KINGSTON PLACE

PRELIMINARY DRAINAGE REPORT

DECEMBER 2020

For:
Jeff McCann

McCann and Company
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APPROVED FOR ONE YEAR FROM THIS DATE	
City Engineer	Date
Aurora Water Department	Date

ENGINEER'S STATEMENT:

I hereby certify that this report and plan for the preliminary drainage design of Kingston PLACE, was prepared by me (or under my direction supervision) in accordance with the provisions of the City of Aurora Drainage Criteria Manual for the owners thereof.

____

Benjamin Murphy, P.E. Date
State of Colorado No. 51733
For and on behalf of Calibre Engineering, Inc.

TABLE OF CONTENTS

APPENDICES

A. Maps and Exhibits

B. Hydrologic Computations

C. Hydraulic Calculations

D. Existing Reports

REPORT UPDATE AND PROJECT HISTORY:

The intent of this report is to update the design for drainage facilities discussed in the *Kingston Place Subdivision Filing No. 1 Final Drainage Report*, prepared by Calibre Engineering, Inc (Calibre), *October 2004, City of Aurora (COA) Approval Number 204252.* Since the original design and report were approved the COA in 2004, the following changes have been made to the site and surrounding areas:

- Four of the Eleven duplexes have been constructed,
- The pond, overflow weir, outlet structure, and other drainage infrastructure have been constructed,
- S Kenton Way Rights-of-Way (ROW) were vacated,
- And the Centro Apartment Complex was constructed west of the site.

The vacation of S Kenton Way and the construction of the Centro Apartment Complex have resulted in the pond overflow path being blocked by Centro's MSE block retaining wall and wood fence. Calibre had several discussions with COA staff (Craig Perl) to discuss potential steps to amend the current design and allow the construction of the remaining 7 duplex units. The following represents the agreed to conditions that will allow the site to continue construction:

- Existing overflow western overflow weir must be removed, and the western pond slope raised to prevent pond overtopping along the western property line.
- A new overflow weir must be constructed in the north slope of the pond.
- A new maintenance road must be constructed to the new overflow weir. The road will connect from the weir to the existing Westerly Creek recreational trail.
- No floodplain modifications will be required.
- Floodplain permitting fees will be waved.
- No CLOMR or No-Rise analyses will be required.
- No modifications to the existing outlet structure will be required.

This Kingston PLACE report includes updated hydraulic calculations, as well as tables, graphs and exhibits showing drainage basins and routing.

VERTICAL DATUM SHIFT NOTE:

Please note that due to a datum change from the original 2004 survey and report, there is a change of approximately +3.0' to all elevations referenced from the 2004 report. Any elevations given in the text of this report will be the updated elevations, followed by the 2004 elevations in parentheses. For example, an updated elevation would be shown as 298' (295').

A. INTRODUCTION

1. Location

- The site is located in the City of Aurora, Arapahoe County and State of Colorado. The site is located in the northwest quarter Section 23, Township 4 South, Range 67 West, of the 6th principal meridian
- North of Ridermark Filing No. 1 subdivision.
- South of Westerly Creek
- East of Buckingham Square Subdivision Filing 8, previously South Kenton Way right-of-way
- West of South Kingston Street and Carriage Village Subdivision Filing 2.
- See Vicinity Map located in Appendix A.

2. Proposed Development

- Kingston Place in its entirety is approximately 2.52 acres in size of which 0.23 acres were dedicated to the Kingston Street right-of-way, reducing the area to 2.29 acres.
- The areas where the proposed houses will be consists entirely of undeveloped land and native grass.
- The site generally drains northwest at slopes varying from 0.5% to 2%.
- Site Soil Mapping Units consist of BmB (70.9%) (Bijou sandy loam, Hydrologic Soil Group A) and TrC (29.1%) (Truckton loamy sand, Hydrologic Soil Group A).
- The proposed development will include 22 duplex units, of which 14 have been built per the approved Construction Documents (EDN #204252).
- A description of the site and proposed development is as follows:
  - The existing undeveloped area is covered with native grasses. The general topography slopes to the north & west with average slopes between 0.5-3% towards the existing detention pond facility in the northwest corner of the site.
  - Currently the existing detention pond facility does not have an emergency overflow path due to the construction of Buckingham Subdivision Filing 8 directly west of the site. In the approved Drainage Report from 2004 (EDN #204252), the emergency overflow path was to outfall into Kingston Way right-of-way, which has since been vacated and developed. This development is now blocking the originally proposed emergency overflow path.
  - Westerly Creek lies directly to the north of the project site and will serve as the recipient of a new emergency outfall for the existing detention pond. From Westerly Creek, emergency flows from the Kingston Place site will continue on its historic path per the approved Drainage Report from 2004.

- Generally, the overall imperviousness of the existing area will be in conformance with the previously approved *Kingston Place Subdivision Filing No. 1* drainage report prepared by *Calibre Engineering, October 2004 COA Approval Number 204252* .

- This site lies within the area of FEMA FIRM Map Number 08005C0178K, although the site itself is outside the limits of FEMA's study area and is delineated as Zone X; therefore, there is no delineated floodplain on this site.

    - Westerly Creek does run just to the north of this site, and has an anticipated 100-year WSEL of 5501.0 (5498.0) as determined by a 1996 study performed by Merrick and Company. A 2015 study by CH2M Hill recommends improvements to Westerly Creek that could potentially reduce this 100-year WSEL to 5495.5 (5492.5), however it is not know whether these improvements have been implemented.

    - This 'floodplain' does not encroach into the existing site due to the berm on the north side of the site. Improvements to this berm to incorporate the new emergency overflow will not impact the blockage of the Westerly Creek floodplain.

3. Variances

- No variances are requested at this time.

B. HISTORIC DRAINAGE

1. Overall Basin Description

- Kingston Street has been constructed with curb, gutter and cross pans to control flows within its right-of-way and prevent flows from entering the project site. Additionally, Kingston Way, a private road with curb and gutter within the project site, has been constructed per the approved construction documents (COA #204252).

- The Ridermark subdivision to the south is graded such that negligible flows are expected to enter the project area from offsite.

- The Kingston Place property is elevated in comparison to the Buckingham Square Filing 8 subdivision to the west, preventing any flows from the Buckingham site encroaching onto our project site.

- Westerly Creek is a concrete-lined major drainage channel directly north of the site. Its flows travel from east to west where they enter a 5'x12' concrete culvert traveling north beneath E. Kenton Way.

2. Drainage Patterns Through Property

- Runoff flows in a northwesterly direction across the site to the existing detention pond facility which was constructed per the approved Construction Plans (COA#204252).
- There are no existing major irrigation facilities on the Kingston PLACE property.
- Water detained in the existing pond on the northwest corner of the site is released via outlet structure (constructed as per the approved plans) to Westerly Creek.

3. Outfalls Downstream of Property

- Runoff from the site flows to Westerly Creek.
- The creek flows to the Westerly Creek Dam within the Lowry Development (formally Lowry Air Force Base) which is a regional flood control facility for Westerly Creek.
- The current existing emergency overflow from the pond is non-functional due to the development west of this site. A new emergency overflow will be designed and implemented on the north side of the pond.

C. DESIGN CRITERIA

1. References

- The Final drainage design for this site is based on the following studies:
  - Preliminary Drainage Report for Kingston Place Subdivision Filing No. 1 by Calibre Engineering (2004)
  - Final Drainage Report for The Ridermark Subdivision Filing No. 1 by KMD Inc., COA #202057
  - Final Drainage Report for Carriage Village Subdivision by Spiska Engineering Inc., COA# 950092
  - Final Drainage Report for Kingston Place Subdivision Filing 1 by Calibre Engineering, COA #204252
- Calculations and design were done in accordance with:
  - City of Aurora Storm Drainage Design and Technical Criteria
  - Urban Storm Drainage Criteria Manual (USDCM)
- The Final drainage design for this site is based on the following Master Plans:
  - Outfall Systems Planning Westerly Creek East of Havana by Merrick and Company
  - Final Westerly Creek (Upstream of the Westerly Creed Dam Outlet) Major Drainageway Plan by CH2MHill, January 2015

- The main guide used in the development of this Final Drainage Report is the *City of Aurora Storm Drainage Design and Technical Criteria* (Criteria).
- The Mile High Flood District's *Urban Storm Drainage Criteria Manual* (USDCM) was also used as a reference and guide for criteria.

2. Hydrologic Criteria

- Peak storm runoff was determined using the Rational Formula: Q=CIA. This method is considered appropriate for basin areas up to 90 acres.
- Rainfall intensity data and runoff coefficients were taken from the City's Criteria for south of East Alameda Avenue, per the approved Final Drainage Report.
- The Detention pond volume and release rate were determined using the equation V=KA as specified by the City according to the approved Final Drainage Report.

- The 2-year storm event was used as the minor storm and the 100-year storm event was used as the major storm.

3. Hydraulic Criteria

- Hydraulic criteria are based on UDFCD and the City of Aurora Storm Drainage Design and Technical Criteria Manual
- The 100-year storm was used to size onsite storm drain facilities.
- Water surface profiles are calculated using the NeoUDSewer program.
- According to the OSP, the projected existing flow in Westerly Creek is approximately 3000 cfs. However, a Major Drainageway Plan and study by CH2MHill from 2015 indicates that this peak flow may be reduced to 950 cfs.
- It is unknown if any of the proposed Westerly Creek improvements from the CH2MHill study have been implanted at this time, therefore a flow of 3000 cfs in Westerly Creek was used for all calculations.
- Proposed water surface calculations in Kingston Street were performed using existing surrounding conditions and proposed Kingston Place improvements per the approved Drainage Report.
- Conservative calculations have been performed to determine the water surface of Westerly Creek assuming the flow will overtop the culverts at Kingston Street at a width of 100'. This assumes future development of the site north of Westerly Creek.

D. DRAINAGE PLAN

1. General Concept

- The onsite drainage will be, in general, captured by existing storm sewers and drainage facilities that were constructed per the approved Construction Documents (COA #204252). The drainage patterns have been developed to preserve natural drainageways and follow historic patterns whenever possible.
- The majority of offsite flows remain offsite.
- A small piece of The Ridermark Subdivision flows onto the proposed Kingston Place Subdivision.
- This runoff is routed through the onsite detention/water quality pond.
- Kingston Street improvements from the approved Construction Documents included the addition of curb and gutter on the west side of the road and a new sump inlet just south of the Westerly Creek crossing. These have been constructed and are now existing conditions.
- The Westerly Creek culverts at Kingston Street and Kenton Way are assumed to be undersized. It is likely that Westerly Creek will backup and overflow onto Kingston Street until upstream improvements are in place and the peak flow through Westerly Creek is reduced.

- During proposed conditions when Westerly Creek can encroach onto the property north of the creek, the water elevation as it crosses Kingston Street is 5499.0 on the NAVD88 datum (5496.0 on the Aurora Vertical Control 1981 Datum on the approved Construction Plans).
- Because we do not control how the property to the north of Westerly Creek will be developed, a conservative analysis was performed using a weir width of 100’.
- Westerly Creek could pond to an elevation of 5500.1 (5497.6) as it overtops Kingston Street if the flow is restricted to a 100’ wide path.
- The conservative analysis results in water surface elevations of 5501.6 (5497.6) along the north property line.
- A wall is currently provided along the north property line at an elevation of 5500.6 (5497.6), which was intended to provide freeboard during an event where Westerly Creek would encroach the future development to the north. However, since the emergency spillway is proposed to be moved to this location, Westerly Creek flows will enter the Kingston site at the spillway crest elevation of 5498.0 (5495.0).
- The onsite detention pond is located in the northwest corner of the site.
- The detention pond volume has been sized for the 100-year storm event.
- The detention pond release rate is also based on the 100-year storm event.
- Multiple volumes and discharges do not need to be analyzed due to the fact the pond will discharge directly to an improved drainageway.
- Water quality volume is currently provided for the site.

2. Specific Details

- Detention Pond parameters
  - Nearly all of the Kingston Place Subdivision drains to a single detention pond located in the northwest corner of the site.
  - The detention pond is designed to detain the 100-year storm event and the water quality capture volume.
  - The pond outfalls directly to Westerly Creek via an outlet structure and storm drainpipe. The pipe is at an elevation 2’ higher than the channel invert. One 14’ section of concrete will be removed and reconstructed where the outfall pipe enters the channel. The reconstructed channel section shall be recessed so a flap gate can be installed.
  - The detention pond outlet structure is a modified type C inlet.
  - Water Quality Capture Volume has been provided in the detention facility. The outlet control structure incorporates a perforated plate to allow the WQCV water to release at a slow rate.
  - The top of the grate is placed at the water quality water surface elevation.
  - Any volume grater that the WQCV is released through the top of the inlet.

  - The release rate will be controlled by an orifice plate that is placed on the inside of the outlet structure over the 12” outlet pipe.
  - The orifice plate is placed 3.5” above the invert of the pipe and the pond volume will be released at a rate of 2.3cfs (allowable release rate) until the water surface in Westerly Creek is 89.8+/-.
  - If the tailwater on the pipe is assumed to be 91 (top of channel elevation) then the orifice plate should be placed 4” above the invert of the pipe to release the pond volume at 2.3cfs.
  - It is recommended to place the orifice plate 4” above the invert of the pipe. If tailwater is not present, the pond volume will be released at a rate of 2.8cfs.
  - In an emergency condition, the pond will overflow to Westerly Creek via a proposed emergency overflow weir located on the north side of the detention pond.
  - The Kingston Place detention pond outlet pipe invert is at an elevation of 5492.5 (5489.5) and the invert of Westerly Creek adjacent to the site is roughly 5489 (5486).
  - If the culvert is plugged, using the City’s criteria for plugged culverts with an area greater than 20 square feet, and the weir overflow is restricted to 100’ wide; the overflow water surface could reach an elevation of 5501.0 (5498.0).
  - If Westerly Creek backs up into the onsite pond it should not damage proposed structures. The minimum foundation elevation adjacent to the pond and/or Westerly Creek is 5503.2 (5500.2) (2.2’ above Westerly Creek’s emergency water surface elevation)
  - No unit adjacent to Westerly Creek will be a garden level unit or have a basement or crawl space.
  - The peak site discharge of 18cfs has a time of concentration of 5 minutes. Therefore, the pond will likely fill before the water surface in Westerly Creek is high enough to back up into the pond.
  - The simultaneous filling of the onsite pond by Westerly Creek water and the Kingston Place Subdivision runoff is unlikely.
- An elevation of 5500.6 (5497.6) will be provided along the east property line to prevent flows from the detention pond entering the easterly adjacent Buckingham Square Filing 8 site during the 100-year storm event.
- The remaining construction on this site is anticipated to be completed in one phase, and the detention pond already exists onsite. A new overflow weir will be added to this existing pond on the north side.
- During the minor event, runoff from Basin A1A will be collected in the rear of the proposed 5’ R inlet at DP1 through a 6” circular orifice. Runoff from the major event will overtop the back of the inlet and will be captured in the curb opening of the inlet.
- Runoff during both the minor and major event from Basin A1B will be collected in the 5’ R sump inlet at DP1.
- Runoff from Basin A2 will be collected in the 5’ R sump inlet at DP2.

- Runoff from Basin A3 will flow directly to the onsite detention pond represented at DP3.
- Runoff during the minor event from Basin B1 will be collected in a proposed 5' R sump inlet at DP4 in Kingston Street and will be piped to Westerly Creek. Runoff during the major event will overtop the Kingston Street curb and will flow directly to Westerly Creek.
- Runoff between units will be conveyed via grass-lined swales or paved driveways to either the private drive or directly to the proposed detention pond.

3. Site Conformance

- The tables below show a comparison of the updated percent imperviousness values for Kingston PLACE with the existing imperviousness values from the approved Drainage Report. The analysis shows that the updates to the amenity site and associated imperviousness show some decreases in flow and negligible increases of flow during the 2-year minor storm event.

BASIN	%I (2004)	%I (2020)	C2 (cfs, 2004)	C2 (cfs, 2020)
A1 (A1A/B)	60	44	0.45	0.30
A2	100	100	0.87	0.89
A3	60.42	44	0.45	0.30
B1	61.57	68.89	0.55	0.56

- As it is built currently, the detention pond onsite does have enough capacity to detain the 100 year flows on the site, however, the outlet structure does not allow for proper release rates. Due to grading changes involving the FFE of nearby structures, the pond was redesigned (regraded) with this updated plan set.
  - The newly graded pond also has enough volume to detain the 100-year flows from this site. This site requires 0.308 ac-ft of detention for the 100-year storm and this pond provides 0.32 ac-ft of storage plus 1' freeboard to the overflow weir (please refer to the plan set associated with this submittal).
  - As is built currently, the outlet structure stands 2.5' tall with a grated top and a 28"x3" rectangular vertical slot on the front of the box. This box releases the water quality volume in approximately 1 hour and the 100-year flows at rates considerably higher than is allowed.
    - To resolve the outflow issue with the 100-year flow, a restrictor plate can be added to the outfall pipe on the back of the outlet structure. This would release the 100-year flows at 3.2 cfs, which is within the allowable release rates. Please see Appendix B for the detention calculations with just the restrictor plate.

E. BEST MANAGEMENT PRACTICES (BMPS)

4. Temporary BMPs

- Separate Stormwater Management Plan for details regarding temporary (construction) BMPs will be provided with the Construction Drawings.

5. Permanent BMPs

- Permanent BMPs for the Kingston PLACE site include the as-built detention pond.

F. CONCLUSIONS

1. Compliance with Standards

- This report is in general accordance with the *City of Aurora Storm Drainage Design and Technical Criteria*.
- This report is in general accordance, where applicable and not superseded by other criteria, to the USDCM.
- This report is in general accordance with FEMA. There are no known existing floodplains within the site boundary.

2. Summary of Concept

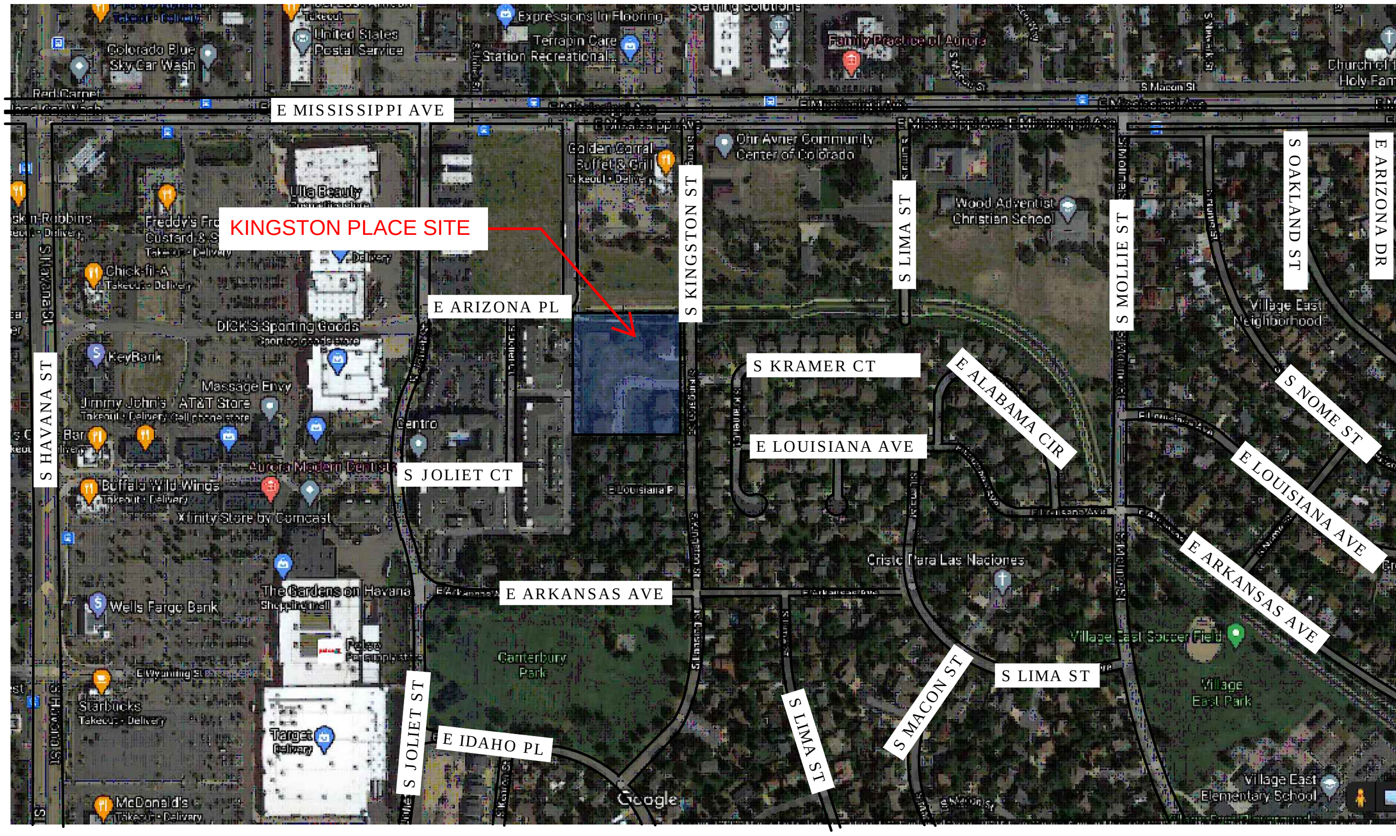
- Downstream properties will not be adversely affected by the updates to the existing site.
- The lowest finished floor elevation adjacent to Westerly Creek is a minimum of 2' above the estimated floodplain.
- The proposed storm drain system and detention facilities will provide adequate site drainage and water quality for the site.
- The proposed development and improvements will not adversely impact any adjacent properties.

G. LIST OF REFERENCES

1. *Preliminary Drainage Report for Kingston Place Subdivision Filing No. 1*, Calibre Engineering, July 2004.
2. *Final Drainage Report for The Ridermark Subdivision Filing No. 1*, KMD, Inc., April 2, 2002.
3. *City of Aurora Storm Drainage Design and Technical Criteria*, City of Aurora, January 2002.
4. *Urban Storm Drainage Criteria Manual*, Urban Drainage Flood Control District, September 1999.
5. *Outfall Systems Planning Westerly Creek East of Havana*, Merrick and Company, October, 1996.
6. *Final Drainage Report for Carriage Village Subdivision*, Spiska Engineering, Inc., May 1995.
7. *Storm Drainage Planning Upper Westerly Creek Outfall System*, Simons, Li and Associates, Inc., March 1982.
8. *Soil Survey of Arapahoe County, Colorado*, USDA – Soil Conservation Service, March 1971.
9. *Westerly Creek (Upstream of the Westerly Creek Dam Outlet) Major Drainageway Plan*, CH2MHill, January 2015.

APPENDIX A

MAPS AND EXHIBITS



NORTH

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Construction Management Civil Engineering Surveying

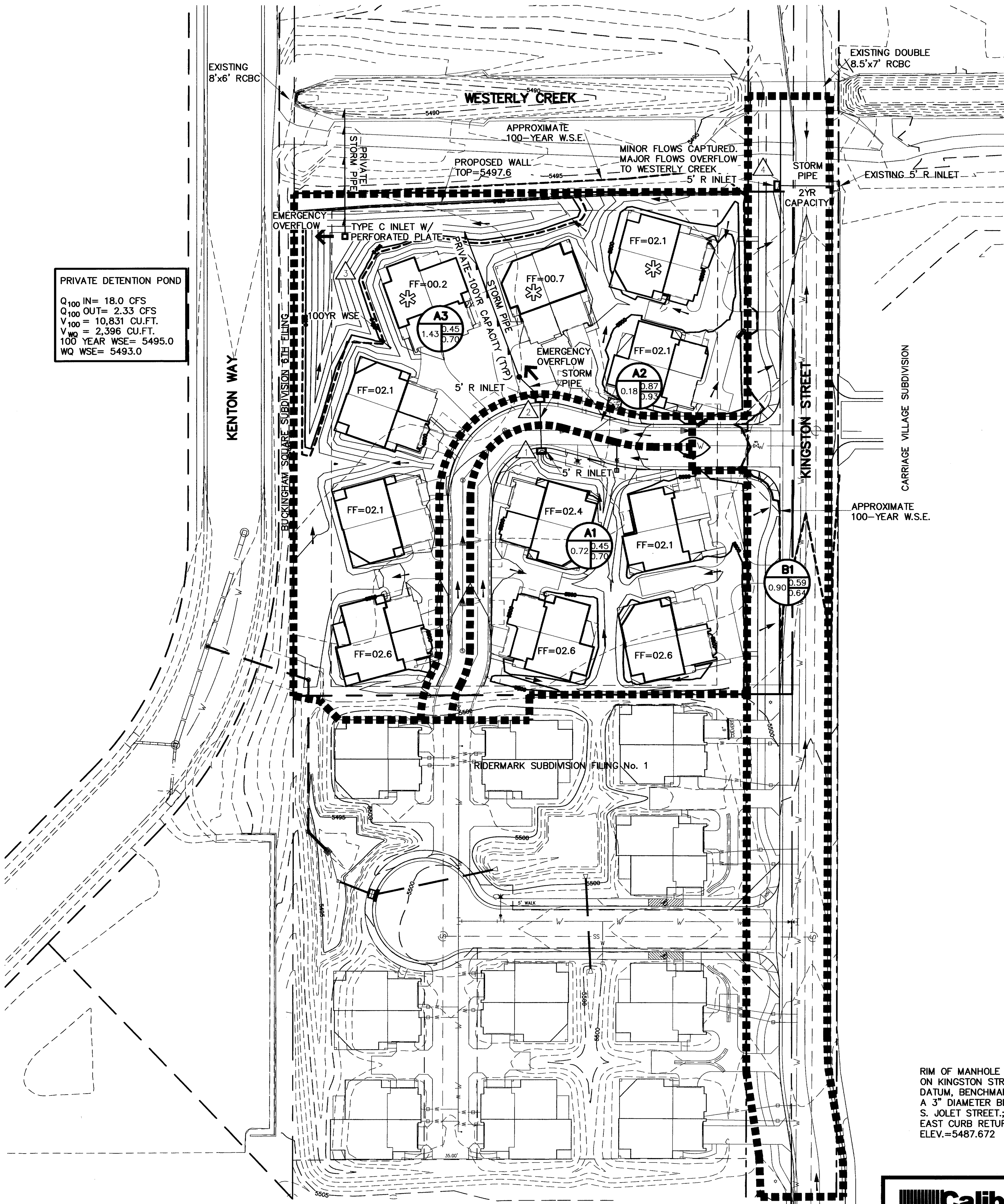
KINGSTON DEVELOPMENT
SITE DEVELOPMENT
VICINITY MAP

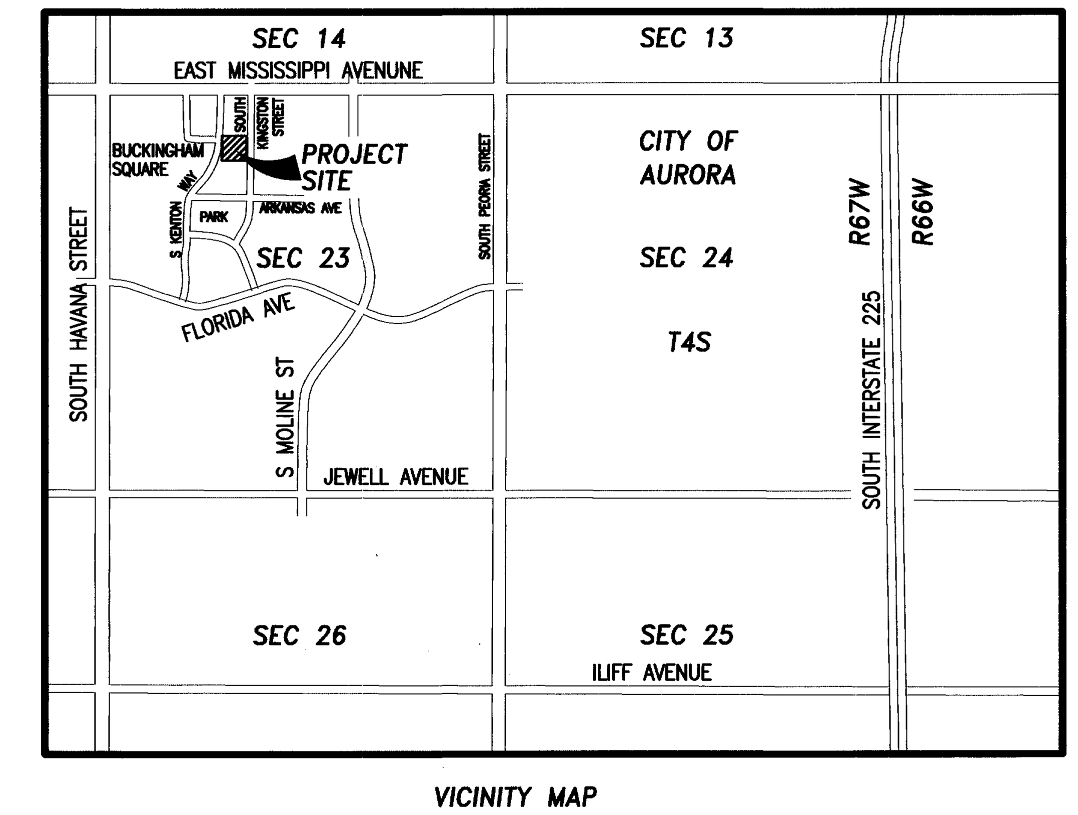
Sheet VM

Scale N.T.S.

Date 10/14/2020

P:\MCCANN KINGSTON\CADD\MASTER\ Vicinity Map.dwg





VICINITY MAP
1"=2000'

LEGEND

DEVELOPED BASIN LABEL

- A3 — BASIN DESIGNATION
- AREA (AC.) 1.43
- 0.45 — MINOR RUNOFF COEF.
- 0.70 — MAJOR RUNOFF COEF.
- DEVELOPED BASIN LINE
- DESIGN POINT
- PROPOSED FLOW ARROW
- 5250 PROPOSED MAJOR CONTOUR (5')
- PROPOSED MINOR CONTOUR (1')
- PROPOSED STORM DRAIN PIPE
- PROPOSED STORM DRAIN INLET
- 5250 EXISTING MAJOR CONTOUR (5')
- EXISTING MINOR CONTOUR (1')
- UNITS SHALL NOT BE GARDEN LEVEL OR HAVE BASEMENTS OR CRAWL SPACES

SUMMARY RUNOFF TABLE

DESIGN PT.	TOTAL AREA	TOTAL Q_2	TOTAL Q_{100}
	(ACRES)	(CFS)	(CFS)
1	0.72	1.3	5.4
2	0.90	1.9	7.1
3	2.33	4.4	17.7
4	0.90	1.7	5.2

NORTH

0 20 40 80
1 inch = 40 ft. Horizontal

NOTE:
ALL STORM SEWER IS PUBLIC UNLESS OTHERWISE NOTED.

COA NOTE:
THE CITY OF AURORA PLAN REVIEW IS ONLY FOR GENERAL CONFORMANCE WITH THE CITY OF AURORA DESIGN CRITERIA AND THE CITY CODE. THE CITY IS NOT RESPONSIBLE FOR THE ACCURACY AND ADEQUACY OF THE DESIGN, OF DIMENSIONS AND ELEVATIONS WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE. THE CITY OF AURORA THROUGH THE APPROVAL OF THIS DOCUMENT, ASSUMES NO RESPONSIBILITY FOR THE COMPLETENESS AND/OR ACCURACY OF THIS DOCUMENT.

BENCHMARK:

RIM OF MANHOLE ±NORTH OF THE ENTRANCE TO RIDER-MARK SUBDIVISION AT STATION 2+11.29 ON KINGSTON STREET ELEVATION=5500.73, LOOPED TO CITY OF AURORA VERTICAL CONTROL 1981 DATUM, BENCHMARK #M-012.5:
A 3" DIAMETER BRASS CAP IN CONCRETE AT THE N.E. CORNER OF E. MISSISSIPPI AVENUE AND S. JOLET STREET.; ±7' NORTH OF THE NORTH FLOWLINE OF MISSISSIPPI AVENUE AND AT THE EAST CURB RETURN AT THE CORNER AND ALSO BEING 2 FEET NORTH BACK OF WALK, ELEV.=5487.672

APPROVED FOR ONE YEAR FROM THIS DATE
8-18-04

CITY ENGINEER	DATE 8-4-04
UTILITIES DEPARTMENT	DATE 8-9-04

Calibre ENGINEERING
Calibre Engineering, Inc.
8000 South Lincoln Street, Unit 206
Littleton, CO. 80122 (303) 730-0434
Municipal Engineering Development Master Planning
Prepared for: KINGSTON PLACE DEVCO, LLC

KINGSTON PLACE
SUBDIVISION FILING NO. 1
PRELIMINARY DRAINAGE EXHIBIT
JULY 29, 2004

Sheet
DR1
of 1 Sheets
Designer: RWL Drafter: RWL Checked: GVM
Drawing Name: 2DR1.dwg
Path: L:\PROJECTS\HAM QUEEN\CIVIL\CADD\

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided by the Arapahoe County and Cities of Aurora and Littleton GIS depts. The coordinate system used for production of the digital FIRM is Universal Transverse Mercator, Zone 13N, referenced to the North American Datum of 1983 and the GRS 80 spheroid, Western Hemisphere.

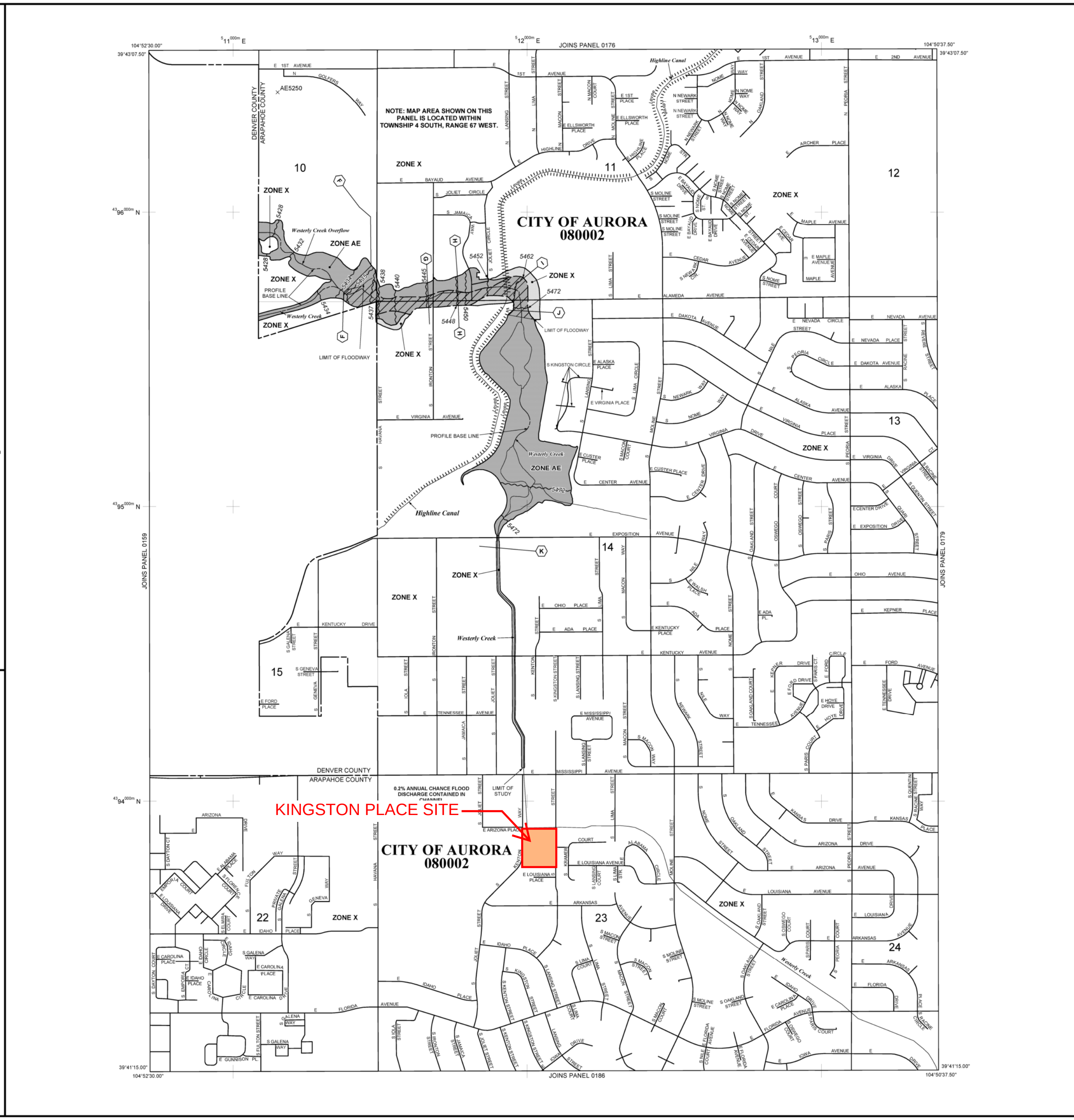
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data)* may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)—(A)	Cross section line
(23)- - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 13
6000000 M	5000-foot grid ticks: New York State Plane coordinate system, east zone (FIPSZONE 3101), Transverse Mercator
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
April 17, 1989
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
March 4, 1991 December 3, 1993 August 16, 1995
December 17, 2010 - to update map format, to change Special Flood Hazard Areas, and to change Base Flood Elevations.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0178K

FIRM
FLOOD INSURANCE RATE MAP
ARAPAHOE COUNTY, COLORADO
AND INCORPORATED AREAS

PANEL 178 OF 725
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

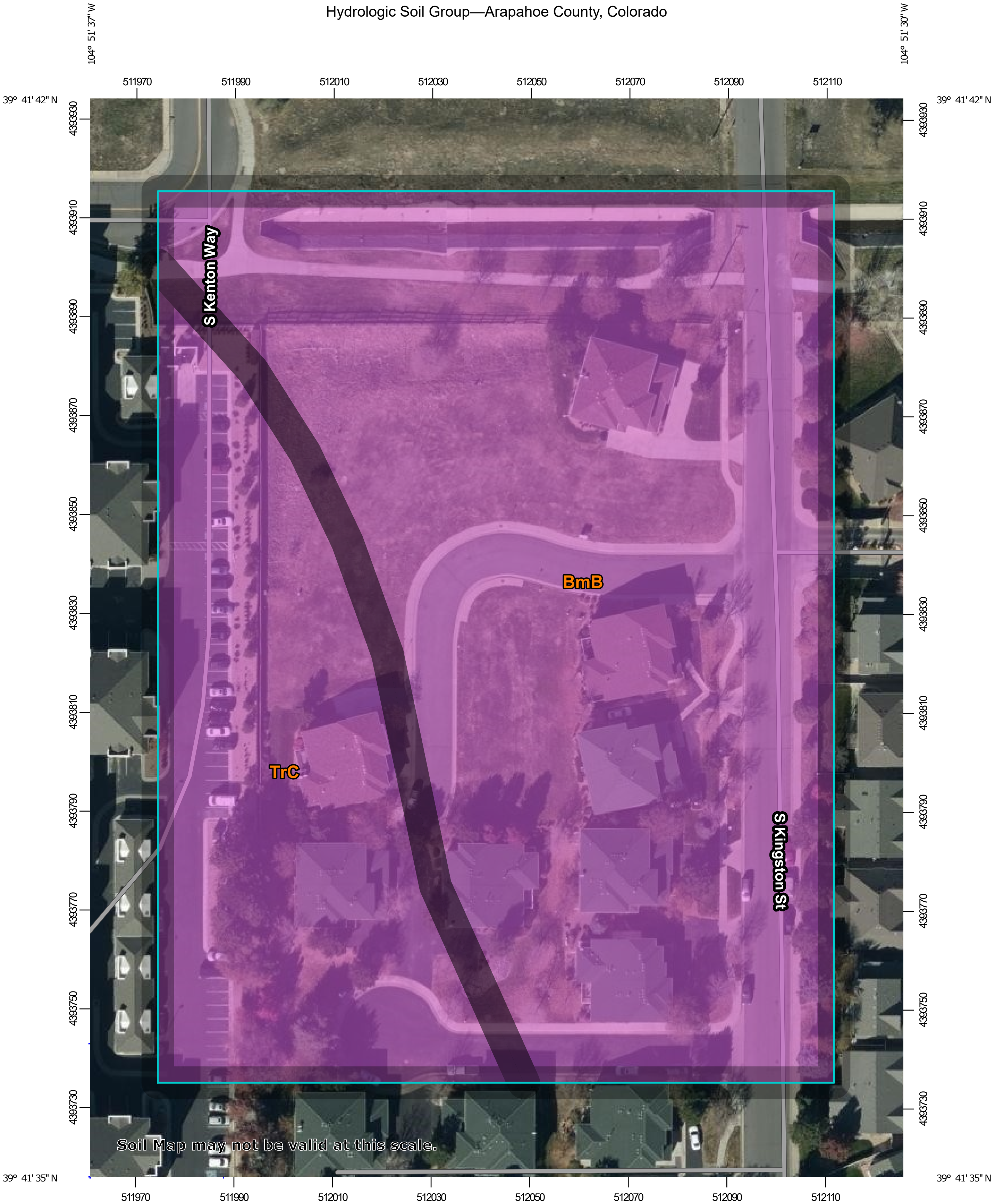
COMMUNITY	NUMBER	PANEL	SUFFIX
AURORA, CITY OF	080002	0178	K

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 08005C0178K

MAP REVISED DECEMBER 17, 2010

Federal Emergency Management Agency



Map Scale: 1:1,060 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Arapahoe County, Colorado
Survey Area Data: Version 16, Jun 4, 2020

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

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BmB	Bijou sandy loam, wet, 0 to 3 percent slopes	A	4.3	70.9%
TrC	Truckton loamy sand, 1 to 5 percent slopes	A	1.8	29.1%
Totals for Area of Interest			**6.1**	**100.0%**

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX B

HYDROLOGIC CALCULATIONS

EXISTING RATIONAL CALCULATIONS

PROPOSED RATIONAL CALCULATIONS

Calibre

COMPOSITE 'C' FACTORS

LOCATION: aurora **DATE :** 10/14/2020

BASIN						SOIL	PAVED					LAWNS					SF-0.25					COMP. C FACTOR				
DESIGNATION	PAVED	LAWNS	SF-0.25	TOTAL	TOTAL (SQ MI)	TYPE	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR
DEVELOPED																										
A-1	0.00	0.00	0.72	0.72	0.0011	A	100	0.89	0.90	0.92	0.96	0	0.05	0.15	0.25	0.50	44	0.30	0.36	0.43	0.59	44.00	0.30	0.36	0.43	0.59
A-2	0.18	0.00	0.00	0.18	0.0003	A	100	0.89	0.90	0.92	0.96	0	0.05	0.15	0.25	0.50	44	0.30	0.36	0.43	0.59	100.00	0.89	0.90	0.92	0.96
A-3	0.00	0.00	1.43	1.43	0.0022	A	100	0.89	0.90	0.92	0.96	0	0.05	0.15	0.25	0.50	44	0.30	0.36	0.43	0.59	44.00	0.30	0.36	0.43	0.59
B-1	0.40	0.00	0.50	0.90	0.0014	A	100	0.89	0.90	0.92	0.96	0	0.05	0.15	0.25	0.50	44	0.30	0.36	0.43	0.59	68.89	0.56	0.60	0.65	0.75

Calibre

TIME OF CONCENTRATION

LOCATION: aurora   **redo**   **BY: jnk**   **DATE: 10/14/2020**

BASIN DATA			INIT./OVERLAND TIME (Ti)			TRAVEL TIME (Tt)						TOTAL	Tc Check		FINAL Tc	REMARKS
DESIGNATION	C5	AREA (AC)	LENGTH (FT)	SLOPE %	Ti (Min.)*	GRASS/ PAVED	LENGTH (FT)	SLOPE %	VEL. (FPS)**	Tt(Min.)	GRASS/ PAVED	Ti+Tt(Min.)	LENGTH (FT)	Urbanized Basins Tc = (L/180) + 10	(minutes)	FORMULAS: * Ti = 0.395 (1.1-C5)L^0.5/S^1/3 ** V=Cv(Sw^1/2) where Cv=15 for grassed waterways and 20 for paved areas
DEVELOPED																
A-1	0.36	0.72	200	2.5	14.1	GRASS	10	2.5	2.4	0.1	GRASS	14.2	210.00	11.2	11	
A-2	0.90	0.18	10	2.0	0.9	PAVED	230	2.0	2.8	1.4	PAVED	2.3	240.00	11.3	5	
A-3	0.36	1.43	250	2.3	16.3	GRASS	30	2.3	2.3	0.2	GRASS	16.5	280.00	11.6	12	
B-1	0.60	0.90	10	2.3	2.2	PAVED	670	2.3	3.0	3.7	PAVED	5.9	680.00	13.8	6	

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

DESIGN STORM: 2-YEAR DEVELOPED

Calc. by: jnk
Chk'd by: bp
Date: 10/14/2020

LOCATION: aurora aurora

		DIRECT RUNOFF							TOTAL RUNOFF								n	DITCH					PIPE				TRAVEL TIME			REMARKS
STRUCTURE	DESIGN POINT	BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./ hr.)	Q (cfs)	SUM AREA	SUM Tc (min.)	I (in./hr.)	SUM CA	TOTAL Q (cfs)	FLOW IN PIPE	FLOW IN STREET	DITCH OR PIPE	ROUGHNESS	SLOPE %	FLOW (CFS)	FRONT SLOPE	BOTTOM WIDTH	BACK SLOPE	FLOW (CFS)	SLOPE %	PRELIM. SIZE	PIPE SIZE	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	
		DEVELOPED																												
IN-1	1	A-1	0.72	0.36	11	0.26	2.90	0.8						0.8									0.8	0.50%	8.47	18	1			A
IN-2	2	A-2	0.18	0.90	5	0.16	3.80	0.6						0.6									0.6	0.50%	7.86	18	1			B
IN-3	3	A-3	1.43	0.36	12	0.51	2.86	1.5						1.5									1.5	0.50%	10.90	18	1			C
IN-4	4	B-1	0.90	0.60	6	0.54	3.63	2.0						2.0									2.0	0.50%	12.14	18	1			A

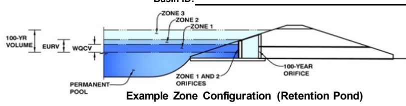
DETENTION WITH 100-YEAR RESTRICTOR BUT NO WQ PLATE ADDED

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: KINGSTON - NO WQ PLATE

Basin ID:



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	3.23	acres		
Watershed Length =	450	ft		
Watershed Slope =	0.023	ft/ft		
Watershed Imperviousness =	54.06%	percent		
Percentage Hydrologic Soil Group A =	100.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	Aurora Reservoir			
Water Quality Capture Volume (WQCV) =	0.059	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.206	acre-feet		
2-yr Runoff Volume (P1 = 0.84 in.) =	0.100	acre-feet		inches
5-yr Runoff Volume (P1 = 1.13 in.) =	0.139	acre-feet		inches
10-yr Runoff Volume (P1 = 1.39 in.) =	0.180	acre-feet		inches
25-yr Runoff Volume (P1 = 1.77 in.) =	0.248	acre-feet		inches
50-yr Runoff Volume (P1 = 2.08 in.) =	0.319	acre-feet		inches
100-yr Runoff Volume (P1 = 2.42 in.) =	0.404	acre-feet		inches
500-yr Runoff Volume (P1 = 3.3 in.) =	0.625	acre-feet		inches
Approximate 2-yr Detention Volume =	0.094	acre-feet		
Approximate 5-yr Detention Volume =	0.131	acre-feet		
Approximate 10-yr Detention Volume =	0.168	acre-feet		
Approximate 25-yr Detention Volume =	0.229	acre-feet		
Approximate 50-yr Detention Volume =	0.265	acre-feet		
Approximate 100-yr Detention Volume =	0.308	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.059	acre-feet
Zone 2 Volume (10-year - Zone 1) =	0.110	acre-feet
Zone 3 (100yr + 1 / 2 WQCV - Zones 1 & 2) =	0.169	acre-feet
Total Detention Basin Volume =	0.337	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = 1 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	168	0.004		
	--	1.00	--	--	--	724	0.017	439	0.010
	--	2.00	--	--	--	1,455	0.033	1,521	0.035
	--	3.00	--	--	--	3,131	0.072	3,828	0.088
	--	4.00	--	--	--	5,158	0.118	7,973	0.183
	--	5.00	--	--	--	6,790	0.156	13,947	0.320
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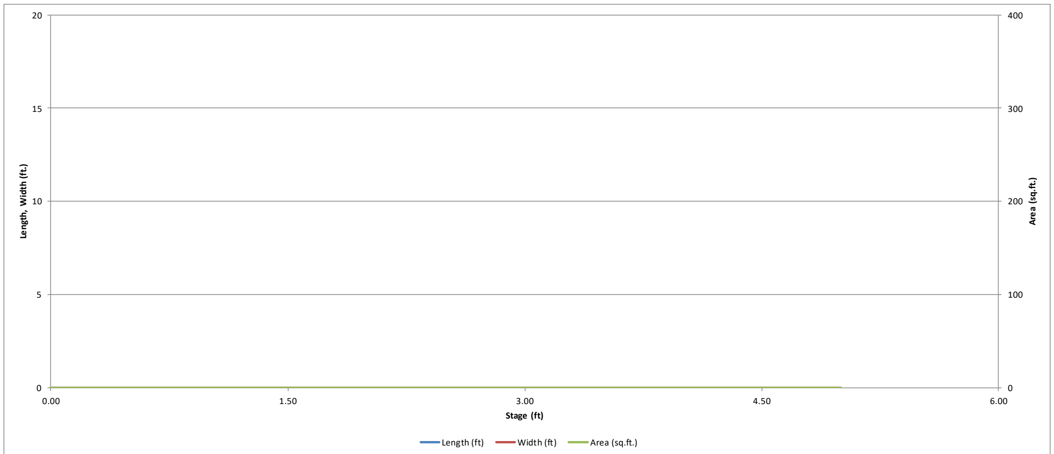
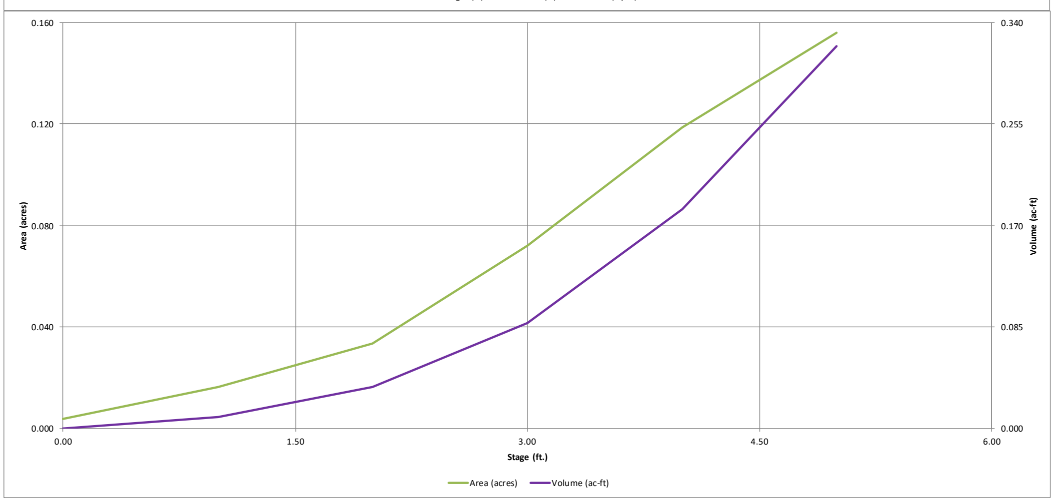
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



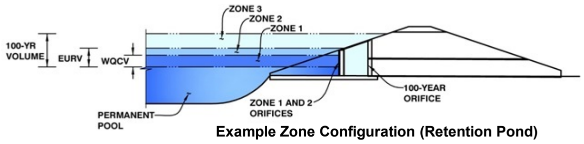


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: KINGSTON - NO WQ PLATE

Basin ID:



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.54	0.059	Orifice Plate
Zone 2 (10-year)	3.88	0.110	Rectangular Orifice
(100+1/2WQCV)		0.169	Weir&Pipe (Restrict)
		0.337	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	2.54	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	N/A	inches
Orifice Plate: Orifice Area per Row =	0.00	sq. inches - area too small, increase vertical spacing

Calculated Parameters for Plate

WQ Orifice Area per Row =	0.000E+00	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.00	0.00					
Orifice Area (sq. inches)	0.00	0.00	0.00					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Zone 2 Rectangular	Not Selected	
Invert of Vertical Orifice =	0.00	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	2.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Height =	27.00	N/A	inches
Vertical Orifice Width =	3.00		inches

Calculated Parameters for Vertical Orifice

	Zone 2 Rectangular	Not Selected	
Vertical Orifice Area =	0.56	N/A	ft^2
Vertical Orifice Centroid =	1.13	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	2.75	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	3.35	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	2.50	N/A	feet
Over Flow Weir Slope Length =	3.35	N/A	feet
Grate Open Area / 100-yr Orifice Area =	18.37	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	6.45	N/A	ft^2
Overflow Grate Open Area w/ Debris =	3.22	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	12.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	5.50		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	0.35	N/A	ft^2
Outlet Orifice Centroid =	0.27	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	1.49	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	18.00	feet
Spillway End Slopes =	5.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

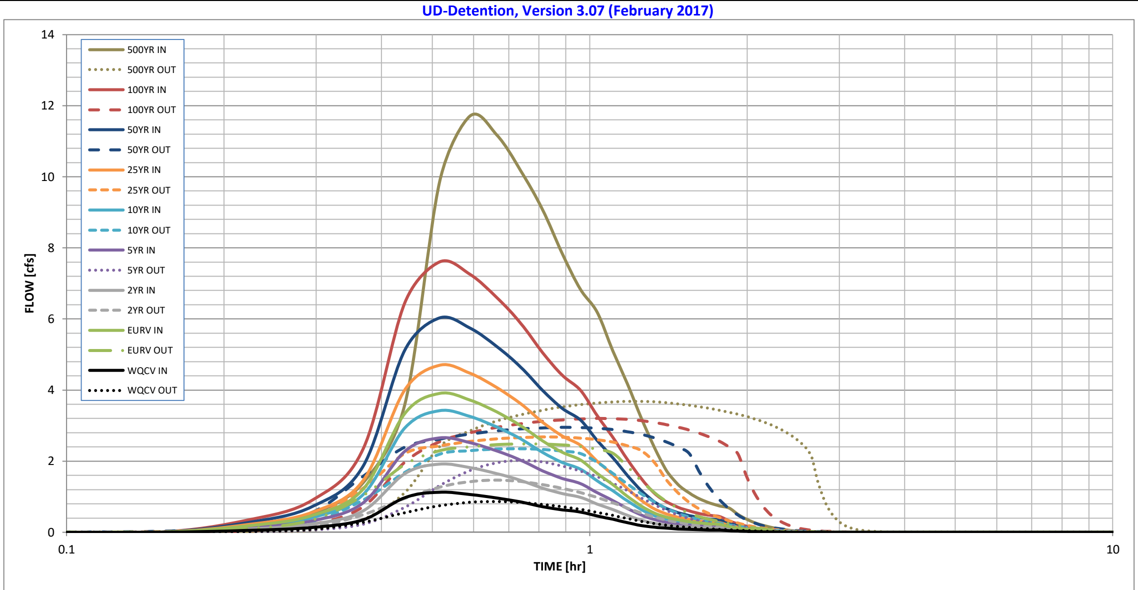
Spillway Design Flow Depth=	0.26	feet
Stage at Top of Freeboard =	6.26	feet
Basin Area at Top of Freeboard =	0.16	acres

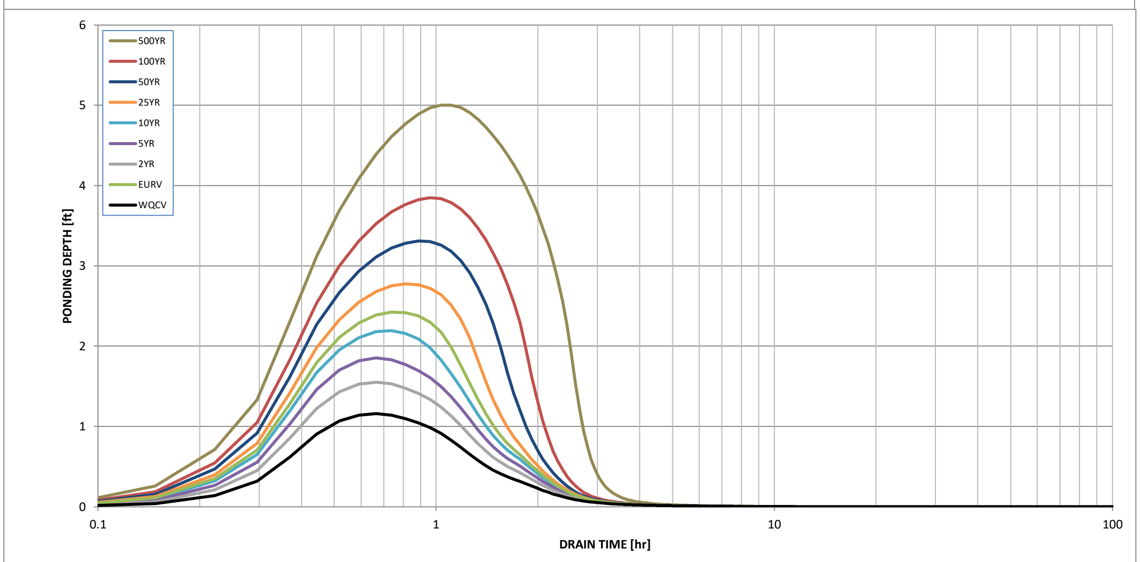
Routed Hydrograph Results

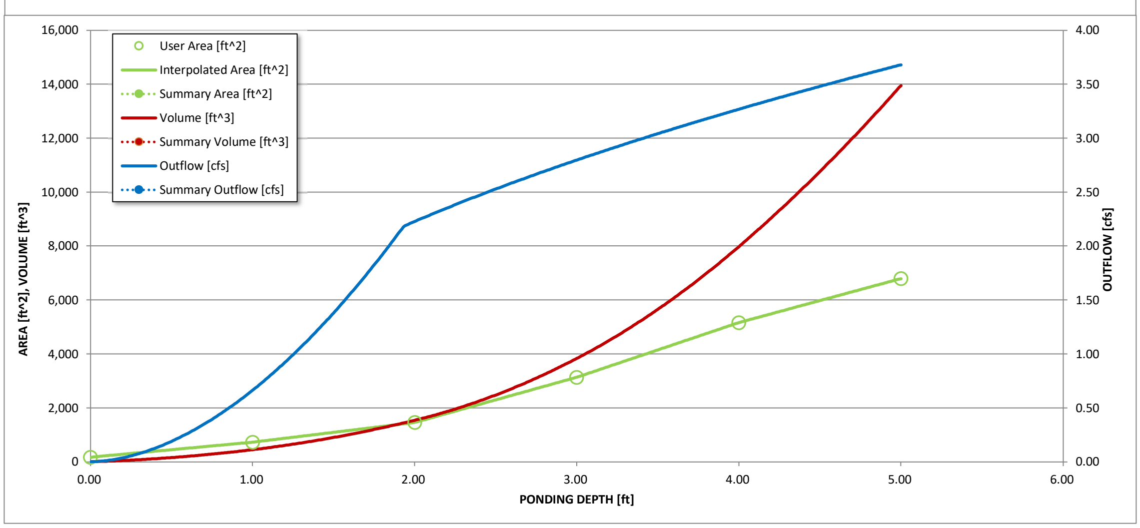
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.84	1.13	1.39	1.77	2.08	2.42	3.30
Calculated Runoff Volume (acre-ft) =	0.059	0.206	0.100	0.139	0.180	0.248	0.319	0.404	0.625
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.058	0.206	0.100	0.139	0.180	0.248	0.319	0.404	0.624
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.00	0.00	0.01	0.03	0.22	0.54	1.32
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.1	0.7	1.8	4.3
Peak Inflow Q (cfs) =	1.1	3.9	1.9	2.7	3.4	4.7	6.0	7.6	11.7
Peak Outflow Q (cfs) =	0.9	2.5	1.5	2.0	2.3	2.7	2.9	3.2	3.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	136.4	64.6	29.4	4.2	1.8	0.9
Structure Controlling Flow =	Vertical Orifice 1	Outlet Plate 1	Vertical Orifice 1	Vertical Orifice 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	-0.1	-0.2	-0.2	-0.3
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	2	2	2	2	2	2	2	2	3
Time to Drain 99% of Inflow Volume (hours) =	2	2	2	2	2	2	2	2	3
Maximum Ponding Depth (ft) =	1.16	2.43	1.55	1.85	2.19	2.77	3.31	3.85	5.00
Area at Maximum Ponding Depth (acres) =	0.02	0.05	0.03	0.03	0.04	0.06	0.09	0.11	0.16
Maximum Volume Stored (acre-ft) =	0.013	0.053	0.022	0.030	0.042	0.072	0.112	0.165	0.320

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
4.43 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:04:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph Constant	0:08:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:13:17	0.05	0.18	0.09	0.12	0.16	0.21	0.27	0.34	0.52
1.130	0:17:43	0.14	0.47	0.23	0.32	0.41	0.57	0.73	0.91	1.40
	0:22:09	0.35	1.21	0.60	0.83	1.07	1.46	1.86	2.35	3.59
	0:26:35	0.97	3.34	1.65	2.28	2.93	4.01	5.12	6.45	9.87
	0:31:01	1.13	3.91	1.91	2.65	3.42	4.70	6.03	7.61	11.71
	0:35:26	1.06	3.72	1.82	2.52	3.25	4.47	5.74	7.25	11.17
	0:39:52	0.97	3.38	1.65	2.29	2.96	4.07	5.22	6.60	10.17
	0:44:18	0.85	3.00	1.46	2.03	2.62	3.61	4.65	5.88	9.08
	0:48:44	0.72	2.57	1.24	1.73	2.25	3.10	3.99	5.06	7.84
	0:53:10	0.63	2.25	1.09	1.51	1.96	2.71	3.49	4.41	6.83
	0:57:35	0.57	2.03	0.98	1.37	1.78	2.45	3.16	4.00	6.19
	1:02:01	0.46	1.66	0.79	1.11	1.45	2.00	2.58	3.28	5.11
	1:06:27	0.36	1.34	0.64	0.89	1.17	1.62	2.10	2.67	4.17
	1:10:53	0.27	1.01	0.47	0.67	0.88	1.23	1.60	2.04	3.21
	1:15:19	0.19	0.74	0.34	0.48	0.64	0.90	1.17	1.51	2.39
	1:19:44	0.14	0.54	0.25	0.36	0.47	0.66	0.86	1.10	1.73
	1:24:10	0.11	0.42	0.20	0.28	0.37	0.51	0.67	0.85	1.34
	1:28:36	0.09	0.35	0.16	0.23	0.30	0.42	0.55	0.70	1.10
	1:33:02	0.08	0.30	0.14	0.20	0.26	0.36	0.47	0.60	0.94
	1:37:28	0.07	0.26	0.12	0.18	0.23	0.32	0.41	0.53	0.82
	1:41:53	0.06	0.24	0.11	0.16	0.21	0.29	0.37	0.47	0.74
	1:46:19	0.06	0.22	0.11	0.15	0.19	0.27	0.35	0.44	0.68
	1:50:45	0.04	0.16	0.08	0.11	0.14	0.20	0.25	0.32	0.50
	1:55:11	0.03	0.12	0.06	0.08	0.10	0.14	0.19	0.24	0.37
	1:59:37	0.02	0.09	0.04	0.06	0.08	0.10	0.14	0.17	0.27
	2:04:02	0.02	0.06	0.03	0.04	0.05	0.08	0.10	0.13	0.20
	2:08:28	0.01	0.04	0.02	0.03	0.04	0.05	0.07	0.09	0.14
	2:12:54	0.01	0.03	0.01	0.02	0.03	0.04	0.05	0.06	0.10
	2:17:20	0.01	0.02	0.01	0.01	0.02	0.03	0.03	0.04	0.07
	2:21:46	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05
	2:26:11	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.03
	2:30:37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	2:35:03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:39:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:43:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:48:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:52:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:57:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:01:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:06:04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:14:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:19:21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:23:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:28:13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:32:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:37:04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:41:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:54:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:59:13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:03:39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:08:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:12:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:16:56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:21:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:34:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:39:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:43:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:47:57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:52:23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:56:49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:01:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:14:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:18:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX C

HYDRAULIC CALCULATIONS

DETENTION POND DESIGN

INLET DESIGN

SPILLWAY CALCULATION

HYDRFLOW HYDRAULIC MODEL

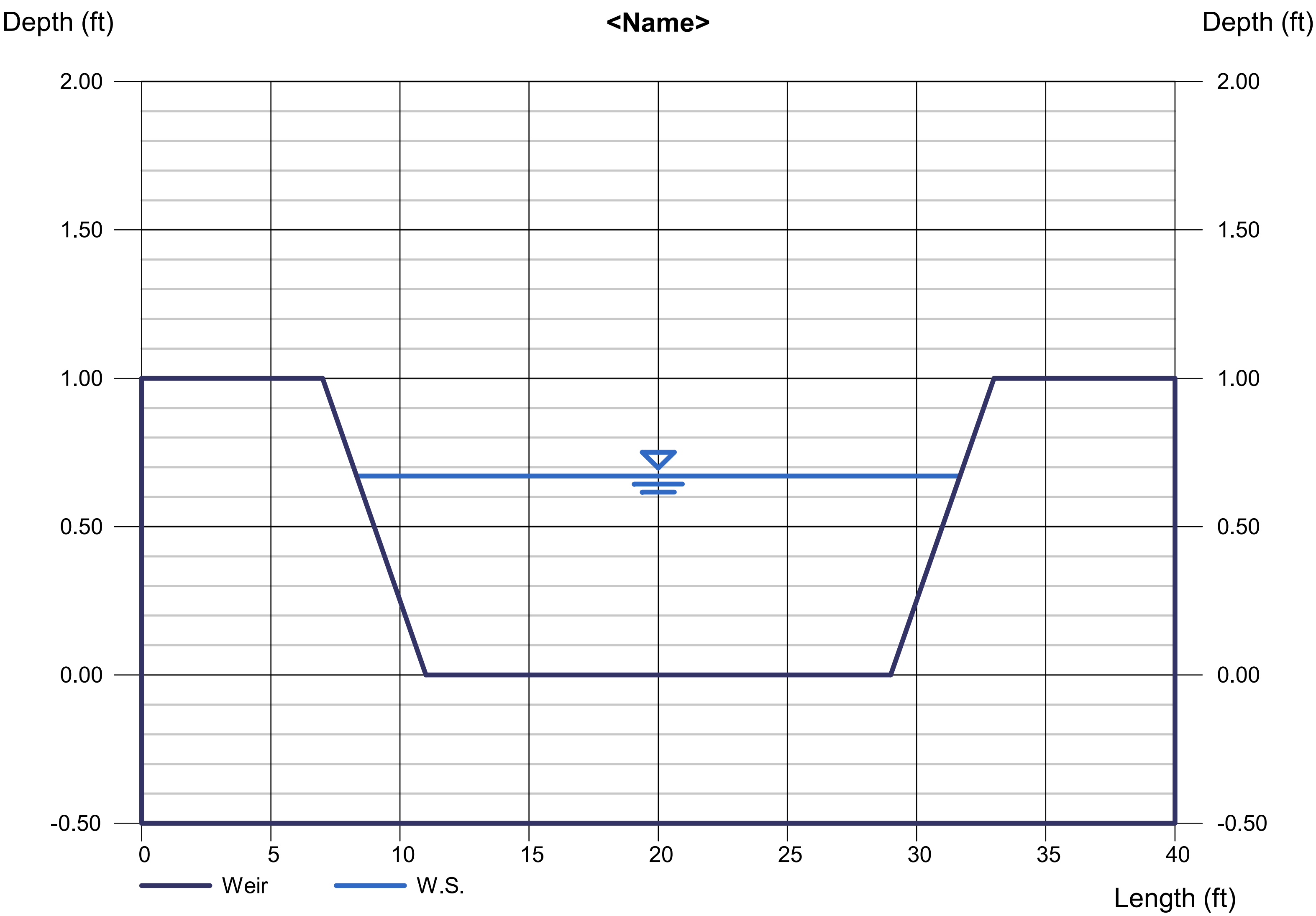
Weir Report

<Name>

Trapezoidal Weir	
Crest	= Sharp
Bottom Length (ft)	= 18.00
Total Depth (ft)	= 1.00
Side Slope (z:1)	= 4.00

Calculations	
Weir Coeff. Cw	= 3.10
Compute by:	Known Q
Known Q (cfs)	= 34.20

Highlighted	
Depth (ft)	= 0.67
Q (cfs)	= 34.20
Area (sqft)	= 13.86
Velocity (ft/s)	= 2.47
Top Width (ft)	= 23.36



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INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet A1	Inlet A2	Inlet B1
Site Type (Urban or Rural)	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.8	0.6	2.0
Major Q_{Known} (cfs)	0.8	0.6	2.0

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**0.8**	**0.6**	**2.0**
Major Total Design Peak Flow, Q (cfs)	**0.8**	**0.6**	**2.0**
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A
C_5	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A
C_5	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A

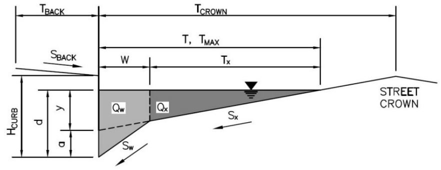
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Enter Your Project Name Here

Inlet ID: Inlet A1



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	1.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.018	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.018	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	5.0	5.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

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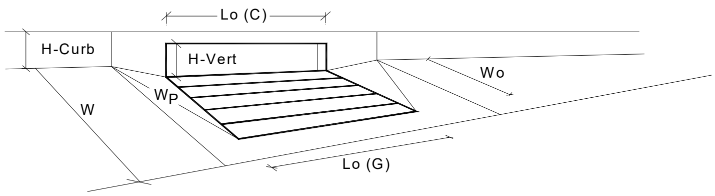


Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.42	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.77	0.77	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**5.9**	**5.9**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	0.8	0.8	cfs

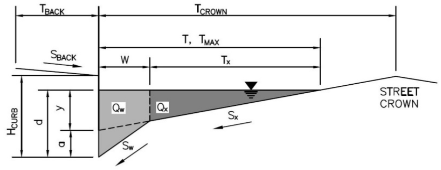
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Enter Your Project Name Here

Inlet ID: Inlet A2



Gutter Geometry (Enter data in the blue cells)

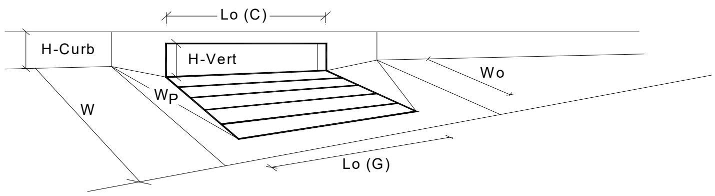
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	2.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.018	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.018	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	6.0	6.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

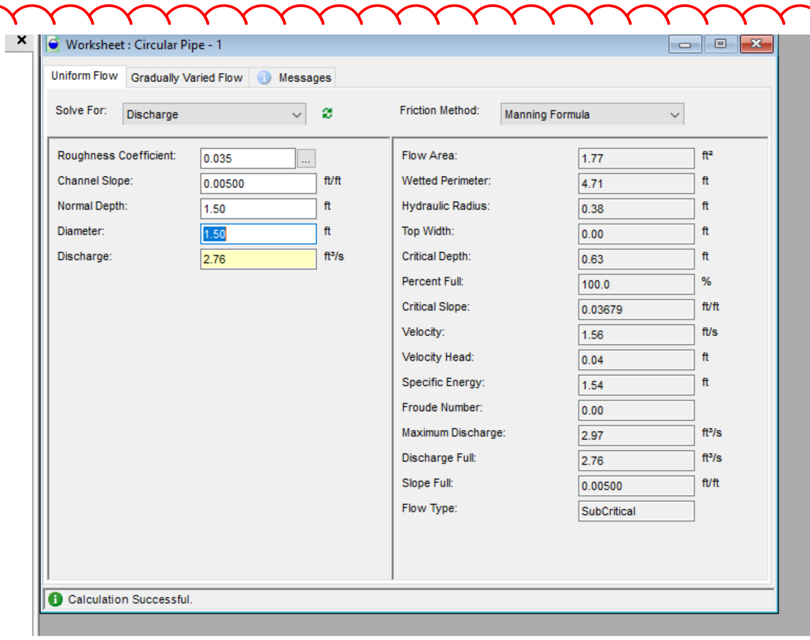
Version 4.06 Released August 2018



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	3.0	3.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.17	0.17	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.38	0.38	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	0.93	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**1.4**	**1.4**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	0.6	0.6	cfs



18" circular pipe taking flows from IN A1 and A2 is appropriately sized.

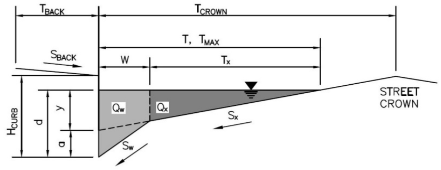
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Enter Your Project Name Here

Inlet ID: Inlet B1



Gutter Geometry (Enter data in the blue cells)

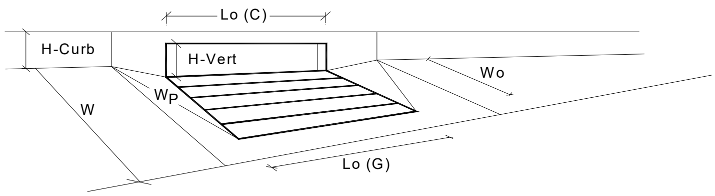
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	2.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.018	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.018	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	5.0	5.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



			MINOR	MAJOR	
Design Information (Input)	CDOT Type R Curb Opening				
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.42	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.77	0.77	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
			MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)		Q_a =	**5.9**	**5.9**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	2.0	2.0	cfs

APPENDIX D

CALIBRE 2004 DRAINAGE REPORT

Calibre

204252
11C
Rpt - 204252
2004-3019

Calibre ENGINEERING

Kingston Place Subdivision Filing No. 1

FINAL DRAINAGE REPORT

OCTOBER 2004

COLORADO REGISTERED PROFESSIONAL ENGINEER GREGORY V. MURPHY 24262
10-29-04

For:
Kingston Place Devco, LLC
Scott Hamilton
10164 Sumac Run
Littleton, CO 80125
303.948.7450

APPROVED FOR ONE YEAR FROM THIS DATE	
11-17-04	
City Engineer	Date 11-4-04
Utilities Department	Date 11-8-04

Calibre Engineering, Inc.
8000 South Lincoln Street, Unit 206, Littleton, CO 80122
303-730-0434 fax 303-730-1139
Municipal Engineering Development Master Planning

TABLE OF CONTENTS

A. INTRODUCTION

1. Location

The project is located as follows:

- Within the northwest quarter of Section 23, Township 4 South, Range 67 West, of the 6th Principal Meridian
- Within the city of Aurora
- North of Ridermark Filing No. 1 subdivision
- South of Westerly Creek
- East of South Kenton Way
- West of South Kingston Street
- See appendix for Vicinity Map

2. Proposed Development

The following are characteristics of the property:

- Approximately 2.52 acres, of which 0.23 acres will be dedicated to the Kingston Street right-of-way, reducing the area to 2.29 acres.
- The site is currently occupied by a boarding facility for horses which will be removed with the development of the subject site.
- Ground cover is mainly native grasses.
- The site currently drains northwest at slopes varying from 0.5% to 2%.
- The native soil onsite is Bijou sandy loam, which belongs to Hydrologic Soil Group C.
- The proposed development will include 22 duplex units yielding 9.6 dwelling units per acre.
- An imperviousness of 63 percent is used for all detention and water quality calculations.
- Access will be provided via a private drive off of Kingston Street.
- No variances are requested for this development.

B. HISTORIC DRAINAGE

1. Overall Basin Description

- Currently, a portion of Kingston Street may flow onto the subject site.
- There is presently no curb and gutter along the west side of Kingston Street to keep the street runoff off the subject site.

- The Ridermark subdivision to the south is graded such that nearly all runoff generated by the site stays onsite.
- The Kingston Place property is elevated in comparison to Kenton Way preventing any flow in Kenton Way from encroaching onto the subject property.
- Westerly Creek, which is a concrete-lined major drainage channel, flows from east to west just north of the Kingston Place property.
- The FEMA regulated floodplain ends on the north side of Mississippi Avenue; therefore our site is well outside of the regulated floodplain.
- The upstream limit of the FHAD for Westerly Creek is well downstream of the subject area.
- Although water surfaces were not given in the Outfall System Plan for Upper Westerly Creek, it stated that the culvert for Westerly Creek at Kenton Way is undersized.
- When the culvert is at capacity the excess flow overtops the sidewalk and flows onto Kenton Way. It is possible that, currently, flooding occurs on the northwest corner of the subject site as the flow continues to rise.

2. Drainage Patterns through Property

- Runoff flows in a northwesterly direction across the site where shallow ponding occurs in the northwest corner of the site.
- The runoff then overtops a small berm on the north side of the site where runoff is either collected in an area inlet and piped to Westerly Creek or flows directly into Westerly Creek.

3. Outfalls Downstream from Property

- Runoff from the site flows to Westerly Creek.
- The creek flows to the Westerly Creek Dam within the Lowry Development (formally Lowry Air Force Base) which is a regional flood control facility for Westerly Creek.

C. DESIGN CRITERIA

1. References

- The Final drainage design for this site is based on the following studies:

    - Preliminary Drainage Report for Kingston Place Subdivision Filing No. 1 by Calibre Engineering
    - Final Drainage Report for The Ridermark Subdivision Filing No. 1 by KMD Inc., COA# 202057
    - Final Drainage Report for Carriage Village Subdivision by Spiska Engineering Inc., COA# 950092
- Calculations and design were done in accordance with:
    - City of Aurora Storm Drainage Design and Technical Criteria
    - Urban Storm Drainage Criteria Manual (USDCM)
- The Final drainage design for this site is based on the following Master Plans:
    - Outfall Systems Planning Westerly Creek East of Havana by Merrick and Company

2. Hydrologic Criteria

- Rainfall intensity data and runoff coefficients have been taken from the City's Criteria for south of East Alameda Avenue.
- The rational method was used to develop runoff rates for onsite storm-drain pipes and inlets.
- The detention pond volume and release rate were determined using the equation V=KA as specified by the City.
- The 2-year storm was used as the minor storm and the 100-year storm was used as the major storm.

3. Hydraulic Criteria

- No references were used other than the USDCM.
- The 100-year storm was used to size onsite storm drain facilities.
- Water surface profiles are calculated using the NeoUDSewer program.
- According to the OSP, the projected existing flow in Westerly Creek is approximately 3000 cfs.
- A flow of 3000 cfs in Westerly Creek was used for all calculations.
- Proposed water surface calculations in Kingston Street and Kenton Way were performed using existing surrounding conditions and proposed Kingston Place improvements.
- Conservative calculations have been performed to determine the water surface of Westerly Creek assuming the flow will overtop the culverts at

Kingston Street and Kenton Way at a width of 100'. This assumes the site north of Westerly Creek will develop prior to master plan improvements and will restrict the existing flow patterns.

D. DRAINAGE PLAN

1. General Concept

- The majority of offsite flows remain offsite.
- A small piece of The Ridermark Subdivision will flow onto the proposed Kingston Place Subdivision.
- This runoff will be routed through the onsite detention/water quality pond.
- Kingston Street improvements include the addition of curb and gutter on the west side of the road.
- Kingston Street runoff will be conveyed in Kingston Street to a sump inlet just south of the Westerly Creek crossing.
- There is an existing type R inlet on the east side of Kingston Street at the proposed low point. A type R inlet is proposed on the west side of Kingston Street just south of the Westerly Creek crossing. It is anticipated runoff from the minor event will be collected in the proposed inlet will be piped across Kingston Street to the existing inlet and eventually to Westerly Creek. Runoff from the major event will overtop the inlet and flow directly to Westerly Creek.
- The Westerly Creek culverts at Kingston Street and Kenton Way are undersized. It is likely that Westerly Creek will backup and overflow onto Kingston Street and Kenton Way until upstream improvements are in place and the peak flow through Westerly Creek is reduced.
- During proposed conditions when Westerly Creek can encroach onto the property to the north, the water elevation as it overtops onto Kenton Way is 5496.0.
- During proposed conditions when Westerly Creek can encroach onto the property north of the creek, the water elevation as it crosses Kingston Street is 5499.0.
- Because we do not control how the property to the north of Westerly Creek will be developed, a conservative analysis was performed using a weir width of 100'.

- Westerly Creek could pond to an elevation of 5497.6 as it overtops Kenton Way if the width of flow is restricted to 100'.
- Westerly Creek could pond to an elevation of 5500.1 as it overtops Kingston Street if the flow is restricted to a 100' wide path.
- The conservative analysis results in water surface elevations of 5497.6 along the north property line and 5500.1 along the east property line.
- Therefore, a wall is provided along the north property line at an elevation of 5497.6. An elevation of 5500.1 must be obtained along the east property line to prevent potential Westerly Creek flows from entering the site.
- The wall and the berm will provide at least 1' of freeboard for the 5496.0 and 5499.0 elevations.
- The onsite detention pond will be located in the northwest corner of the site.
- The detention pond volume is sized for the 100-year storm event.
- The detention pond release rate is also based on the 100-year storm event.
- Multiple volumes and discharges do not need to be analyzed due to the fact the pond will discharge directly to an improved drainageway.
- Water quality volume will be provided for the site.

2. Specific Details

- Detention Pond parameters
    - Nearly all of the Kingston Place Subdivision will drain to a single detention pond located in the northwest corner of the site.
    - The detention pond is designed to detain the 100-year storm event and the water quality capture volume.
    - The pond will outfall directly to Westerly Creek via an outlet structure and storm drain pipe. The pipe will be at an elevation 2' higher than the channel invert. One 14' section of concrete will be removed and reconstructed where the outfall pipe enters the channel. The reconstructed channel section shall be recessed so a flap gate can be installed.
    - The detention pond outlet structure will be a modified type C inlet.
    - Water Quality Capture Volume has been provided in the detention facility. The outlet control structure will incorporate a perforated plate to allow the WQCV water to release at a slow rate.
    - The top of the grate will be placed at the water quality water surface elevation.

- Any volume grater that the WQCV will be released through the top of the inlet.
- The release rate will be controlled by an orifice plate placed on the inside of the outlet structure over the 12" outlet pipe.
- If the orifice plate is placed 3.5" above the invert of the pipe, the pond volume will be released at a rate of 2.3cfs (allowable release rate) until the water surface in Westerly Creek is 89.8+/-.
- If the tailwater on the pipe is assumed to be 91 (top of channel elevation) then the orifice plate should be placed 4" above the invert of the pipe to release the pond volume at 2.3cfs.
- It is recommended to place the orifice plate 4" above the invert of the pipe. If tailwater is not present, the pond volume will be released at a rate of 2.8cfs.
- In an emergency condition, the pond will overflow to Kenton Way via an emergency overflow weir located on the west side of the proposed detention pond.
- The Kingston Place detention pond outlet pipe invert is at an elevation of 5489.5 and the invert of Westerly Creek adjacent to the site is roughly 5486.
- The 100-year water surface in Westerly Creek at Kenton Way is roughly 5496.0 using the OSP existing flow of 3000 cfs.
- At the elevation of 5496.0, water is flowing onto Kenton Way at a depth of 2.3' (Weir elevation of the sidewalk varies from 5493.7 to 5493.95).
- If the overflow width onto Kenton Way is reduced to the 100' ROW of Westerly Creek, then the water surface could rise to 5497.6.
- A wall will be constructed along the north property line to prevent Westerly Creek flow from entering the site. The top of wall elevation is proposed to be 5497.6.
- If the culvert is plugged, using the City's criteria for plugged culverts with an area greater that 20 square feet, and the weir overflow is restricted to 100' wide; the overflow water surface could reach an elevation of 5498.0.
- At this elevation, the water in Westerly Creek will back up/overflow into the Kingston Place detention pond and flow out onto Kenton Way.
- If Westerly Creek backs up into the onsite pond it should not damage proposed structures. The minimum foundation elevation adjacent to the

Under Kingston St.?

pond and/or Westerly Creek is ~~5400.2~~ 5500.2 (2.2' above Westerly Creek's emergency water surface elevation)

  - No unit adjacent to Westerly Creek will be a garden level unit or have a basement or crawl space.
  - The peak site discharge of 18cfs has a time of concentration of 5 minutes. Therefore, the pond will likely fill before the water surface in Westerly Creek is high enough to back up into the pond.
  - The simultaneous filling of the onsite pond by Westerly Creek water and the Kingston Place Subdivision runoff is unlikely.
  - However, a flap gate shall be implemented to prevent Westerly Creek from backing into the onsite pond in an effort to keep the creek and the pond hydraulically disconnected.
  - At an elevation higher than the required volume all water will be safely directed to Kenton Way via the overflow weir.
- The culvert at Kingston Street was analyzed using the OSP flow of 3000 cfs and a tail water of 5496.0 (calculated water surface at Kenton Way).
- During proposed conditions when Westerly Creek can encroach onto the property north of the creek, the water elevation as it crosses Kingston Street is 5499.0.
- Westerly Creek could reach an elevation of 5500.1 as it overtops Kingston Street if the creek is restricted to a 100' wide flow path.
- An elevation of 5500.1 will be provided along the east property line to reduce the potential of Westerly Creek flows from entering the site.
- The proposed development is to be constructed during a single phase. The detention pond will be constructed during the initial overlot grading.
- The proposed grading will incorporate a single low point in the private drive.
- During the minor event, runoff from Basin A1A will be collected in the rear of the proposed 5' R inlet at DP1 through a 6" circular orifice. Runoff from the major event will overtop the back of the inlet and will be captured in the curb opening of the inlet.
- Runoff during both the minor and major event from Basin A1B will be collected in the 5' R sump inlet at DP1.
- Runoff from Basin A2 will be collected in the 5' R sump inlet at DP2.
- Runoff from Basin A3 will flow directly to the onsite detention pond represented at DP3.

- Runoff during the minor event from Basin B1 will be collected in a proposed 5' R sump inlet at DP4 in Kingston Street and will be piped to Westerly Creek. Runoff during the major event will overtop the Kingston Street curb and will flow directly to Westerly Creek.
- Runoff between units will be conveyed via grass-lined swales or paved driveways to either the private drive or directly to the proposed detention pond.

E. CONCLUSIONS

1. Compliance with Standards

- This study is in compliance with the following Standards:
  - *City of Aurora Storm Drainage Design and Technical Criteria*
  - *Urban Storm Drainage Criteria Manual*

2. Summary of Concept

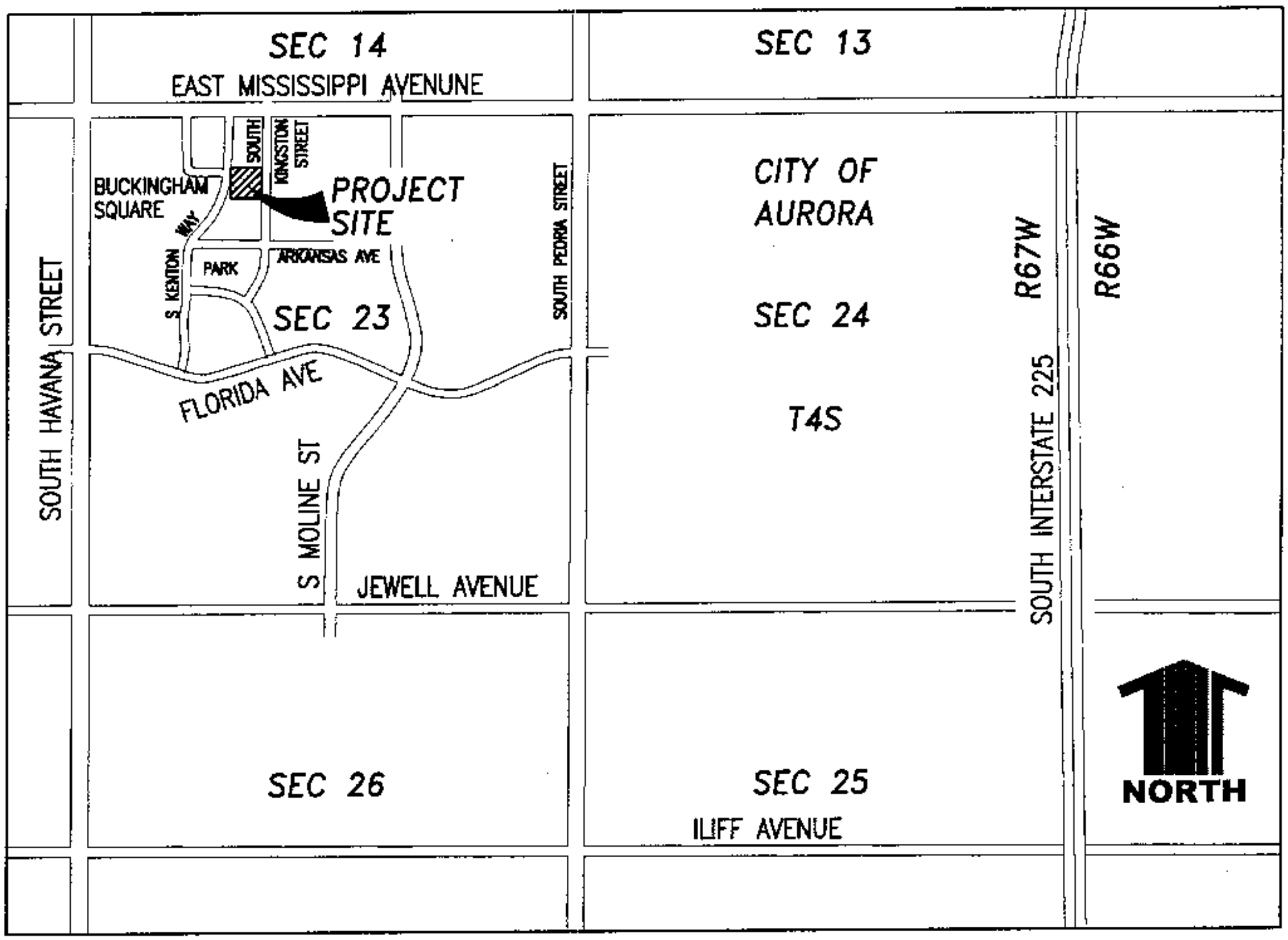
- The design flow of 3000 cfs from the OSP is conservative because it does not account for any runoff that potentially escapes the Westerly Creek right of way.
- The lowest finished floor elevation adjacent to Westerly Creek is a minimum of 2' above the estimated floodplain.
- The detention pond emergency overflow path will be designed to safely convey site runoff away from any proposed structures.
- The proposed storm drain system and detention facilities will provide adequate site drainage and water quality for the site.
- The proposed development does not adversely impact any adjacent properties.

F. REFERENCES

1. *Preliminary Drainage Report for Kingston Place Subdivision Filing No. 1,* Calibre Engineering, July 2004.
2. *Final Drainage Report for The Ridermark Subdivision Filing No. 1,* KMD, Inc., April 2, 2002.
3. *City of Aurora Storm Drainage Design and Technical Criteria,* City of Aurora, January 2002.
4. *Urban Storm Drainage Criteria Manual,* Urban Drainage Flood Control District, September 1999.
5. *Outfall Systems Planning Westerly Creek East of Havana,* Merrick and Company, October, 1996.
6. *Final Drainage Report for Carriage Village Subdivision,* Spiska Engineerin, Inc., May 1995.
7. *Storm Drainage Planning Upper Westerly Creek Outfall System,* Simons, Li and Associates, Inc., March 1982.
8. *Soil Survey of Arapahoe County, Colorado,* USDA – Soil Conservation Service, March 1971.

APPENDIX

MAPS



Calibre ENGINEERING
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Littleton, CO. 80122 (303) 730-0434
Municipal Engineering Development Master Planning

KINGSTON PLACE

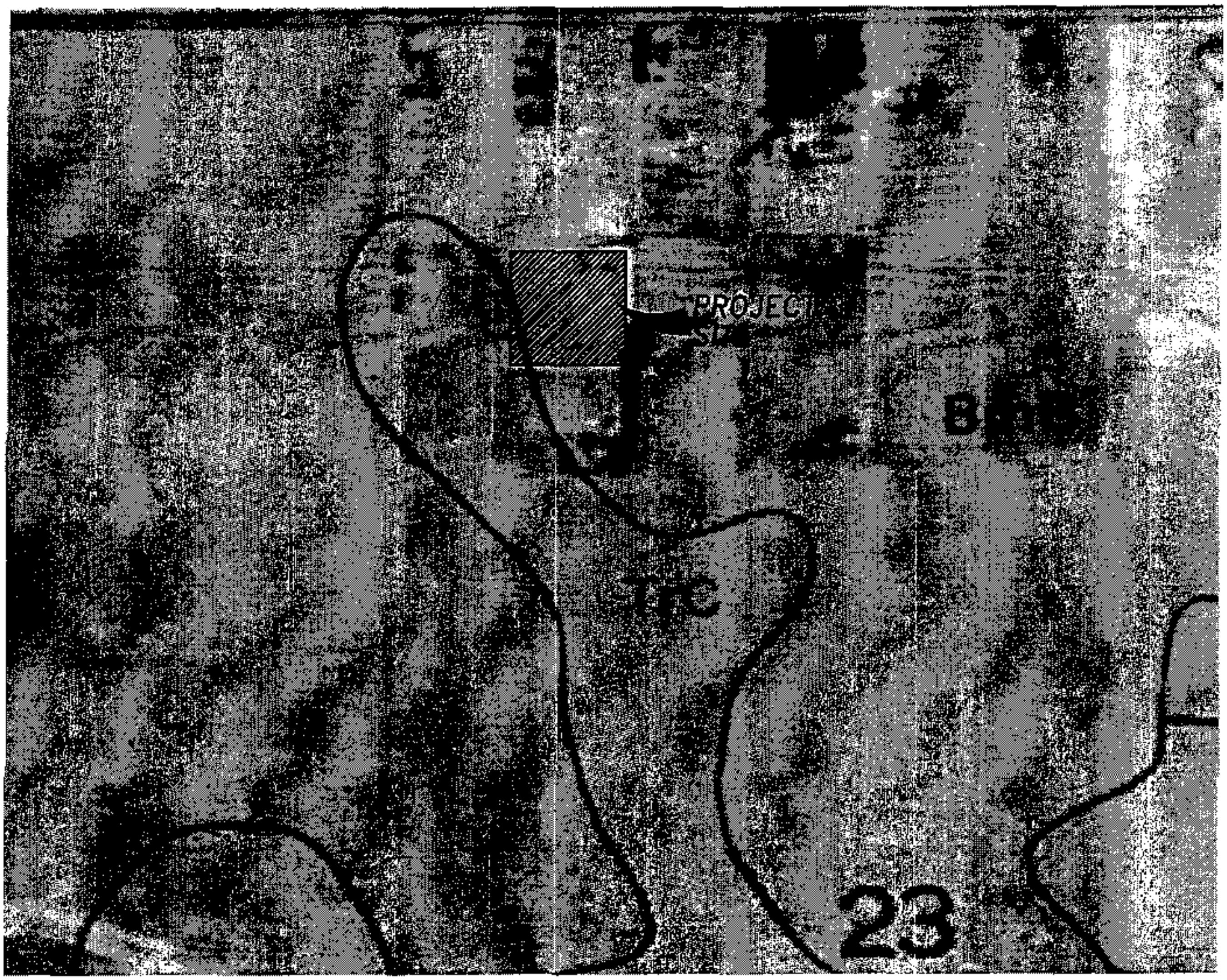
VICINITY MAP

FINAL DRAINAGE REPORT

Sheet 1

SCALE: 1"= 2000'
DATE: 8.16.04

11



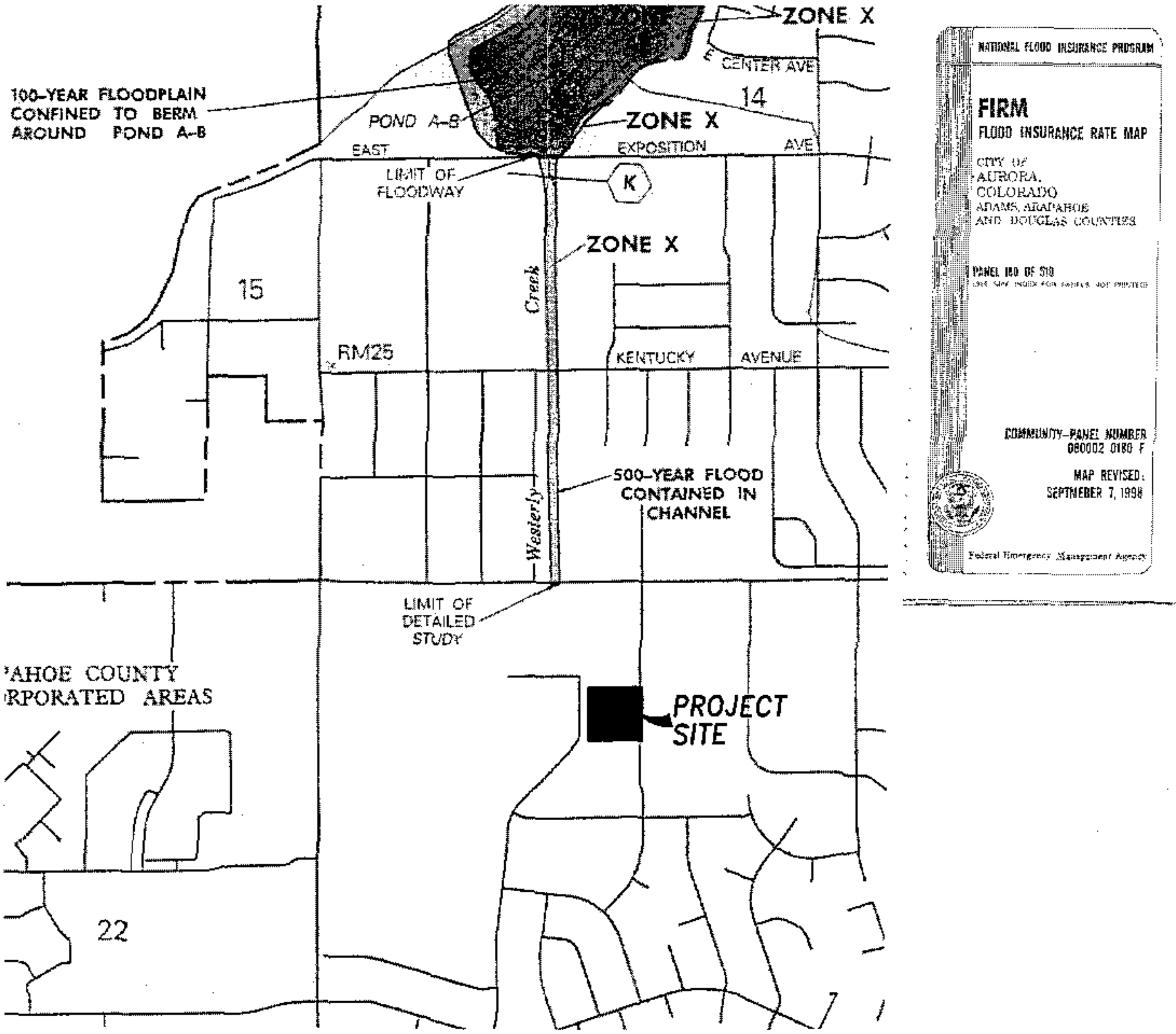
NORTH

Calibre ENGINEERING
Calibre Engineering, Inc.
8000 South Lincoln Street, Unit 5
Littleton, CO 80122 (303) 730-0434
Municipal Engineering Development Master Planning

KINGSTON PLACE
SCS SOILS MAP
FINAL DRAINAGE REPORT

Sheet
1

SCALE: 1"= 500'
DATE: 8.16.04



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KINGSTON PLACE

FLOOD INSURANCE RATE MAP

FINAL DRAINAGE REPORT

Sheet
1

SCALE: 1"= 1000'
DATE: 8.18.04

APPENDIX

HYDROLOGIC COMPUTAIONS

Calibre

COMPOSITE 'C' FACTORS

LOCATION: KINGSTON PLACE **FINAL** **BY: RWL** **DATE: 10/29/2004**

BASIN					MU-D				LAWNS				STREETS				COMPOSITE C FACTOR			
DESIGNATION	MU-D	LAWNS	STREETS	TOTAL	%I	2YR	5 YR	100 YR	%I	2YR	5 YR	100 YR	%I	2YR	5 YR	100 YR	%I	2YR	5 YR	100 YR
A1A	0.55	0.00	0.00	0.55	60	0.45	0.50	0.70	2	0.05	0.06	0.10	100	0.87	0.88	0.93	60.00	0.45	0.50	0.70
A1B	0.14	0.00	0.00	0.14	60	0.45	0.50	0.70	2	0.05	0.06	0.10	100	0.87	0.88	0.93	60.00	0.45	0.50	0.70
A2	0.00	0.00	0.16	0.16	60	0.45	0.50	0.70	2	0.05	0.06	0.10	100	0.87	0.88	0.93	100.00	0.87	0.88	0.93
A3	1.43	0.00	0.00	1.42	60	0.45	0.50	0.70	2	0.05	0.06	0.10	100	0.87	0.88	0.93	60.42	0.45	0.50	0.70
B1	0.00	0.40	0.62	1.02	60	0.45	0.50	0.70	2	0.05	0.06	0.10	100	0.87	0.88	0.93	61.57	0.55	0.56	0.60

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TIME OF CONCENTRATION

LOCATION: KINGSTON PLACE **FINAL** **BY: RWL** **DATE: 10/29/2004**

BASIN DATA			INIT./OVERLAND TIME (Ti)			TRAVEL TIME (Tt)					TOTAL	Tc Check (Urbanized Basins)		FINAL Tc	REMARKS
DESIGNATION	C5	AREA (AC)	LENGTH (FT)	SLOPE %	Ti (Min.)*	GRASS/ PAVED	LENGTH (FT)	SLOPE %	VEL. (FPS)**	Tt(Min.)	Ti+Tt(Min.)	LGTH. (FT)	Tc = (L/180) + 10	(minutes)	FORMULAS: * $Ti = (0.395(1.1-C_5)*L^{(1/2)})/S^{(1/3)}$ ** V=10^(.5 log(S/100)+k
A1A	0.50	0.55	15	10.00	0.43	PAVED	260	0.96	1.96	2.21	2.6	275.00	11.5	5.0	
A1B	0.50	0.14	30	5.00	0.76	PAVED	100	2.00	2.82	0.59	1.3	130.00	10.7	5.0	
A2	0.88	0.16	10	2.00	0.22	PAVED	230	0.98	1.95	1.96	2.2	240.00	11.3	5.0	
A3	0.50	1.42	10	15.00	0.30	GRASS	370	2.57	2.43	2.54	2.8	380.00	12.1	5.0	
B1	0.56	1.02	25	6.00	2.68	PAVED	670	1.04	2.04	5.48	8.2	695.00	13.9	8.2	

16

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STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

DESIGN STORM: 2-YEAR DEVELOPED

Calc. by: RWL
Chk'd by: RBM
Date: 10/29/2004

LOCATION: KINGSTON PLACE **FINAL DESIGN** **CITY OF AURORA**

	DIRECT RUNOFF							TOTAL RUNOFF								PIPE			TRAVEL TIME			REMARKS
DESIGN POINT	BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./hr.)	Q (cfs)	Sum AREA	Sum Tc (min.)	I (in./hr.)	Sum CA	Total Q (cfs)	FLOW IN PIPE	FLOW IN STREET	DITCH OR PIPE	FLOW (CFS)	SLOPE %	PIPE SIZE	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	
1	A1A	0.55	0.45	5.0	0.25	4.00	1.0															Collected in rear 5' R Inlet
1	A1B	0.14	0.45	5.0	0.06	4.00	0.3	0.69	5	4.00	0.31	1.2	1.2		P	1.2	0.50%	15	25	2.0	0.2	Collected in 5' R Inlet; Total runoff A1A, A1B
2	A2	0.16	0.87	5.0	0.14	4.00	0.6	0.85	5	3.95	0.45	1.8	1.8		P	1.8	0.50%	18	100	2.0	0.8	Collected in 5' R Inlet, Piped to Detention Pond, Total runoff A1-2
3	A3	1.42	0.45	5.0	0.64	4.00	2.6	2.27	5	3.95	1.09	4.3										Basin A3 flows directly to pond; Total runoff is total flow into Pond
4	B1	1.02	0.55	8.2	0.56	3.30	1.8															Collected in 5' R Inlet in Kingston Street

Calibre

STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

DESIGN STORM: 100-YEAR DEVELOPED

Calc. by: RWL
Chk'd by: RBM
Date: 10/29/2004

LOCATION: KINGSTON PLACE **FINAL DESIGN** **CITY OF AURORA**

		DIRECT RUNOFF						TOTAL RUNOFF								PIPE			TRAVEL TIME			REMARKS
DESIGN POINT	BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./hr.)	Q (cfs)	Sum AREA	Sum Tc (min.)	I (in./hr.)	Sum CA	Total Q (cfs)	FLOW IN PIPE	FLOW IN STREET	DITCH OR PIPE	FLOW (CFS)	SLOPE %	PIPE SIZE	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	
1	A1A	0.55	0.70	5.0	0.39	10.75	4.1															Collected in rear of 5' R Inlet
1	A1B	0.14	0.70	5.0	0.10	10.75	1.1	0.69	5	10.75	0.48	5.2			P	5.2	0.50%	15	25	4.2	0.1	Collected in 5' R Inlet; Total runoff A1A, A1B
2	A2	0.16	0.93	5.0	0.15	10.75	1.6	0.85	5	10.60	0.63	6.7	6.7		P	6.7	0.50%	18	100	3.8	0.4	Collected in 5' R Inlet, Piped to Detention Pond, Total runoff A1-2
3	A3	1.42	0.70	5.0	1.00	10.75	10.8	2.27	5	10.60	1.63	17.3										Basin A3 flows directly to pond; Total runoff is total flow into Pond
4	B1	1.02	0.60	8.2	0.62	9.00	5.5															Collected in 5' R Inlet in Kingston Street/ Overflows to Westerly Cr

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APPENDIX

HYDRAULIC COMPUTAIONS

Rear of 5' Type R Inlet at DP1

ORIFICE EQUATION

$Q=C_d*A*((2*G*H)^{0.5})$

Q_{100}=	5.4
Q_5=	1.0
C_d=	0.65
g=	32.2
W.S.=	5497.00
H=	1.64
Orifice D=	0.50
Orifice Inv.=	5495.61
A=	0.20
CALC Q=	1.3

ORIFICE WILL PASS MINOR FLOWS.
ADDITIONAL FLOW WILL OVERTOP BACK OF INLET & WILL BE CAPTURED IN INLET.

Formula Method Detention (V=KA)

Required Volume

$A =$ 2.27 acre

$I =$ 63.0 %

Soil Type C

Allowable Release Rates for Detention Ponds

Control Frequency	Soil Group A	B	C	D
10 Year	0.13	0.23	0.30	0.30
100 Year	0.50	0.85	1.00	1.00

~~For 10 Year Event~~

~~$K_{10} = (0.95 I - 1.90)/1000$~~

~~$K_{10} =$ 0.0580~~

~~$V_{10} =$ 0.13 ac-ft~~

~~$Q_{10} =$ 0.681 cfs~~

Not used since pond discharges to an improved drainageway

For 100 Year Event

$K_{100} = (1.78 I - 0.002 I^2 - 3.56)/900$

$K_{100} =$ 0.1118

$V_{100} =$ 0.25 ac-ft

$=$ 11057 ft^3

$Q_{100} =$ 2.27 cfs

$V_{wq} =$ 2439 ft^3

$V_{tot} = V_{wq} + V_{100}$

$V_{tot} =$ 13497 ft^3

Elev -ft	Area ft^2	Step Vol ft^3	Cumml Conic ft^3	
5495.0	7798	1505	13878	← $V_{100} + V_{WQ}$
5494.8	7251	1399	12375	
5494.6	6744	1299	10976	
5494.4	6247	1200	9677	
5494.2	5760	1104	8476	
5494.0	5283	1000	7372	
5493.8	4722	901	6379	
5493.6	4293	816	5477	
5493.4	3874	734	4661	
5493.2	3467	651	3927	
5493.0	3048	557	3646	
5492.8	2533	478	3099	
5492.6	2250	423	2621	← V_{WQ}
5492.4	1978	369	2199	
5492.2	1719	319	1829	
5492.0	1471	265	1510	
5491.8	1181	221	1252	
5491.6	1032	192	1031	
5491.4	889	164	839	
5491.2	753	138	675	
5491.0	628	100	537	
5490.8	387	73	447	← V_{MP}
5490.6	341	64	374	
5490.4	295	55	311	
5490.2	251	46	256	
5490.0	208	39	210	
5489.8	183	34	171	
5489.6	160	30	137	
5489.4	138	25	107	
5489.2	117	21	82	
5489.0	98	18	60	
5488.8	81	15	42	
5488.6	66	12	28	
5488.4	52	9	16	
5488.2	39	7	7	
5488.0	28		0	

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Sheet 1

Designer:	RWL
Company:	CALIBRE ENGINEERING
Date:	August 13, 2004
Project:	KINGSTON PLACE FILING NO. 1
Location:	AURORA

1. Basin Storage Volume	
A) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	I_a = 63.00 % i = 0.63
B) Contributing Watershed Area (Area)	Area = 2.27 acres
C) Water Quality Capture Volume (WQCV) (WQCV =1.0 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV = 0.25 watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area * 1.2	Vol = 0.056 acre-feet
2. Outlet Works	
A) Outlet Type (Check One)	X Orifice Plate Perforated Riser Pipe Other:
B) Depth at Outlet Above Lowest Perforation (H)	H = 1.80 feet
C) Required Maximum Outlet Area per Row, (A_o)	A_o = 0.14 square inches
D) Perforation Dimensions (**enter one only**): i) Circular Perforation Diameter **OR** ii) 2" Height Rectangular Perforation Width	D = 0.406 inches, **OR** W = inches
E) Number of Columns (nc, See Table 6a-1 For Maximum)	nc = 1 number
F) Actual Design Outlet Area per Row (A_o)	A_o = 0.13 square inches
G) Number of Rows (nr)	nr = 5 number
H) Total Outlet Area (A_{ot})	A_{ot} = 0.70 square inches
3. Trash Rack	
A) Needed Open Area: A_t = 0.5 * (Figure 7 Value) * A_{ot}	A_t = 26 square inches
B) Type of Outlet Opening (Check One)	X ≤ 2" Diameter **Round** 2" High **Rectangular** Other:
C) For 2", or Smaller, **Round Opening** (Ref.: Figure 6a):	
i) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 6a-1	W_{conc} = 3 inches
ii) Height of Trash Rack Screen (H_{TR})	H_{TR} = 52 inches

Designer: RWL

Company: CALIBRE ENGINEERING

Date: August 13, 2004

Project: KINGSTON PLACE FILING NO. 1

Location: AURORA

iii) Type of Screen (Based on Depth H), Describe if "Other"	X S.S. #93 VEE Wire (US Filter) Other:
iv) Screen Opening Slot Dimension, Describe if "Other"	X 0.139" (US Filter) Other:
v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 6a-2)	0.75 inches #156 VEE
vi) Type and Size of Holding Frame (Ref.: Table 6a-2)	3/8 in. x 1.0 in. flat bar
D) For 2" High **Rectangular Opening** (Refer to Figure 6b):	
i) Width of Rectangular Opening (W)	W = inches
ii) Width of Perforated Plate Opening (W_{conc} = W + 12")	W_{conc} = inches
iii) Width of Trashrack Opening ($W_{opening}$) from Table 6b-1	$W_{opening}$ = inches
iv) Height of Trash Rack Screen (H_{TR})	H_{TR} = inches
v) Type of Screen (based on depth H) (Describe if "Other")	Klemp™ KPP Series Aluminum Other:
vi) Cross-bar Spacing (Based on Table 6b-1, Klemp™ KPP Grating). Describe if "Other"	inches Other:
vii) Minimum Bearing Bar Size (Klemp™ Series, Table 6b-2) (Based on depth of WQCV surcharge)	
4. Detention Basin length to width ratio	(L/W)
5 Pre-sedimentation Forebay Basin - Enter design values	
A) Volume (no less than 5% of Design Volume from 1D)	acre-feet
B) Surface Area	acres
C) Connector Pipe Diameter (Size to drain this volume in 5-minutes under inlet control)	inches
D) Paved/Hard Bottom and Sides	yes/no

Calibre ENGINEERING

Project	Date	Page
KINGSTON PLACE	8·13·04	1/1
Subject	**Job No.**	**Initials**
DETENTION POND OUTLET STRUCTURE	HAM QUEEN	RWL

100YR WSE = 95

WQ WSE = 92.6

SIZE FOR SINGLE DISCHARGE (100 YR STORM) SINCE POND OUTFALLS TO WESTERLY CREEK.

PLACE GRATE AT WQ WSE

SIZE GRATE FOR 2x 100YR RELEASE

Q_{100} = 2.3 CFS ∴ GRATE MUST PASS 4.6 CFS

$Q = C_d A \sqrt{2gh}$

SOLVE FOR A

$h = 95 - 92.6 = 2.4'$ $C_d = 0.65$

$4.6 = 0.65 A \sqrt{2(32.2)(2.4)}$

$A = 0.57\ FT^2$

SINCE TYPE C CLOSE MESH GRATE AREA = 6.03 FT^2,

USE SINGLE TYPE C INLET W/ RESTRICTOR PLATE AT OUTLET PIPE.

100 - YEAR PLATE DURING 100-YR EVENT

ORIFICE EQUATION

$Q=C_d*A*((2*G*H)^{0.5})$

Qrelease=	2.3		
C_d=	0.65		
g=	32.2		
W.S.=	5495.00		
H=	5.34		
Pipe D=	1.00		
Pipe Inv.=	5489.50	Plate Elev.	5489.83
A=	0.23		
CALC Q=	2.8		

IF NO TW ON OUTLET PIPE & PLATE PLACED 4" ABOVE PIPE INVERT (RECOMMENDED)

100 - YEAR PLATE DURING 100-YR EVENT W/O TAILWATER

ORIFICE EQUATION

$Q=C_d*A*((2*G*H)^{0.5})$

Qrelease=	2.3		
C_d=	0.65		
g=	32.2		
W.S.=	5495.00		
H=	5.36		
Pipe D=	1.00		
Pipe Inv.=	5489.50	Plate Elev.	5489.79
A=	0.19		
CALC Q=	2.3		

PLACE PLATE 3.5" ABOVE INVERT OF OUTLET PIPE

100 - YEAR PLATE DURING 100-YR EVENT

ORIFICE EQUATION

$Q=C_d*A*((2*G*H)^{0.5})$

Qrelease=	2.3		
C_d=	0.65		
g=	32.2		
W.S.=	5495.00		
Channel W.S.=	5491.00		
H=	4.00		
Pipe D=	1.00		
Pipe Inv.=	5489.50	Plate Elev.	5489.83
A=	0.23		
CALC Q=	2.4		

IF CHANNEL WS = 91 THEN PLATE 4" ABOVE INVERT WOULD RESTRICT FLOW TO MAX ALLOWABLE RELEASE

Culvert Calculator Report
12" Pond Outlet - Neglect Tailwater

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	95.00 ft	Headwater Depth/Height	1.07
Computed Headwater Elevation	90.07 ft	Discharge	2.30 cfs
Inlet Control HW Elev.	90.00 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	90.07 ft	Control Type	Entrance Control

Grades

Upstream Invert	89.00 ft	Downstream Invert	87.10 ft
Length	67.00 ft	Constructed Slope	2.84 %

Hydraulic Profile

Profile	S2	Depth, Downstream	0.43 ft
Slope Type	Steep	Normal Depth	0.43 ft
Flow Regime	Supercritical	Critical Depth	0.65 ft
Velocity Downstream	7.13 ft/s	Critical Slope	0.73 %

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.00 ft
Section Size	12 inch	Rise	1.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	90.07 ft	Upstream Velocity Head	0.28 ft
Ke	0.50	Entrance Loss	0.14 ft

Inlet Control Properties

Inlet Control HW Elev.	90.00 ft	Flow Control	Unsubmerged
Inlet Type	Square edge w/headwall	Area Full	0.8 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

- CHANNEL INVERT ≅ 85±, TOP OF CHANNEL ≅ 91± AT POND OUTLET PIPE
- IF ORIFICE PLATE IS PLACED 3.5" ABOVE INVERT OF PIPE, MAX RELEASE = 2.3CFS UNTIL THE WS IN WESTERLY CREEK = 89.8±
- IF TW ON PIPE IS ASSUMED TO BE 91 (TOP OF CHANNEL) THEN PLACE ORIFICE PLATE 4" ABOVE INVERT OF PIPE
- IT IS RECOMMENDED TO PLACE PLATE 4" ABOVE PIPE INVERT. IF NO TW IS PRESENT, POND WILL RELEASE 2.8CFS

Detention Pond

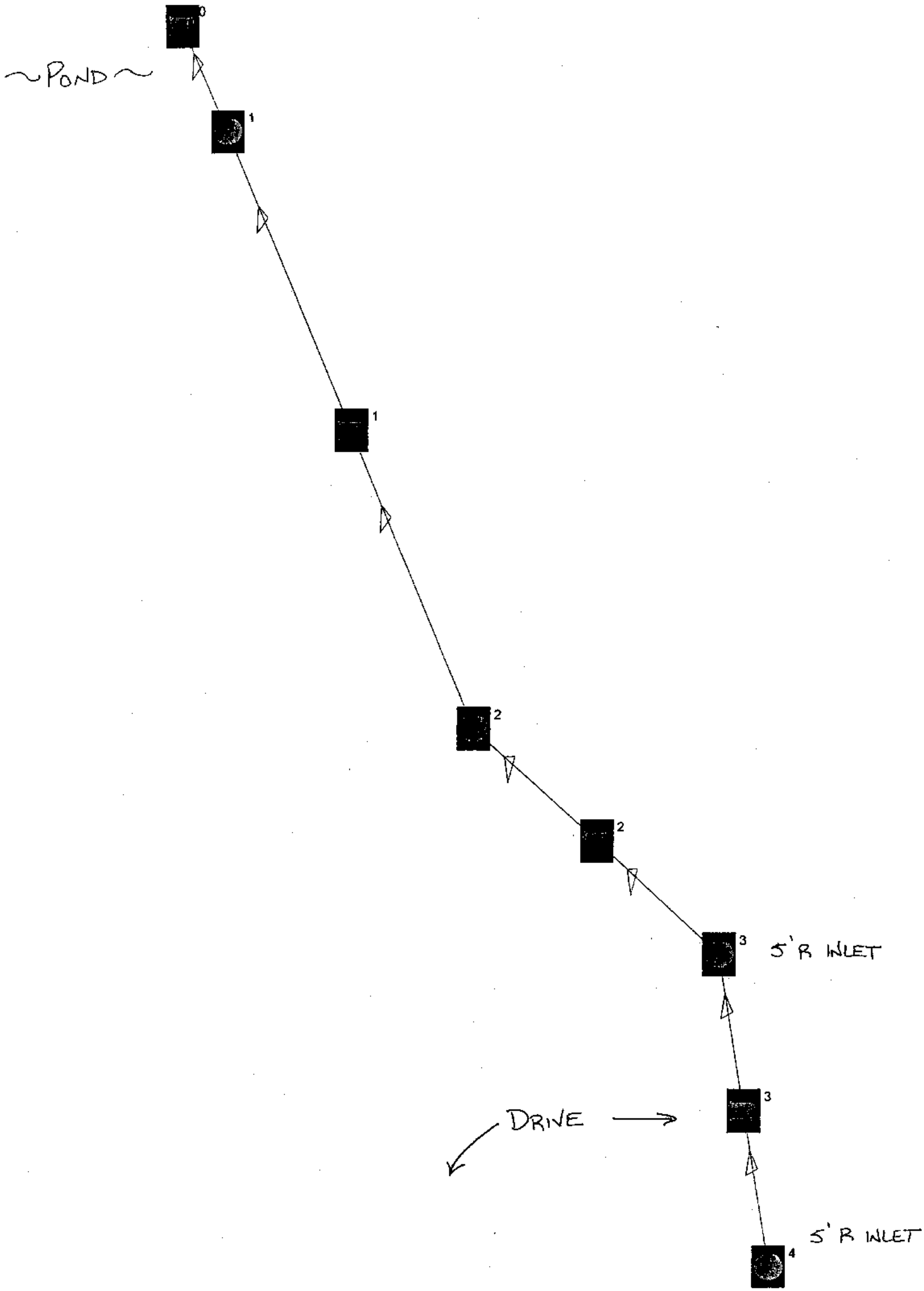
Emergency Overflow Weir

Weir must pass 34.2 cfs

Bottom of Weir elevation = 5495
Top of weir elevation = 5496
Available head = 1
Weir Coefficient = 3.1

Length of Rectangular Weir			18
Side Slope 1	20%	Angle 1	78.69
Side Slope 2	20%	Angle 2	78.69
	Total Angle For. V-notch Weir		157.38

WSE	head (ft.)	Freeboard (ft.)	Rect weir (cfs)	v-notch (cfs)	total Q (cfs)	
5495.66	0.66	0.3	29.9	4.4	34	<---2x100 YR Flow into Pond


~POND~
0
1
1
2
2
3
5' R INLET
DRIVE
3
5' R INLET
4

NeoUDS Results Summary

Project Title: Kingston Place
Project Description: Final Drainage Report
Output Created On: 8/13/2004 at 8:36:24 AM
Using NeoUDSewer Version 1.5.
Rainfall Intensity Formula **Used.**
Return Period of Flood is 2 **Years.**

Sub Basin Information

		Time of Concentration				
Manhole ID #	**Basin Area * C**	**Overland (Minutes)**	**Gutter (Minutes)**	**Basin (Minutes)**	**Rain I (Inch/Hour)**	**Peak Flow (CFS)**
2	0.48	5.0	0.0	0.0	3.77	1.8
3	0.45	5.0	0.0	0.0	4.00	1.8
4	0.31	5.0	0.0	0.0	3.86	1.2
1	0.48	5.0	0.0	0.0	3.77	1.8

The shortest design rainfall duration is 5 minutes.
For rural areas, the catchment time of concentration is always => 10 minutes.
For urban areas, the catchment time of concentration is always => 5 minutes.
At the first design point, the time constant is <= (10+Total Length/180) in minutes.
When the weighted runoff coefficient => 0.2, then the basin is considered to be urbanized.
When the Overland Tc plus the Gutter Tc does not equal the catchment Tc, the above criteria supercedes the calculated values.

Summary of Manhole Hydraulics

Manhole ID #	**Contributing Area * C**	**Rainfall Duration (Minutes)**	**Rainfall Intensity (Inch/Hour)**	**Design Peak Flow (CFS)**	**Ground Elevation (Feet)**	**Water Elevation (Feet)**	**Comments**
2	1.24	32.4	1.45	1.8	97.70	94.32	
3	0.76	12.8	2.37	1.8	97.55	94.62	
4	0.31	5.0	3.86	1.2	97.54	94.91	
1	0	0.0	0.00	1.8	95.00	93.00	

Summary of Sewer Hydraulics

Note: The given depth to flow ratio is 0.9.

	Manhole ID Number			Calculated	Suggested	Existing	
Sewer ID #	Upstream	Downstream	Sewer Shape	Diameter (Rise) (Inches) (FT)	Diameter (Rise) (Inches) (FT)	Diameter (Rise) (Inches) (FT)	Width (FT)
2	3	2	Round	11.2	12	18	N/A
3	4	3	Round	9.6	12	15	N/A
1	2	1	Round	11.2	12	18	N/A

Round and arch sewers are measured in inches.
Box sewers are measured in feet.
Calculated diameter was determined by sewer hydraulic capacity.
Suggested diameter was rounded up to the nearest commercially availible size
All hydraulics where calculated using the existing parameters.
If sewer was sized mathematically, the suggested diameter was used for hydraulic calculations.

Sewer ID	Design Flow (CFS)	Full Flow (CFS)	Normal Depth (Feet)	Normal Velocity (FPS)	Critical Depth (Feet)	Critical Velocity (FPS)	Full Velocity (FPS)	Froude Number	Comment
2	1.8	6.5	0.54	3.1	0.52	3.3	1.0	0.87	
3	1.2	4.0	0.47	2.8	0.44	3.1	1.0	0.84	
1	1.8	6.5	0.54	3.1	0.52	3.3	1.0	0.87	

A Froude number = 0 indicated that a pressured flow occurs.

Summary of Sewer Design Information

		Invert Elevation		Buried Depth		
Sewer ID	Slope %	Upstream (Feet)	Downstream (Feet)	Upstream (Feet)	Downstream (Feet)	Comment
2	0.50	94.08	93.99	1.97	2.21	
3	0.50	94.44	94.28	1.85	2.02	
1	0.50	93.78	93.25	2.42	0.25	Sewer Too Shallow

Summary of Hydraulic Grade Line

			Invert Elevation		Water Elevation		
Sewer ID #	Sewer Length (Feet)	Surcharged Length (Feet)	Upstream (Feet)	Downstream (Feet)	Upstream (Feet)	Downstream (Feet)	Condition
2	18.97	0	94.08	93.99	94.62	94.32	Subcritical
3	31.34	0	94.44	94.28	94.91	94.62	Subcritical
1	106.63	0	93.78	93.25	94.32	93.00	Subcritical

Summary of Energy Grade Line

	Upstream Manhole			Juncture Losses				Downstream Manhole	
Sewer ID #	Manhole ID #	Energy Elevation (Feet)	Sewer Friction (Feet)	Bend K Coefficient	Bend Loss (Feet)	Lateral K Coefficient	Lateral Loss (Feet)	Manhole ID #	Energy Elevation (Feet)
2	3	94.77	0.30	0.05	0.00	0.00	0.00	2	94.47
3	4	95.04	0.26	0.05	0.00	0.00	0.00	3	94.77
1	2	94.47	1.47	0.05	0.00	0.00	0.00	1	93.00

Bend loss = Bend K * Flowing full vhead in sewer.
Lateral loss = Outflow full vhead - Junction Loss K * Inflow full vhead.
A friction loss of 0 means it was negligible or possible error due to jump.
Friction loss includes sewer invert drop at manhole.
Notice: Vhead denotes the velocity head of the full flow condition.
A minimum junction loss of 0.05 Feet would be introduced unless Lateral K is 0.
Friction loss was estimated by backwater curve computations.

Summary of Earth Excavation Volume for Cost Estimate

The user given trench side slope is 1.

Manhole ID #	Rim Elevation (Feet)	Invert Elevation (Feet)	Manhole Height (Feet)
2	97.70	93.78	3.92
3	97.55	94.08	3.47
4	97.54	94.44	3.10
1	95.00	93.25	1.75

	Upstream Trench Width		Downstream Trench Width				
Sewer ID #	On Ground (Feet)	At Invert (Feet)	On Ground (Feet)	At Invert (Feet)	Trench Length (Feet)	Wall Thickness (Inches)	Earth Volume (Cubic Yards)
2	7.0	3.9	7.5	3.9	18.97	2.50	15
3	6.6	3.6	6.9	3.6	31.34	2.25	20
1	7.9	3.9	3.6	3.9	106.63	2.50	67

Total earth volume for sewer trenches = 102.37 Cubic Yards. The earth volume was estimated to have a bottem width equal to the diameter (or width) of the sewer plus two times either 1 foot for diameters less than 48 inches or 2 feet for pipes larger than 48 inches.

If the bottom width is less than the minimum width, the minimum width was used.
The backfill depth under the sewer was assumed to be 1 foot.
The sewer wall thickness is equal to: (equivelant diameter in inches/12)+1

NeoUDS Results Summary

Project Title: Kingston Place
Project Description: Final Drainage Report
Output Created On: 8/13/2004 at 8:43:09 AM
Using NeoUDSewer Version 1.5.
Rainfall Intensity Formula **Used.**
Return Period of Flood is 100 **Years.**

Sub Basin Information

		Time of Concentration				
Manhole ID #	**Basin Area * C**	**Overland (Minutes)**	**Gutter (Minutes)**	**Basin (Minutes)**	**Rain I (Inch/Hour)**	**Peak Flow (CFS)**
2	0.67	5.0	0.0	0.0	10.06	6.7
3	0.67	5.0	0.0	0.0	10.06	6.7
4	0.50	5.0	0.0	0.0	10.32	5.2
1	0.67	5.0	0.0	0.0	10.06	6.7

The shortest design rainfall duration is 5 minutes.
For rural areas, the catchment time of concentration is always => 10 minutes.
For urban areas, the catchment time of concentration is always => 5 minutes.
At the first design point, the time constant is <= (10+Total Length/180) in minutes.
When the weighted runoff coefficient => 0.2, then the basin is considered to be urbanized.
When the Overland Tc plus the Gutter Tc does not equal the catchment Tc, the above criteria supercedes the calculated values.

Summary of Manhole Hydraulics

Manhole ID #	**Contributing Area * C**	**Rainfall Duration (Minutes)**	**Rainfall Intensity (Inch/Hour)**	**Design Peak Flow (CFS)**	**Ground Elevation (Feet)**	**Water Elevation (Feet)**	**Comments**
2	1.84	35.6	3.65	6.7	97.70	96.01	
3	1.17	15.7	5.73	6.7	97.55	96.12	
4	0.5	5.0	10.32	5.2	97.54	96.35	
1	0	0.0	0.00	6.7	95.00	95.66	**Surface Water Present**

Summary of Sewer Hydraulics

Note: The given depth to flow ratio is 0.9.

Sewer ID #	Manhole ID Number Upstream	Manhole ID Number Downstream	Sewer Shape	Calculated Diameter (Rise) (Inches) (FT)	Suggested Diameter (Rise) (Inches) (FT)	Existing Diameter (Rise) (Inches) (FT)	Existing Width (FT)
2	3	2	Round	18.3	21	18	N/A
3	4	3	Round	16.6	18	15	N/A
1	2	1	Round	18.3	21	18	N/A

Round and arch sewers are measured in inches.
Box sewers are measured in feet.
Calculated diameter was determined by sewer hydraulic capacity.
Suggested diameter was rounded up to the nearest commercially availible size
All hydraulics where calculated using the existing parameters.
If sewer was sized mathematically, the suggested diameter was used for hydraulic calculations.

Sewer ID	Design Flow (CFS)	Full Flow (CFS)	Normal Depth (Feet)	Normal Velocity (FPS)	Critical Depth (Feet)	Critical Velocity (FPS)	Full Velocity (FPS)	Froude Number	Comment
2	6.7	6.5	1.50	3.8	1.00	5.4	3.8	N/A	
3	5.2	4.0	1.25	4.2	0.93	5.3	4.2	N/A	
1	6.7	6.5	1.50	3.8	1.00	5.4	3.8	N/A	

A Froude number = 0 indicated that a pressured flow occurs.

Summary of Sewer Design Information

Sewer ID	Slope %	Invert Elevation Upstream (Feet)	Invert Elevation Downstream (Feet)	Buried Depth Upstream (Feet)	Buried Depth Downstream (Feet)	Comment
2	0.50	94.08	93.99	1.97	2.21	
3	0.50	94.44	94.28	1.85	2.02	
1	0.50	93.78	93.25	2.42	0.25	Sewer Too Shallow

Summary of Hydraulic Grade Line

Sewer ID #	Sewer Length (Feet)	Surcharged Length (Feet)	Invert Elevation Upstream (Feet)	Invert Elevation Downstream (Feet)	Water Elevation Upstream (Feet)	Water Elevation Downstream (Feet)	Condition
2	18.97	18.97	94.08	93.99	96.12	96.01	Pressured
3	31.34	31.34	94.44	94.28	96.35	96.12	Pressured
1	106.63	106.63	93.78	93.25	96.01	95.66	Pressured

Summary of Energy Grade Line

	Upstream Manhole			Juncture Losses				Downstream Manhole	
Sewer ID #	Manhole ID #	Energy Elevation (Feet)	Sewer Friction (Feet)	Bend K Coefficient	Bend Loss (Feet)	Lateral K Coefficient	Lateral Loss (Feet)	Manhole ID #	Energy Elevation (Feet)
2	3	96.35	0.10	0.05	0.01	0.00	0.00	2	96.23
3	4	96.63	0.27	0.05	0.01	0.00	0.00	3	96.35
1	2	96.23	0.57	0.05	0.00	0.00	0.00	1	95.66

Bend loss = Bend K * Flowing full vhead in sewer.
Lateral loss = Outflow full vhead - Junction Loss K * Inflow full vhead.
A friction loss of 0 means it was negligible or possible error due to jump.
Friction loss includes sewer invert drop at manhole.
Notice: Vhead denotes the velocity head of the full flow condition.
A minimum junction loss of 0.05 Feet would be introduced unless Lateral K is 0.
Friction loss was estimated by backwater curve computations.

Summary of Earth Excavation Volume for Cost Estimate

The user given trench side slope is 1.

Manhole ID #	Rim Elevation (Feet)	Invert Elevation (Feet)	Manhole Height (Feet)
2	97.70	93.78	3.92
3	97.55	94.08	3.47
4	97.54	94.44	3.10
1	95.00	93.25	1.75

	Upstream Trench Width		Downstream Trench Width				
Sewer ID #	On Ground (Feet)	At Invert (Feet)	On Ground (Feet)	At Invert (Feet)	Trench Length (Feet)	Wall Thickness (Inches)	Earth Volume (Cubic Yards)
2	7.0	3.9	7.5	3.9	18.97	2.50	15
3	6.6	3.6	6.9	3.6	31.34	2.25	20
1	7.9	3.9	3.6	3.9	106.63	2.50	67

Total earth volume for sewer trenches = 102.37 Cubic Yards. The earth volume was estimated to have a bottem width equal to the diameter (or width) of the sewer plus two times either 1 foot for diameters less than 48 inches or 2 feet for pipes larger than 48 inches.

If the bottom width is less than the minimum width, the minimum width was used.
The backfill depth under the sewer was assumed to be 1 foot.
The sewer wall thickness is equal to: (equivelant diameter in inches/12)+1

Channel DS of ex dual 12x5 RCBC
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Channel DS of ex dual 12x5 RCBC
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Slope	1.85	%
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	10.00	ft
Discharge	3,150.00	cfs

Results		
Depth	5.24	ft
Flow Area	107.4	ft²
Wetted Perimeter	33.45	ft
Top Width	30.97	ft
Critical Depth	8.74	ft
Critical Slope	0.21	%
Velocity	29.33	ft/s
Velocity Head	13.37	ft
Specific Energy	18.61	ft
Froude Number	2.78	
Flow Type	Supercritical	

Culvert Calculator Report
Ex Dual 12x5 RCBC

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	5,498.00 ft	Headwater Depth/Height	1.06
Computed Headwater Elevation	5,484.40 ft	Discharge	700.00 cfs
Inlet Control HW Elev.	5,483.81 ft	Tailwater Elevation	5,483.35 ft
Outlet Control HW Elev.	5,484.40 ft	Control Type	Outlet Control

Grades			
Upstream Invert	5,479.10 ft	Downstream Invert	5,478.10 ft
Length	130.00 ft	Constructed Slope	0.77 %

Hydraulic Profile			
Profile	CompositePressureProfileS1	Depth, Downstream	5.25 ft
Slope Type	N/A	Normal Depth	2.14 ft
Flow Regime	Subcritical	Critical Depth	2.98 ft
Velocity Downstream	5.83 ft/s	Critical Slope	0.29 %

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	12.00 ft
Section Size	12 x 5 ft	Rise	5.00 ft
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	5,484.40 ft	Upstream Velocity Head	0.77 ft
Ke	0.50	Entrance Loss	0.38 ft

Inlet Control Properties			
Inlet Control HW Elev.	5,483.81 ft	Flow Control	Unsubmerged
Inlet Type	45° non-offset wingwall flares	Area Full	120.0 ft²
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Overflow onto Kenton Way

100-Year Overflow Weir - Ultimate Conditions

Weir and Culvert must pass 3000 cfs

Bottom of Weir elevation 1 = 5493.7
Bottom of Weir elevation 2 = 5493.75
Bottom of Weir elevation 3 = 5493.95
Top of weir elevation = 5497.6
Available head 1 = 3.9
Available head 2 = 3.85
Available head 3 = 3.65
Weir Coefficient = 3.1

Length of Rectangular Weir 1			80
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir 1	v-notch	total Q
3.9	1910.1	0.0	1910

Length of Rectangular Weir 2			10
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
3.85	234.2	0.0	234

Length of Rectangular Weir 3			10
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
3.65	216.2	0.0	216
		$Q_{Culvert}$	681
		Q_{TOTAL}=	3041

Culvert Calculator Report
Existing 8'x6' RCBC – ULTIMATE CONDITIONS

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	5,497.60 ft	Headwater Depth/Height	1.93
Computed Headwater Elevation	5,497.60 ft	Discharge	680.65 cfs
Inlet Control HW Elev.	5,497.60 ft	Tailwater Elevation	5,484.40 ft
Outlet Control HW Elev.	5,496.69 ft	Control Type	Inlet Control

Grades

Upstream Invert	5,486.00 ft	Downstream Invert	5,479.10 ft
Length	600.00 ft	Constructed Slope	1.15 %

Hydraulic Profile

Profile	S2	Depth, Downstream	4.32 ft
Slope Type	Steep	Normal Depth	4.28 ft
Flow Regime	Supercritical	Critical Depth	6.00 ft
Velocity Downstream	19.71 ft/s	Critical Slope	0.75 %

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 6 ft	Rise	6.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	5,496.69 ft	Upstream Velocity Head	3.12 ft
Ke	0.50	Entrance Loss	1.56 ft

Inlet Control Properties

Inlet Control HW Elev.	5,497.60 ft	Flow Control	Submerged
Inlet Type	45° non-offset wingwall flares	Area Full	48.0 ft²
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Culvert Calculator Report

Existing 8'x6' RCBC – ULTIMATE CONDITIONS

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	5,497.60 ft	Headwater Depth/Height	1.93
Computed Headwater Elevation	5,497.60 ft	Discharge	680.65 cfs
Inlet Control HW Elev.	5,497.60 ft	Tailwater Elevation	5,488.40 ft ← SHOWS THAT THERE IS 4' OF FLEXIBILITY
Outlet Control HW Elev.	5,497.59 ft	Control Type	Inlet Control

Grades

Upstream Invert	5,486.00 ft	Downstream Invert	5,479.10 ft
Length	600.00 ft	Constructed Slope	1.15 %

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	4.32 ft
Slope Type	N/A	Normal Depth	4.28 ft
Flow Regime	N/A	Critical Depth	6.00 ft
Velocity Downstream	19.71 ft/s	Critical Slope	0.75 %

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 6 ft	Rise	6.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	5,497.59 ft	Upstream Velocity Head	3.12 ft
Ke	0.50	Entrance Loss	1.56 ft

Inlet Control Properties

Inlet Control HW Elev.	5,497.60 ft	Flow Control	Submerged
Inlet Type	45° non-offset wingwall flares	Area Full	48.0 ft²
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Calibre ENGINEERING

Project	Date	Page
KINGSTON PLACE	7.27.04	1/1
Subject	**Job No.**	**Initials**
% OVERFLOW @ KENTON CULVERT	HAM QUEEN	RWL

8x6 RCBC

OPEN AREA = 48 SF

$$\% \text{ OVERFLOW} = (100)\frac{(20+(A-20).2)}{A}$$

$$= (100)\frac{20+(48-20).2}{48}$$

% OVERFLOW = 53%

Overflow onto Kenton Way

100-Year Overflow Weir - Ultimate Conditions, Plugged Culvert

Weir and Culvert must pass 3000 cfs
Culvert must pass 47% of unplugged capacity

Bottom of Weir elevation 1 = 5493.7
Bottom of Weir elevation 2 = 5493.75
Bottom of Weir elevation 3 = 5493.95
Top of weir elevation = 5498.0
Available head 1 = 4.3
Available head 2 = 4.25
Available head 3 = 4.05
Weir Coefficient = 3.1

Length of Rectangular Weir 1			80
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir 1	v-notch	total Q
4.3	2211.3	0.0	2211

Length of Rectangular Weir			10
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
4.25	271.6	0.0	272

Length of Rectangular Weir			~~10~~
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
4.05	252.7	0.0	253

$Q_{Culvert}$ 320.07

Q_{TOTAL}= **3056**

Overflow onto Kingston Street

100-Year Overflow Weir - Ultimate Conditions

Weir and Culvert must pass 3000 cfs

Bottom of Weir elevation 1 = 5497.9
Bottom of Weir elevation 2 = 5497.65
North along Kingston = 5497.25
Top of weir elevation = 5500.1
Available head 1 = 2.2
Available head 2 = 2.45
Available head Kingston = 2.85
Weir Coefficient = 3.1

Length of Rectangular Weir 1			75
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir 1	v-notch	total Q
2.2	758.7	0.0	759

Length of Rectangular Weir			25
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
2.45	297.2	0.0	297

Length of Rectangular Weir			60
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
2.85	894.9	0.0	895

$Q_{Culvert}$ 1097

Q_{TOTAL}= 3048

Culvert Calculator Report

Existing Dual 8.5x7 RCBC - Ultimate Conditions

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	5,500.10 ft	Headwater Depth/Height	1.73
Computed Headwater Elevation	5,500.10 ft	Discharge	1,097.45 cfs
Inlet Control HW Elev.	*5,497.60 ft*	*Tailwater Elevation*	5,497.60 ft
Outlet Control HW Elev.	5,500.10 ft	Control Type	Outlet Control

Grades

Upstream Invert	5,488.83 ft	Downstream Invert	5,487.74 ft
Length	60.00 ft	Constructed Slope	1.82 %

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	9.86 ft
Slope Type	N/A	Normal Depth	2.91 ft
Flow Regime	N/A	Critical Depth	5.06 ft
Velocity Downstream	9.93 ft/s	Critical Slope	0.41 %

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.50 ft
Section Size	8.5 x 6.5 ft	Rise	6.50 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	5,500.10 ft	Upstream Velocity Head	1.53 ft
Ke	0.50	Entrance Loss	0.77 ft

Inlet Control Properties

Inlet Control HW Elev.	5,497.60 ft	Flow Control	Transition
Inlet Type	45° non-offset wingwall flares	*Area Full*	*110.5 ft²*
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Overflow onto Kenton Way

100-Year Overflow Weir - Proposed Conditions

Weir and Culvert must pass 3000 cfs

Bottom of Weir elevation 1 = 5493.7
Bottom of Weir elevation 2 = 5493.75
Bottom of Weir elevation 3 = 5493.95
Top of weir elevation = 5496
Available head 1 = 2.3
Available head 2 = 2.25
Available head 3 = 2.05
Weir Coefficient = 3.1

Length of Rectangular Weir 1			80
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir 1	v-notch	total Q
2.3	865.1	0.0	865

Length of Rectangular Weir 2			10
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
2.25	104.6	0.0	105

Length of Rectangular Weir 3			165
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
	Total Angle For V-notch Weir		0.00

head	Rect weir	v-notch	total Q
2.05	1501.3	0.0	1501

$Q_{Culvert}$ 595

Q_{TOTAL}= 3066

Culvert Calculator Report
Existing 8'x6' RCBC - Proposed Conditions

Solve For: Discharge

Culvert Summary			
Allowable HW Elevation	5,496.00 ft	Headwater Depth/Height	1.67
Computed Headwater Elevation	5,496.00 ft	Discharge	595.43 cfs
Inlet Control HW Elev.	5,496.00 ft	Tailwater Elevation	5,484.40 ft
Outlet Control HW Elev.	5,495.74 ft	Control Type	Inlet Control

Grades			
Upstream Invert	5,486.00 ft	Downstream Invert	5,479.10 ft
Length	600.00 ft	Constructed Slope	1.15 %

Hydraulic Profile			
Profile	S2	Depth, Downstream	3.89 ft
Slope Type	Steep	Normal Depth	3.87 ft
Flow Regime	Supercritical	Critical Depth	5.56 ft
Velocity Downstream	19.14 ft/s	Critical Slope	0.44 %

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 6 ft	Rise	6.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	5,495.74 ft	Upstream Velocity Head	2.78 ft
Ke	0.50	Entrance Loss	1.39 ft

Inlet Control Properties			
Inlet Control HW Elev.	5,496.00 ft	Flow Control	Submerged
Inlet Type	45° non-offset wingwall flares	Area Full	48.0 ft²
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Overflow onto Kingston Street

100-Year Overflow Weir - Proposed Conditions

Weir and Culvert must pass 3000 cfs

Bottom of Weir elevation 1 = 5497.9
Bottom of Weir elevation 2 = 5497.65
Bottom of Weir elevation 3 = 5497.25
Top of weir elevation = 5499
Available head 1 = 1.1
Available head 2 = 1.35
Available head 3 = 1.75
Weir Coefficient = 3.1

Length of Rectangular Weir 1			100
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
		Total Angle For V-notch Weir	0.00

head	Rect weir 1	v-notch	total Q
1.1	357.6	0.0	358

Length of Rectangular Weir			40
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
		Total Angle For V-notch Weir	0.00

head	Rect weir	v-notch	total Q
1.35	194.5	0.0	195

Length of Rectangular Weir			170
Side Slope 1	0.00%	Angle 1	0.00
Side Slope 2	0.00%	Angle 2	0.00
		Total Angle For V-notch Weir	0.00

head	Rect weir	v-notch		total Q
1.75	1220.0	0.0		1220
			$Q_{Culvert}$	1202
			Q_{TOTAL}=	**2974**

Culvert Calculator Report

Existing Dual 8.5x7 RCBC - Proposed Conditions

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	5,499.00 ft	Headwater Depth/Height	1.56
Computed Headwater Elevation	5,499.00 ft	Discharge	1,202.20 cfs
Inlet Control HW Elev.	5,498.00 ft	Tailwater Elevation	5,496.00 ft
Outlet Control HW Elev.	5,499.00 ft	Control Type	Outlet Control

Grades

Upstream Invert	5,488.83 ft	Downstream Invert	5,487.74 ft
Length	60.00 ft	Constructed Slope	1.82 %

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	8.26 ft
Slope Type	N/A	Normal Depth	3.11 ft
Flow Regime	N/A	Critical Depth	5.38 ft
Velocity Downstream	10.86 ft/s	Critical Slope	0.42 %

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.50 ft
Section Size	8.5 x 6.5 ft	Rise	6.50 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	5,499.00 ft	Upstream Velocity Head	1.84 ft
Ke	0.50	Entrance Loss	0.92 ft

Inlet Control Properties

Inlet Control HW Elev.	5,498.00 ft	Flow Control	Submerged
Inlet Type	45° non-offset wingwall flares	Area Full	110.5 ft²
K	0.49700	HDS 5 Chart	12
M	0.66700	HDS 5 Scale	1
C	0.03390	Equation Form	2
Y	0.80300		

Private Road Capacity - North Half
Worksheet for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Slope	0.50 %
Water Surface Elevation	0.43 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results		
Mannings Coefficient	0.015	
Elevation Range	0.00 to 0.43	
Discharge	5.38	cfs
Flow Area	2.8	ft²
Wetted Perimeter	21.09	ft
Top Width	21.00	ft
Actual Depth	0.43	ft
Critical Elevation	0.42	ft
Critical Slope	0.61	%
Velocity	1.89	ft/s
Velocity Head	0.06	ft
Specific Energy	0.49	ft
Froude Number	0.91	
Flow Type	Subcritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+13	0.016
0+13	0+21	0.013

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	0.43
0+13	0.17
0+15	0.00
0+16	0.33
0+16	0.33
0+21	0.43

Private Road Capacity - Minor Storm (North Half)
Rating Table for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Water Surface Elevation	0.43 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

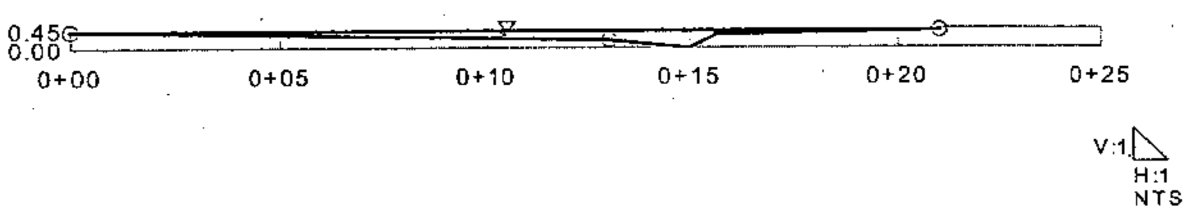
Attribute	Minimum	Maximum	Increment
Slope (%)	0.50	4.00	0.50

Slope (%)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.50	5.38	1.89	2.8	21.09	21.00
1.00	7.61	2.68	2.8	21.09	21.00
1.50	9.32	3.28	2.8	21.09	21.00
2.00	10.76	3.79	2.8	21.09	21.00
2.50	12.04	4.24	2.8	21.09	21.00
3.00	13.18	4.64	2.8	21.09	21.00
3.50	14.24	5.01	2.8	21.09	21.00
4.00	15.22	5.36	2.8	21.09	21.00

Private Road Capacity - North Half
Cross Section for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.015
Slope	0.50 %
Water Surface Elevation	0.43 ft
Elevation Range	0.00 to 0.43
Discharge	5.38 cfs



Private Road Capacity - South Half
Worksheet for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - South Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Slope	0.50 %
Water Surface Elevation	0.33 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results		
Mannings Coefficient	0.015	
Elevation Range	0.00 to 0.43	
Discharge	2.02	cfs
Flow Area	1.2	ft²
Wetted Perimeter	10.76	ft
Top Width	10.67	ft
Actual Depth	0.33	ft
Critical Elevation	0.31	ft
Critical Slope	0.72	%
Velocity	1.63	ft/s
Velocity Head	0.04	ft
Specific Energy	0.37	ft
Froude Number	0.84	
Flow Type	Subcritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
-0+16	-0+13	0.013
-0+13	0+00	0.016

Natural Channel Points

Station (ft)	Elevation (ft)
-0+16	0.33
-0+15	0.00
-0+13	0.17
0+00	0.43

Private Road Capacity - South Half
Rating Table for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - South Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Water Surface Elevation	0.33 ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

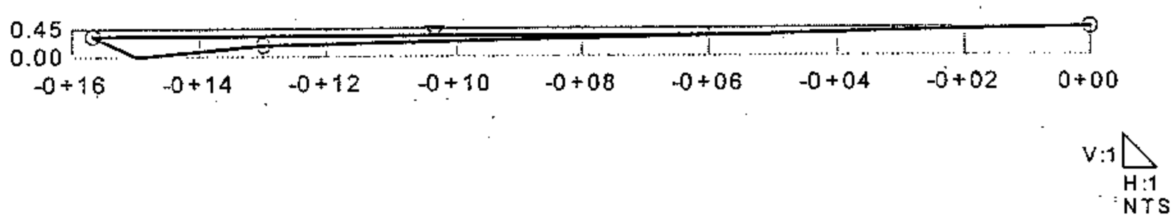
Attribute	Minimum	Maximum	Increment
Slope (%)	0.50	4.00	0.50

Slope (%)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.50	2.02	1.63	1.2	10.76	10.67
1.00	2.86	2.31	1.2	10.76	10.67
1.50	3.51	2.83	1.2	10.76	10.67
2.00	4.05	3.26	1.2	10.76	10.67
2.50	4.53	3.65	1.2	10.76	10.67
3.00	4.96	4.00	1.2	10.76	10.67
3.50	5.35	4.32	1.2	10.76	10.67
4.00	5.72	4.61	1.2	10.76	10.67

Private Road Capacity - South Half
Cross Section for Irregular Channel

Project Description	
Worksheet	Private Road Capacity - South Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.015
Slope	0.50 %
Water Surface Elevation	0.33 ft
Elevation Range	0.00 to 0.43
Discharge	2.02 cfs



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INLET SIZING

LOCATION: CITY OF AURORA **FINAL** **BY:** RWL **DATE:** 10/27/2004

Contributing Basin(s)	Design Point	Q2 (cfs)	Q100 (cfs)	h feet	H feet	H/h	Q/L (Figure 4)	Reduction Factor	Q/L, allowable (cfs/ft)	L	Inlet Size & Type	Carryover (cfs)	Comments
A1A & A1B	1	--	3.9	0.50	1.00	2.00	2.50	0.80	2.00	1.9	5' Type R	0.0	Carryover to DP2
A2	2	--	1.6	0.50	1.00	2.00	2.50	0.80	2.00	0.8	5' Type R	0.0	100yr flows are collected
B1	4	1.8	--	0.50	0.75	1.50	1.75	0.80	1.40	1.3	5' Type R	0.0	100yr flows are collected

RIPRAP SIZING

From "Design of Low Tailwater Riprap Basins for Storm Sewer Pipe Outlets", UDFCD 1996

18" Outfall into WQ Pond From Target Low Point

D = 1.5 ft (pipe diam.)

From Stormcadd results:

Q_{100} = 6.70 cfs

V = 3.79 fps

d = 1.29 ft (full flow)

From UDFCD:

$P_d = (V^2 + gd)^{1/2}$

P_d = 7.48

From Figure 4* : Use Type M Riprap - D_{50}= 12 in.

*Note: Use min. Type M riprap

Thickness (T) = 1.75 x D_{50}

T = 21 inches

Find Basin Length and Width:

L = 6 ft

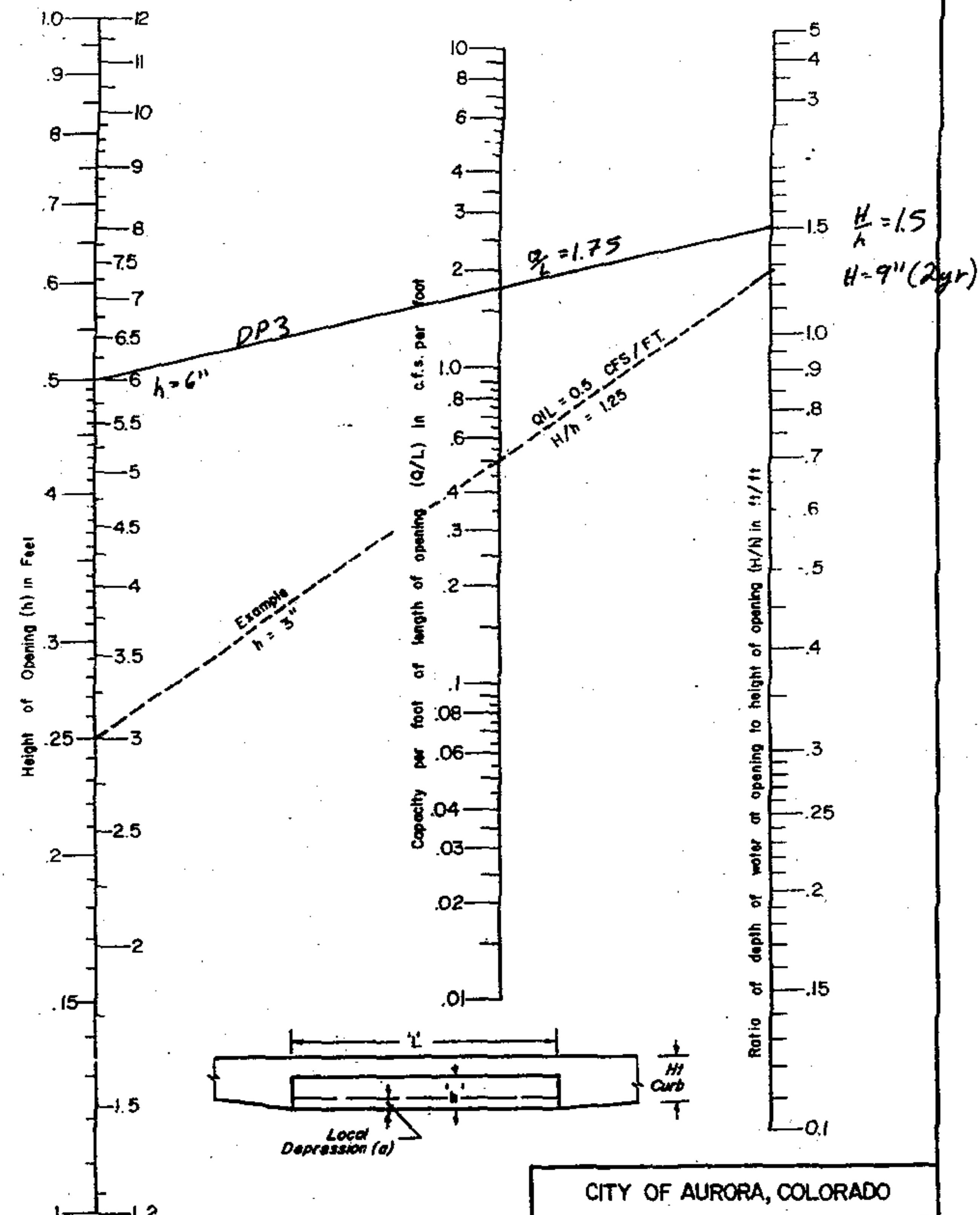
W = 6 ft

Find Concrete Cutoff Wall Depth:

B = 30 inches

APPENDIX

GRAPHS AND TABLES



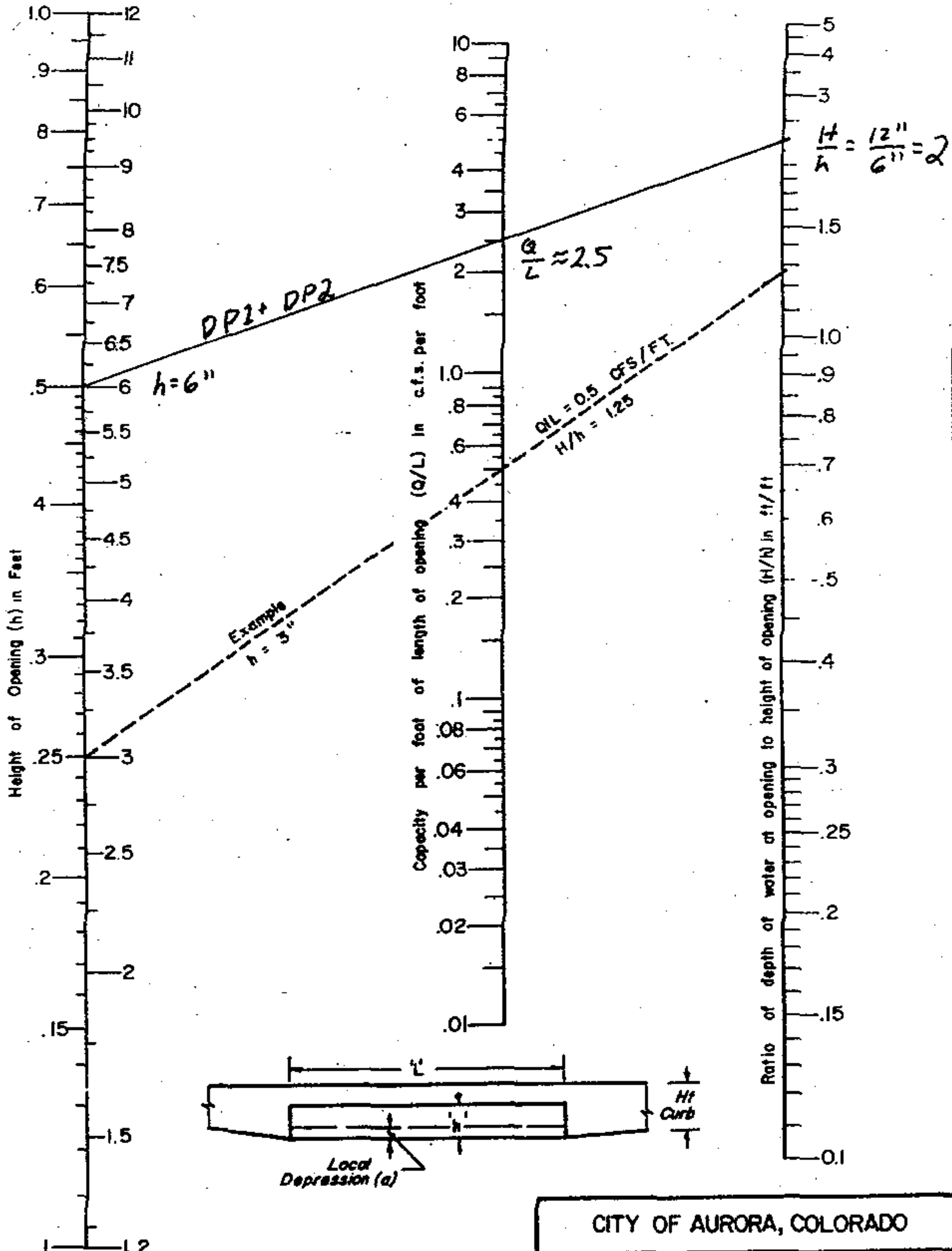
Note: Apply reduction factor to the theoretical capacity determined from nomograph to arrive at the allowable inlet capacity (refer to Section 6.52).

CITY OF AURORA, COLORADO

NOMOGRAPH FOR CAPACITY OF CURB OPENING INLETS AT SUMP

FIGURE 4

Rev. 1/00



<u>Note</u>: Apply reduction factor to the theoretical capacity determined from nomograph to arrive at the allowable inlet capacity (refer to Section 6.52).

CITY OF AURORA, COLORADO		
NOMOGRAPH FOR CAPACITY OF CURB OPENING INLETS AT SUMP		
[illegible]	[illegible]	

Rev. 1/00

FIGURE 4

TABLE 1
RUNOFF COEFFICIENTS AND PERCENTS IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
Business:					
Commercial Areas	95	.87	.87	.88	.89
Neighborhood Areas	85	.60	.65	.70	.80
Residential:					
Single-Family (**)	(*)	.40	.45	.50	.60
Multi-Unit (detached)	60	.45	.50	.60	.70
Multi-Unit (attached)	75	.60	.65	.70	.80
1/2 Acre Lot or Larger	(*)	.30	.35	.40	.60
Apartments	80	.65	.70	.70	.80
Industrial:					
Light Areas	80	.71	.72	.76	.82
Heavy Areas	90	.80	.80	.85	.90
Parks, Cemeteries	5	.10	.10	.35	.60
Playgrounds	10	.15	.25	.35	.65
Schools	50	.45	.50	.60	.70
Railroad Yard Areas	15	.40	.45	.50	.60
Undeveloped Areas:					
Historic Flow Analysis, Greenbelts, Agricultural	2	(See "Lawns")			
Off-Site Flow Analysis (when land use not defined)	45	.43	.47	.55	.65

TABLE 1 (continued)

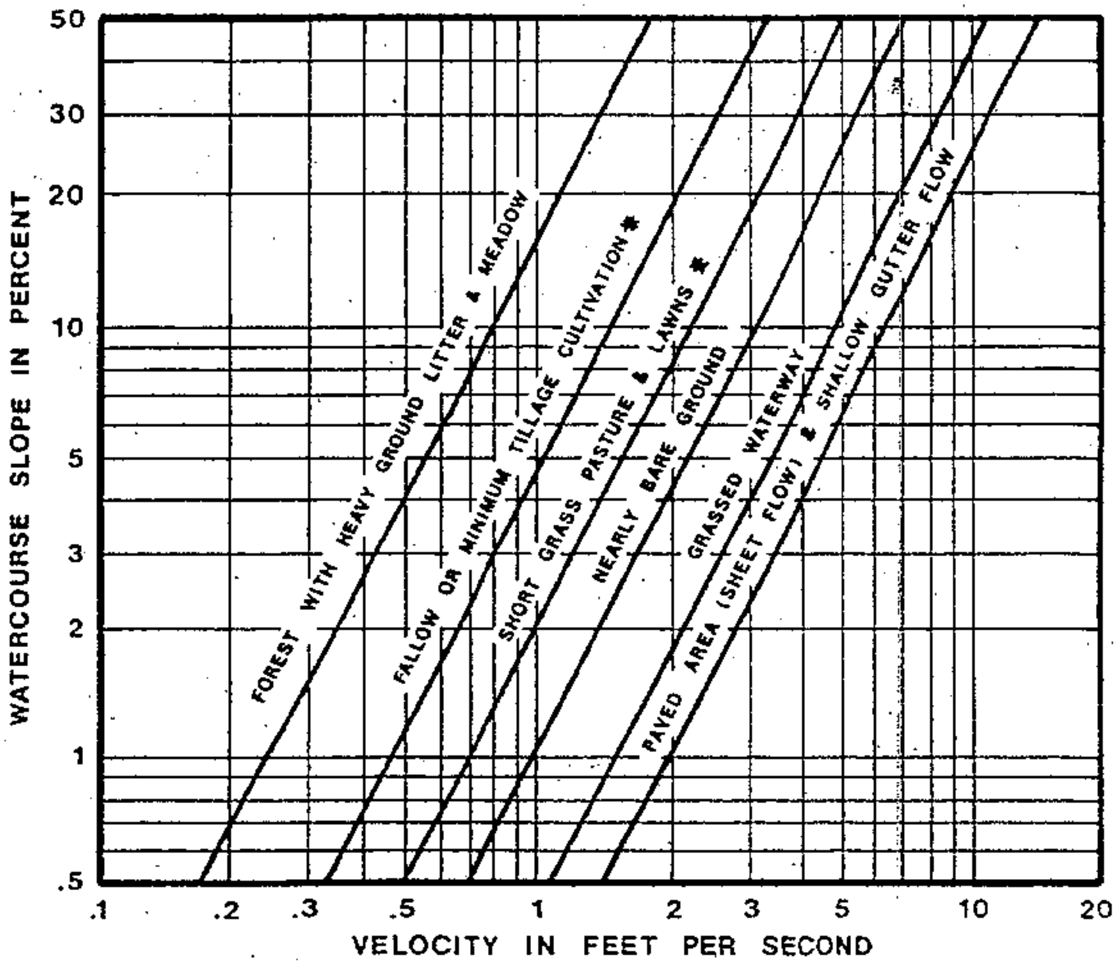
RUNOFF COEFFICIENTS AND PERCENTS IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
Streets:					
Paved	100	.87	.88	.90	.93
Gravel	40	.15	.25	.35	.65
Concrete Drive and Walks	96	.87	.87	.88	.89
Roofs	90	.80	.85	.90	.90
Lawns, Sandy Soil:	2				
2% Slope		.05	.06	.08	.10
2-7% Slope		.10	.11	.13	.15
>7% Slope		.15	.16	.18	.20
Lawns, Clay Soil:	5				
2% Slope		.13	.14	.15	.17
2-7% Slope		.18	.19	.20	.22
>7% Slope		.25	.27	.30	.35

NOTE: These Rational Formula coefficients may not be valid for large basins

(*)See Figures *RO-3 through RO-5* of USDCM Volume 1 for percent impervious.

(**)Up to 5 units per acre. Single-family with more than 5 units per acre, use values for multi-unit/detached.

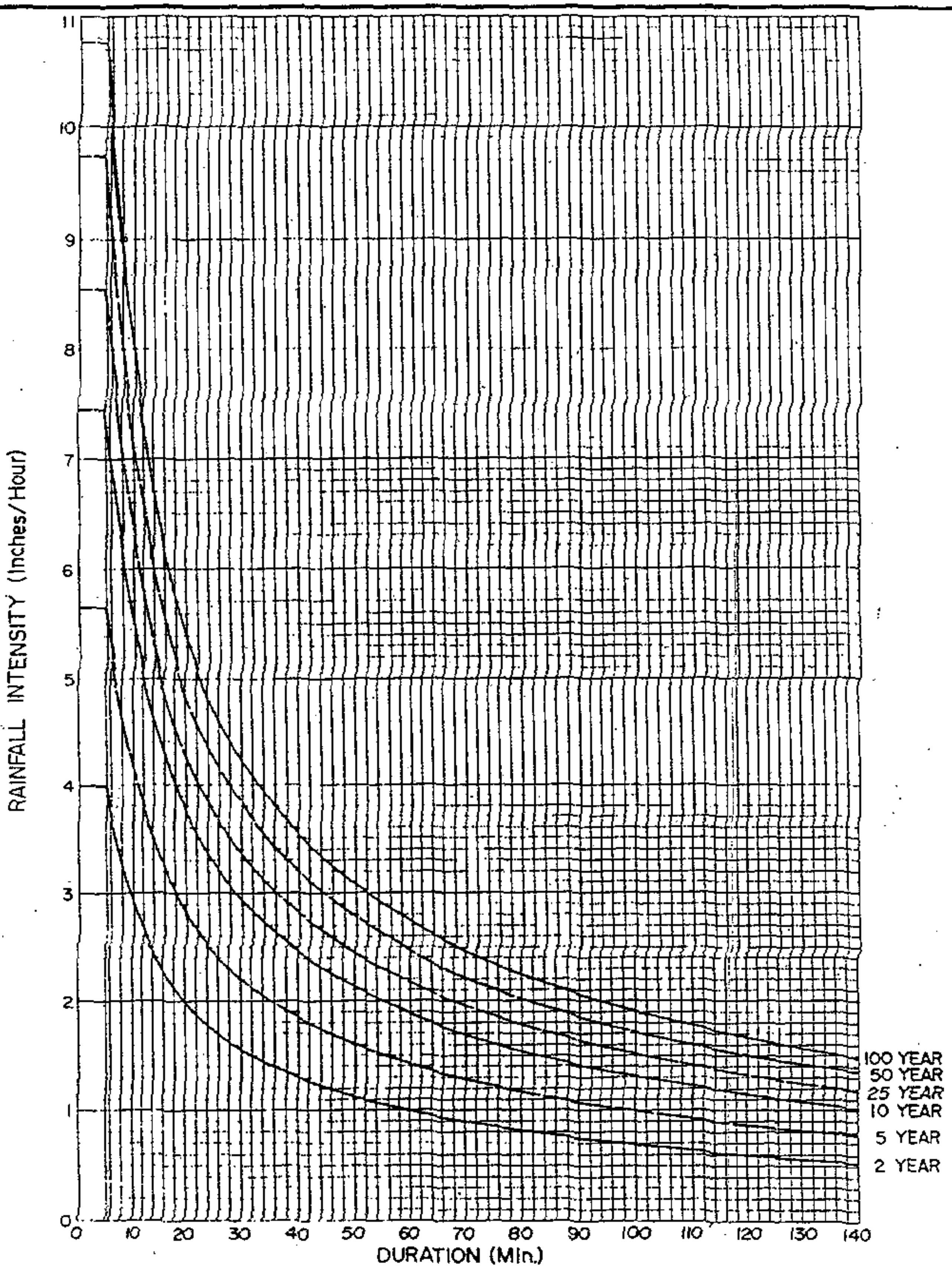


ESTIMATE OF AVERAGE FLOW VELOCITY FOR USE WITH THE RATIONAL FORMULA.

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

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

FIGURE 1



CITY OF AURORA, COLORADO	INTENSITY-DURATION-FREQUENCY CURVES
M. Hopewell, Drawn By	SOUTH OF E. ALAMEDA AVE.
City Engineer; 6/16/72 Date	0-140 MIN.
	SHEET 2 OF 2

FIGURE 3