CSAH 112 Reconstruction

WATER RESOURCES PRELIMINARY DRAINAGE DESIGN REPORT

Final

Hennepin County

Prepared by:

SRF Consulting Group, Inc.
ENGINEERS
PLANNERS
DESIGNERS

Date: October 2013

Revised: June 2016

SRF No.0127738.00

Table of Contents

Table of Contents - Continued

Table of Appendices

H:\Projects\7738\WR\DOC\Prelim Design Report\7738_WR Preliminary Design Report_Final.docx

Chapter 1 Purpose and Background

1.1 Purpose

Hennepin County retained SRF Consulting Group to provide technical assistance in the preliminary design for the reconstruction of CSAH 112. CSAH 112 is a four-mile long corridor within the cities of Long Lake and Orono that was previously Trunk Highway (TH) 12 prior to the construction of the TH 12 bypass by MnDOT. This report provides guidance for the final water resources design and includes: storm sewer/culvert layout, alignments, and design; pond and Best Management Practice (BMP) designs; and regulatory considerations. The report also documents the water resources design issues that are expected to be encountered given the proposed roadway improvements along this corridor and next steps for issues that are yet to be resolved. Layouts that provide a pictorial overview of the water resources issues are provided in Appendix A.

1.2 Data Collection

The following data was reviewed during the preliminary design:

- Available record and as-built drawings for storm sewer, sanitary sewer and watermain – provided by the Hennepin County, the Cities of Long Lake and Orono, and the Minnesota Department of Transportation (MnDOT)
- Existing contours and aerial mapping – provided by Hennepin County LiDAR
- Existing topography and planimetrics – provided by Martinez Geospatial
- Flood Insurance Rate Maps (numbers 27053C0301E, 27053C0302E, 27053C0306E all with effective dates of September 2, 2004)
- Floodplain elevations – provided by Minnehaha Creek Watershed District and the Minnesota Department of Natural Resources (MnDNR)
- Wellhead protection areas – provided by the Cities of Long Lake and Orono; GIS data provided by the Minnesota Department of Health
- Surface Water Management Plans – provided by the Cities of Long Lake (dated June 2011) and Orono (dated January 2011)

1.3 Corridor Segments

The corridor has been divided into segments based upon geography and other characteristics. The segments also represent likely phases of construction. Segment numbering is from west to east and does not represent the order in which they would be constructed. The segments are as follows:

1. Westerly Project Terminus to Old Crystal Bay Road

   a. Existing road/drainage section is rural (road runoff sheet flows into roadside ditches).
   b. Predominant land uses are open space, institutional, and agricultural.
2. Old Crystal Bay Road to Brown Road
   a. Existing road/drainage section is rural for roughly half of the length (west of Willow Drive) and is urban (road runoff flows into gutters and is collected in storm sewer pipes) for the remainder.
   b. Predominant land uses are suburban-type commercial areas, and residential.
3. Brown Road to Cemetery Road
   a. Existing road/drainage section is a combination of urban and rural sections:
      i. Urban between Brown Road and Martha Lane,
      ii. Semi-rural in the "pinch-point" between Long Lake and TH 12, with westbound lanes draining via sheet flow into Long Lake and eastbound lanes captured in storm sewer,
      iii. Rural for the remaining portion of the segment.
   b. Predominant land uses are urban-type commercial areas and residential.
4. Cemetery Road to Easterly Project Terminus
   a. Existing road/drainage section is rural.
   b. Predominant land uses are open space and single-family residential.

Chapter 2 Regulatory Environment

2.1 Introduction

As noted previously, the project corridor is located in the cities of Orono and Long Lake and is contained entirely within the boundaries of the Minnehaha Creek Watershed District (MCWD). In addition to the permit rules and ordinances of these agencies, the project will need to meet the requirements of the National Pollutant Discharge Elimination System (NPDES) Permit for construction activity administered by the Minnesota Pollution Control Agency. Stormwater management requirements will vary depending on the agency and the degree to which the project will increase impervious surfaces. See Appendix A for the regulatory matrix reflecting the current requirements that could affect the CSAH 112 reconstruction.

Runoff from the corridor flows to the following receiving waters, listed from west to east:

- Segment 1: Wetlands associated with Classen Lake and Classen Creek, both of which drain to Stubbs Bay (part of Lake Minnetonka)
- Segment 2: Existing ponds and conveyance channels that drain to Long Lake
- Segment 3: A Public Water conveyance channel upstream of Long Lake, Long Lake itself, and Long Lake Creek, all of which drain to Tanager Lake immediately upstream of Browns Bay of Lake Minnetonka
- Segment 4: Several wetlands that drain to Long Lake, Long Lake Creek, or Browns Bay

It is expected that the permits required for the project will include the following. The actual permits may vary for each segment depending on the changes in land cover and impacts to wetlands and floodplains.

- MCWD – a permit covering erosion control, floodplain alteration, shoreline and streambank stabilization, stormwater management, waterbody crossings and structures, and wetland protection
- Minnesota Pollution Control Agency –NPDES Permit for construction activity, along with the associated Stormwater Pollution Prevention Plan (SWPPP)
- Wetland Conservation Act and/or MnDNR Joint Notification Permit – for impacts to wetlands
- MnDNR – Public Water Work permit for construction activity below the ordinary high water level of Public Waters

The following sections reflect issues that may require documentation in future environmental studies and reports.

2.2 Water Quantity and Quality

This section focuses primarily on the requirements of the two permitting agencies: MCWD and MPCA. However, as summarized in the regulatory matrix, the cities also have stormwater management requirements built into their City Codes. Coordination meetings have been held with the two cities and the MCWD and should continue as the concepts progress through final design. It is assumed that any permits required by the cities will be incorporated into the municipal consent process.

2.2.1 MCWD

In general, the proposed roadway improvements maintain the footprint of the existing roadway. However, trails and sidewalks will be added in many locations. According to MCWD rules when a linear reconstruction project adds 10,000 square feet or more of impervious surface, rate and volume control BMPs are required. When a linear reconstruction project adds one acre or more of impervious surface, phosphorus control BMPs are also required.

Also according to MCWD rules, the construction of sidewalks and trails that will not exceed 12 feet in width and will be bordered on the downgradient side by a pervious buffer averaging at least one-half the width of the sidewalk or trail is exempt from the new impervious calculation. The philosophy is that the narrow strip of impervious surface generates minimal runoff, which the pervious buffer is able to absorb and mitigate any increase in flow that does occur. With that exception in mind, the amount of impervious surface will decrease from that of the existing condition when looked at from the standpoint of the entire project, and therefore, no stormwater management best management practices (BMPs) will be required by the MCWD.

2.2.2 NPDES

According to the NPDES permit, permanent stormwater treatment BMPs are not required for projects creating less than one acre of added impervious surface. Unlike the MCWD rules, the NPDES permit does not make an exemption for trails, and all proposed impervious surfaces must be taken in to account when determining the need for BMPs. When proposed "exempt" trails are included, the overall project would result in a 1.2-acre increase in impervious surface, and BMPs would be required. The primary treatment mechanism preferred by the NPDES permit is infiltration, but other BMPs are allowed when site conditions are not conducive for infiltration.

2.2.3 Preliminary Design Approach

It should be noted that it is likely that the project would be designed and constructed in phases. Each phase should be evaluated on its own to determine what permits and BMPs will be required. Table 2.1 documents the expected change in impervious surface. Taken on their own, none of the segments would require new stormwater treatment BMPs based on MCWD or NPDES permits. However, depending on the timing of construction for the different segments, they may be seen by the regulatory agencies as being "connected actions" that are part of a larger common plan of construction. Therefore, additional correspondence with the regulatory agencies should occur during final design.

Table 2.1 Changes in Land Cover

Segment	Existing Condition Impervious (acre)	Proposed Condition			MCWD Change in Impervious (acre)	MCWD Change in Impervious (sq. ft.)	NPDES Change in Impervious (acre)
		Non-exempt Impervious (acre)	Exempt Impervious (acre)	Total Impervious (acre)			
1	4.3	4.4	0.2	4.6	< 0.1	2,890	0.3
2	12.0	10.8	1.8	12.6	-1.2	-51,535	0.6
3	6.8	5.7	0.9	6.6	-1.2	-50,000	-0.3
4	8.1	8.2	0.5	8.7	0.1	4,565	0.6
Total	31.2	29.1	3.4	32.5	-2.2	–94080	1.2

For this preliminary design, we have assumed that the reconstruction of the four segments will meet the connected action criteria, and therefore, stormwater BMPs are proposed at various locations along the corridor to meet NPDES requirements as shown on the Water Resource Overview Maps in Appendix B. BMPs have been proposed based on the locations of existing treatment systems, limitations of existing topography and right of way, balancing treatment with maintaining drainage patterns, likely depth to groundwater, and the presence of silty/clayey soils and wellhead protection areas (WHPAs). BMPs proposed for this project include proprietary hydrodynamic separators (referred to as grit chambers throughout this document and on the overview maps), treatment within roadside ditches, existing stormwater treatment ponds, new stormwater treatment ponds, and a thicker layer of topsoil on embankments in rural drainage sections without ditches. The relevant degrees to which these could meet the criteria are:

- Grit chambers do provide a measure of water quality treatment but do not provide rate attenuation or volume control. They remove larger sediments and typically have a baffle to capture floatables, such as oil and buoyant debris. They have been proposed for locations as pretreatment to other BMPs or where other factors preclude the use of anything else.
- Ditch treatment can provide some measure of volume control and rate control if ditch checks are used to encourage infiltration (where soils and groundwater allow) and plant uptake. Where silty or clayey soils are present, the ditch could be augmented with an infiltration trench.
- Existing stormwater treatment ponds that currently receive roadway drainage would continue to be utilized for stormwater treatment. These are assumed to have been designed to provide moderate to high levels of rate control and water quality treatment for their existing drainage areas. It is assumed that their design did not include a volume reduction component. Additional dead pool and active pool storage would be added where there is an increase in drainage area or in impervious surface.
- A new stormwater treatment pond is proposed near Cemetery Road to provide rate control and water quality treatment. Due to the presence of the Long Lake WHPA, infiltration has not been

incorporated into its design. However, because of available space, it is not possible to incorporate a safety bench, and therefore, the pond has been designed to drain completely between rain events.

- A second stormwater treatment pond is proposed near Old Long Lake Road for rate control and water quality treatment. This pond has been designed as a wet pond due to its proximity to the WHPA mentioned above. The feasibility of implementing infiltration or bioretention in this location could be investigated during final design.
- In the rural drainage sections where road runoff cannot be captured prior to reaching a receiving water, the use of thicker topsoil sections on the embankment should be investigated. The thicker section allows for better plant establishment and, therefore, increases filtration and can help to reduce volume and discharge rates.

In summary, there will be a slight increase in the total impervious surface from the existing condition, but the amount of directly connected impervious surface will decrease as a result of the proposed project. A variety of BMPs are proposed throughout the project corridor in an effort to provide water quality and water quantity treatment for roadway runoff. Therefore, the project is expected to improve the quality of runoff and to reduce the peak discharges and overall volumes of runoff reaching the receiving waters.

2.3 Floodplains

According to the Flood Insurance Rate Maps for this area, there are two mapped floodplains that cross the CSAH 112 corridor. The first is associated with Classen Creek and abuts both sides of the roadway in the two floodplain wetland areas associated with the creek. The second is associated with Long Lake. The floodplains are mapped as Zone A, for which specific floodplain elevations are not indicated. Based upon communication with staff from the MCWD and MnDNR, which is included in Appendix L, it was determined that the elevations are:

Classen Creek	Base Flood Elevation = 974.0 feet (NGVD 1929) Regulated Floodplain Elevation = 975.0 feet (NGVD 1929)
Long Lake	Floodplain Elevation = 944.3 feet (NGVD 1929)

Due to the widening of the shoulders to meet current roadway design standards, trail along the north side of the road by Long Lake, and the addition of a turn lane near Cemetery Road as a safety improvement, impacts to both floodplains are anticipated. Floodplain impacts must be mitigated through the provision of compensatory storage within the same system. Potential mitigation locations near Classen Lake are indicated on the overview map for Segment 1. It is believed that the impacts to the Long Lake floodplain can be mitigated along the shoreline through geometric changes that will pull the CSAH 112 embankment back from the lake's edge. It should be noted that there is insufficient topographic information to understand the volume of floodplain that would be filled as a result of this project. Additional field survey should be performed in the areas of potential fill at the start of final design. The approximate floodplain boundaries and anticipated impacts are shown on the overview maps in Appendix B.

2.4 Wetlands

There are several wetlands along the corridor. A wetland delineation report has been prepared. See Chapter 6 of the Project Summary Report. Based on the footprint of the proposed project, up to 0.7 acres of wetland impacts are anticipated. Wetland mitigation may be incorporated into the floodplain mitigation areas as shown on the overview maps in Appendix B. MCWD is the Wetland Conservation Act local governmental unit for the cities of Long Lake and Orono.

The wetlands have been classified by the MCWD according to their wetland functions and values. MCWD rules require different levels of stormwater management depending on the receiving wetland's classification. Where practicable, all project runoff will receive some measure of treatment with the possible exception of some of the rural drainage sections. As noted above, a thickened topsoil section on the embankment should be investigated to increase filtration and volume reduction of the runoff in those areas, especially when discharging to "preserve" wetlands. In other areas, the wetlands are adjacent to the roadway and providing a treatment basin would result in wetland impacts that would have to be mitigated elsewhere. Therefore, grit chambers or treatment ditches are proposed.

MCWD and both cities have wetland buffer requirements for projects adjacent to wetlands. In many instances, the vegetated road embankment will continue to act as the wetland buffer. In other areas, the minimum buffer width may not be feasible. Additional coordination and variances may be required as the project goes through final design and the construction limits are finalized.

Chapter 3 Summary of Drainage Design Approach

3.1 Stormwater Management

Coordination meetings were held with staff from MCWD, Hennepin County, and the Cities of Orono and Long Lake to discuss expectations for stormwater management given the proposed reconstruction project. Additional communication occurred as needed to address particular issues. A matrix, which is included in Appendix A, summarizing the requirements of the permitting agencies was prepared early during preliminary design and revised to reflect the new NPDES permit that became effective on August 1, 2013. As noted above, the governing stormwater management requirements are dependent on the amount of new impervious surface created. The size and type of BMPs proposed are based on space constraints along much of the corridor, existing stormwater treatment facilities, and the presence of WHPAs.

3.1.1 Drainage Patterns

Existing drainage patterns are shown on the overview maps. The preliminary design maintains the existing patterns, with the following exceptions/observations:

- Based on discussions at the above-referenced meetings, a portion of the drainage area that would have discharged directly into Long Lake was rerouted to the east to be treated at the proposed Cemetery Pond. This means that water would be diverted from Long Lake to Long Lake Creek. However, the area that would be diverted is very small in relation to the overall drainage areas to these two water bodies, and therefore, the diversion is not expected to cause adverse impacts. This is discussed further in Chapter 4.
- The Public Water Ditch that runs alongside the Golf Dome is relatively flat and has additional inputs from large impervious areas downstream of CSAH 112. Water in the ditch has overtopped the banks and caused nuisance flooding near the Golf Dome during some rainfall events. Runoff from eastbound CSAH 112 and the outflow from Kelley Pond drain to this ditch in the existing condition. Therefore, to provide rate attenuation for the runoff from eastbound CSAH 112, proposed storm sewer will route this water to an expanded Kelley Pond.
- Parallel storm trunk lines occur in many locations in Segments 2 and 3. Where the trunk lines discharged to different water bodies, this pattern has been maintained. An example of this can be seen between Tamarack and Shaughnessy Avenues in Segment 2. Where the trunk lines discharge to the same water body, the proposed layout combines the flows into one trunk line. An example of this can be seen between Brown Road and the Public Water Ditch/Drainageway in Segment 3.

3.2 Design Methodology

During the course of this preliminary design, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation frequency estimates for the Midwestern States in Atlas 14 Volume 8. This information supersedes Technical Paper 40 (TP-40) published in 1961 and NOAA Technical Memorandum NWS Hydro 35 published in 1977. These are the sources of precipitation frequency data and Intensity-Duration-Frequency (IDF) curves that have been in use throughout the state and that are currently included in MnDOT's Drainage Manual. In this part of the Twin Cities Metropolitan Area, the rainfall intensities estimated by Atlas 14 for storm frequencies at or below the 10-year recurrence interval do not differ significantly from the previous systems. However, above the 10-year event, the differences become more significant, with Atlas 14 predicting higher rainfall depths.

MnDOT has adopted the new IDF curves and recommends that they be used effective immediately for trunk highway projects where feasible. MnDOT will require the use of Atlas 14 data for hydraulic design on all trunk highway projects that will be let after June 30, 2014. Because it is likely that many of the local road authorities and watershed districts will also adopt the new data, this preliminary design is based on the Atlas 14 data.

Proposed storm sewer trunk systems were designed using the Rational Method in Geopak Drainage. Sizes were based upon the 10-year storm event. The layout shows the proposed locations of trunk storm sewer systems. Spread calculations were not performed at this time, and the catch basins shown on the layout indicate those needed to respond to roadway low points, geometric considerations, or pipe connectivity. Spread analysis will occur during final design.

The NRCS Curve Number Method was used for determining peak flows and hydrographs for culvert and pond design. Culverts were designed using HY-8. The 100-year high water levels (HWLs) for ponds were modeled in HydroCAD using the NRCS Type II, 24-hour distribution. Pond performance is shown in Table 4.1. The HydroCAD modeling responded to the following:

- Minimal information is known about the existing pond near Kelley Parkway (labeled as Kelley Pond on the overview maps). A normal water level (NWL) and outlet pipe configuration was assumed based on the existing contours. HydroCAD models were run using Atlas 14 rainfall data for existing and proposed drainage conditions in order to check that the proposed system would not cause a relative increase in the HWL.
- More information was known about the existing pond at Brown Road (labeled as Brown Pond on the overview maps). The Local Surface Water Management Plan included the drainage area, as well as water levels and outflow rates for a variety of storm events. Based on the better precision of the existing contours now available, we believe that the offsite drainage area to the pond is roughly five acres more than what was published. Therefore, a model was first created using the TP-40 100-year rainfall data with the published drainage area to verify the remaining hydrologic data and match the published HWL. Then the models were run using the Atlas 14 rainfall and the larger offsite drainage for both existing and proposed roadway conditions to compare existing and proposed HWL.

- HydroCAD models were prepared for the proposed Cemetery Pond and Long Lake Pond to determine the expected HWL. Note that for the preliminary design, the outlet pipes have been modeled but skimmer structures have not. The design of the outlet structure and skimmer device will be part of the final design process.

Additional design criteria to be used during final design included in Appendix A.

3.3 Existing Storm Sewer Infrastructure

There are several existing trunk storm sewer systems in the corridor. Some of these systems are located under the current gutter location, but some are located behind the existing curb. Due to the proposed road narrowing, the gutter location, primarily for westbound CSAH 112, will change, and storm sewer that might have been under the gutter will be no longer. The following were considered in the design of the proposed storm sewer layout:

- In many instances where the existing storm sewer is located behind the curb, existing watermains are located less than 10 feet from the proposed gutter. The existing trunk storm sewer will be maintained with new catch basins constructed in the proposed gutter in order to have the required 10-foot horizontal clearance to watermain. The existing system is assumed to be in good condition, but this should be confirmed during final design.
- Where there is no conflict with other known underground utilities and adequate clearance to watermain, the storm sewer will be relocated to the new gutter location. However, the existing systems could be left in place, with new catch basins as needed, if their condition is sufficient and there is no conflict with other proposed uses.
- Storm sewer will be rebuilt where the existing pipes do not have adequate capacity.

Chapter 4 Design Issues and Recommendations

4.1 Design Issues by Segment

Each of the four segments contains several drainage systems. The proposed systems are intended to maintain existing drainage patterns while dealing with issues such as pipe capacity, rate control, volume control, and water quality. Offsite connections will be maintained unless otherwise noted. Culverts will be relocated or other provisions made where existing ditches might be impacted or filled by the proposed reconstruction.

The individual segments may decrease or increase the amount of impervious surfaces from those of the existing conditions. On an individual basis, none of the segments would require permanent stormwater treatment BMPs to meet either NPDES or MCWD permit requirements. As shown in Table 2.1, the total change in impervious surface does not trigger MCWD's stormwater management rule but is over the minimum threshold requiring permanent BMPs for NPDES. Therefore, the preliminary design assumes that the stormwater management plan should address the impervious changes for the entire corridor.

A general layout of the subwatersheds, ponds, storm sewer/culverts, and water resource issues can be found Appendix B. Preliminary pond grading is found in Appendix F. The storm sewer and culvert layout shown on the overview maps address the following issues:

- Connections to existing pipes
- Culverts to be maintained or new pipes that may require jacking
- Critical constraints such as existing utility crossings

4.1.1 Segment 1 – Easterly Project Terminus to Old Crystal Bay Road

The western half of this segment will remain rural. An early concept included a trail along the north side of the road, but due to the adjacent wetland and floodplain, the trail was eliminated to minimize those impacts. Therefore, roadway footprint will increase only slightly over the existing condition to provide a shoulder meeting current design standards. The overall impervious area in Segment 1 will increase as a result of the reconstruction, but will be below the threshold requiring treatment according to the MCWD and NPDES permits. Runoff from the roadway will be collected in roadside ditches or flow over the vegetated embankment directly into the adjacent floodplain wetlands associated with Classen Lake and Classen Creek.

The eastern half will have curb and gutter on the westbound side but will remain rural on the eastbound side. The majority of the runoff from the westbound lanes will be collected in storm sewer and discharged to the Classen Lake wetland. Due to space and topographic constraints, treatment for this system will occur in a grit chamber prior to discharging to the wetland. The remainder will be collected in storm sewer and routed to Kelley Pond for treatment matching the drainage patterns of the existing condition.

The eastbound lanes will drain into roadside ditches flowing west to the floodplain wetland associated with Classen Creek. Treatment for this runoff could be provided in the ditches by adding ditch blocks and encouraging infiltration. If the soils are not conducive to infiltration, the ditch bottom could include a rock trench to provide filtration. A thickened topsoil section could be provided on the embankment where there is no ditch.

4.1.2 Segment 2 – Old Crystal Bay Road to Brown Road

Old Crystal Bay Road to Willow Drive

The existing roadway has a rural drainage system. The northern half drains to the existing pond near Kelley Parkway (labeled as Kelley Pond on the overview maps), while the southern half drains to a Public Water conveyance ditch that in turn drains to a pond built with the TH 12 reconstruction. The outflow from Kelley Pond drains to this ditch, which is relatively flat and receives additional runoff from large impervious areas downstream of CSAH 112. Water in the ditch has overtopped the banks and caused nuisance flooding near the Golf Dome during some rainfall events.

In the proposed conditions, the roadway in this segment will become narrower, and the rural drainage system will be converted to a fully urban one. The overall impervious area in Segment 2 will increase as a result of the reconstruction, but will be below the threshold requiring treatment according to the MCWD and NPDES permits. All stormwater runoff generated in this section will be collected in storm sewer and routed to Kelley Pond for treatment. This will provide water quality treatment for the added impervious and rate attenuation for the drainage from the south half of the roadway, which will help address the capacity problems in the downstream ditch.

No information could be obtained for the original design of Kelley Pond. It was assumed that the pond was designed to provide NURP treatment for the original tributary area. Additional dead pool storage to account for the increased impervious surface will be provided by expanding the pond at the west end and along the road. The grading will also provide additional active storage. Field survey should be performed to determine the NWL and outlet structure elevations early in the final design process. As shown in Table 4.1, with the assumed NWL and outlet configuration, the HWL will increase slightly. Once the survey has been completed, the models should be updated to determine if more active storage, outlet modifications, or a combination of the two are needed to maintain the HWL.

Willow Drive to Brown Road

The existing roadway has an urban drainage system in this section. The westbound lanes are collected in a trunk storm sewer on the north side of the road that discharges to the existing pond at Brown Road (labeled as Brown Pond on the overview maps). A second trunk storm sewer picks up drainage from the eastbound lanes and runs parallel on the south side, where it then drains south along Shaughnessy Avenue to an existing, unnamed basin near the intersection of TH 12 and Brown Road. This second trunk is located 5 to 20 feet behind the existing curb.

The proposed roadway will be narrower than the existing, with the south curb line being maintained. To match the existing drainage patterns, a new trunk storm sewer will be constructed on the north side in the new gutter and will be routed to Brown Pond, while the eastbound lanes will continue to drain to the unnamed basin. Due to the proximity of a parallel watermain, the southern trunk is proposed to be maintained, but its condition is unknown. We recommend having the system televised to determine its condition early in the final design process.

As shown in Table 4.1, the HWL for Brown Pond shows a slight increase in the proposed condition. This is due to slightly more road runoff being directed into the pond. During final design, the storm sewer layout will be refined, and catch basin locations will respond to maximum allowable spread criteria. The catch basin layout should also ensure that the drainage area to the pond from the roadway does not increase from the existing condition.

4.1.3 Segment 3 – Brown Road to Cemetery Road

Brown Road to the Drainageway Crossing (CSAH 112 Station 1122+00)

This portion of Segment 3 has similar parallel trunk storm sewer systems as described above. However in this case, both systems discharge to the same location in the Public Water Ditch, which is herein referred to as the drainageway. A 72-inch-span by 54-inch-rise arch culvert conveys the drainageway under CSAH 112. The northerly system starts as the outfall for Brown Pond, collects roadway runoff, and discharges through a 48-inch diameter pipe to the west of the arch culvert. The southerly system crosses over the top of the arch culvert and discharges through a 24-inch diameter pipe to the east of the culvert.

The proposed roadway is narrower than the existing, with both curb lines being affected. Because the two existing systems discharge to the same location in the drainageway there is an opportunity to simplify the storm sewer infrastructure. Catch basins in the south gutter would be directed to a new 48-inch diameter trunk storm sewer in the proposed north gutter location that will discharge to the drainageway at the location and elevation of the existing 48-inch outlet. The outlet from Brown Pond is relatively steep, and the roadway runoff will enter the storm sewer much more quickly than the outflow from Brown Pond. Therefore, the additional drainage to the trunk line is not expected to affect the pond's performance. Modeling with XP-SWMM should be done once the final layout is confirmed.

An existing flow splitter is located in the drainageway downstream of the 48-inch outlet. It directs low flows to a series of treatment basins recently constructed in Lakeside Park. The proposed project will result in a reduction in impervious surface in this segment, and no additional stormwater treatment would be required to meet the MCWD or NPDES permits.

Drainageway Crossing to Mill Street

The existing roadway in this section is collected in a trunk storm sewer in the south gutter. It then discharges to the drainageway through the 24-inch diameter pipe noted above. Because the existing storm sewer would be behind the proposed curb, a new trunk line is proposed in the south gutter's new location. It will discharge at the same location and elevation as the existing 24-inch outlet. Alternatively, if the existing pipe's location behind the curb does not pose conflicts with other improvements, the existing pipe could be televised, and it could be maintained if its condition is adequate.

As described above, treatment for runoff in the drainageway occurs in a series of basins recently constructed in Lakeside Park. The proposed project will result in a reduction in impervious surface in this segment, and no additional stormwater treatment would be required by MCWD or for the NPDES permit.

Mill Street to Cemetery Road

In the existing condition, this section of the roadway is semi-urban: it is fully urban west of Martha Lane, urban only on the eastbound side between Martha Lane and station 1147+50, and rural everywhere else. Much of the runoff from this section is treated in an existing grit chamber that was constructed with the TH 12 relocation. According to correspondence with MnDOT, this grit chamber does not have capacity for additional flows. The remainder of the section drains directly to Long Lake without any treatment.

In the proposed condition, an urban drainage section will be used throughout. Storm sewer on Martha Lane picks up a small portion of the roadway runoff and discharges it into a riprap-lined channel between a residence and CSAH 112. There has been erosion at the outlet, and the City of Long Lake requested that the proposed storm sewer provide a connection and more stable outlet for the storm sewer. Because of the capacity constraints at the existing grit chamber, drainage between Mill Street and station 1146+50 will be captured in a new storm sewer and treated in a new grit chamber located to the east of the existing grit chamber. The existing grit chamber will be removed.

Although the impervious surface will decrease with proposed project, the cities and MCWD are interested in providing additional treatment where practicable to improve the water quality of Long Lake, which is on the 303d Impaired Waters List for nutrients. Given the immediate proximity of the lake, treatment options other than grit chambers are limited. Direction was given during the initial coordination with the cities and MCWD to investigate options to reroute drainage from this section to the east where it would discharge to Long Lake Creek downstream of Long Lake. It was determined that road runoff from station 1146+50 to the high point at station 1149+50 could be rerouted based on the proposed road profile and downstream elevations.

All road runoff from station 1146+50 to Cemetery Road will be treated at the proposed Cemetery Pond near the Long Lake Creek crossing. Due to its location within Long Lake's WHPA, a clay liner should be incorporated per Minnesota Department of Health and City of Long Lake standards based on correspondence with city staff. The pond is being designed as a bioretention (filtration) basin because adequate space is not available to construct a safety bench with a typical wet pond. Perforated underdrains will ensure that the basin dries out between rainfalls. A grit chamber is proposed upstream of the basin to provide pretreatment by removing the larger sediment and debris and thereby reducing the maintenance burden within the basin itself. The elevation of the Long Lake Creek channel will control the elevation of the underdrains. Due to their proximity, the berm between the basin and the creek should be constructed with a clay core.

Southwood Shores townhomes, which is located south of CSAH 112 at the west intersection with Cemetery Road, drains to a series of shallow ditches and landscaped drainage features along the existing roadway. The proposed improvements include a trail in the north side of the roadway, leaving the existing drainage features mostly intact. More detailed analysis will need to be performed in final design to verify if any of these features will be affected, and if they were originally part of the stormwater treatment system. If so, this project will need to replace the functions of the features or provide appropriate treatment volume at Cemetery Pond.

The lakeshore along the road embankment has experienced erosion and localized slumping. A shoreline stabilization detail has been designed using FHWA's Hydraulic Toolbox based upon methodologies in Design Guideline 17 incorporated into the third edition of HEC-23. Appendix K includes design computations and a typical section for the stabilization.

4.1.4 Segment 4 – Cemetery Road to Easterly Project Terminus

The existing roadway has a rural drainage section throughout and discharges to a variety of wetlands. The proposed project will maintain a rural section on one side, but will utilize an urban section on the opposite to minimize right-of-way impacts responding to different topographic and environmental constraints on either side of the roadway. The overall impervious area in Segment 4 will increase as a result of the reconstruction, but will be below the threshold requiring treatment according to the MCWD and NPDES permits. For areas with the rural drainage section, water quality treatment could be provided by incorporating ditch checks and underdrains as needed to encourage infiltration or filtration. Alternatively, a thickened topsoil section could be provided to enhance vegetation establishment and infiltration.

Cemetery Road to Heather Lane

The proposed project will maintain the rural section for the eastbound lanes, but will utilize an urban section for the westbound lanes in order to minimize right-of-way impacts. Runoff from the westbound lanes west of the high point near Heather Lane will be collected in a storm sewer and routed to Cemetery Pond for treatment, which will entail crossing the Long Lake Creek culvert. Much of the storm sewer trunk line is placed along a lane line, this is due to utility conflicts with existing watermain running parallel to the gutter under the proposed curb line on both sides of the road. When possible, the trunk line shifts to the north curb to minimize structures while maintaining adequate clearance of existing utilities. Runoff from the eastbound lanes will continue flow into the existing drainage ditch.

The existing culvert carrying Long Lake Creek under CSAH 112 is a 4-foot-wide by 6-foot-tall box culvert. There is a 90-degree bend in the creek immediately downstream of the culvert, and streambank erosion has occurred. The culvert is proposed to be replaced with a 73-inch-span by 45-inch rise reinforced concrete arch pipe due to its age and to facilitate the above-described storm sewer crossing. Further coordination is needed with MCWD to determine the appropriate solution for the streambank erosion.

The proposed improvements include a trail along the westbound lanes. A retaining wall is proposed to support the trail and minimize impacts to Long Lake Creek and the adjacent wetland.. On the eastbound side, it will be necessary to realign roughly 130 feet of the creek, shifting it approximately 10 to 15 feet to move the creek out of the proposed roadway embankment. It is likely that a combination of hard armoring and bioengineering techniques will be required.

Heather Lane to Old Long Lake Road

As above, the proposed project will maintain the rural section for the majority of the eastbound lanes, but will utilize an urban section for the westbound lanes in order to minimize right-of-way impacts. The trail continues along the north side of the road, as in previous segments, and the eastbound lanes will also have curb and gutter in this area. Runoff from the westbound lanes will be collected in storm sewer and routed to the proposed Long Lake Pond at the intersection with Old Long Lake Road. The pond is designed as a wet pond following the procedures in the NPDES permit. Alternatively, this could be designed as a bioretention basin with a grit chamber for pretreatment. The pond is not located within a WHPA, and infiltration could be allowed if the soils are conducive. The pond will outlet across Old Long Lake Road via a culvert and flow into a wetland near the southeastern quadrant of Long Lake.

The storm sewer layout shows the proposed storm sewer primarily along a lane line to avoid utility conflicts. Similar to the segment from Cemetery Road to Heather Lane, an existing watermain and sanitary sewer runs parallel to the gutter on both sides of the road for much of this area.

During the course of the public outreach for this project, residents near Russell Lane discussed existing drainage problems in their yards for a variety of reasons. They raised concerns that these would be exacerbated by the proposed project or expressed hope that the project could provide a solution. The following have been added to the layout to address these issues:

- Drop inlets have been included on the south side of the road at CSAH 112 station 1174+49 and 1176+28 to address a landlocked area that affects several properties on Russell and Heather Lanes. The drop inlet would have an invert elevation of roughly 986.50 ft. that would allow for a future piped connection from the landlocked area. The runoff would be routed to the west and discharged to the north of CSAH 112, matching the drainage patterns for the remaining area that would be captured by the system. Field survey should be done during final design to verify the lowest elevation in the landlocked area. Also during final design, the conveyance system downstream of the outlet should be evaluated to ensure that modifications are not needed to accommodate the additional flow.

- With the trail on the north side, the existing drainage ditch along the south side of the road will be maintained to control drainage problems and direct water to the proposed drop inlets mentioned above.

Old Long Lake Road to Project Easterly Terminus

The proposed roadway will be slightly wider than the existing road in this section. For the most part the proposed road will have a rural section, but there are two short segments of curb and gutter. Storm sewer will capture the runoff in each area and discharge to ditches, depressions, and wetlands matching the existing drainage patterns. Grit chambers are shown upstream of the outfalls to provide treatment.

Table 4.1 Pond Water Levels

Pond	Normal Water Level (feet)	Existing HWL if applicable (feet)	Proposed HWL (feet)
Kelley Pond	1009.0 (assumed)	1013.0 [1]	1013.2 [1]
Brown Pond			
TP-40 - original area	972.0	974.7 (Published)	
TP-40 - revised area	972.0	975.0	975.1
Atlas 14	972.0	975.8	975.8
Cemetery Pond	N/A (dry)	N/A	947.6
Long Lake Pond	985.0	N/A	986.5

Notes: [1] **Existing and proposed HWL are based upon the assumed NWL and outlet configuration.**

Chapter 5 Next Steps

Preliminary design has brought up some important issues and next steps for the final design process. The following is a listing of such issues:

- Coordination should be continued with MCWD as the concepts are being finalized.
- Only critical culverts were surveyed during preliminary design. The following items should be surveyed early during the final design process:
  - Existing storm sewer to confirm connection and critical crossing elevations.
  - The outlet control structure for Kelley Pond to confirm the pond's NWL and for determining the HWL. The need for additional active storage and/or outlet structure modifications should be determined based upon that information.
  - The outlet control structure and downstream pipe at Brown Pond to confirm model performance. Using XP-SWMM, confirm performance of Brown Pond and the downstream pipe with the flows from eastbound CSAH 112 rerouted to this system.
  - The sanitary sewer (as necessary) to confirm critical crossing elevations.
  - Comprehensive survey of the existing ground elevations at all areas where floodplains are likely to be filled by the project. This information will be needed to determine the volume of floodplain fill and the feasibility of providing the necessary compensatory storage within the subwatershed. Additional mitigation areas should be identified if needed. Floodplain mitigation should be designed to also serve as wetland mitigation.
- Existing storm sewer pipes that are proposed to remain in place should be televised to confirm their condition is sufficient. Where storm sewer is proposed to be reconstructed under the new gutter location, the existing storm sewer pipes could also be televised to confirm condition if there is a desire to maintain more of the existing infrastructure and it does not create an obstacle for other improvements.
- Coordination should be continued with the Cities of Orono and Long Lake regarding the proposed storm sewer layout and BMP design. Coordination should also confirm design for basins within the WHPAs.
- Coordination with MCWD should occur to discuss the appropriate solution for the streambank erosion and channel realignment of Long Lake Creek immediately downstream of CSAH 112.

Appendix A: Design Criteria and Regulatory Matrix

CSAH 112 Reconstruction

CSAH 6 to TH 12

WATER RESOURCES DESIGN CRITERIA

Water Resources Engineering for CSAH 112 Reconstruction

The following tables provide a summary of the water resources design criteria to be used for the final design of this project.

REFERENCE DESIGN MANUALS AND OTHER DOCUMENTS

Mn/DOT Drainage Manual	Drainage design criteria
Mn/DOT State Aid Manual	Drainage design criteria
MnDOT Road Design Manual	Drainage design and erosion control reference
FHWA HDS-5	Hydraulic Design of Highway Culverts
FHWA HEC-14	Hydraulic Design of Energy Dissipaters for Culverts and Channels
FHWA HEC-22	Urban Drainage Design Manual (Storm drainage systems for transportation facilities)
MPCA NPDES Permit	Water quality treatment criteria
MCWD Rules	Permit requirements for stormwater management, erosion control, shoreline/water body alterations, floodplains, and wetlands

HYDROLOGY

Rational Method	• Drainage Area < 200 acres (Customary, as per Mn/DOT Drainage Manual for storm sewer design)
SCS Method	• 1 acre < Drainage Area < 2000 acres
Runoff Coefficient	• Pavement: c = 0.9, CN = 98 • Ditches: c = 0.5, CN = 74 • Minimum: c = 0.3, CN = 58
Time of Concentration	• Minimum Tc: 7 minutes (100% impervious, urban/paved areas) • Other Areas: Calculate Tc (Mn/DOT Drainage Manual, Ch. 3.4) • Include short reaches of sheet flow where applicable
Rainfall	• Atlas 14 for Hennepin County Intensity-Duration-Frequency (IDF) Curve • Rainfall depths (Atlas 14): - 100-year = 7.3 in. - 50-year = 6.3 in. - 10-year = 4.3 in. - 2-year = 2.9 in.
Models/Design Software	• Geopak Drainage • HydroCAD • HY-8

CATCH BASINS/MANHOLES/STORM SEWER

Castings/ Placement	• Place CBs where practical upstream of intersections, crosswalks, pedestrian ramps, and at low points. Do not place CBs on curb radius, unless absolutely necessary.
Structures	• 400 ft. maximum spacing for 15 in. to 54 in. diameter pipe. • 600-800 ft. maximum spacing for larger than 54 in. diameter pipe. • Angle between pipes greater than or equal to 90 degrees wherever possible. • 48-inch minimum structure diameter is desired for all structures. Smaller diameters may be used for lead structures if needed to achieve physical clearances. • Precast concrete structures are preferred. • Design H (see note above), C or G, A or F, or 4020, SD-48, SD-60, SD-72, SD-84, SD-96
Storm Sewer	• Full flow capacity $\geq$ rational method peak discharge for design event. Capacity calculated using Manning's equation (Manning's n=0.012 for RCP). • Design Event = 10-year • Max velocity in storm sewer pipes = 14 ft/s (check for hydraulic jump if greater) • Max velocity discharging to ponds = 10 ft/s. • Min velocity in pipes = 3 ft/s (during design storm flow). If < 3 fps, use 80% full flow capacity to account for sediment. • The minimum depth of cover for RCP or CMP (as measured from the top of pipe) shall be as follows: o 1.25 ft. under rigid pavement o 1.75 ft. under flexible • Min pipe size = 15" for trunk; 12" for leads if needed to attain minimum velocity or to attain cover. • Use MnDOT certified RC pipe underneath mainline.
Culverts	• Design Event = 50-year storm minimum - For Long Lake Creek culvert, use 100-year storm - Freeboard = the larger of 1 ft. or 2 times the velocity head. • SCS Curve Number Design Method • Max velocity in new culverts, V_o = 12 ft/s • Minimum Size: o CSAH Centerline = 18 in • In general, new centerline culverts shall be concrete. Other pipe material will be considered based on engineering judgment. • Corrugated steel pipe shall be used under driveways and secondary roads. No spiral metal pipe is allowed.

Ditches	• Permanent roadside ditch linings shall have a 100-year frequency while temporary linings shall be designed for the 2-year frequency. • Channel side slopes shall not exceed the angle of repose of the soil and/or lining and shall be 1V:3H or flatter. • Channel side slopes should meet requirements for clear zones as specified in the MnDOT Road Design Manual. • Ditch depths shall be at least 4 ft. wherever possible in order to provide adequate drainage for the base of the road. • Channel freeboard shall be the larger of one foot or two velocity heads.
Water Quality (Based on NPDES as governing criteria)	• Dead pool storage = 1800 cu. ft. per acre of drainage area. • Water Quality Volume (WQV) = 1” runoff from new impervious surface
Physical Design Criteria	*Wet Detention Basin* • Provide access for future maintenance. • Prevent short-circuiting of flow from inlets to outlets. • Min. depth = 3 feet; Max. depth = 10 feet. • Side slopes equal to or flatter than 1v:4h, if possible. • Min. bench = 10 feet at 1v:10h.
Permits	• NPDES • MCWD

Regulatory Matrix for Hennepin CSAH 112 SRF Project #7738.00

The following is a matrix of the regulatory requirements pertinent to the CSAH 112 project. They do **not** represent a comprehensive summation of all water resource rules of the agencies listed below.

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Waterbody Crossings & Structures	Wetland Quality	Erosion & Sediment Control and Shoreline & Streambank Stabilization
Minnehaha Creek Watershed District **(Minnehaha Creek Watershed District Comprehensive Water Resources Management Plan, 2010, and Rules [adopted 2010 - 2011])** Permits will likely be needed for the following rules: - Erosion control - Floodplain Alteration - Shoreline and Streambank Stabilization - Stormwater Management - Waterbody Crossings & Structures - Wetland Protection	See "Stormwater Management Rule" RATE CONTROL (a) Linear Transportation Reconstruction shall result in no net increase in the peak runoff rate for the 1-, 10- and 100-year design storms (b) No increase in peak runoff rates for the 1-, 10- and 100-year design storms within a specific drainage area of the site that will create or exacerbate drainage or erosion problems. VOLUME CONTROL (a) The required level of treatment is dependent on the increase in impervious surface for **linear reconstruction** projects: i. <10,000 SF None ii. ≥ 10,000 SF & < 1 AC None iii. > 1 AC YES (b) If iii applies, abstract the first 1" of rainfall from the **added** impervious surfaces. Credit will be calculated using industry accepted hydrologic models and Appendix A: Volume Abstraction Credit Schedule. (c) If meeting abstraction requirements is not feasible, abstract runoff to the greatest extent feasible (0.5" min.) **and** provide phosphorus control equivalent to that achieved through abstraction of 1" of rainfall. Infeasibility will demonstrated by an Abstraction Analysis (See Rule). The construction of sidewalks and trails that will not exceed 12 feet in width and will be bordered on the downgradient side(s) by a pervious buffer averaging at least one-half the width of the sidewalk or trail is exempt.	See "Stormwater Management Rule" PHOSPHORUS CONTROL: (a) The required level of treatment is dependent on the increase in impervious surface for **linear reconstruction** projects: i. <10,000 SF None ii. > 10,000 SF & < 1 AC YES iii. > 1 AC YES (b) No net increase in phosphorus loading from existing conditions for the **added** impervious surfaces. REGIONAL STORMWATER MANAGEMENT See "Stormwater Management Rule" Section 7 if construction of a regional treatment facility is proposed. IMPACT ON DOWNSTREAM WATERBODIES (a) No **new** point source may discharge to a waterbody without pretreatment (sediment & nutrient removal). (b) See Table 1 of the Rule for limits on allowable changes to the bounce, the duration of inundation, or runout control elevation for any downstream lake or wetland. *i. Note: Wetlands of all management classes exist along the corridor.* The construction of sidewalks and trails that will not exceed 12 feet in width and will be bordered on the downgradient side(s) by a pervious buffer averaging at least one-half the width of the sidewalk or trail is exempt.	FLOODPLAIN ALTERATION See "Floodplain Alteration Rule" (a) No net decrease in storage capacity below the projected 100-year HWL of a waterbody. See section (C) for exceptions. i. Floodplain storage mitigation shall occur before any fill is placed in the floodplain. ii. This requirement does not apply to fill in a waterbody other than a watercourse if the applicant shows that the proposed fill, together with the filling of all other properties on the waterbody to the same degree of encroachment as proposed by the applicant, will not cause high water or aggravate flooding on other properties and will not unduly restrict flood flows. (b) No increase in the 100-year flood elevation of a watercourse. WATERBODY CROSSINGS & STRUCTURES See "Waterbody Crossings & Structures Rule ▪ Applies to waterbody alterations to enclose it in a pipe or culvert. ▪ May be waived if Board determines waterbody has already been altered/degraded. (a) Retain adequate hydraulic capacity (b) Preserve aquatic and upland wildlife passage along each bank and may require an upland bank, multiple offset culverts, or wildlife shelf above bankfull height. i. See rule for more information. (c) Shall not adversely affect water quality.	See "Wetland Protection Rule" ▪ No **new** point source may discharge to a wetland without pretreatment for sediment and nutrient removal. Pretreatment may be provided by nonstructural means. ▪ The District regulates activity impacting wetlands pursuant to the Wetland Conservation Act and the Watershed Law. REPLACEMENT/MITIGATION (a) Site wetland replacement in the following order of priority: i. On site; ii. Within the same subwatershed as the impacted wetland (see Appendix 1); iii. Within the District. BUFFER (a) Any activity that requires certain permits and that increases the imperviousness of the subject parcel must provide for buffer adjacent to each wetland and public waters wetland. i. Buffer must be provided on that part of the wetland edge that is downgradient from the activity or construction and around each wetland that will be disturbed. (b) The minimum buffer width is dependent on the management class of each wetland (see Section 6). i. *Note: Wetlands of all management classes exist along the corridor.* (c) See Sections 7 for buffer vegetation requirements.	EROSION & SEDIMENT CONTROL See "Erosion Control Rule" ▪ Prepare and implement erosion control plan meeting the requirements of the rule. SHORELINE & STREAMBANK STABILIZATION See "Shoreline & Streambank Stabilization Rule" ▪ Applicable to new riprap placed along shorelines or streambanks. ▪ Applicable to maintenance of existing riprap if new material will also be placed. ▪ Must include detailed erosion intensity calculations of the shoreline (see section 3) or streambank (see section 4). (a) The proposed stabilization practice shall be consistent with the calculated erosion intensity (shorelines) or shear stress (streambanks). (b) Practices proposed at slopes steeper than 1v:2h shall be evaluated as retaining walls (see section 12). (c) See section 6 for the criteria for stabilization techniques of high erosion intensity shorelines.
City of Orono **(Orono City Code, 2003 [updated 2010]; and Orono Surface Water Management Plan, January 2011)** Permits for land-	▪ Future peak rates of discharge from new development and redevelopment will not exceed pre-development peak rates of discharge for the 1-yr or 2-yr, 10-yr and 100-yr, 24-hr storm events. ▪ Critical event analysis shall be used for establishing 100-year high water levels for stormwater ponds and wetlands with the higher level obtained from the 100-year, 24-hour rainfall or the 100-year, 10-day runoff	▪ Newly constructed stormwater outfalls to public waters must provide for filtering or settling of suspended solids and skimming of surface debris before discharge. ▪ Minimum standard is water quality treatment that meets the requirements of the NPDES construction site permit. ▪ Sites needing to obtain an NPDES construction site permit will be required to reduce phosphorus loadings over current	▪ No net loss of flood storage in natural or constructed systems. FLOODWAY CONDITIONAL USES ▪ No increase in the stage of the 100-year or regional flood. ▪ Elevation to the regulatory flood protection elevation shall be provided where failure or interruption of these transportation facilities would result in danger to the public health or safety or where such facilities are essential to	BUFFERS Wetland buffer must be created or existing buffer areas must be maintained when project is within 50 feet of a wetland. Additional requirements include: ▪ When the wetland is required to be replaced or restored, or when the wetland is being altered; ▪ When any construction or land alteration activity that does not fall within the meaning	▪ A SWPPP meeting the City's Construction Site Runoff Control Ordinance dated 2009 or later and meeting the NPDES permit must be prepared (submit 2 copies). ▪ An erosion and sedimentation control plan specifying the measures to be used before, during and after construction until the soil and slope are stabilized by permanent cover. ▪ Disturbed areas must be stabilized and protected as soon as possible and facilities or

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Waterbody Crossings & Structures	Wetland Quality	Erosion & Sediment Control and Shoreline & Streambank Stabilization
disturbing activity and wetlands will be required unless incorporated into municipal consent process.	event being used as the designated high water level. ▪ Freeboard of 2 feet is required from the high water level to the low floor of an adjacent building. ▪ Linear projects will be required to implement runoff volume management practices for **new** impervious surfaces such that these surfaces cause no increase in runoff volume. ○ Linear projects will need to consider whether additional runoff volume management practices might feasibly be incorporated for existing impervious surfaces, as well. ALLOWABLE CHANGE IN BOUNCE FOR DISCHARGE TO WETLANDS: (a) "Preserve" at or below existing (b) "Manage 1" as above + 0.5 ft. (c) "Manage 2" as above + 0.5 ft. (d) "Manage 3" no requirement	conditions. Where existing land cover has previously been altered from the natural condition, a 20% reduction in P loading over current rates for current conditions will be required. For redevelopment projects, only disturbed areas fall under this requirement. ▪ Outlet skimming is required in all water quality ponds. Skimming shall occur for up to the 10-year, 24-hour event. ○ *The use of submerged pipes to provide skimming is **not** allowed.* PHOSPHORUS LOAD LIMITS FOR DISCHARGE TO WETLANDS: (a) "Preserve" 0.14 lbs/ac/yr (b) "Manage 1" 0.28 lbs/ac/yr (c) "Manage 2" 200 ppb (d) "Manage 3" 225 ppb	the orderly functioning of the area.	of 'redevelopment' has the potential to adversely impact a wetland. STANDARDS ▪ All hard-surface runoff must be treated in accordance with the requirements of the city and the watershed district. ▪ Discharge into the wetlands – maximum allowable as allowed by the city engineer in accordance with the city's surface water management plan and the appropriate MCWD requirements. A permit is required for wetland alteration – water storage must be provided in an amount compensatory to that removed.	methods used to retain sediment on the site.
City of Long Lake **(Long Lake City Ordinances, [2003 & 2006]; and Long Lake Water Resources Management Plan, 2010)** Permits for Erosion/Sediment Control, as well as variances for work within the Shoreland Overlay, Wetland Protection, and Water Management Overlay Districts may be required unless incorporated into municipal consent process.	▪ No increase in runoff rates for the 1-, 10-, and 100-year rainfall events as indicated in the Water Resources Management Plan. ▪ Maintain freeboard between HWL of new ponds and low floor, including basement floor, elevation as follows: ○ 2 ft. above the 100-year HWL, or ○ 2 ft. above the emergency overflow elevation. ▪ Increased volumes of runoff due to development should be minimized by: ○ Abstraction; ○ Limiting impervious cover; ○ And encouraging infiltration of storm water where soil conditions are appropriate.	WET DETENTION POND DESIGN ▪ Size ponds using NURP design that achieves a total phosphorus removal efficiency of 65% or greater for each pond or series of ponds. ▪ Physical design features: ○ Permanent pool volume $\geq$ runoff volume from 2.5" rainfall. ○ Permanent pool depth: - Minimum depth = 4 ft. - Mean depth = 3 – 4 ft. depending on overall pond size. - Maximum depth = 10 ft. ○ Max. length to max. width ratio $\geq$ 3:1 ▪ Use baffles or ponds in series if 3:1 ratio is not achievable. ○ Min. bench width = 15 ft. at 1v:10h max. slope ○ Max. 1v:3h side slopes below NWL. ○ Provide settling forebay at pond inlets. ○ Skimming for the 1-year event. ○ Max. 1v:3h side slopes above NWL. ○ Emergency overflow above the 100-year design storm HWL.	▪ No net loss of floodplain storage from development or redevelopment projects. ▪ Public utility facilities, roads, railroad tracks, and bridges within the floodplain should be designed to minimize increases in flood elevations and should be compatible with existing local comprehensive floodplain development plans. CONDITIONAL USES IN SHORELAND AREAS ▪ A thorough evaluation of the water body and the topographic, vegetation, and soil conditions on the site shall be made to ensure the prevention of soil erosion or other possible pollution of public waters, both during and after construction; ▪ The visibility of structures and other facilities as viewed from public waters is limited;	The Wetland Protection District consists of all upland within fifty feet (50') of the wetland boundary of wetlands identified in the Water Resource Management Plan that drain to the waterbody. ○ Include any water course, natural drainage system, water body, or wetland that may be subject to periodic flooding, overflow, or seasonally high water tables. ○ Ponds are not permitted unless conditionally permitted. ○ Minimum buffer width = 25 feet	▪ Land disturbing or filling activities shall be required to be permitted by the City of Long Lake and may be required to be permitted by the MCWD. ▪ Land disturbing activities shall provide for silt fencing, catch basin inlet protection and rock construction entrances consistent with the BMPs required by MCWD rules and the Long Lake WRMP. ▪ Care must be taken to ensure that the introduction of storm water into natural ravine and drainage way systems and flow within the ravines does not cause bank erosion.
MPCA	▪ When there is an increase in impervious coverage of > 1 acre, a volume equivalent to 1" of runoff from the new impervious surface	▪ Water quality volume is equal to 1" of runoff from new impervious surfaces created by the project for projects in which the ultimate		▪ Stormwater must be discharged in a manner that does not cause nuisance conditions, erosion in receiving channels or on	FOR DRAINAGE TO LONG LAKE ▪ All exposed soil areas must be stabilized as

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Waterbody Crossings & Structures	Wetland Quality	Erosion & Sediment Control and Shoreline & Streambank Stabilization
(General Stormwater NPDES/SDS Permit issued August 1, 2013) NPDES permit(s) and Stormwater Pollution Prevention Plan(s) will be required. IMPAIRED OR SPECIAL WATERS: - Long Lake is impaired for nutrients & is w/in 1 mile. - Stubbs Bay is impaired for nutrients, but is expected to be > 1 mile from project. - Tanager Lake is impaired for nutrients, but is expected to be > 1 mile from project. * *As each segment progresses to final design, these should be verified.*	must be retained on site. Restrictions on infiltration include: ○ ≤ 3 ft. separation to season high groundwater elevation or top of bedrock ○ Where high levels of soil or groundwater contamination that could be mobilized ○ Where predominantly Hydrologic Soil Group D exists unless allowed by local MS4 ○ Where Drinking Water Supply Mgmt Area exists unless allowed by local MS4 ○ Where native soil infiltration rates are ≥ 8.3 inches per hour unless soils are amended to reduce rate or unless allowed by local MS4 ▪ For linear projects with limited r/w that cannot obtain easement, the project must maximize the volume that is treated prior to discharge to surface waters using: ○ Smaller wet ponds and/or ○ Grassed swales and/or ○ Filtration systems and/or ○ Grit chambers. ○ Must document attempts to obtain r/w in the SWPPP. ▪ Infiltration/Filtration Design parameters: ○ Water quality volume = 1" of runoff from new impervious surfaces (less the volume treated by another BMP on site). ○ 48 hours maximum detention time. ○ Filtration design to have a minimum 80% TSS removal. ○ The specific BMP(s) chosen must have pretreatment that removes to the maximum extent possible: - Settleable solids - Floating materials - Oils and grease	development replaces pervious surfaces with one or more acres of accumulative impervious surface. ○ The preferred treatment is infiltration where site and soil conditions allow. See adjacent column for design parameters. DETENTION BASIN DESIGN ▪ For pretreatment or when infiltration or filtration is not possible. ▪ Permanent volume = 1800 cu. ft. per acre of drainage area. ○ Permanent pool depth ≥ 3 ft. ○ Permanent pool depth ≤ 10 ft. ▪ Water quality volume = 1" of runoff from new impervious surfaces (less the volume treated by another BMP on site). ▪ Water quality volume maximum discharge shall be no more than 5.66 cfs per acres of surface area of the pond at the water quality volume. ▪ Prevent short circuiting and the discharge of floating debris. ▪ Basin outlets must have energy dissipation. ▪ Provide stabilized emergency overflow. ▪ Design must include adequate maintenance access. ○ Typically 8 ft. wide Other treatment practices such as grasses swales, small ponds, grit chambers, etc. are required prior to discharge to surface waters for road projects where the lack of right of way restricts the ability to construct ponds or infiltration basins.		downslope properties, or inundation in wetlands causing significant adverse impacts to the wetlands.	soon as possible but no later than 7 days after construction activity has temporarily or permanently ceased in that portion. ▪ Temp sediment basin is required If ≥ 5 acres of disturbed soil drain to a common location, prior to runoff leaving the construction site and before entering surface waters. DRAINAGE TO OTHER AREAS ▪ All exposed soil with a continuous positive slope within 200 ft. of a surface water (including a stormwater conveyance system) must have temporary erosion control or permanent cover for exposed soil areas within 24 hours of connecting to surface water. ▪ Sediment control practices must minimize sediment from entering surface waters, including curb and gutter systems and storm sewer inlets. ▪ There shall be no unbroken slope length greater than 75 feet for slopes with a grade of 3:1 or steeper. ▪ All exposed soil areas must be stabilized as soon as possible but no later than 14 days after construction activity has temporarily or permanently ceased in that portion. ▪ Temp. soil stockpiles must have effective sediment controls and can not be placed in surface waters, including curb and gutter and ditches. ▪ Temp. sediment basins are required when ≥ 10 acres of disturbed soil drain to a common location. See permit for design standards.
Minnesota Department of Health **(MDH Source Water Assessments, 2012)**	Contact MDH for more information concerning Well Head Protection Plans for Orono Well Number 2 and 3 Well Head Protection Area and Long Lake Well Number 2 Well Head Protection Area. These areas may also be referred to as Long Lake East, Long Lake West, and Orono 3 Well Head Protection Areas, according to the County Well Index. Long Lake East and West are both classified as "Low Vulnerability"; Orono 3 is classified as "Not Vulnerable". See Map PDFs				

Appendix B: Water Resources Overview Maps

CSAH 112 Reconstruction

CSAH 6 to TH 12


CSAH 6
POTENTIAL FLOODPLAIN MITIGATION AREA
CLASSON LAKE
BASE FLOOD ELEVATION = 974.0 FT.
REGULATED FLOOD PLAIN ELEVATION = 975.0 FT.
(NGND 1929)
PWI#162P
POTENTIAL FLOODPLAIN & WETLAND MITIGATION AREA
POTENTIAL FLOODPLAIN & WETLAND MITIGATION AREA
US 12
BNSF RAILWAY
PWI#841W FLOODPLAIN ELEV. = 973.8 FT. (NGVD 1929)
CLASSON CREEK
WEST PROJECT LIMITS
MAINTAIN OR REPLACE EXISTING CULVERTS
MAINTAIN OR REPLACE EXISTING CULVERTS
CSAH 112
EXISTING 36" RCP CULVERT TO BE MAINTAINED INLET = 972.26 FT.
POTENTIAL FLOODPLAIN IMPACTS
POTENTIAL FLOODPLAIN IMPACTS
EXISTING 36" RCP CULVERT TO BE MAINTAINED INLET = 972.34 FT.
MAINTAIN OR REPLACE CULVERT
MAINTAIN OR REPLACE CULVERT
MAINTAIN OR REPLACE CULVERT
MAINTAIN OR REPLACE CULVERT
5103
5102
5101
5100
KELLEY PARKWAY
LEGEND
MAJOR DRAINAGE BOUNDARY
EXISTING CULVERT/STORM SEWER
PROPOSED CULVERT/STORM SEWER
EXISTING SANITARY SEWER
EXISTING WATERMAIN
PROPOSED LIMITS OF CONSTRUCTION
APPROXIMATE FLOODPLAIN
XXXX
PROPOSED STORM DRAIN STRUCTURE/NODE
SURFACE FLOW
POTENTIAL WETLAND
PROPOSED POND
PROPOSED DRY POND
N
0 100 200
scale in feet
PRELIMINARY
SUBJECT TO CHANGE
SRF Consulting Group, Inc.
STORMWATER OVERVIEW MAP
C.S.A.H. 112
SEGMENT 1


MAINTAIN OR REPLACE CULVERT
MAINTAIN OR REPLACE CULVERT
MAINTAIN OR REPLACE CULVERT
OLD CRYSTAL BAY ROAD
KELLEY PARKWAY
WELL HEAD PROTECTION AREA
EXPAND POND'S DEAD POOL FOR WATER QUALITY TREATEMENT AND ACTIVE STORAGE TO INCREASE RATE ATTENUATION
KELLEY POND
EX. NWL = 1009.0 FT. (ASSUMED)
EX. HWL = 1013.0 FT. (ASSUMED)
PROP. HWL = 1013.2 FT.
CSAH 112
EXISTING 18" RCP CULVERT TO BE MAINTAINED (VERIFY SIZE) UNKNOWN ELEVATION
EXISTING CAPACITY PROBLEMS IN DITCH
GOLF DOME
W. INDUSTRIAL BLVD.
POTENTIAL CONFLICT WITH WATERMAIN
EXISTING PUBLIC WATER DITCH/ CONVEYANCE CHANNEL
CITY OF ORONO
CITY OF LONG LAKE
KENOBI POND
NWL = 999.0
HWL = 1003.5
WILLOW DR.
CONNECT TO EXISTING STORM SEWER
EXISTING STORM SEWER ON WESTBOUND SIDE TO BE REMOVED
CONNECT TO EXISTING STORM SEWER
CONNECT TO EXISTING STORM SEWER
TAMARACK AVE.
BRIMHALL AVE.
MAINTAIN DRAINAGE PATTERNS BY: EXTEND CB LEADS AND MAINTAIN STORM SEWER OR REBUILD IN RIGHT OF WAY. THE LATTER MAY REQUIRE PARTIAL RELOCATION OF WATERMAIN.
SHAUGHNESSY AVE.
DANIELS ST.
WELL HEAD PROTECTION AREA
WELL HEAD PROTECTION AREA
MAINTAIN DRAINAGE PATTERNS BY: EXTEND CB LEADS AND MAINTAIN STORM SEWER OR REBUILD IN RIGHT OF WAY. THE LATTER MAY REQUIRE PARTIAL RELOCATION OF WATERMAIN.
BROWN POND
EX. NWL = 972.0 FT.
EX. HWL = 974.7 FT.
PROP. HWL = 975.1 FT.
REROUTE STORM SEWER TO SINGLE TRUNK ON WESTBOUND GUTTER
VIRGINIA AVE.
BROWN RD. (CSAH 146)
NO MODIFICATIONS TO POND OR OUTLET STRUCTURE
CONNECT TO EXISTING 48" RCP STORM SEWER INLET = 965.36 FT.
LEGEND
MAJOR DRAINAGE BOUNDARY
EXISTING CULVERT/STORM SEWER
PROPOSED CULVERT/STORM SEWER
EXISTING SANITARY SEWER
EXISTING WATERMAIN
PROPOSED LIMITS OF CONSTRUCTION
APPROXIMATE FLOODPLAIN
PROPOSED STORM DRAIN STRUCTURE/NODE
SURFACE FLOW
POTENTIAL WETLAND
PROPOSED POND
PROPOSED DRY POND
PRELIMINARY
SUBJECT TO CHANGE
SRF Consulting Group, Inc.
STORMWATER OVERVIEW MAP
C.S.A.H. 112
SEGMENT 1

WELLHEAD PROTECTION AREA
BROWN RD. (CSAH 146)
BROWN POND
EX. NWL = 972.0 FT.
EX. HWL = 974.7 FT.
PROP. HWL = 975.1 FT.
NO MODIFICATIONS TO POND OR OUTLET STRUCTURE
CONNECT TO EXISTING 48" RCP STORM SEWER INLET = 965.36 FT.
LAKESIDE PARK
DRAINAGE WAY AND PUBLIC WATER DITCH
CITY OF ORONO
CITY OF LONG LAKE
MAINTAIN DRAINAGE PATTERNS BY: EXTEND CB LEADS AND MAINTAIN STORM SEWER OR REBUILD IN RIGHT OF WAY. THE LATTER MAY REQUIRE PARTIAL RELOCATION OF WATERMAIN.
MAINTAIN DRAINAGE PATTERNS BY: EXTEND CB LEADS AND MAINTAIN STORM SEWER OR REBUILD IN RIGHT OF WAY. THE LATTER MAY REQUIRE PARTIAL RELOCATION OF WATERMAIN.
REROUTE STORM SEWER TO SINGLE TRUNK ON WESTBOUND GUTTER
NEW TRAIL CROSSING: USE BRIDGE OR ARCH PIPE WITH EQUIVALENT FLOW AREA AS UPSTREAM CULVERT
EXISTING STORM WATER TREATMENT SYSTEM
REMOVE EXISTING STORM SEWER EAST OF BROWN ROAD
PROPOSED 48" RCP OUTLET TO MATCH EXISTING ELEV. = 950.81 FT.
EXISTING FLOW SPLITTER TO DIRECT LOW FLOWS INTO TREATMENT BASINS
MAINTAIN EXIST. 54"X72" ARCH CULVERT INLET = 951.71 FT.
PROPOSED 24" RCP OUTLET TO MATCH EXISTING ELEV. = 951.09 FT.
BRIMHALL AVE.
SHAUGHNESSY AVE.
VIRGINIA AVE.
DANIELS ST.
SYMES ST.
POTENTIAL WATERMAIN CONFLICTS
MAINTAIN EXISTING 30" STORM SEWER INVERT ELEV. AT CROSSING = 949.6 FT.
LAKE ST.
LONG LAKE
FLOODPLAIN ELEVATION = 944.3 FT.
ORDINARY HIGH WATER = 944.3 FT.
(NGVD 1929)
PWI#160P
PUBLIC LIBRARY
CONNECT TO EXISTING STORM SEWER
MILL ST.
MARTHA LA.
WELLHEAD PROTECTION AREA
MAINTAIN EXISTING 27" STORM OUTLET CROSSING ELEVATION (WITH PROPOSED PIPE) APPROX. 944.5 FT.
EROSION/SCOUR AT EXISTING OUTLET AND DITCH
POTENTIAL FLOODPLAIN IMPACTS
LONG LAKE OUTLET
CEMETERY RD.
CEMETERY POND (DRY)
BTM = 944.7 FT.
HWL = 948.2 FT.
POTENTIAL FLOODPLAIN MITIGATION
INSTALL RIPRAP FOR SHORELINE PROTECTION ALONG ENTIRE BOUNDARY WITH ROAD
CSAH 112
CONNECT TO EXISTING MARTHA LA. STORM SEWER
US 12
BNSF RAILWAY
ORCHARD LA.
EXISTING GRIT CHAMBER TO REMAIN INPLACE DO NOT INCREASE FLOW TO GRIT CHAMBER
MAINTAIN EXISTING 30" STORM OUTLET CROSSING ELEVATION (WITH PROPOSED PIPE) APPROX. 946.0 FT.
PROPOSED GRIT CHAMBER
REPLACE EXISTING CULVERTS
EXISTING 4' WIDE X 6' HIGH CULVERT TO BE REPLACED WITH 45"X73" SPAN ARCH PIPE
INLET = 942.70 FT.
OUTLET = 942.08 FT.
TRAIL IMPACTS EXISTING STORM WATER MANAGEMENT FACILITY. COORDINATE WITH CITY AND OWNER TO REPLACE IN KIND
LONG LAKE CREEK
WOLF POINTE TR.
WELLHEAD PROTECTION AREA
LEGEND
MAJOR DRAINAGE BOUNDARY
EXISTING CULVERT/STORM SEWER
PROPOSED CULVERT/STORM SEWER
EXISTING SANITARY SEWER
EXISTING WATERMAIN
PROPOSED LIMITS OF CONSTRUCTION
APPROXIMATE FLOODPLAIN
XXXX
PROPOSED STORM DRAIN STRUCTURE/NODE
SURFACE FLOW
POTENTIAL WETLAND
PROPOSED POND
PROPOSED DRY POND
N
0
100
200
scale in feet
PRELIMINARY
SUBJECT TO CHANGE
SRF
Consulting Group, Inc.
STORMWATER OVERVIEW MAP
C.S.A.H. 112
SEGMENT 3


LEGEND
MAJOR DRAINAGE BOUNDARY
EXISTING CULVERT/STORM SEWER
PROPOSED CULVERT/STORM SEWER
EXISTING SANITARY SEWER
EXISTING WATERMAIN
PROPOSED LIMITS OF CONSTRUCTION
APPROXIMATE FLOODPLAIN
PROPOSED STORM DRAIN STRUCTURE/MH#
SURFACE FLOW
POTENTIAL WETLAND
PROPOSED POND
PROPOSED DRY POND
0 100 200
SCALE IN FEET
PRELIMINARY
SUBJECT TO CHANGE
SRF Consulting Group, Inc.
STORMWATER OVERVIEW MAP
C.S.A.H. 112
SEGMENT 4
LONG LAKE
FLOODPLAIN ELEVATION = 944.3 FT.
ORDINARY HIGH WATER = 944.3 FT.
(NGVD 1929)
PWI#160P
WELL HEAD PROTECTION AREA
CITY OF ORONO
CITY OF LONG LAKE
OLD LONG LAKE RD.
LONG LAKE POND
BTM = 981.0 FT.
NWL = 985.0 FT.
HWL = 987.2 FT.
PROPOSED GRIT CHAMBER
MCWD "PRESERVE" WETLAND
UNDERHILL CIR.
WATERMAIN ON E.B. SIDE TO BE RELOCATED FROM STATIONS 1175+20 TO 1181+00
PROVIDE INLETS FOR FRONT YARD DRAINAGE
PICK UP DITCH FLOW
PROVIDE STRUCTURE TO PICK UP FUTURE CONNECTION FROM LANDLOCKED AREA
EXISTING LANDLOCKED AREA
RUSSELL LA.
GREEN HILL LA.
LINDAWOOD LA.
HEATHER LA.
GLENMOOR LA.
VERIFY THAT EXISTING CONVEYANCE SYSTEM HAS CAPACITY FOR ADDED FLOWS FROM LANDLOCKED AREA
CSAH 112
WATERMAIN TO BE RELOCATED FROM STATIONS 1157+00 TO 1170+00
LONG LAKE OUTLET
CEMETERY POND (DRY)
BTM = 944.7 FT.
HWL = 948.2 FT.
CEMETERY RD.
INSTALL RIPRAP FOR SHORELINE PROTECTION ALONG ENTIRE BOUNDARY WITH ROAD
POTENTIAL FLOODPLAIN IMPACTS
WOLF POINTE TR.
LONG LAKE CREEK
EXISTING 4' WIDE X 6' HIGH CULVERT TO BE REPLACED WITH 45"X73" SPAN ARCH PIPE
INLET = 942.70 FT.
OUTLET = 942.08 FT.
TRAIL IMPACTS EXISTING STORM WATER MANAGEMENT FACILITY. COORDINATE WITH CITY AND OWNER TO REPLACE IN KIND
LUCE LINE TRAIL
VERIFY CULVERT ELEVATIONS.
PWI#831W
PWI#851W OR 857W
WAYZATA BLVD.
EAST PROJECT LIMITS
US 12
BNSF RAILWAY

Appendix C: Trunk Storm Sewer Design and Profiles

CSAH 112 Reconstruction

CSAH 6 to TH 12

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

DRAFT PRELIMINARY DESIGN

CSAH 112 - CSAH 6 TO TH 12	DESIGN FREQUENCY: 10 YRS	INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE	COMP. BY: JAD
HENNEPIN COUNTY	LOW PT FREQUENCY: 10 YRS		CHECKED BY: LAG
			SHEET NO. 1
			DATE: 09/24/13
			DATE: 09/24/13

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112A																					
5100		FROM	1057+76.000000	36.0 LT	0.32	0.83	0.26	7.0	7.1	1.9	7.10	12.0	400.1	2.92	15 in	Concrete			1022.25	1010.56	11.69	1026.50	1014.81	
5101		TO	1053+76.000000	29.5 LT							7.10													
		ON	EB112A																					
5101		FROM	1053+76.000000	29.5 LT	0.82	0.82	0.67	7.9	6.9	4.7	9.71	13.0	346.1	3.43	15 in	Concrete			1010.46	998.58	11.87	1014.81	1002.83	
5102		TO	1050+30.000000	22.6 LT							9.70													
		ON	EB112A																					
5102		FROM	1050+30.000000	22.6 LT	1.20	0.82	0.98	8.5	6.7	6.6	5.50	8.8	50.9	0.60	18 in	Concrete			998.31	998.00	0.31	1002.83	1000.99	
5103		TO	1049+80.526852	34.5 LT							3.75													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: JAD
CHECKED BY: LAG
SHEET NO. 2

DATE: 09/24/13
DATE: 09/24/13

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	WB112A																					
5200		FROM	1062+88.00000	19.0 LT	0.62	0.83	0.51	7.0	7.1	3.6	4.40	4.9	164.1	0.50	15 in	Concrete			1022.60	1021.78	0.82	1026.85	1026.66	
5201		TO	1064+52.00000	25.0 LT							4.22													
		ON	WB112A																					
5201		FROM	1064+52.00000	25.0 LT	1.80	0.83	1.49	7.6	7.0	10.4	5.63	12.1	278.0	0.50	21 in	Concrete			1021.28	1019.89	1.39	1026.66	1027.27	
5202		TO	1067+30.00000	25.0 LT							5.90													
		ON	WB112A																					
5202		FROM	1067+30.00000	25.0 LT	1.94	0.82	1.60	8.4	6.8	10.8	5.73	12.1	200.1	0.50	21 in	Concrete			1019.79	1018.79	1.00	1027.27	1026.62	
5203		TO	1069+30.00000	19.0 LT							6.02													
		ON	WB112A																					
5203		FROM	1069+30.00000	19.0 LT	2.43	0.82	2.00	9.0	6.6	13.1	6.05	17.3	400.0	0.50	24 in	Concrete			1018.54	1016.54	2.00	1026.62	1024.11	
5204		TO	1073+30.00000	19.0 LT							5.31													
		ON	WB112A																					
5204		FROM	1073+30.00000	19.0 LT	3.44	0.83	2.84	10.1	5.6	15.9	6.25	17.3	315.0	0.50	24 in	Concrete			1016.44	1014.86	1.58	1024.11	1020.16	
5206		TO	1076+45.00000	19.0 LT							6.58													
		ON	WB112A																					OUTLET ELEV. TO BE
5206		FROM	1076+45.00000	19.0 LT	4.75	0.82	3.91	11.0	5.4	21.1	8.92	33.6	69.8	1.00	24 in	Concrete			1009.95	1009.25	0.70	1020.16	1012.00	CONFIRMED
5207		TO	1076+74.73042	104.1 LT							8.64													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	WB112A																					
5205		FROM	1078+90.00000	19.0 LT	0.54	0.81	0.44	7.0	7.1	3.1	4.25	4.9	245.0	0.50	15 in	Concrete			1012.81	1011.59	1.23	1017.06	1020.16	
5206		TO	1076+45.00000	19.0 LT							4.33													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

DRAFT PRELIMINARY DESIGN

CSAH 112 - CSAH 6 TO TH 12 HENNEPIN COUNTY	DESIGN FREQUENCY: 10 YRS LOW PT FREQUENCY: 10 YRS	INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE	COMP. BY: JAD CHECKED BY: LAG SHEET NO. 3	DATE: 09/24/13 DATE: 09/24/13	

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
 5250 5252		ON FROM TO	EB112B 1090+95.000000 1089+19.000000	 41.0 LT 19.0 LT	1.07	0.71	0.76	12.0	5.2	3.9	6.44 6.43	7.9	176.1	1.28	15 in	Concrete			1018.78	1016.53	2.25	1023.03	1020.78	CONNECT TO OFFSITE DI
 5252 5253		ON FROM TO	WB112A 1089+19.000000 1085+19.000000	 19.0 LT 19.0 LT	1.95	0.74	1.44	12.5	5.1	7.3	6.42 6.42	10.5	400.0	0.85	18 in	Concrete			1016.28	1012.88	3.40	1020.78	1017.38	
 5253 5256		ON FROM TO	WB112A 1085+19.000000 1084+25.000000	 19.0 LT 19.0 LT	2.92	0.76	2.23	13.5	4.9	10.9	7.09 7.06	15.8	94.0	0.85	21 in	Concrete			1012.63	1011.83	0.80	1017.38	1016.58	
 5256 5257		ON FROM TO	WB112A 1084+25.000000 1084+07.119677	 19.0 LT 95.5 LT	4.26	0.77	3.29	13.7	4.8	15.9	8.31 8.05	24.5	57.3	1.00	24 in	Concrete			1009.57	1009.00	0.57	1016.58	1016.83	OUTLET ELEV. TO BE CONFIRMED
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 5251 5252		ON FROM TO	NBWILLOW 2103+20.000000 1089+19.000000	 49.0 LT 19.0 LT	0.53	0.72	0.38	12.0	5.2	2.0	4.78 4.77	6.7	84.0	0.93	15 in	Concrete			1017.31	1016.53	0.78	1021.56	1020.78	PIPE RUN MAY BE IN CONFLICT WITH SIGNAL POLE
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 5254 5255		ON FROM TO	WB112A 1081+35.000000 1082+88.000000	 19.0 LT 19.0 LT	0.77	0.80	0.62	7.0	7.1	4.4	4.54 4.94	4.9	153.0	0.50	15 in	Concrete			1011.82	1011.05	0.77	1015.57	1015.73	
 5255 5256		ON FROM TO	WB112A 1082+88.000000 1084+25.000000	 19.0 LT 19.0 LT	1.11	0.80	0.88	7.6	7.0	6.2	5.01 3.56	8.0	137.0	0.50	18 in	Concrete			1010.80	1010.12	0.69	1015.73	1016.58	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
 0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

DRAFT PRELIMINARY DESIGN

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: JAD
CHECKED BY: LAG
SHEET NO. 4

DATE: 09/24/13
DATE: 09/24/13

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					CONNECT TO OFFSITE
5300		FROM	1096+20.00000	32.8 LT	1.88	0.63	1.19	15.0	4.6	5.4	6.61	7.4	318.7	1.13	15 in	Concrete			1019.34	1015.73	3.60	1023.59	1019.98	DI
5301		TO	1099+34.00000	31.0 LT							6.61													
		ON	EB112B																					
5301		FROM	1099+34.00000	31.0 LT	2.27	0.67	1.51	15.8	4.5	6.8	7.61	8.4	261.4	1.44	15 in	Concrete			1015.63	1011.87	3.77	1019.98	1016.12	
5302		TO	1101+92.00000	31.0 LT							7.61													
		ON	EB112B																					
5302		FROM	1101+92.00000	31.0 LT	2.59	0.69	1.78	16.4	4.4	7.9	7.72	8.4	122.0	1.44	15 in	Concrete			1011.77	1010.04	1.76	1016.12	1014.29	
5303		TO	1103+14.00000	31.0 LT							7.72													
		ON	EB112B																					CONNECT TO OFFSITE
5303		FROM	1103+14.00000	31.0 LT	7.57	0.63	4.80	20.0	4.1	19.6	9.92	21.0	141.0	1.50	21 in	Concrete			1009.54	1007.42	2.12	1014.29	1012.17	DI
5304		TO	1104+55.00000	31.0 LT							9.88													
		ON	EB112B																					CONNECT TO OFFSITE
5304		FROM	1104+55.00000	31.0 LT	9.63	0.63	6.07	20.2	4.1	24.7	10.89	30.8	135.1	1.58	24 in	Concrete			1007.17	1005.03	2.14	1012.17	1010.03	DI
5305		TO	1105+92.00000	31.0 LT							10.74													
		ON	EB112B																					
5305		FROM	1105+92.00000	31.0 LT	10.76	0.64	6.85	20.4	4.1	27.7	12.77	36.5	204.7	2.22	24 in	Concrete			1004.93	1000.39	4.54	1010.03	1005.39	
5306		TO	1108+00.00000	31.0 LT							12.65													
		ON	EB112B																					ADD DROPS AND
5306		FROM	1108+00.00000	31.0 LT	11.92	0.64	7.65	20.7	4.0	30.8	15.33	44.7	286.2	3.32	24 in	Concrete			1000.29	990.79	9.50	1005.39	995.79	FLATTEN PIPE
5307		TO	1110+91.00000	31.0 LT							15.26													
		ON	EB112B																					ADD DROPS AND
5307		FROM	1110+91.00000	31.0 LT	13.20	0.64	8.50	21.0	4.0	34.0	16.00	45.9	108.6	3.51	24 in	Concrete			990.69	986.88	3.81	995.79	991.88	FLATTEN PIPE
5308		TO	1112+00.00000	25.0 LT							15.09													
		ON	EB112B																					ADD DROPS AND
5308		FROM	1112+00.00000	25.0 LT	13.49	0.65	8.71	21.1	4.0	34.7	15.99	45.6	291.6	3.46	24 in	Concrete			986.78	976.69	10.09	991.88	981.69	FLATTEN PIPE
5309		TO	1114+91.00000	30.0 LT							15.88													
		ON	EB112B																					
5309		FROM	1114+91.00000	30.0 LT	13.49	0.65	8.71	21.1	4.0	34.7	9.98	44.4	41.5	1.00	30 in	Concrete			972.42	972.00	0.41	981.69	974.25	
5310		TO	1114+95.44851	71.2 LT							7.08													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY:	10	YRS
LOW PT FREQUENCY:	10	YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY:	JAD
CHECKED BY:	LAG
SHEET NO.	5

DATE:	09/24/13
DATE:	09/25/13

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Local Tc (min)	RAINFALL INTEN-SITY (in/hr)	Local Flow Only TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					OUTLET FOR BROWN
5400		FROM	1116+31.886958	72.6 LT	1.00	0.72	0.72	7.0	7.1	5.1	9.70	333.0	125.2	4.58	48 in	Concrete			965.36	959.63	5.73	976.14	971.70	POND - SEE MODEL
5401		TO	1117+42.000000	31.0 LT							9.67													
		ON	EB112B																					REROUTE SOUTH
5401		FROM	1117+42.000000	31.0 LT	8.76	0.60	5.27	25.2	3.6	19.2	10.30	207.0	218.2	1.77	48 in	Concrete			959.53	955.66	3.86	971.70	963.85	DRAINAGE TO THIS
5402		TO	1119+50.809391	36.9 LT							10.24													SYSTEM
		ON	EB112B																					2 CONNECTIONS TO
5402		FROM	1119+50.809391	36.9 LT	10.24	0.60	6.16	25.5	3.6	22.2	10.75	207.0	131.2	1.77	48 in	Concrete			955.56	953.24	2.32	963.85	960.59	OFFSITE
5403		TO	1120+76.000000	31.0 LT							10.42													
		ON	EB112B																					
5403		FROM	1120+76.000000	31.0 LT	11.13	0.60	6.71	25.7	3.6	24.1	11.18	211.1	92.5	1.84	48 in	Concrete			953.14	951.44	1.70	960.59	959.24	
5404		TO	1121+66.000000	30.0 LT							10.44													
		ON	EB112B																					
5404		FROM	1121+66.000000	30.0 LT	11.32	0.61	6.87	25.9	3.6	24.6	11.24	211.1	28.6	1.84	48 in	Concrete			951.34	950.81	0.53	959.24	957.00	
5405		TO	1121+88.308792	47.9 LT							1.96													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	EB112B																					
5400A		FROM	1117+39.285203	24.8 RT	5.34	0.57	3.04	25.0	3.7	11.1	5.89	12.6	55.9	0.54	21 in	Concrete			967.25	966.95	0.30	972.00	971.70	
5401		TO	1117+42.000000	31.0 LT							6.09													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: JAD
CHECKED BY: LAG
SHEET NO. 6

DATE: 09/24/13
DATE: 09/25/13

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	LOCATION STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					ASSUME NO
5450		FROM	1130+93.00000	20.0 LT	0.39	0.74	0.28	7.0	7.1	2.0	5.51	8.2	101.4	1.37	15 in	Concrete			962.73	961.34	1.38	966.98	965.59	CONNECTION FROM
5451		TO	1129+88.00000	20.0 LT							5.51													LIBRARY
		ON	EB112B																					
5451		FROM	1129+88.00000	20.0 LT	0.60	0.76	0.45	7.3	7.1	3.2	6.47	8.6	299.3	1.49	15 in	Concrete			961.24	956.77	4.47	965.59	961.02	
5452		TO	1126+86.00000	24.0 LT							6.47													
		ON	EB112B																					
5452		FROM	1126+86.00000	24.0 LT	1.23	0.82	1.01	8.1	6.9	7.0	5.13	8.0	59.1	0.50	18 in	Concrete			956.52	956.23	0.30	961.02	961.21	
5453		TO	1126+27.00000	20.0 LT							5.43													
		ON	EB112B																					CONNECT TO OFFSITE
5453		FROM	1126+27.00000	20.0 LT	2.72	0.72	1.95	15.0	4.6	8.9	5.51	12.1	370.0	0.50	21 in	Concrete			955.98	954.13	1.85	961.21	958.89	
5454		TO	1122+57.00000	24.4 LT							5.51													
		ON	EB112B																					
5454		FROM	1122+57.00000	24.4 LT	3.91	0.73	2.85	16.1	4.5	12.7	6.01	17.3	37.1	0.50	24 in	Concrete			953.88	953.69	0.19	958.89	958.92	
5455		TO	1122+20.00000	26.8 LT							6.01													
		ON	EB112B																					
5455		FROM	1122+20.00000	26.8 LT	4.02	0.73	2.95	16.2	4.5	13.1	6.05	17.3	26.4	0.50	24 in	Concrete			951.22	951.09	0.13	958.92	953.09	
5456		TO	1122+00.00000	44.0 LT							4.18													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

DRAFT PRELIMINARY DESIGN

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: JAD DATE: 09/24/13
CHECKED BY: LAG DATE: 09/25/13
SHEET NO. 7

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION	OFFSET	CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					
5500		FROM	1133+57.00000(	20.0 LT	0.09	0.88	0.08	7.0	7.1	0.6	4.30	9.5	369.0	1.83	15 in	Concrete			962.58	955.82	6.76	966.83	960.07	
5501		TO	1137+26.00000(	20.0 LT							4.30													
		ON	EB112B																					
5501		FROM	1137+26.00000(	20.0 LT	0.49	0.82	0.40	8.4	6.8	2.7	7.39	10.9	92.0	2.45	15 in	Concrete			955.72	953.47	2.25	960.07	957.72	
5502		TO	1138+18.00000(	20.0 LT							7.34													
		ON	EB112B																					CONNECT TO MARTHA
5502		FROM	1138+18.00000(	20.0 LT	2.97	0.59	1.74	20.0	4.1	7.1	5.70	9.1	308.5	0.64	18 in	Concrete			953.22	951.26	1.96	957.72	955.26	LANE STORM SEWER
5503		TO	1141+26.00051(	19.0 LT							5.70													
		ON	EB112B																					
5503		FROM	1141+26.00051(	19.0 LT	3.15	0.60	1.90	20.9	4.0	7.6	5.79	9.1	285.2	0.64	18 in	Concrete			951.16	949.33	1.83	955.26	954.01	
5504		TO	1144+11.00000(	18.0 LT							5.79													
		ON	EB112B																					
5504		FROM	1144+11.00000(	18.0 LT	3.55	0.63	2.23	21.7	3.9	8.8	7.08	11.4	26.0	1.00	18 in	Concrete			944.26	944.00	0.26	954.01	952.26	
5505		TO	1144+11.52675(	44.0 LT							4.96													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: DSP
CHECKED BY: JAD
SHEET NO. 8

DATE: 06/07/16
DATE: 06/07/16

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					FLOW AT 80%
5550A		FROM	1146+50.00	18.0 LT	0.13	0.84	0.11	7.0	7.1	0.8	2.91	4.9	127.6	0.50	15 in	Concrete			952.02	951.38	0.64	955.77	956.69	CAPACITY
5550		TO	1147+80.00	18.0 LT							2.91													
		ON	EB112B																					
5550		FROM	1147+80.00	18.0 LT	0.29	0.84	0.24	7.7	7.0	1.7	3.65	4.9	323.3	0.50	15 in	Concrete			951.28	949.67	1.62	956.69	956.50	
5551		TO	1151+05.00	18.0 LT							3.65													
		ON	EB112B																					
5551		FROM	1151+05.00	18.0 LT	0.44	0.84	0.37	9.2	6.4	2.4	4.00	4.9	354.1	0.50	15 in	Concrete			949.57	947.80	1.77	956.50	954.16	
5552		TO	1154+56.99	22.3 LT							4.00													
		ON	EB112B																					
5552		FROM	1154+56.99	22.3 LT	2.10	0.70	1.48	15.0	4.6	6.8	5.09	8.0	218.2	0.50	18 in	Concrete			947.55	946.45	1.09	954.16	952.74	
5560		TO	1156+75.00	21.0 LT							5.36													
		ON	EB112B																					
5560		FROM	1156+75.00	21.0 LT	4.14	0.73	3.03	15.7	4.5	13.7	6.14	17.3	26.0	0.50	24 in	Concrete			945.13	945.00	0.13	952.74	947.00	
5561		TO	1156+82.98	45.7 LT							4.35													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	EB112B																					
5553		FROM	1169+74.00	5.5 LT	0.66	0.69	0.45	12.0	5.2	2.4	7.41	11.6	167.0	2.75	15 in	Concrete			985.45	980.86	4.59	989.70	985.62	
5554		TO	1168+07.00	5.5 LT							7.41													
		ON	EB112B																					
5554		FROM	1168+07.00	5.5 LT	0.85	0.72	0.61	12.4	5.1	3.1	8.29	12.1	96.0	3.00	15 in	Concrete			980.76	977.88	2.88	985.62	982.26	
5555		TO	1167+11.00	5.5 LT							8.26													
		ON	EB112B																					
5555		FROM	1167+11.00	5.5 LT	0.96	0.73	0.70	12.6	5.1	3.5	9.60	14.2	400.0	4.10	15 in	Concrete			977.78	961.38	16.40	982.26	964.65	
5556		TO	1163+11.00	5.5 LT							9.58													
		ON	EB112B																					
5556		FROM	1163+11.00	5.5 LT	1.37	0.75	1.02	13.3	4.9	5.0	9.97	13.1	203.8	3.50	15 in	Concrete			960.30	953.16	7.13	964.65	957.09	
5557		TO	1161+08.00	23.5 LT							9.97													
		ON	EB112B																					
5557		FROM	1161+08.00	23.5 LT	1.59	0.75	1.19	13.6	4.9	5.8	6.38	7.0	316.0	1.00	15 in	Concrete			951.17	948.01	3.16	957.09	952.33	
5558		TO	1157+92.00	23.5 LT							6.38													
		ON	EB112B																					
5558		FROM	1157+92.00	23.5 LT	2.05	0.76	1.56	14.4	4.7	7.3	4.83	10.9	117.0	0.40	21 in	Concrete			947.51	947.04	0.47	952.33	952.74	
5560		TO	1156+75.00	21.0 LT							5.14													Cont to 5560
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY: 10 YRS
LOW PT FREQUENCY: 10 YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY: DSP
CHECKED BY: JAD
SHEET NO. 9

DATE: 06/07/16
DATE: 06/07/16

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					FLOW AT 80%
5600A		FROM	1175+26.00	5.5 LT	0.13	0.84	0.11	7.0	7.1	0.8	2.46	3.8	209.0	0.30	15 in	Concrete			988.90	988.27	0.63	992.61	991.85	CAPACITY
5601		TO	1177+35.00	5.5 LT							0.62													
		ON	EB112B																					
5601		FROM	1177+35.00	5.5 LT	0.77	0.61	0.46	15.0	4.6	2.1	3.24	3.8	135.0	0.30	15 in	Concrete			988.27	987.87	0.41	991.85	991.42	
5602		TO	1178+70.00	5.5 LT							1.73													
		ON	EB112B																					
5602		FROM	1178+70.00	5.5 LT	3.57	0.47	1.68	25.0	3.7	6.1	4.09	6.3	113.0	0.31	18 in	Concrete			987.62	987.27	0.35	991.42	991.47	
5603		TO	1179+83.00	5.5 LT							3.47													
		ON	EB112B																					
5603		FROM	1179+83.00	5.5 LT	5.10	0.47	2.40	25.5	3.6	8.7	4.41	9.4	186.9	0.30	21 in	Concrete			987.02	986.46	0.56	991.47	991.62	
5604		TO	1181+70.00	4.9 RT							3.61													
		ON	EB112B																					
5604		FROM	1181+70.00	4.9 RT	6.81	0.48	3.27	26.2	3.6	11.6	4.81	13.4	146.0	0.30	24 in	Concrete			986.46	986.02	0.44	991.62	992.64	
5605		TO	1183+16.00	4.0 LT							3.70													
		ON	EB112B																					
5605		FROM	1183+16.00	4.0 LT	6.81	0.48	3.27	26.7	3.5	11.5	4.87	13.4	117.4	0.30	24 in	Concrete			986.01	985.66	0.35	992.64	993.60	
5606		TO	1184+30.00	23.5 LT							3.66													
		ON	EB112B																					
5606		FROM	1184+30.00	23.5 LT	7.99	0.48	3.82	27.1	3.5	13.3	4.83	13.4	95.9	0.30	24 in	Concrete			985.53	985.24	0.29	993.60	991.88	
5607		TO	1185+22.39	33.2 LT							4.24													
		ON	EB112B																					
5607		FROM	1185+22.39	33.2 LT	8.28	0.48	3.99	27.4	3.5	13.8	5.09	18.4	16.5	0.30	27 in	Concrete			985.24	985.19	0.05	991.88	988.00	
5608		TO	1185+24.24	49.6 LT							3.47													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

CSAH 112 - CSAH 6 TO TH 12
HENNEPIN COUNTY

DRAFT PRELIMINARY DESIGN

DESIGN FREQUENCY:	10	YRS
LOW PT FREQUENCY:	10	YRS

INVERT ELEV'S ARE TO: x CENTER OF STRUCTURE

COMP. BY:	DSP
CHECKED BY:	JAD
SHEET NO.	10

DATE:	06/07/16
DATE:	06/07/16

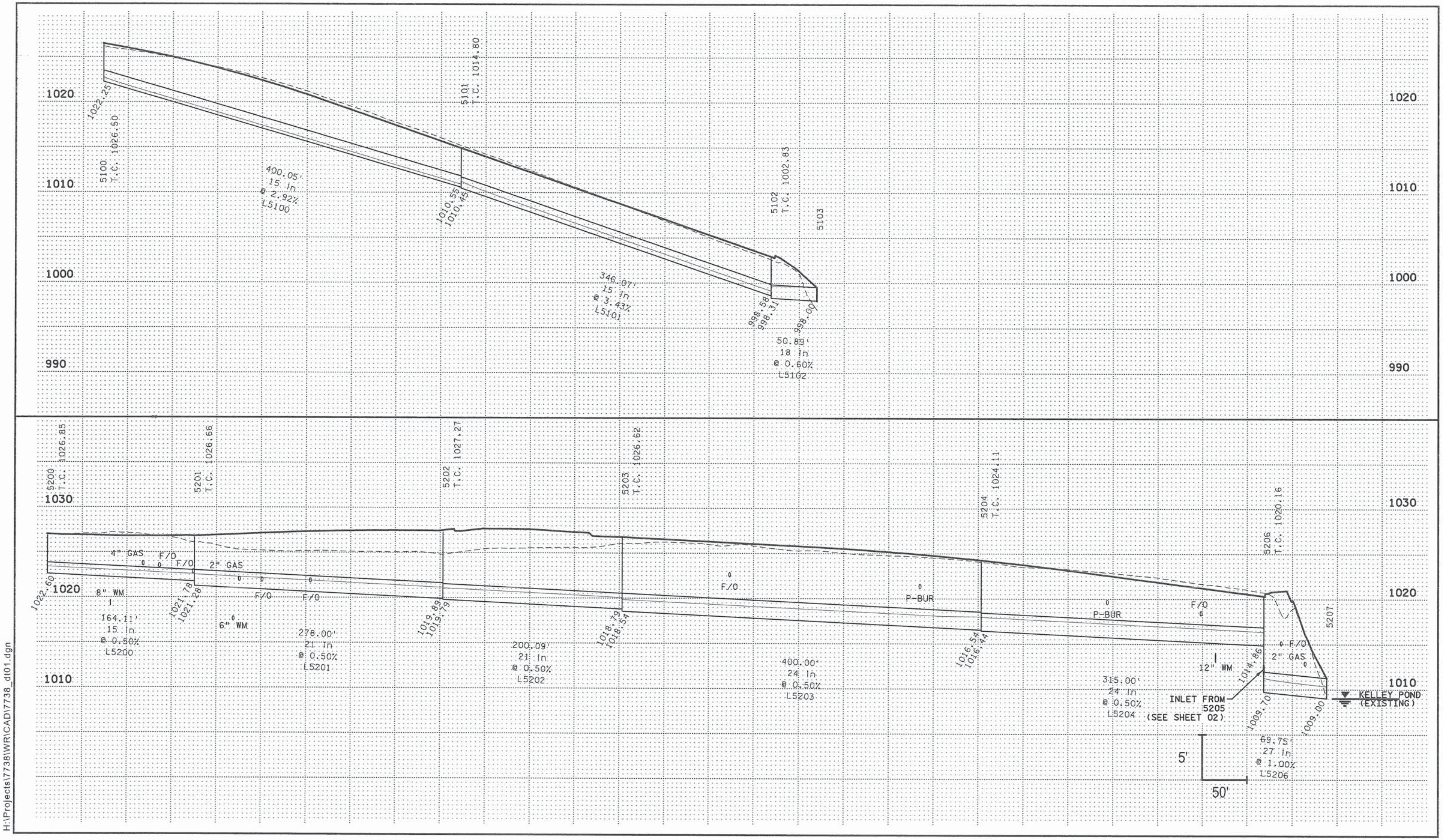
STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION		CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
		ON	EB112B																					
5650		FROM	1187+30.00	23.5 RT	0.59	0.57	0.34	12.0	5.2	1.8	6.80	11.5	97.1	2.72	15 in	Concrete			983.24	980.59	2.64	987.49	984.84	
5651		TO	1188+30.00	23.5 RT							6.77													
		ON	EB112B																					
5651		FROM	1188+30.00	23.5 RT	0.86	0.58	0.50	12.2	5.1	2.5	7.32	11.1	113.6	2.50	15 in	Concrete			980.49	977.65	2.84	984.84	981.90	
5652		TO	1189+47.00	23.5 RT							7.31													
		ON	EB112B																					
5652		FROM	1189+47.00	23.5 RT	0.99	0.61	0.61	12.5	5.1	3.1	7.61	18.0	19.5	2.50	18 in	Concrete			976.84	976.35	0.49	981.90	980.54	
5652A		TO	1189+60.00	38.5 RT							6.71													
		ON	EB112B																					
5652A		FROM	1189+60.00	38.5 RT	1.37	0.56	0.76	12.5	5.1	3.9	4.48	8.0	51.4	0.50	18 in	Concrete			976.35	976.09	0.26	980.54	977.50	
5653		TO	1190+11.53	44.9 RT							2.19													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													
		ON	0																					
0		FROM	0	0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0		TO	0	0.0 RT							0.00													

GEOPAK DRAINAGE STORM DRAIN COMPUTATION SHEET

DRAFT PRELIMINARY DESIGN

CSAH 112 - CSAH 6 TO TH 12	
HENNEPIN COUNTY	
DESIGN FREQUENCY:	10 YRS
LOW PT FREQUENCY:	10 YRS
INVERT ELEV'S ARE TO:	x CENTER OF STRUCTURE
COMP. BY:	DSP
CHECKED BY:	JAD
SHEET NO.	11
DATE:	06/07/16
DATE:	06/07/16

STRUCTURE NUMBER	STRUCTURE TYPE	LOCATION	STREET OR STATION	OFFSET	CUM AREA (acre)	CUM C	SUM C X A	Tc (min)	RAINFALL INTEN-SITY (in/hr)	TOTAL Q (cfs)	FLOW VEL. V normal / V out (ft/s)	FULL PIPE CAP. (cfs)	PIPE DETAILS: APPROX PIPE LENGTH (ft)	SLOPE (%)	PIPE SIZE	PIPE MAT'L	PIPE CLASS OR GAGE	DO NOT USE P.E. ALT.	PIPE INVERT ELEVATION UPPER END	PIPE INVERT ELEVATION LOWER END	FALL (ft)	APPROX. TOP OF CASTING ELEV. UPPER END	APPROX. TOP OF CASTING ELEV. LOWER END	REMARKS
5700 5701		ON FROM TO	EB112B 1206+70.00 1205+35.51	 26.0 LT 19.3 LT	0.89	0.67	0.60	12.0	5.2	3.1	4.26 2.97	4.9	132.8	0.50	15 in	Concrete			963.32	962.66	0.66	967.57	967.38	
5701 5704		ON FROM TO	EB112B 1205+35.51 1205+35.51	 19.3 LT 16.0 RT	1.65	0.66	1.10	12.5	5.1	5.6	4.88 4.96	8.0	35.3	0.50	18 in	Concrete			962.41	962.23	0.18	967.38	968.01	
5704 5705		ON FROM TO	EB112B 1205+35.51 1205+35.51	 16.0 RT 54.0 RT	1.65	0.66	1.10	12.5	5.1	5.6	4.88 3.16	8.0	38.0	0.50	18 in	Concrete			960.65	960.46	0.19	968.01	961.96	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	
0 0		ON FROM TO	0 0 0	 0.0 RT 0.0 RT	0.00	0.00		0.0	0.0	0.0	0.00 0.00	0.0	0.0	0.00	0.000	0.000			0.00	0.00	0.00	0.00	0.00	



H:\Projects\7738\WR\CAD\7738_dl01.dgn

Preliminary Trunk Storm Sewer Profiles

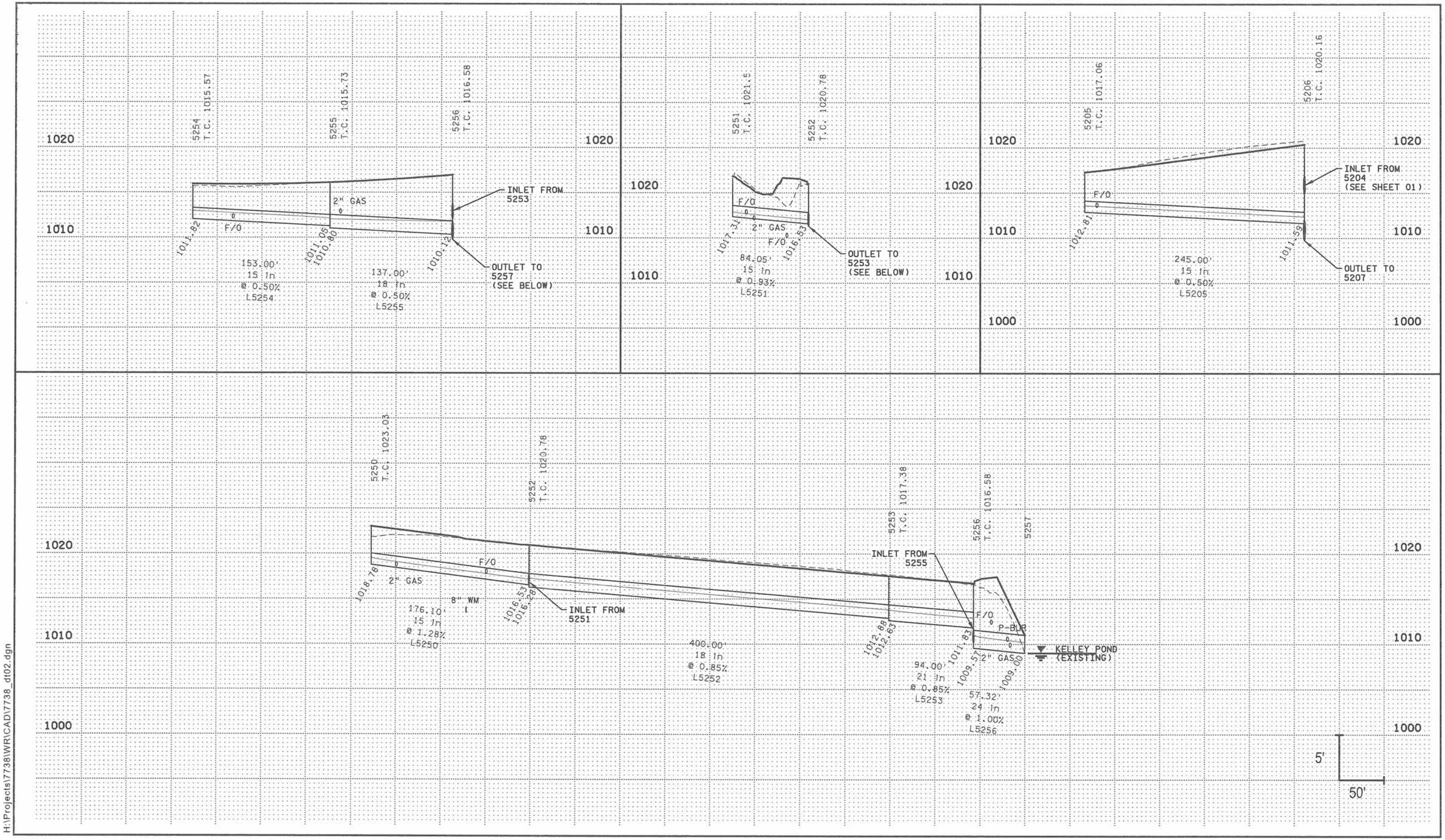
Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

SRF Consulting Group, Inc.

Job 7738
10/23/2013

Sheet 01



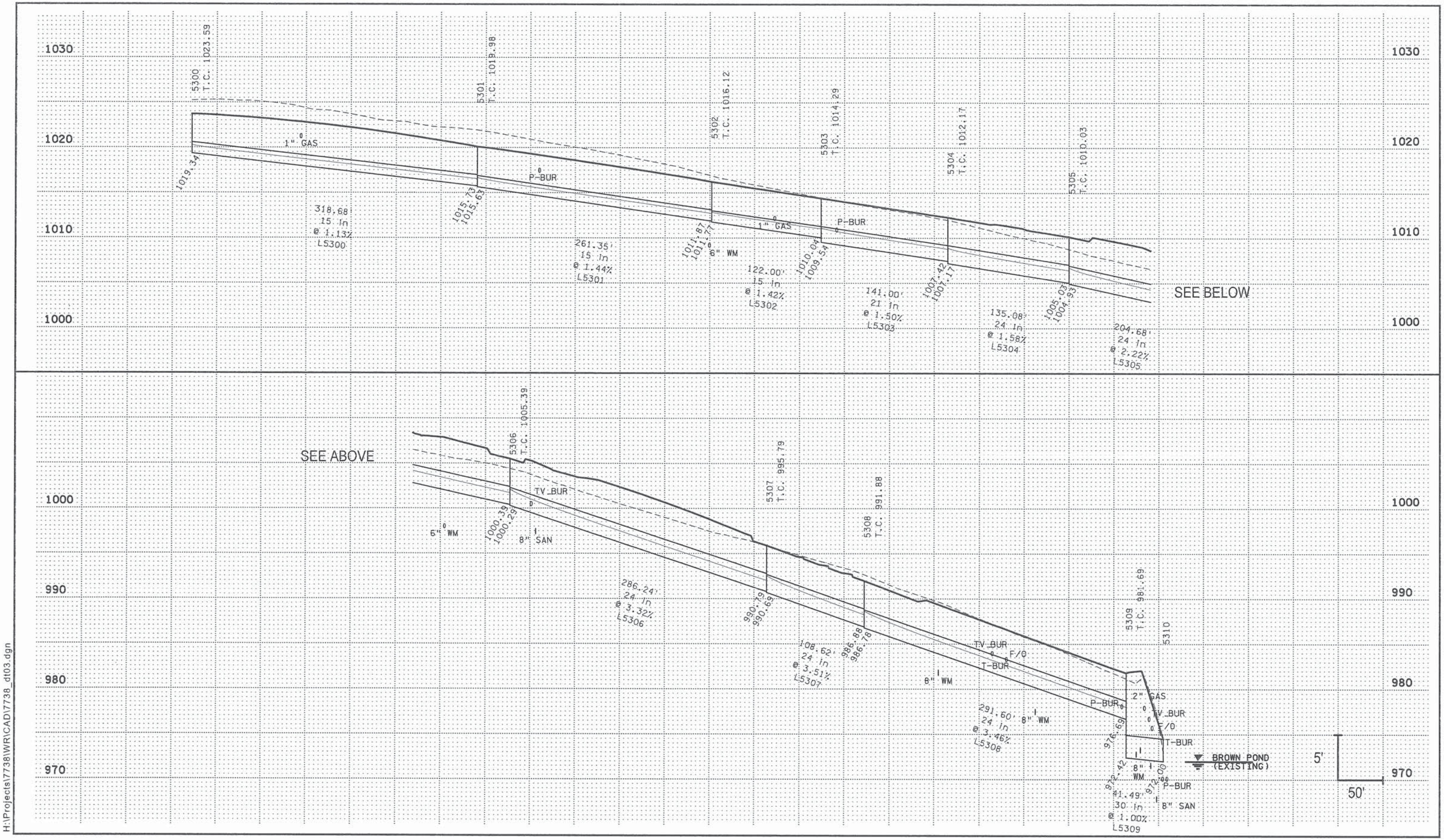
SRF Consulting Group, Inc.

Job 7738
10/23/2013

Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction



H:\Projects\7738\WR\CAD\7738_d103.dgn

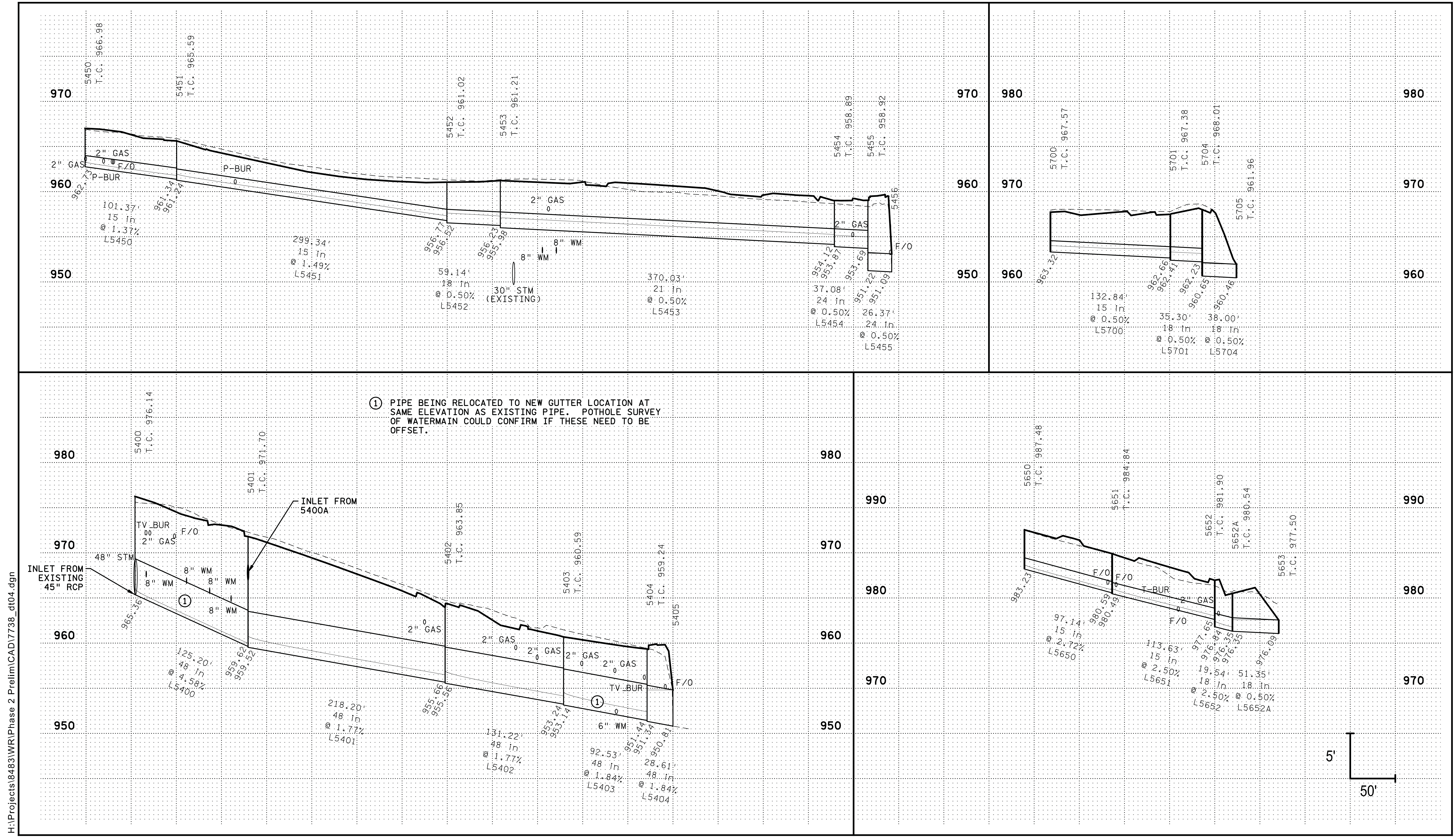
SRF Consulting Group, Inc.

Job 7738
10/23/2013

Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction



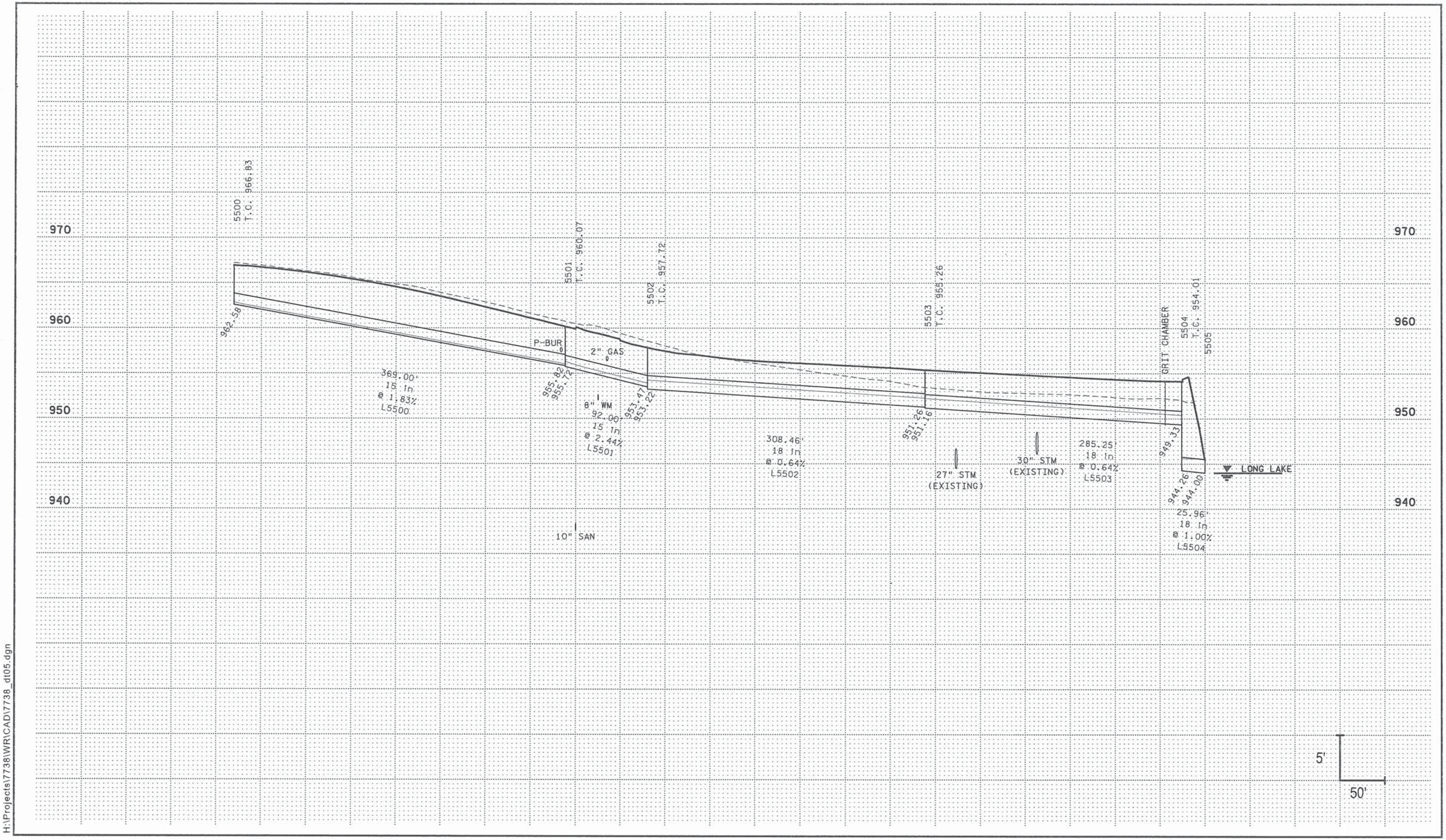
SRF Consulting Group, Inc.

Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Job 7738
6/6/2016



SRF Consulting Group, Inc.

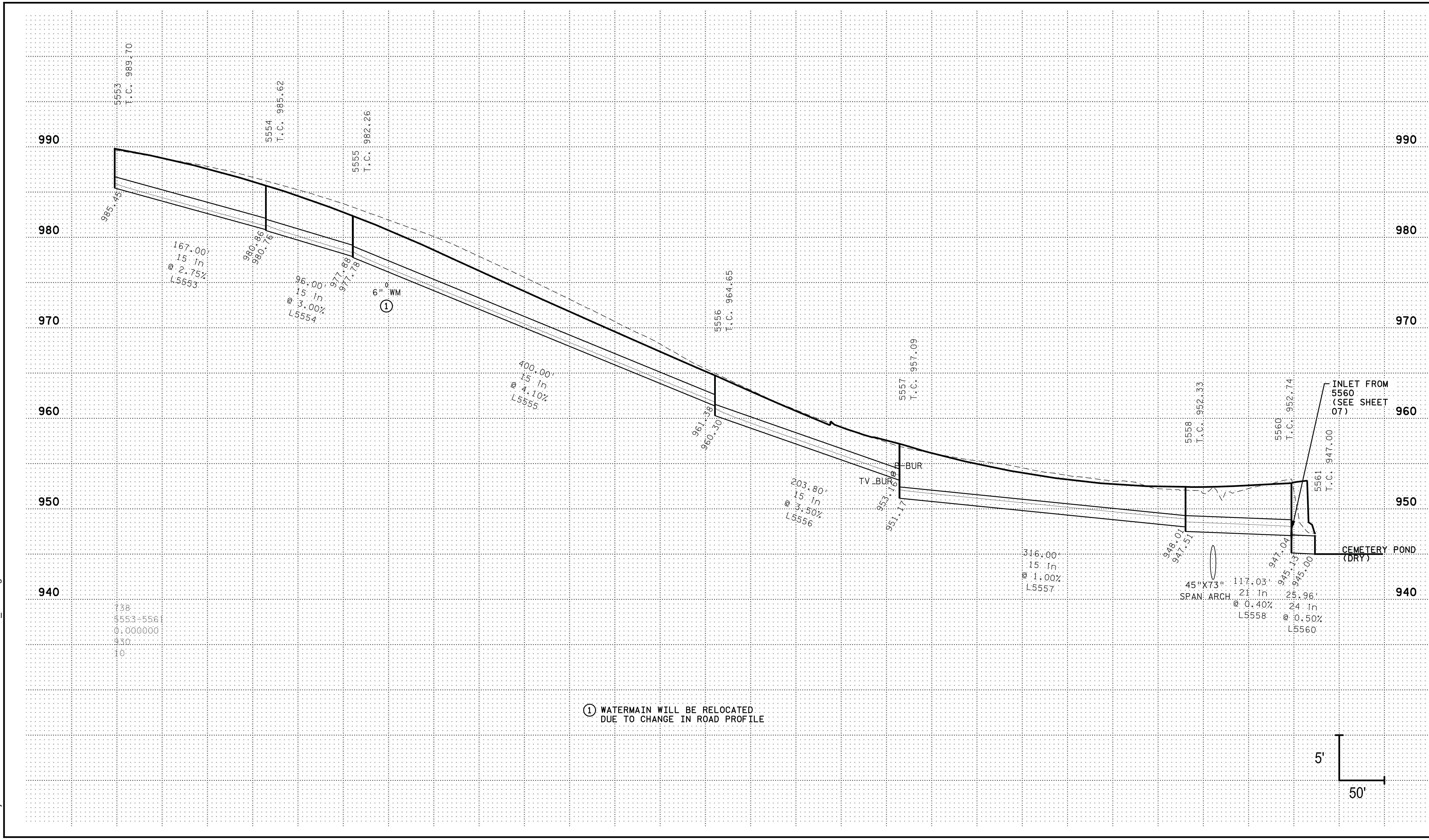
Job 7738
10/23/2013

Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Sheet 05



H:\Projects\8483\WR\Phase 2 Prelim\CAD\7738_dt06.dgn

SRF Consulting Group, Inc.

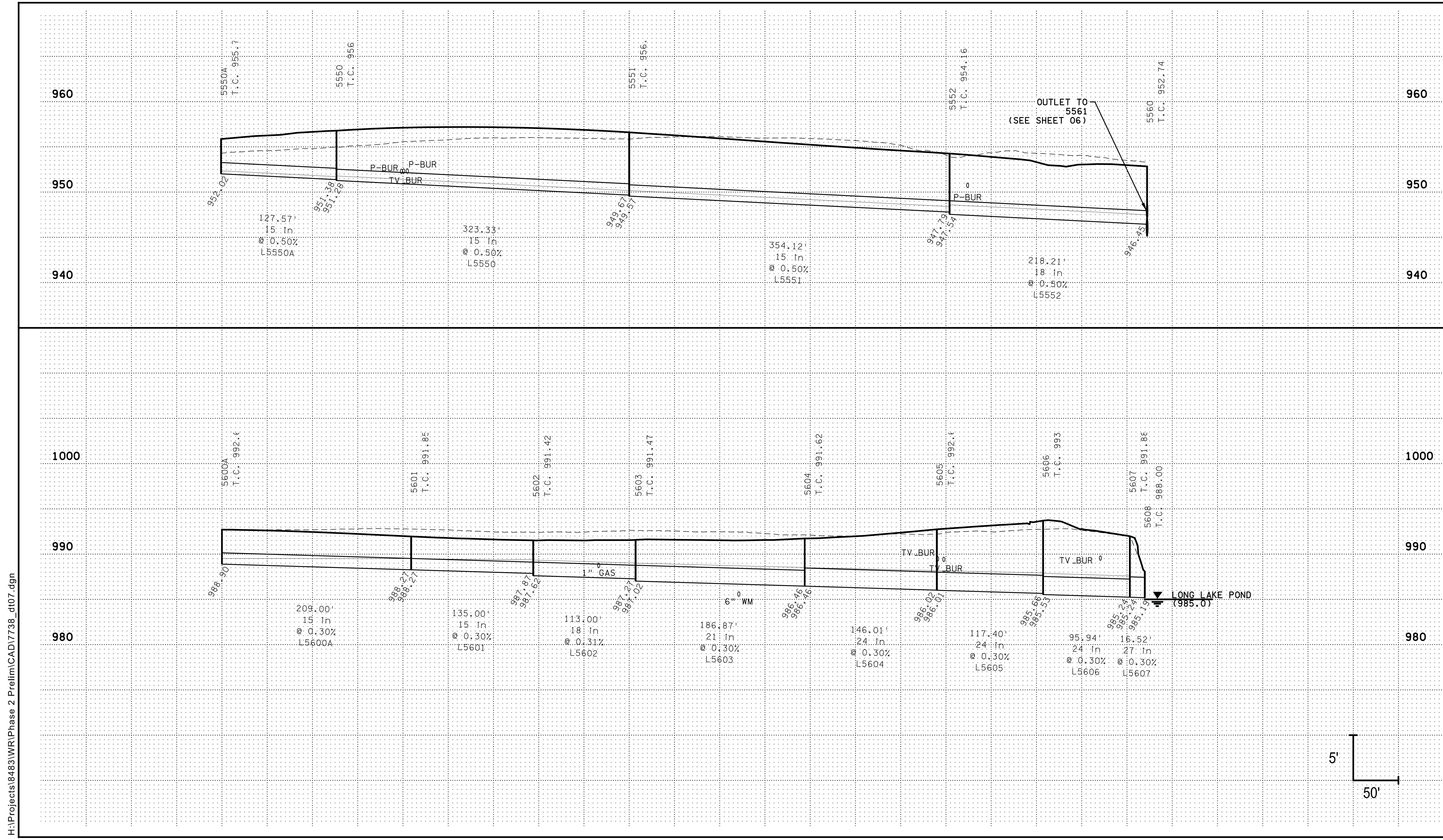
Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Job 7738
6/6/2016

Sheet 06



SRF Consulting Group, Inc.

Preliminary Trunk Storm Sewer Profiles

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Job 7738
6/6/2016

Sheet 07

Appendix D: Culvert Design

CSAH 112 Reconstruction

CSAH 6 to TH 12

HY-8 Culvert Analysis Report

DESIGNED BY: LAB
CHECKED BY: JAD 10/4/13

Table 1 - Summary of Culvert Flows at Crossing: Lakeside Park Trail Crossing

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed Discharge (cfs)	Roadway Discharge (cfs)	Iterations
948.60	0.00	0.00	0.00	1
949.80	21.86	21.86	0.00	1
950.38	43.71	43.71	0.00	1
950.86	65.56	65.56	0.00	1
951.34	87.42	87.42	0.00	1
951.83	109.28	109.28	0.00	1
952.33	131.13	131.13	0.00	1
952.56	141.27	141.27	0.00	1
953.27	174.84	170.73	4.07	4
953.58	196.69	183.32	13.35	4
953.86	218.55	194.31	24.23	4
953.00	159.83	159.83	0.00	Overtopping

*NOTE:

A LARGE ENOUGH CULVERT (UNDERNEATH THE TRAIL) CANNOT BE PLACED IN ORDER TO CONVEY THE LARGE AMOUNT OF ~~[illegible]~~ FLOW. A BRIDGE IS RECOMMENDED.

Table 2 - Culvert Summary Table: Proposed

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	948.60	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
21.86	21.86	949.80	1.204	0.0*	1-S2n	0.547	0.878	0.673	0.000	6.585	0.000
43.71	43.71	950.38	1.777	0.0*	1-S2n	0.777	1.271	1.018	0.000	7.690	0.000
65.56	65.56	950.86	2.256	0.0*	1-S2n	0.970	1.588	1.295	0.000	8.529	0.000
87.42	87.42	951.34	2.742	0.0*	1-S2n	1.121	1.873	1.543	0.000	9.205	0.000
109.28	109.28	951.83	3.230	0.0*	1-S2n	1.271	2.126	1.767	0.000	9.820	0.000
131.13	131.13	952.33	3.726	0.0*	1-S2n	1.410	2.362	1.982	0.000	10.363	0.000
141.27	141.27	952.56	3.960	0.0*	1-S2n	1.468	2.465	2.077	0.000	10.607	0.000
174.84	170.73	953.27	4.665	0.0*	5-S2n	1.638	2.754	2.342	0.000	11.269	0.000
196.69	183.32	953.58	4.979	0.0*	5-S2n	1.710	2.864	2.448	0.000	11.559	0.000
218.55	194.31	953.86	5.261	0.0*	5-S2n	1.773	2.961	2.540	0.000	11.799	0.000

****

Inlet Elevation (invert): 948.60 ft, Outlet Elevation (invert): 948.40 ft

Culvert Length: 13.00 ft, Culvert Slope: 0.0154

****

Site Data - Proposed

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 948.60 ft

Outlet Station: 13.00 ft

Outlet Elevation: 948.40 ft

Number of Barrels: 1

Culvert Data Summary - Proposed

Barrel Shape: Pipe Arch

Barrel Span: 88.00 in

Barrel Rise: 54.00 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Lakeside Park Trail Cross

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	948.40	0.00
21.86	948.40	0.00
43.71	948.40	0.00
65.56	948.40	0.00
87.42	948.40	0.00
109.28	948.40	0.00
131.13	948.40	0.00
141.27	948.40	0.00
174.84	948.40	0.00
196.69	948.40	0.00
218.55	948.40	0.00

Tailwater Channel Data - Lakeside Park Trail Crossing

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 948.40 ft

Roadway Data for Crossing: Lakeside Park Trail Crossing

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 10.00 ft

Crest Elevation: 953.00 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 1 - Summary of Culvert Flows at Crossing: Long Lake Creek Crossing

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Discharge (cfs)	Roadway Discharge (cfs)	Iterations
942.90	0.00	0.00	0.00	1
943.91	10.38	10.38	0.00	1
944.51	20.75	20.75	0.00	1
945.00	31.13	31.13	0.00	1
945.45	41.51	41.51	0.00	1
945.85	51.88	51.88	0.00	1
946.22	62.26	62.26	0.00	1
946.57	72.64	72.64	0.00	1
946.91	83.02	83.02	0.00	1
947.08	88.55	88.55	0.00	1
947.54	103.77	103.77	0.00	1
953.50	291.81	291.81	0.00	Overtopping

Table 2 - Culvert Summary Table: Existing

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	942.90	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
10.38	10.38	943.91	1.011	0.0*	1-S2n	0.352	0.595	0.415	0.000	6.255	0.000
20.75	20.75	944.51	1.614	0.0*	1-S2n	0.658	0.944	0.668	0.000	7.768	0.000
31.13	31.13	945.00	2.101	0.0*	1-S2n	0.858	1.237	0.867	0.000	8.976	0.000
41.51	41.51	945.45	2.550	0.0*	1-S2n	1.057	1.499	1.114	0.000	9.318	0.000
51.88	51.88	945.85	2.954	0.0*	1-S2n	1.248	1.739	1.255	0.000	10.333	0.000
62.26	62.26	946.22	3.322	0.0*	1-S2n	1.417	1.964	1.502	0.000	10.365	0.000
72.64	72.64	946.57	3.672	0.0*	1-S2n	1.586	2.176	1.685	0.000	10.775	0.000
83.02	83.02	946.91	4.006	0.0*	1-S2n	1.755	2.379	1.861	0.000	11.153	0.000
88.55	88.55	947.08	4.179	0.0*	1-S2n	1.841	2.483	1.954	0.000	11.326	0.000
103.77	103.77	947.54	4.636	0.0*	1-S2n	2.070	2.760	2.204	0.000	11.768	0.000

****

Inlet Elevation (invert): 942.90 ft, Outlet Elevation (invert): 942.04 ft

Culvert Length: 86.74 ft, Culvert Slope: 0.0099

****

Site Data - Existing

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 942.90 ft

Outlet Station: 86.74 ft

Outlet Elevation: 942.04 ft

Number of Barrels: 1

Culvert Data Summary - Existing

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Long Lake Creek Crossing)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	942.04	0.00
10.38	942.04	0.00
20.75	942.04	0.00
31.13	942.04	0.00
41.51	942.04	0.00
51.88	942.04	0.00
62.26	942.04	0.00
72.64	942.04	0.00
83.02	942.04	0.00
88.55	942.04	0.00
103.77	942.04	0.00

Tailwater Channel Data - Long Lake Creek Crossing

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 942.04 ft

Roadway Data for Crossing: Long Lake Creek Crossing

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 1116.00 ft

Crest Elevation: 953.50 ft

Roadway Surface: Paved

Roadway Top Width: 40.47 ft

Table 1 - Summary of Culvert Flows at Crossing: Long Lake Creek Crossing

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed Discharge (cfs)	Roadway Discharge (cfs)	Iterations
942.70	0.00	0.00	0.00	1
943.56	10.38	10.38	0.00	1
943.97	20.75	20.75	0.00	1
944.30	31.13	31.13	0.00	1
944.60	41.51	41.51	0.00	1
944.91	51.88	51.88	0.00	1
945.21	62.26	62.26	0.00	1
945.52	72.64	72.64	0.00	1
945.83	83.02	83.02	0.00	1
946.00	88.55	88.55	0.00	1
946.48	103.77	103.77	0.00	1
953.19	253.03	253.03	0.00	Overtopping

Table 2 - Culvert Summary Table: Proposed

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	942.70	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
10.38	10.38	943.56	0.861	0.0*	1-S2n	0.499	0.612	0.502	0.000	5.270	0.000
20.75	20.75	943.97	1.269	0.0*	1-S2n	0.734	0.901	0.740	0.000	6.331	0.000
31.13	31.13	944.30	1.603	0.0*	1-S2n	0.894	1.140	0.900	0.000	7.361	0.000
41.51	41.51	944.60	1.901	0.0*	1-S2n	1.048	1.329	1.049	0.000	8.110	0.000
51.88	51.88	944.91	2.206	0.0*	1-S2n	1.189	1.515	1.228	0.000	8.369	0.000
62.26	62.26	945.21	2.511	0.0*	1-S2n	1.317	1.673	1.327	0.000	9.155	0.000
72.64	72.64	945.52	2.818	0.0*	1-S2n	1.445	1.831	1.453	0.000	9.602	0.000
83.02	83.02	945.83	3.130	0.0*	1-S2n	1.569	1.974	1.635	0.000	9.606	0.000
88.55	88.55	946.00	3.299	0.0*	1-S2n	1.634	2.048	1.705	0.000	9.783	0.000
103.77	103.77	946.48	3.777	0.0*	5-S2n	1.813	2.250	1.887	0.000	10.252	0.000

****

Inlet Elevation (invert): 942.70 ft, Outlet Elevation (invert): 942.08 ft

Culvert Length: 100.31 ft, Culvert Slope: 0.0062

****

Site Data - Proposed

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 942.70 ft

Outlet Station: 100.31 ft

Outlet Elevation: 942.08 ft

Number of Barrels: 1

Culvert Data Summary - Proposed

Barrel Shape: Pipe Arch

Barrel Span: 73.00 in

Barrel Rise: 45.00 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Long Lake Creek Crossing)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	942.08	0.00
10.38	942.08	0.00
20.75	942.08	0.00
31.13	942.08	0.00
41.51	942.08	0.00
51.88	942.08	0.00
62.26	942.08	0.00
72.64	942.08	0.00
83.02	942.08	0.00
88.55	942.08	0.00
103.77	942.08	0.00

Tailwater Channel Data - Long Lake Creek Crossing

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 942.08 ft

Roadway Data for Crossing: Long Lake Creek Crossing

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 1116.00 ft

Crest Elevation: 953.19 ft

Roadway Surface: Paved

Roadway Top Width: 72.80 ft

Appendix E: Pond Design Computations

CSAH 112 Reconstruction

CSAH 6 to TH 12

CSAH 112 PRELIMINARY DESIGN
POND WATER QUALITY TREATMENT

SRF Commission Number: 7738
Designed by: LAB **Date:** 9/12/2013
Checked by: JAD **Date:** 9/26/2013
Revised by: DSP **Date:** 6/7/2016

Pond Water Quality Treatment

Pond	Total Drainage Area to Proposed BMP (ac)	Existing Impervious (ac)	Proposed Conditions			Required Water Quality Volume[2] (cf)	Dead Pool Volume[3] (ac ft)	Comments
			Non-Exempt Impervious (ac)	Exempt Impervious[1] (ac)	Total Change In Impervious (ac)			
Kelley Pond (existing) - located across from Golf Dome	40.40	7.11	6.98	1.11	0.98	0.08	0.18	4.25 acres of additional drainage area was used to calculate the additional dead pool needed.
Brown Pond (existing) - located at intersection with Brown Rd.	30.77	4.84	3.78	0.70	-0.36	N/A	N/A	No additional water quality treatment needed.
Cemetery Pond	4.75	3.23	3.23	0.40	0.40	0.03	DRY	See bioretention computations.
Long Lake Pond - located at intersection with Old Long Lake Road	9.50	1.62	1.64	0.19	0.21	0.02	0.39	
Total		16.80	15.64	2.38	1.22	0.13	0.57	

(positive values only)

Notes:
1. For MCWD, trails that are 12 ft. or less in width and are bordered on the down gradient side by pervious surface that is at least one half of the trail's width are exempt from their stormwater management rule.
2. Water quality volume based on 1"/acre of new impervious.
3. Dead pool volumes based on 1800 cu ft/acre.
- Only takes into account new area draining to existing ponds; assumes ponds have been sized appropriately for current conditions

BIORETENTION SIZING (Mn Stormwater Manual Method)

PROJECT NAME: CSAH 112

SRF Commission Number: 7738

SRF Consulting Group, Inc.

Designed: LAG Date: 9/30/2013

Checked: Date:

Basin Name	HYDROLOGIC DATA				BASIN DESIGN INPUT DATA				
	Tributary Area (Acres)	Composite Curve Number	Design Rainfall (Inches)	Water Quality Volume (Cu. Ft.)	d_f, Depth of Soil Media (Feet)	h_f, Maximum Water Depth (Feet)	t_f, Maximum Time to Drain (Days)	k (In/Hr)	Surface Area (Sq. Ft.)
Cemetery Pond	4.8	91	1.0	5,995.1	2.5	1.5	2	0.6	1,561

 H:\Projects\7738\WR\Excel\Treatment\Cemetery Pond - bioretention sizing.xlsx

POND STORAGE VOLUMES

CUMULATIVE VOLUME (AC-FT)

Project Name: CSAH 112
SRF Commission Number: 7738

Designed By: LAB 01/09/2013
Checked By: JAD 09/25/2013

Pond stage-storage information is taken from the final pond grading plans.

KELLEY POND - ADDITIONAL STORAGE

CONTOUR ELEVATION (FT)	AREA (AC)	VOLUME (AC-FT)	CUMULATIVE VOLUME (AC-FT)	COMMENTS
NWL = 1009	0.24			
		0.13	0.13	
1010	0.27			
		0.27	0.40	
1011	0.27			
		0.27	0.68	
1012	0.27			
		0.27	0.95	
1013	0.27			
		0.05	1.00	ADDITIONAL STORAGE
HWL = 1013.3	0.08			

CEMETERY POND - DRY

CONTOUR ELEVATION (FT)	AREA (AC)	VOLUME (AC-FT)	CUMULATIVE VOLUME (AC-FT)	COMMENTS
BOTTOM = 944.7	0.04			
		0.05	0.05	
945	0.06			
		0.07	0.12	
946	0.07			
		0.08	0.20	
947	0.09			
		0.10	0.29	TOTAL STORAGE
947.25	0.10			

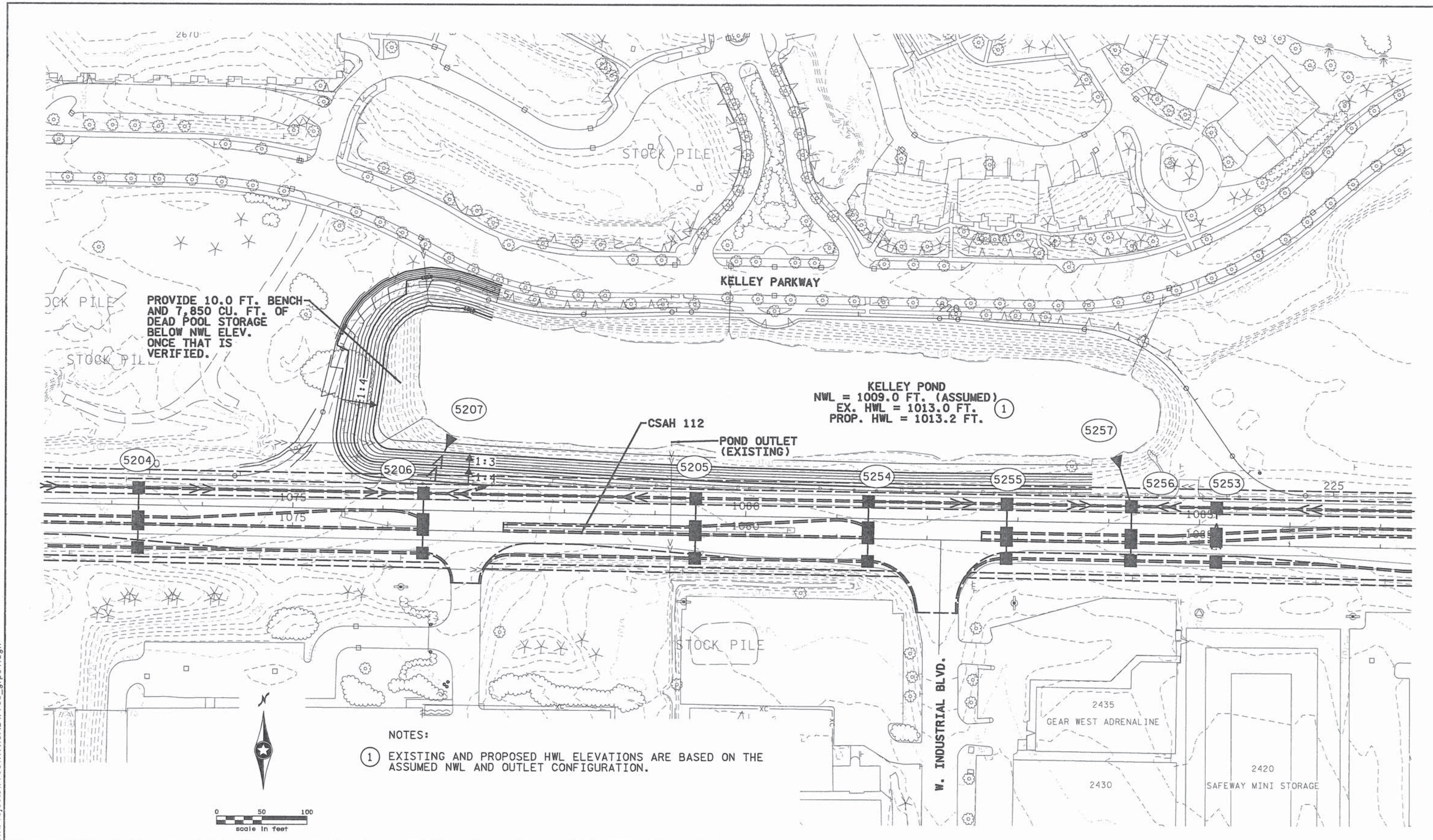
LONG LAKE POND

CONTOUR ELEVATION (FT)	AREA (AC)	VOLUME (AC-FT)	CUMULATIVE VOLUME (AC-FT)	COMMENTS
BOTTOM = 981	0.02			
		0.03	0.03	
982	0.03			
		0.04	0.06	
983	0.04			
		0.05	0.11	
984	0.05			
		0.07	0.17	TOTAL DEAD STORAGE
NWL = 985	0.08			
		0.09	0.26	
986	0.10			
		0.12	0.38	
987	0.13			
		0.03	0.40	TOTAL STORAGE
HWL = 987.2	0.16			

Appendix F: Preliminary Pond Grading

CSAH 112 Reconstruction

CSAH 6 to TH 12



SRF Consulting Group, Inc.

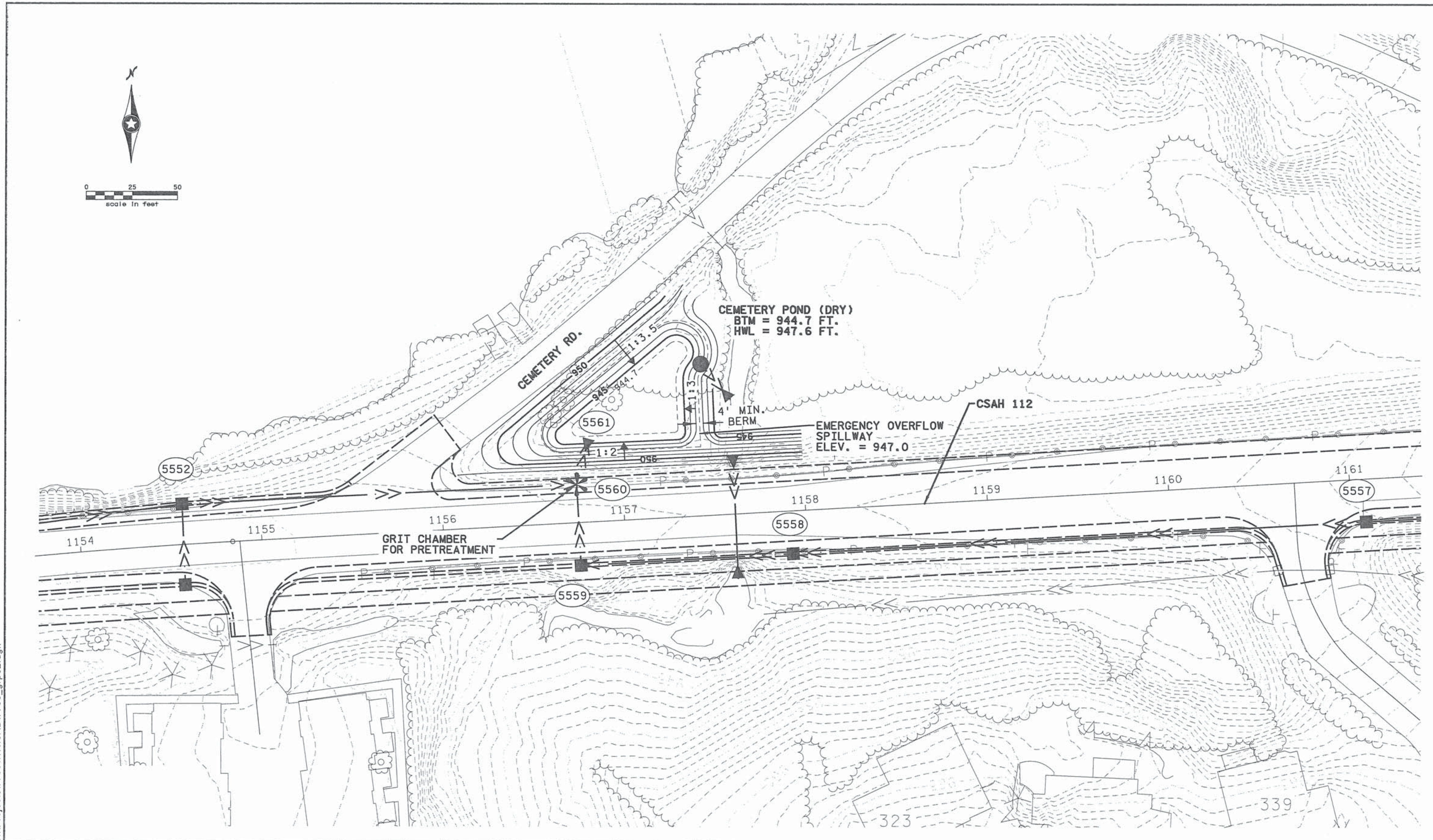
Preliminary Pond Grading

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Job 7738
10/23/2013

Fig 1



SRF Consulting Group, Inc.

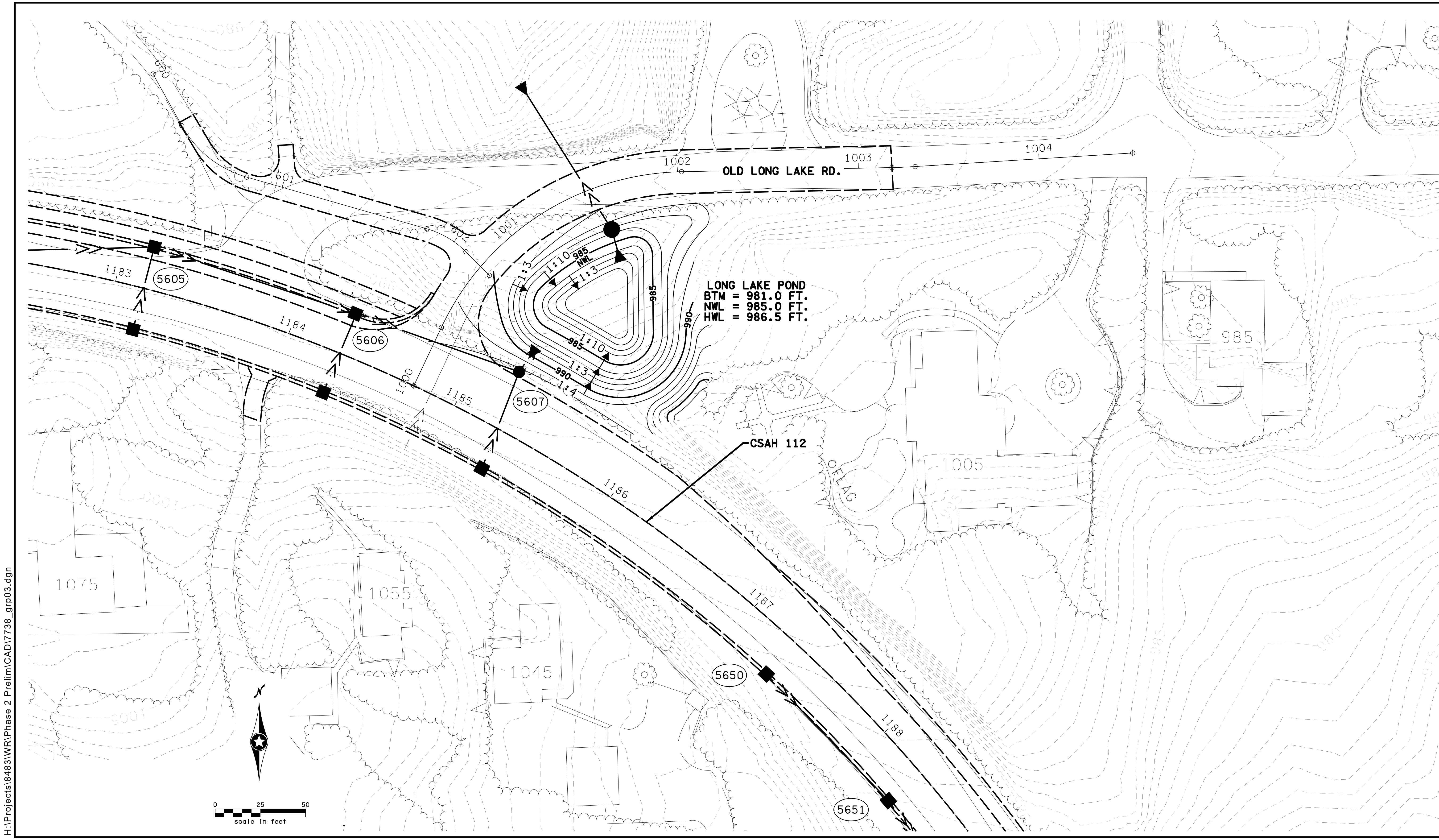
Job 7738
10/23/2013

Preliminary Pond Grading

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Fig 2



SRF Consulting Group, Inc.

Job 7738
6/7/2016

Preliminary Pond Grading

Water Resources Preliminary Drainage Design Report

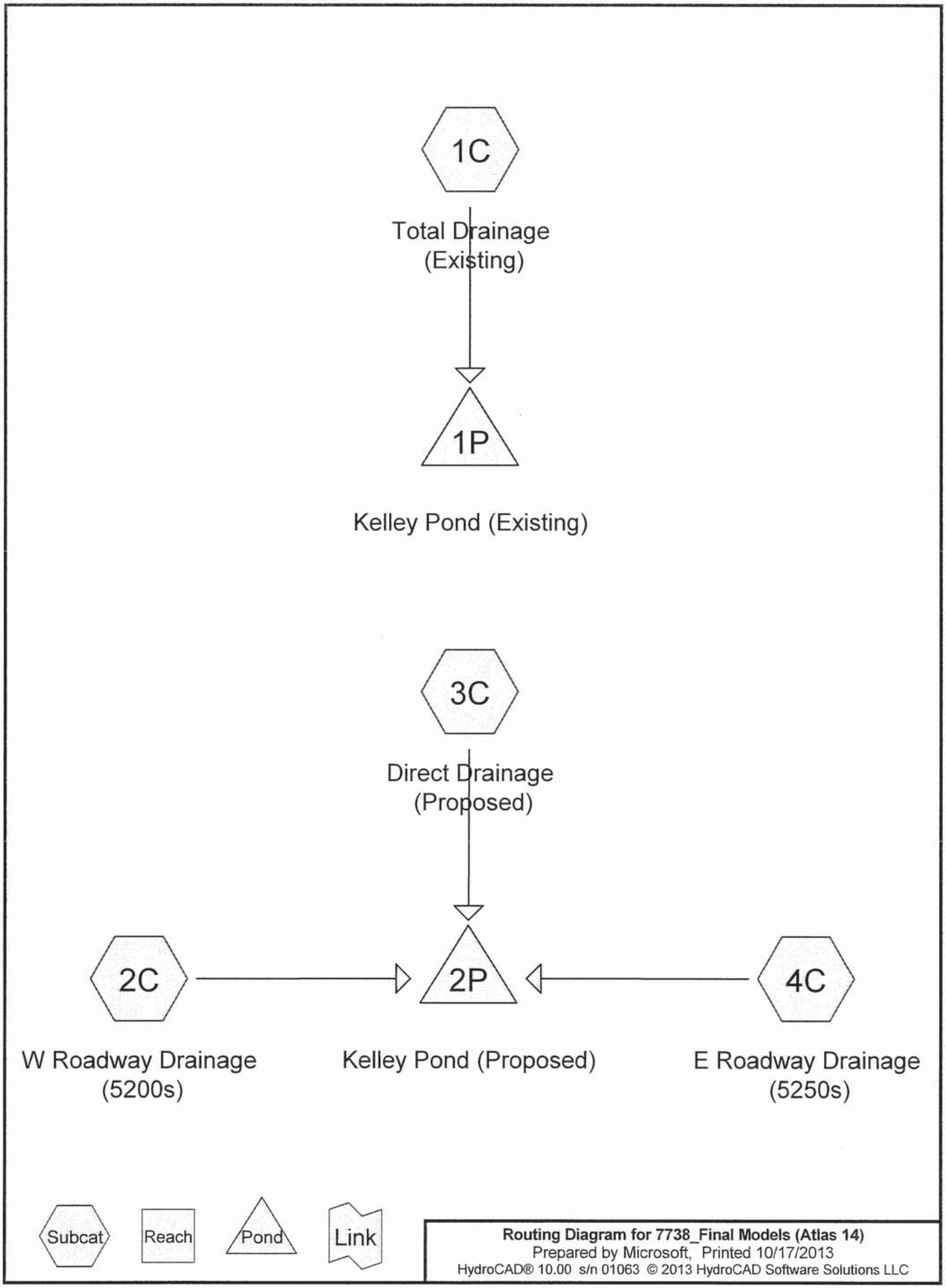
CSAH 112 Reconstruction

Fig 3

Appendix G: HydroCAD Model – Kelley Pond System

CSAH 112 Reconstruction

CSAH 6 to TH 12



Routing Diagram for 7738_Final Models (Atlas 14)
Prepared by Microsoft, Printed 10/17/2013

Summary for Subcatchment 1C: Total Drainage (Existing)

Runoff = 43.29 cfs @ 12.27 hrs, Volume= 4.308 af, Depth= 1.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
4.240	98	Paved roads w/curbs & sewers, HSG C
6.340	61	>75% Grass cover, Good, HSG B
6.340	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
4.560	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
36.660	84	Weighted Average
18.524		50.53% Pervious Area
18.136		49.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	300	0.0133	0.19		**Sheet Flow,** Range n= 0.130 P2= 2.80"
4.8	200	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
31.3	500	Total			

Summary for Subcatchment 2C: W Roadway Drainage (5200s)

Runoff = 14.40 cfs @ 12.02 hrs, Volume= 0.843 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
3.830	98	Paved roads w/curbs & sewers, HSG C
0.920	74	>75% Grass cover, Good, HSG C
4.750	93	Weighted Average
0.920		19.37% Pervious Area
3.830		80.63% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 3C: Direct Drainage (Proposed)

Runoff = 35.16 cfs @ 12.27 hrs, Volume= 3.513 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
0.960	98	Paved roads w/curbs & sewers, HSG C
5.730	61	>75% Grass cover, Good, HSG B
5.720	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
3.810	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
31.400	83	Weighted Average
17.084		54.41% Pervious Area
14.316		45.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.3					**Direct Entry, Matches Existing**

Summary for Subcatchment 4C: E Roadway Drainage (5250s)

Runoff = 11.40 cfs @ 12.05 hrs, Volume= 0.722 af, Depth= 2.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
2.720	98	Paved roads w/curbs & sewers, HSG C
0.780	74	>75% Grass cover, Good, HSG C
0.750	91	Urban industrial, 72% imp, HSG C
4.250	92	Weighted Average
0.990		23.29% Pervious Area
3.260		76.71% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.8					**Direct Entry, See Pipe Comps**

Summary for Pond 1P: Kelley Pond (Existing)

Inflow Area = 36.660 ac, 49.47% Impervious, Inflow Depth = 1.41" for 2-yr event
Inflow = 43.29 cfs @ 12.27 hrs, Volume= 4.308 af
Outflow = 4.02 cfs @ 13.88 hrs, Volume= 4.060 af, Atten= 91%, Lag= 96.6 min
Primary = 4.02 cfs @ 13.88 hrs, Volume= 4.060 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 1,010.07' @ 13.88 hrs Surf.Area= 2.382 ac Storage= 2.426 af

Plug-Flow detention time= 545.1 min calculated for 4.060 af (94% of inflow)
Center-of-Mass det. time= 513.3 min (1,368.2 - 854.9)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	13.165 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.160	0.000	0.000
1,010.00	2.370	2.265	2.265
1,011.00	2.550	2.460	4.725
1,012.00	2.720	2.635	7.360
1,013.00	2.900	2.810	10.170
1,014.00	3.090	2.995	13.165

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=4.02 cfs @ 13.88 hrs HW=1,010.07' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 4.02 cfs @ 4.19 fps)

Summary for Pond 2P: Kelley Pond (Proposed)

Inflow Area = 40.400 ac, 52.98% Impervious, Inflow Depth = 1.51" for 2-yr event
Inflow = 45.78 cfs @ 12.10 hrs, Volume= 5.078 af
Outflow = 4.56 cfs @ 13.80 hrs, Volume= 4.775 af, Atten= 90%, Lag= 102.1 min
Primary = 4.56 cfs @ 13.80 hrs, Volume= 4.775 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 1,010.16' @ 13.80 hrs Surf.Area= 2.668 ac Storage= 2.936 af

Plug-Flow detention time= 570.1 min calculated for 4.774 af (94% of inflow)
Center-of-Mass det. time= 537.0 min (1,378.0 - 840.9)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	14.500 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.400	0.000	0.000
1,010.00	2.640	2.520	2.520
1,011.00	2.820	2.730	5.250
1,012.00	2.990	2.905	8.155
1,013.00	3.170	3.080	11.235
1,014.00	3.360	3.265	14.500

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=4.56 cfs @ 13.80 hrs HW=1,010.16' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 4.56 cfs @ 4.31 fps)

Summary for Subcatchment 1C: Total Drainage (Existing)

Runoff = 80.41 cfs @ 12.27 hrs, Volume= 7.948 af, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
4.240	98	Paved roads w/curbs & sewers, HSG C
6.340	61	>75% Grass cover, Good, HSG B
6.340	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
4.560	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
36.660	84	Weighted Average
18.524		50.53% Pervious Area
18.136		49.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	300	0.0133	0.19		**Sheet Flow,** Range n= 0.130 P2= 2.80"
4.8	200	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
31.3	500	Total			

Summary for Subcatchment 2C: W Roadway Drainage (5200s)

Runoff = 22.83 cfs @ 12.02 hrs, Volume= 1.375 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
3.830	98	Paved roads w/curbs & sewers, HSG C
0.920	74	>75% Grass cover, Good, HSG C
4.750	93	Weighted Average
0.920		19.37% Pervious Area
3.830		80.63% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 3C: Direct Drainage (Proposed)

Runoff = 66.58 cfs @ 12.27 hrs, Volume= 6.577 af, Depth= 2.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
0.960	98	Paved roads w/curbs & sewers, HSG C
5.730	61	>75% Grass cover, Good, HSG B
5.720	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
3.810	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
31.400	83	Weighted Average
17.084		54.41% Pervious Area
14.316		45.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.3					**Direct Entry, Matches Existing**

Summary for Subcatchment 4C: E Roadway Drainage (5250s)

Runoff = 18.37 cfs @ 12.05 hrs, Volume= 1.193 af, Depth= 3.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
2.720	98	Paved roads w/curbs & sewers, HSG C
0.780	74	>75% Grass cover, Good, HSG C
0.750	91	Urban industrial, 72% imp, HSG C
4.250	92	Weighted Average
0.990		23.29% Pervious Area
3.260		76.71% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.8					**Direct Entry, See Pipe Comps**

Summary for Pond 1P: Kelley Pond (Existing)

Inflow Area = 36.660 ac, 49.47% Impervious, Inflow Depth = 2.60" for 10-yr event
Inflow = 80.41 cfs @ 12.27 hrs, Volume= 7.948 af
Outflow = 8.30 cfs @ 13.55 hrs, Volume= 7.687 af, Atten= 90%, Lag= 77.0 min
Primary = 8.30 cfs @ 13.55 hrs, Volume= 7.687 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 1,010.92' @ 13.55 hrs Surf.Area= 2.536 ac Storage= 4.525 af

Plug-Flow detention time= 446.8 min calculated for 7.686 af (97% of inflow)
Center-of-Mass det. time= 427.7 min (1,265.2 - 837.4)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	13.165 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.160	0.000	0.000
1,010.00	2.370	2.265	2.265
1,011.00	2.550	2.460	4.725
1,012.00	2.720	2.635	7.360
1,013.00	2.900	2.810	10.170
1,014.00	3.090	2.995	13.165

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=8.30 cfs @ 13.55 hrs HW=1,010.92' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 8.30 cfs @ 4.76 fps)

Summary for Pond 2P: Kelley Pond (Proposed)

[87] Warning: Oscillations may require Finer Routing or smaller dt (severity=1)

Inflow Area =	40.400 ac, 52.98% Impervious, Inflow Depth = 2.72" for 10-yr event		
Inflow =	82.41 cfs @ 12.11 hrs, Volume=	9.145 af	
Outflow =	8.31 cfs @ 15.27 hrs, Volume=	8.822 af,	Atten= 90%, Lag= 189.3 min
Primary =	8.31 cfs @ 15.27 hrs, Volume=	8.822 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 1,011.05' @ 13.66 hrs Surf.Area= 2.828 ac Storage= 5.383 af

Plug-Flow detention time= 488.8 min calculated for 8.822 af (96% of inflow)
Center-of-Mass det. time= 467.8 min (1,293.6 - 825.7)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	14.500 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.400	0.000	0.000
1,010.00	2.640	2.520	2.520
1,011.00	2.820	2.730	5.250
1,012.00	2.990	2.905	8.155
1,013.00	3.170	3.080	11.235
1,014.00	3.360	3.265	14.500

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=8.31 cfs @ 15.27 hrs HW=1,010.94' (Free Discharge)
↑**1=Culvert** (Barrel Controls 8.31 cfs @ 4.74 fps)

Summary for Subcatchment 1C: Total Drainage (Existing)

Runoff = 165.62 cfs @ 12.24 hrs, Volume= 16.604 af, Depth= 5.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
4.240	98	Paved roads w/curbs & sewers, HSG C
6.340	61	>75% Grass cover, Good, HSG B
6.340	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
4.560	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
36.660	84	Weighted Average
18.524		50.53% Pervious Area
18.136		49.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	300	0.0133	0.19		**Sheet Flow,** Range n= 0.130 P2= 2.80"
4.8	200	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
31.3	500	Total			

Summary for Subcatchment 2C: W Roadway Drainage (5200s)

Runoff = 41.02 cfs @ 12.02 hrs, Volume= 2.564 af, Depth= 6.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
3.830	98	Paved roads w/curbs & sewers, HSG C
0.920	74	>75% Grass cover, Good, HSG C
4.750	93	Weighted Average
0.920		19.37% Pervious Area
3.830		80.63% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 3C: Direct Drainage (Proposed)

Runoff = 139.26 cfs @ 12.25 hrs, Volume= 13.923 af, Depth= 5.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
0.960	98	Paved roads w/curbs & sewers, HSG C
5.730	61	>75% Grass cover, Good, HSG B
5.720	74	>75% Grass cover, Good, HSG C
2.130	98	Water Surface, HSG C
3.810	91	Urban industrial, 72% imp, HSG C
13.050	90	1/8 acre lots, 65% imp, HSG C
31.400	83	Weighted Average
17.084		54.41% Pervious Area
14.316		45.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.3					**Direct Entry, Matches Existing**

Summary for Subcatchment 4C: E Roadway Drainage (5250s)

Runoff = 33.43 cfs @ 12.05 hrs, Volume= 2.253 af, Depth= 6.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
2.720	98	Paved roads w/curbs & sewers, HSG C
0.780	74	>75% Grass cover, Good, HSG C
0.750	91	Urban industrial, 72% imp, HSG C
4.250	92	Weighted Average
0.990		23.29% Pervious Area
3.260		76.71% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.8					**Direct Entry, See Pipe Comps**

Summary for Pond 1P: Kelley Pond (Existing)

Inflow Area = 36.660 ac, 49.47% Impervious, Inflow Depth = 5.43" for 100-yr event
Inflow = 165.62 cfs @ 12.24 hrs, Volume= 16.604 af
Outflow = 13.05 cfs @ 13.84 hrs, Volume= 16.311 af, Atten= 92%, Lag= 95.4 min
Primary = 13.05 cfs @ 13.84 hrs, Volume= 16.311 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 1,013.00' @ 13.84 hrs Surf.Area= 2.900 ac Storage= 10.164 af

Plug-Flow detention time= 492.9 min calculated for 16.309 af (98% of inflow)
Center-of-Mass det. time= 482.2 min (1,298.8 - 816.6)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	13.165 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.160	0.000	0.000
1,010.00	2.370	2.265	2.265
1,011.00	2.550	2.460	4.725
1,012.00	2.720	2.635	7.360
1,013.00	2.900	2.810	10.170
1,014.00	3.090	2.995	13.165

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=13.05 cfs @ 13.84 hrs HW=1,013.00' (Free Discharge)
↑**1=Culvert** (Barrel Controls 13.05 cfs @ 7.39 fps)

Summary for Pond 2P: Kelley Pond (Proposed)

Inflow Area =	40.400 ac, 52.98% Impervious, Inflow Depth = 5.57"	for 100-yr event	
Inflow =	167.37 cfs @	12.14 hrs, Volume=	18.740 af
Outflow =	13.35 cfs @	13.92 hrs, Volume=	18.371 af, Atten= 92%, Lag= 107.1 min
Primary =	13.35 cfs @	13.92 hrs, Volume=	18.371 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 1,013.15' @ 13.92 hrs Surf.Area= 3.198 ac Storage= 11.706 af

Plug-Flow detention time= 546.6 min calculated for 18.368 af (98% of inflow)
Center-of-Mass det. time= 534.6 min (1,341.6 - 807.0)

Volume	Invert	Avail.Storage	Storage Description
#1	1,009.00'	14.500 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,009.00	2.400	0.000	0.000
1,010.00	2.640	2.520	2.520
1,011.00	2.820	2.730	5.250
1,012.00	2.990	2.905	8.155
1,013.00	3.170	3.080	11.235
1,014.00	3.360	3.265	14.500

Device	Routing	Invert	Outlet Devices
#1	Primary	1,009.00'	**18.0" Round Culvert** L= 149.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,009.00' / 1,008.26' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

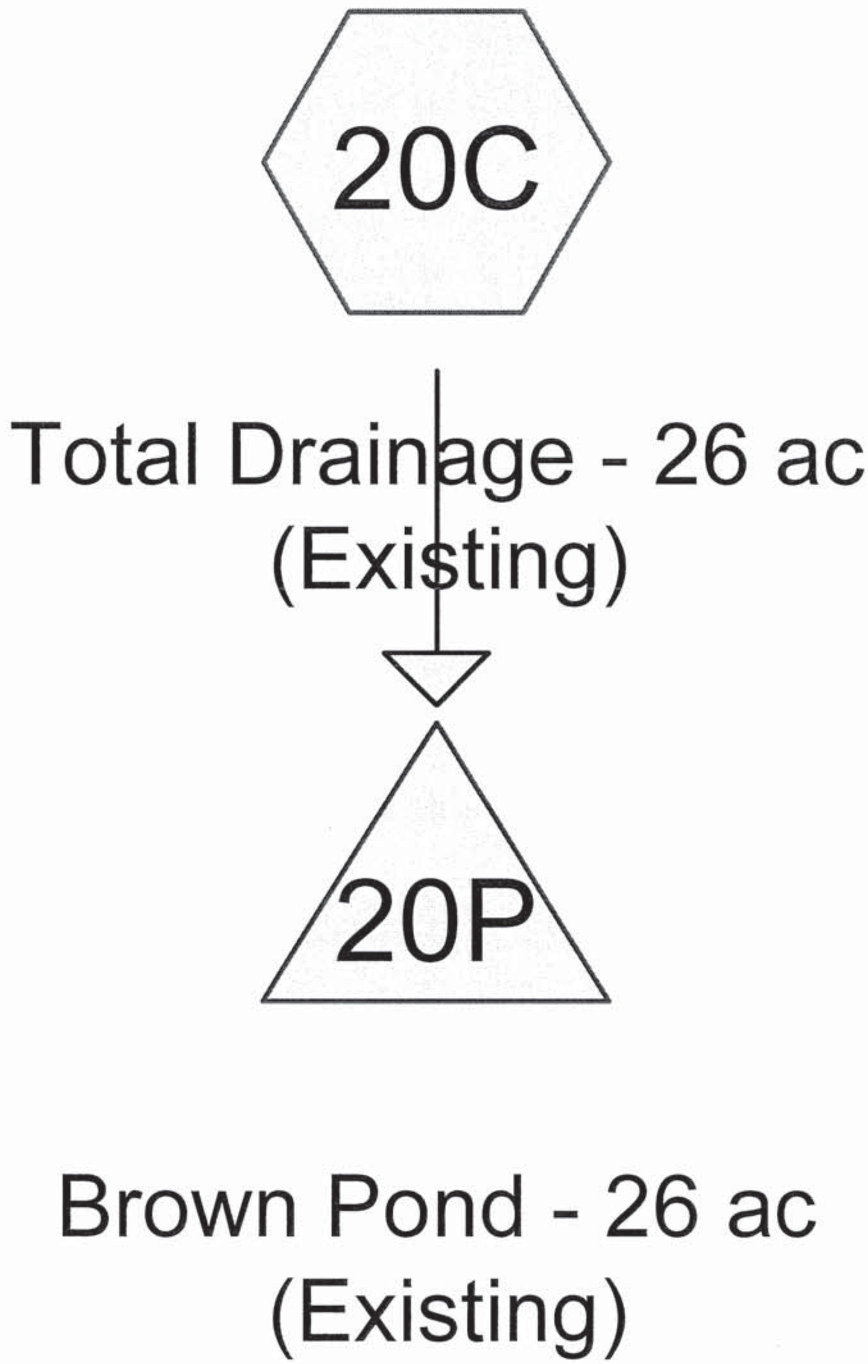
Primary OutFlow Max=13.35 cfs @ 13.92 hrs HW=1,013.15' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 13.35 cfs @ 7.56 fps)

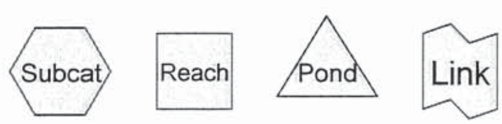
Appendix H: HydroCAD Model – Brown Pond System

CSAH 112 Reconstruction

CSAH 6 to TH 12

TP-40 WITH AREA
FROM SWMP





Routing Diagram for 7738_Final Models (TP 40)
Prepared by Microsoft, Printed 10/17/2013
HydroCAD® 10.00 s/n 01063 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 20C: Total Drainage - 26 ac (Existing)

Runoff = 16.19 cfs @ 12.50 hrs, Volume= 2.309 af, Depth= 1.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-Year Rainfall=2.75"

	Area (ac)	CN	Description
*	26.000	80	
	26.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 20P: Brown Pond - 26 ac (Existing)

Inflow Area = 26.000 ac, 0.00% Impervious, Inflow Depth = 1.07" for 2-Year event
Inflow = 16.19 cfs @ 12.50 hrs, Volume= 2.309 af
Outflow = 12.47 cfs @ 12.80 hrs, Volume= 2.307 af, Atten= 23%, Lag= 17.6 min
Primary = 12.47 cfs @ 12.80 hrs, Volume= 2.307 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.23' @ 12.80 hrs Surf.Area= 0.422 ac Storage= 0.427 af

Plug-Flow detention time= 49.4 min calculated for 2.307 af (100% of inflow)
Center-of-Mass det. time= 48.9 min (937.3 - 888.4)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=12.47 cfs @ 12.80 hrs HW=973.23' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 12.47 cfs @ 3.78 fps)

Summary for Subcatchment 20C: Total Drainage - 26 ac (Existing)

Runoff = 34.28 cfs @ 12.50 hrs, Volume= 4.694 af, Depth= 2.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-Year Rainfall=4.15"

	Area (ac)	CN	Description
*	26.000	80	
	26.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 20P: Brown Pond - 26 ac (Existing)

Inflow Area = 26.000 ac, 0.00% Impervious, Inflow Depth = 2.17" for 10-Year event
Inflow = 34.28 cfs @ 12.50 hrs, Volume= 4.694 af
Outflow = 28.90 cfs @ 12.72 hrs, Volume= 4.692 af, Atten= 16%, Lag= 13.0 min
Primary = 28.90 cfs @ 12.72 hrs, Volume= 4.692 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.95' @ 12.72 hrs Surf.Area= 0.457 ac Storage= 0.742 af

Plug-Flow detention time= 36.5 min calculated for 4.692 af (100% of inflow)
Center-of-Mass det. time= 36.2 min (904.0 - 867.8)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=28.89 cfs @ 12.72 hrs HW=973.95' (Free Discharge)
└**1=Culvert** (Inlet Controls 28.89 cfs @ 4.75 fps)

Summary for Subcatchment 20C: Total Drainage - 26 ac (Existing)

Runoff = 58.82 cfs @ 12.50 hrs, Volume= 7.997 af, Depth= 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-Year Rainfall=5.90"

	Area (ac)	CN	Description
*	26.000	80	
	26.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 20P: Brown Pond - 26 ac (Existing)

Inflow Area = 26.000 ac, 0.00% Impervious, Inflow Depth = 3.69" for 100-Year event
Inflow = 58.82 cfs @ 12.50 hrs, Volume= 7.997 af
Outflow = 51.30 cfs @ 12.68 hrs, Volume= 7.996 af, Atten= 13%, Lag= 10.9 min
Primary = 51.30 cfs @ 12.68 hrs, Volume= 7.996 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 974.73' @ 12.68 hrs Surf.Area= 0.482 ac Storage= 1.107 af

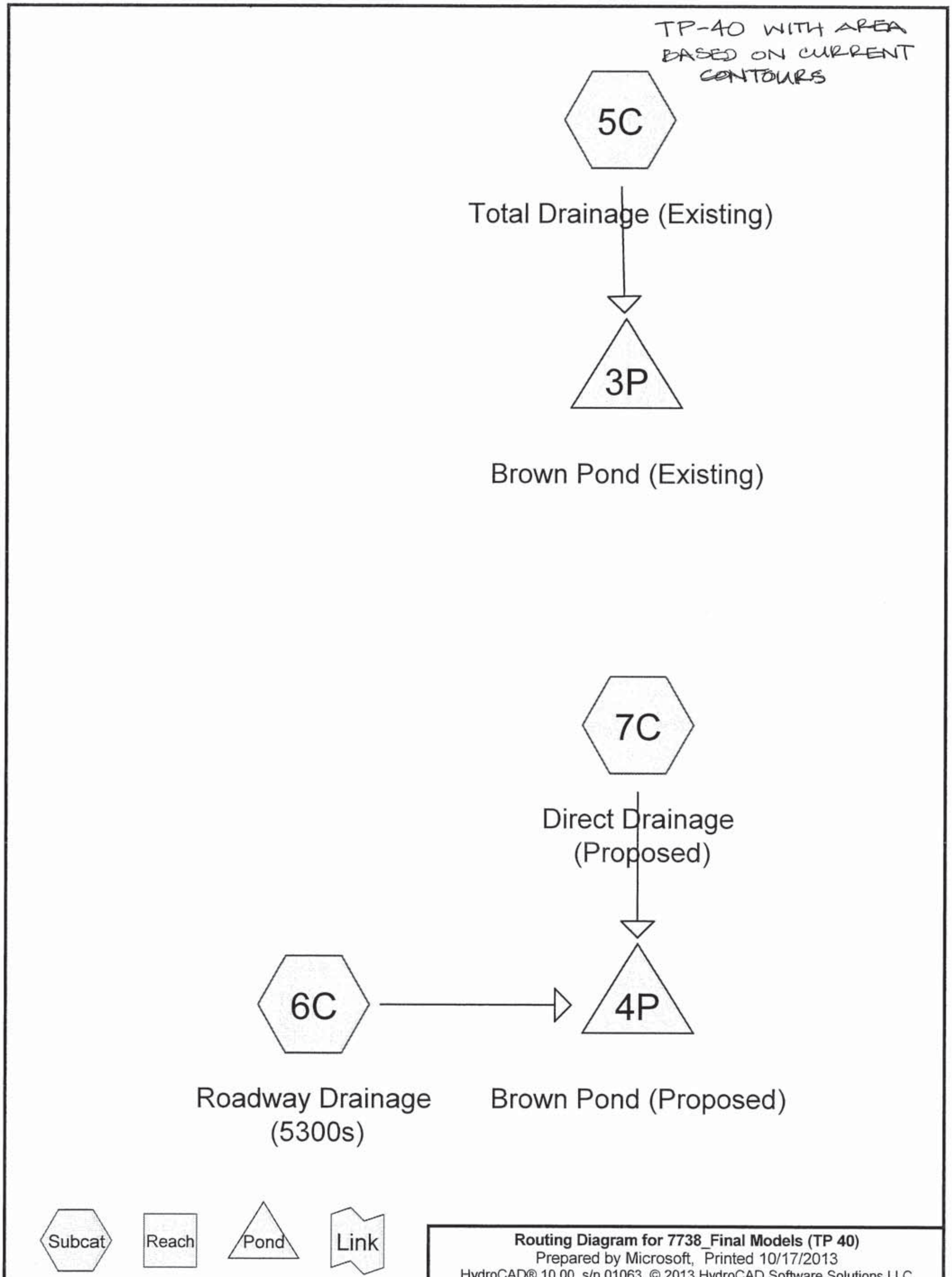
Plug-Flow detention time= 29.6 min calculated for 7.995 af (100% of inflow)
Center-of-Mass det. time= 29.7 min (882.3 - 852.6)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=51.30 cfs @ 12.68 hrs HW=974.73' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 51.30 cfs @ 5.62 fps)



Routing Diagram for 7738_Final Models (TP 40)
Prepared by Microsoft, Printed 10/17/2013
HydroCAD® 10.00 s/n 01063 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 19.14 cfs @ 12.50 hrs, Volume= 2.729 af, Depth= 1.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-Year Rainfall=2.75"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 26.56 cfs @ 12.13 hrs, Volume= 2.068 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-Year Rainfall=2.75"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 5.84 cfs @ 12.56 hrs, Volume= 0.956 af, Depth= 0.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-Year Rainfall=2.75"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 1.07" for 2-Year event
Inflow = 19.14 cfs @ 12.50 hrs, Volume= 2.729 af
Outflow = 15.06 cfs @ 12.78 hrs, Volume= 2.728 af, Atten= 21%, Lag= 16.8 min
Primary = 15.06 cfs @ 12.78 hrs, Volume= 2.728 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.37' @ 12.78 hrs Surf.Area= 0.428 ac Storage= 0.483 af

Plug-Flow detention time= 45.8 min calculated for 2.728 af (100% of inflow)
Center-of-Mass det. time= 45.4 min (933.7 - 888.4)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=15.06 cfs @ 12.78 hrs HW=973.37' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 15.06 cfs @ 3.98 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 1.18" for 2-Year event
Inflow = 28.20 cfs @ 12.14 hrs, Volume= 3.023 af
Outflow = 18.75 cfs @ 12.34 hrs, Volume= 3.022 af, Atten= 34%, Lag= 11.7 min
Primary = 18.75 cfs @ 12.34 hrs, Volume= 3.022 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.54' @ 12.34 hrs Surf.Area= 0.437 ac Storage= 0.557 af

Plug-Flow detention time= 45.4 min calculated for 3.021 af (100% of inflow)
Center-of-Mass det. time= 45.4 min (895.8 - 850.4)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=18.75 cfs @ 12.34 hrs HW=973.54' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 18.75 cfs @ 4.22 fps)

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 40.52 cfs @ 12.50 hrs, Volume= 5.547 af, Depth= 2.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-Year Rainfall=4.15"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 44.77 cfs @ 12.13 hrs, Volume= 3.554 af, Depth= 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-Year Rainfall=4.15"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 15.73 cfs @ 12.50 hrs, Volume= 2.255 af, Depth= 1.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-Year Rainfall=4.15"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 2.17" for 10-Year event
Inflow = 40.52 cfs @ 12.50 hrs, Volume= 5.547 af
Outflow = 34.56 cfs @ 12.71 hrs, Volume= 5.546 af, Atten= 15%, Lag= 12.5 min
Primary = 34.56 cfs @ 12.71 hrs, Volume= 5.546 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 974.16' @ 12.71 hrs Surf.Area= 0.465 ac Storage= 0.838 af

Plug-Flow detention time= 34.0 min calculated for 5.546 af (100% of inflow)
Center-of-Mass det. time= 33.8 min (901.5 - 867.8)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=34.56 cfs @ 12.71 hrs HW=974.16' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 34.56 cfs @ 5.00 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 2.27" for 10-Year event
Inflow = 50.96 cfs @ 12.15 hrs, Volume= 5.809 af
Outflow = 37.74 cfs @ 12.33 hrs, Volume= 5.807 af, Atten= 26%, Lag= 10.7 min
Primary = 37.74 cfs @ 12.33 hrs, Volume= 5.807 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 974.27' @ 12.33 hrs Surf.Area= 0.468 ac Storage= 0.890 af

Plug-Flow detention time= 34.7 min calculated for 5.806 af (100% of inflow)
Center-of-Mass det. time= 34.8 min (872.3 - 837.4)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=37.74 cfs @ 12.33 hrs HW=974.27' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 37.74 cfs @ 5.13 fps)

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 69.53 cfs @ 12.50 hrs, Volume= 9.452 af, Depth= 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-Year Rainfall=5.90"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 67.39 cfs @ 12.13 hrs, Volume= 5.463 af, Depth= 4.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-Year Rainfall=5.90"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 30.47 cfs @ 12.50 hrs, Volume= 4.193 af, Depth= 2.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-Year Rainfall=5.90"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 3.69" for 100-Year event
Inflow = 69.53 cfs @ 12.50 hrs, Volume= 9.452 af
Outflow = 60.86 cfs @ 12.68 hrs, Volume= 9.451 af, Atten= 12%, Lag= 10.7 min
Primary = 60.86 cfs @ 12.68 hrs, Volume= 9.451 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 975.04' @ 12.68 hrs Surf.Area= 0.492 ac Storage= 1.260 af

Plug-Flow detention time= 27.7 min calculated for 9.449 af (100% of inflow)
Center-of-Mass det. time= 27.9 min (880.4 - 852.6)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=60.85 cfs @ 12.68 hrs HW=975.04' (Free Discharge)
↑**1=Culvert** (Inlet Controls 60.85 cfs @ 5.94 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 3.77" for 100-Year event
Inflow = 80.96 cfs @ 12.15 hrs, Volume= 9.656 af
Outflow = 63.01 cfs @ 12.33 hrs, Volume= 9.654 af, Atten= 22%, Lag= 10.4 min
Primary = 63.01 cfs @ 12.33 hrs, Volume= 9.654 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 975.11' @ 12.33 hrs Surf.Area= 0.494 ac Storage= 1.295 af

Plug-Flow detention time= 29.0 min calculated for 9.654 af (100% of inflow)
Center-of-Mass det. time= 28.8 min (855.7 - 826.9)

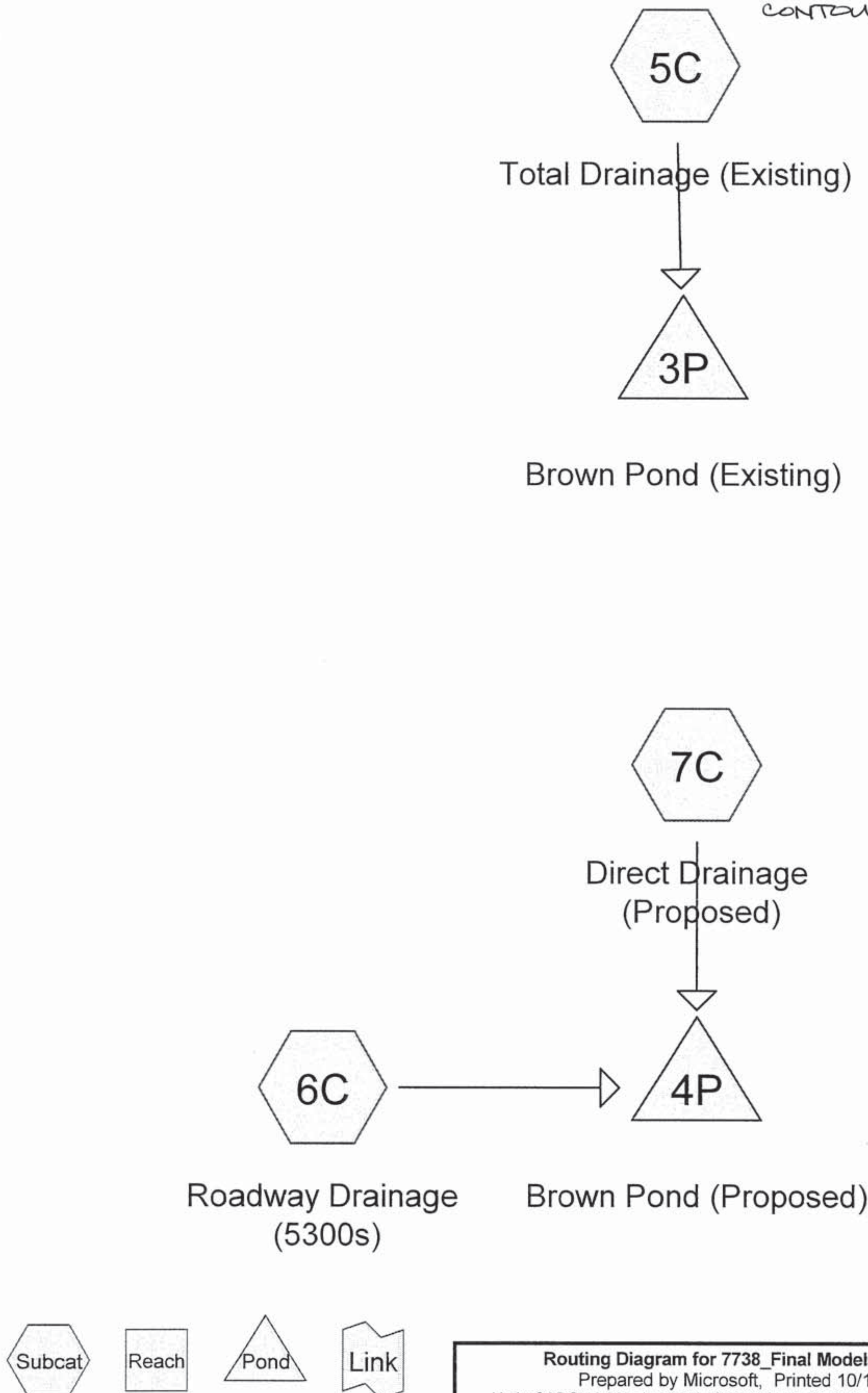
Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=63.01 cfs @ 12.33 hrs HW=975.11' (Free Discharge)
↑**1=Culvert** (Inlet Controls 63.01 cfs @ 6.01 fps)

ATLAS 14 WITH AREA BASED ON CURRENT CONTOURS



Routing Diagram for 7738_Final Models (Atlas 14)
Prepared by Microsoft, Printed 10/17/2013
HydroCAD® 10.00 s/n 01063 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 20.85 cfs @ 12.50 hrs, Volume= 2.954 af, Depth= 1.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 28.11 cfs @ 12.13 hrs, Volume= 2.193 af, Depth= 1.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 6.57 cfs @ 12.56 hrs, Volume= 1.054 af, Depth= 0.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 1.15" for 2-yr event
Inflow = 20.85 cfs @ 12.50 hrs, Volume= 2.954 af
Outflow = 16.61 cfs @ 12.77 hrs, Volume= 2.952 af, Atten= 20%, Lag= 16.2 min
Primary = 16.61 cfs @ 12.77 hrs, Volume= 2.952 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.44' @ 12.77 hrs Surf.Area= 0.432 ac Storage= 0.515 af

Plug-Flow detention time= 44.2 min calculated for 2.952 af (100% of inflow)
Center-of-Mass det. time= 43.8 min (929.8 - 886.0)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=16.61 cfs @ 12.77 hrs HW=973.44' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 16.61 cfs @ 4.08 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 1.27" for 2-yr event
Inflow = 30.06 cfs @ 12.14 hrs, Volume= 3.246 af
Outflow = 20.26 cfs @ 12.34 hrs, Volume= 3.245 af, Atten= 33%, Lag= 11.6 min
Primary = 20.26 cfs @ 12.34 hrs, Volume= 3.245 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 973.60' @ 12.34 hrs Surf.Area= 0.440 ac Storage= 0.586 af

Plug-Flow detention time= 44.4 min calculated for 3.245 af (100% of inflow)
Center-of-Mass det. time= 44.0 min (893.1 - 849.0)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=20.26 cfs @ 12.34 hrs HW=973.60' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 20.26 cfs @ 4.31 fps)

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 42.29 cfs @ 12.50 hrs, Volume= 5.783 af, Depth= 2.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 46.20 cfs @ 12.13 hrs, Volume= 3.672 af, Depth= 3.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 16.60 cfs @ 12.50 hrs, Volume= 2.369 af, Depth= 1.65"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 2.26" for 10-yr event
Inflow = 42.29 cfs @ 12.50 hrs, Volume= 5.783 af
Outflow = 36.18 cfs @ 12.70 hrs, Volume= 5.782 af, Atten= 14%, Lag= 12.3 min
Primary = 36.18 cfs @ 12.70 hrs, Volume= 5.782 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 974.21' @ 12.70 hrs Surf.Area= 0.466 ac Storage= 0.865 af

Plug-Flow detention time= 33.5 min calculated for 5.782 af (100% of inflow)
Center-of-Mass det. time= 33.2 min (899.8 - 866.6)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=36.18 cfs @ 12.70 hrs HW=974.21' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 36.18 cfs @ 5.07 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 2.36" for 10-yr event
Inflow = 52.81 cfs @ 12.15 hrs, Volume= 6.041 af
Outflow = 39.32 cfs @ 12.33 hrs, Volume= 6.040 af, Atten= 26%, Lag= 10.7 min
Primary = 39.32 cfs @ 12.33 hrs, Volume= 6.040 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 974.32' @ 12.33 hrs Surf.Area= 0.470 ac Storage= 0.916 af

Plug-Flow detention time= 34.2 min calculated for 6.039 af (100% of inflow)
Center-of-Mass det. time= 34.3 min (870.9 - 836.6)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=39.31 cfs @ 12.33 hrs HW=974.32' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 39.31 cfs @ 5.19 fps)

Summary for Subcatchment 5C: Total Drainage (Existing)

Runoff = 93.57 cfs @ 12.50 hrs, Volume= 12.756 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
2.670	98	Paved roads w/curbs & sewers, HSG C
2.290	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
2.950	88	Urban industrial, 72% imp, HSG B
8.830	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
30.730	80	Weighted Average
15.992		52.04% Pervious Area
14.738		47.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Subcatchment 6C: Roadway Drainage (5300s)

Runoff = 85.45 cfs @ 12.13 hrs, Volume= 7.019 af, Depth= 6.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
2.470	98	Paved roads w/curbs & sewers, HSG C
1.260	74	>75% Grass cover, Good, HSG C
9.760	91	Urban industrial, 72% imp, HSG C
13.490	91	Weighted Average
3.993		29.60% Pervious Area
9.497		70.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 7C: Direct Drainage (Proposed)

Runoff = 43.26 cfs @ 12.50 hrs, Volume= 5.896 af, Depth= 4.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
1.270	74	>75% Grass cover, Good, HSG C
0.250	98	Water Surface, HSG C
1.620	88	Urban industrial, 72% imp, HSG B
0.400	91	Urban industrial, 72% imp, HSG C
3.180	85	1/8 acre lots, 65% imp, HSG B
3.380	72	1/3 acre lots, 30% imp, HSG B
0.850	81	1/3 acre lots, 30% imp, HSG C
5.060	55	Woods, Good, HSG B
1.270	72	Woods/grass comb., Good, HSG C
17.280	72	Weighted Average
12.240		70.83% Pervious Area
5.040		29.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
50.0					**Direct Entry,**

Summary for Pond 3P: Brown Pond (Existing)

Inflow Area = 30.730 ac, 47.96% Impervious, Inflow Depth = 4.98" for 100-yr event
Inflow = 93.57 cfs @ 12.50 hrs, Volume= 12.756 af
Outflow = 80.95 cfs @ 12.68 hrs, Volume= 12.755 af, Atten= 13%, Lag= 11.0 min
Primary = 80.95 cfs @ 12.68 hrs, Volume= 12.755 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 975.76' @ 12.68 hrs Surf.Area= 0.520 ac Storage= 1.624 af

Plug-Flow detention time= 25.2 min calculated for 12.753 af (100% of inflow)
Center-of-Mass det. time= 25.3 min (869.4 - 844.0)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=80.95 cfs @ 12.68 hrs HW=975.76' (Free Discharge)
└1=Culvert (Inlet Controls 80.95 cfs @ 6.60 fps)

Summary for Pond 4P: Brown Pond (Proposed)

Inflow Area = 30.770 ac, 47.25% Impervious, Inflow Depth = 5.04" for 100-yr event
Inflow = 105.70 cfs @ 12.16 hrs, Volume= 12.915 af
Outflow = 81.84 cfs @ 12.34 hrs, Volume= 12.914 af, Atten= 23%, Lag= 11.3 min
Primary = 81.84 cfs @ 12.34 hrs, Volume= 12.914 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 975.80' @ 12.34 hrs Surf.Area= 0.522 ac Storage= 1.645 af

Plug-Flow detention time= 26.2 min calculated for 12.914 af (100% of inflow)
Center-of-Mass det. time= 26.1 min (846.8 - 820.7)

Volume	Invert	Avail.Storage	Storage Description
#1	972.00'	2.305 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
972.00	0.250	0.000	0.000
973.00	0.410	0.330	0.330
974.00	0.460	0.435	0.765
975.00	0.490	0.475	1.240
976.00	0.530	0.510	1.750
977.00	0.580	0.555	2.305

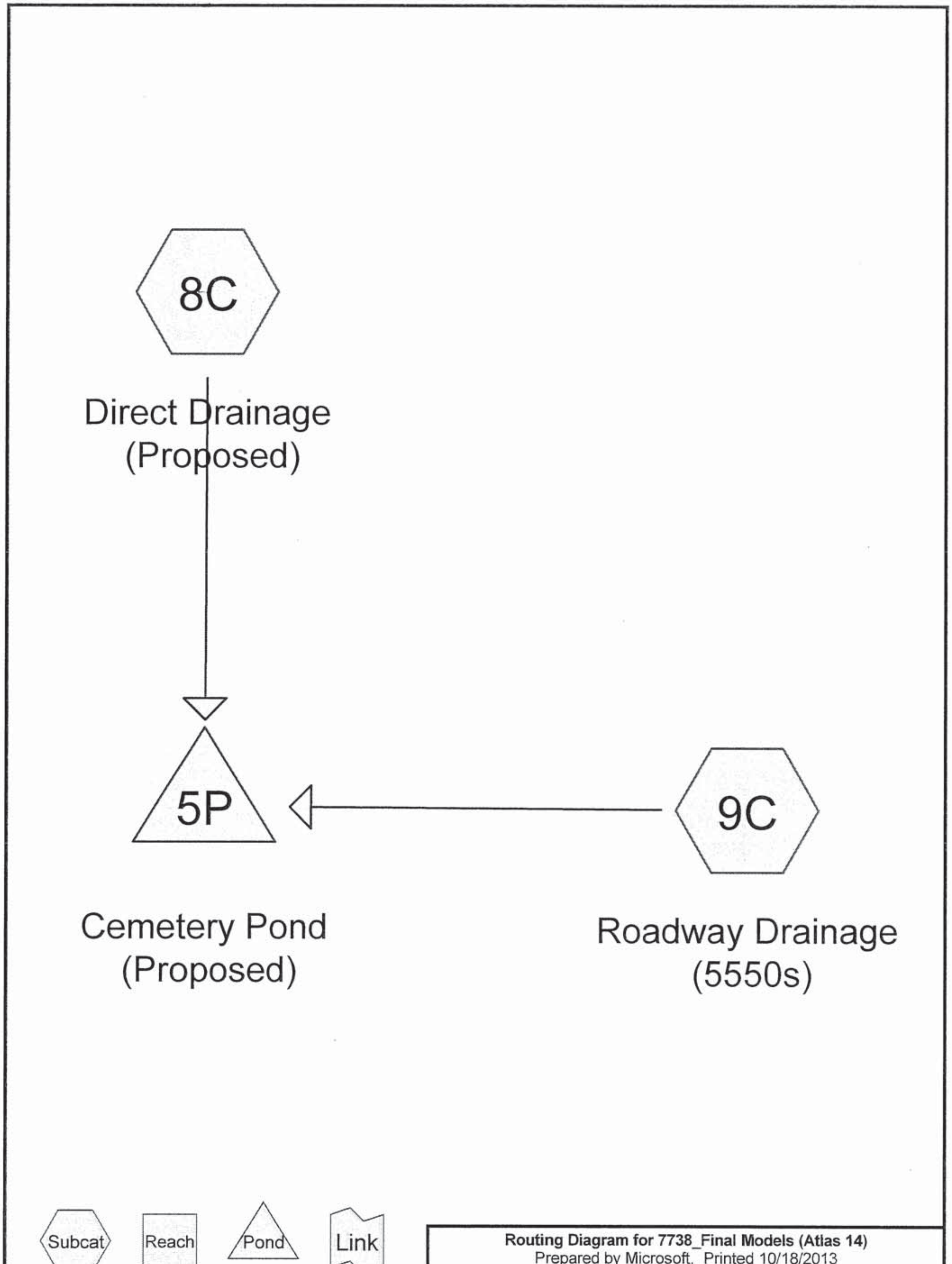
Device	Routing	Invert	Outlet Devices
#1	Primary	972.00'	**48.0" Round Culvert** L= 45.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 972.00' / 963.95' S= 0.1789 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 12.57 sf

Primary OutFlow Max=81.83 cfs @ 12.34 hrs HW=975.80' (Free Discharge)
└1=Culvert (Inlet Controls 81.83 cfs @ 6.64 fps)

Appendix I: HydroCAD Model – Cemetery Pond System

CSAH 112 Reconstruction

CSAH 6 to TH 12



Routing Diagram for 7738_Final Models (Atlas 14)
Prepared by Microsoft, Printed 10/18/2013
HydroCAD® 10.00 s/n 01063 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 8C: Direct Drainage (Proposed)

Runoff = 0.07 cfs @ 12.02 hrs, Volume= 0.004 af, Depth= 0.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 1" Event Rainfall=1.00"

	Area (ac)	CN	Description
	0.140	98	Paved roads w/curbs & sewers, HSG C
	0.200	74	>75% Grass cover, Good, HSG C
	0.340	84	Weighted Average
	0.200		58.82% Pervious Area
	0.140		41.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Summary for Subcatchment 9C: Roadway Drainage (5550s)

Runoff = 1.49 cfs @ 12.09 hrs, Volume= 0.105 af, Depth= 0.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 1" Event Rainfall=1.00"

	Area (ac)	CN	Description
	2.390	98	Paved roads w/curbs & sewers, HSG C
	1.110	74	>75% Grass cover, Good, HSG C
*	0.910	82	Urban industrial, 72% imp, HSG C
	4.410	89	Weighted Average
	1.365		30.95% Pervious Area
	3.045		69.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.7					**Direct Entry, See Pipe Comps**

Summary for Pond 5P: Cemetery Pond (Proposed)

[87] Warning: Oscillations may require Finer Routing or smaller dt (severity=570)

Inflow Area = 4.750 ac, 67.06% Impervious, Inflow Depth = 0.28" for 1" Event event
Inflow = 1.54 cfs @ 12.09 hrs, Volume= 0.109 af
Outflow = 0.62 cfs @ 12.31 hrs, Volume= 0.109 af, Atten= 60%, Lag= 13.4 min
Primary = 0.62 cfs @ 12.31 hrs, Volume= 0.109 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 945.03' @ 12.31 hrs Surf.Area= 0.060 ac Storage= 0.017 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)

Center-of-Mass det. time= 5.8 min (882.8 - 877.0)

Volume	Invert	Avail.Storage	Storage Description
#1	944.70'	0.355 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
944.70	0.040	0.000	0.000
945.00	0.060	0.015	0.015
946.00	0.070	0.065	0.080
947.00	0.090	0.080	0.160
948.00	0.100	0.095	0.255
949.00	0.100	0.100	0.355

Device	Routing	Invert	Outlet Devices
#1	Primary	947.00'	**30.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#2	Primary	943.20'	**6.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 943.20' / 942.90' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#3	Device 2	942.00'	**Special & User-Defined** Head (feet) 0.00 1.00 2.00 3.00 4.00 Disch. (cfs) 0.000 0.200 0.400 0.600 1.100

Primary OutFlow Max=0.62 cfs @ 12.31 hrs HW=945.03' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└—**2=Culvert** (Passes 0.62 cfs of 0.75 cfs potential flow)
  ↑—**3=Special & User-Defined** (Custom Controls 0.62 cfs)

Summary for Subcatchment 8C: Direct Drainage (Proposed)

Runoff = 0.80 cfs @ 12.00 hrs, Volume= 0.040 af, Depth= 1.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
0.140	98	Paved roads w/curbs & sewers, HSG C
0.200	74	>75% Grass cover, Good, HSG C
0.340	84	Weighted Average
0.200		58.82% Pervious Area
0.140		41.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Summary for Subcatchment 9C: Roadway Drainage (5550s)

Runoff = 9.90 cfs @ 12.08 hrs, Volume= 0.655 af, Depth= 1.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

	Area (ac)	CN	Description
	2.390	98	Paved roads w/curbs & sewers, HSG C
	1.110	74	>75% Grass cover, Good, HSG C
*	0.910	82	Urban industrial, 72% imp, HSG C
	4.410	89	Weighted Average
	1.365		30.95% Pervious Area
	3.045		69.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.7					**Direct Entry, See Pipe Comps**

Summary for Pond 5P: Cemetery Pond (Proposed)

[95] Warning: Outlet Device #3 rise exceeded
[87] Warning: Oscillations may require Finer Routing or smaller dt (severity=361)

Inflow Area = 4.750 ac, 67.06% Impervious, Inflow Depth = 1.76" for 2-yr event
Inflow = 10.43 cfs @ 12.07 hrs, Volume= 0.695 af
Outflow = 8.13 cfs @ 12.16 hrs, Volume= 0.695 af, Atten= 22%, Lag= 5.7 min
Primary = 8.13 cfs @ 12.16 hrs, Volume= 0.695 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 947.21' @ 12.16 hrs Surf.Area= 0.092 ac Storage= 0.179 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 41.3 min (863.4 - 822.1)

Volume	Invert	Avail.Storage	Storage Description
#1	944.70'	0.355 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
944.70	0.040	0.000	0.000
945.00	0.060	0.015	0.015
946.00	0.070	0.065	0.080
947.00	0.090	0.080	0.160
948.00	0.100	0.095	0.255
949.00	0.100	0.100	0.355

Device	Routing	Invert	Outlet Devices
#1	Primary	947.00'	**30.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#2	Primary	943.20'	**6.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 943.20' / 942.90' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#3	Device 2	942.00'	**Special & User-Defined** Head (feet) 0.00 1.00 2.00 3.00 4.00 Disch. (cfs) 0.000 0.200 0.400 0.600 1.100

Primary OutFlow Max=8.10 cfs @ 12.16 hrs HW=947.21' (Free Discharge)
├─**1=Broad-Crested Rectangular Weir** (Weir Controls 7.00 cfs @ 1.10 fps)
└─**2=Culvert** (Passes 1.10 cfs of 1.15 cfs potential flow)
  └─**3=Special & User-Defined** (Custom Controls 1.10 cfs)

Summary for Subcatchment 8C: Direct Drainage (Proposed)

Runoff = 1.45 cfs @ 11.99 hrs, Volume= 0.074 af, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
0.140	98	Paved roads w/curbs & sewers, HSG C
0.200	74	>75% Grass cover, Good, HSG C
0.340	84	Weighted Average
0.200		58.82% Pervious Area
0.140		41.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Summary for Subcatchment 9C: Roadway Drainage (5550s)

Runoff = 16.74 cfs @ 12.07 hrs, Volume= 1.127 af, Depth= 3.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

	Area (ac)	CN	Description
	2.390	98	Paved roads w/curbs & sewers, HSG C
	1.110	74	>75% Grass cover, Good, HSG C
*	0.910	82	Urban industrial, 72% imp, HSG C
	4.410	89	Weighted Average
	1.365		30.95% Pervious Area
	3.045		69.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.7					**Direct Entry, See Pipe Comps**

Summary for Pond 5P: Cemetery Pond (Proposed)

[95] Warning: Outlet Device #3 rise exceeded
[87] Warning: Oscillations may require Finer Routing or smaller dt (severity=276)

Inflow Area = 4.750 ac, 67.06% Impervious, Inflow Depth = 3.03" for 10-yr event
Inflow = 17.71 cfs @ 12.06 hrs, Volume= 1.201 af
Outflow = 17.55 cfs @ 12.08 hrs, Volume= 1.201 af, Atten= 1%, Lag= 1.1 min
Primary = 17.55 cfs @ 12.08 hrs, Volume= 1.201 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 947.36' @ 12.08 hrs Surf.Area= 0.094 ac Storage= 0.193 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 34.6 min (841.2 - 806.6)

Volume	Invert	Avail.Storage	Storage Description
#1	944.70'	0.355 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
944.70	0.040	0.000	0.000
945.00	0.060	0.015	0.015
946.00	0.070	0.065	0.080
947.00	0.090	0.080	0.160
948.00	0.100	0.095	0.255
949.00	0.100	0.100	0.355

Device	Routing	Invert	Outlet Devices
#1	Primary	947.00'	**30.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#2	Primary	943.20'	**6.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 943.20' / 942.90' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#3	Device 2	942.00'	**Special & User-Defined** Head (feet) 0.00 1.00 2.00 3.00 4.00 Disch. (cfs) 0.000 0.200 0.400 0.600 1.100

Primary OutFlow Max=17.54 cfs @ 12.08 hrs HW=947.36' (Free Discharge)
└1=**Broad-Crested Rectangular Weir** (Weir Controls 16.44 cfs @ 1.51 fps)
└2=**Culvert** (Passes 1.10 cfs of 1.17 cfs potential flow)
  └3=**Special & User-Defined** (Custom Controls 1.10 cfs)

Summary for Subcatchment 8C: Direct Drainage (Proposed)

Runoff = 2.92 cfs @ 11.99 hrs, Volume= 0.154 af, Depth= 5.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
0.140	98	Paved roads w/curbs & sewers, HSG C
0.200	74	>75% Grass cover, Good, HSG C
0.340	84	Weighted Average
0.200		58.82% Pervious Area
0.140		41.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Summary for Subcatchment 9C: Roadway Drainage (5550s)

Runoff = 31.69 cfs @ 12.07 hrs, Volume= 2.209 af, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

	Area (ac)	CN	Description
	2.390	98	Paved roads w/curbs & sewers, HSG C
	1.110	74	>75% Grass cover, Good, HSG C
*	0.910	82	Urban industrial, 72% imp, HSG C
	4.410	89	Weighted Average
	1.365		30.95% Pervious Area
	3.045		69.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.7					**Direct Entry, See Pipe Comps**

Summary for Pond 5P: Cemetery Pond (Proposed)

[95] Warning: Outlet Device #3 rise exceeded

Inflow Area = 4.750 ac, 67.06% Impervious, Inflow Depth = 5.97" for 100-yr event
Inflow = 33.67 cfs @ 12.06 hrs, Volume= 2.363 af
Outflow = 33.52 cfs @ 12.07 hrs, Volume= 2.363 af, Atten= 0%, Lag= 0.7 min
Primary = 33.52 cfs @ 12.07 hrs, Volume= 2.363 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 947.55' @ 12.07 hrs Surf.Area= 0.095 ac Storage= 0.211 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)

Center-of-Mass det. time= 31.2 min (819.1 - 788.0)

Volume	Invert	Avail.Storage	Storage Description
#1	944.70'	0.355 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
944.70	0.040	0.000	0.000
945.00	0.060	0.015	0.015
946.00	0.070	0.065	0.080
947.00	0.090	0.080	0.160
948.00	0.100	0.095	0.255
949.00	0.100	0.100	0.355

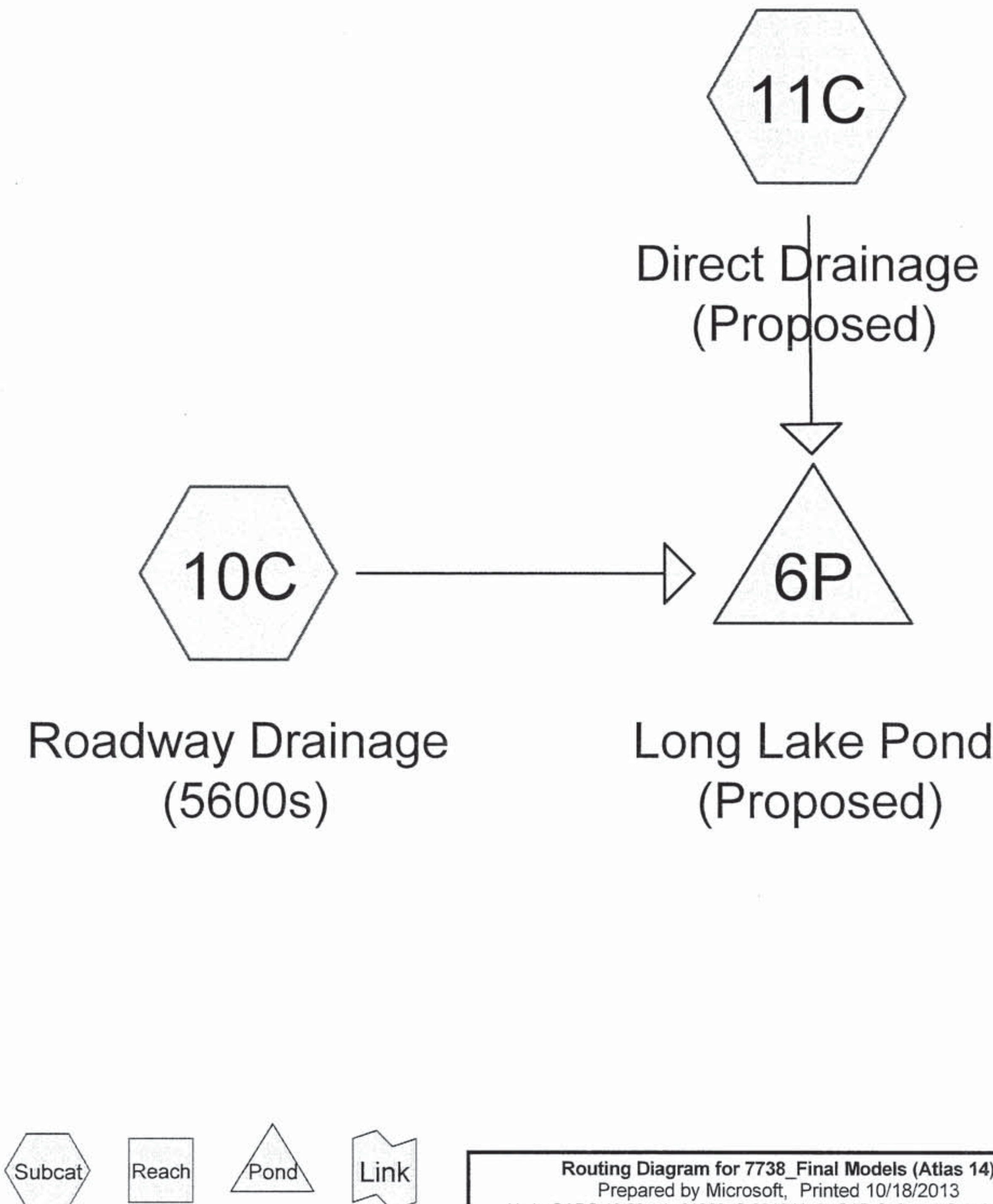
Device	Routing	Invert	Outlet Devices
#1	Primary	947.00'	**30.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#2	Primary	943.20'	**6.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 943.20' / 942.90' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#3	Device 2	942.00'	**Special & User-Defined** Head (feet) 0.00 1.00 2.00 3.00 4.00 Disch. (cfs) 0.000 0.200 0.400 0.600 1.100

Primary OutFlow Max=33.50 cfs @ 12.07 hrs HW=947.55' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 32.40 cfs @ 1.97 fps)
└—**2=Culvert** (Passes 1.10 cfs of 1.20 cfs potential flow)
  ↑—**3=Special & User-Defined** (Custom Controls 1.10 cfs)

Appendix J: HydroCAD Model – Long Lake Pond System

CSAH 112 Reconstruction

CSAH 6 to TH 12



Routing Diagram for 7738_Final Models (Atlas 14)
Prepared by Microsoft, Printed 10/18/2013
HydroCAD® 10.00 s/n 01063 © 2013 HydroCAD Software Solutions LLC

Summary for Subcatchment 10C: Roadway Drainage (5600s)

Runoff = 6.13 cfs @ 12.25 hrs, Volume= 0.605 af, Depth= 0.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
1.250	98	Paved roads w/curbs & sewers, HSG B
0.500	61	>75% Grass cover, Good, HSG B
6.530	72	1/3 acre lots, 30% imp, HSG B
8.280	75	Weighted Average
5.071		61.24% Pervious Area
3.209		38.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.5					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 11C: Direct Drainage (Proposed)

Runoff = 1.39 cfs @ 12.03 hrs, Volume= 0.079 af, Depth= 0.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 2-yr Rainfall=2.87"

Area (ac)	CN	Description
0.300	98	Paved roads w/curbs & sewers, HSG B
0.840	61	>75% Grass cover, Good, HSG B
0.080	98	Water Surface, HSG B
1.220	73	Weighted Average
0.840		68.85% Pervious Area
0.380		31.15% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 6P: Long Lake Pond (Proposed)

Inflow Area = 9.500 ac, 37.78% Impervious, Inflow Depth = 0.86" for 2-yr event
Inflow = 6.53 cfs @ 12.22 hrs, Volume= 0.684 af
Outflow = 6.31 cfs @ 12.28 hrs, Volume= 0.684 af, Atten= 3%, Lag= 3.3 min
Primary = 6.31 cfs @ 12.28 hrs, Volume= 0.684 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Starting Elev= 985.00' Surf.Area= 0.080 ac Storage= 0.170 af
Peak Elev= 985.47' @ 12.28 hrs Surf.Area= 0.089 ac Storage= 0.210 af (0.040 af above start)

Plug-Flow detention time= 162.9 min calculated for 0.514 af (75% of inflow)

Center-of-Mass det. time= 8.4 min (889.7 - 881.3)

Volume	Invert	Avail.Storage	Storage Description
#1	981.00'	0.520 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
981.00	0.020	0.000	0.000
982.00	0.030	0.025	0.025
983.00	0.040	0.035	0.060
984.00	0.050	0.045	0.105
985.00	0.080	0.065	0.170
986.00	0.100	0.090	0.260
987.00	0.130	0.115	0.375
988.00	0.160	0.145	0.520

Device	Routing	Invert	Outlet Devices
#1	Primary	981.50'	**27.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 981.50' / 981.00' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.98 sf
#2	Device 1	985.00'	**6.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=6.31 cfs @ 12.28 hrs HW=985.47' (Free Discharge)
└─**1=Culvert** (Passes 6.31 cfs of 30.67 cfs potential flow)
  └─**2=Sharp-Crested Rectangular Weir** (Weir Controls 6.31 cfs @ 2.25 fps)

Summary for Subcatchment 10C: Roadway Drainage (5600s)

Runoff = 13.92 cfs @ 12.22 hrs, Volume= 1.286 af, Depth= 1.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
1.250	98	Paved roads w/curbs & sewers, HSG B
0.500	61	>75% Grass cover, Good, HSG B
6.530	72	1/3 acre lots, 30% imp, HSG B
8.280	75	Weighted Average
5.071		61.24% Pervious Area
3.209		38.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.5					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 11C: Direct Drainage (Proposed)

Runoff = 3.22 cfs @ 12.02 hrs, Volume= 0.175 af, Depth= 1.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 10-yr Rainfall=4.26"

Area (ac)	CN	Description
0.300	98	Paved roads w/curbs & sewers, HSG B
0.840	61	>75% Grass cover, Good, HSG B
0.080	98	Water Surface, HSG B
1.220	73	Weighted Average
0.840		68.85% Pervious Area
0.380		31.15% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 6P: Long Lake Pond (Proposed)

Inflow Area = 9.500 ac, 37.78% Impervious, Inflow Depth = 1.85" for 10-yr event
Inflow = 14.84 cfs @ 12.20 hrs, Volume= 1.461 af
Outflow = 14.52 cfs @ 12.25 hrs, Volume= 1.461 af, Atten= 2%, Lag= 3.3 min
Primary = 14.52 cfs @ 12.25 hrs, Volume= 1.461 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Starting Elev= 985.00' Surf.Area= 0.080 ac Storage= 0.170 af
Peak Elev= 985.83' @ 12.25 hrs Surf.Area= 0.097 ac Storage= 0.244 af (0.074 af above start)

Plug-Flow detention time= 84.8 min calculated for 1.291 af (88% of inflow)

Center-of-Mass det. time= 6.6 min (864.8 - 858.2)

Volume	Invert	Avail.Storage	Storage Description
#1	981.00'	0.520 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
981.00	0.020	0.000	0.000
982.00	0.030	0.025	0.025
983.00	0.040	0.035	0.060
984.00	0.050	0.045	0.105
985.00	0.080	0.065	0.170
986.00	0.100	0.090	0.260
987.00	0.130	0.115	0.375
988.00	0.160	0.145	0.520

Device	Routing	Invert	Outlet Devices
#1	Primary	981.50'	**27.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 981.50' / 981.00' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.98 sf
#2	Device 1	985.00'	**6.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=14.52 cfs @ 12.25 hrs HW=985.83' (Free Discharge)
↑—**1=Culvert** (Passes 14.52 cfs of 33.05 cfs potential flow)
↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 14.52 cfs @ 2.99 fps)

Summary for Subcatchment 10C: Roadway Drainage (5600s)

Runoff = 33.61 cfs @ 12.20 hrs, Volume= 3.052 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
1.250	98	Paved roads w/curbs & sewers, HSG B
0.500	61	>75% Grass cover, Good, HSG B
6.530	72	1/3 acre lots, 30% imp, HSG B
8.280	75	Weighted Average
5.071		61.24% Pervious Area
3.209		38.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.5					**Direct Entry, See Pipe Comps**

Summary for Subcatchment 11C: Direct Drainage (Proposed)

Runoff = 7.86 cfs @ 12.02 hrs, Volume= 0.427 af, Depth= 4.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=7.31"

Area (ac)	CN	Description
0.300	98	Paved roads w/curbs & sewers, HSG B
0.840	61	>75% Grass cover, Good, HSG B
0.080	98	Water Surface, HSG B
1.220	73	Weighted Average
0.840		68.85% Pervious Area
0.380		31.15% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 6P: Long Lake Pond (Proposed)

Inflow Area = 9.500 ac, 37.78% Impervious, Inflow Depth = 4.40" for 100-yr event
Inflow = 35.98 cfs @ 12.19 hrs, Volume= 3.480 af
Outflow = 35.29 cfs @ 12.23 hrs, Volume= 3.480 af, Atten= 2%, Lag= 2.4 min
Primary = 35.29 cfs @ 12.23 hrs, Volume= 3.480 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Starting Elev= 985.00' Surf.Area= 0.080 ac Storage= 0.170 af
Peak Elev= 986.53' @ 12.23 hrs Surf.Area= 0.116 ac Storage= 0.317 af (0.147 af above start)

Plug-Flow detention time= 44.4 min calculated for 3.309 af (95% of inflow)

Center-of-Mass det. time= 5.2 min (838.5 - 833.3)

Volume	Invert	Avail.Storage	Storage Description
#1	981.00'	0.520 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
981.00	0.020	0.000	0.000
982.00	0.030	0.025	0.025
983.00	0.040	0.035	0.060
984.00	0.050	0.045	0.105
985.00	0.080	0.065	0.170
986.00	0.100	0.090	0.260
987.00	0.130	0.115	0.375
988.00	0.160	0.145	0.520

Device	Routing	Invert	Outlet Devices
#1	Primary	981.50'	**27.0" Round Culvert** L= 100.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 981.50' / 981.00' S= 0.0050 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.98 sf
#2	Device 1	985.00'	**6.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=35.29 cfs @ 12.23 hrs HW=986.53' (Free Discharge)
↑—**1=Culvert** (Passes 35.29 cfs of 37.25 cfs potential flow)
  ↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 35.29 cfs @ 4.05 fps)

Appendix K: Shoreline Stabilization Computations

CSAH 112 Reconstruction

CSAH 6 to TH 12

Hydraulic Analysis Report

Project Data

Project Title: CSAH 112 - Long Lake Shoreline Riprap

Designer: Lisa Breu/Lisa Goddard

Project Date: Monday, October 21, 2013

Project Units: U.S. Customary Units

Notes:

Riprap Analysis: Max Annual Ave Wind Speed_East

Notes:

Input Parameters

Riprap Type: Wave Attack

Wave Input Parameters

Calculate Wave Parameters

See USACE Coastal Engineering Manual for more information on wind speed, fetch length, and still water depth.

Wind Speed: 17.893 ft/s

Fetch Length: 3326.41 ft

Still Water Depth: 3.28 ft

Wave Result Parameters

Wind Velocity Coefficient: 0.0107

Coefficient of Drag: 0.00129146

Friction Velocity: 0.643018 ft/s

Dimensionless Fetch Length: 259051

Dimensionless Wave Height: 21.0205

10% Wave Height: 0.342797 ft

10% Wave Height = 1.27 * Significant Wave Height

5% Wave Height: 0.372488 ft

5% Wave Height = 1.38 * Significant Wave Height

1% Wave Height: 0.450764 ft

1% Wave Height = 1.67 * Significant Wave Height

Dimensionless Wave Period: 45.9259

Significant Wave Height: 0.269919 ft

This is the lesser of the calculated value or 0.8 * still water depth

Wave Period: 0.917116 s

Wave Attack Input Parameters

Angle of Slope Inclination: 1:1 H:V

Freeboard: 2 ft

Armor Roughness Coefficient: 0.55

Specific Gravity of Riprap: 2.65

A lot of riprap used in coastal areas have specific gravity values less than 2.65, designers should not assume specific gravity equal to 2.65

Specific Gravity of Water: 1

Fresh water = 1.0, sea water = 1.03

Pilarczyk Method is Selected

Pilarczyk Coefficient: 2.25

Stability Upgrade Factor: 1

Stability Factor: 1

Result Parameters

Relative Unit Weight of Riprap: 1.65 lb/ft^3

Dimensionless Breaker Parameter: 3.97183

0-0.5: Spilling wave, 0.5-2.5: Plunging wave, 2.5-3.5: Collapsing Wave, >3.5: Surging wave

Computed D50: 5.53274 in

Riprap Class

Riprap Class Name: CLASS III

Riprap Class Order: 3

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 15.5 in

d85: 12.8 in

d50: 6.5 in

d15: 2.5625 in

Layout Recommendations

Wave Runup: 0.475057 ft

Lesser of computed or 1.76*Hs

Vertical Height of Riprap above the Toe of Slope: 6.09785 ft

Thickness of Riprap Protection: 15.5 in.

No channel used in calculations

Riprap Analysis: Max Annual Ave Wind Speed_West

Notes:

Input Parameters

Riprap Type: Wave Attack

Wave Input Parameters

Calculate Wave Parameters

See USACE Coastal Engineering Manual for more information on wind speed, fetch length, and still water depth.

Wind Speed: 17.893 ft/s

Fetch Length: 4910.4 ft

Still Water Depth: 3.28 ft

Wave Result Parameters

Wind Velocity Coefficient: 0.0107

Coefficient of Drag: 0.00129146

Friction Velocity: 0.643018 ft/s

Dimensionless Fetch Length: 382408

Dimensionless Wave Height: 25.5396

10% Wave Height: 0.416492 ft

10% Wave Height = 1.27 * Significant Wave Height

5% Wave Height: 0.452567 ft

5% Wave Height = 1.38 * Significant Wave Height

1% Wave Height: 0.547671 ft

1% Wave Height = 1.67 * Significant Wave Height

Dimensionless Wave Period: 52.2245

Significant Wave Height: 0.327947 ft

This is the lesser of the calculated value or 0.8 * still water depth

Wave Period: 1.0429 s

Wave Attack Input Parameters

Angle of Slope Inclination: 1:1 H:V

Freeboard: 2 ft

Armor Roughness Coefficient: 0.55

Specific Gravity of Riprap: 2.65

A lot of riprap used in coastal areas have specific gravity values less than 2.65, designers should not assume specific gravity equal to 2.65

Specific Gravity of Water: 1

Fresh water = 1.0, sea water = 1.03

Pilarczyk Method is Selected

Pilarczyk Coefficient: 2.25

Stability Upgrade Factor: 1

Stability Factor: 1

Result Parameters

Relative Unit Weight of Riprap: 1.65 lb/ft^3

Dimensionless Breaker Parameter: 4.09752

0-0.5: Spilling wave, 0.5-2.5: Plunging wave, 2.5-3.5: Collapsing Wave, >3.5: Surging wave

Computed D50: 6.82773 in

Riprap Class

Riprap Class Name: CLASS IV

Riprap Class Order: 4

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 20 in

d85: 16.4 in

d50: 8.5 in

d15: 3.6875 in

Layout Recommendations

Wave Runup: 0.577186 ft

Lesser of computed or 1.76*Hs

Vertical Height of Riprap above the Toe of Slope: 6.27368 ft

Thickness of Riprap Protection: 20 in.

No channel used in calculations

CSAH 112 RECONSTRUCTION
Long Lake Shoreline Stabilization

Wave height calculations

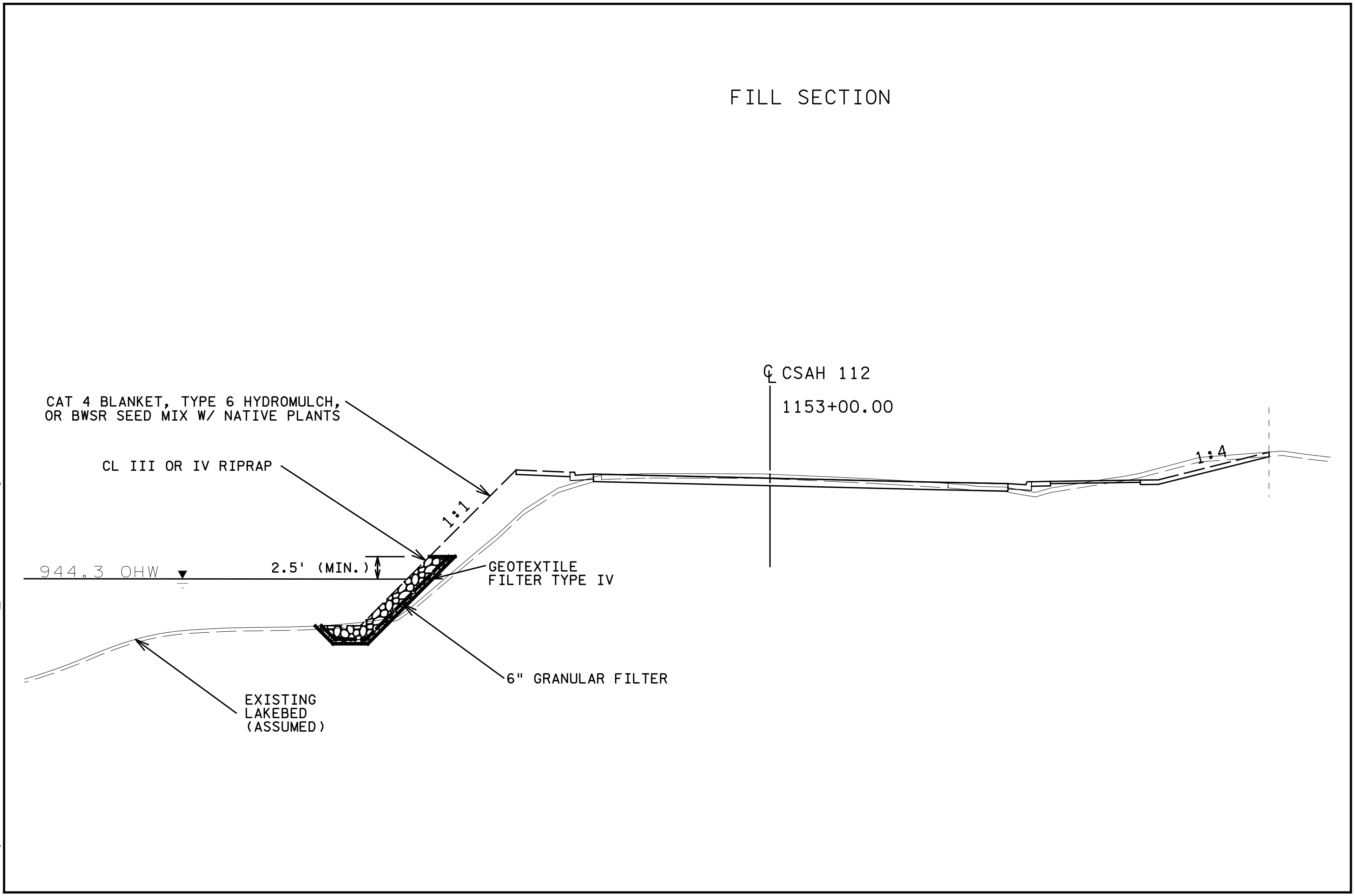
SRF Comm #7738.00
By LAB 2/15/2013
Checked JAD

Inputs:

gravitational constant	9.8	m/sec2
depth of water	1	m
fetch - west end	1496.7	m
fetch - east end	1013.9	m

Month	Mean Wind speed (MPH)	Peak Gust Speed (MPH)	Prevailing Wind Direction	Wave Height - West End		Wave Height - East End	
				Mean Wave Height (ft)	Peak Wave Height (ft)	Mean Wave Height (ft)	Peak Wave Height (ft)
January	10.5	51	SW	0.28	1.40	0.24	1.29
February	10.4	37	SW	0.28	1.05	0.24	0.95
March	11.3	37	NW	0.31	1.05	0.26	0.95
April	12.2	45	SW	0.34	1.26	0.28	1.15
May	11.1	49	SW	0.30	1.35	0.26	1.24
June	10.4	48	SW	0.28	1.33	0.24	1.22
July	9.4	43	NW	0.25	1.21	0.21	1.10
August	9.2	44	S	0.24	1.23	0.20	1.12
September	10	39	SW	0.27	1.11	0.23	1.00
October	10.6	43	SW	0.29	1.21	0.24	1.10
November	11	41	SW	0.30	1.16	0.25	1.05
December	10.4	38	SW	0.28	1.08	0.24	0.97
Annual	10.5	51	SW	0.28	1.40	0.24	1.29

Wind speeds source: Current Results research news & science facts http://www.currentresults.com/Weather/US/wind-speed-city-annual.php



H:\Projects\7738\HI-MU\DRAINAGE\7738_xsSHORELINE.dgn

SRF Consulting Group, Inc.

Job # 7738
10/22/2013

Shoreline Stabilization Concept

Water Resources Preliminary Drainage Design Report

CSAH 112 Reconstruction

Figure 1

Appendix L: Meeting Minutes and Correspondence

CSAH 112 Reconstruction

CSAH 6 to TH 12

SRF No. 7738
County Project No. 0911

CSAH 112
Water Resources Coordination Meeting
November 26, 2012; 1:30 pm – 3:00 pm
MEETING RECORD

A water resources coordination meeting for the referenced project was held at SRF Consulting Group offices on November 26, 2012. **Some of the same coordination items were discussed at the TAC meeting held on November 28, 2012.** The following is a summary of the water resources discussion at both meetings based on the Agenda which is attached to this record. **Revisions to the draft meeting minutes are shown in bold.**

Meeting Summary:

1. *Introductions:*

   Lisa Goddard opened the meeting with a round of introductions. A list of meeting attendees is attached. Terry Post and Mike Panzer were not able to attend. **Terry Post was in attendance at the TAC meeting.**

2. *Project Background and Overview:*
   a. *Roadway Design Elements*

   The new road will have a similar footprint and occupy the same area as the existing road. In general, the proposed roadway will follow the current profile grade. A trail is proposed to run the length of the corridor, and a sidewalk will run along a portion of the corridor. There are a number of trail connections, and the preliminary design responds to pedestrian safety concerns. Although trails have been added, many are exempt according to the Minnehaha Creek Watershed District's (MCWD) stormwater rule, and the current roadway concept is narrower than the existing road, creating a net loss in impervious surface. If the project does result in a net loss of impervious surface, it would not trigger MCWD's stormwater rule. Lisa Goddard stated that the end product is a preliminary layout with an environmental summary and vision study report.

   i. *Rural to Urban Roadway Section*

   Mike Turner indicated that segments 1 and 4 of the road will remain more rural. Portions of segments 1and 4 are semi-urban where curb and gutter runs along the trail. The roadway from Old Crystal Bay Road through downtown to the southwest corner of Long Lake, segments 2 and 3, will become urban throughout.

3. *Stormwater Management:*
   a. *Segment 1: CSAH 6 to Old Crystal Bay Rd.*

   Classen Lake and Classen Creek are the major water bodies in this segment. Their floodplain and wetlands are very close to the existing road. The culvert conveying Classen Creek under the road will be analyzed to determine if the additional length due to the proposed trail decreases the hydraulic capacity of the culvert.

   Given the adjacent wetlands and floodplain, there is little land available for stormwater treatment best management practices (BMPs), such as a pond or bioretention if they should become necessary (i.e., if the project results in more than 10,000 square-feet of new impervious surface). Mike Turner noted that he had been told Classen Creek is impaired for phosphorous. Lisa responded that Long Lake is impaired for nutrients. Classen Creek is not on the current list of impaired waters, but it may be on the draft list of impaired waters. Steve Christopher will check on the status of Classen Creek.

   b. *Segment 2: Old Crystal Bay Road to Brown Road*

   If additional treatment is required for the project, the group discussed the possibility to expand the existing pond north of CSAH 112 in this segment given the limited space available. Mike Gaffron indicated that the pond was sized for CSAH 112 from just west of Old Crystal Bay Road to just east of Willow Drive and the surrounding development. The pond then drains under the road and south through a channel to another pond. The City of Orono has approved developments in most of the open parcels on either side of the pond. However, both outlots are available, which include the pond and some of the upland, and the City has not received a proposed development plan for the lot immediately west of the pond. It may also be possible to allow the pond to bounce more, which could help meet possible rate control requirements. Lisa Goddard pointed out that although the layout shows a wetland delineation line around the pond, it will likely not be considered a jurisdictional wetland.

   c. *Segment 3: Brown Rd. to Wolf Pointe Trail*

   All runoff from this segment flows into Long Lake. As with segments 1 and 2, there is limited space available for BMPs in this segment, and treatment, if needed, would likely be limited to boulevards areas or underground structures. Mike Gaffron stated redevelopment of the Burger King parcel is desired, but it may be possible to incorporate a small pond close to the road while leaving the majority of the parcel available for redevelopment.

   A drainageway carries runoff from CSAH 112 and from residential and other land uses south of CSAH 112 to Long Lake. Therefore, if there is an increase in impervious surface, treatment should be located upstream of the drainageway, if possible. Potential sites include:
   - Land owned by the City of Long Lake on the corner of CSAH 112 and Brown Road.
   - Site of a former gas station at the intersection of CSAH 112 and Lake Street, but contamination issues at the site may preclude its use for stormwater treatment.

- Expansion of the ponds by the drainageway. The ponds were constructed in 2009 and were designed to treat the roadway and downtown area. **However, Terry Post noted that there was some degree of opposition to the loss of parkland with the original construction of the ponds, and he advised that residents will likely not be in favor of any plans that would take away more parkland.**

As noted above, Long Lake is impaired for nutrients. According to NPDES rules, the project will be required to provide infiltration for runoff from added impervious surface if conditions allow. However, this area is in the wellhead protection zones for two municipal wells. Lisa Breu reported that in a telephone conversation with the Minnesota Department of Health, they expressed no concerns regarding the reconstruction of CSAH 112 and the wells. Jesse Struve did not express concerns if stormwater runoff is infiltrated within the wellhead protection zone for Orono's well due to its location in relation to CSAH 112.

Even if the project does not increase impervious surfaces, one of the project priorities is improving the water quality of Long Lake, and therefore, the City of Long Lake may be interested in providing some treatment if possible. If desired, treatment could be provided via grit chambers, hydrodynamic separators, or other underground system. Mike Turner reported that the City of Long Lake had discussed rerouting runoff from at least a portion of the segment directly to Long Lake Creek, if feasible. **Terry Post said that it would be important to provide treatment for the area by the lakeshore or to route stormwater to Long Lake Creek.** It is possible that that MCWD could provide some funding for the grit chamber if the project decreases impervious acreage and constructs a BMP. **Terry suggested the possibility of utilizing the old sewage pond of the railway corridor and immediately east of Long Lake Creek. He also said that the City of Long Lake has an easement by Long Lake Creek between Highway 12 and CSAH 112 that could potentially be utilized for treatment.**

The floodplain and shoreline for Long Lake are very close to the current roadway. The current concept shows the trail potentially encroaching on both. The floodplain location is based off GIS data, which was digitized from the FIRM maps and, therefore, is not very precise. The actual floodplain elevation is regulated by MCWD and is likely based off the 100-year high water elevation for Long Lake. However, the trail may need to move closer to the road in order to avoid impacts to the shoreline. Jim Grube indicated that we need to be careful about the trail along Long Lake due to erosion in that area.

Long Lake Creek is the outfall from Long Lake. It crosses CSAH 112 in a culvert. Lisa Goddard asked if there were any creek stability issues in the area. Steve Christopher said that the District currently has a project to address channel stabilization south of Highway 12. A hydraulic analysis of the Long Lake Creek crossing will be needed to determine if the additional length caused by the roadway/trail widening would decrease the hydraulic capacity. Its condition should also be assessed. The culvert was likely owned by MnDOT and turned back to Hennepin County, but ownership of the lake's outlet structure is unclear.

d. Segment 4: Wolf Pointe Trail to Wayzata Blvd.

The eastern portion of the project is more residential and rural. There are several wetlands of all management classes close to the road. Mike Gaffron pointed out that the large wetland near the bridge for the Luce Line Trail was a tax forfeiture and that the DNR now owns it. Steve Christopher said that a buffer would only have to be in the right of way on the construction side of the wetland. By maintaining vegetation, there could also be a reduced width buffer. Mike Turner advised that retaining walls may be required in some areas of segment 4. Steve Christopher said it would be acceptable to have a retaining wall in the buffer.

The northern end of segment 4 is flat to rolling. Curb and gutter is proposed on the trail side of the road, while the other side of the road would still sheet flow into ditches. Mike Gaffron stated that there is a stormwater project that will be undertaken within the next five years near Summit Beach Park. If there was enough benefit provided by the pond for treatment of CSAH 112 runoff, the benefits may outweigh the pipe costs. Water could be conveyed by a swale/ditch to reduce cost.

e. Criteria

Lisa Goddard presented a draft summary of the regulatory matrix for the project (see attached). She pointed out that although there may be no stormwater criteria due to the decrease in impervious surface project wide, we still need wetland buffers. Steve Christopher added that the buffers also provide pretreatment. Lisa Goddard asked everyone to make sure that the regulations are complete. The City of Orono's Stormwater Management Plan may have some stormwater regulations that are not in the city ordinances. Also, Orono has strict buffer rules, but otherwise they usually default to MCWD rules. Steve Christopher indicated that the culverts in this project will trigger the water body crossing rule, and the section at southwest Long Lake will require shoreline stabilization rule. A DNR general permit will be required for work below the ordinary high water elevation of public waters. MCWD is the LGU for Long Lake for all of their rules.

f. Other Drainage Issues/Concerns

Mike Gaffron indicated that a culvert near the intersection at Old Long Lake Road has become exposed due to erosion. This area was marked on the layout.

Erosion near the southwest corner of Long Lake should be addressed by this project.

Jesse Struve indicated that the wetland and upland area south of CSAH 112 near Classen Lake is a capped landfill and would not be suitable for wetland or floodplain mitigation. It is unlikely that the road reconstruction would directly affect the landfill.

There is also a persistent dip in the road near there the eastern culvert out of Classen Lake.

4. *Wetlands and Flood plains*
    a. *Wetland Buffers*
    MCWD has a set of regulations concerning buffers, although Orono's may be stricter. These will be checked in the regulatory matrix. Long Lake was not delineated due to the 1:1 slope along the shore and resulting lack of fringe wetlands.

    b. *Potential Impacts*
    With the proposed trails, there may be wetland and floodplain impacts. Mike Turner indicated that cross-sections are currently being made. Those will be compared against the floodplain elevations and wetland boundaries. Mike Gaffron indicated that the trail extending west from Classen Lake to CSAH 6 is not in Orono's comprehensive plan, but as there is a park to the west, the City would likely be in favor of the trail. It may be necessary to move the trail closer to the roadway to minimize impacts.

    c. *Mitigation Requirements and Strategies*
    Floodplain volume that has been removed by the project must be compensated on a 1:1 basis, and mitigation must be constructed before fill is placed. Jim Grube indicated that this could be a timing issue with the four different segments. SRF will obtain floodplain elevations and determine where mitigation for floodplain fill is possible within the two subwatersheds where impacts are likely.

    Options for wetland mitigation will also be addressed. The City of Orono owns land in the curve by CSAH 6. MnDOT used some of this land for a pond, which is either treating runoff from Highway 12 or designed for wetland mitigation. It may be possible to utilize the area for mitigation, but this would need to be coordinated with MnDOT and the City.

5. *Schedule*
    A Public Open House will be held in February or March.

    A preliminary layout will be due in the second quarter of 2013. The environmental planning and vision report will be due at the same time.

6. *Follow Up Items/Action Items:*

    For tracking purposes, we have assigned a responsible party and a due date for completing the following action items, which were identified at the meeting:

Task	**Responsible Party**	**Due Date**	**Resolution**
Provide Long Lake 100-year high water elevation and discharge rate.	Steve Christopher		
Check impairment status of Classen Creek.	Steve Christopher		

Review regulatory matrix and provide comments to SRF.	All		
Analyze fill impacts with cross sections.	Lisa Breu		
As design progresses, confirm change in impervious acreage and coordinate with city staff again, if needed, regarding BMP locations.	Lisa Breu and Lisa Goddard		
Determine floodplain elevation of Long Lake and Classen Lake. Update floodplain base file based upon the actual elevations.	Lisa Breu		
Follow up with City of Long Lake staff regarding infiltration of stormwater in the other wellhead protection zone.	Lisa Goddard		
Follow up with City of Long Lake staff regarding rerouting stormwater to Long Lake Creek in segment 3.	Lisa Goddard		
Provide information on wetland mitigation/pond to the west of Classen Lake.	Jesse Struve or Mike Gaffron		

7. *Upcoming Meetings:*

TAC Meeting: November 28, 2012; 1:00 pm- 3:00 pm

Meeting Record Revisions:

The preceding represents SRF Consulting Group's understanding of the referenced meeting. If you identify discrepancies or items that require clarification, please contact Lisa Goddard at SRF within 10 days of receipt via email at lgoddard@srfconsulting.com or via telephone at 763-475-2429.

cc: Terry Post – City of Long Lake
Eric Evenson – Minnehaha Creek Watershed District
Mike Panzer – Wenck Associates
Jim Gersema – SRF

CSAH 112 Project

Water Resources Coordination Meeting Sign-In Sheet

Monday, November 26, 2012 (1:30 – 3:00 p.m.)

Present	Name/Organization	Mailing Address	Phone	Email
☒	Jim Grube Hennepin County	1600 Prairie Drive Medina, MN 55340	612-596-0307	James.Grube@co.hennepin.mn.us
☒	Mike Turner SRF Consulting Group	1 Carlson Parkway, Suite 150 Minneapolis, MN 55447	763-249-6717	MTurner@SRFConsulting.com
☒	Lisa Goddard SRF Consulting Group	1 Carlson Parkway, Suite 150 Minneapolis, MN 55447	763-249-6743	LGoddardr@SRFConsulting.com
☒	Jesse Struve City of Orono	P.O. Box 66 Crystal Bay, MN 55323	952-249-4661	JStruve@ci.orono.mn.us
☒	Mike Gaffron City of Orono	P.O. Box 66 Crystal Bay, MN 55323	952-249-4622	MGaffron@ci.orono.mn.us
☒	Steve Christopher MCWD	18202 Minnetonka Boulevard Deephaven, MN 55391	952-471-0590	schristopher@minnehahacreek.org

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Water Body Alterations	Wetland Quality	Erosion and Sediment Control
Minnehaha Creek Watershed District **(Taken from Minnehaha Creek Watershed District Comprehensive Water Resources Management Plan [2010] and Rules [adopted 2010 - 2011])** Permits will likely be needed for the following rules: - Floodplain Alteration - Wetland Protection - Stormwater Management - Erosion control - *Also shoreline, and water body alteration?*	See "Stormwater Management Rule" RATE CONTROL (a) Linear Transportation Reconstruction shall result in no net increase in the peak runoff rate for the 1-, 10- and 100-year design storms (b) No increase in peak runoff rates for the 1-, 10- and 100-year design storms within a specific drainage area of the site that will create or exacerbate drainage or erosion problems. VOLUME CONTROL (a) The required level of treatment is dependent on the increase in impervious surface for **linear reconstruction** projects: i. <10,000 SF None ii. ≥ 10,000 SF & < 1 AC None iii. > 1 AC YES (b) If iii applies, abstract the first 1" of rainfall from the **added** impervious surfaces. Credit will be calculated using industry accepted hydrologic models and Appendix A: Volume Abstraction Credit Schedule. (c) If meeting abstraction requirements is not feasible, abstract runoff to the greatest extent feasible – ½" min. - **and** provide phosphorus control equivalent to that achieved through abstraction of 1" of rainfall. Infeasibility will demonstrated by an Abstraction Analysis (See Rule). (d) No increase in runoff volume to a landlocked receiving area unless any additional runoff from the project will be effectively abstracted. i. Analyze back-to-back 100-year runoff events.	See "Stormwater Management Rule" PHOSPHORUS CONTROL: (a) The required level of treatment is dependent on the increase in impervious surface for **linear reconstruction** projects: i. <10,000 SF None ii. > 10,000 SF & < 1 AC YES iii. > 1 AC YES (b) No net increase in phosphorus loading from existing conditions for the **added** impervious surfaces. REGIONAL STORMWATER MANAGEMENT See "Stormwater Management Rule" Section 7 if construction of a regional treatment facility is proposed. IMPACT ON DOWNSTREAM WATERBODIES (a) No **new** point source may discharge to a waterbody without pretreatment (sediment & nutrient removal). (b) See Table 1 of the Rule for limits on allowable changes to the bounce, the duration of inundation, or runout control elevation for any downstream lake or wetland. *i. Wetlands of all management classes exist along the corridor.*	FLOODPLAIN ALTERATION See "Floodplain Alteration Rule" (a) No net decrease in storage capacity below the projected 100-year HWL of a waterbody. See section (C) for exceptions. i. Floodplain storage mitigation shall occur before any fill is placed in the floodplain, unless the applicant demonstrates that doing so is impractical and that placement of fill and creation of storage capacity can be achieved concurrently. ii. This requirement does not apply to fill in a waterbody other than a watercourse if the applicant shows that the proposed fill, together with the filling of all other properties on the waterbody to the same degree of encroachment as proposed by the applicant, will not cause high water or aggravate flooding on other properties and will not unduly restrict flood flows. (b) No increase in the 100-year flood elevation of a watercourse. WATER BODY ALTERATIONS See "Waterbody Crossings & Structures Rule	See "Wetland Protection Rule" ▪ No **new** point source may discharge to a wetland without pretreatment for sediment and nutrient removal. Pretreatment may be provided by nonstructural means. ▪ The District regulates activity impacting wetlands pursuant to the Wetland Conservation Act and the Watershed Law. REPLACEMENT/MITIGATION (a) Site wetland replacement in the following order of priority: i. On site; ii. Within the same subwatershed as the impacted wetland (see Appendix 1); iii. Within the District. BUFFER (a) Any activity for which a permit is required under this Wetland Protection Rule, the Stormwater Management Rule or the District Waterbody Crossings and Structures Rule that increases the imperviousness of the subject parcel must provide for buffer adjacent to each wetland and public waters wetland. i. Buffer must be provided on that part of the wetland edge that is downgradient from the activity or construction and around each wetland that will be disturbed. (b) The minimum buffer width is dependent on the management class of each wetland (see Section 6). i. *Wetlands of all management classes exist along the corridor.* (c) See Sections 7 for buffer vegetation requirements.	See "Erosion Control Rule" ▪ Prepare and implement erosion control plan meeting the requirements of the rule.
Minnesota Department of Health (Taken from MDH County Well Index, and MDH Source Water Assessments, 2012)	Contact MDH for more information concerning Well Head Protection Plans for Orono Well Number 2 and 3 Well Head Protection Area and Long Lake Well Number 2 Well Head Protection Area. These areas may also be referred to as Long Lake East, Long Lake West, and Orono 3 Well Head Protection Areas, according to the County Well Index. Long Lake East and West are both classified as "Low Vulnerability"; Orono 3 is classified as "Not Vulnerable". See Map PDFs				

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Water Body Alterations	Wetland Quality	Erosion and Sediment Control
City of Orono (from, Orono City Code, 2003) Permits for land-disturbing activity and wetlands will be required unless incorporated into municipal consent process.	DRAINAGE PLAN ▪ The direction, quantity or quality of drainage shall not be changed unless plans for the development are submitted to the city engineer, and are found to be in compliance with the city's stormwater management policies. ▪ Runoff shall be properly channeled into a storm drain, watercourse, ponding area or other public facility.	STORMWATER MANAGEMENT ▪ When possible, existing natural drainageways, wetlands and vegetated soil surfaces must be used to convey, store, filter and retain stormwater runoff before discharge to public waters. ▪ A development must be planned and conducted in a manner that will minimize the extent of disturbed areas, runoff velocities and erosion potential, and reduce and delay runoff volumes. Disturbed areas must be stabilized and protected as soon as possible and facilities or methods used to retain sediment on the site. ▪ New constructed stormwater outfalls to public waters must provide for filtering or settling of suspended solids and skimming of surface debris before discharge.	FLOODWAY CONDITIONAL USES ▪ (a) No structure (temporary or permanent), fill (including fill for roads and levees), deposit, obstruction, storage of materials or equipment, or other uses may be allowed as a conditional use that will cause any increase in the stage of the 100-year or regional flood or cause an increase in flood damages in the reach or reaches affected. (See section 78-1117 (d) for additional fill requirements.) Sec. 78-1129. - Public transportation facilities. ▪ Elevation to the regulatory flood protection elevation shall be provided where failure or interruption of these transportation facilities would result in danger to the public health or safety or where such facilities are essential to the orderly functioning of the area. Minor or auxiliary roads or railroads may be constructed at a lower elevation where failure or interruption of transportation services would not endanger the public health or safety.	BUFFERS Wetland buffer must be created or existing buffer areas must be maintained when project is within 50 feet of a wetland. Additional requirements include: ▪ When the wetland is required to be replaced or restored, or when the wetland is being altered; ▪ When any construction or land alteration activity that does not fall within the meaning of 'redevelopment' has the potential to adversely impact a wetland. STANDARDS ▪ All hard-surface runoff must be treated in accordance with the requirements of the city and the watershed district. ▪ Discharge into the wetlands – maximum allowable as allowed by the city engineer in accordance with the city's surface water management plan and the appropriate MCWD requirements. ▪ New non-structural impervious surfaces shall maintain a buffer setback from the delineated wetland boundary per the chart in [section] 78-1605(c) according to wetland class. (See additional requirements in section 78-1608.) Land may be removed from the wetlands overlay district (i.e., by filling, etc.) by: (a) A zoning amendment and amendment of the official city wetland map. (b) Following WCA rules and creating at least an equal area of wetland to compensate for the wetland being filled. Alteration of wetlands are allowed if: (a) A wetlands alteration permit is obtained (b) If water storage is provided in an amount compensatory to that removed. See ordinance for additional requirements See Sec. 78-1605 for detailed wetland buffer requirements.	▪ A plan for erosion and sedimentation control specifying the measures to be used before, during and after construction until the soil and slope are stabilized by permanent cover shall be presented with the site plan. TOPOGRAPHIC ALTERATIONS/ GRADING AND FILLING. ▪ Grading, filling or excavating of more than ten cu. yd. is prohibited within 75 ft. of the OHW of the public waters listed in section 78-1217. ▪ Grading, filling or excavating of ten cu. yd. or less shall require city staff review and permit and be subject to other pertinent sections of this chapter. ▪ Public roads shall not be constructed within 75 ft. of the OHW of the public waters listed in section 78-1217, or, such improvements are subject to the standard zoning variance review procedure. ▪ Vegetation alteration within 75 feet of the shoreline or within the bluff impact zone is subject to Sec. 78-1285.

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Water Body Alterations	Wetland Quality	Erosion and Sediment Control
City of Long Lake (From Long Lake City Ordinances [2003] and Water Resources Management Plan []) Permits for Erosion/Sediment Control, ____________ as well as variances for work within the Shoreland Overlay, Wetland Protection, and Water Management Overlay Districts may be required unless incorporated into municipal consent process.	▪ No increase in runoff rates for the 1-, 10-, and 100-year rainfall events as indicated in the Water Resources Management Plan. ▪ Increased volumes of runoff due to development should be minimized by: o Abstraction; o Limiting impervious cover; o And encouraging infiltration of storm water where soil conditions are appropriate.	WET DETENTION POND DESIGN ▪ Size ponds using NURP design that achieves a total phosphorus removal efficiency of 65% or greater for each pond or series of ponds. o Is there a greater standard for runoff draining to Long Lake or Long Lake Creek to meet MCWD phosphorus reduction goal? ▪ Physical design features: o Permanent pool depth greater than or equal to runoff volume from 2.5" rainfall under complete watershed development. o Min. permanent pool depth = 4 ft. o Mean permanent pool depth = 3 – 4 ft. depending on overall pond size. o Max. permanent pool depth = 10 ft. o Max. length to max. width ratio = 3:1 ▪ Use baffles or ponds in series if 3:1 ratio is not achievable. o Min. bench width = 15 ft. at 1v:10h max. slope o Provide settleing forebay at pond inlets o Skimming for the 1-year event.	▪ All utilities and transportation facilities, including railroad tracks, roads and bridges, shall be constructed in accordance with state flood plain management standards contained in Minnesota Rules 1983 Parts 6120.5000 - 6120.6200. ▪ Public utility facilities, roads, railroad tracks, and bridges within the floodplain should be designed to minimize increases in flood elevations and should be compatible with existing local comprehensive floodplain development plans.	The Wetland Protection District consists of all upland within fifty feet (50') of the wetland boundary of wetlands identified in the Water Resource Management Plan that drain to the waterbody. o Include any water course, natural drainage system, water body, or wetland that may be subject to periodic flooding, overflow, or seasonally high water tables. o Ponds are not permitted unless conditionally permitted.	▪ The design, testing, installation, and maintenance of erosion and sediment control operations and facilities shall adhere to the standards and specifications contained in the Minnesota Pollution Control Agencies handbook of best management practices entitled "Protecting Water Quality in Urban Areas," dated October 1989, as amended. ▪ Except as otherwise provided in the Uniform Building Code, as adopted by the City of Long Lake, no person may grade, fill, excavate, store, stockpile or dispose of earth materials or perform any other land disturbing or land filling activity without first obtaining a building permit from the Building Inspector.
MPCA NPDES permits and Stormwater Pollution Prevention Plan will be required. Long Lake is impaired for nutrients.	FOR DRAINAGE TO LONG LAKE ▪ No increase in peak discharge rate or runoff volume from the 1- and 2-year, 24-hour precipitation events over those of the pre-project condition. ▪ At least ½" of runoff from the added impervious surfaces must be infiltrated where soil conditions allow or filtrated where site conditions allow. o 48 hours max. detention time. o Design to have a reasonable chance of achieving 80% TSS removal.	FOR DRAINAGE TO LONG LAKE ▪ Water quality volume is equal to 1" of runoff from new impervious surfaces created by the project for projects in which the ultimate development replaces pervious surfaces with one or more acres of accumulative impervious surface. o Half of the water quality volume must be infiltrated or filtrated where site and soil conditions allow. DETENTION BASIN DESIGN ▪ Permanent volume = 1800 cu. ft. per acre of drainage area. ▪ Water quality volume = ½" of runoff from new impervious surfaces. ▪ Min. permanent pool depth = 3 ft. ▪ Max. permanent pool depth = 10 ft. ▪ Water quality volume maximum discharge shall be no more than 5.66 cfs per acres of surface area of the pond at the water quality volume. ▪ Outlets must prevent short circuiting and the discharge of floating debris, provide stabilized emergency overflow and energy dissipation.		▪ Stormwater must be discharged in a manner that does not cause nuisance conditions, erosion in receiving channels or on downslope properties, or inundation in wetlands causing significant adverse impacts to the wetlands.	FOR DRAINAGE TO LONG LAKE ▪ All exposed soil areas must be stabilized as soon as possible but no later than 7 days after construction activity has temporarily or permanently ceased in that portion. ▪ If 5 or more acres of disturbed soil drain to a common location, a temporary sediment basin must be provided prior to runoff leaving the construction site and before entering surface waters. DRAINAGE TO OTHER AREAS ▪ All exposed soil with a continuous positive slope within 200 ft. of a surface water (including a stormwater conveyance system) must have temporary erosion control or permanent cover for exposed soil areas within 24 hours of connecting to surface water. ▪ Sediment control practices must minimize sediment from entering surface waters, including curb and gutter systems and storm sewer inlets. ▪ There shall be no unbroken slope length greater than 75 feet for slopes with a grade of 3:1 or steeper.

Entity	Surface Water Quantity	Surface Water Quality	Floodplain and Water Body Alterations	Wetland Quality	Erosion and Sediment Control
		▪ Other treatment practices such as grasses swales, small ponds, grit chambers, etc. are required prior to discharge to surface waters for road projects where the lack of right of way restricts the ability to construct ponds or infiltration basins.			▪ All exposed soil areas must be stabilized as soon as possible but no later than 14 days after construction activity has temporarily or permanently ceased in that portion. ▪ Temporary soil stockpiles must have effective sediment controls and can not be placed in surface waters, including curb and gutter and ditches.