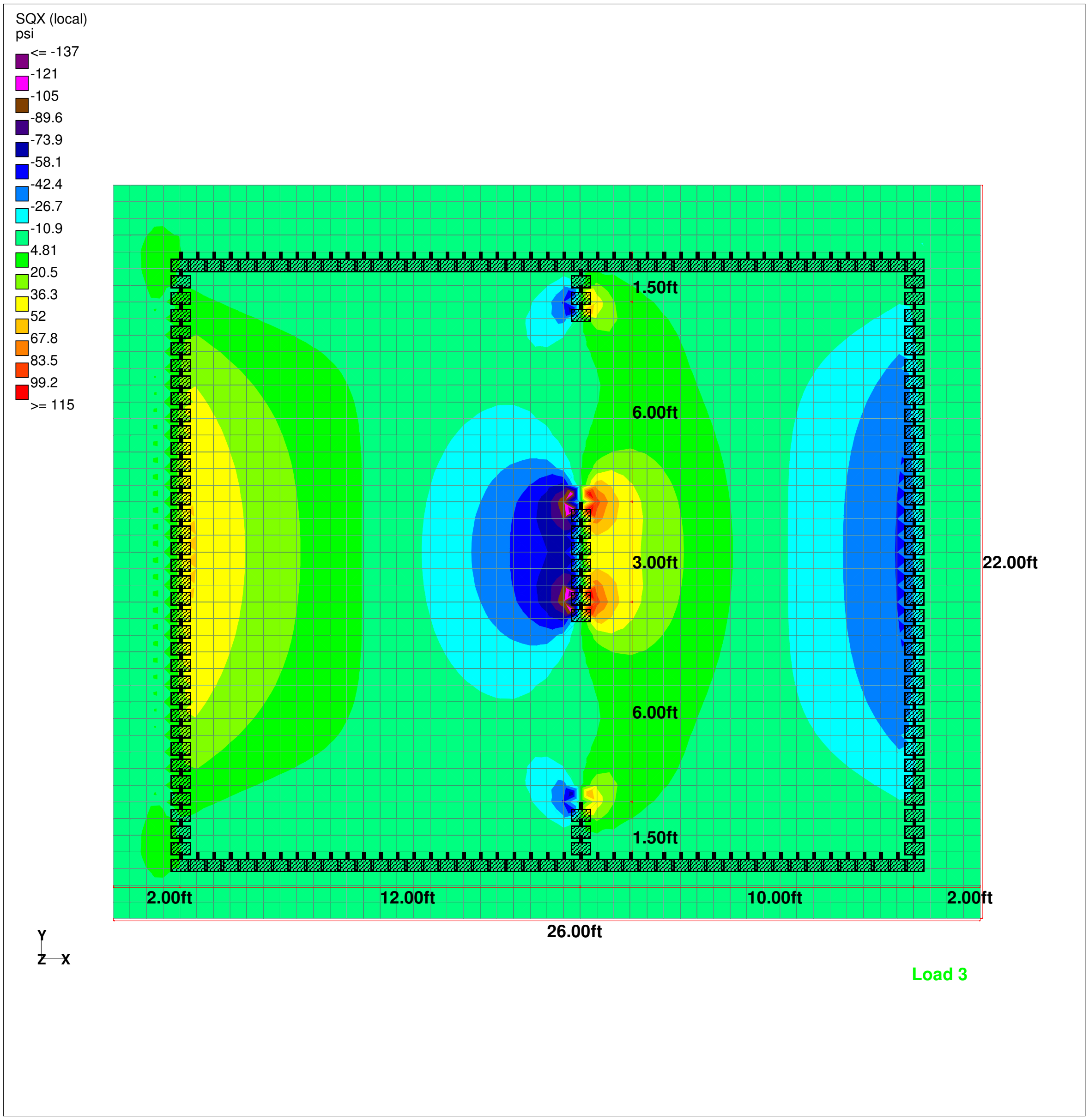


Local Mx Distribution in the Bottom Slab

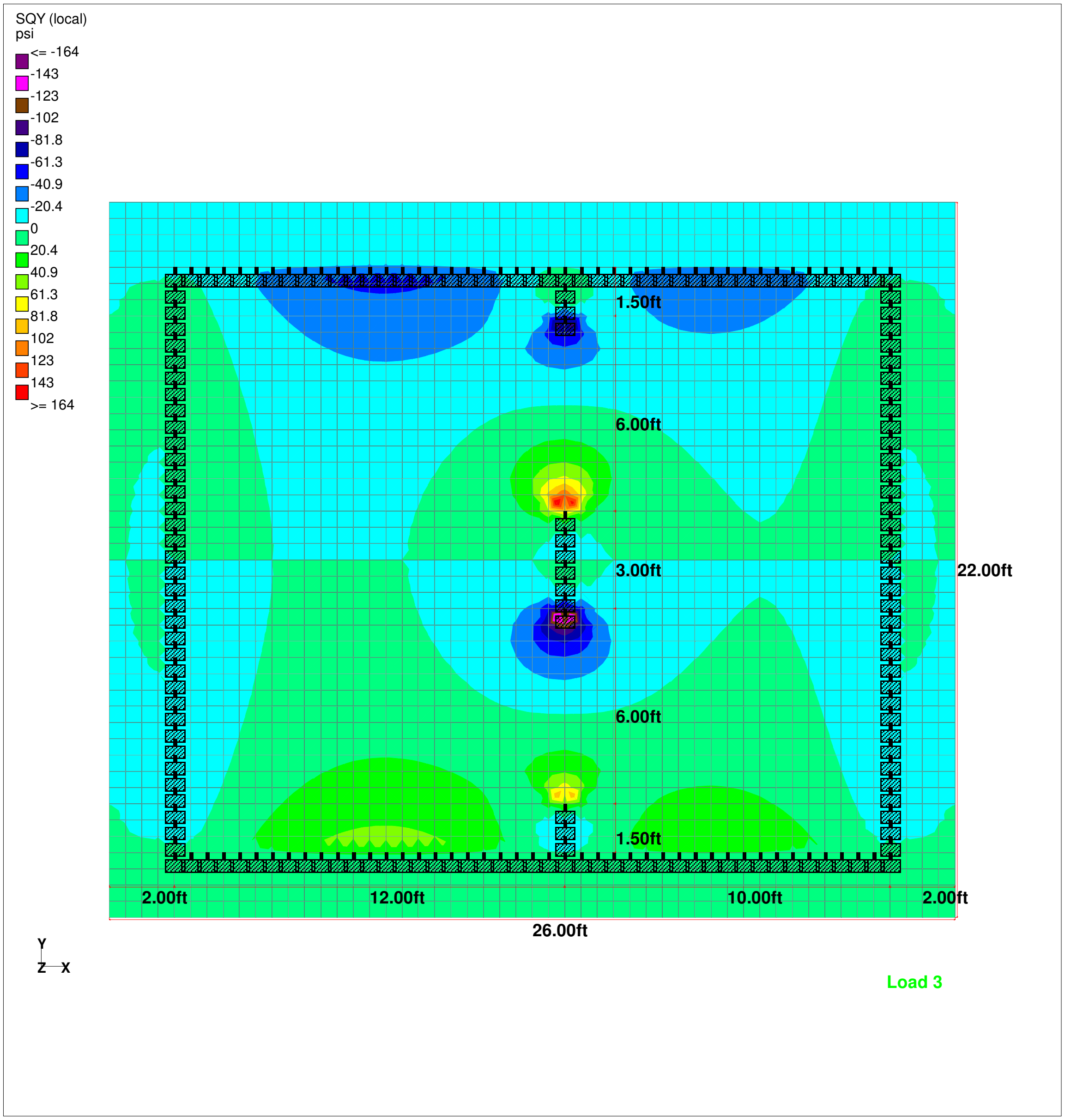


Local My Distribution in the Bottom Slab

Software licensed to HDR	Job No	Sheet No 4	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 1_Slab.std	Date/Time 21-Jan-2013 15:08	

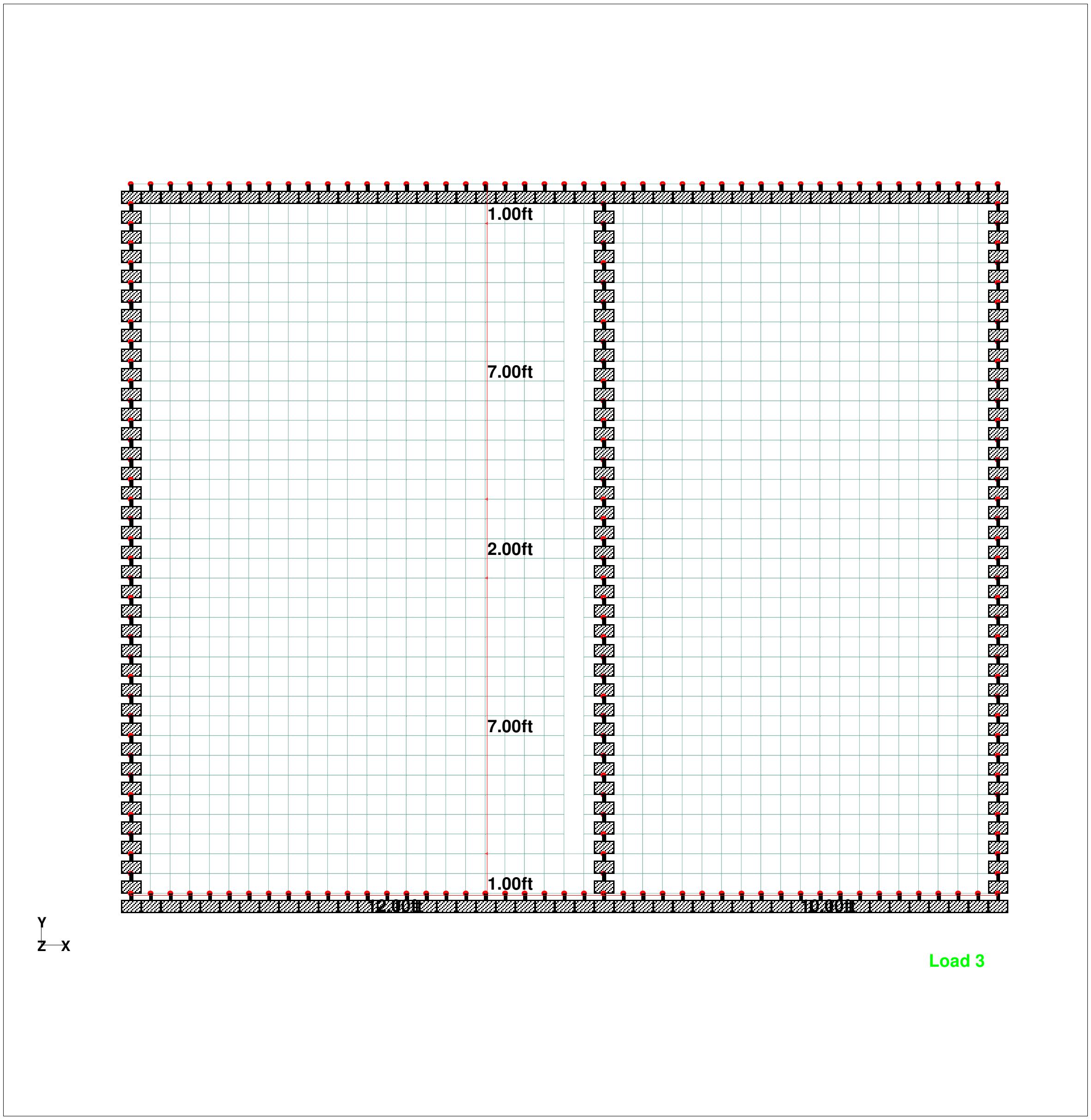


Local SQX Distribution in the Bottom Slab



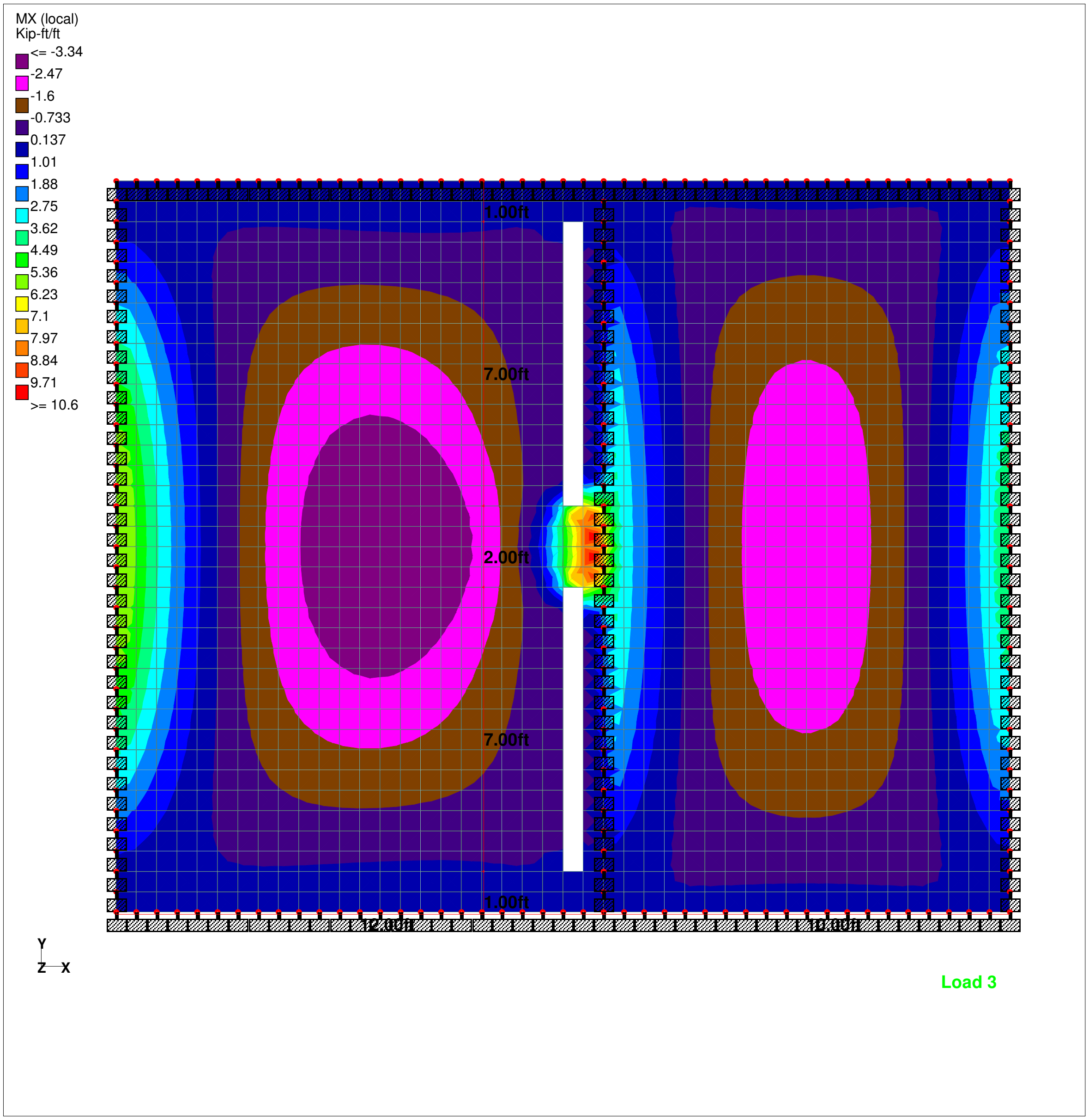
Local SQY Distribution in the Bottom Slab

Software licensed to HDR	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 2_Cover.std	Date/Time 21-Jan-2013 15:19	

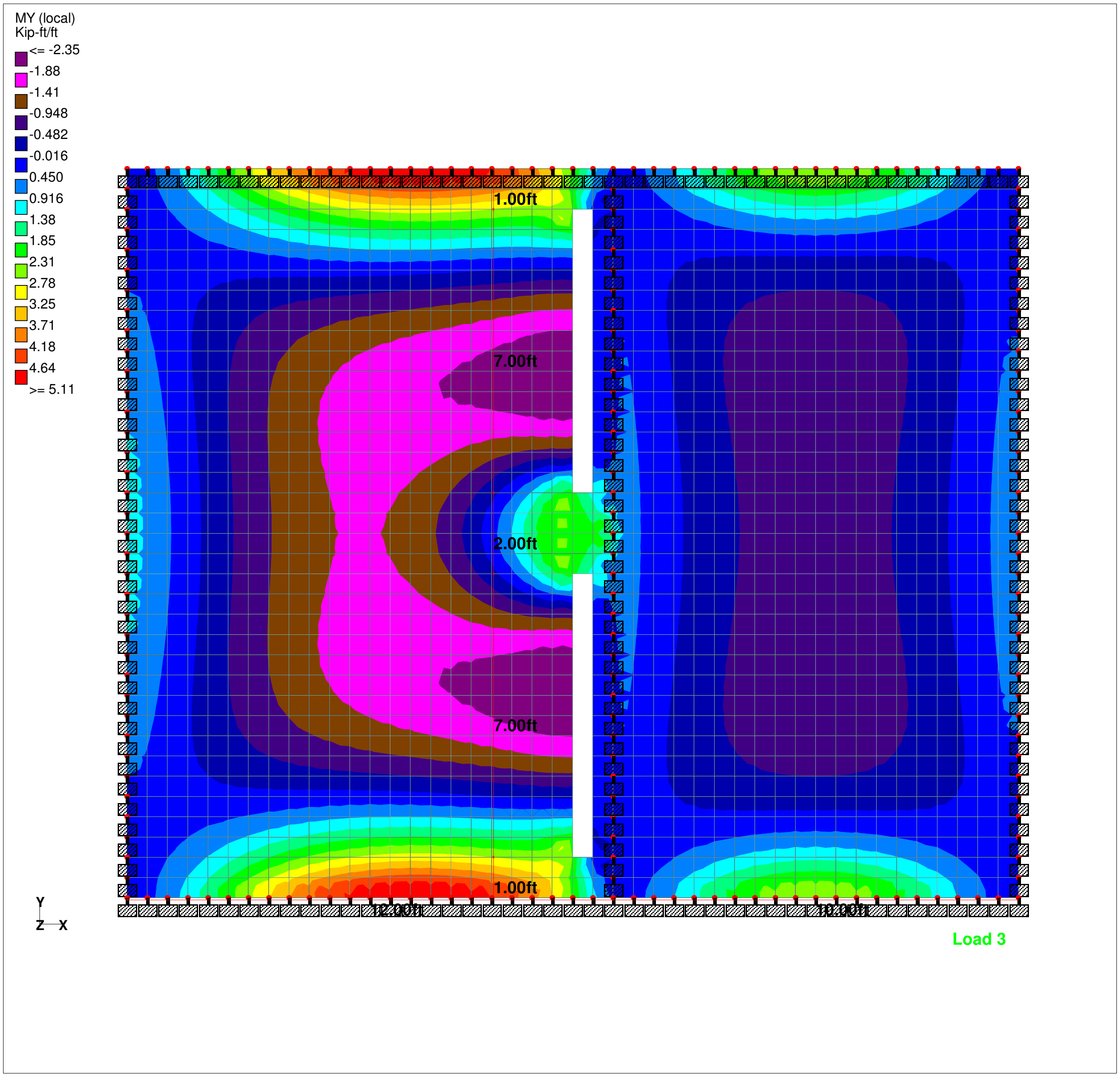


Top Slab Layout

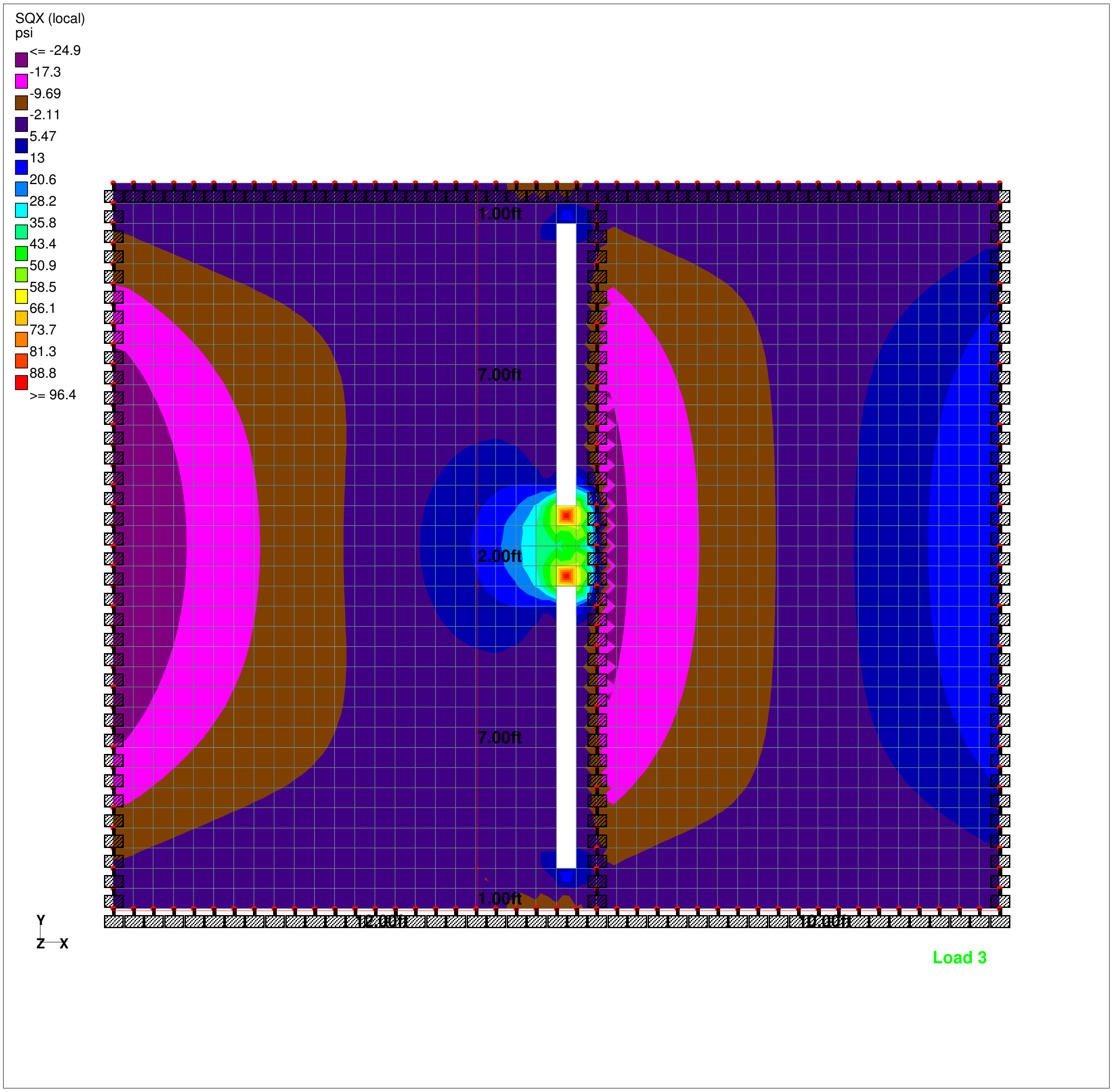
Software licensed to HDR	Job No	Sheet No 2	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 2_Cover.std	Date/Time 21-Jan-2013 15:19	



Local Mx Distribution (Top Slab)

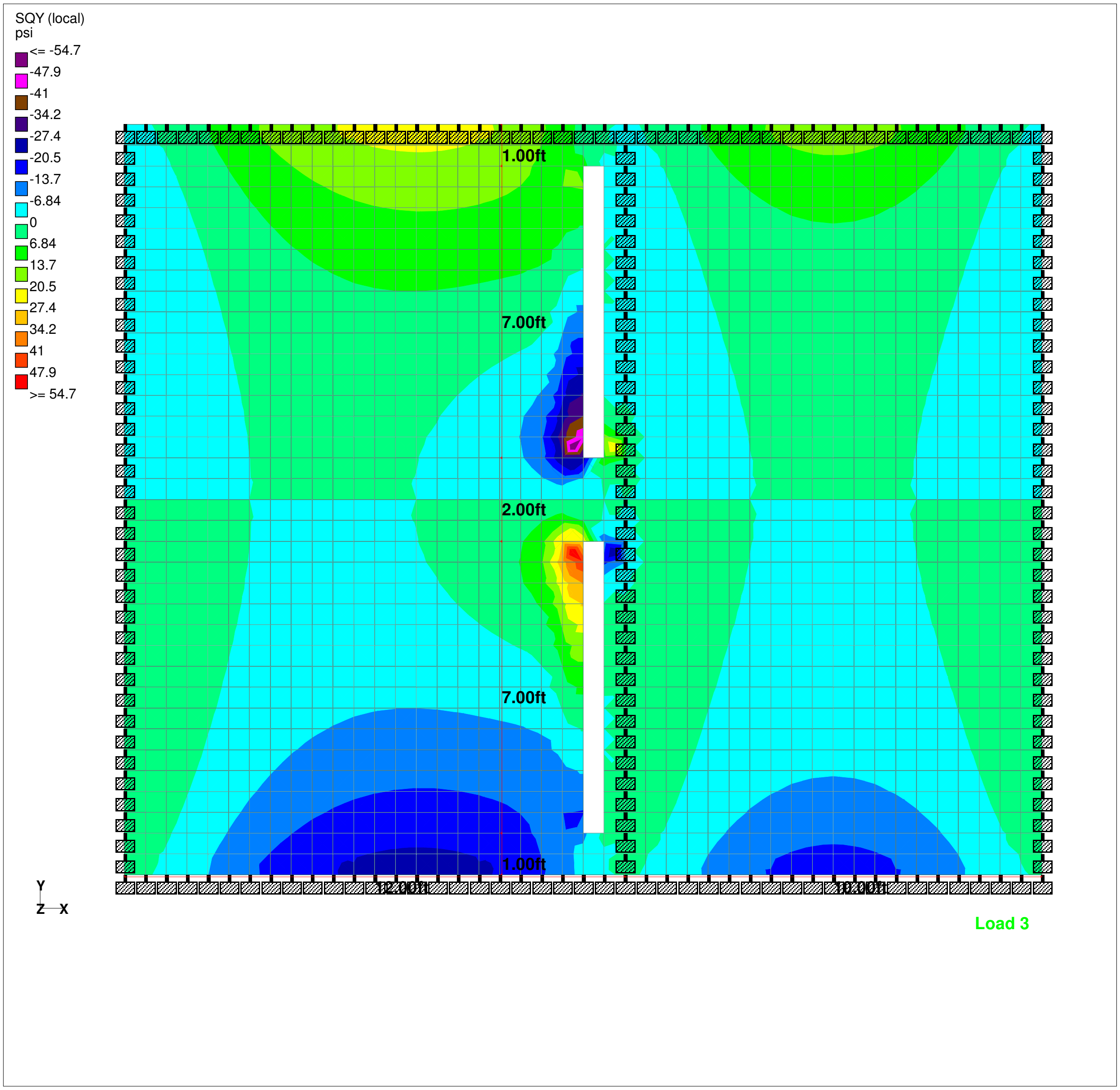


Local My Distribution (Top Slab)



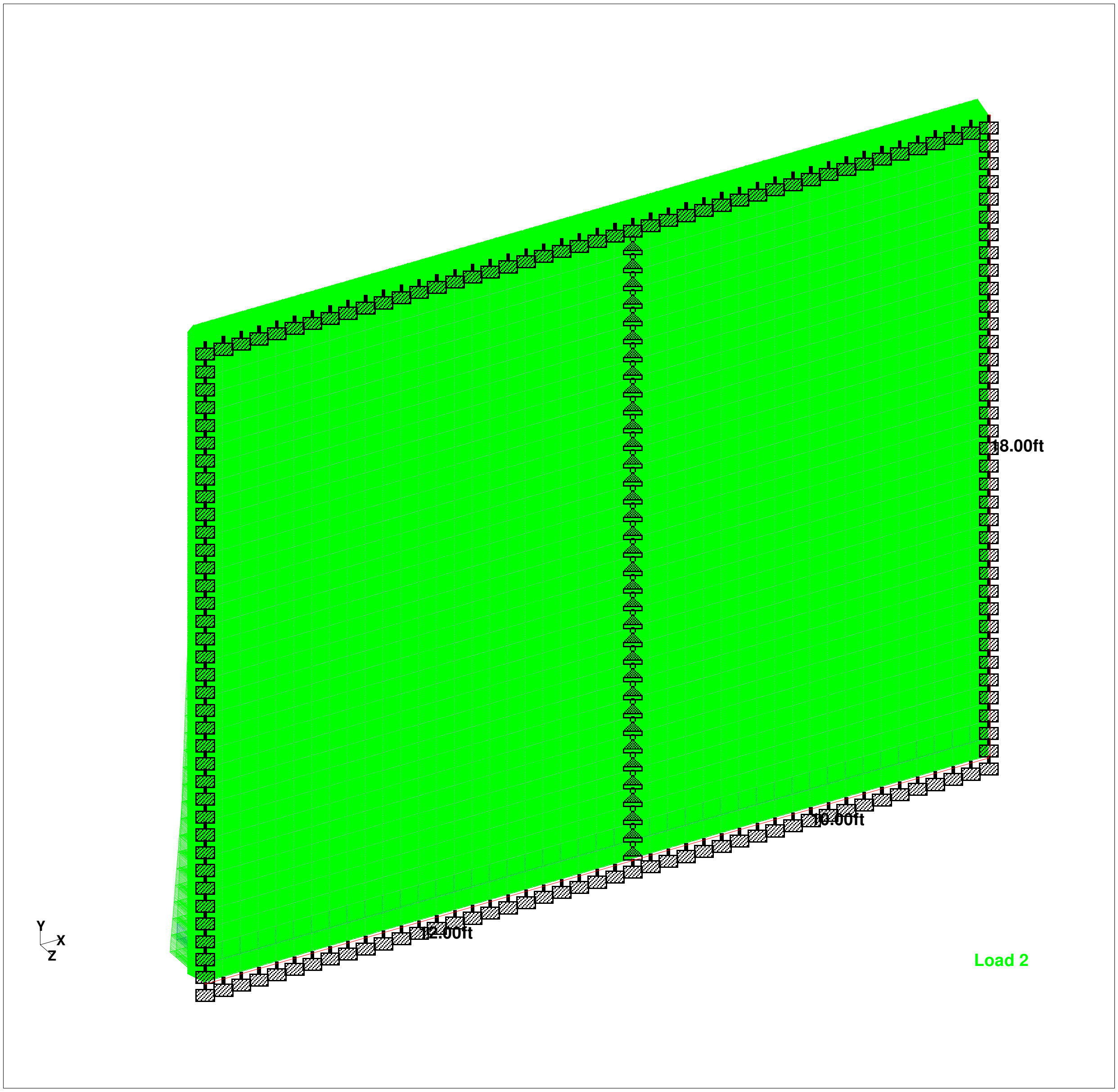
Local SQX Distribution (Top Slab)

Software licensed to HDR	Job No	Sheet No 5	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File 2_Cover.std	Date/Time 21-Jan-2013 15:19	

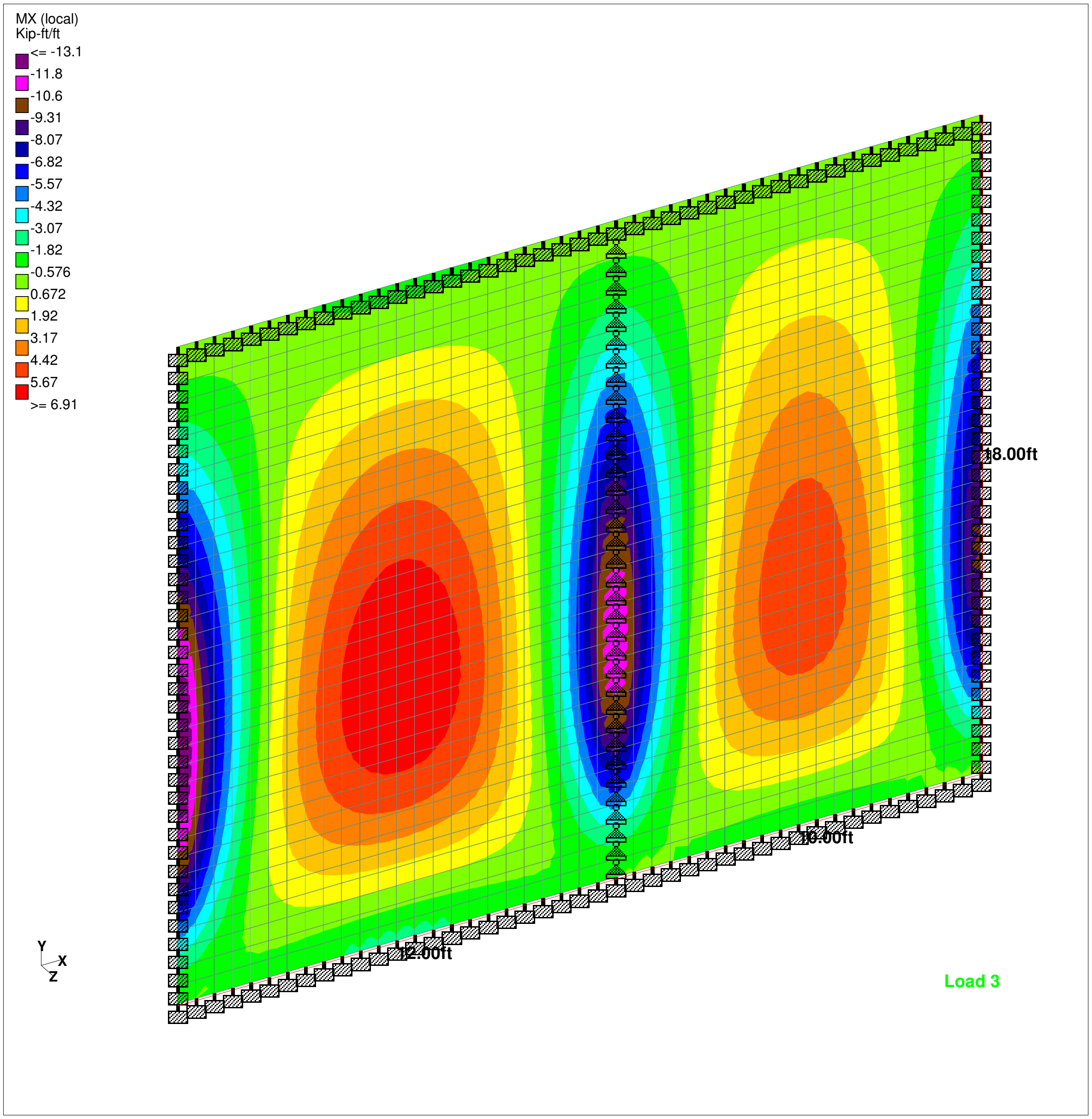


Local SQY Distribution (Top Slab)

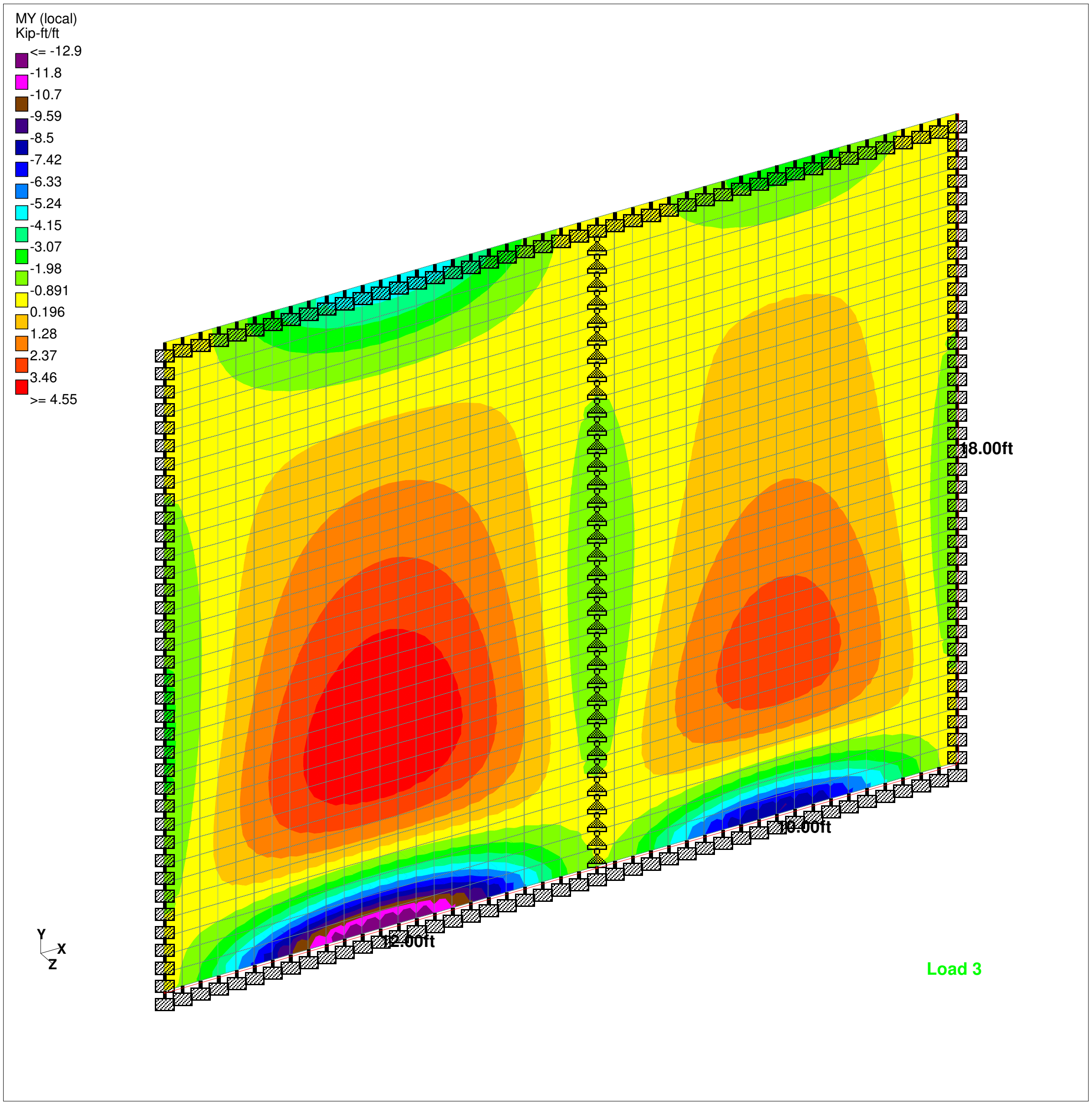
Software licensed to HDR	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_in_YZ.std	Date/Time 21-Jan-2013 15:41	



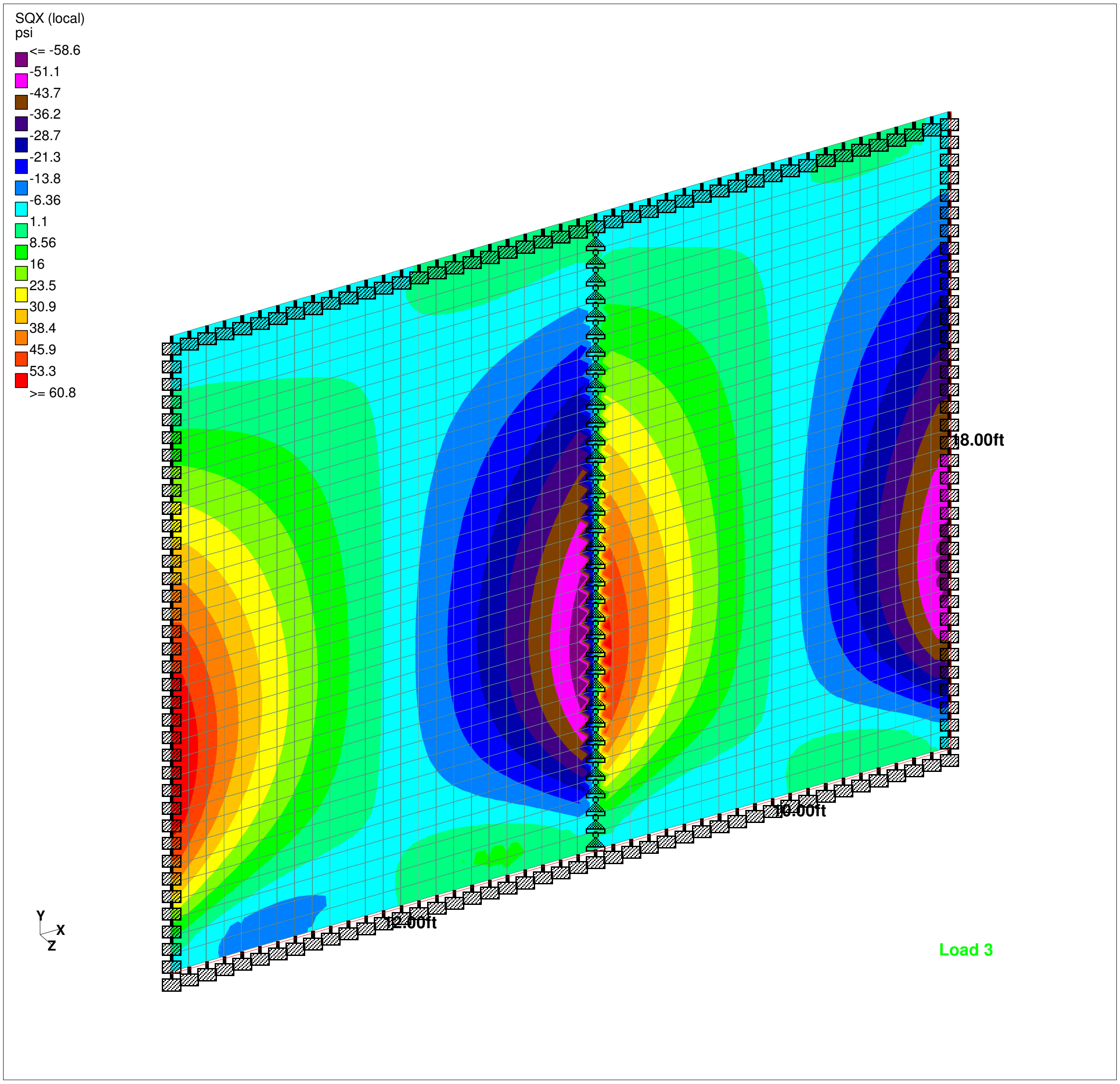
Lateral Loads on the Wall in the Longitudinal Direction



Local Mx Distribution in Wall (in Longitudinal Direction)

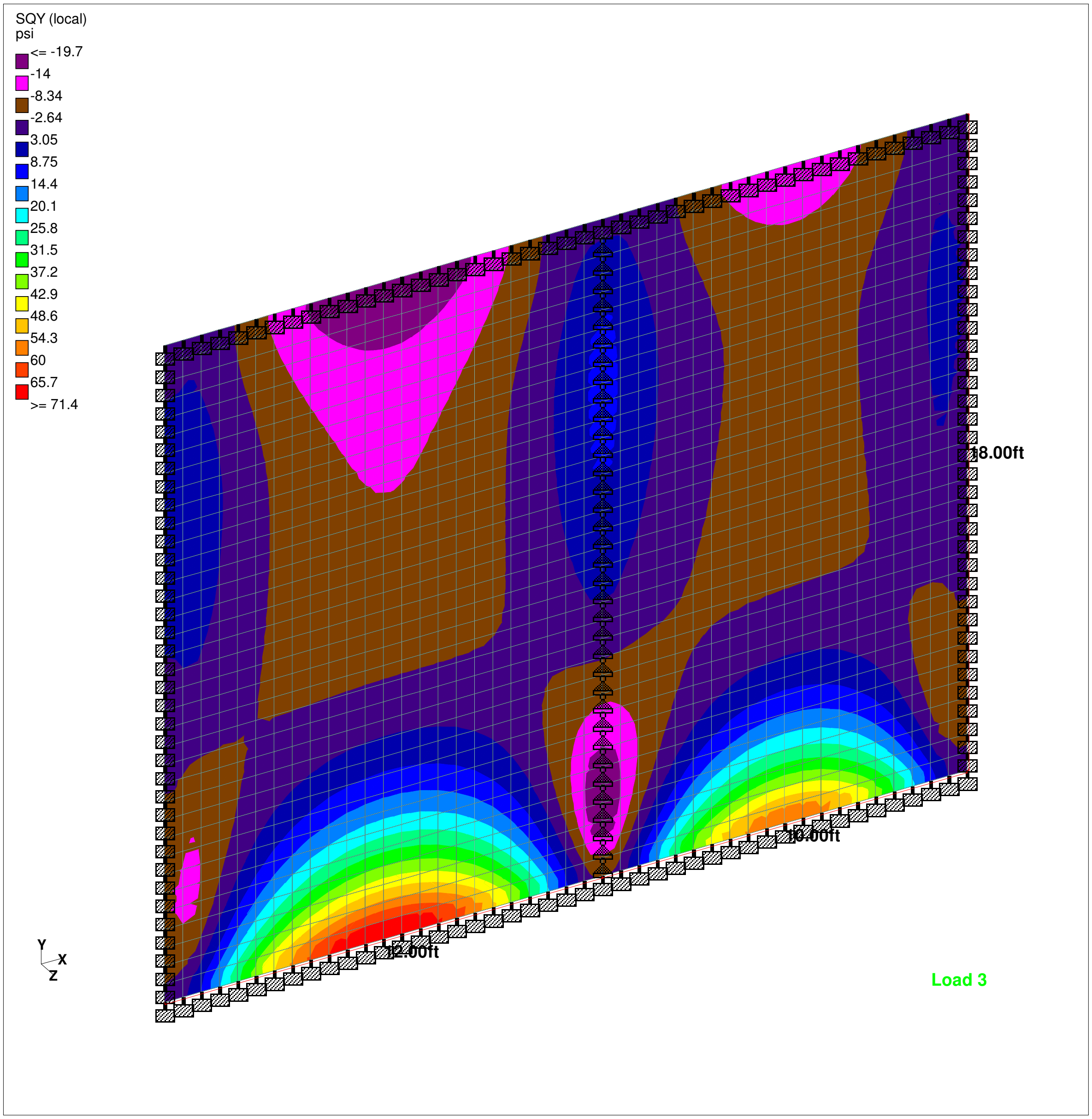


Local My Distribution in Wall (in Longitudinal Direction)



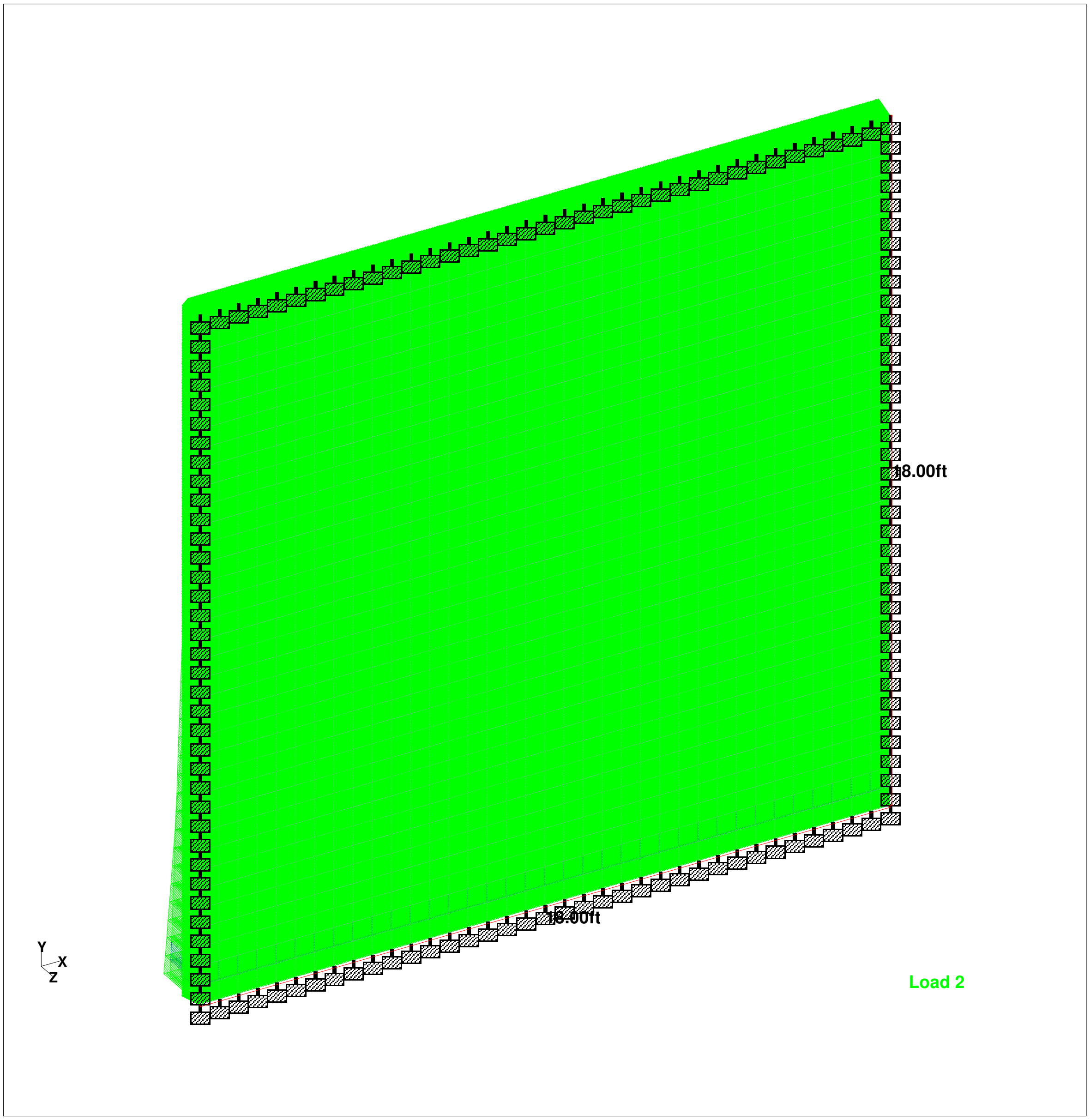
Local SQX Distribution in Wall (in Longitudinal Direction)

Software licensed to HDR	Job No	Sheet No 5	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_in_YZ.std	Date/Time 21-Jan-2013 15:41	

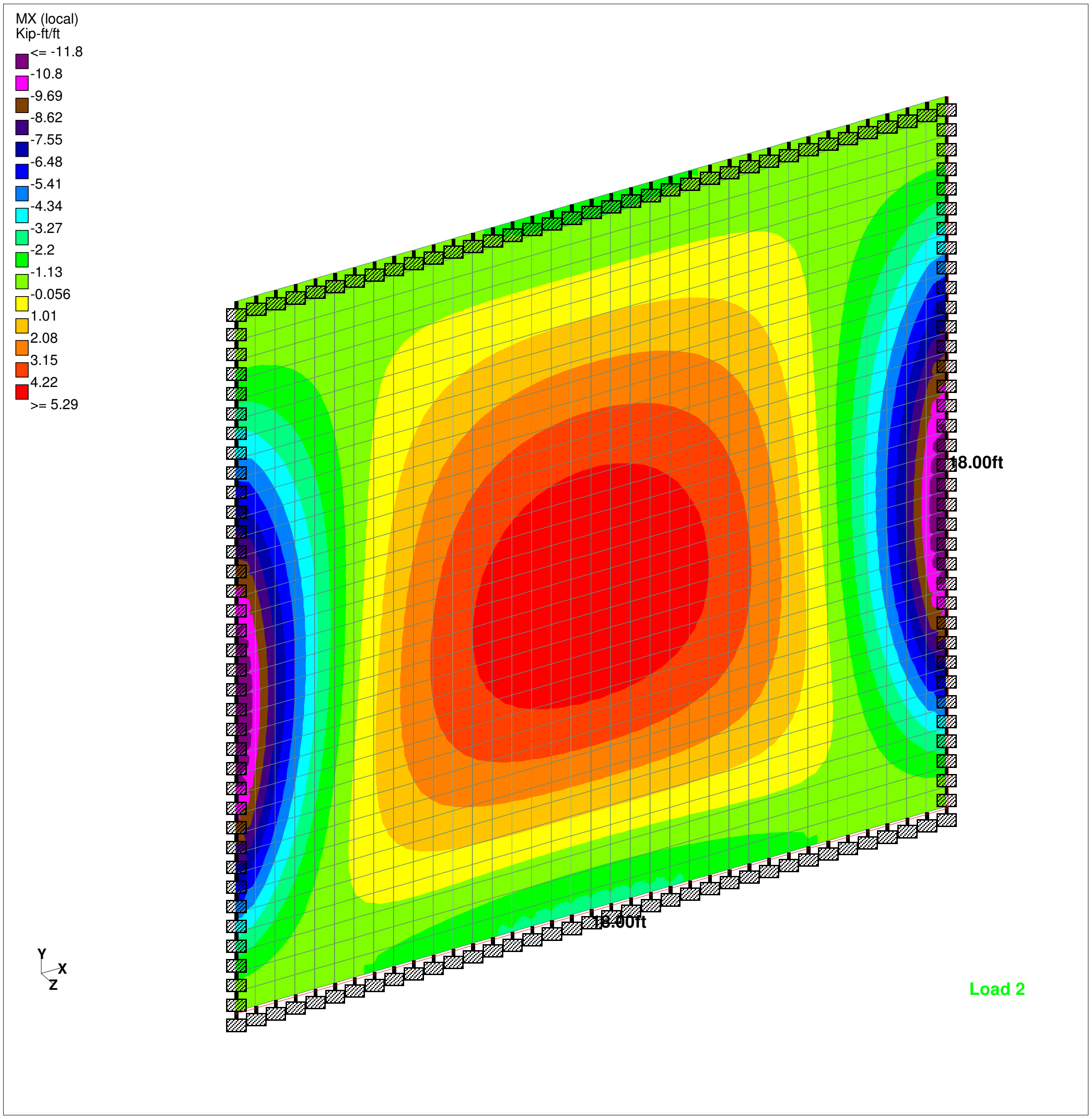


Local SQY Distribution in Wall (in Longitudinal Direction)

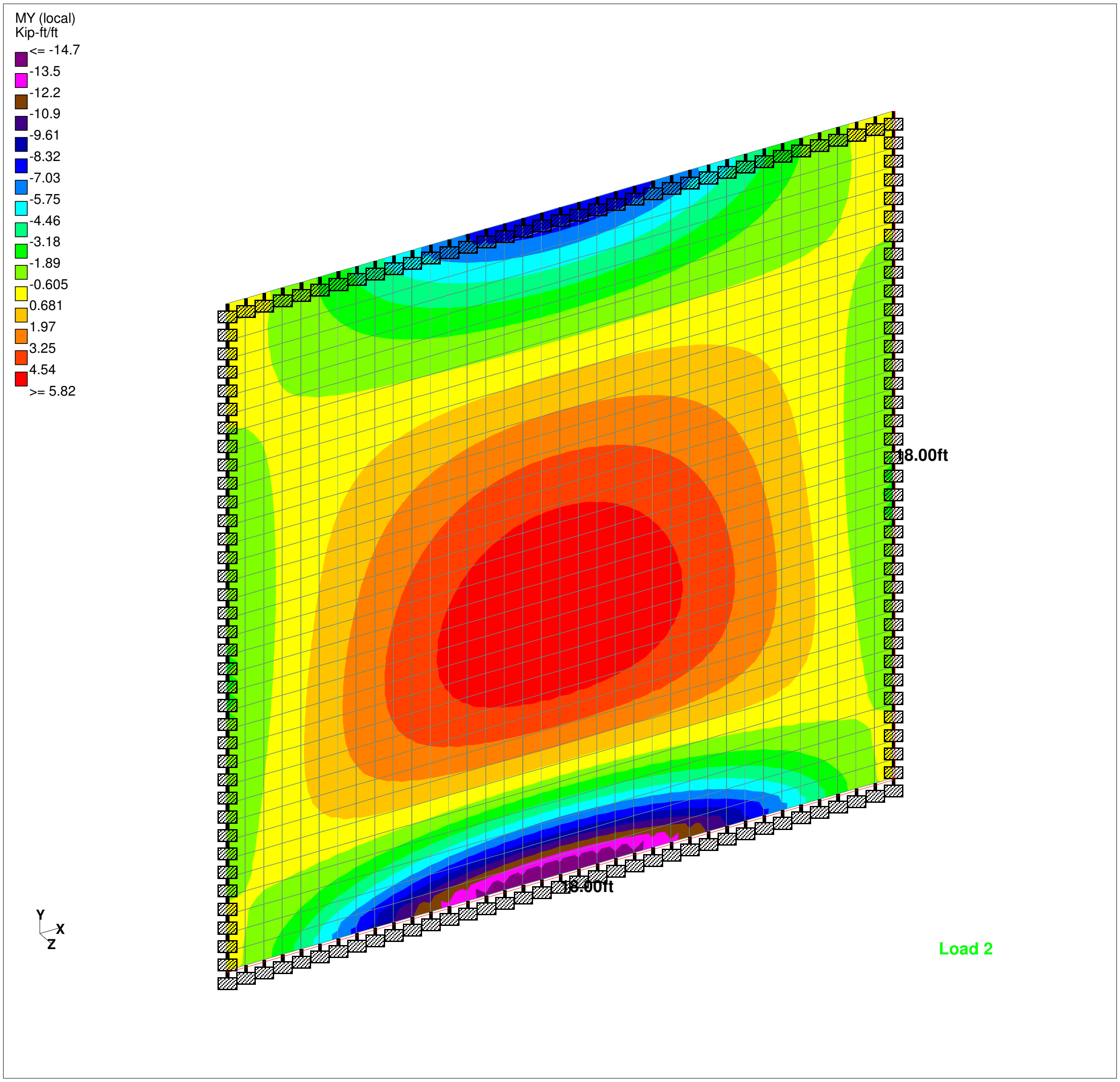
Software licensed to HDR	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_in_YX.std	Date/Time 06-Dec-2012 12:14	



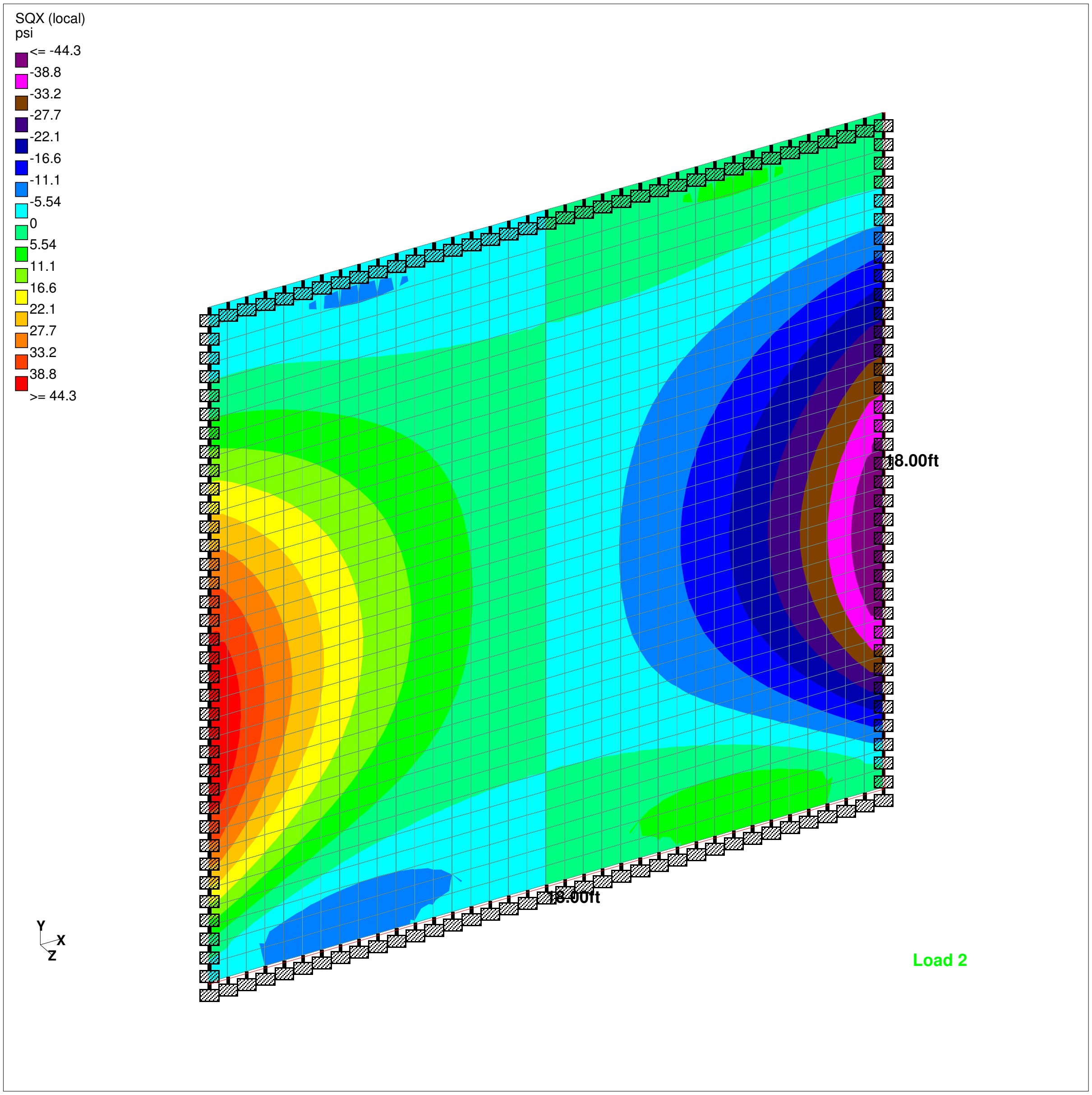
Wall Layout (in Transverse Direction)



Local Mx Distribution in Wall (in Transverse Direction)

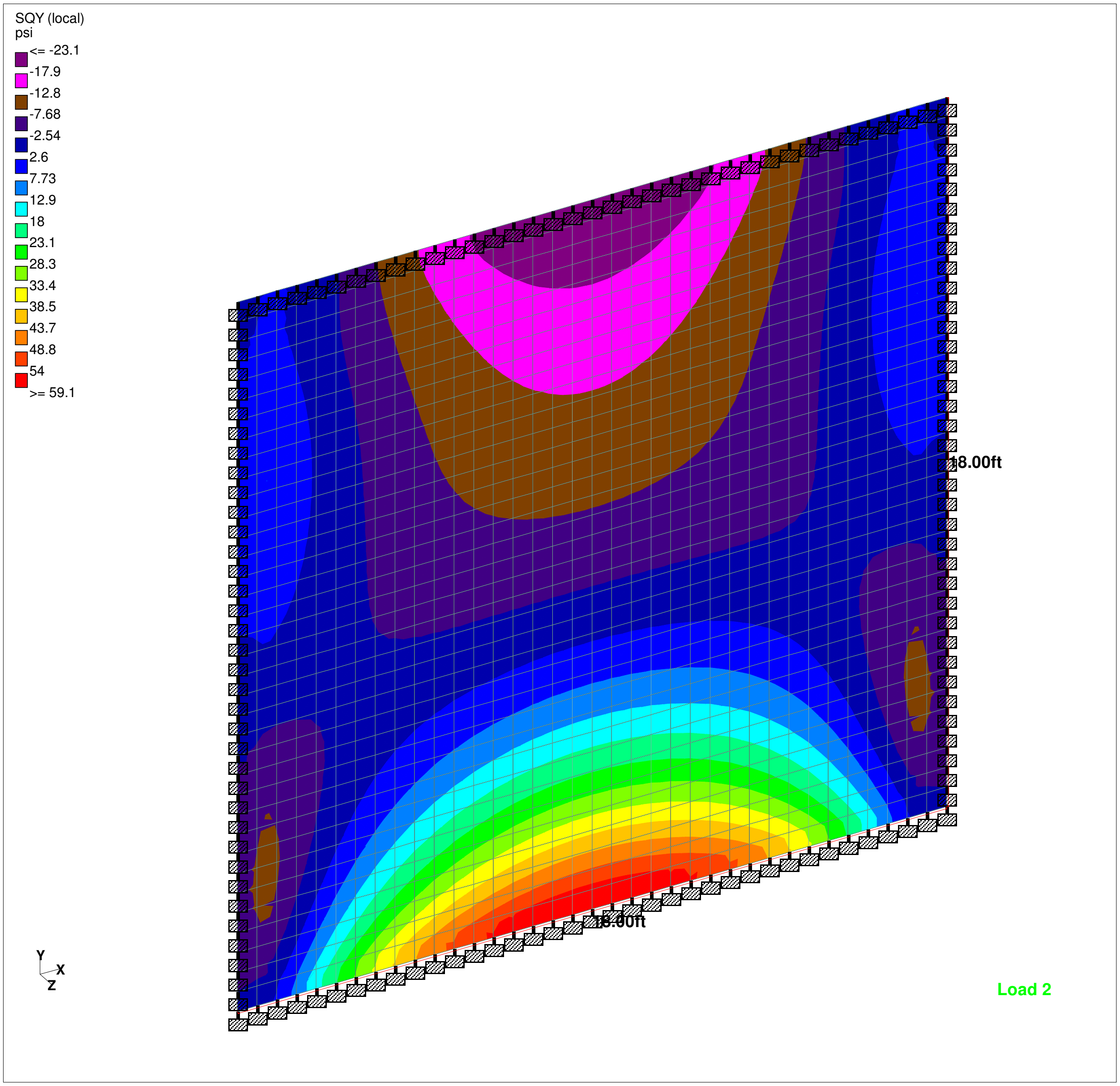


Local My Distribution in Wall (in Transverse Direction)



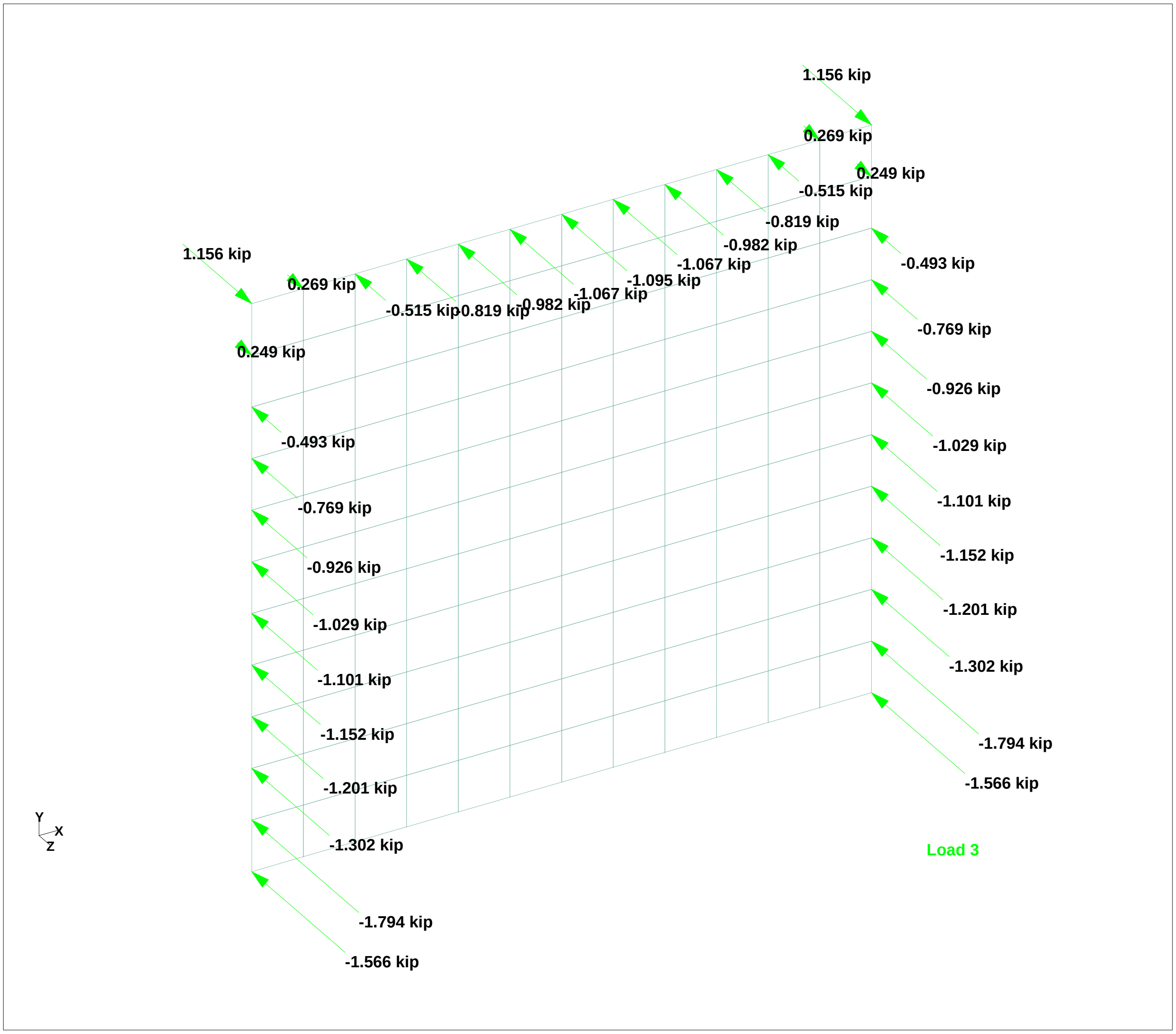
Local SQX Distribution in Wall (in Transverse Direction)

Software licensed to HDR	Job No	Sheet No 5	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_in_YX.std	Date/Time 06-Dec-2012 12:14	



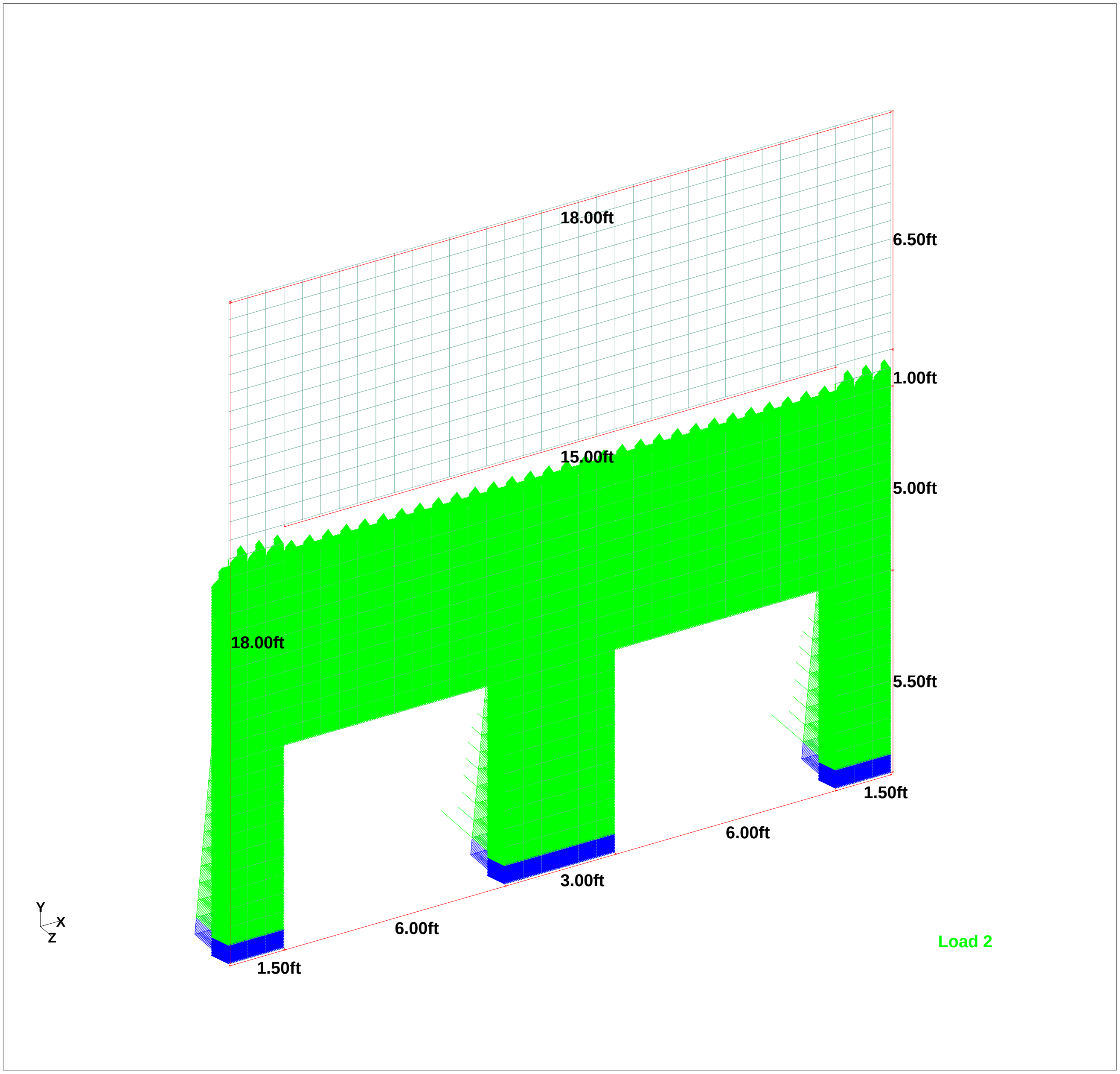
Local SQY Distribution in Wall (in Transverse Direction)

Software licensed to HDR	Job No	Sheet No **1**	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Gate Load.std	Date/Time 24-May-2013 11:35	



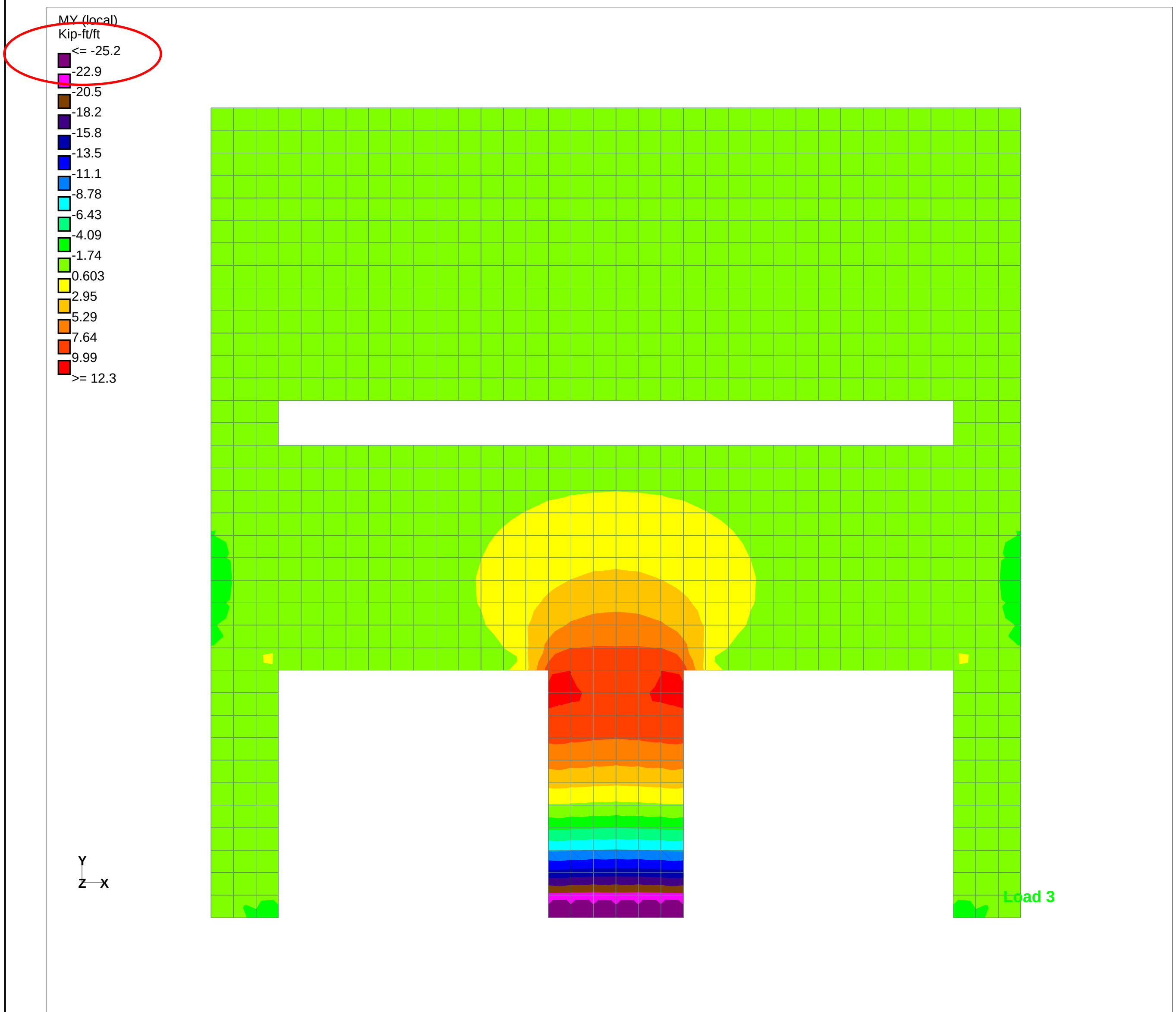
Force from Gate

Software licensed to HDR	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_inside.std	Date/Time 24-May-2013 11:51	



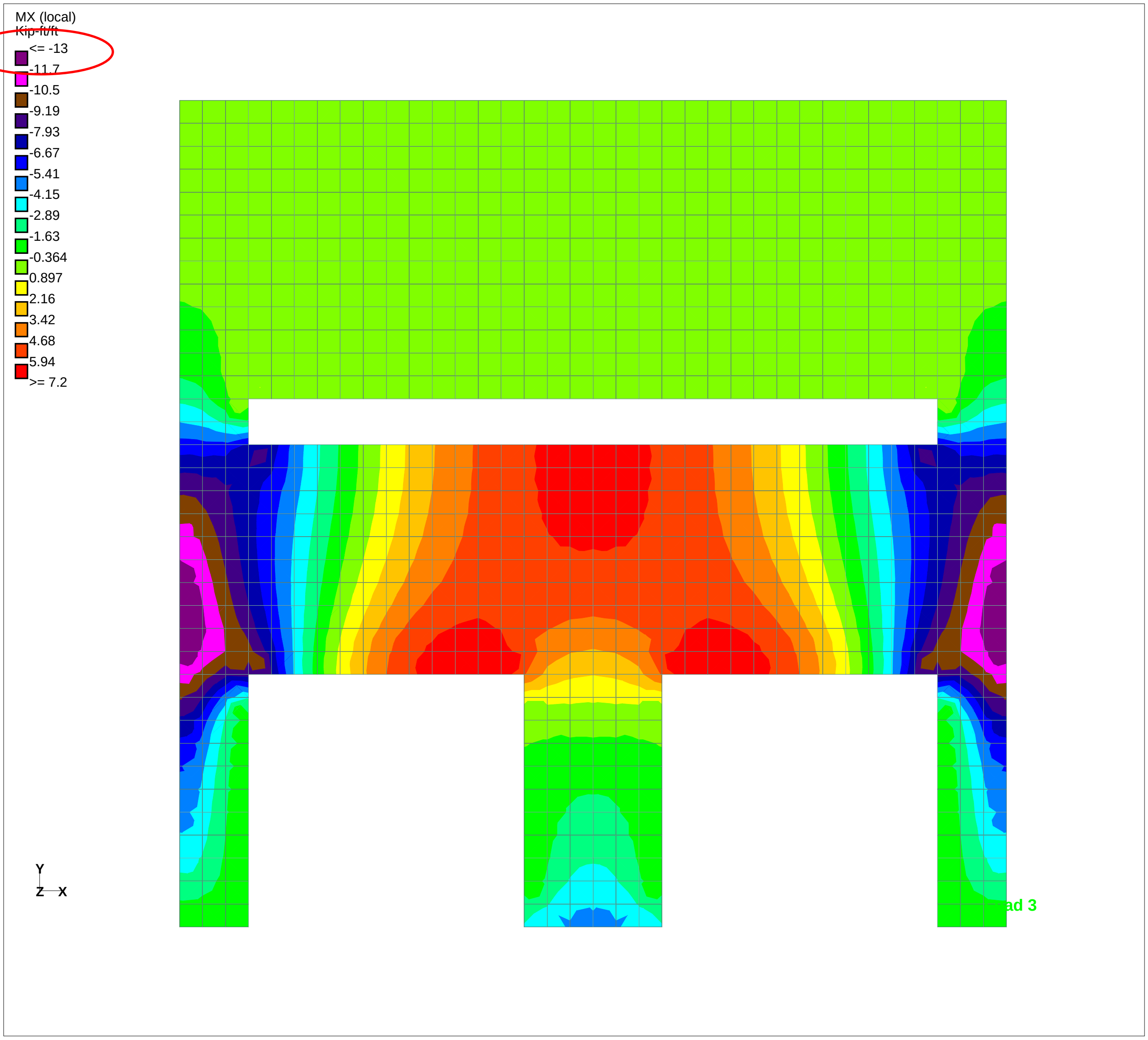
Layout and Loads

Software licensed to HDR	Job No	Sheet No **2**	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_inside.std	Date/Time 24-May-2013 11:51	



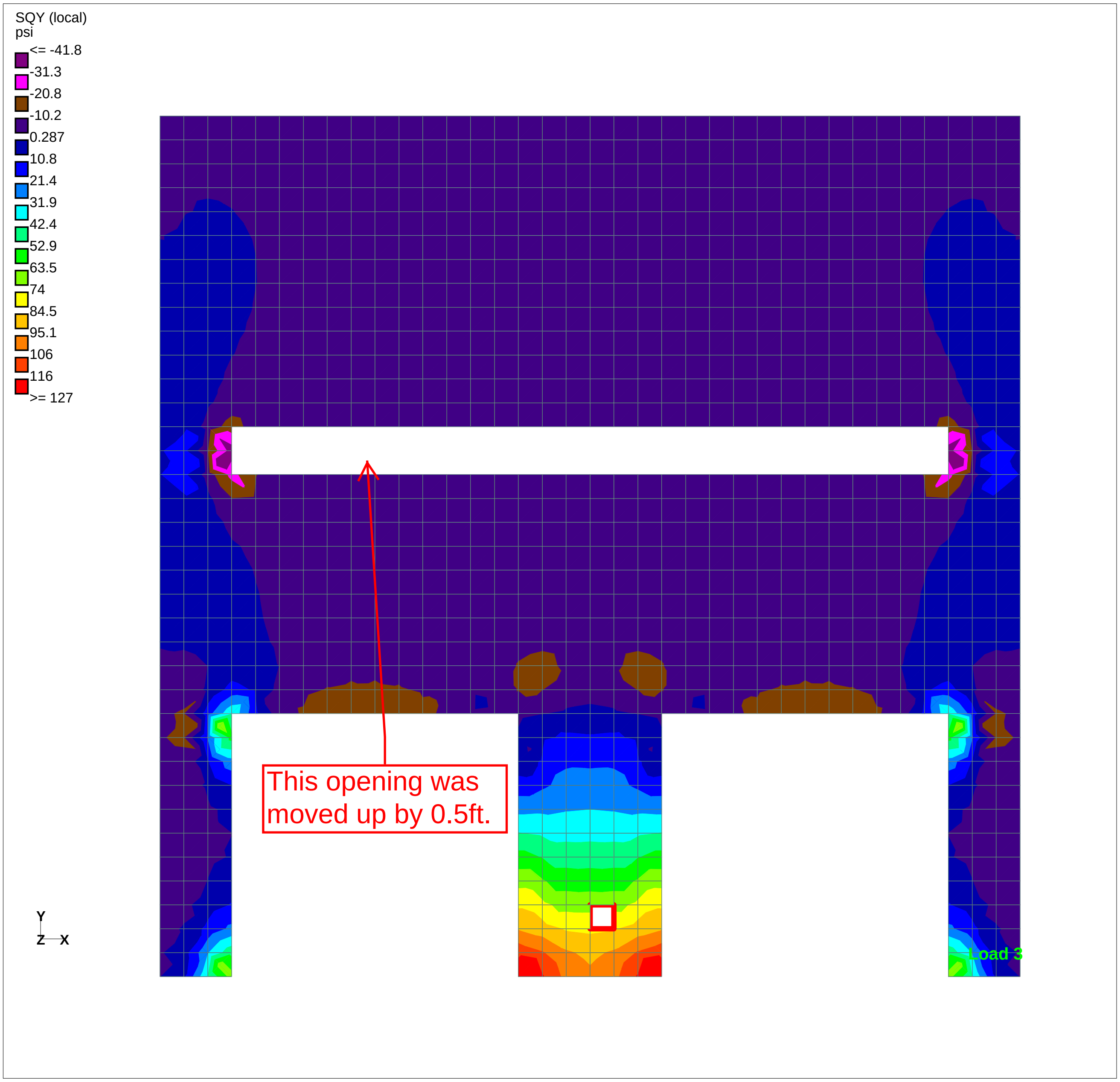
My Distribution in Interior Wall

Software licensed to HDR	Job No	Sheet No 3	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_inside.std	Date/Time 24-May-2013 11:51	



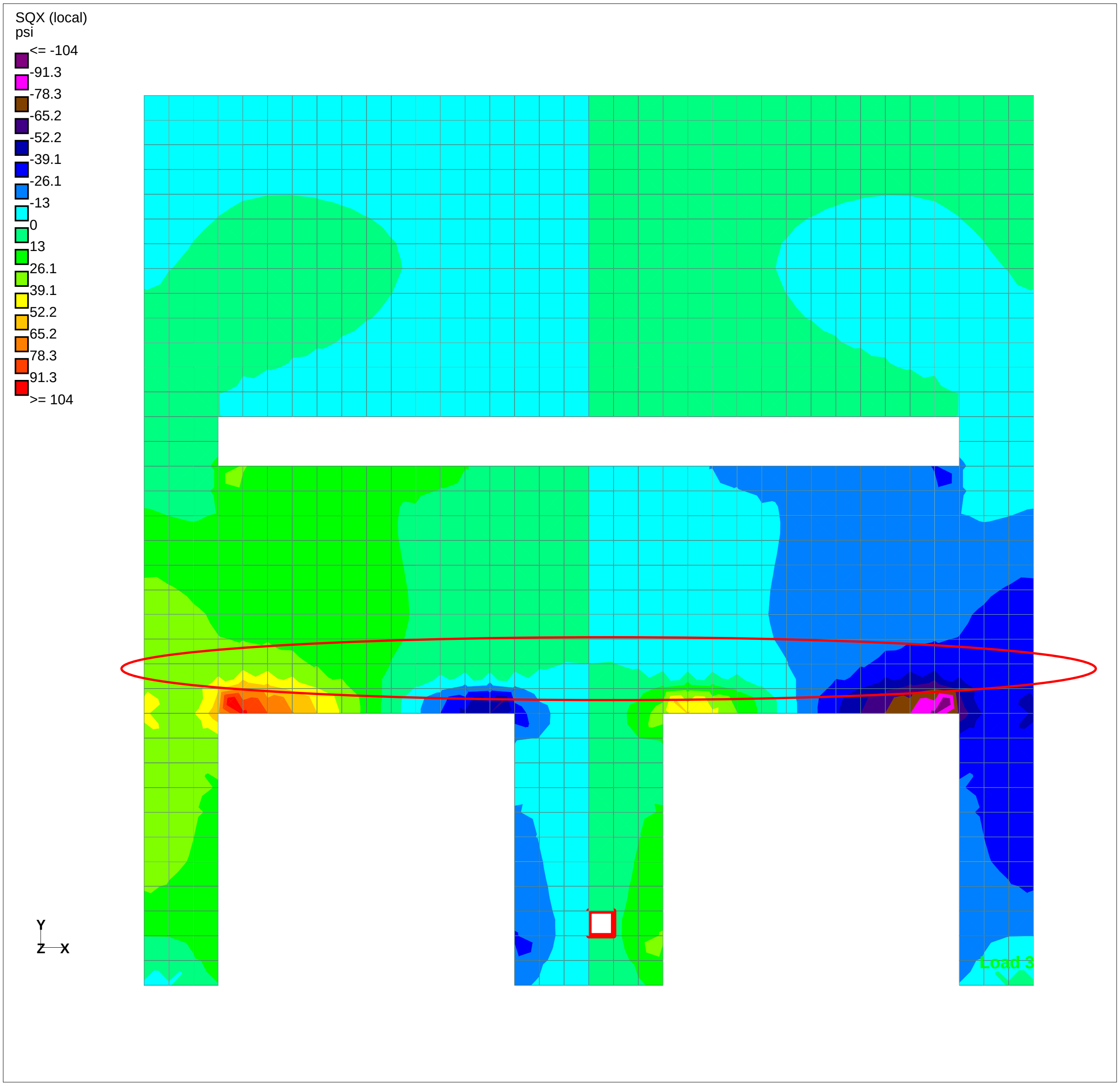
Mx Distribution in Interior Wall

Software licensed to HDR	Job No	Sheet No 4	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_inside.std	Date/Time 24-May-2013 11:51	



SQy Distribution in Interior Wall

Software licensed to HDR	Job No	Sheet No 5	Rev
	Part		
Job Title	Ref		
	By	Date 05-Dec-12	Chd
Client	File Wall_inside.std	Date/Time 24-May-2013 11:51	



SQx Distribution in Interior Wall

HDR

Project:		Computed:		Date:	
Subject:		Checked:		Date:	
Task:		Page:		of:	
Job #:		No:			

Based on the analysis results, we can perform the steel design as show in the following pages.

In summary,

For walls, #5@6" E.W. E.F. and #6@6" vertical dowels at lower part of the interior wall

For Top and Bottom slabs #5@6" E.F in short span direction

#5@12" E.F. in long span direction

The max shear stress at critical sections is about 45psi, which occurs in the inside walls. This is less than half of the shear capacity $2\phi\sqrt{f'_c} = 2\times0.75\times\sqrt{4000} = 95\,psi$

So no shear stirrups are needed. (The plain concrete shall be placed on both sides of the interior wall)

Reinforcing Design (Bottom Slab - Short Span Direction)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 15in$

Maximum Factored Muy in the Slab: $Mu := 20.3 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$$db := \frac{Nb}{8} in = 0.63\,in$$

$$deff := TH - 2in - \frac{db}{2} = 12.69\,in$$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00238$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := min(1.33 \cdot \rho formula, \rho min) = 0.00317$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00317$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00403$$

$$Check\_Reinf\_FootBottom := \left| \begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right. = \text{"Good"}$$

Capacity Check: $$\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 33.78703 \cdot \frac{kip \cdot ft}{ft}$$

Reinforcing Design (Bottom Slab - Long Span Direction)

Concrete Strength: $fc := 4ksi$ Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 15in$ Maximum Factored Muy in the Slab: $Mu := 12.6 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$ $db := \frac{Nb}{8} in = 0.63\,in$ $deff := TH - 2in - \frac{3 \cdot db}{2} = 12.06\,in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00162$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := min(1.33 \cdot \rho formula, \rho min) = 0.00216$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00216$$

Provide rebar #: $Nb = 5$ with space of $sp := 12in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00212$$

$$Check\_Reinf\_FootBottom := \left| \begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right. = \text{"Not Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 16.34196 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Top Slab, Short Span Direction)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$

Maximum Factored Muy in the Slab: $Mu := 10.6\frac{kip\cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8}in = 0.63\,in$

$deff := TH - 2in - \frac{db}{2} = 9.69\,in$

$$\rho formula := 0.85\frac{fc}{fy}\cdot\left(1 - \sqrt{1 - \frac{Mu}{0.383\cdot fc\cdot deff^2}}\right) = 0.00213$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3\cdot\frac{\sqrt{fc\cdot psi}}{fy}, 200\cdot\frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := min(1.33\cdot\rho formula, \rho min) = 0.00283$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00283$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi\cdot db^2}{deff\cdot sp} = 0.00528$$

$$Check\_Reinf\_FootBottom := \left(\begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array}\right) = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9\cdot fy\cdot deff(deff\cdot\rho pro)\cdot\left(1 - \frac{0.588\rho pro\cdot fy}{fc}\right) = 25.50353\cdot\frac{kip\cdot ft}{ft}$

Reinforcing Design (Top Slab, Long Span Direction)

Concrete Strength: $fc := 4ksi$ Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$ Maximum Factored Muy in the Slab: $Mu := 5.11 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$ $db := \frac{Nb}{8} in = 0.63\,in$ $deff := TH - 2in - \frac{3 \cdot db}{2} = 9.06\,in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00116$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := \max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := \min(1.33 \cdot \rho formula, \rho min) = 0.00155$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := \max(\rho formula, \rho min1, \rho min2) = 0.0018$$

Provide rebar #: $Nb = 5$ with space of $sp := 12in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00282$$

$$Check\_Reinf\_FootBottom := \begin{cases} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{cases} = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 12.20022 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Exterior Wall - 2 Span Longitudinal Direction, Horizontal)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$

Maximum Factored Muy in the Slab: $Mu := 13.1 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8} in = 0.63\, in$

$deff := TH - 2in - \frac{db}{2} = 9.69\, in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00264$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := \max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := \min(1.33 \cdot \rho formula, \rho min) = 0.00333$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := \max(\rho formula, \rho min1, \rho min2) = 0.00333$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00528$$

$$Check\_Reinf\_FootBottom := \left(\begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right) = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 25.50353 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Exterior Wall - 2 Span Longitudinal Direction, Vertical)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$

Maximum Factored Muy in the Slab: $Mu := 12.9 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8} in = 0.63\, in$

$deff := TH - 2in - \frac{3 \cdot db}{2} = 9.06\, in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00298$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := \max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := \min(1.33 \cdot \rho formula, \rho min) = 0.00333$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := \max(\rho formula, \rho min1, \rho min2) = 0.00333$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00564$$

$$Check\_Reinf\_FootBottom := \left| \begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right. = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 23.7778 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Exterior Wall - Transverse Direction, Horizontal)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 15in$

Maximum Factored Muy in the Slab: $Mu := 11.8\frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8}in = 0.63\,in$

$deff := TH - 2in - \frac{db}{2} = 12.69\,in$

$$\rho formula := 0.85\frac{fc}{fy}\cdot\left(1 - \sqrt{1 - \frac{Mu}{0.383\cdot fc\cdot deff^2}}\right) = 0.00137$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3\cdot\frac{\sqrt{fc\cdot psi}}{fy}, 200\cdot\frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := min(1.33\cdot\rho formula, \rho min) = 0.00183$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00183$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi\cdot db^2}{deff\cdot sp} = 0.00403$$

$$Check\_Reinf\_FootBottom := \left(\begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right) = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9\cdot fy\cdot deff(deff\cdot\rho pro)\cdot\left(1 - \frac{0.588\rho pro\cdot fy}{fc}\right) = 33.78703\cdot\frac{kip\cdot ft}{ft}$

HDR Calculations Project: SWWD Subject: Struc. 1004 Project: 161580	Computed by: ET Checked by:	Date: 01/20/2013 Date: 01/20/2013

Reinforcing Design (Exterior Wall - Transverse Direction, Vertical)

Concrete Strength: $fc := 4ksi$ Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$ Maximum Factored Muy in the Slab: $Mu := 14.7 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$ $db := \frac{Nb}{8} in = 0.63\, in$ $deff := TH - 2in - \frac{3 \cdot db}{2} = 9.06\, in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00341$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := \max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := \min(1.33 \cdot \rho formula, \rho min) = 0.00333$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := \max(\rho formula, \rho min1, \rho min2) = 0.00341$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00564$$

$$Check\_Reinf\_FootBottom := \begin{vmatrix} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{vmatrix} = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 23.7778 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Inside Wall - Horizontal)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$

Maximum Factored Muy in the Slab: $Mu := 21.5 \frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8} in = 0.63\ in$

$deff := TH - 2in - \frac{db}{2} = 9.69\ in$

$$\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00441$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := min(1.33 \cdot \rho formula, \rho min) = 0.00333$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00441$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00528$$

$$Check\_Reinf\_FootBottom := \left(\begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array} \right) = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff(deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 25.50353 \cdot \frac{kip \cdot ft}{ft}$

Reinforcing Design (Inside Wall, Vertical)

Concrete Strength: $fc := 4ksi$

Reinformcent Strength: $fy := 60ksi$

Slab Thickness: $TH := 12in$

Maximum Factored Muy in the Slab: $Mu := 35.5\frac{kip \cdot ft}{ft}$

Rebar #: $Nb := 5$

$db := \frac{Nb}{8}in = 0.63\,in$

$deff := TH - 2in - \frac{db}{2} = 9.69\,in$

$$\rho formula := 0.85\frac{fc}{fy}\cdot\left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00749$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := \max\left(3\cdot\frac{\sqrt{fc \cdot psi}}{fy}, 200\cdot\frac{psi}{fy}\right) = 0.0033$$

$$\rho min1 := \min(1.33\cdot\rho formula, \rho min) = 0.00333$$

$$\rho min2 := 0.0018 = 0.0018$$

$$\rho req := \max(\rho formula, \rho min1, \rho min2) = 0.00749$$

Provide rebar #: $Nb = 5$ with space of $sp := 3.6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.0088$$

$$Check\_Reinf\_FootBottom := \left|\begin{array}{ll} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{array}\right. = \text{"Good"}$$

Capacity Check: $$\phi Mn := 0.9\cdot fy \cdot deff(deff \cdot \rho pro)\cdot\left(1 - \frac{0.588\rho pro \cdot fy}{fc}\right) = 41.12226\cdot\frac{kip \cdot ft}{ft}$$

Reinforcement Design

Concrete Strength: $fc := 4 \cdot ksi$ Reinformcent Strength: $fy := 60ksi$

5. Vertical Reinforcment of Interior Wall (Each Face)

5.1. Moment Design

Max. Mu in the Slab: $Mu := 25.2 \frac{kip \cdot ft}{ft}$ Max. Shear Stress: $SQ := 75psi$ Slab Thickness: $TH := 12in$ Rebar #: $Nb := 6$

$$db := \frac{Nb}{8} in = 0.75\, in \qquad deff := TH - 2in - \frac{db}{2} = 9.62\, in \qquad \rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00528$$

Minimum Reinforcement Ratio (single layer):

$$\rho min := max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033 \qquad \rho min1 := min(1.33 \cdot \rho formula, \rho min) = 0.00333 \qquad \rho min2 := \frac{0.0018}{2} = 0.0009$$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00528$$

Provide rebar #: $Nb = 6$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00765$$

$$Check\_Reinf\_Wall\_Heel\_Vert := \begin{pmatrix} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{pmatrix} = \text{"Good"}$$

Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff (deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 35.68758 \cdot \frac{kip \cdot ft}{ft}$

5.2. Shear Check

Max. Shear Capacity: $\phi Vn := 0.75 \cdot 2 \cdot \sqrt{fc \cdot psi} \cdot deff = 10.96 \cdot \frac{kip}{ft}$ Max. Shear Force: $Vu := SQ \cdot TH = 10.8 \cdot \frac{kip}{ft}$

Moment Capacity Check:

$$Check\_Shear := \begin{pmatrix} \text{"Good. No shear sturrups are needed."} & \text{if } \phi Vn > Vu \\ \text{"Not Good"} & \text{otherwise} \end{pmatrix} = \text{"Good. No shear sturrups are needed."}$$

6. Horizontal Reinforcment Interior Wall (Each Face)

6.1. Moment Design

Max. Mu in the Slab: $Mu := 13.\frac{kip \cdot ft}{ft}$ Max. Shear Stress: $SQ := 50 \cdot psi$ Slab Thickness: $TH := 12in$ Rebar #: $Nb := 5$

$db := \frac{Nb}{8} in = 0.63\,in$ $deff := TH - 2in - \frac{3 \cdot db}{2} = 9.06\,in$ $\rho formula := 0.85 \frac{fc}{fy} \cdot \left(1 - \sqrt{1 - \frac{Mu}{0.383 \cdot fc \cdot deff^2}}\right) = 0.00301$

Minimum Reinforcement Ratio (single layer):

$\rho min := max\left(3 \cdot \frac{\sqrt{fc \cdot psi}}{fy}, 200 \cdot \frac{psi}{fy}\right) = 0.0033$ $\rho min1 := min(1.33 \cdot \rho formula, \rho min) = 0.00333$ $\rho min2 := \frac{0.0018}{2} = 0.0009$

$$\rho req := max(\rho formula, \rho min1, \rho min2) = 0.00333$$

Provide rebar #: $Nb = 5$ with space of $sp := 6in$

$$\rho pro := \frac{0.25\pi \cdot db^2}{deff \cdot sp} = 0.00564$$

$$Check\_Reinf\_Wall\_Heel\_Vert := \begin{cases} \text{"Good"} & \text{if } \rho pro > \rho req \\ \text{"Not Good"} & \text{otherwise} \end{cases} = \text{"Good"}$$

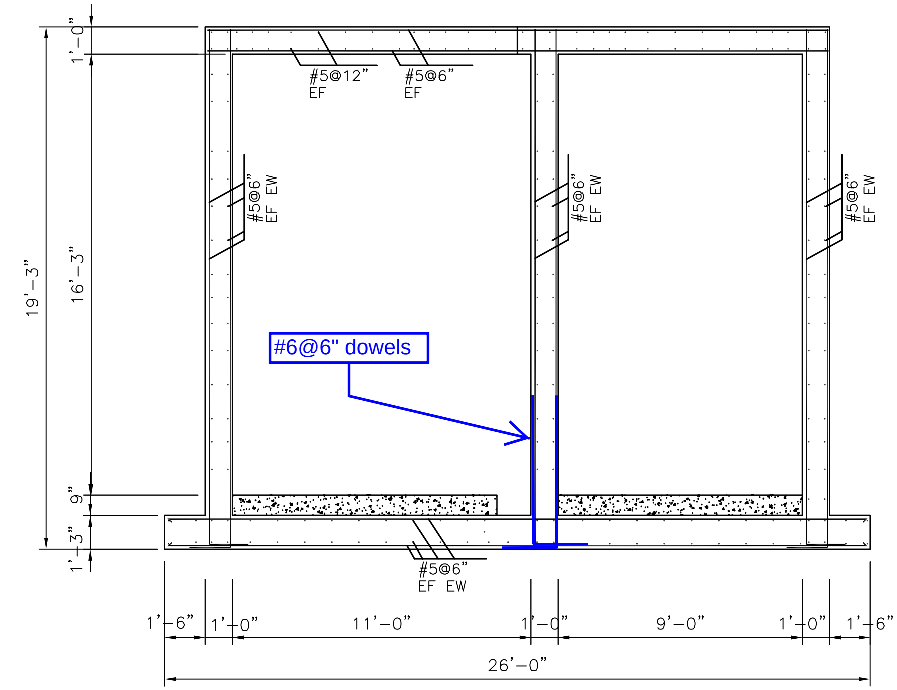
Capacity Check: $\phi Mn := 0.9 \cdot fy \cdot deff (deff \cdot \rho pro) \cdot \left(1 - \frac{0.588 \rho pro \cdot fy}{fc}\right) = 23.7778 \cdot \frac{kip \cdot ft}{ft}$

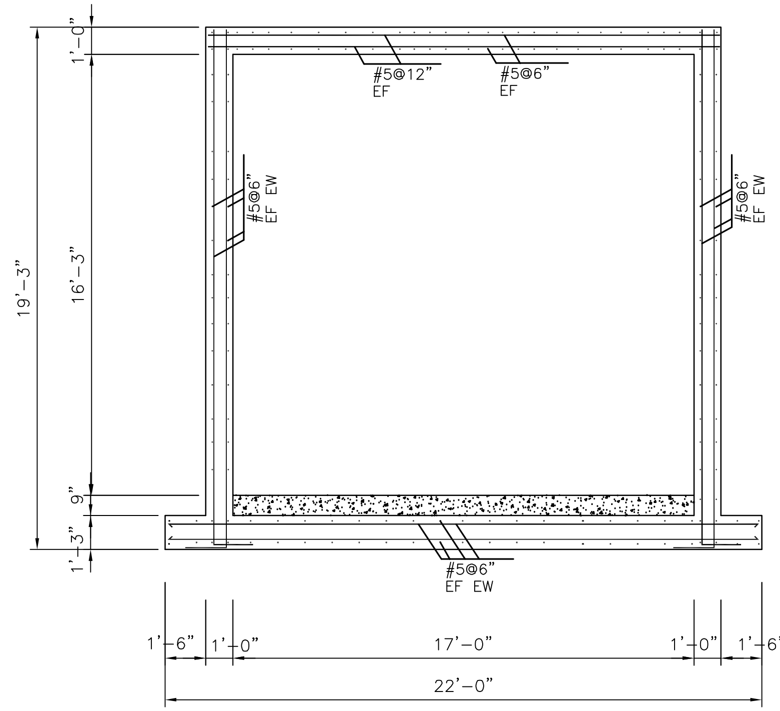
6.2. Shear Check

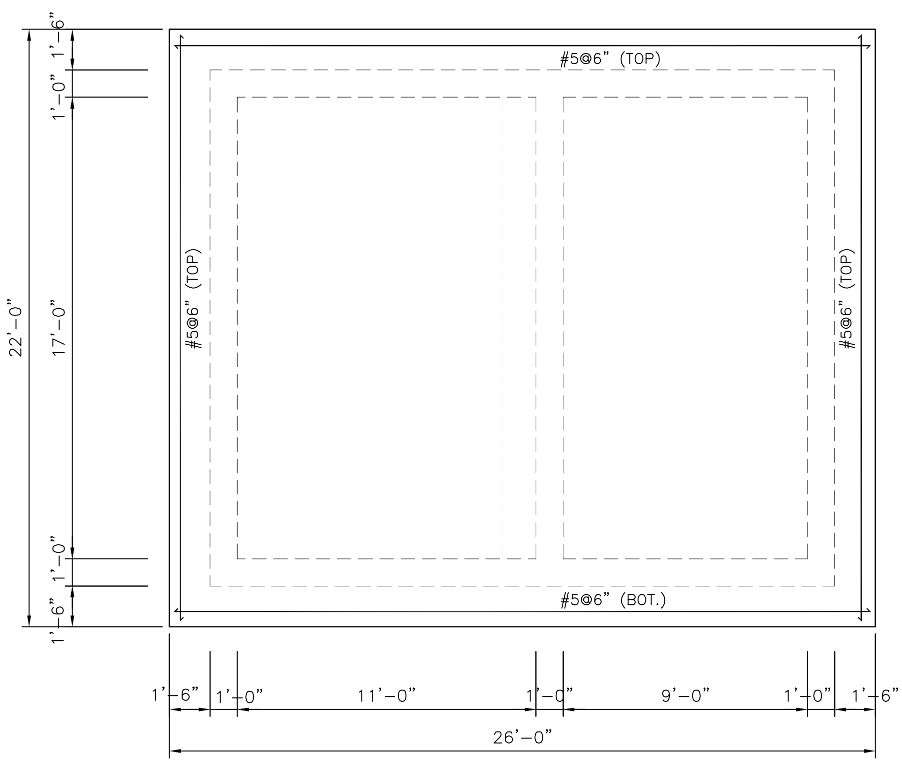
Max. Shear Capacity: $\phi Vn := 0.75 \cdot 2 \cdot \sqrt{fc \cdot psi} \cdot deff = 10.32 \cdot \frac{kip}{ft}$ Max. Shear Force: $Vu := SQ \cdot TH = 7.2 \cdot \frac{kip}{ft}$

Moment Capacity Check:

$$Check\_Shear := \begin{cases} \text{"Good. No shear sturrups are needed."} & \text{if } \phi Vn > Vu \\ \text{"Not Good"} & \text{otherwise} \end{cases} = \text{"Good. No shear sturrups are needed."}$$







Reinforcing Plan of the Drainage Structure