Technical Memorandum

Date:	Friday, May 06, 2016
Project:	Stormwater Master Plan Update
To:	City of Cedar Rapids
From:	Mike Butterfield/HDR, David Dechant/HDR
Subject:	TM 1.0 Existing Stormwater System

This technical memorandum presents information on the Existing Stormwater System. The information within this document provides a history of flooding in the city of Cedar Rapids, Iowa; identifies urban watersheds; describes current stormwater system assets; documents current operations and maintenance; summarizes flood control; and identifies considerations from prior studies. The intent of this document is to provide relevant information to build upon in preparing a Stormwater Master Plan.

It is organized as follows:

- Objective
- Summary
- Background
- Watersheds
    - West Side Watersheds
    - East Side Watersheds
- Current Assets
    - Stormwater Conveyance System
    - Detention Basins
    - Wetlands
    - Flood Mitigation Berms and Levees
    - Open Channels and Ditches
- Operations and Maintenance
- Flood Control
- Prior Studies
- Attachment A National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer (MS4) Permit
- Attachment B Prior Studies
- Attachment C Known Problem Areas
- Attachment D Hydrologic Cycle
- Attachment E Watershed and Sub Watershed Maps

Objective

The objective of this Technical Memorandum 1.0, Existing Stormwater System, is to provide an overall understanding of storm drainage systems, characteristics, and facilities within Cedar Rapids. This information will be used to facilitate the development of the City of Cedar Rapids' (the City's) upcoming Stormwater Master Plan.

Summary

Cedar Rapids has experienced considerable flooding due to both regional flooding on the Cedar River and localized flooding on urban tributaries and drainageways. Continued growth in Cedar Rapids, in spite of considerable flood damage, is a reflection of the City's resiliency.

The City's comprehensive plan, EnvisionCR, identifies the City's vision for the future. This vision for the future includes growth forecasts, future land use plans, a cursory review of infrastructure suitability in growth areas, and several specific stormwater-related initiatives. EnvisionCR divided Cedar Rapids into eight watersheds associated with the Cedar River and major tributary creeks to the Cedar River (see Figure 5). For purposes of preparing the Stormwater Master Plan, this document divides the watersheds into 13 west side and 10 east side sub watersheds (Figure 6). One west side sub watershed is tributary to the Iowa River. The remainder of the west side sub watersheds and all of the east side sub watersheds are tributary to the Cedar River. Varying degrees of flooding, including some severe events, have occurred in the watersheds.

The City's stormwater system comprises multiple assets, including more than 500 miles of conveyance structures; nearly 800 detention basins; 3 constructed wetlands; 127 miles of open channels and ditches; and flood mitigation berms and levees. The stormwater system is intended to:

1. Protect against regularly recurring damage; reduce street maintenance costs; provide an orderly urban drainage system; and provide public conveyance from the runoff associated with a minor storm event (that is, an event with a return interval of 5 years or less)
2. Prevent major property damage or loss of life from the runoff associated with a major storm event (that is, an event with a return interval of 100 years or less).

The Sewer Maintenance Division of the City's Public Works Department operates and maintains the City's stormwater system and has drafted procedures for routine operations and maintenance activities. The procedures include inspections, minor repairs, mowing, street sweeping, and educational outreach. The procedures also include reactive responses to the public, cleaning and clearing, and minor repairs.

Given a history of both Cedar River and localized tributary flooding, the City has implemented a number measures to mitigate flood damage. These mitigation measures include construction of permanent berms and floodwalls and a Flood Response Plan that outlines specific tasks to be performed at specific stages (that is, water surface levels) of the Cedar River. The Flood

Response Plan has evolved with experience over the years to include tasks such as closing flood gates, plugging storm sewers, installing portable pumps, closing roads, placing sand bags, shutting down traffic signals, evacuating neighborhoods, and installing temporary barriers. The Flood Control System Master Plan will implement permanent flood protection systems over the next 20 years.

Previous stormwater master plans and studies provide relevant insight with respect to historical, current, and future challenges and needs. Most notably, a 1998 Stormwater Master Plan for the Cedar Rapids Metropolitan Area prepared by Camp Dresser McKee and the recent EnvisionCR prepared by RDG Planning and Design. These documents provide a baseline for drainage issues, recommended improvements, and a number of policy and planning topics relative to this Stormwater Master Plan.

Background

Cedar Rapids encompasses an area of more than 72 square miles in Linn County, Iowa. In recent years, Cedar Rapids has seen steady growth despite sustaining an historic flood in June 2008, which flooded 10,000 properties (see Figure 1). The population has increased from 110,243 in 1980; to 108,772 in 1990; to 120,758 in 2000; to 126,326 in 2010. This population increase has resulted in increased demand for new development; changes in the landscape have led to increases of some runoff volumes.

As a river city, Cedar Rapids has sustained considerable flooding on the Cedar River as summarized in Figure 2. Most recently, the Cedar River has flooded in 1993, 1998, 2004, 2008, 2013, and 2014. Depending on precipitation, local creek flooding has also been a problem in the Vinton Drainageway along E Avenue NW, on Meth-Wick Creek along O Avenue NW, on Indian Creek, and Prairie Creek. The most notable years for localized flooding included 1971, 1993, 2002, 2008, and 2014.

Figure 1 – Flooded Downtown in 2008

Flood Categories (in feet)

Major Flood Stage:	16
Moderate Flood Stage:	14
Flood Stage:	12
Action Stage:	10

Historic Crests

(1) 31.12 ft on 06/13/2008
(2) 20.00 ft on 06/01/1851
(3) 20.00 ft on 03/18/1929
(4) 19.66 ft on 03/31/1961
(5) 19.27 ft on 04/04/1993
(6) 18.60 ft on 04/04/1933
(7) 18.51 ft on 04/10/1965
(8) 18.31 ft on 07/25/1999
(9) 18.30 ft on 05/27/2004
(10) 18.23 ft on 06/02/2013

Recent Crests

(1) 16.52 ft on 07/04/2014 **(P)**
(2) 17.34 ft on 06/25/2014 **(P)**
(3) 15.00 ft on 06/28/2013
(4) 18.23 ft on 06/02/2013
(5) 13.82 ft on 05/25/2013
(6) 11.46 ft on 03/28/2011
(7) 15.06 ft on 03/17/2010
(8) 12.17 ft on 08/28/2009
(9) 31.12 ft on 06/13/2008
(10) 14.12 ft on 03/17/2008

Figure 2 – Cedar River Flooding

Watersheds

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds come in all shapes and sizes; they cross county, state, and national boundaries. Often, watersheds are named to provide a common convention for identifying them by the name of the associated water body; they are also designated based on the size of area, which is called a hydrologic unit.

The United States is divided and subdivided into successively smaller hydrologic units, which are classified into four levels: regions, sub regions, accounting units, and cataloging units.

- The first level of classification divides the United States into 21 major geographic areas, or *regions*. These geographic areas contain either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers, such as the Texas-Gulf region, which includes a number of rivers draining into the Gulf of Mexico. Eighteen of the regions occupy the land area of the conterminous United States.
- The second level of classification divides the 21 regions into 221 sub regions. A sub region includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin(s), or a group of streams forming a coastal drainage area.
- The third level of classification subdivides many of the sub regions into accounting units. These 378 accounting units are nested within or can be equivalent in size to the sub regions.
- The fourth level of classification is the *cataloging unit*, the smallest element in the hierarchy of hydrologic units. A cataloging unit is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. These units subdivide the sub regions and accounting units into smaller areas.

Figure 3 – Map of Iowa Watersheds

There are 2,264 cataloging units in the United States. Cataloging units are more commonly referred to as watersheds. Figure 3 shows watersheds in the state of Iowa.

Hydrologic units are arranged or nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

Figure 4 – Map of Cedar Rapids Hydrologic Units

As shown in Figure 4, Cedar Rapids is located in 3 Hydrologic Units.

- 07080205 Middle Cedar; state(s): Iowa
- 07080206 Lower Cedar; state(s): Iowa
- 07080208 Middle Iowa; state(s): Iowa

Furthermore, as shown in Figure 5, EnvisionCR subdivides Cedar Rapids into the following watersheds:

- Morgan Creek
- Prairie Creek
- Hoosier Creek
- Indian Creek
- Indian Creek – Dry Creek
- East Otter Creek
- Silver Creek – Cedar River
- Pleasant Run – Cedar River

For the purpose of preparing the Stormwater Master Plan, the delineation of naming will be by the water feature, such as a drainageway name (for example, creek or stream) where possible. However, the naming of smaller areas by its water feature may not be sufficient. For smaller areas, or sub watersheds, the naming will be based on a historical identification (prior township name or person) or road as shown in Table 1.

Table 1 – Watershed Naming

Reason	Naming
Water flow name	Indian Creek, Prairie Creek, Hoosier Creek, Otter Creek, Morgan Creek, McLoud Run, Dry Creek, Squaw Creek, Silver Creek, Cedar River, Pleasant Creek
Historical identification	Czech Village, Ushers Ferry, Downtown, Kenwood
Road	O Avenue (O Avenue NW), E Avenue (E Avenue NW), Rockford Road

All but one of Cedar Rapids' sub watersheds are tributary to, or flow into, the Cedar River. The one exception is Hoosier Creek, which covers the areas to the north and south of Wright Brothers Boulevard SW; Hoosier Creek is tributary to the Iowa River. Attachment E includes detailed maps of the watersheds and sub watersheds described below.

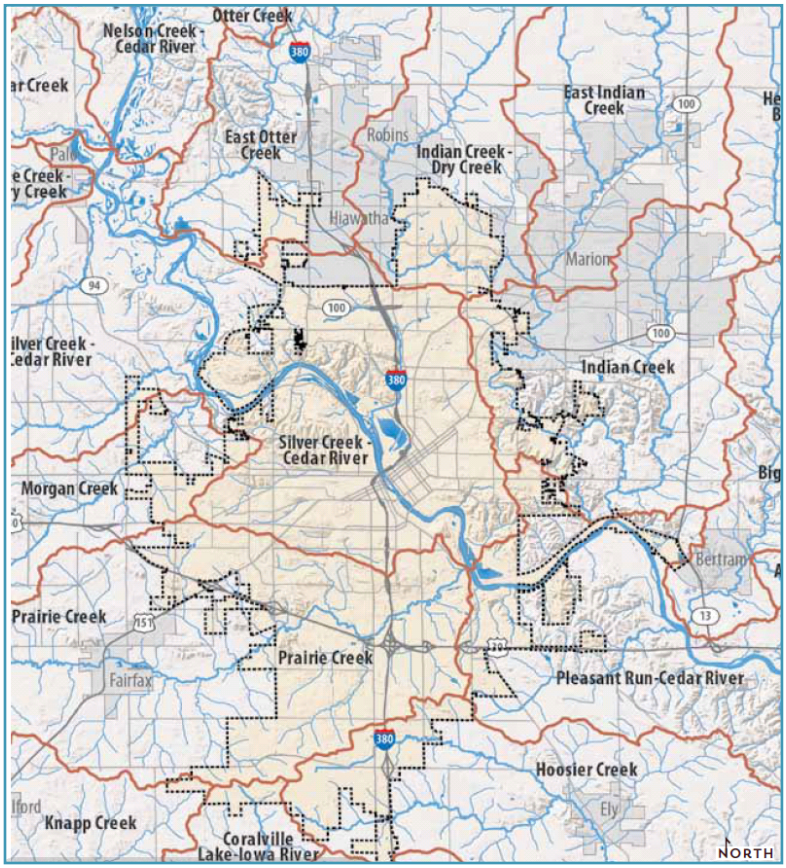


Figure 5 – Cedar Rapids Watersheds from Envision CR

West Side Watersheds

The west side of the Cedar River includes the sub watersheds identified in Table 2 and shown in Figure 6. Each is discussed below.

MORGAN CREEK WATERSHED

The Morgan Creek watershed is located on the edge of northwest Cedar Rapids (see Appendix E, Exhibit 5). It has a 35,000-foot reach, starting in Benton County, Iowa, and terminating at the Cedar River. It drains an area of approximately 19 square miles, two-thirds of which is in Linn County and the remainder in Benton County.

The United States Geological Survey (USGS) performed a survey in May 1970. The survey found that Morgan Creek's flow varied between 7,000 cubic feet per second (cfs) at the county line to 12,000 cfs at the mouth of the creek, which has an elevation of 744.0 feet. The maximum floodway of the creek is 200 to 300 feet. The flood risk is minimal and most of the land surrounding the creek is categorized as agriculture use. No properties within the city limits of Cedar Rapids have been threatened by its flows in the period of 2003 to 2015. The extension of Iowa Highway 100 will go through this sub watershed and may require future evaluation of flood risks.

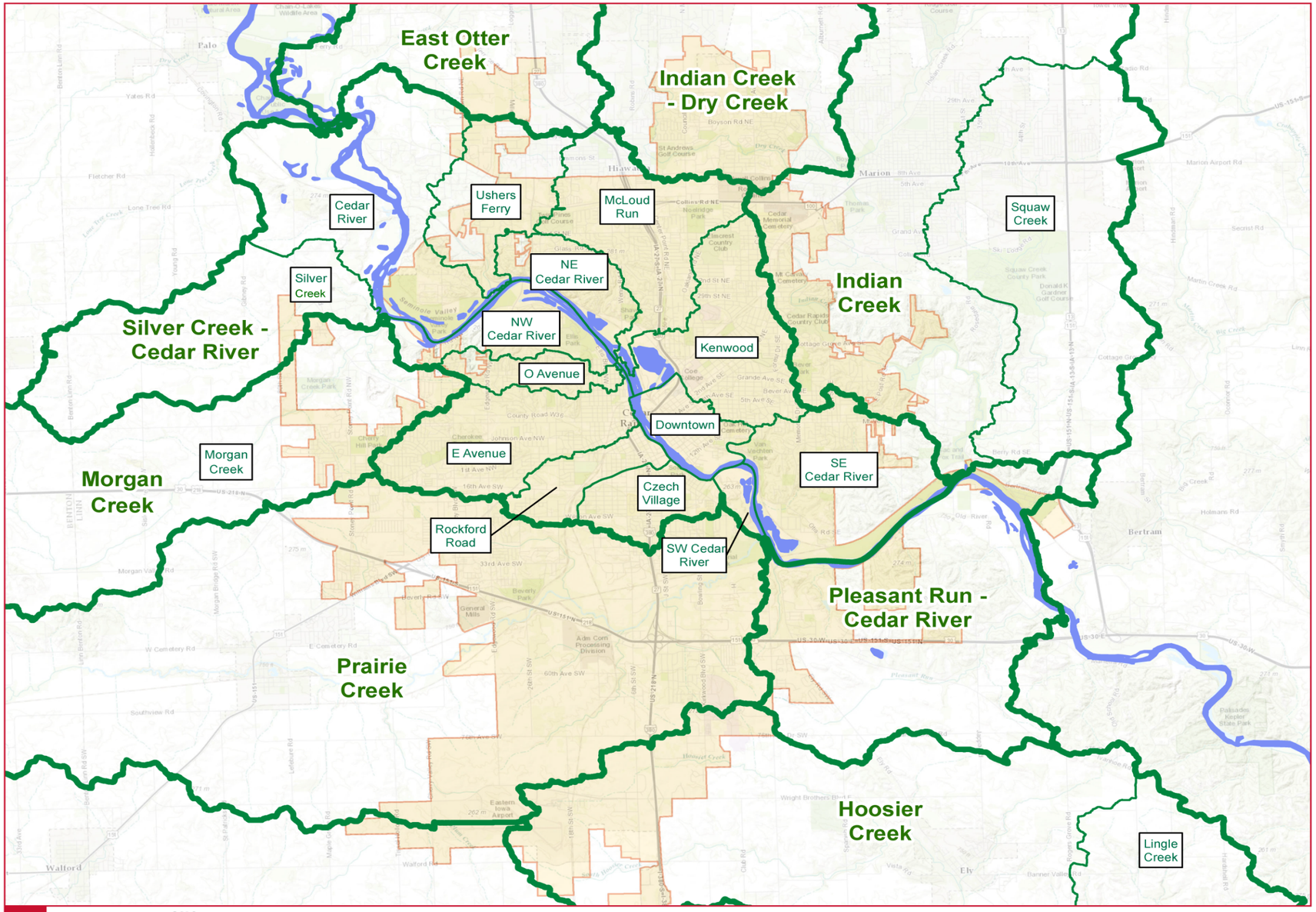
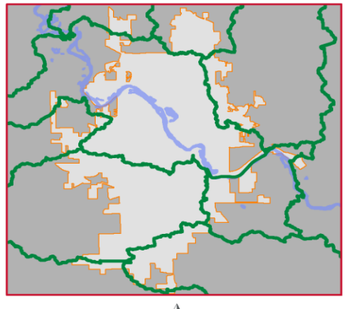


FIGURE 6
WATERSHED AND
SUB WATERSHED MAP

City Boundary
Cedar River
Watershed
Sub Watershed



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DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

CITY OF CEDAR RAPIDS
STORMWATER MASTER PLAN

PATH: Z:\PROJECTS\258297-CR_STROMWATER_MASTER_PLAN\MAP_DOCS\MXD\CR_TM1_FIG_6_11X17_WATERSHED_OVERVIEW.MXD - USER: WWHEELER - DATE: 5/6/2016

Table 2 – West Side Watersheds						
Watershed	**Sub Watershed[1]**	**Section of City**	**Receiving Water**	**Acres**	**Acres in City**	**% in City**
Morgan Creek	Morgan Creek (5)	NW	Morgan Creek	12,152	1,294	11%
Prairie Creek	Prairie Creek (9)	SW	Prairie Creek	35,471	12,795	36%
Hoosier Creek	Hoosier Creek (10)	SW	Hoosier Creek	16,927	3,211	19%
	Lingle Creek (24)	SW	Hoosier Creek	5,379	-	0%
Silver Creek - Cedar River	Cedar River (2)	NW	Cedar River	5,597	985	18%
	Silver Creek (22)	SW	Cedar River	5,177	175	3%
	NW Cedar River (3)	NW	Cedar River	1,508	1,202	80%
	O Avenue (4)	NW	Cedar River	808	735	91%
	E Avenue (6)	NW, SW	Cedar River	2,919	2,919	100%
	Rockford Rd (7)	SW	Cedar River	994	994	100%
	Czech Village (8)	SW	Cedar River	1,158	1,158	100%
	SW Cedar River (23)	SW	Cedar River	307	307	100%
Pleasant Run – Cedar River	Pleasant Run (11)	SW	Cedar River	9,622	2,252	23%

Note: [1.] The number in parentheses corresponds to the exhibit numbers in Appendix E.

PRAIRIE CREEK WATERSHED

The Prairie Creek watershed is located in the southwestern area of Cedar Rapids (see Appendix E, Exhibit 9). It runs west to east north of U.S. Highway 30. The creek starts west of Keystone, Iowa, and has its mouth flow into the Cedar River by the Tate Cummings Baseball complex on C Street SW. It is more than 23 miles long and has a drainage area of 214 square miles. The land use is mostly farms to the west of Cedar Rapids with township flows from Keystone, Blairstown, Iowa, Watkins, Iowa, Norway, Iowa, and Fairfax, Iowa. In Cedar Rapids, it has significant flows from commercial properties, farms, open space, and a golf course.

Prairie Creek was studied in February 1966 by the United States Army Corps of Engineers (USACE). The maximum floodway along the path varies up to 700 feet at some spots. It typically floods at least once per year over J Street SW in the 3900 block. It threatens to flood and has flooded structures near it during the 2008 Cedar River Flood at 6th Street and J Street SW. In 2008, 6th Street SW was over topped by Prairie Creek. A bridge and roadway improvement was designed to prevent a reoccurrence on 6th Street SW. Flooding of the Jones Park Golf Course in 2004, 2008, and 2014, caused extensive damages. In 2014, a bridge sensor was added west of Cedar Rapids to enhance flood response warning. Because of its large urban watershed, flooding of Prairie Creek may be caused by snow pack and rain events that occur outside of Cedar Rapids. The 2008 flooding was a result of both heavy rains to the west of Cedar Rapids and the backflow from the Cedar River.

HOOSIER CREEK WATERSHED

The Hoosier Creek watershed is located in the southwest section of Cedar Rapids (see Appendix E, Exhibit 10). There are two sub watersheds in this watershed: the Hoosier Creek sub watershed and the Lingle Creek sub watershed.

Hoosier Creek Sub Watershed

The Hoosier Creek watershed is located in the southwest section of Cedar Rapids (see Appendix E, Exhibit 10). The creek flows west of the Eastern Iowa Airport and has tributaries that are to the north and south of Wright Brothers Boulevard that run the west to the east. It is the only creek or watershed in Cedar Rapids that flows directly into the Iowa River.

USGS performed a survey in May 1970. A total of 11 miles of stream is included in the two reaches. The drainage area of Hoosier Creek is 1.1 square miles near Interstate 380 (I-380) and 17.1 square miles near the city of Ely, Iowa. The drainage of South Hoosier Creek is 2.5 square miles near I-380 and 9.2 miles at the mouth of the creek. The elevation of Hoosier Creek drops from 870 feet in sections of Cedar Rapids to 710 feet at Ely.

The land area near Hoosier Creek includes the Eastern Iowa Airport, some industrial and commercial areas, and farmland in Cedar Rapids, and a few houses in the east portion of Ely. There is minimal risk of flooding to structures in Cedar Rapids and there have not been any road closures due to flooding in the period of 2003 to 2015.

Lingle Creek Sub Watershed

The Lingle Creek sub watershed (Appendix E, Exhibit 24) is a 5,379 acre subwatershed located east of the Hoosier Creek subwatershed. The watershed is largely agricultural. Lingle Creek flows into Hoosier near the upper part of the Coralville Reservoir (Iowa River). The watershed is not located within Cedar Rapids city limits and is not anticipated to affect stormwater management infrastructure within the City.

SILVER CREEK – CEDAR RIVER WATERSHED (WEST SIDE)

There are six sub watersheds within the Silver Creek – Cedar River Watershed on the west side of the river.

Cedar River Sub Watershed

The Cedar River sub watershed is toward the upstream end of the Cedar River within the corporate limits of Cedar Rapids (see Appendix E, Exhibit 2). Drainage within this sub watershed flows directly to the Cedar River via six tributaries. The total area is 8.7 square miles, of which 1.5 square miles are located within the city limits of Cedar Rapids. Land use is predominantly rural and undeveloped land, with storm drain infrastructure limited to two subdivisions in Cedar Rapids.

Silver Creek Sub Watershed

The Silver Creek sub watershed (Appendix E, Exhibit 22) is a 5,177 acre area located at the northwest edge of the City limits. Silver Creek flows through the town of Covington directly into the Cedar River upstream of Cedar Rapids. The watershed is mostly agricultural. Only 175 acres of this watershed intersect city limits. This watershed is not considered a significant aspect of the City's stormwater collection and conveyance system.

NW Cedar River Sub Watershed

The NW Cedar River sub watershed is a collection of several sub watersheds: River Bluff, Robins Lake, and 18th Street NW (see Appendix E, Exhibit 3). The total area is approximately

1,253 acres; drainage flows into the Cedar River. Land use is primarily composed of a golf course and other undeveloped land.

- The River Bluff sub watershed drainage area is approximately 11 acres and nearly all of it is being developed into appartments or condos. The River Bluff sub watershed flows northwest into the Cedar River. The water flows have not threatened structures but have resulted in mud slides, heavy errosion, and overtopping Ellis Road NW with debris when the storm sewer becomes blocked with debris.
- The Robins Lake sub watershed drainage area is approximately 246 acres east of Edgewood Road. Over the last decade, the land is now nearly fully developed into residential and the western third of the Ellis Golf Course. The threat of flooding to structures includes the west side of Sugar Creek Drive NW and the east ends of Ellis View Court, Paulyn Court, and Shawn Court NW. The sediment from the flow into Robins Lake has caused changes to the depth in the western end of the lake and there are reported potential water quality issues. Drainage in this sub watershed directly impacts the water quality of Robin Lake and poses a risk for the surface water flooding of the structures on the courts to the east of 26th Street NW.
- The 18th Street NW sub watershed drainage area is approximately 38 acres. It collects drainage off of Ellis Golf Course that then flows north through Meiers Court NW, down a gulley, and through a culvert into the eastern end of Robins Lake. The flow threatens the structures on the western end of Meiers Court and overtops Meiers Court NW during peak rain events.

O Avenue Sub Watershed

The O Avenue sub watershed is located in northwest Cedar Rapids along the path of O Avenue (see Appendix E, Exhibit 4). It starts to the west of Edgewood Road and then flows east. Most of the flow goes underground into a box culvert just north of Harrison Elementary School on 11th Street NW. The culvert starts as an 8-foot-by-4.3-foot box that then becomes an 11-foot-by-5-foot box at 5th Street until its outlet into the Cedar River. The water shed is approximately 808 acres. It is mostly developed as residential properties and a senior living center except for an area west of Edgewood Road NW.

The drainageway has a history of flooding. In peak events High Drive NW has been overtopped. In 1993, 1998, and 2014, 11th Street NW near the school has been overtopped and the residential area flooded. Areas to the east along the river have been flooded but that is a result of backflow from the Cedar River through the storm piping or lack of a storm pump station to handle precipitation during high river events. A 1983 study by Shive-Hattery & Associates and 1998 Stormwater Master Plan recommended either expansion of drainage capacity or enlargement of detention facilities. The studies provided the most cost efficient method would be the expansion of the drainage facility. This has not been done as of 2014.

E Avenue Sub Watershed

The E Avenue sub watershed is located mostly in the northwest section of Cedar Rapids (see Appendix E, Exhibit 6). It starts west of Jacolyn Park in the Cedar Hills area and runs from west to east. There are two arterial drainageways in the E Avenue watershed: Vinton Ditch to the north and an unnamed tributary to the south. Vinton Ditch has a length of approximately 2.6 miles before it enters into a pipe at 15th Street NW. The unnamed tributary to the south is approximately 1 mile long and flows underground at 18th Street NW and Johnson Avenue.

The E Avenue sub watershed has a drainage area of 2,919 acres. There are 2.7 square miles of drainage area upstream from the start of an underground conveyance at 15th Street NW. The land use of the area is fully developed into residential with minor commercial contribution. The waterway has a history of flooding houses in the area of 1500 to 3300 blocks of E Avenue NW; this has happened in 1971, 1993, 1998, 2008, and 2014. It has an established 100-year floodplain where the City recommends that residents buy flood insurance.

Rockford Road Sub Watershed

The Rockford Road sub watershed is in the southwest side of Cedar Rapids just south of 1st Avenue (see Appendix E, Exhibit 7). It flows from west to east starting in the area of Jefferson High School and Wilson Avenue SW. Originally, the Rockford Road sub watershed was located on 3rd Avenue SW in a brick structure with an approximate 72-inch diameter. During construction of I-380, the Rockford Road sub watershed was moved to 4th Avenue and reconstructed into a 6.5-foot-by-8-foot box outlet. It has an area of 994 acres that includes 12 acres from I-380. There is a history of flooding on Rockford Road SW as recent as the June 2014 flash flood event. The area is nearly all residential except for large impervious areas from Jefferson High School and sports stadiums in the area. The storm pipes start with a 36-inch pipe at 5th Avenue and the railroad tracks. The sub watershed was not addressed in the 1998 Stormwater Master plan; it has minimal reports of street ponding except in events such as the June 2014 storm.

Czech Village Sub Watershed

The Czech Village sub watershed is located in the southwest side of Cedar Rapids (see Appendix E, Exhibit 8). It is bounded on the south by Wilson Avenue SW and the Cedar River and the Czech National Cemetery on the east. There are two outfalls into the Cedar River; one with a drainage area of 578 acres that drains into the river via an 84-inch pipe in the 2100 block of A Street SW, the other with a drainage area of 580 acres that drains into the river via parallel 72-inch and 84-inch storm sewers just south of the 12th Avenue bridge.

The flow pattern for the outfall near the 12th Avenue bridge starts in Young's Hill, flows north and then flows east just south of the rail road track on the north side of the City Services Center. A 42-inch storm sewer and open channel drain to a 72- to 84-inch storm sewer that runs next to the City Services Center. The 84-inch storm sewer continues under I-380 and connects to the parallel outfall sewers. The existing sewer from L Street to C Street SW is a brick construction from 1887 with a diameter equivalent to 84 inches. From C Street SW is an 84-inch diameter reinforced concrete pipe.

Land use in the sub watershed is mostly residential but does include a cemetery, commercial activity on 6th Street SW, the City Services Center, and the west edge of the Linn County Cedar Rapids Solid Waste Agency Site 1 landfill (closed) and compost facility.

In general, the threat of flooding to the area is not from a creek or flash rain events, but from the Cedar River. Heavy rains cause minor street and yard ponding that last roughly 30 to 100 minutes. Overtopping in the lower areas of Cedar River where the crests are greater than 15 feet has resulted in significant flooding in 1961, 1965, and 2008. Some areas have 1 to 2 feet of ponding behind the river flood protection that is mitigated by pumping. The area drainage will be part of the west side levee model designs.

There are two detention basins in the sub watershed located near Wilson Avenue that control 121 acres. The area near the City Services Center has flooded in 1993, 1998, 2008, and 2014. The reason for the flooding in the area is the lack of capacity or inadequate detention, except for the flood in 2008.

The 1998 Stormwater Master Plan recommended adding a 48-acre-foot detention facility to the west of the former Public Works facility as the least costly solution; it has not been constructed.

SW Cedar River Sub Watershed

The SW Cedar River sub watershed (Appendix E, Exhibit 23) is an area west of the Cedar River including the Linn County Solid Waste Agency Landfill and the adjacent areas. This area, which is approximately 307 acres, does not contain a major stormwater collection system. Local rainfall either flows overland to the Cedar River or is conveyed there by a local storm sewer or culvert.

PLEASANT RUN WATERSHED

The Pleasant Run watershed (Appendix E, Exhibit 11) describes the 9,622 acres (mostly rural) that contribute to the Cedar River via Pleasant run or a series of smaller tributaries. The headwaters of the watershed are located along southern edge of the Cedar RapidsCity limits, east of I-380. The watershed intersects the City boundary, but flows south and east of the City. Therefore, the Pleasant Run watershed does not constitute a significant feature in the City's stormwater management and collection system. However, runoff from the city would impact conditions downstream.

East Side Watersheds

The east side of the Cedar River includes the watersheds identified in Table 3 and shown in Figure 6. Each is discussed below.

Table 3 – East Side Watersheds

Watershed	Sub Watershed[1]	Section of City	Receiving Water	Acres	Acres in City	% in City
East Otter Creek	E Otter Creek (12)	NE	Otter Creek	25,699	610	2%
Indian Creek	Indian Creek (20)	SE, NE	Indian Creek	30,695	2,471	8%
	Squaw Creek (21)	NE	Indian Creek	9,252	-	0%
Indian Creek - Dry Creek	Dry Creek (16)	NE	Indian Creek	20,139	2,509	12%
Silver Creek - Cedar River	Usher Ferry (13)	NE	Cedar River	2,233	1,207	54%
	NE Cedar River (14)	NE	Cedar River	1,508	1,202	80%
	McLoud Run (15)	NE	Cedar River	3,249	2,811	87%
	Kenwood (17)	SE, NE	Cedar River	3,019	3,019	100%
	Downtown (18)	SE	Cedar River	1,005	1,005	100%
	SE Cedar River (19)	SE	Cedar River	3,626	2,480	68%

Note: [1.] The number in parentheses corresponds to the exhibit numbers in Appendix E.

EAST OTTER CREEK WATERSHED

The East Otter Creek sub watershed is located on the western edge of northeastern Cedar Rapids to the west of Miller Road NE (see Appendix E, Exhibit 12). It includes a drainage area of 40.2 square miles at the mouth into the Cedar River. The land is nearly all agriculture with some newer residential areas moving westward from Miller Road NE. As of 2014, no current drainage issues have been noted, but nitrates from farm land are of concern for Cedar Rapids. The Otter Creek HUC 12 watershed includes West Otter Creek with 28.7 square miles of drainage area that flows into the Cedar River.

INDIAN CREEK WATERSHED

The Indian Creek watershed is located on the east side of Cedar Rapids. It starts in the northern part of Linn County and runs north to south. Its drainage area has three major tributaries: Squaw Creek, Indian Creek, and Dry Creek (see Table 4). Over the last 50 years, it is the most studied watershed in the area other than the Cedar River. The area has studies starting in 1964 and includes a complete hydrologic study by USACE in 2013.

Table 4 – Indian Creek Sub Watersheds

Area	Drainage Area (square miles)	Entry Point to the Creek
East Indian Creek	8.4	Origin east of Alburnett
Dry Creek	27.4	11.3 miles
Squaw Creek	14.5	1.2
Total Watershed	87.5	Mouth to Cedar River is southeast of intersection of Otis Road and Bertram Road SE near the Nature Center

Indian Creek Sub Watershed

The Indian Creek sub watershed is nearly all farmland before reaching Marion, Iowa (see Appendix E, Exhibit 20). From the city limits of Marion to where Dry Creek joins the sub watershed at Thomas Park, it is all residential or park land.

Indian Creek has flooded in 1993, 1998, 2002, 2004, 2008, 2010, 2013, and 2014. The largest flood was in September 2002 when a peak rain event (estimated to be greater than a 500 year return frequency event) occurred in the northern portion of the sub watershed. There are two areas of Cedar Rapids that are threatened by flooding from the creek: 1) 30th Street Drive and Sidney Street SE on the west side of the creek and 30th Street Drive SE on the east side of the creek just north of the 29th Street Drive SE bridge; and 2) through Cottage Grove Avenue SE and into the Sun Valley development at Sunland Drive and Cottage Grove Parkway SE.

Damages on the creek have been in excess of one million dollars. Through hazard flood mitigation in Marion, the threat of flooding to most private property has been eliminated by removing residential structures. There is still a threat of flooding to the Linn Mar High School and Indian Creek Elementary School in Marion.

Public infrastructure in Thomas Park and trails along Dry Creek and Indian Creek are threatened or damaged by flooding on an annual basis. The City closed a swimming pool in Thomas Park more than 20 years ago and is considering moving parts of the trail to reduce future damages from flooding.

For Cedar Rapids, flooding of the creek has threatened or damaged both private and public infrastructure. Of the 87.5 square miles of the Indian Creek sub watershed, 72 square miles are upstream of Cedar Rapids; approximately 12 percent of the watershed is within the corporate limits of Cedar Rapids. Private property in the areas of Sidney and 30th Street Drive SE and Sun Valley were extensively damaged due to flooding of the Indian Creek sub watershed in 2002 and 2008.

Public infrastructure has been less damaged by flooding than private property. A sanitary sewer line in the floodplain received significant inflow and infiltration along Cottage Grove Parkway, which necessitated bypass pumping to minimize basement backups. A cure-in-place lining of the piping was completed in 2006; the need for bypass pumping has since been significantly reduced. The Sac & Fox Trail along Indian Creek to the east of the East Post Road SE bridge has sustained damaged from flooding multiple times throughout the years. While part of the Indian Creek Sanitary Trunk Line is being reconstructed, efforts are being made to move the trail out of the floodplain of Indian Creek sub watershed. There has not been significant damage to the road or bridge from flooding of the creek, but work is required to remove debris in the floodplain to reduce peak flood levels. Silting issues at the 29th Street Drive SE bridge require regular removals; recent silt removal work was done in 2009 and 2014.

The City's policy for flood mitigation for private property is to encourage flood insurance, restrict new construction in the 100-year floodplain, and building a berm in the Sun Valley area.

Construction of the berm will be completed in 2015 and will reduce the threat of flooding, but will not mitigate an event like the 2002 storm.

Squaw Creek Sub Watershed

The Squaw Creek sub watershed starts in Marion and then has farmland contributions on the southern part before joining Indian Creek (see Appendix E, Exhibit 21). Squaw Creek sub watershed drains an area of approximately 14.5 square miles. Although the sub watershed is not located within the corporate limits of Cedar Rapids, flows in Squaw Creek have a significant impact on Indian Creek and infrastructure in Cedar Rapids. Notably, the Indian Creek Trunk Sanitary Sewer, a critical sewer for wastewater conveyance from Marion and Cedar Rapids, is aligned near Squaw Creek south of Cottage Grove Parkway.

Dry Creek Sub Watershed

The Dry Creek sub watershed is located in northeastern Cedar Rapids south of Boyson Road NE (see Appendix E, Exhibit 16). It runs from the west to east and includes the sub watershed area of Bowmanwoods. It has a drainage area of 31.5 square miles, of which nearly 27 square miles are upstream of Cedar Rapids. Its origin is north of Alburnett, Iowa, and runs south through Robins and Hiawatha, Iowa, before entering Cedar Rapids. The upper sub watershed is farmland and then becomes residential Robins and Hiawatha. For most of the area in Cedar Rapids, the floodplain is natural or a golf course, receiving flows from residential areas.

In Cedar Rapids, flooding of the Dry Creek sub watershed threatens a golf course, a few residential structures on Teakwood Lane and Purple Drive NE, and overtopping of C Avenue and Council Street NE. The residential structures are on the edge of the 100-year floodplain and have not been damaged in the major events of the last 20 years. The roads have not been overtopped due to proper drainage maintenance, which ensures proper flow. The golf course does not have structures in the floodway and only has short periods of flooding.

Bowmanwoods sub watershed, within the Dry Creek sub watershed, is located in the area north of Boyson Road, on the east and west of C Avenue in northeastern Cedar Rapids. It drains an area of 4.1 miles, which includes parts of Marion, Robins, Cedar Rapids, and Linn County. The area comprises some commercial properties but mostly residential in Robins and Cedar Rapids; the part of Linn County and the part of Marion that is within Bowmanwoods sub watershed is farmland. It flows through an unnamed creek to the east of Brentwood Drive NE into Dry Creek to the south of Boyson Road in Marion. Boyson Road has been overtopped by the creek in 2008, 2013, and 2014 during peak rain events.

Bowmanwoods sub watershed was studied in 1987 as part of the development of the area. The results of a study in 1987 by Brice, Petrides-Donohue concluded that there was inadequate drainage capacity under Robins Road NE and C Avenue NE. The 1987 study recommended the construction of detention facility to the west of C Avenue NE and an extensive ground flow path between Chelsea Drive NE and Berkshire Drive NE that would then go through a box culvert of at least 96 square feet under Kent Drive. Since the completion of the 1987 study, nearly all of the recommendations have been applied. The above ground flow path was designed and built, but has 1 to 2 feet of sediment built up. The built-up sediment did not cause

overtopping of Kent Drive or damage to properties during peak events in 2002, 2004, 2008, 2010, 2013, and 2014. The low flow intakes in the flow path are required to be cleaned at least two times per year. Root cutting for the low flow pipe is required every 2 to 4 years. The box culvert under Kent Drive is required to have periodic inspections and to be cleaned on a 2- to 4-year basis.

SILVER CREEK – CEDAR RIVER WATERSHED (EAST SIDE)

There are six sub watersheds within the Silver Creek – Cedar River Watershed on the east side of the river.

Ushers Ferry Sub Watershed

The Ushers Ferry sub watershed is located in northeastern Cedar Rapids, west of I-380 (see Appendix E, Exhibit 13). The drainage area is 2,230 acres and starts in Hiawatha and then flows west under Miller Road NE. At the Viola Gibson Elementary School area, the flows turn south and run to the west of Ushers Ferry Road NE. The land use is a combination of mostly residential with some undeveloped area such as the Isaac Walton League environmental conservation. Generally, there has been minimal threat of flooding to structures noted in the sub watershed despite significant development. There are two locations with ongoing difficulties: 1) south of Riverview Road NE has a history of beavers that dammed an unnamed portion of a creek tributary, which causes flooding in backyards of residential structures; 2) along Usher Ferry Road NE where the creek flows have come close to the road surface but did not overtop the road in 2008 or 2014.

NE Cedar River Sub Watershed

The NE Cedar River sub watershed is located upstream on the Cedar River from the Kenwood and McLoud Run sub watersheds (see Appendix E, Exhibit 14). Developed land within the sub watershed primarily is residential; a small portion of the sub watershed at the downstream and south end contains several industries and the J Avenue Water Treatment Plant. However, the majority of the land is undeveloped, wooded area. The total sub watershed is approximately 1,508 acres and drains into the Cedar River through several small, unnamed drainageways.

Applewood Mesa is a small sub watershed that is located within the NE Cedar Rapids sub watershed. It starts to the north of Glass Road NE and then flows south to the Cedar River. It drains an area of approximately 205 acres. Less than one-third of the area is developed into residential on the edges of the large ravine area.

During the 1993 rain events, the properties on the edges of the large ravine area had erosion of their backyards into the ravine that threatened the structures. The flows from potential rain events cause a threat of overtopping to J Street NE. This sub watershed is significant in that the flooding is not as much of an issue as is the erosion and potential loss of residential structures into the ravines that the flooding would cause.

McLoud Run Sub Watershed

The McLoud Run sub watershed lies along I-380 in the northeastern portion of Cedar Rapids (see Appendix E, Exhibit 15). It includes the only urban trout stream in Iowa. It has a drainage

area of 3,249 acres and the headwaters start in Hiawatha. The land use is fully developed as residential.

In general, structures have not been threatened by flooding of the creek. A problem with beavers near 42nd Street NE has resulted in some minor damages due to flooding during the period of 2005 to 2013.

The 1998 Stormwater Master Plan reported street flooding at 42nd Street NE and Center Point Road. A Capital Improvements Program (CIP) project was constructed to improve cleaning of the line; maintenance is required annually.

To prevent flooding at the intersection of Ozark and 42nd Street NE, the inlet has to be checked 2 to 3 times per year for debris and cleared. The flow comes from Noelridge Park and is aboveground through a wooded area that provides the vegetation debris.

The creek has a history of fish kills caused by water main breaks and thermal heating of flows from Iowa Highway 100. In 2004, the pond in Noelridge Park was reconstructed to address the thermal problem and no additional fish kills have been noted at this location.

Kenwood Sub Watershed

The Kenwood sub watershed is in parts of the southeast and northeast of Cedar Rapids (see Appendix E, Exhibit 17). The drainage area is 3,019 acres and it flows from the east to the west with an 18-foot-by-10-foot box structure into Cedar Lake. It is bounded by McCloud Run on the northwest and Indian Creek on the east. On the south, it goes to Mount Vernon Road SE and includes the Vernon Heights area. The land is fully developed into residential areas plus one golf course, two colleges, some commercial areas along 1st Avenue East, and minor industrial along I Avenue NE.

This sub watershed has a history of significant damages during flash rain events in 1971, 1993, 2008, and 2014. The flood damaged areas include:

- Collins Plant NE on 35th Street NE
- 37th Street NE near Elmcrest Country Club
- A and B Avenue NE at 15th Street
- Bever Avenue at Meadow Brook SE
- Grande Avenue and Forest Avenue SE

Following the 1971 flooding, additional capacity was added to a line of 16th Street NE to parallel the 15th Street NE brick line. The magnitude of the 2014 event exceeded the capacity of the 1955 outlet line and backed up flows into a low area at A and B Avenue at 15th Street NE. Many of the pipes are limited to 5- to 10-year rain event flows and there are no overland paths, resulting in street ponding that reached 3 feet in depth in 2014.

Downtown Sub Watershed

The Downtown sub watershed is located on the east side of the Cedar River and generally is identified from Quaker Oats to Otis Road (see Appendix E, Exhibit 18). The area is

approximately 1.0 square mile. In this area, there are currently 19 separate stormwater outfalls to the Cedar River. The flood risk mitigation project (which will result in the construction of a levee and floodwall) will result in rerouting or eliminating several of these outfalls. The proposed configuration consolidates these to 11 outfalls and five permanent stormwater pumping stations, and up to five temporary stormwater pumping stations. The largest outfall and proposed stormwater pumping station are at 10th Avenue (108-inch diameter outfall and 36,000 gallons per minute (gpm) pump).

Several areas in the Downtown sub watershed have been identified as experiencing problematic ponding during intense rainfall event. These areas include:

- North side of Mercy Medical Center along 10th Street
- New Bohemia Neighborhood
- 1st Street SE and 4th Avenue SE
- 2nd and 3rd Streets SE between 8th and 14th Avenues SE
- 3rd Street SE and 8th Avenue SE
- 6th Avenue SE and 7th Street SE

SE Cedar River Sub Watershed

The SE Cedar River sub watershed is located in southeastern Cedar Rapids, generally south of Mount Vernon Road (see Appendix E, Exhibit 19). The full sub watershed is approximately 3,626 acres, of which 2,480 acres are located within the Cedar Rapids city limits. The sub watershed drains into the Cedar River through Bena Brook on the east of the sub watershed and several other small, unnamed drainageways. There are two smaller sub watersheds that make up portions of the SE Cedar River sub watershed: Van Vechten and Bel Air.

The Van Vechten sub watershed is located in southeastern Cedar Rapids and covers primarily the flow through the park. It is approximately 297 acres. The land use is approximately two-thirds residential and one-third undeveloped or park area because of the slopes. Peak events have been noted in 2008 and 2014.

First, heavy precipitation caused erosion in the stream area of the park, which threatens the culvert under McCarthy Road SE and uncovers a concrete sanitary line in the creek bottom. Second, the flow then buries the rail road tracks with debris and overtops Otis Road SE before entering the river. What makes this small watershed significant is the threat to the sanitary line and the damages along Otis Road SE.

The Bel Air area and sub watershed is in southeastern Cedar Rapids. It is located to south of Mount Vernon Road SE and generally east of 34th Street SE and west of 44th Street SE. It has a drainage area of approximately 962 acres. The northern one-third is mostly developed as residential and the rest is low density rural. This watershed has a history in 1993, 1998, and 2014 of overland flow damages in the areas of:

- 14th Avenue and Harold Drive SE
- East dead end of Bel Air Drive SE

- North and south of 14th Avenue SE west of 39th Street
- 44th Street SE just north of Otis Road

In 2014, the flow was significant enough to remove the asphalt overlays on 14th Avenue, Harold Drive, and Bel Air Drive SE. To the west of 39th Street SE, a 15- to 20-foot hole was formed by the flow. The flow caused a mudslide that closed the road at 44th Street SE, which combined with other road damages and the flooding of Cedar River, isolated the Cedar Valley area.

Current Assets

> *"The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value."*
> Theodore Roosevelt, 1907

The City's stormwater system includes multiple assets, notably conveyance structures, detention basins, wetlands, flood mitigation berms and levees, and open channels and ditches. Each is described below. In accordance with Cedar Rapids Metro Area Standards, the stormwater system is intended to capture, store, and/or convey stormwater runoff from an event up to a 5-year return interval to protect against regularly recurring damage, to reduce street maintenance costs, to provide an orderly urban drainage system, and to provide public convenience. It is intended to accommodate stormwater runoff from an event with up to a 100-year return interval to prevent major property damage or loss of life.

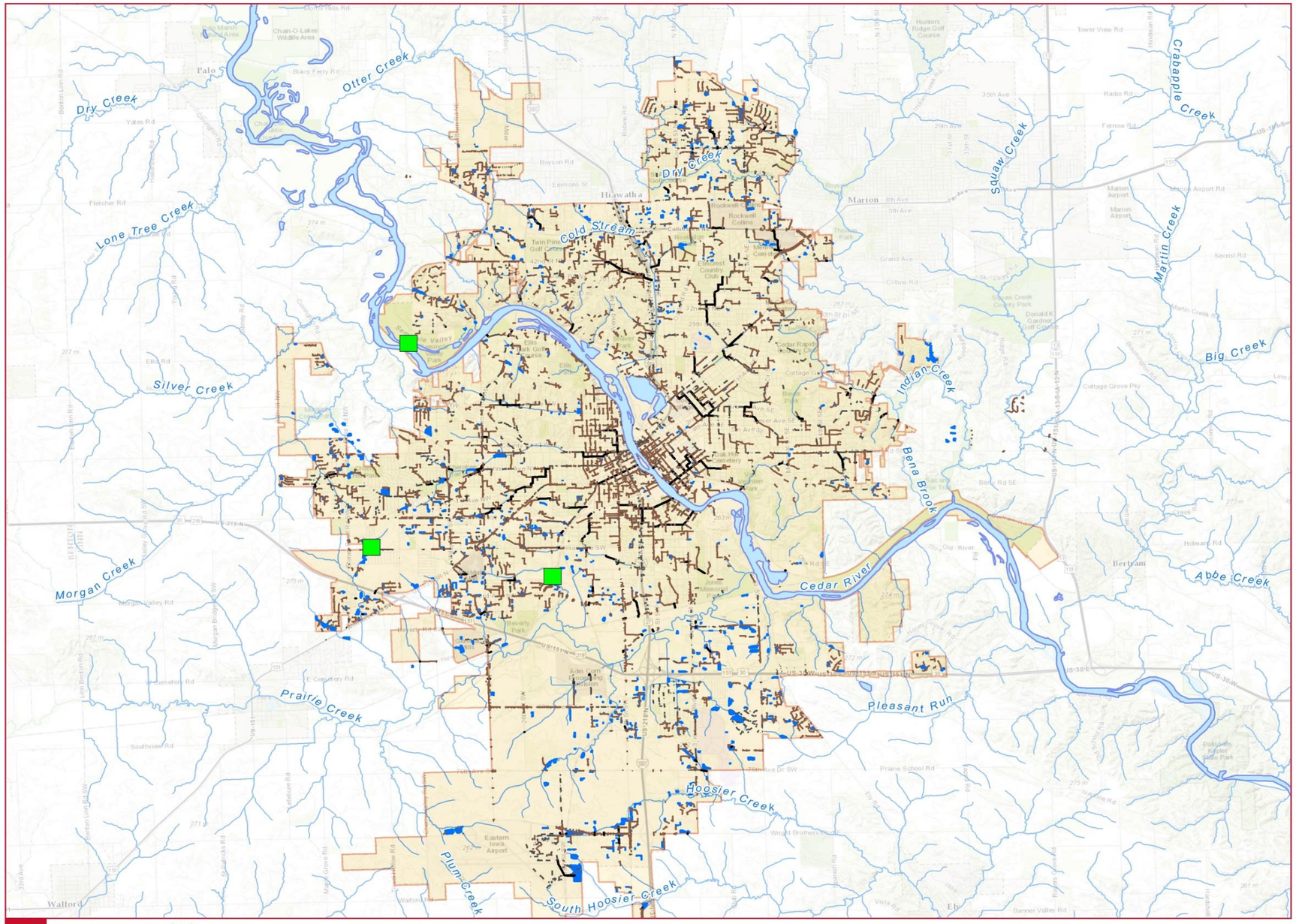


FIGURE 7
STORMWATER CONVEYANCE SYSTEM

City Boundary

Cedar River

Constructed Wetland

Detention Pond

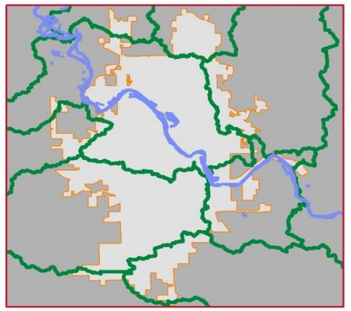
Open Channel

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Miles 1.5

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

CEDAR RAPIDS
City of Five Seasons®

CITY OF CEDAR RAPIDS
STORMWATER MASTER PLAN

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Stormwater Conveyance System

The stormwater conveyance system captures and routes surface runoff from precipitation. The system is designed to control the quantity, quality, timing, and distribution of runoff, thereby protecting property and residents in the process. As shown in Figure 8, a typical system consists of inlets, storm sewers, and outlets to surface water bodies.

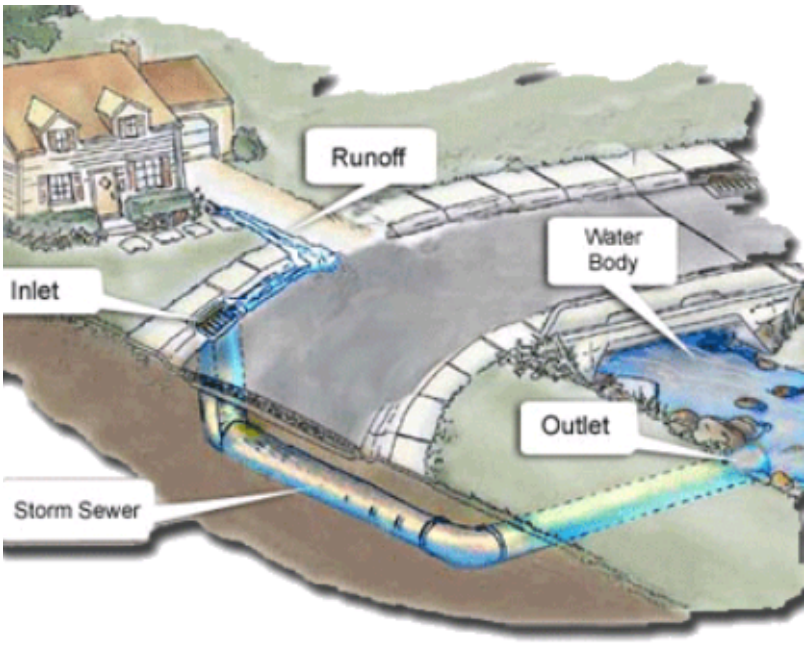


Figure 8 – Typical Stormwater Conveyance System

As indicated in Table 5 and shown in Figure 7, Cedar Rapids has more than 435 miles of storm conveyance pipes that range in size from 6 inches in diameter behind the curb drain tile to a 10-foot-by-18-foot outlet structure into Cedar Lake. There are approximately 26,000 structures in the system.

Table 5 – Stormwater Conveyance System

Pipe Shape	Pipe Height (inches)	Total Length (miles)
Unknown	Unknown	0.2
Arched (with flat bottom)	Unknown	2.3
	18 – 24	0.04
	24 – 36	0.3
	36 – 48	1.1
	48 – 72	1.5
	72 – 108	0.4
Circular	Unknown	110.2
	2 – 18	256.6
	18 – 24	40.5
	24 – 36	51.6
	36 – 48	21.6
	48 – 72	13.9
	72 – 108	6.9
	108 – 148	0.3
Oval or Elliptical	Unknown	0.3
	27 – 78	0.2
	Total	**508**

Detention Basins

A detention basin is an excavated area installed on, or adjacent to, tributaries of rivers, streams, lakes, or bays to store water for a limited period of a time. Storing water limits the quantity flowing downstream and protects against flooding and, in some cases, downstream erosion.

These detention basins are also called dry ponds, holding ponds, or dry detention basins if no permanent pool of water exists. Retention ponds, also known as wet ponds, are designed to permanently retain some volume of water at all times. Detention basins are used to manage water quantity while having a limited effectiveness in protecting water quality, unless it includes a permanent pool feature.

A detention basin functions by allowing large storm water flows to enter while limiting the outflow. The outflow is limited by having a small opening at the lowest point of the structure. The size of this opening is determined by the capacity of underground and downstream culverts and washes to handle the release of the contained water.

Basins are part of the Stormwater Management Plan for a site, development, or project. The requirement is in the City of Cedar Rapids Code Chapter 72, which reads as follows:

Cedar Rapids Code 72.203 – STORMWATER MANAGEMENT REQUIREMENTS

> *(a) Unless otherwise exempt, no development may occur without an approved Stormwater Management Plan. For purposes of obtaining approval of a Stormwater Management Plan, a plan for the site meeting the requirements established in the Design Standards Manual shall be submitted to the City Engineer for review and approval. All design criteria and plan details shall be in conformance with the Design Standards Manual.*
>
> *(b) Construction of stormwater management facilities shall be in conformance with the approved Stormwater Management Plan for the site.*
>
> *(c) The Stormwater Management Plan, including on-site stormwater detention facilities, shall be reviewed and approved by the City Engineer prior to the issuance of foundation permits, or building permits for the site. The improvements shall be constructed prior to the issuance of final certificates of occupancy. The requirements of this paragraph may be deferred at the discretion of the City Engineer.*
>
> *(d) For sites on which privately owned and maintained stormwater detention and/or conveyance facilities are located, the property owner shall be responsible for the following:*
>
> > *1. All future grading, repairs, and maintenance.*
> >
> > *2. Maintenance of the minimum stormwater detention volume, as approved by the City Engineer.*

3. Maintenance of the detention basin control structure(s) and discharge pipe(s) to insure the maximum theoretical stormwater release rate, as approved by the City Engineer, is not increased.

Some basins are public and some basins are private as delineated by City of Cedar Rapids Code Chapter 72.202 which reads as follows:

Cedar Rapids Code 72.202 – APPLICATION

(a) Except for exemptions provided for hereinabove, the requirements of this chapter shall apply to all development within the city.

(b) Stormwater detention basins intended to serve single family residential development shall be publicly owned and maintained, unless approved otherwise by the City Engineer.

(c) Non single family lots with an overall area of one acre or more shall provide on-site stormwater detention. Non-single-family lots with an overall area less than one acre shall comply with one of the following, as approved by the City Engineer:

1. Privately owned, on-site detention basin.

2. Tributary to a privately or publicly owned detention basin.

In some watersheds, on-site stormwater detention may be required, at the discretion of the City Engineer, for non-single-family lots with an overall area of less than one acre.

(d) At the discretion of the City Engineer, if a detention basin serves non-single family zoning districts and can provide stormwater attenuation for a substantial drainage area, the facilities may be publicly owned and maintained.

As of March 2015, the City has 95 public and 701 private basins located. Detention basins are shown in the watershed maps in Attachment E. Public detention basins are inspected on an annual basis. Private detention basins are typically owned by a development company or a homeowner's association. Private basins have historically been inspected on a 10-year basis, but will be inspected on a 5-year basis starting in 2015.

Wetlands

As defined by United States Environmental Protection Agency (EPA) regulations, a wetland is a land area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

As indicated in Iowa's Stormwater Management Manual, wetlands have three essential characteristics, all of which must be present for an area to be identified as a wetland:

- Hydrophytic (water-loving) vegetation
- Hydric soils
- Wetland hydrology

Wetlands can be considered nature's septic system, removing harmful pollutants and providing habitat for wildlife. They are generally natural but can be constructed artificially as a water management tool. Wetlands perform in a manner similar to a retention pond, with a significant presence of vegetation to improve water quality.

EPA has a number of programs for wetland conservation, restoration, and monitoring. EPA, along with USACE, establishes environmental standards for reviewing construction permits for discharges that affect wetlands, such as residential development, roads, and levees. Under Section 404 of the Clean Water Act, USACE issues permits that meet environmental standards.

Effort should be made at the beginning of a project to avoid or minimize impacts on wetlands. Any project that does not meet the conditions of any one of the Nationwide Permits must be sent to USACE and would require satisfactory mitigation for the loss of wetlands.

Mitigation is defined as wetland restoration, creation, enhancement, or preservation for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial. As indicated in the Iowa Stormwater Manual, compensation of impacted resources is only accepted if mitigation occurs in the following sequence:

1) Avoid direct or indirect impact by not taking a certain action
2) Minimize impacts by limiting the degree of action
3) Rectify the impact by repairing, rehabilitating, or restoring the affected environment
4) Reducing or eliminating the impact over time by preservation and maintenance operations
5) Discharge of stormwater into jurisdictional wetlands is to be avoided
6) Compensating for unavoidable impact by replacing or providing substitute resources:
    a. Replace or provide substitute resources on-site
    b. Replace or provide substitute resources off-site at an approved location, owned by either the project sponsor or a federal, state, or local conservation

Where projects have impacted wetlands, Cedar Rapids has designed and constructed wetlands and/or has purchased credits in a wetland constructed by others. In recent years, purchased credits have been the most frequent choice.

The City's three designed and constructed wetlands are located as follows and as shown in Figure 13. A fourth proposed wetlands is also shown.

- Wilson Avenue SW east of Stoney Point Road
- 18th Street SW north of 33rd Avenue
- Seminole Park
- Tait Cummins Memorial Park

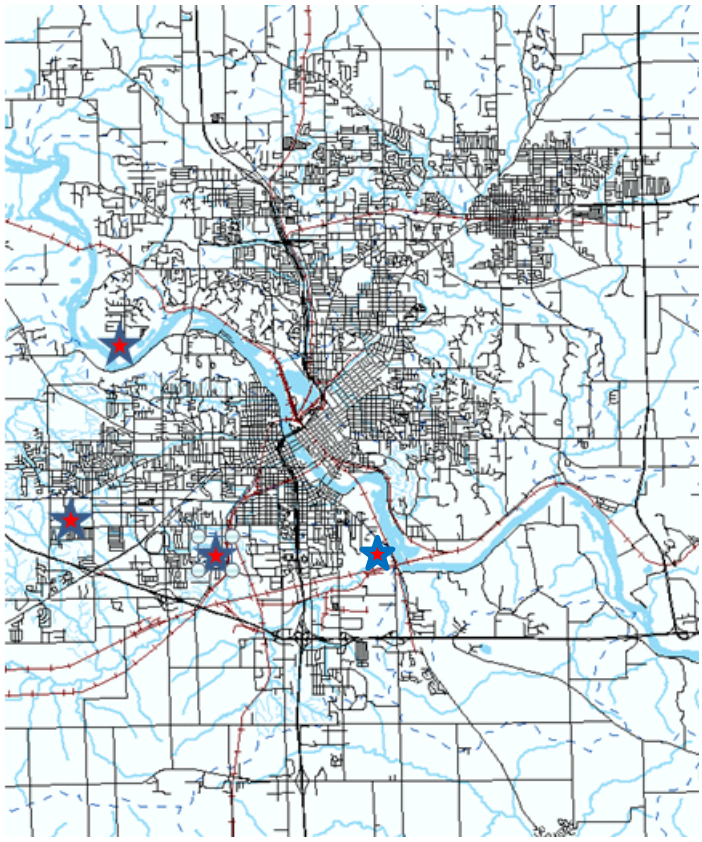


Figure 13 – Cedar Rapids Constructed Wetlands

The Wilson Avenue SW location is still within the time frame of USACE required annual inspections. The location is under the review of the Engineering Division. It was found to have deficiencies in 2014 and is being mitigated in 2015. The other two areas are inspected by Sewer Maintenance Division staff as part of the basin program. The wetlands at Tait Cummins Memorial Park are proposed as part of mitigation for the Prairie Creek Sanitary Sewer Phase 3 and will be constructed in 2016.

Flood Mitigation Berms and Levees

As defined by USACE, a levee is a human-made structure; usually an earthen embankment or concrete floodwall designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide reasonable assurance of excluding temporary flooding from the leveed area. A levee system is one or more levee segments and other features such as floodwalls and pump stations, which are interconnected and necessary to ensure exclusion of the design flood from the associated leveed area.

It is a common misperception that USACE manages all levees in the United States. In reality, the levees included in the USACE Levee Safety Program represent approximately 10 percent of the levees in the United States as estimated by the National Committee on Levee Safety. However, more than 10 million people live or work behind USACE program levees. For this reason, USACE considers its role in assessing, communicating, and managing risk to be a top

priority. They are designed, maintained, and inspected in accordance with agreements between jurisdictions and USACE.

A berm is a mound of generally earthen material that is used to protect a structure or area of land in a similar manner as a levee. They may be permanent or temporary in nature with designs varying in quality. Berms are not USACE designed or inspected. Flood protection in Cedar Rapids as of 2015, as identified below and shown in Figure 14, are not USACE levees, but berms.

1. 1St Street NW from Penn Avenue to F Avenue (Time Check) – berm for river flooding mitigation, 3,500 linear feet, 22-foot stage
2. Ellis Lane NW from Ellis Boulevard to 8th Street (Time Check next to Ellis Pool) – berm for river flooding mitigation, 500 linear feet, 21-foot stage
3. A Street SW from 12th Avenue bridge to south of 22nd Avenue (Czech Village) – berm for river flooding mitigation, 2,100 linear feet, 22-foot stage
4. Valor Way SW north of the 8th Avenue bridge (riverside of police station) – berm for river flooding mitigation, 400 linear feet, 20-foot stage
5. Cottage Grove Parkway SE (Sun Valley) – berm for Indian Creek flooding mitigation, 700 linear feet, 75-year event frequency
6. 1st Street SE from 16th Avenue south through the Sinclair property (New Bo) – berm for river flooding mitigation, 2,700 linear feet, 21-foot stage
7. 7525 Bertram Road SE (Water Pollution Control Facility) – 5,300 linear feet (including 1,440 feet of concrete floodwall), 31-foot stage berm and wall for river flooding mitigation

Each spring, once the ice is out of the Cedar River, Sewer Maintenance Division staff checks the berms along the river for damages. With the completion of the Quaker Oats plant levee and the Cottage Grove Parkway SE berm in 2015–2016, these will be added to the maintenance schedule.

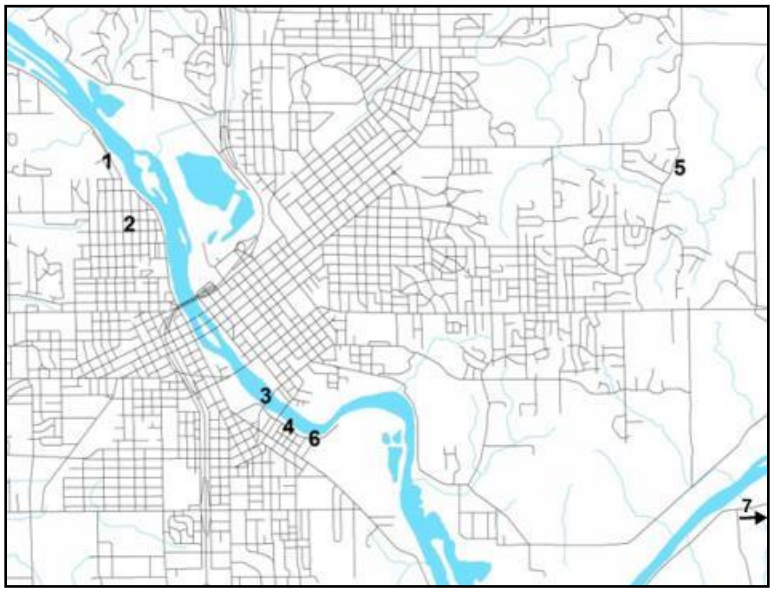


Figure 14 - Existing Flood Protection Berm Locations

WATER POLLUTION CONTROL FACILITY FLOOD PROTECTION SYSTEM

The Water Pollution Control Facility (WPCF) sustained substantial damages in the 2008 flood that made the plant non-operational for more than 2

months. To prevent similar damages, the flood protection system shown in Figure 15 was designed and constructed with completion in 2014. Operation and maintenance is administered by the facility staff. Its specifications are included in Table 6.

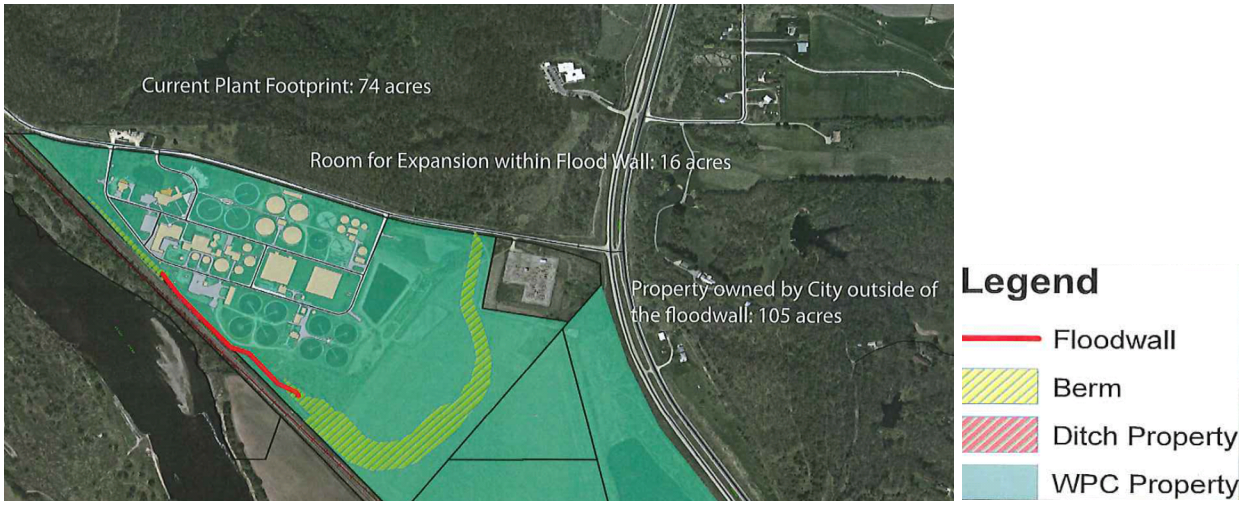


Figure 15 – Wastewater Treatment Plant Flood Protection

Table 6 – Cedar Rapids Water Pollution Control Facility Flood Protection Specifications

Parameter	Basis of Design
Floodwall and Berm:	
- Top of Berm and Floodwall Elevation	- Exceeds flood of record plus 3 feet of freeboard (elevation varies on site but exceeds 720 feet NAVD88 + 3 feet = 723 feet)
- Hydraulics and Hydrology Model	- USACE 2008 HEC-RAS Model, including January 2011 Feasibility Study Report
- Berm Consolidation	- Overbuild 0.2 feet for consolidation
- Design Standard	- 44 CFR 65.10
- Clear Zone	- 15 feet to structures or woody vegetation on either side of the berm and floodwall
Effluent Pump Station:	
- Firm Capacity	- 132.5 MGD
- Total Capacity	- 177 MGD
- Drive Type	- Variable frequency
Storm Water Pump Station:	
- Firm Capacity	- 10-year storm, 146 cfs
- Total Capacity	- 25-year storm, 194 cfs
- Drive Type	- Constant speed, reduced voltage soft starter
Design Codes:	- 2012 International Building Code - 2011 National Electrical Code - NFPA Life Safety Code - Hydraulic Institute

Notes: North American Vertical Datum of 1988 (NAVD88)
United States Army Corps of Engineers (USACE)
Hydrologic Engineering Centers River Analysis System (HEC-RAS)
Code of Federal Regulations (CFR)
Million gallons per day (MGD)
Cubic feet per second (cfs)
National Fire Protection Association (NFPA)

Open Channels and Ditches

In the context of stormwater, open channels and ditches are natural or human-made surface conveyance paths for storm related surface runoff. Flow is by gravity and at atmospheric pressure as opposed to flow in pipes that can be under pressure. They are a method for surface flow where natural streams, creeks, or rivers are non existent.

Generally, an open channel is a more definitive, designed depression of larger size than a roadway ditch. They can be constructed of concrete, much like the open channel on Shaver Road NE that connects McCloud Run to Cedar Lake as shown in Figure 16. The Shaver Road NE open channel is the only known concrete-lined open channel in Cedar Rapids.

Generally, a ditch is a small to moderate depression created to channel water. A ditch channels runoff to drain water from low-lying areas, alongside roadways to provide stormwater conveyance, and to drain the road subgrade to improve service life of the street. There are approximately 40 miles of roadway ditches in Cedar Rapids.

Figure 16 – McCloud Run Open Channel

Twenty years ago, the City maintained ditches on a regular 5- to 8-year basis without much consideration of the appropriate timing. Sometimes, ditches were made deeper and resources were expended before there was a need to do so. Currently, the City does not routinely clear open channels or ditches. The City's practice is to maintain ditches on an as-needed basis to reduce emergency responses. This approach has resulted in less frequent maintenance that generally occurs from 1 to 3 years after a problem is detected depending on the impact on the street and structures.

The best management practice would likely be somewhere in between and based on regular inspections. Street supervisors would inspect facilities each year followed by work on those needing maintenance the following next year. Maintenance locations would be tracked on a map overlay to provide a visualization of the locations that have ditches and the frequency of maintenance activities. This approach would reduce unnecessary erosion and sediment into streams while tailoring maintenance activities to identified needs.

Operations and Maintenance

The Sewer Maintenance Division of the City's Public Works Department performs the routine cleaning, televising, and minor repairs to the stormwater system. Staff responds to approximately 700 requests per year based on a 3-year average for the period of May 1, 2012, to April 30, 2015. Historically, the program televises 0.5 mile and cleans 0.5 to 1.0 mile of lines per year.

City-provided services include the following:

- Reactive cleaning, televising, and clearing of obstructions in storm sewers
- Minor repairs to storm sewer pipes and structures
- Educational outreach to school children and community groups
- Inspections of more than 1,800 storm structures annually
- More than 550 annual inspections of constructions sites and industrial properties as required by Iowa Department of Natural Resources and the Environmental Protection Agency
- Inspections of more than 75 private detention basins annually
- Inspection and minor maintenance of public detention basins
- Funding half of the bond debt for the 5 in 1 dam with the other half funded by the Water Utility
- Public detention basin mowing
- Inspection and compliance of erosion and stormwater violations
- Outfall water inspections into the Cedar River as required by state and federal regulatory agencies
- Street sweeping to reduce the amount of debris and sediment in detention basins, storm pipes, and streams ultimately flowing into the Cedar River

As part of preparations for American Public Works Association Certification, the City has drafted a procedures manual that documents the following:

1. Stormwater and Flood Management Service Levels
2. Operation Plan
3. Floodplain and Floodway Management
4. Water Quality Goals
5. System In-Flow of Polluted Runoff
6. Allowable Non-Stormwater Discharge into System
7. Watershed Stormwater Drainage Master Plan
8. Infrastructure Inventory
9. Infrastructure Condition
10. Stormwater Design
11. Stormwater System Improvement
12. Sediment and Erosion Control
13. Stormwater Flood Warning Systems
14. Infrastructure Inspection

15. Conveyance, Storage, and BMP Operations
16. Private Owner Operations and Maintenance
17. Private Facility Inspection
18. Pollution Prevention Plans
19. Public Education
20. Ice Jam Procedure

Situations to which the Sewer Maintenance Division responds vary on a case-by-case basis; the above procedures are followed to the extent possible and adapted as the specific situation(s) require.

Flood Control

Cedar Rapids is a river city that has seen multiple floods during its more than 150-year history. Progressive actions have been taken in the last 60 years to mitigate the effects of the river crests.

Pre-2008

Following near record setting flooding in 1961, the City started actions to mitigate flooding to river crests levels of 20 to 22 feet. The confidence levels increased over the decades as additional measures were added to the responses.

BARRIER PROTECTION AND ISOLATION

City Street Department staff constructed non-certified USACE earthen levees in the Time Check and Czech Village sections of Cedar Rapids in the period of 1962 to 1964. Isolation valves for the stormwater system were constructed west of Edgewood Road NW on Ellis Road and along A Street SW. The levees provide protection for crests of 21 to 22 feet.

In later years, a concrete wall was constructed west of Edgewood Road NW on Ellis Road to provide partial protection to roughly a dozen properties and a former marina in that location. It provides protection to an 18.5-foot crest and can be extended up to roughly 19 feet with the addition of sand bags on top of the wall.

Duck bill isolations were added on smaller storm pipes in the period of 2000-2008.

FLOOD RESPONSE PLAN

Following the 1993 flooding, the City Engineering Division created a Flood Response Plan that lists specific tasks by staff at specific river flood stages. The identified tasks include closing flood gates at the river, putting plugs in storm sewers, closing roads, placing sandbag closers, and shutting down traffic signals. Over the years, general information regarding historic flood elevations and evacuation routes were added to the manual. The manual is updated annually and is posted on the City's Public Works Department website. As the Cedar River Flood Control System is constructed, the Flood Response Plan will be updated to reflect new features and responses.

PUMP PLAN

Portable trash pumps are used to relieve surcharges in the sanitary sewer system and associated flash flooding during period of high precipitation. To decrease the response time, a prioritized deployment plan with setup plans has been generated. The prioritization is based on the predicted rain depth. The pumps are deployed to 30 sites identified in the City's Sanitary Sewer Master Plan.

Figure 17 – Concrete Barrel Protection

POINT ISOLATION

Sand bag wells are filled and placed as a secondary mitigation measure on storm structures. In the 1990s more than 250,000 sandbags were routinely used for moderate levels. A single 3-foot-high well with a 2-foot radius could take more than 5,000 sandbags if properly constructed. As of 2015, there are more than 100 locations to protect for a 22-foot crest. Starting in the mid 1990s, concrete barrels and cones were used in conjunction with sandbags. It takes roughly 300 bags as a leveling base per location along with a concrete barrel (see Figure 17).

Figure 18 – Tiger Dams

Based on past events, the requirements for sandbag use include:

- 14 feet: 2,000 to 3,000 sandbags
- 16 feet: 4,000 to 5,000 sandbags
- 17 feet: 9,000 sandbags
- 18 feet: 15,000 to 16,000 sandbags
- 19 feet: 40,000 to 60,000 sandbags

When sandbags are distributed to the public for private use, additional resources are required.

Figure 19 – Hesco Barriers

Post 2008

Following the historic 2008 flood, the City Council of Cedar Rapids directed additional mitigation for river flooding.

INTERIM FLOOD PROTECTION

After a review of possible measures and cost, a plan was agreed to for an additional 2 feet of protection to a stage 24-foot crest. The plan includes temporary

sand- and water-filled barriers known as Tiger Dams and Hesco Barriers, respectively, along the existing floodwalls and levees along the Cedar River (see Figures 18 and 19). These temporary barriers can add up to 4 feet of additional protection depending on the location. They reduce the risk of flood damage, but do not prevent all flood damage.

In accordance with City Council direction in 2009, implementation of the temporary barriers will commence if a forecast by the Nation Weather Service Advanced Hydrologic Prediction Service exceeds a crest of 20 feet. Neighborhood evacuations are requested before installing temporary barriers.

City crews and contractors can install nearly 3 miles of temporary flood barriers in four main locations; the Time Check Neighborhood area, the east and west sides of downtown, and the Czech Village area. Maps of the protection can be seen on the City website.

The Tiger Dams and Hesco Barriers require substantial resources. Tiger Dams are reusable, but may start to fail after the third use. Hesco Barriers are designed to be reusable, but require refitting for the fabric if they come in contact with flood waters. The fill material for the Hesco Barrier system requires roughly 10,000 cubic yards of material. In the period of 2009-2014, sweeper dumps have been staged at the former Sinclair site for this purpose. To fully implement the plan, more than 200 structures will require isolation. As of 2014, the City had approximately half that number of concrete cones and barrels to support the isolations.

PERMANENT FLOOD RISK REDUCTION

To reduce the risk of a future flood, much like the 2008 flood, a permanent flood control system is being designed and built. The City Council adopted the Cedar River Flood Control System Master Plan in June 2015; the adopted alignment is shown in Figure 20. The 7.5 miles of components that protect both sides of the river will include:

- Concrete floodwalls in areas where there are width restrictions, for example, near Penford, Quaker Oats, Cargill, the north rail yards, and through portions of downtown
- Earthen levee sections in wider areas, for example, on the former Sinclair site, in the Time Check Neighborhood area, and under the amphitheater near the police station
- Removable floodwalls in areas where a view of the river is advantageous for development
- Wall openings for neighborhood connections
- Road closure gates at bridges and roads passing through the line of protection
- Storm water pump stations to pump interior drainage during a high river event
- Storm sewer closure gates at storm outfalls and interceptor sewers connecting to the pump stations
- Levee greenway between flood control structures and Cedar River

Figure 20 – Cedar River Flood Control System as approved by City Council

Funding is anticipated to come through three sources:

1. Growth Reinvestment Initiative (GRI) – The GRI dedicates the next 10 to 20 years of growth in the 6 percent sales tax revenue collected in Linn County to fund the flood management system and will provide the majority of the funding
2. Federal – East side flood protection is included in the USACE Water Resource Development Bill and has been authorized but not funded as of 2015. Funding is uncertain but anticipated to be a source for east side protection.
3. Local contribution – A combination of multiple inputs is anticipated, perhaps including local option sales tax, stormwater fees, capital improvement project bonding, and/or in-kind work by City staff or property taxes. Other sources of funding may also become available including economic development grants or Community Development Block Grants (CDBG) that could count as part of the local City contribution.

Once built, the system will have to be operated and maintained by the City. This includes annual work (for example, inspections of components and mowing of levees) and longer term replacement of components such as pumps as well as deployment of removable sections of the flood wall and gates.

Prior Studies

Attachment B identifies multiple prior studies with relevance to this current stormwater master planning effort. The two most significant, the 1998 Stormwater Master Plan prepared by Camp Dresser McKee (CDM) and the 2014 EnvisionCR prepared by RDG Planning and Design, are summarized in the following sections.

1998 Stormwater Master Plan

The 1998 Stormwater Master Plan for the Cedar Rapids Metropolitan area was performed through the Metropolitan Planning Organization. It provided an assessment of policies and planning and recommended improvements to address identified drainage problems.

A total of 26 drainage problems were identified and characterized as follows:

- 18 undersized stream roadway crossings
- 2 erosion related
- 1 structure flooding
- 3 over bank flooding
- 2 yard or parking ponding

Of the reported problems, four had reported damages, three had significant potential for flood damages, and most of the rest were associated with nuisance ponding of yards and streets.

An assessment level capacity analysis was conducted of 201 outfalls 36 inches in diameter and larger to determine whether they met the local 5-year flow capacity design standard. The analysis concluded that 127 outfalls met the 5-year flow capacity design standard, but the remaining 74 outfalls had potential capacity problems.

Areas draining to the major outfalls, referred to as subbasins, were screened and tiered based on the severity of existing problems or the potential for future problems. Of the subbasins, 79 were determined to have not problems. Those with problems were tiered as follows with tier 1 being the most critical.

- 84 Tier 1
- 9 Tier 2
- 29 Tier 3

Eight of the reported problem areas had already been addressed by others. As summarized in Table 7, improvements were recommended for the remaining 18 plus one additional problem area subsequently identified. Those improvements included additional storm sewers, flood protection measures, new detention basins, and enforcement of existing policies. The 1998 estimated construction cost for the recommendations was $14.44 million, prompting the need for additional funding beyond current revenue levels at that time.

All but two of the problems and improvements were located in Cedar Rapids and represented $14.19 million of the total estimated construction cost. The remainder were in Hiawatha and account for the balance of the total estimated construction cost.

The current status of each is also summarized in Table 7. As noted, numerous issues have not yet been addressed while some detention has been improved.

The 1998 Stormwater Master Plan provided discussion and recommendations on a number of policy and planning related topics. Those recommendations are summarized in Table 8 along with the current status of each.

Following the June 2014 flash flood event, issues identified by City staff and citizens were documented and a number of projects were identified. The issues and projects were used to develop a new Capital Improvements Plan starting in Fiscal Year 2016. The current table of issues and projects is included in Attachment C.

Table 7 – 1998 Stormwater Master Plan Reported Problem Areas				
Location	**Concern**	**Proposed Improvements**	**Cost ($millions)**	**Current Status**
Former Public Works facility flooded – 1200 block 4th Street SW	Structural flooding of City facility and residential area			• City facility reconstructed • Residential area sustained flooding in 2014
Edgewood Road SW at 16th Avenue	Overtopping of roadway crossing	Flood-proof KFC with floodwall	$0.04	• Sustained flooding in 2014 • No actions taken
Edgewood Road NW at Johnson Avenue	Overtopping of roadway crossing	Add 78-inch elliptical culvert	$0.73	• Sustained minor flooding in 2014 • No actions taken • New business raised to address threat of 1 percent yearly event
Stoney Point Development	Back yard ponding, roadway overflow	Add two 72-inch and one 66-inch culverts	$1.13	• Sustained flooding in 2014 • No actions taken
Time Check	General area flooding	Add 8-foot-by-5-foot box storm sewer and pump station	$1.25	• Sustained minor flooding in 2014 • No actions taken • Plan is to include in west side Flood Control System
Forest and Grande Avenue SE	Street and garage flooding	Implement replacement of 78-inch storm sewer	--	• Sustained minor flooding in 2014 • No actions taken
Executive Plaza/Cedar Memorial Cemetery	Building flooding and burial area	Improve inlets in parking lot, buy out buildings the flood at the cemetery	$0.30	• Buildings moved • Flooding still exists in peak events
Collins Radio plant on 35th Street NE	Potential building and parking lot flooding	Add a 2-foot high berm on north side of building, add 36-inch storm sewer	$0.47	No flooding noted in last 10 years
Harding School on Golf Street NE	Parking lot and play area flooding	Add 54-inch storm sewer downstream of school, modify weir, add 15 acre-feet of storage upstream of school	$1.10	Flooding exists in peak events
Center Point Road NE at 42nd Street	Roadway ponding	Add 72-inch storm sewer	$0.28	Improved maintenance practices conducted to prevent debris in pipe, structure reconstructed
G Avenue NE near Elmcrest Country Club	Roadway flooding			• Sustained flooding in 2014 • No actions taken

Table 7 – 1998 Stormwater Master Plan Reported Problem Areas				
Location	**Concern**	**Proposed Improvements**	**Cost ($millions)**	**Current Status**
H Avenue and 37th Street NE	Roadway ponding			• Sustained minor flooding in 2014 • No actions taken
29th Street NE and Mount Farm	Roadway ponding and basement flooding			• Sustained minor flooding in 2014 • No actions taken
Bowman Woods	Overtopping of roadway crossing	Enforce Detention Policy	--	• Basin was reconstructed • C Avenue reconstructed • C Avenue did not overtop in 2014
Cargill facility on 10th Street SW	Parking lot and back yard flooding	Add 72-inch storm sewer and 15 acre-feet of storage	$1.50	• Sustained minor flooding in 2014 • No actions taken

Table 8 – 1998 Stormwater Master Plan Policy / Planning Related Recommendations		
Recommendation	**Concern**	**Current Status**
Develop and implement EPA Phase II Stormwater regulations	In the 1990s, permits were starting to be required for stormwater to compliant with the Clean Water Act	Complete - City has Stormwater permits starting in 1999
Conduct a pilot study for one major watershed to quantify potential flow and elevation increases associated with current detention policies and determine whether zoning controls could be used to regulate development and prevent damages in areas prone to future flooding.	The metro area had a 5-year standard for detention basin design and release but did not address downstream consequences in more extreme weather events from which new development flows could potentially exceed downstream capacity of areas and cause flooding.	• The number of detention facilities went from 10 to 70+ public and 100 to 700+ private • A berm was install along Cottage Grove Parkway SE to mitigate 1 percent yearly peak rain event • Some location still have downstream problems I • Indian Creek has been modeled by the U.S. Army Corps of Engineers • 2014 model was expanded to include Squaw Creek • An Indian Creek Watershed Management Authority, of which Cedar Rapids is a member, has been created for watershed level planning and implementation.

Table 8 – 1998 Stormwater Master Plan Policy / Planning Related Recommendations		
Recommendation	**Concern**	**Current Status**
Review stormwater program in terms of required costs and available revenue and consider implementation of a stormwater user fee as a primary source in conjunction with or other secondary sources of funding such as general fund, road use taxes, and review/permit fees.	Revenue sources were not adequate for identified capital improvements needs, and fees did not reflect true service costs.	• Fiscal Year (FY) 2015 increased rates to start to include CIP funding • Rates from FY 2007 to 2014 increased to include street sweeping, detention basin mowing, construction barricading, billing, engineering support and staff increases to address new regulatory requirements • City has obtained State Revolving Fund grants for stormwater projects
The Linn County Regional Planning Commission serves as the focal point to facilitate implementation of Master Plan Recommendations.	The was no single or umbrella body or agency with jurisdiction and legal authority to review and implement stormwater management	• Indian Creek Watershed Management Authority was formed in 2012 by seven of the jurisdictions through the 28E agreement process
Restrict development in flood prone area	• Minimize flood damages • Increase floodplain flows	• Following 2008 flood, City has purchased the majority of the properties in the 100 floodplain on the west side of Cedar River • Floodplain ordinance was updated
Adopt the Metro Area Engineering Standards Design Manual and develop a comprehensive model stormwater ordinance for adoption by all.	Metro Design Standards had not been adopted by Hiawatha and needed updating to improve their effectiveness.	• Standards were updated for stormwater items but it did not address all of the items in the report such as a 2 year flow

EnvisionCR

The City adopted a new comprehensive plan prepared by RDG Planning and Design, referred to as EnvisionCR, in January 2015. EnvisionCR is intended to serve the following three primary roles.

1. **Community building.** To create a shared vision for Cedar Rapids' land use, infrastructure, public facilities, and natural resources, to set public priorities, and to provide a set of action steps that collectively improve quality of life and make Cedar Rapids more attractive for potential growth.
2. **Legal basis for land use regulations.** To provide a legal basis for zoning and subdivision ordinances that govern how land is developed to coordinate and harmonize the uses of private property and to promote the "health, safety, morals or general welfare of the community."
3. **Guidance for decision-makers.** To serve as a guide for City staff, the Planning Commission, City Council, and other City boards and commissions, as they set policy and make investment and land use decisions.

EnvisionCR is underpinned by major themes of sustainability, health, place-making, and efficiency.

- **Sustainability.** The ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs by working toward a healthy environment, community, and economy.
- **Health.** Places that support residents' mental and physical health and in so doing, quickly attain a distinction as a place for families and young professionals to call home.
- **Placemaking.** Building memories through public spaces and activities, often associated with a destination like the riverfront, downtown or neighborhood.
- **Efficiency.** Doing things in an optimal way; the right task, completing activities, and achieving goals.

EnvisionCR's guiding principles reflect a community focused on a vibrant and dynamic future of lasting value – one that promotes public health, social engagement, a robust economy, natural resources and life-long learning, while embracing a history and a future of artistic, cultural, scientific, and technical vitality. Those guiding principles are as follows:

- **Achieve a Unified Vision.** Collaborate to achieve a unified vision for the City and region; regionalism and a creative hub to the creative corridor.
- **Live Healthy.** Create a healthy and desirable place to live; a community of choice, downtown vitality, and industry embraced.
- **Strengthen Neighborhoods.** Strengthen the quality of neighborhoods creating housing options for all; traditional and future needs, neighborhood hubs preserving community character.
- **Keep Business Vibrant.** Reinvest in the City's business corridors and districts and compete successfully for private investment; authentic experiences and skilled workers.

- **Connect the City.** Connect all parts of Cedar Rapids, integrate land uses, and encourage pedestrian scaled design; places and paths.
- **Embrace the Outdoors.** Preserve natural areas and manage impacts, and establish a premier system for parks and recreation; a greener city.
- **Streamline Services.** Provide efficient urban services; streamlined government and effective partnerships.

The elements of the resulting plan, with their associated goals, and connectivity to stormwater master planning are as follows (see Figure 21).

STRENGTHEN CR

Make bold moves in community planning to retain the character of neighborhoods and corridors.

Reconstruction and extension of storm sewers strengthens the values of older sections of Cedar Rapids by providing improved conveyance and reduction of flood risk to these areas.

GROW CR

Make bold moves in future planning to encourage sustainable connections of growth areas to existing neighborhoods.

Grow CR includes initiatives to
a) commission detailed studies for extending services to the identified growth areas and
b) to develop an annexation plan that incorporates infrastructure and service issues and costs, geographic features, environmental and other land use constraints, and market needs.

Establish stormwater planning in the Morgan Creek watershed to support future growth in the Iowa Highway 100 corridor west of the Cedar River as outlined in the EnvisionCR in the northwest.

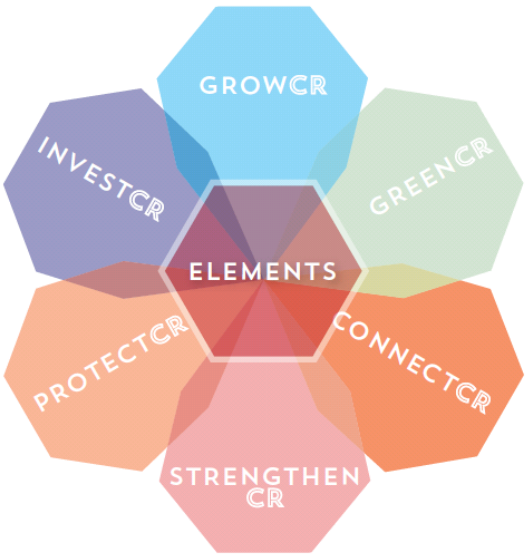


Figure 21 – Envision CR Elements

CONNECT CR

Create a culture that enhances transportation options for pedestrians and cyclists through complete streets, trails, and public transportation.

Connect CR includes and initiative to develop an asset management policy and procedure that clarifies the accountability for the management of each of the assets under the stewardship of the Public Works Department.

As part of stormwater construction, enhance trails and pedestrian options for residents.

GREEN CR

Buffer and connect existing parks, trails, and streams to build a natural network in addition to regional collaborations and individual efforts to improve stormwater management, water quality, wildlife habitat, and outdoor recreation.

Green CR notes that a suite of natural stormwater best management practices (for example, permeable paving, rain gardens, bioswales, bio-retention, stream buffers, wetland restoration, and grassed waterways) are appropriate throughout Cedar Rapids. It identifies opportunities where infiltration-based best management practices can balance the demands of maximizing development yield and protecting critical resources, and identified areas that are especially appropriate for techniques that promote infiltration (that is, soaking up) of rainwater.

Green CR identifies methods to maintain and restore habitat continuity, link communities and features through trail and pathway corridors, and strives to manage stormwater where it falls to the greatest degree possible with the resulting benefits to enhance recreation and habitat protection, flood and stormwater improvements, and increased water quality.

Green CR identifies vegetation and land cover as major resources that can help manage stormwater, prevent erosion, moderate microclimates, and provide more appealing physical environments and notes that steps should be taken to minimize development within these areas and instead secure them to function for stormwater management, habitat, and appropriate recreation.

Green CR includes initiatives to create a green streets policy that encourages future development and repairs to improve the permeability of the paving system and/or buffering of run-off, as well as a stormwater best management practices cost-share program that elicits community involvement, and thereby advancing green infrastructure. Maintaining and improving detention basins will improve water quality and reduce stream bank erosion.

INVEST CR

Make Cedar Rapids a desirable place for businesses to start, move, and grow by leveraging resources to invest in business districts and amenities that keep and attract a skilled workforce.

Construction and maintenance of flood control systems encourages the investment in areas that were damaged in the 2008 flood and reduces the cost of flood insurance.

PROTECT CR

Provide quality services to increase neighborhood safety and keep moving forward with the flood control system.

Protect CR recommends a number of mitigation actions to protect Cedar Rapids from flooding and other hazards, focusing on addressing high priority hazards. These recommendations include the following stormwater related elements to complete the City's Permanent Flood Protection Project, implement flood protection through property acquisition and/or demolition, and to add detention basins to increase stormwater management capacity. Likewise,

improvements to the stormwater system reduce the threat of flooding damages caused by overland flow and inadequate conveyance pipe capacity.

Protect CR includes multiple stormwater related initiatives as follows.

- Prepare watershed management plans that provide improved aquatic habitats, recreational opportunities, and increased public access to natural resources, while maintaining necessary levels of flood control through coordination with appropriate stakeholders, including state and federal agencies, and other jurisdictions.
- Develop watershed stormwater drainage master plan to measure, monitor, and manage stormwater drainage for the City's watersheds.
- Prepare a capital improvements plan that addresses both the needs of existing core neighborhoods and the future infrastructure needs in areas where growth is planned.
- Refine existing stormwater management regulations to enhance clarity and adaptability.
- Identify, evaluate, and acquire technology, equipment, and facilities to improve infrastructure and service delivery
- Analyze and define organizational structure to reflect best management practices in areas of staffing, operations, and equipment.
- Use sustainable practices for the maintenance, rehabilitation, and construction of public facilities prior to adoption of a green building program.

The Grow CR section of the plan identifies growth areas noted below.

- **West.** Orienting development in response to the Iowa Highway 100 expansion, and incorporating the natural environment as an amenity.
- **Southwest.** Dedicating land for industrial projects and establishing a network of streets for emerging neighborhoods.
- **South.** Dedicating land for major employer and large parcel projects, while completing a network of projects that would relate to Kirkwood Boulevard, while setting the stage for future growth past the southern ridgeline, which necessitates improved infrastructure.
- **North.** Dedicating land for residential development, accompanied by a continuous parkway that connects neighborhoods and parks.
- **Northwest.** The concept completes the street network for neighborhoods and discourages development past the ridgeline, which necessitates improved infrastructure.

The intent is for infrastructure, including the storm sewer system, to be consistent with EnvisionCR's themes, guiding principles, and elements and includes an initiative to commission detailed studies for extending services to these growth areas. The plan provides a cursory review of infrastructure serviceability to growth areas as shown in Figure 22.

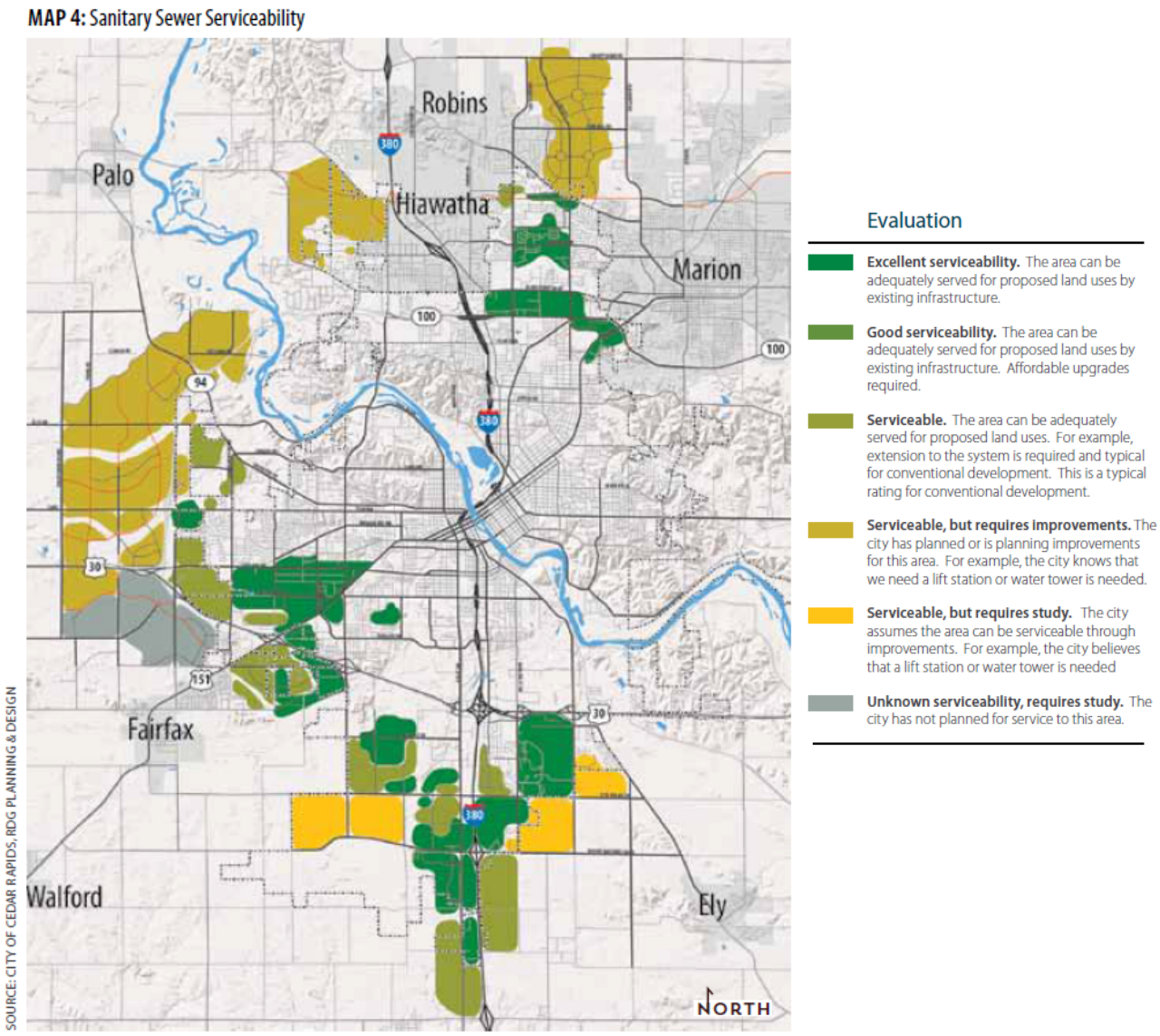


Figure 22 – Serviceability of Growth Areas from Envision CR

The Future Land Use Map from EnvisionCR included as Figure 23 identifies current and future land use across the entire city. More detailed future land use maps are included in the Appendix of EnvisionCR.

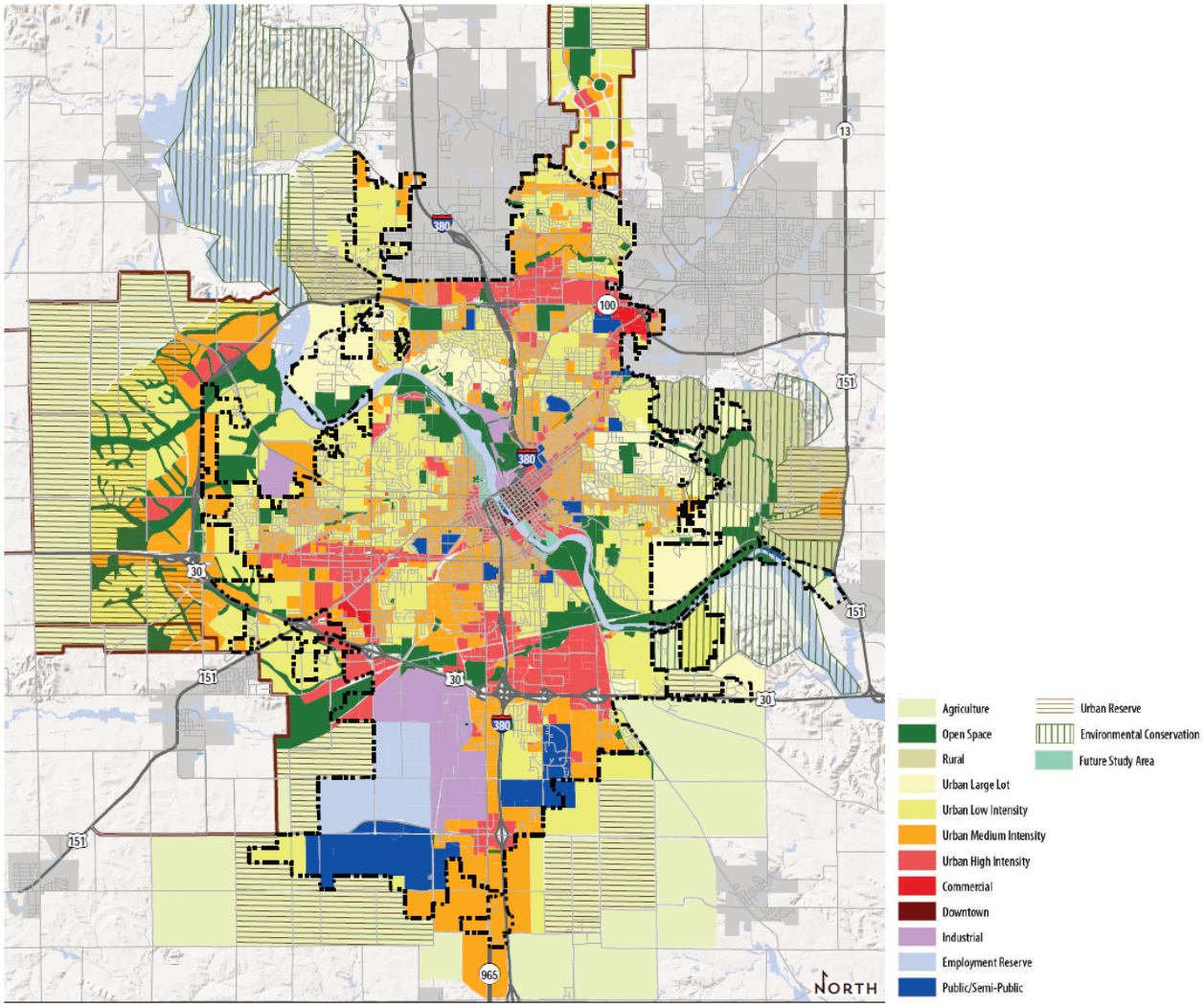


Figure 23 – Future Land Use Map from Envision CR

Figure 24 shows historic and forecast future population for Cedar Rapids as presented in EnvisionCR. As indicated, Cedar Rapids had an estimated population in 2012 of 128,119. Even with the adverse impact of the historic 2008 flood, the population was up 6.1 percent since 2000. The figure forecasts a 2035 population ranging from 142,062 to 161,073 based on annual growth rates from 0.45- to 1.0- percent, respectively.

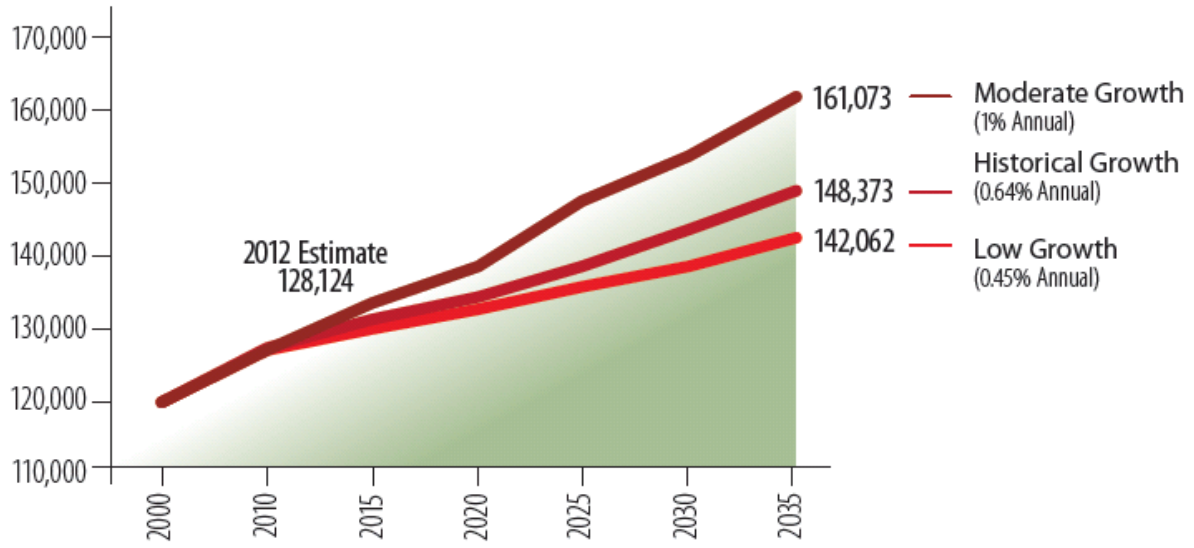


Figure 24 – Historic and Future population from Envision CR

Attachment A – National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer (MS4) Permit

The City of Cedar Rapids has been issued a National Pollutant Discharge Elimination System (NPDES) permit (permit No. 57-15-0-05) by the Iowa Department of Natural Resources (Iowa DNR). This permit authorizes the operation or our Municipal Separate Storm Sewer System (MS4) as well as stormwater point source discharges from the MS4 to waters of the state, in accordance with monitoring requirements and other terms set forth in the permit. The permit is issued on a 5-year cycle, with February 15, 2016, the next Date of Issuance. The City implements various elements of the permit as separate programs and enforces various requirements through Municipal Code. The permit outlines Stormwater Pollution Prevention and Management requirements as covered by the following areas:

1. Public Education and Outreach on Stormwater Impacts
2. Public Involvement and Participation
3. Illicit Discharges
4. Construction Site Storm Water Runoff Control
5. Post-Construction Stormwater Management
6. Pollution Prevention/Good Housekeeping
7. Monitoring Industrial and High Risk Run-Off

1. Public Education and Outreach on Stormwater Impacts	The City provides education on stormwater impacts to both businesses and residents in the context of: ▪ Illicit Discharges (hazardous wastes, fertilizers/pesticides, household wastes, yard waste, etc.) ▪ Pollution Prevention and Good Housekeeping ▪ Stormwater Best Management Practices Multiple and varied avenues of communication/outreach are utilized including: ▪ Brochures ▪ Stormwater Program Website ▪ Utility Inserts ▪ Press Releases ▪ Neighborhood Newsletter ▪ Social Media ▪ Text Casters ▪ Quarterly Our CR publication
2. Public Involvement and Participation	City personnel participate in recurring annual events as well as various City and non-City sponsored events that occur throughout the year, presenting stormwater topics and/or demonstrations. Stormwater volunteer programs, including Adopt-A-Storm-Drain and Mark-A-Storm-Drain, have been developed to help raise awareness through community involvement. The City has a 24/7 stormwater pollution prevention hotline to be used by the public for reporting stormwater concerns and feedback. The hotline is prominently placed on the stormwater program website. City staff continues to take part in various programs to facilitate public involvement, such as the Cedar River Watershed Coalition and Indian Creek Watershed Management Authority.
3. Illicit Discharges	The City continues to develop and implement an illicit discharge and elimination program for detecting and eliminating illicit discharges to the MS4. Standard operating procedures have been developed to include investigations, enforcement, reporting, and education elements. A dry weather flow program continues to be implemented for identifying illicit discharges, with dry weather inspections conducted for 20% of 252 City-defined outfalls on an annual basis. Results are compiled and recorded, and when necessary, sources of dry weather flows eliminated. The City continues to enforce Municipal Code Chapter 13.07(b)2., which prohibits the discharge of anything other than stormwater, allowable non-stormwater and pollutants for which an NPDES permit has been issued and when the discharge is in compliance with the

	permit, from entering the MS4. Violations of this ordinance are considered Municipal Infractions and are enforced, with penalties assessed, according to Municipal Code Chapter 13.19. Training and outreach efforts continue to be targeted to commercial entities that are potential or common violators. Educational material, including brochures and letters, is distributed to residential illicit discharge violators and surrounding neighbors.
4. Construction Site Storm Water Runoff Control	Municipal Code Chapter 71 addresses Erosion and Sediment Controls for Construction Sites. The ordinance requires proper soil erosion and sediment control as well as other waste that may cause adverse water quality impacts. Construction sites that result in a total disturbed area of greater than one-quarter acre are required to obtain an erosion control permit prior to any land-disturbing activity; a major erosion control permit is required for land-disturbance of greater than one acre, a minor erosion control permit is required for land-disturbance between one-quarter and one acre. Major permits require a Stormwater Pollution Prevention Plan conforming to Chapter 71 and the provisions set forth in the Iowa Department of Natural Resources (Iowa DNR) General Permit No. 2 (NPDES). Chapter 71 provides the authority to inspect sites for compliance with the approved erosion control plans as well as authority to enforce any violations of any provisions of the Chapter by civil action, including an action for injunctive relief, as well as a municipal infraction. City personnel are required to conduct a site plan and pollution prevention plan review prior to issuance of any permits. Site inspections by the permittee are required for all construction activities for sites for which coverage under General Permit No. 2 is required. Inspections are conducted quarterly as well as in response to complaints.
5. Post-Construction Stormwater Management	The post-construction stormwater management program ensures that controls are in place for preventing or minimizing water quality impacts from new construction and re-construction projects. Municipal Code Chapter 72: Stormwater Management Ordinance requires water quality and quantity components be considered in the design of new construction and implemented when practical. Private and public stormwater controls are inspected and reviewed for proper maintenance by Sewer Division personnel. A total of 771 private stormwater facilities are inspected on a 5-year cycle (20% per year). All 85 public basins are inspected on an annual basis. A manual titled “Best Management Practices for Maintenance of Private Stormwater Facilities” outlining the role, importance, and maintenance guidelines of stormwater control facilities, is posted on the stormwater program website.

	Inspection results are communicated to private stormwater facility owners in the form of a letter that outlines the role and importance of private stormwater facilities, lists necessary maintenance items specific to that stormwater facility, and is accompanied by an educational brochure. The letter also references the maintenance manual, provides the website link to the manual, and states that a hard copy can be requested.
6. Pollution Prevention/Good Housekeeping	Pesticide and Fertilizer Management Program A pesticide and fertilizer management program that includes Standard Operating Procedures outlining best practices for storage, application, and disposal of pesticides and fertilizers, identifies all municipal entities that apply pesticides and fertilizers by certified and properly trained individuals, as well as employee training, continues to be implemented. Metrics have been developed to assess the current status of application rates to determine if there are practices that can be implemented to reduce application rates. Training Program for Municipal Employees A training program continues to be implemented and developed for municipal employees whose activities could have an impact on stormwater quality. Training that covers pollution prevention, good housekeeping, illicit discharge, and construction site pollution prevention, is offered to municipal employees during the non-field season. This training is facilitated by Sewer Division personnel. Additional training is required by the Municipal Facility SWPPPs that are under development, requiring facility BMP training. Stormwater Pollution Prevention Plans (SWPPPs) are currently being developed for municipal facilities. Detailed SWPPPs will be completed for facilities whose operations pose or generate stormwater risks. A general SWPPP has been developed for all other municipal facilities, outlining universal best management practices to be implemented.
7. Monitoring Industrial and High Risk Run-Off	The City continues to implement a program for monitoring industrial and high-risk runoff. Information is collected from each USEPA identified “313” Industry via a survey and letter. The City performs stormwater inspections of each of these facilities.

Attachment B – Prior Studies

Name	Date	Change since study	Action taken
Floodplain Info Report	December 1964	Significant	Constructed 1st Street SW/NW River Berm
Floodplain Info Report	February 1966	Significant	Completed 1st Street SW/NW River Berm
Effects of Floodplain Encroachment Indian and Dry Creeks	September 1966	Significant	Various, some developments still done in or next to flood areas (Cottage Grove Parkway SE), no houses in the direct 1 percent flood chance areas for surface flows but basements were below the elevations
Flood Profile Study Prairie Creek	October 1966	Moderate and increasing	Minimal – did allow building in floodplain
Floodplain Info Report	October 1967	Significant	Various
Flood Profile Study Squaw Creek	June 1968	Significant	Change in detention basin requirements in new developments
Flood Profile Study Morgan Creek	May 1970	Minor	Change in detention basin requirements in new developments
Flood Profile Study Hoosier Creek	October 1970	Moderate	Change in detention basin requirements in new developments
13th Avenue SW	January 1971	Minor	Completed with I-380
4th Avenue SW	March 1971	Minor	Completed with I-380
City-Wide Storm Water Management Plan	1981	N/A	Very high level plan, many of the items have been done
River Walls Study	March 1977	Minor	Repairs made
FEMA Flood Insurance Study	June 1982	Moderate	N/A
O Avenue NW/Harrison School	January 1983	Minor	Detention basin constructed adjacent to Harrison School. Additional upstream detention is needed.
Bowman Wood	1987	Major	Basins built per plan, C Avenue to Kent Drive NE surface path has significant sediment
FEMA Flood Insurance Study – revised Vinton Drainageway	December 1987	Moderate	Minimal – Removals of sediment in basin south of E Avenue in 2005 and 2006 and Gabion area in 2012
FEMA Flood Insurance Study	March 1991	Moderate	N/A
Stormwater Master Plan	1998	Various depending on area but most had minor	Minimal - Improvement on 42nd and Center Point Road flows

Name	Date	Change since study	Action taken
Flood Management in Dry Creek and Indian Creek Watersheds	December 2002	Moderate	2014 and 2015 built structures and berm on Cottage Grove Parkway SE
Flood Valve Replacement	March 2008	N/A	Completed
Planning of Restoration and Mitigation of Publicly Owned Detention Basins	August 2008	Minor	16 of the basins had repairs by contract or by City Staff
Cedar River West Side Pump Stations and Isolation Valve Study			None
Cedar Rapids River Corridor Redevelopment Flood Mitigation Options	March 2009	N/A	Starting
Cedar river storm sewer improvements – flood valve protection Proj # 3302600004	2009	Minor	None
City of Cedar Rapids Storm Sewer Maps	On going	N/A	60 percent of public surface features inspected in last 6 years, updated with CIPs and new development. Does not provide engineering grade elevation for most features.
City of Cedar Rapids Zoning Map	2014 – IT GIS	N/A	N/A
2 Feet Topographic Mapping	2012 – IT GIS	Minor	N/A
ACOE Indian Creek Watershed Hydraulic Model	2014	Minor	N/A
EnvisionCR Comprehensive Plan	January 2015	NA	N/A

Attachment C – Known Problem Areas

The following table identifies known storm water issues in Cedar Rapids. Issues, a proposed scope of work, and a priority rank (based on rankings developed for the 2017 CIP) are shown.

ID	Watershed	Location	Quad-rant	Issue	Proposed Scope of Work	Est. Total Cost	Evaluation	Prioritized Rank	Prioritization Score	Other Factors
Case 18	Morgan Creek	Rockhurst Drive SW	SW	Overland and residential flooding within the Stoney Point subdivision	Construct an upstream detention basin	1,152,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	1	90	Land Acquisition Required Basin Modelling
Case 23	O Avenue	Detention basin west of 11th Street NW and south of N Avenue	NW	No suitable overland flow path from the detention basin near Harrison Elementary overtops. Outlet structure from basin does not meet design standards	Model drainage area to compare upstream basin vs overland path	1,500,000	O Avenue Drainage Study (Shive, January 1983)	2	79	Basin Modelling
-	Prairie Creek	Beverly Road SW	SW	Culvert failure	Replace failed culvert	216,785	2014 FEMA Site Inspection	3	79	
Case 12	Prairie Creek	27th Street SW north of 29th Avenue	SW	Failure of undersized culvert	Replaced 132-inch steel-plate culvert with triple 12'x7' RBC	776,000	2014 FEMA Site Inspection	4	76	Completed Design (Shive-Hattery)
Case 101	Ushers Ferry	Gibson Drive NE	NE	Detention basins are undersized resulting in overtopping and flooding of yards.	Reconstruct detention basins.	500,000	None	5	72	
Case 102	Prairie Creek	18th Street SW at 29th Avenue	SW	Existing culvert is aging and is undersized.	Replace Existing Culvert.	700,000	None	6	71	
Case 26	E Avenue	Auburn Drive SW north of 16th Avenue	SW	Flooding due to no overland flow path	Construct additional intakes and a stormwater channel to convey overland flow	260,000	2014 City Evaluation (304425)	7	69	
Case 103	Czech Village	20th Avenue SW	SW	Road closed due to culvert failure	Replace Culvert with 5'x7' RBC	332,925	2014 FEMA Site Inspection	8	69	
Case 104	Ushers Ferry	Ushers Ferry	NE	Residential development creating excessive stormwater runoff.	Construct Detention Basin	500,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	9	69	
Case 170	O Avenue	1521 Hidden Hollow Lane NW	NW	Existing 30" RCP Culvert has pipe separation and severe erosion. Located in 30-ft easement between two homes.	Culvert failure with severe erosion between two houses within drainage easement. Existing 30" RCP has separation at joints. Relay culvert, install outlet structure, Install additional culvert in lieu of overland flow path.	115,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	10	69	PROGRESSIVE DAMAGE (Small storms causing continued erosion between two houses.)
Case 20	Kenwood	Forest and Grande SE	SE	Conveyance capacity limited resulting in flooded neighborhood		4,000,000	1998 Stormwater Master Plan	11	62	Basin Modelling
Case 20	Kenwood	Meadowbrook at Bever SE	SE	Flooding in yards	Model drainage area and construct upstream detention basin(s) to attenuate flow	0	None	12	62	Basin Modelling
Case 20, Case 30	Kenwood	Park Court SE	SE	Flooding at Park Ct caused by overland flow		0	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	13	62	Basin Modelling
Case 20, Case 16	Kenwood	Washington Avenue SE	SE	Flooding at Washington Avenue SE caused by overland flow		0	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	14	62	Basin Modelling
Case 29	E Avenue	Johnson Avenue NW Hy-Vee and B Avenue NW	NW	Flooding due to undersized box culvert and inadequate overland flow path	Model drainage area and expand upstream detention	3,000,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	15	62	Basin Modelling
Case 105	E Avenue	Vinton Ditch at D Avenue	NW	Storm sewer separation causing structure instability of gabion wall.	Repair storm sewer.	100,000	None	16	62	Basin Modelling
Case 31	Indian Creek	Between Sunland Court SE and Cottage Grove Parkway	SE	No overland path	Extend storm sewer to reduce backyard flooding.	250,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	17	62	Residential Buy-out

ID	Watershed	Location	Quad-rant	Issue	Proposed Scope of Work	Est. Total Cost	Evaluation	Prioritized Rank	Prioritization Score	Other Factors
Case 27	E Avenue	31st Street SW between 2nd Avenue and 12th Avenue	SW	Excessive overland flow causing flooding on 2nd Avenue SW.	Construct upstream detention, complete localized grading, expand storm sewer	2,250,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	18	62	Basin Modelling
Case 20	Kenwood	A Avenue and B Avenue NE	NE	Extensive property damage from flash flooding. Location is near the end of the Kenwood watershed.	Regrade for overland flow path or add upstream detention to reduce peak flows. Cost estimate if for overland flow path.	2,450,000	2015 Storm Sewer/Drainage Investigations (City)	19	59	Basin Modelling
Case 106	Cedar River	Penn Avenue NW at 1st Street NW	NW	Storm sewer is clogged. Requires new manhole to access pipe.	Install manhole with sluice gate. Remove debris from storm sewer. Construct headwall around storm sewer outlet	150,045	2014 FEMA Site Inspection	20	59	
Case 107	Prairie Creek	Lakeview Drive SW north of Beverly Road	SW	Overland flow resulted in erosion	Bank restoration	65,000	2014 FEMA Site Inspection	21	59	
Case 108	Cedar River (Bel Air)	Bel Air Drive SE	SE	Road washout at dead-end.	Remove and replace damaged road. Provide better path for overland flow.	100,000	2014 FEMA Site Inspection	22	59	
Case 1	Indian Creek	Clark Road SE	SE	No suitable overland flow path. Structures such as fences, wall, and garages encroach onto drainage easement.	Construct overland flow path. Remove encroachments	460,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	23	59	Policy Issue - Drainage Easement Encroachment
Case 111	Rockford Road	18th Street SW south of 16th Avenue	SW	Regional detention basin required as part of development agreement	Construct Regional Detention Basin	650,000	None	24	59	Previous City Commitment
Case 25	Prairie Creek	12th Street SW near 32nd Avenue	SW	No overland path results in flooding of business	Construct swale in 11th street ROW from 29th Street south to 32nd Avenue. Construct culvert crossing 12th Street SW	641,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	25	57	
Case 11	E Avenue	1st Avenue SW at Cleveland Elementary	SW	No suitable overland flow and undersized culvert crossing	Model drainage area, add additional detention, complete culvert replacement, and provide overland path as needed	5,000,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	26	57	Basin Modelling
Case 19	E Avenue	Vinton Ditch at E Avenue NW	NW	Ditch floods at culvert restriction, properties are within FEMA 100-year Floodplain	Construct upstream detention	2,694,204	Vinton Ditch Drainage Issues - July 2, 2010 (Foth, 304037-02), 2015 Storm Sewer/Drainage Investigations (City)	27	57	Basin Modelling
Case 109	E Avenue	Edgewood Road SW at 16th Avenue	SW	Overland flow flooding arterial street	Expand detention basin to reduce flow rate, increase pipe capacity under street.	500,000	1998 Stormwater Master Plan	28	55	
Case 110	Kenwood	35th Street NE at Collins Plant	NE	Potential building flooding	Build berm, extend storm sewer, increase storm capacity	600,000	1998 Stormwater Master Plan	29	55	
Case 38?	Czech Village	6th Street SW 1200 Block	SW	Conveyance capacity limited resulting in flooded neighborhood	Construct Detention Basin	1,000,000	1998 Stormwater Master Plan	30	55	
Case 114	Kenwood	D Avenue NE from 38th Street to 39th Street	NE	Localized flooding caused by undersized storm sewer	Expand storm sewer and intake capacity	250,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	31	55	
Case 115	Kenwood	Meadowbrook Drive SE from 22nd Street to 26th Street	SE	Aging and undersized infrastructure. Large areas with no storm sewer. Overland flow caused road damage and flooding in yards.	Replace and expand storm sewer	250,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	32	55	
Case 116	Kenwood	D Avenue NE From 30th Street to 32nd Street	NE	Existing storm sewer is undersized	Replace storm sewer	450,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	33	55	
Case 117	Kenwood	Grande Avenue SE from Crescent Street to Park Terrace	SE	Aging and undersized infrastructure	Replace storm sewer	500,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	34	55	
Case 120	Rockford Road	South of Jefferson High School west of 18th Street SW	SW	Failed storm sewer and flooding in parking lot	Repair existing storm sewer. Install new 24-inch RCP and intakes	215,000	Anderson-Bogert Design	35	53	

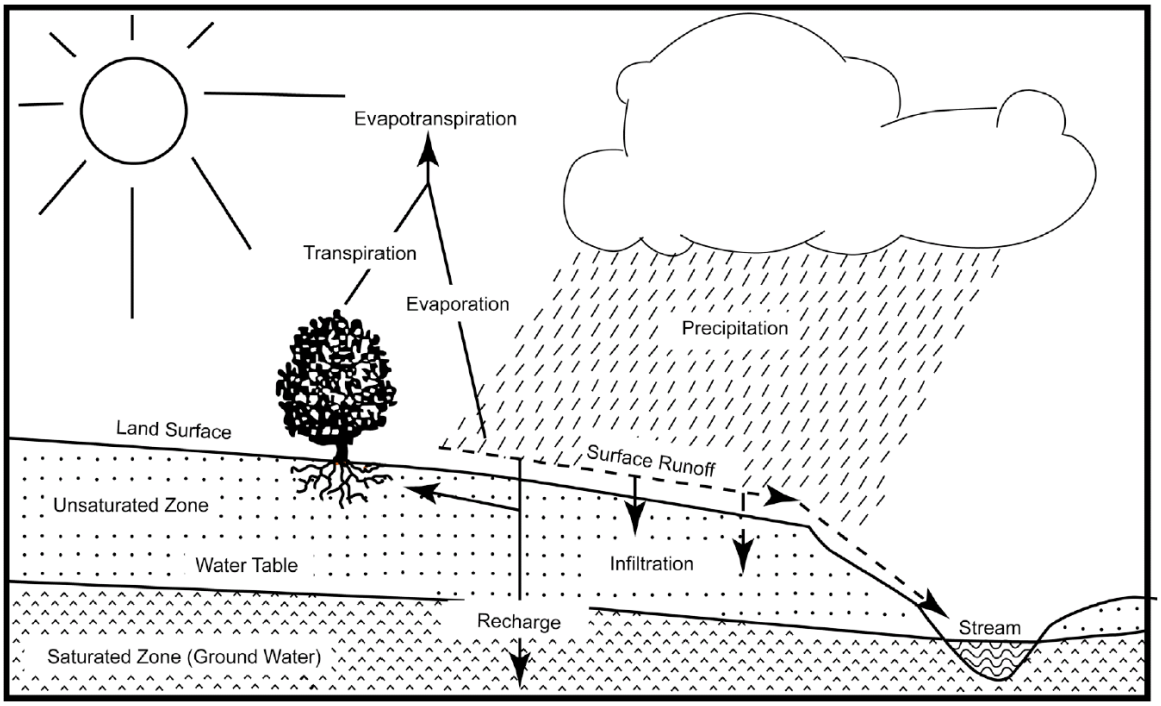
ID	Watershed	Location	Quad-rant	Issue	Proposed Scope of Work	Est. Total Cost	Evaluation	Prioritized Rank	Prioritization Score	Other Factors
Case 47	Czech Village	Wilson Avenue near Murdock Funeral Home	SW	Unsuitable overland flow path	Construct overland flow path through cemetery	491,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	36	52	
Case 118	Cedar River (Bel Air)	Between 38th Street and 39th Street SE	SE	Excessive overland flow	Grade overland flow pathway along the backyards	640,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	37	52	
Case 119	Czech Village	Detention basin north of Novac Court SW	SW	Detention basin overtops causing flooding	Increase outlet pipe capacity and size of basin	1,000,000	None	38	52	
Case 122	E Avenue	Johnson Avenue SW from 1st Avenue to West Post Road	SW	Existing storm sewer is undersized	Replace storm sewer	300,000	1998 Stormwater Master Plan	39	52	
Case 112	Kenwood	Cedar Lake	NE	Cedar Lake sedimentation	Remove potentially contaminated sediment	1,000,000	None	40	50	
Case 125	Kenwood	Blake Boulevard SE from Forest Drive to Crescent Street	SE	Aging and undersized infrastructure	Replace storm sewer	200,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	41	50	
Case 121	O Avenue	Schultz Dive NW	NW	Overland flow from Madison School and hill to the south flood houses on this and apartment complex on O Ave	Construct berm, extend storm sewer	250,000	None	42	48	
Case 123	Kenwood	23rd Street Drive SE East of Forest Drive	SE	Drainage issues at 23rd Street SE East of Forest Drive	Expand storm sewer to improve drainage.	150,000	None	43	48	
Case 124	McLeod Run	Noelridge Park	NE	Additional stormwater detention	Construct new detention basin to reduce down stream impacts caused by new development around Collins Road	340,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	44	48	
Case 40	Rockford Road	Rockford Road near Cargill Plant	SW	Excessive overland flow floods buildings	Regrade Rockford Road to address flooding from overland flow (18th Street detention basin should reduce peak flows to Rockford Road)	2,615,000	1998 Stormwater Master Plan, 2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	45	48	
Case 127	Prairie Creek	J Street SW north of Miller Avenue	SW	Drainage channel needs clearing, flooded street	Clean drainage way	35,000	None	46	48	
Case 128	Kenwood	26th Street SE near Beaver Avenue	SE	Ponding water on southbound lane	Extend Storm Sewer or Regrade Road	250,000	None	47	48	
Case 132	Morgan Creek	Rockvalley Ln Drainage Channel	NW	Stormwater flow is causing excessive channel erosion	Bank stabilization	200,000	None	48	48	
Case 100	Morgan Creek	Morgan Creek	SW	Morgan Creek detention basin is undersized. No suitable overland flow path to the basin.	Grade swale for path to the basin. Increase basin capacity. Replace outlet structure	175,000	City	49	47	Private Development Issue
Case 133	Cedar River	Ellis Road NW	SE	Damaged outfall on Ellis Road NW	Remove 12" drain tile and replace with 24" RCP. Install an in-line flood protection valve.	67,680	2014 FEMA Site Inspection	50	47	
Case 126	Cedar River (Van Vechten)	Van Vechten Park	SE	Van Vechten Park – no name stream exposed sanitary line	Bank stabilization	50,000	None	51	45	
Case 14	Prairie Creek	Badger Drive SW	SW	Properties located within Floodplain	Increase storm sewer capacity and regrade drainage path	67,380	2015 Storm Sewer/Drainage Investigations (City)	52	45	
Case 41	Rockford Road	5th Avenue SW east of Rockford Road	SW	Excessive overland flow floods buildings	Install additional intakes to tie into the large box culvert running underneath the road (Initial evaluation shows culvert meets 100-year event. upstream detention at 18th Street should help issue)	100,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	53	45	

ID	Watershed	Location	Quad-rant	Issue	Proposed Scope of Work	Est. Total Cost	Evaluation	Prioritized Rank	Prioritization Score	Other Factors
Case 129	E Avenue	F Avenue NW at 19th Street	NW	Undersized culvert under F Avenue NW	Replace culvert	50,000	None	54	45	
Case 7	Prairie Creek	Handly Court SW	SW	Undersized culvert at Handley Ct SW	Replace 24" culvert with dual 18" culvert	90,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	55	45	
Case 36	Indian Creek	30th Street Drive SE	SE	Properties located within Floodplain	Assist in elevating 3 homes	266,850	2015 Storm Sewer/Drainage Investigations (City)	56	45	
Case 130	Morgan Creek	Lakeview Drive SW north of Beverly Road	SW	Retention basin overtopping, culvert may be undersized and overland flowpath needs to be assessed	Replace or extend culvert and regrade an overland flow path	350,000	None	57	45	
Case 131	Prairie Creek	Bowling Street SW at Prairie Creek	SW	Flooded business	Build berm or relocate business	600,000	2014 FEMA Site Inspection	58	45	
Case 35	Kenwood	24th Street Drive SE and 1st Avenue	SE	Isolated flooding caused by insufficient overland flow path	Extend storm sewer, or regrade overland flow path	130,000	2015 Storm Sewer/Drainage Investigations (City)	59	43	
Case 135	Cedar River	44th Street SE south of Pioneer Trail	SE	Overland flow flood the street	Construct new culvert and minor bank work	30,000	None	60	41	
Case 136	Morgan Creek	Morgan Creek	SW	Washout caused by overland flow	Replace headwall and wingwall of culvert. Provide rip-rap to limit future erosion.	35,000	2014 FEMA Site Inspection	61	41	
Case 137	Cedar River (Bel Air)	Harold Drive SE at 14th Avenue	SE	Capacity limited overland flow path flooded street	Construct flow path and stabilize or increase detention	500,000	None	62	41	
Case 139	Prairie Creek	Miller Avenue SW east of Vermont Street	SW	Drainage channel needs clearing, flooded street	Clear drainage way	35,000	None	63	41	
Case 13	McLeod Run	Clifton Street NE	NE	Poor drainage due to lack of storm sewer	Extend storm sewer to mitigate drainage issue	50,000	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	64	41	
Case 140	Indian Creek	Green Valley Terrace SE	SE	Damaged 48-inch storm sewer	Repair storm sewer	50,000	2014 FEMA Site Inspection	65	41	
Case 138	Indian Creek	Savannah Court SE	SE	Topography to flat to support outlet flow from street, stagnant water and flooded residential street	Reconstruct of storm sewer	50,000	None	66	40	
Case 44 and 48?	Indian Creek	Skylark Lane at Red Fox Road SE	SE	Overland flow floods yards	Extend storm sewer	66,400	2015 Storm Sewer/Drainage Investigations (Anderson-Bogert)	67	40	
Case 159	Cedar River	18th Street NW south of Ellis Road	NW	Channel erosion	Construct new piping and repair erosion	100,000	None	68	40	
Case 141	Indian Creek	East of 3900 block 1st Avenue	SE	Overland flow path resulting in flooded parking areas	Increase intake and storm sewer capacity	20,000	None	69	38	
Case 142	McLeod Run	Oriole Court NE to Finch Court	NE	Poor drainage	Extend storm sewer	150,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	70	38	
Case 143	Kenwood	37th Street NE and Eastern Avenue	NE	Storm sewer lacks conveyance capacity causing flooded residential streets	Extend storm sewer, increase detention	250,000	None	71	38	
Case 144	McLeod Run	Cavalier Street NE east of Harding School	NE	Inadequate conveyance piping, flooded residential streets	Install drain tile and extend storm sewer	250,000	None	72	38	
Case 145	McLeod Run	Oakland Road NE south of Elmhurst Drive	NE	Flooding occurs within the street on Oakland Road	Install new storm sewer in Oakland Road to reduce flooding and ponding of stormwater on the street	300,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	73	38	

ID	Watershed	Location	Quad-rant	Issue	Proposed Scope of Work	Est. Total Cost	Evaluation	Prioritized Rank	Prioritization Score	Other Factors
Case 146	McLeod Run	48th Street NE west of Council Street	NE	Inadequate conveyance piping, flooded residential streets and yards	Install drain tile and extend storm sewer	350,000	None	74	38	
Case 147	O Avenue	Granny Smith Lane NW	NW	Overland flow at peak period floods residential road	Reconstruct overland path, reconstruct road sections to support, increase pipe capacity to receive the flow	1,400,000	None	75	38	
Case 150	Czech Village	A Street SW near landfill	SW	Damaged storm sewer outfall	Replace 12-inch DIP storm sewer and reconstruct berm with compacted clay and rip-rap.	31,443	2014 FEMA Site Inspection	76	38	
Case 152	McLeod Run	McLeod Run banks near 42nd Street NE	NE	Bank erosion	Bank stabilization	150,000	None	77	38	
Case 148	Cedar River (Bel Air)	Between 38th Street and 39th Street SE	SE	Excessive overland flow	Fill eroded areas, stabilize, and remove debris. Grout upstream storm sewer joints.	83,672	2014 FEMA Site Inspection	78	36	
Case 149	Czech Village	20th Avenue SW north of Wilson Hy-Vee	SW	Overland flow floods backyards	Modification to inlet structure	25,000	None	79	34	
Case 153	Cedar River (Apple Mesa)	J Avenue NE east of Adirondack Drive	NE	Conveyance limited resulting in street flooding	Construct new culvert and minor bank work	10,000	None	80	34	
Case 154	Cedar River (Van Vechten)	Otis Road SE	SE	Undersized culvert resulting in flooded street	Complete hydraulic modeling. Construct new culvert and minor bank work	50,000	2014 FEMA Site Inspection	81	34	
Case 156	Ushers Ferry	Riverview Road NE west of Miller Road	NE	Channel overtops flooding backyards	Bank stabilization	100,000	None	82	34	
Case 157	Indian Creek	34th Street Drive SE from 1st Avenue to Indian Creek	SE	Poor surface water drainage	Increase capacity of existing storm sewer	300,000	Cedar Rapids Capital Improvement Project Program FY2008 through FY2017	83	34	
Case 158	McLeod Run	H Avenue NE to Center Point to I Avenue	NE	Poor drainage	Expand storm sewer to increase capacity and improve drainage from H to Center Point and from Center Point to I Avenue	400,000	None	84	34	
Case 160	O Avenue	Alley between L Ave and K Avenue West of Ellis Boulevard	NW	Alley is flat resulting in poor drainage	Extend storm sewer	50,000	None	85	34	
Case 162	McLeod Run	G Avenue NE at Center Point Road	NE	No conveyance systems resulting in ponding on arterial street	Extend storm sewer to the location	750,000	None	86	28	
Case 163	McLeod Run	Brookland Drive NE	NE	Insufficient storm sewer capacity causing backyard flooding	Replace storm sewer	1,000,000	None	87	28	
Case 164	Cedar River	Old River Road SW	SW	Failed culvert headwalls	Replace headwalls	51,684	2014 FEMA Site Inspection	88	28	
Case 165	Indian Creek	40th Street Drive SE	SE	Bank erosion	Bank stabilization	150,000	None	89	28	
Case 166	Kenwood	Cedar Lake	NE	North end of Cedar Lake into Cedar River outlet structure reduced flow to river	Remove sediment, fix structure	150,000	None	90	28	
Case 161	Cedar River	Robbins Lake at Ellis Road NW	NW	Sedimentation from stream along Edgewood Rd affecting fish habitat	Pump out, remove sediment, restock	250,000	None	91	24	
Case 167	Prairie Creek	Wilson Avenue SW at Arlington Street	SW	Debris and invasive trees in City wetland	Clean wetland	20,000	None	92	19	
Case 168	Czech Village	10th Ave SW at 7th and 8th Street SW	SW	Area is very flat and floods numerous homes. No curb and gutter in the area.		0		93	0	
Case 169	McLeod Run	West of Noelridge Park Outlet Structure	NE	The overland flow from the pond has flooded out at least one home (perhaps more).		0		94	0	

Attachment D – Hydrologic Cycle

Some readers of this plan may not be as familiar with the hydrologic cycle. This is a brief discussion based on the New Jersey Stormwater Best Management Practices Manual, Chapter 1. Land development can dramatically alter the hydrologic cycle of a site and, ultimately, an entire watershed. Prior to development, native vegetation can either directly intercept precipitation or draw that portion that has infiltrated into the ground and return it to the atmosphere through evapotranspiration. Development can remove this beneficial vegetation and replace it with lawn or impervious cover, reducing the site's evapotranspiration and infiltration rates.



Groundwater Recharge in the Hydrologic Cycle

Clearing and grading a site can remove depressions that store rainfall. Construction activities may also compact the soil and diminish its infiltration ability, resulting in increased volumes and rates of stormwater runoff from the site. Impervious areas that are connected to each other through gutters, channels, and storm sewers can transport runoff more quickly than natural areas. This shortening of the transport or travel time quickens the rainfall-runoff response of the drainage area, causing flow in downstream waterways to peak faster and higher than natural conditions. These increases can create new and aggravate existing downstream flooding and erosion problems and increase the quantity of sediment in the channel.

Filtration of runoff and removal of pollutants by surface and channel vegetation is eliminated by storm sewers that discharge runoff directly into a stream. Increases in impervious area can also decrease opportunities for infiltration which, in turn, reduces stream base flow and groundwater recharge. Reduced base flows and increased peak flows produce greater fluctuations between

normal and storm flow rates, which can increase channel erosion. Reduced base flows can also negatively impact the hydrology of adjacent wetlands and the health of biological communities that depend on base flows. Finally, erosion and sedimentation can destroy habitat from which some species cannot adapt.

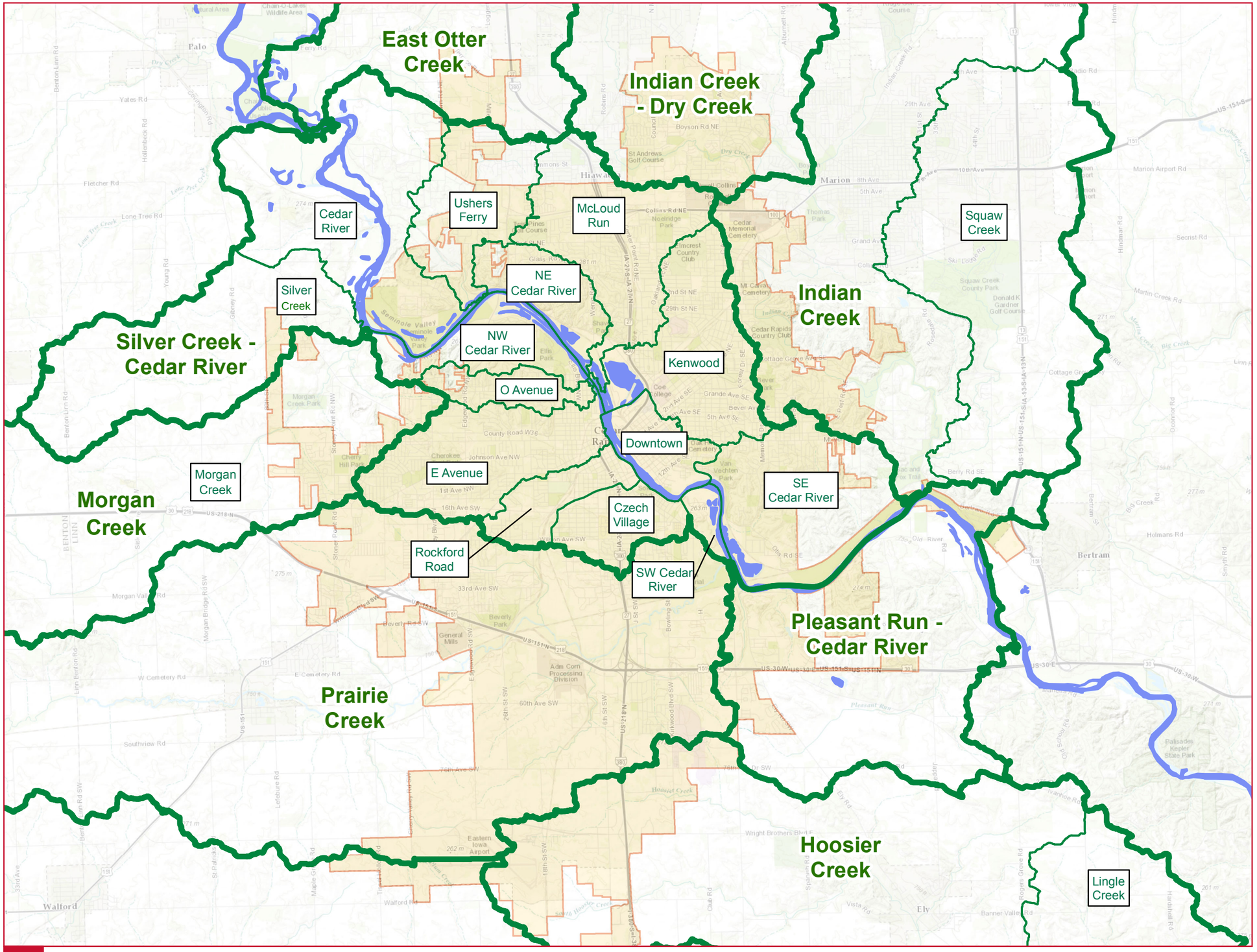
In addition to increases in runoff peaks, volumes, and loss of groundwater recharge, land development often results in the accumulation of pollutants on the land surface that runoff can mobilize and transport to streams. New impervious surfaces and cleared areas created by development can accumulate a variety of pollutants from the atmosphere, fertilizers, animal wastes, and leakage and wear from vehicles. Pollutants can include metals, suspended solids, hydrocarbons, pathogens, and nutrients.

In addition to increased pollutant loading, land development can adversely affect water quality and stream biota in more subtle ways. For example, stormwater falling on impervious surfaces or stored in detention or retention basins can become heated and raise the temperature of the downstream waterway, adversely affecting cold water fish species such as trout. Development can remove trees along stream banks that normally provide shading, stabilization, and leaf litter that falls into streams and becomes food for the aquatic community (New Jersey Stormwater Best Management Practices Manual, Chapter 1, February 2004).

Attachment E – Watershed and Sub Watershed Maps

Exhibit 1	Watershed and Sub Watershed Map
Exhibit 2	Cedar River Sub Watershed
Exhibit 3	NW Cedar River Sub Watershed
Exhibit 4	O Avenue Sub Watershed
Exhibit 5	Morgan Creek Watershed
Exhibit 6	E Avenue Sub Watershed
Exhibit 7	Rockford Road Sub Watershed
Exhibit 8	Czech Village Sub Watershed
Exhibit 9	Prairie Creek Watershed
Exhibit 10	Hoosier Creek Watershed
Exhibit 11	Pleasant Run
Exhibit 12	East Otter Creek Watershed
Exhibit 13	Ushers Ferry Sub Watershed
Exhibit 14	NE Cedar River Sub Watershed
Exhibit 15	McLoud Run Sub Watershed
Exhibit 16	Dry Creek Sub Watershed
Exhibit 17	Kenwood Sub Watershed
Exhibit 18	Downtown Sub Watershed
Exhibit 19	SE Cedar River Sub Watershed
Exhibit 20	Indian Creek Watershed
Exhibit 21	Squaw Creek Sub Watershed
Exhibit 22	Silver Creek Sub Watershed
Exhibit 23	SW Cedar River Sub Watershed
Exhibit 24	Lingle Creek Sub Watershed

EXHIBIT 1
WATERSHED AND SUB WATERSHED MAP

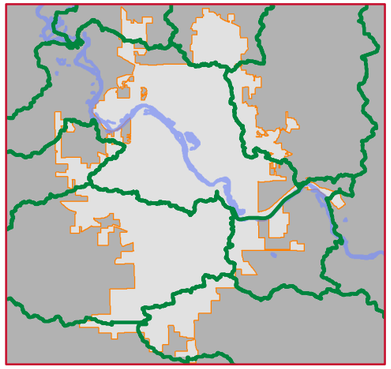


City Boundary

Cedar River

Watershed

Sub Watershed



0 Miles 1.5

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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PATH: Z:\PROJECTS\258297-CR_STROMWATER_MASTER_PLAN\MAP_DOCS\MXD\CR_TM1_FIG_6_11X17_WATERSHED_OVERVIEW.MXD - USER: WWHEELER - DATE: 5/6/2016

EXHIBIT 2
CEDAR RIVER SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

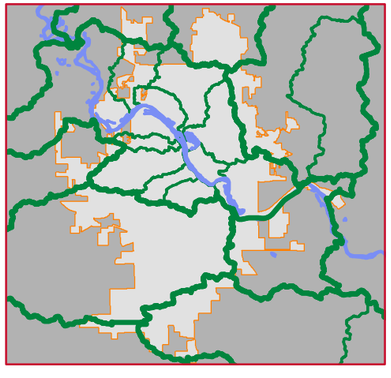
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,600

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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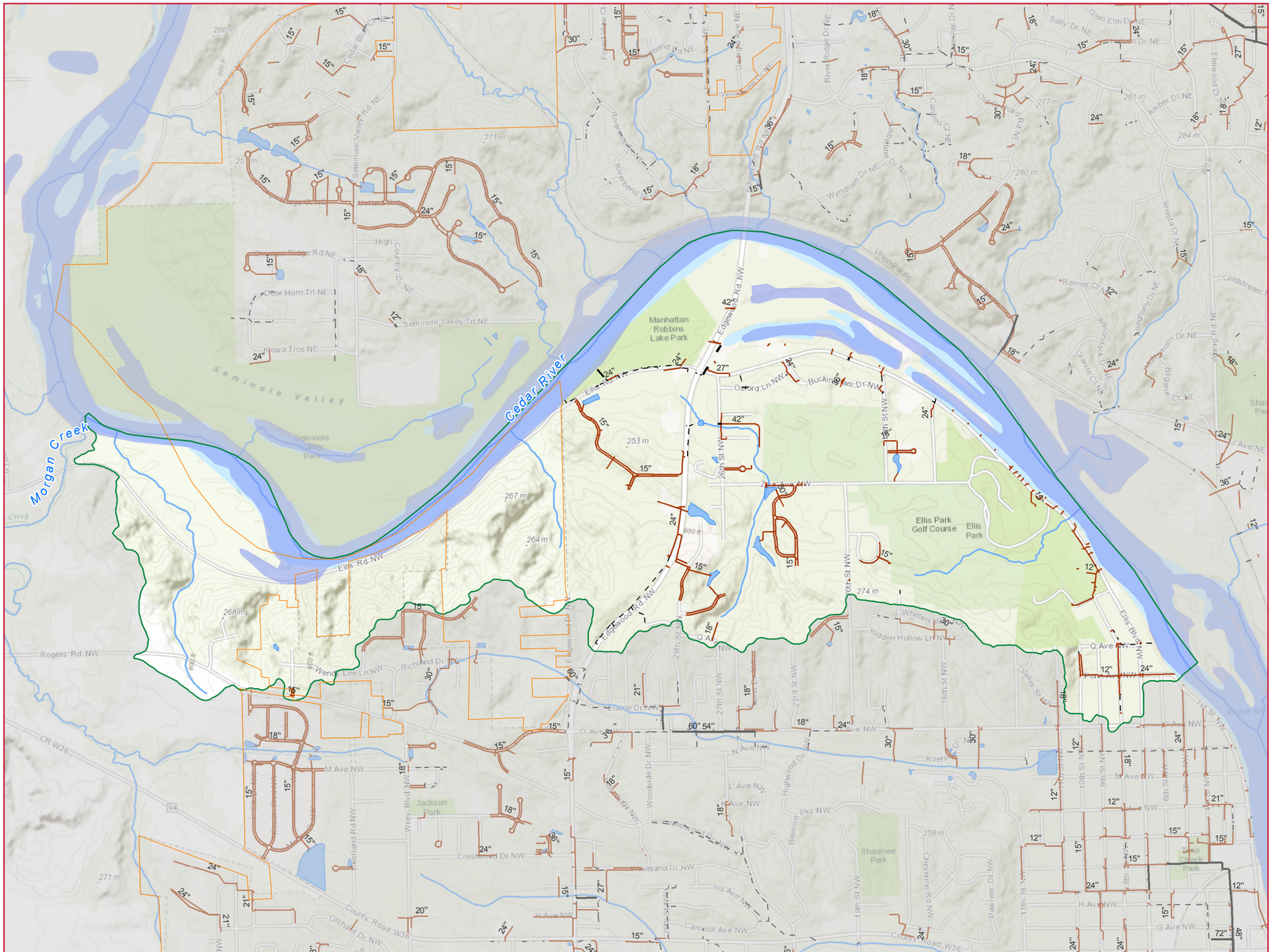


EXHIBIT 3
NW CEDAR RIVER SUB WATERSHED SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

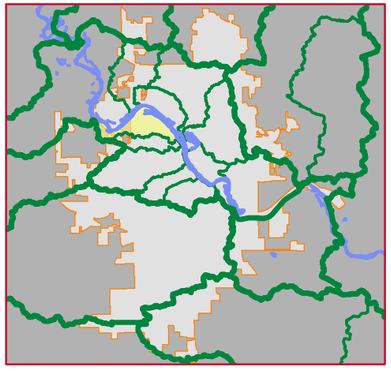
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,600

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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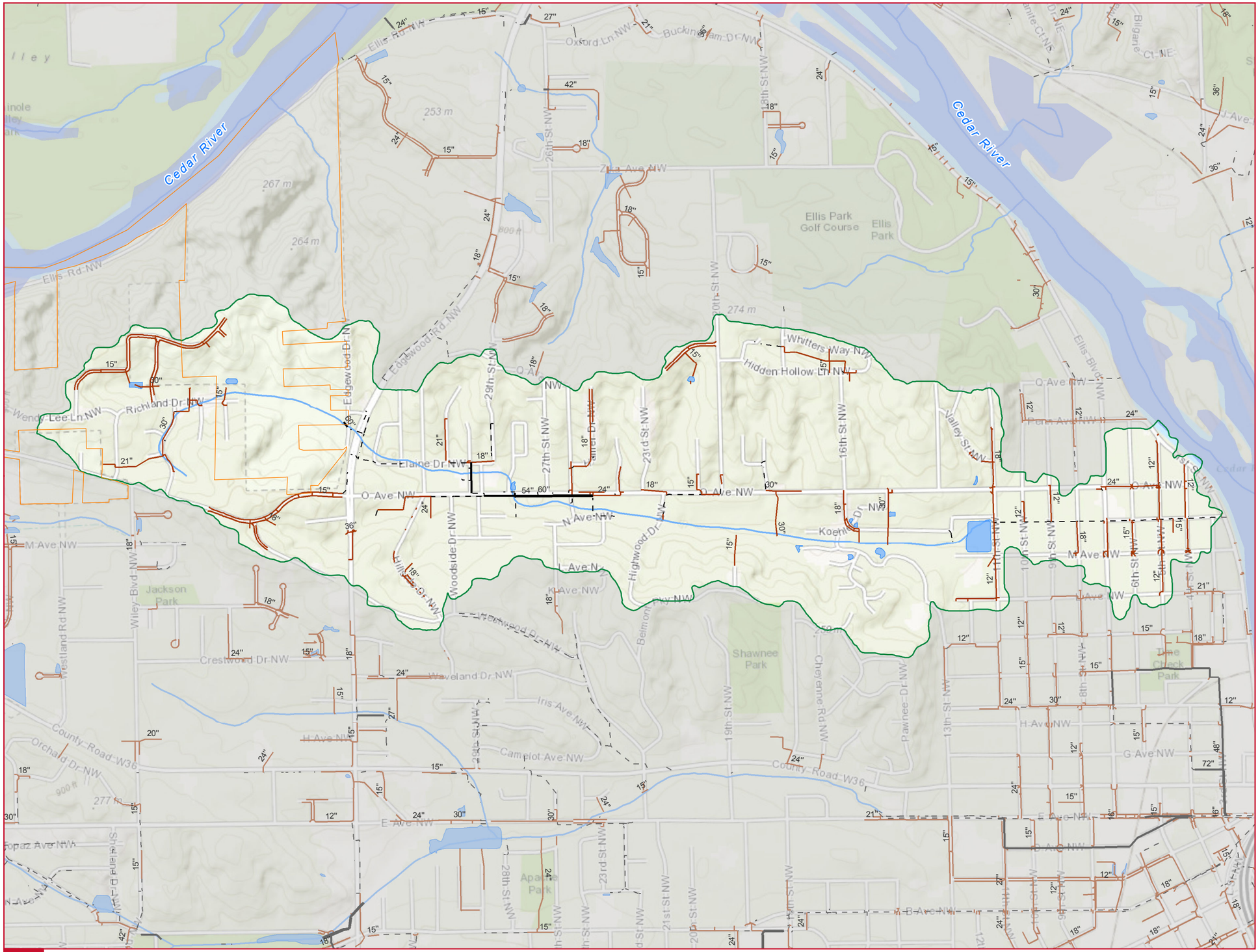


EXHIBIT 4
O AVENUE SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

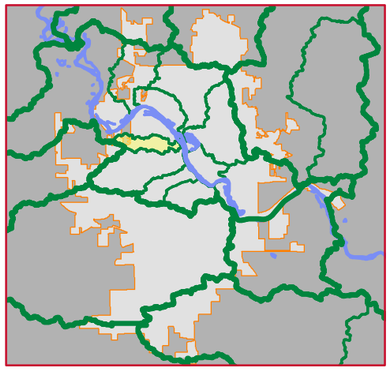
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,200

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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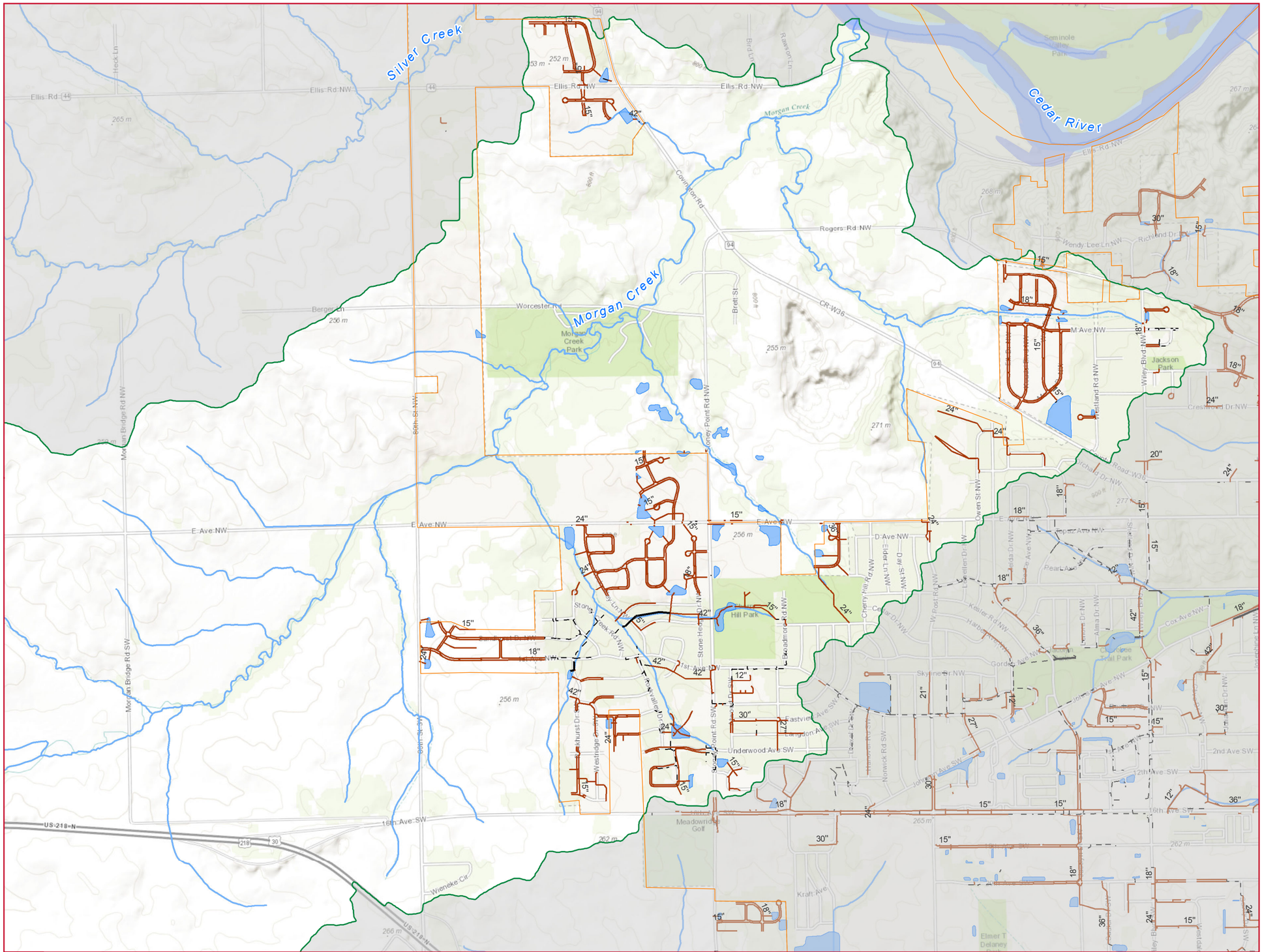


EXHIBIT 5
MORGAN CREEK SUB WATERSHED
MORGAN CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

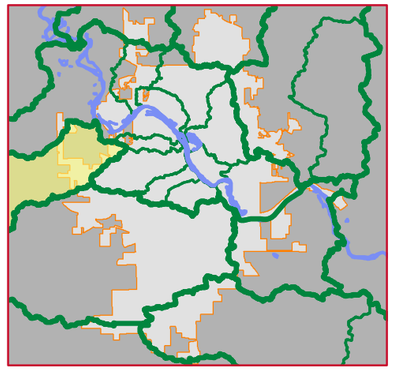
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,800

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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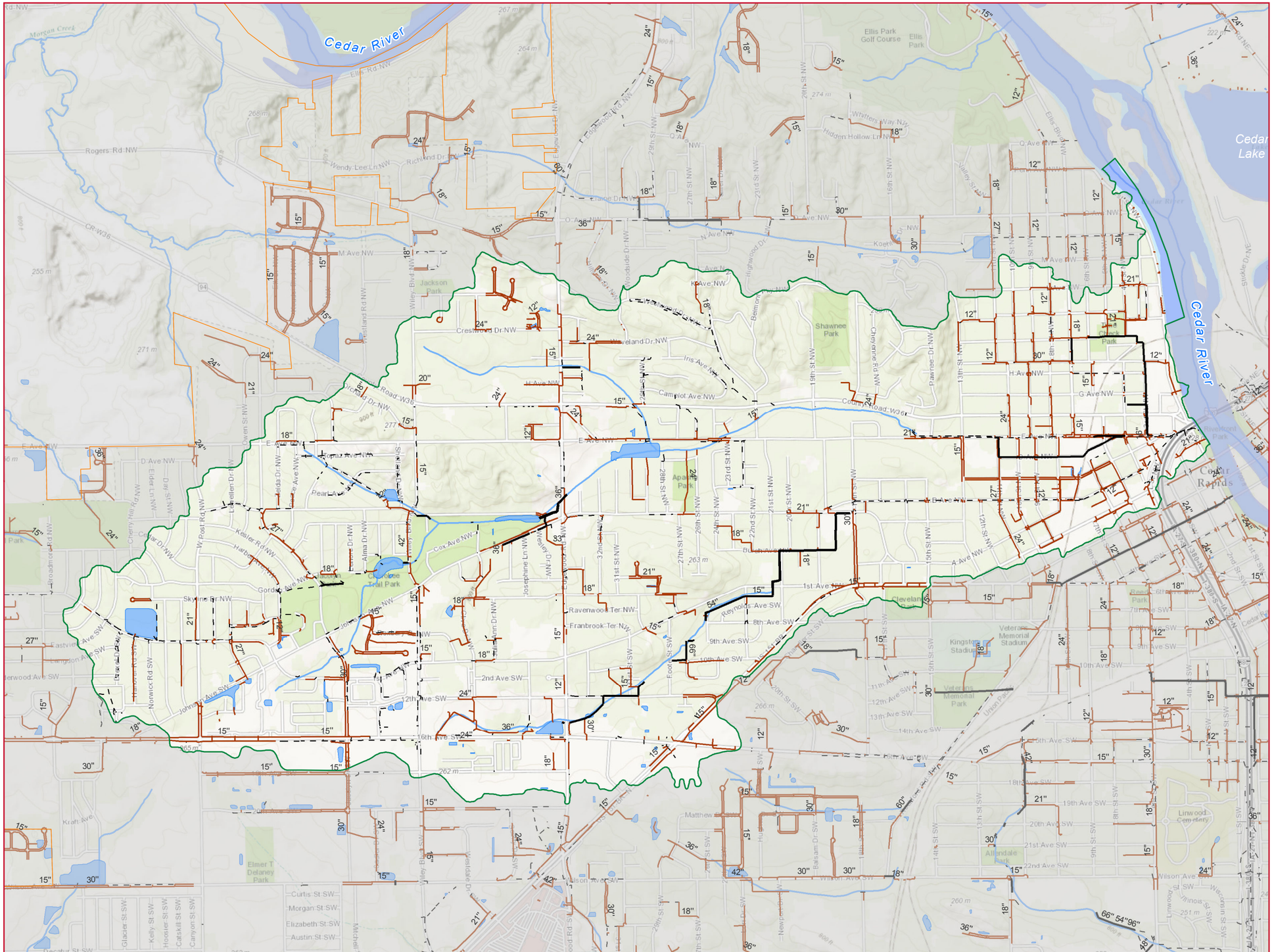


EXHIBIT 6
E AVENUE SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

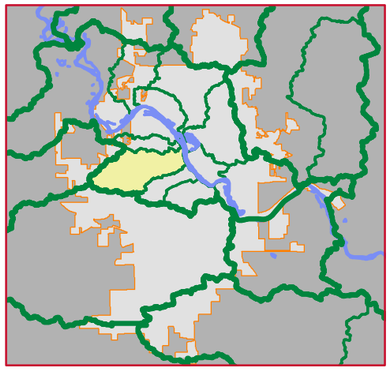
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,800

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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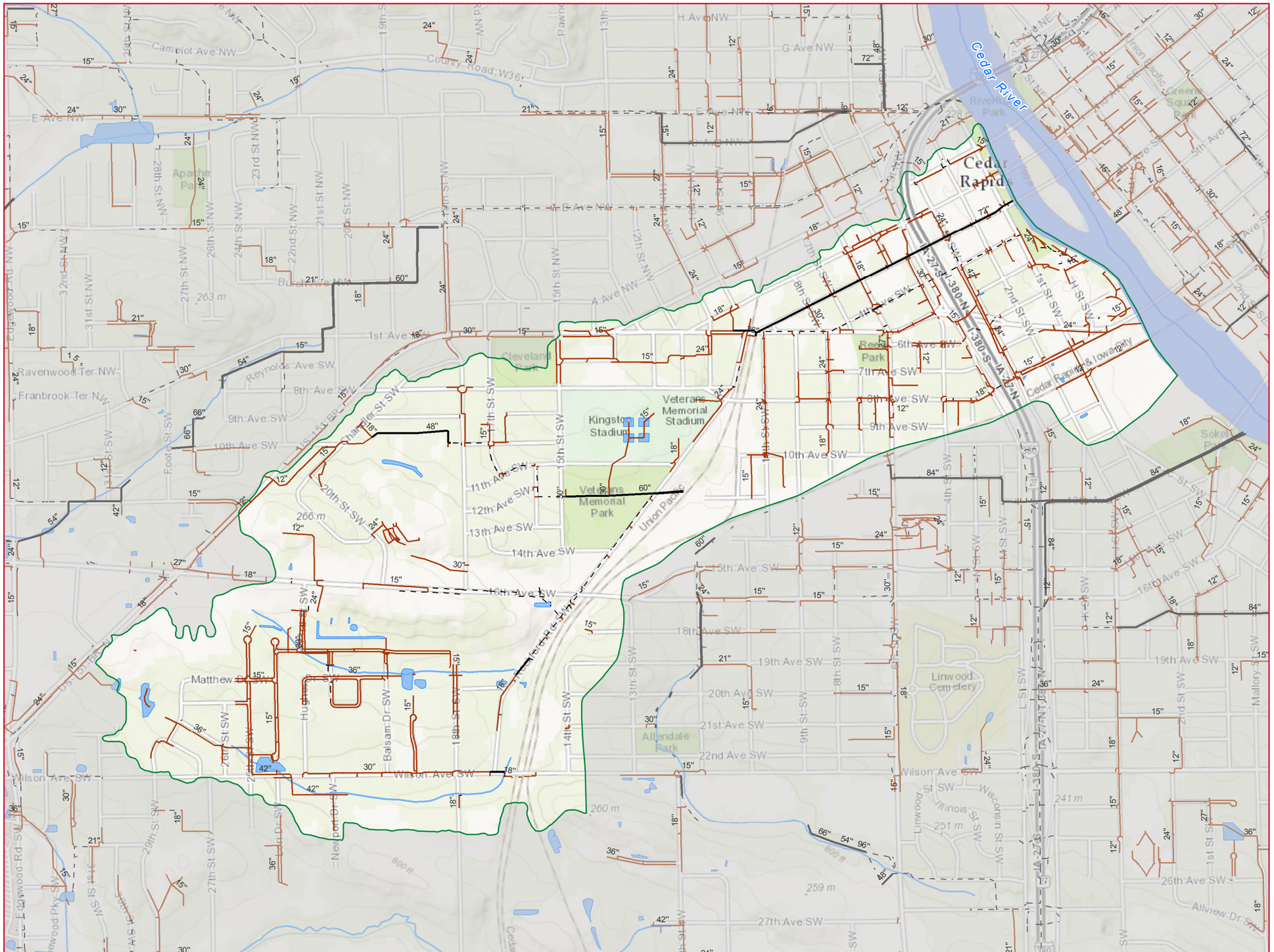


EXHIBIT 7
ROCKFORD ROAD SUB WATERSHED SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

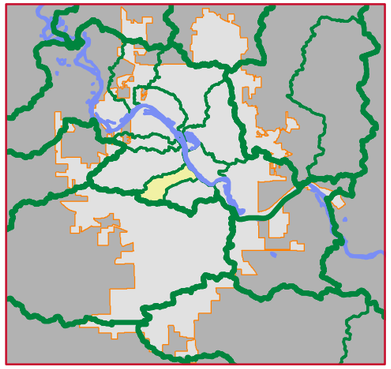
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,200

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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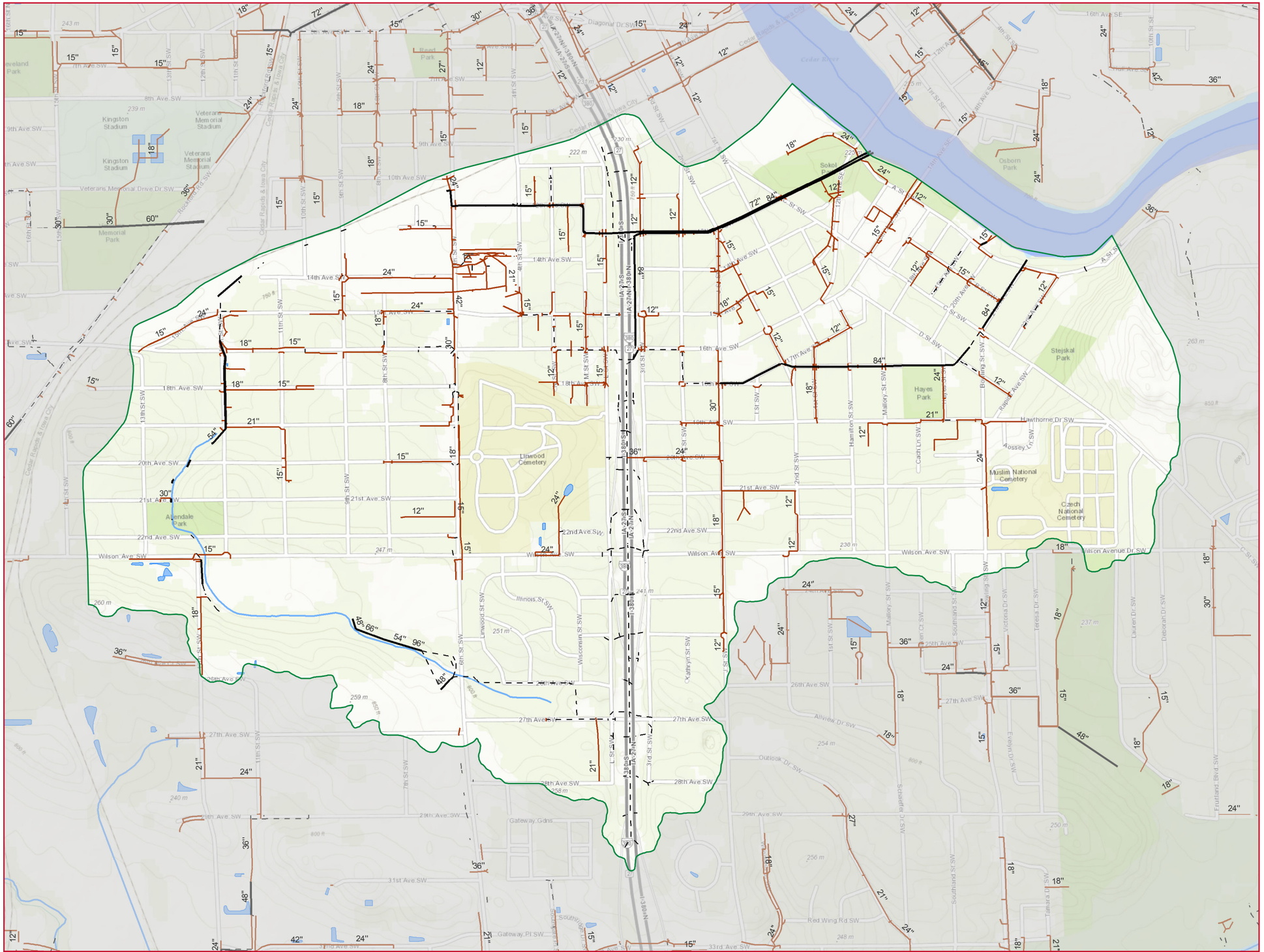


EXHIBIT 8
CZECH VILLAGE SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

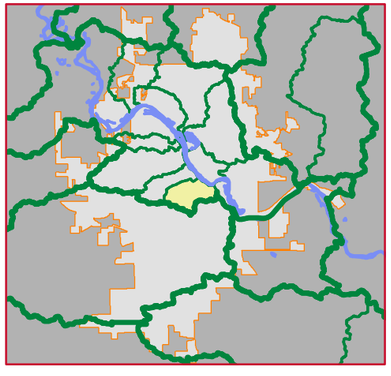
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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EXHIBIT 9
PRAIRIE CREEK SUB WATERSHED
PRAIRIE CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

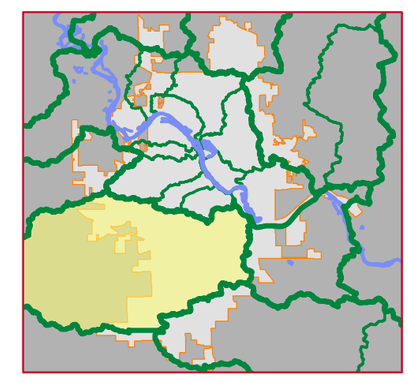
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 4,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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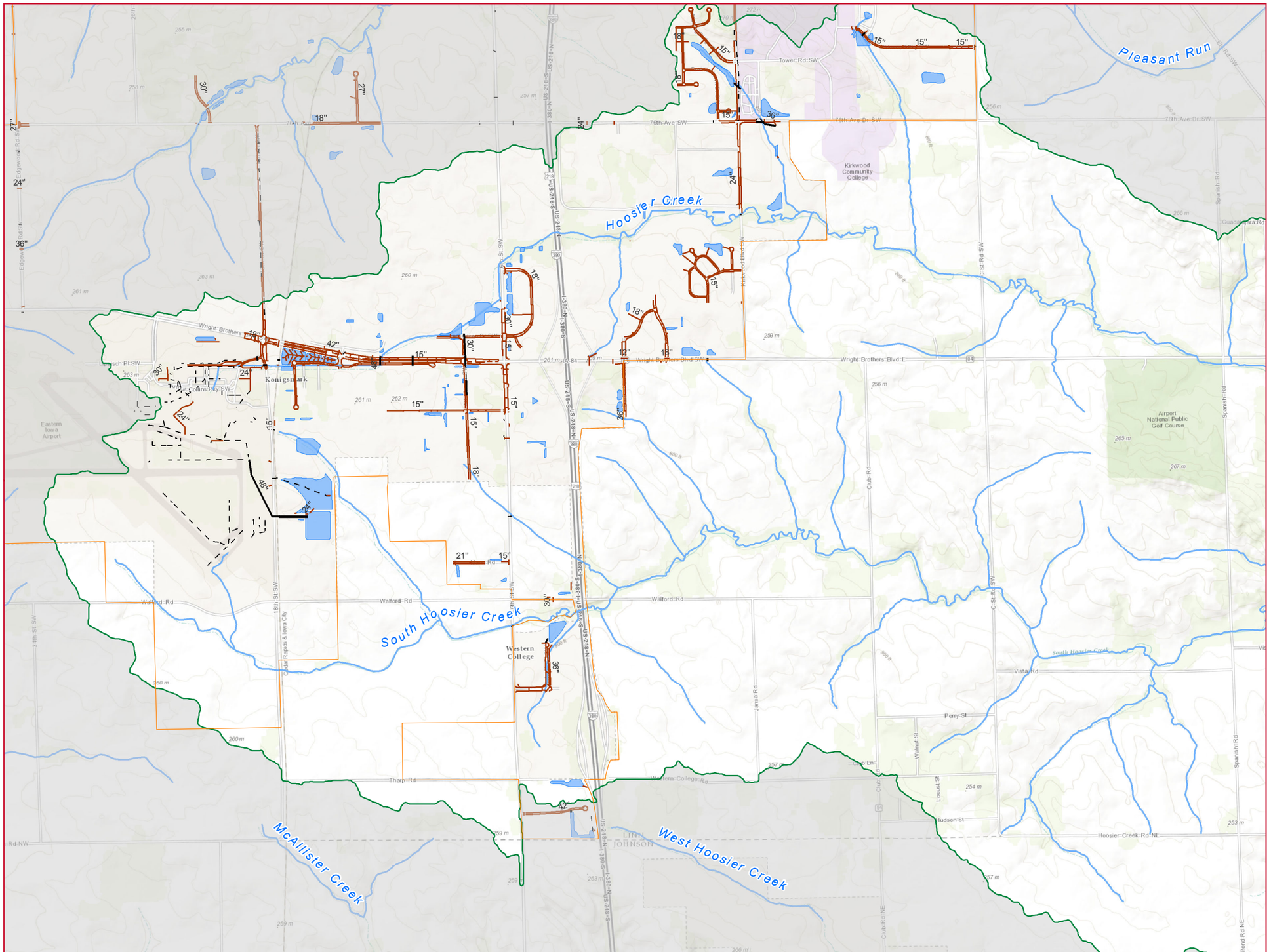


EXHIBIT 10
HOOSIER CREEK SUB WATERSHED
HOOSIER CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

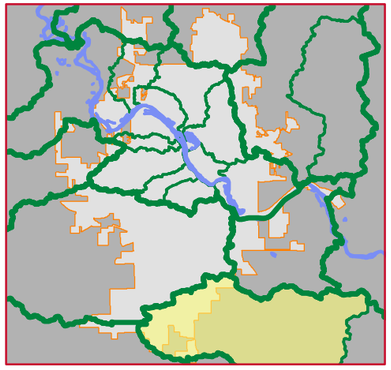
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,200

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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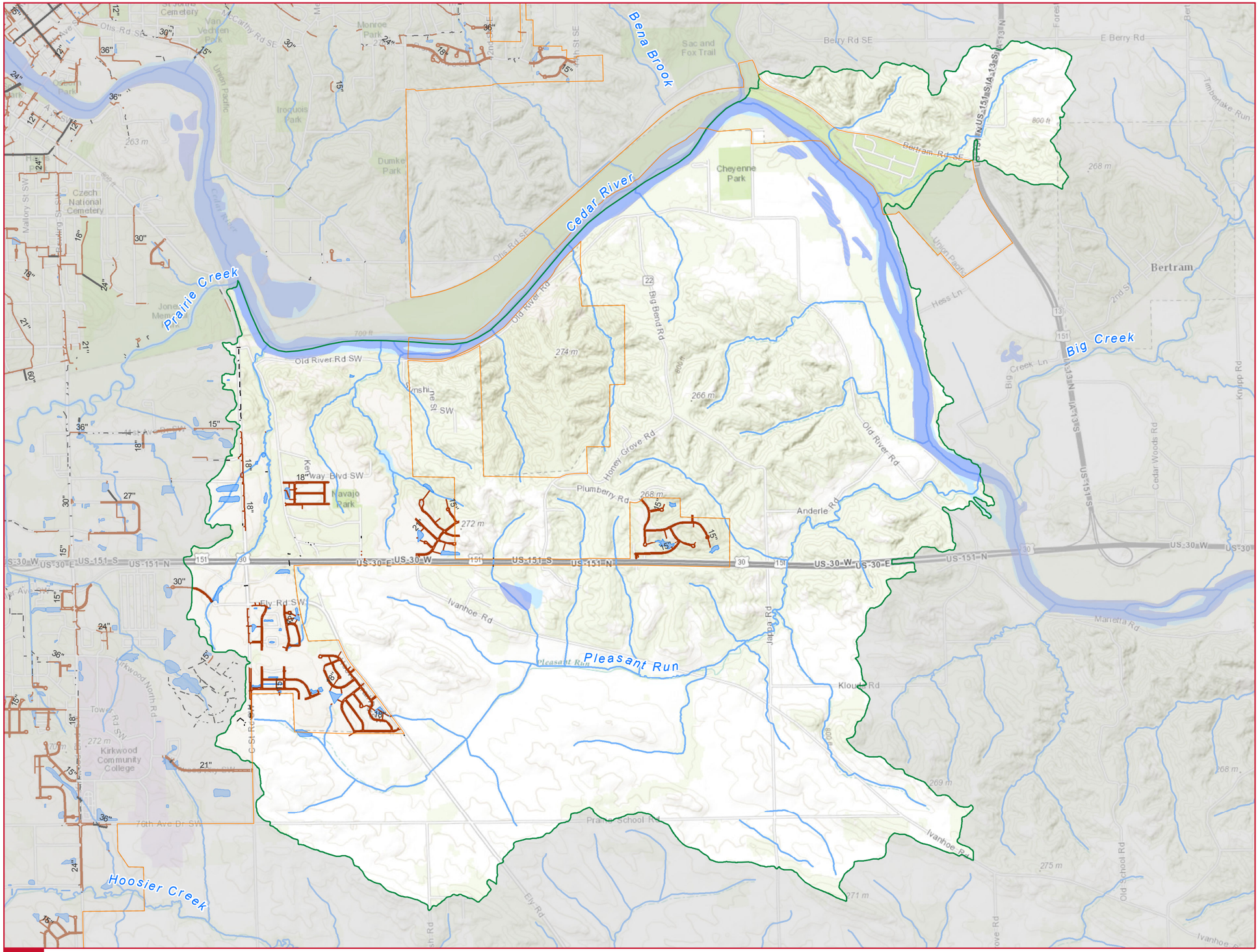


EXHIBIT 11
PLEASANT RUN SUB WATERSHED
PLEASANT RUN - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

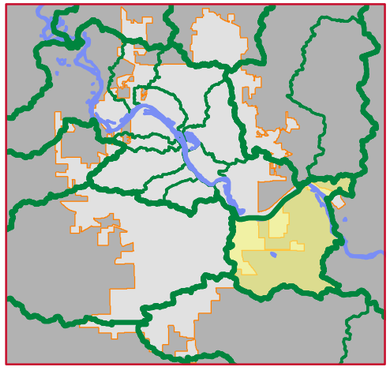
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 3,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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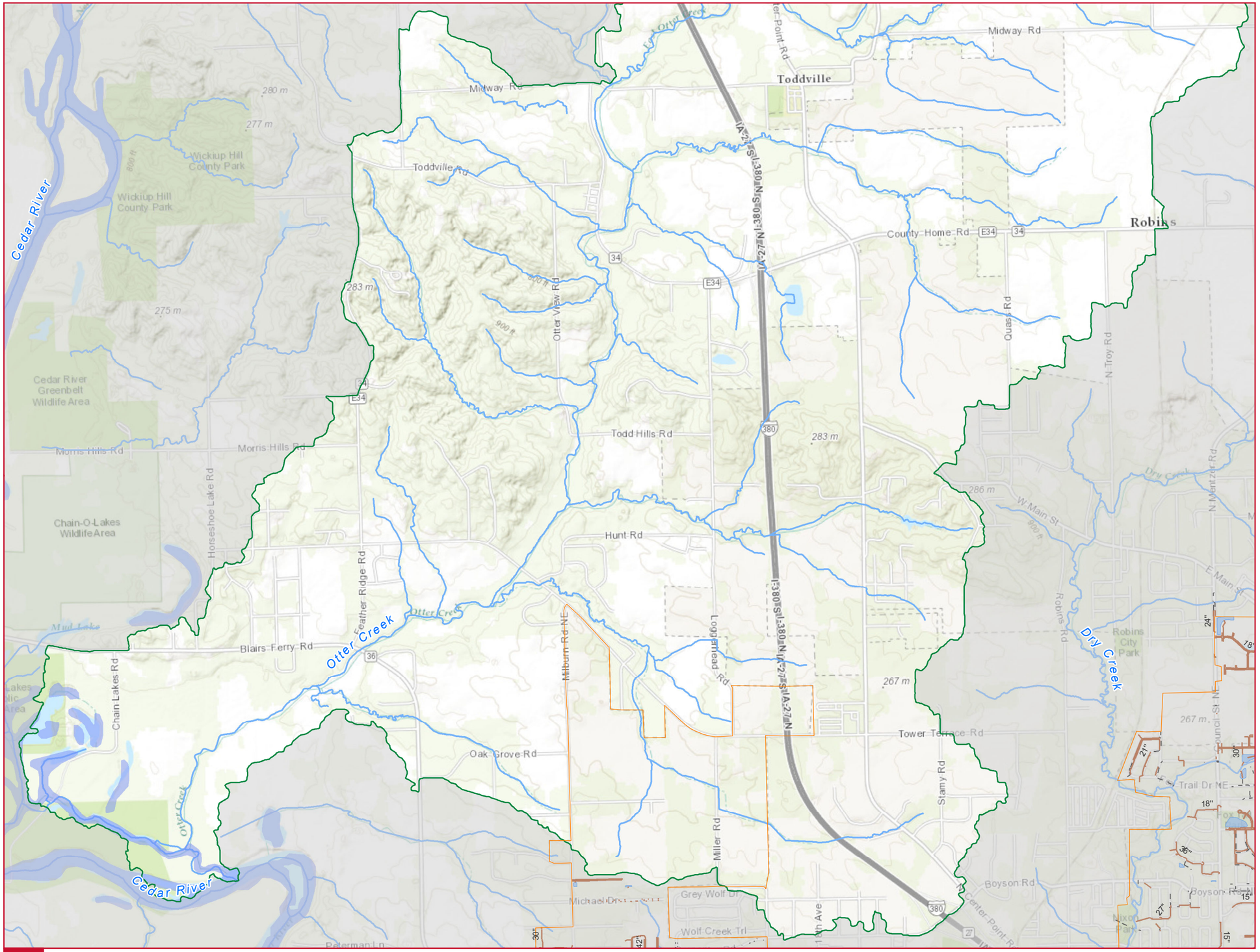
EXHIBIT 12
E OTTER CREEK SUB WATERSHED
EAST OTTER CREEK WATERSHED



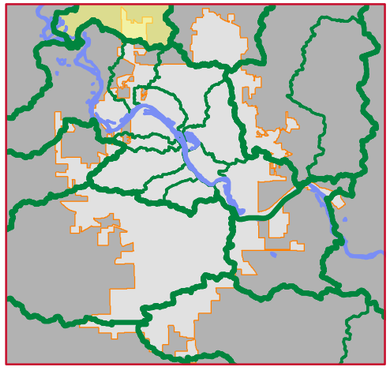
City Boundary
Sub Watershed
Open Channel
Cedar River
Detention

Storm Pipe Height

- - - - - Missing Value

< 48"

>= 48"



0 Feet 2,600

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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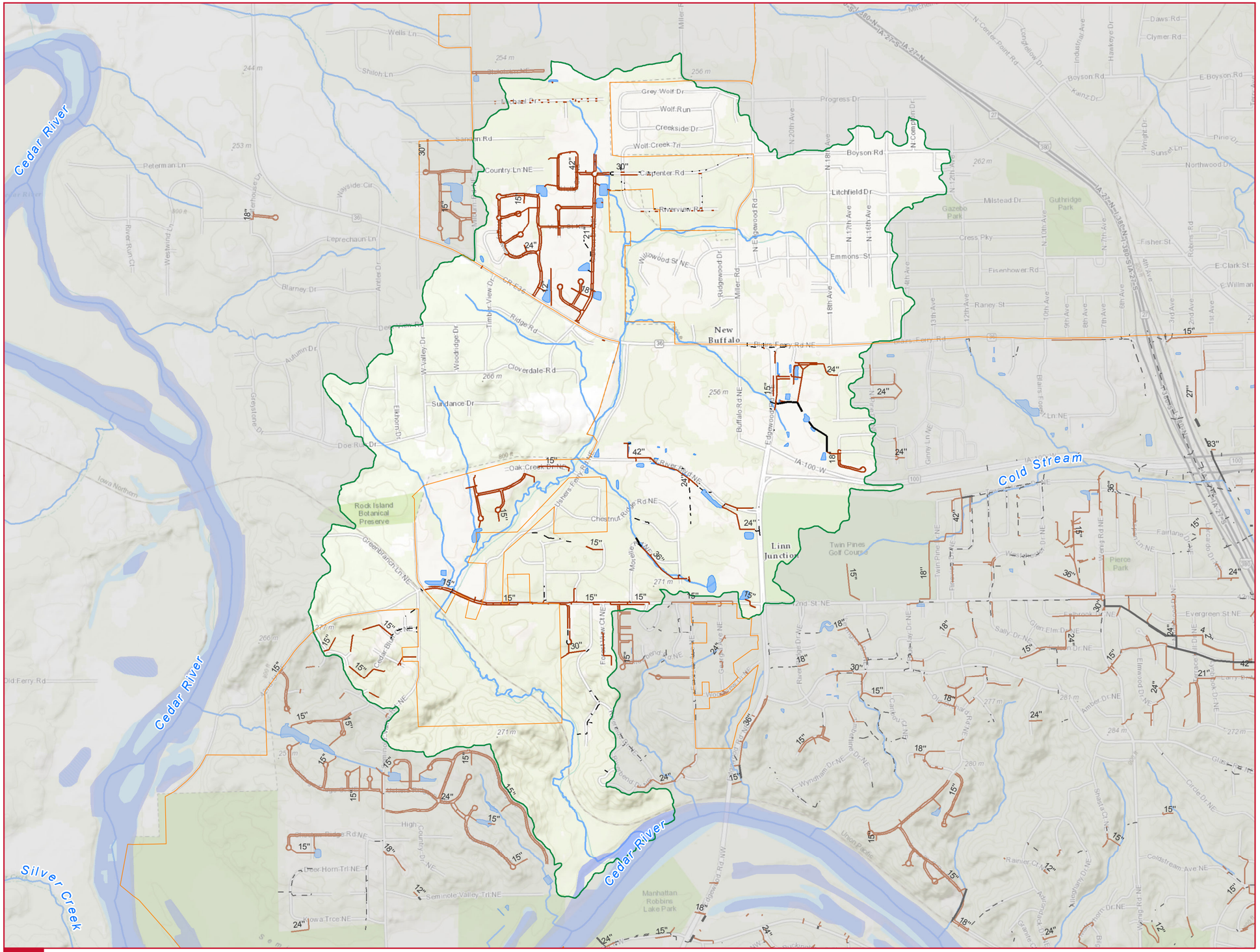


EXHIBIT 13
USHER FERRY SUB WATERSHED SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

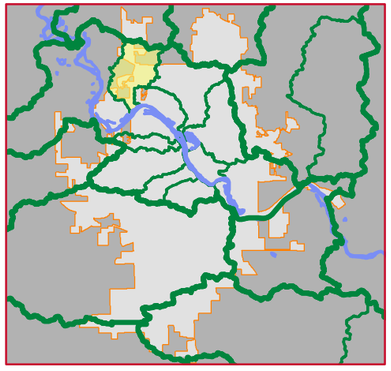
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,800

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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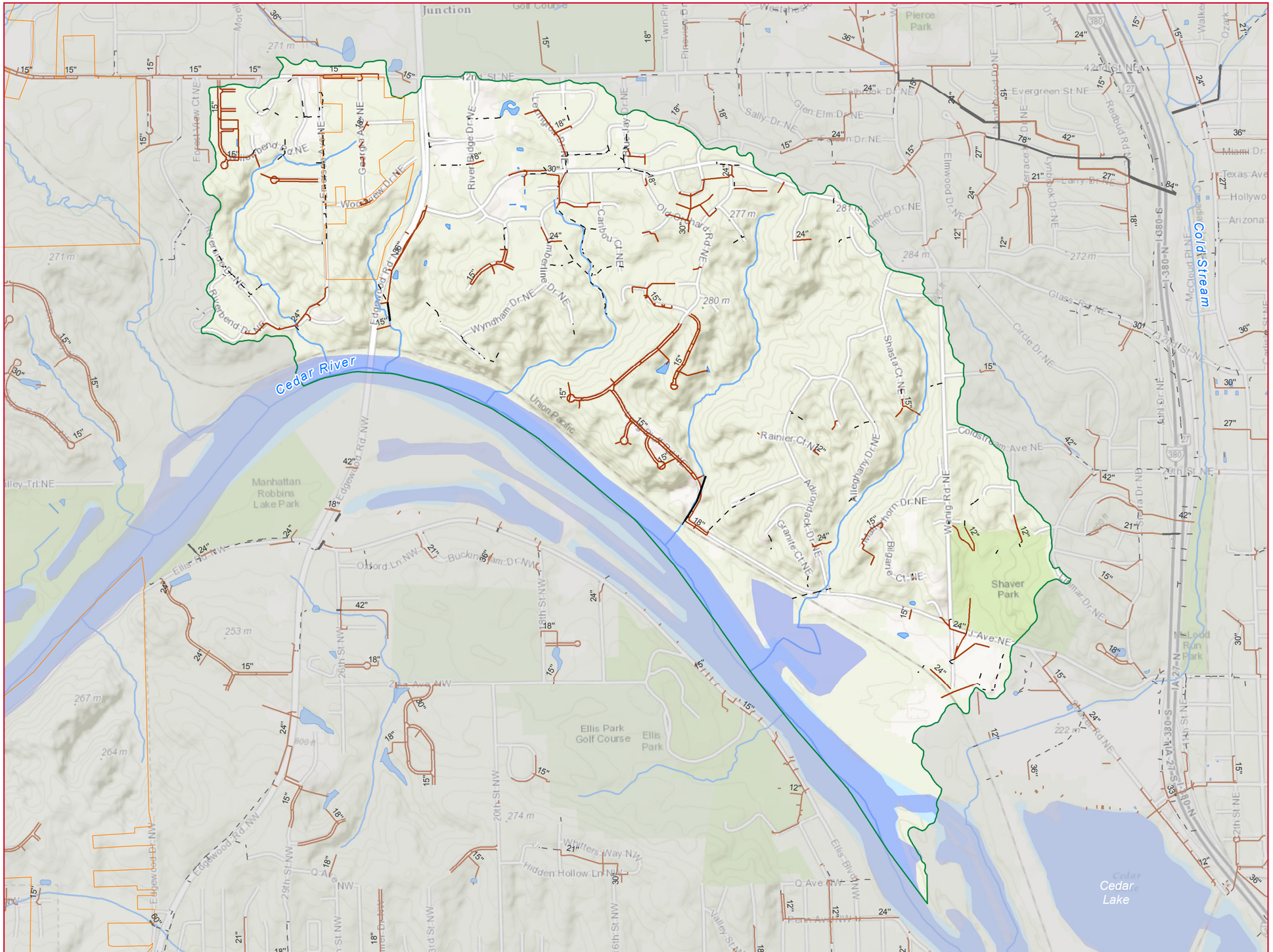


EXHIBIT 14
NE CEDAR RIVER SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

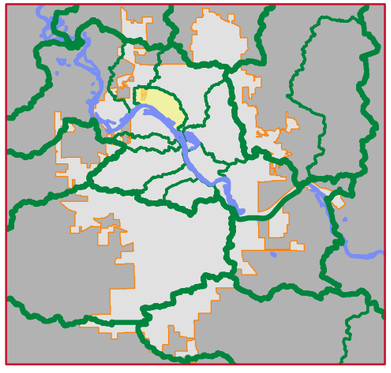
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,300

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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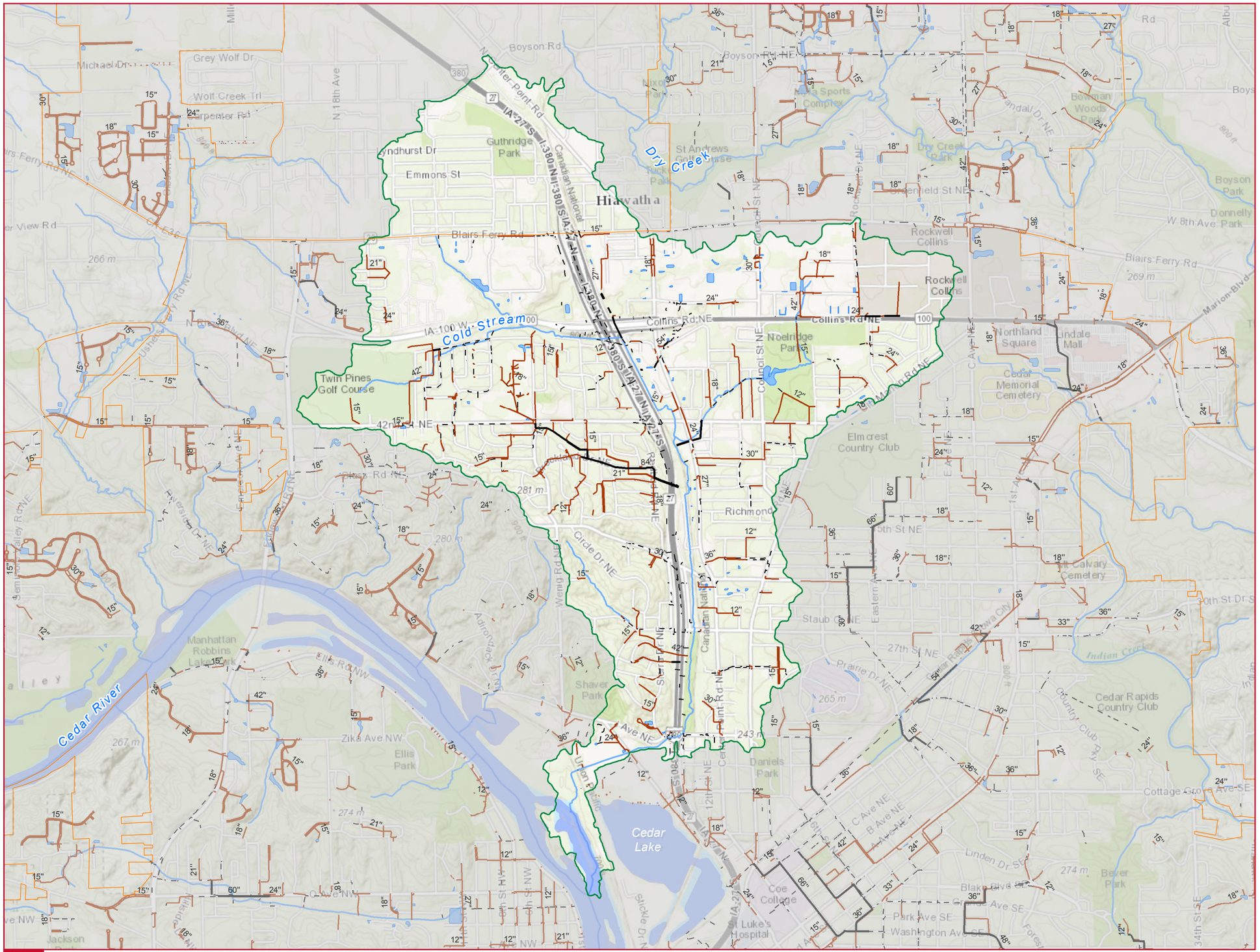
EXHIBIT 15
MCLOUD RUN SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED



City Boundary

Sub Watershed

Open Channel

Cedar River

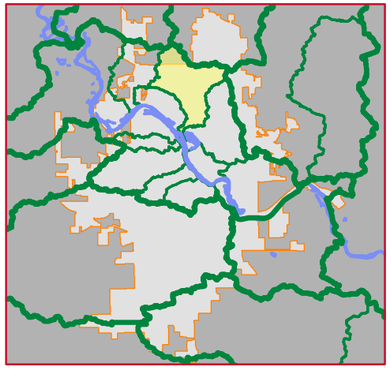
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,500

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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PATH: Z:\PROJECTS\258297-CR_STROMWATER_MASTER_PLAN\MAP_DOCS\MXD\CR_TM1_SUBWATERSHED_MAPBOOK.MXD - USER: WWHEELER - DATE: 5/6/2016

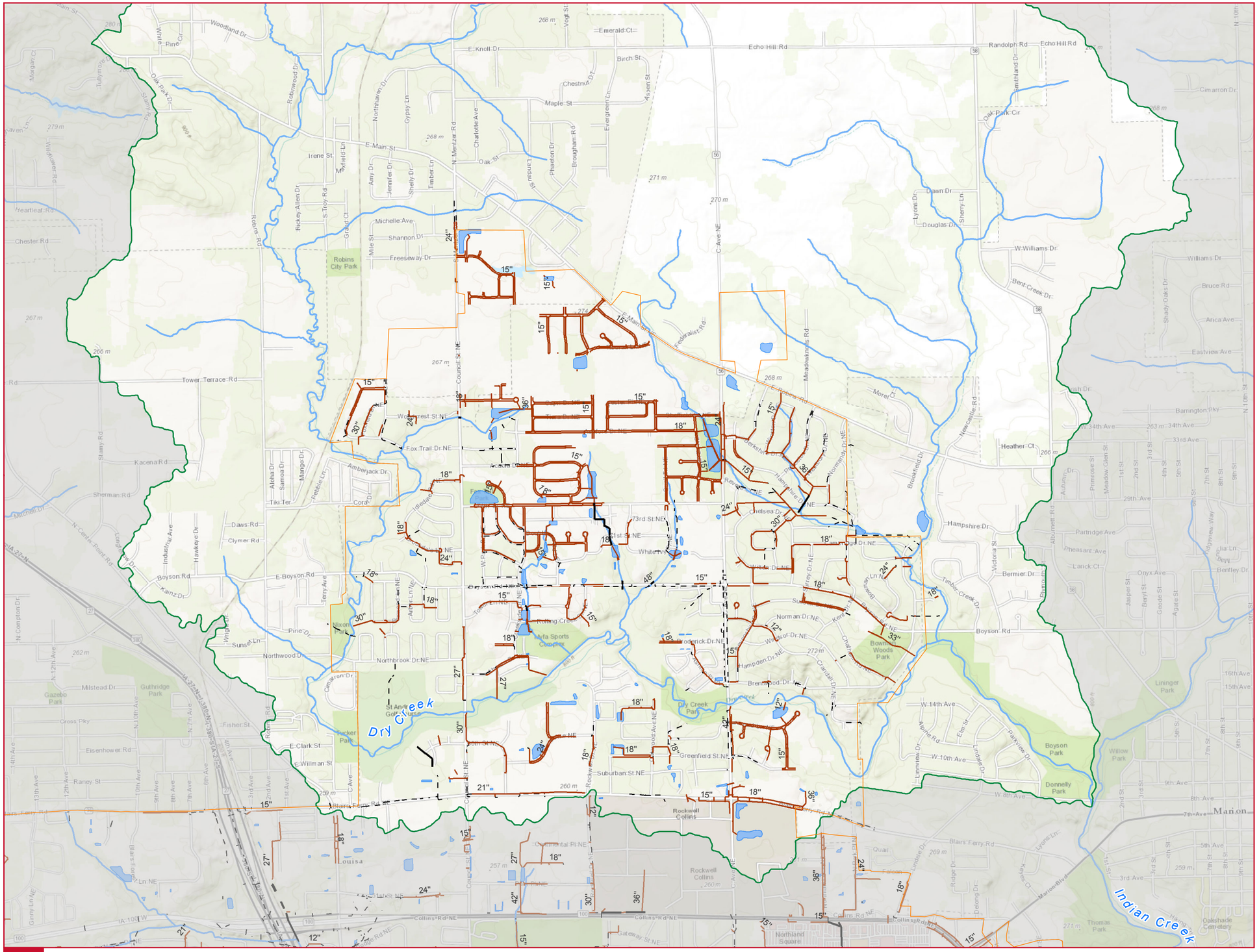


EXHIBIT 16
DRY CREEK SUB WATERSHED
INDIAN CREEK - DRY CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

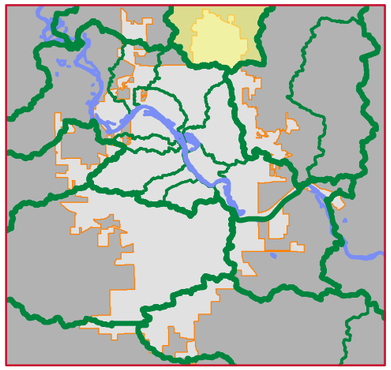
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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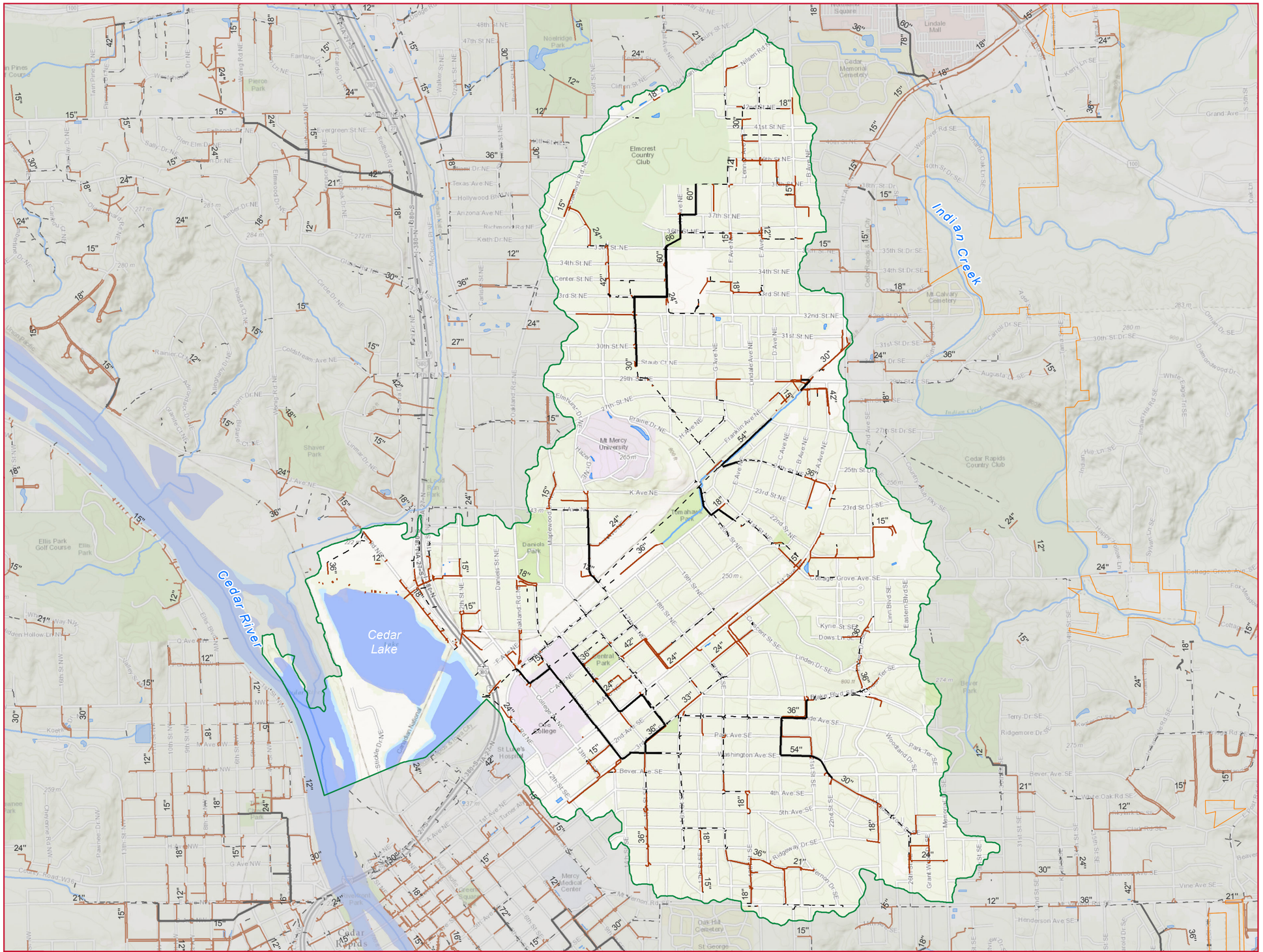


EXHIBIT 17
KENWOOD SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

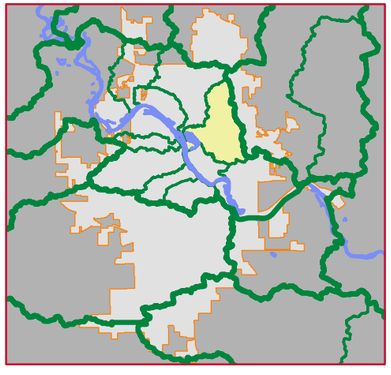
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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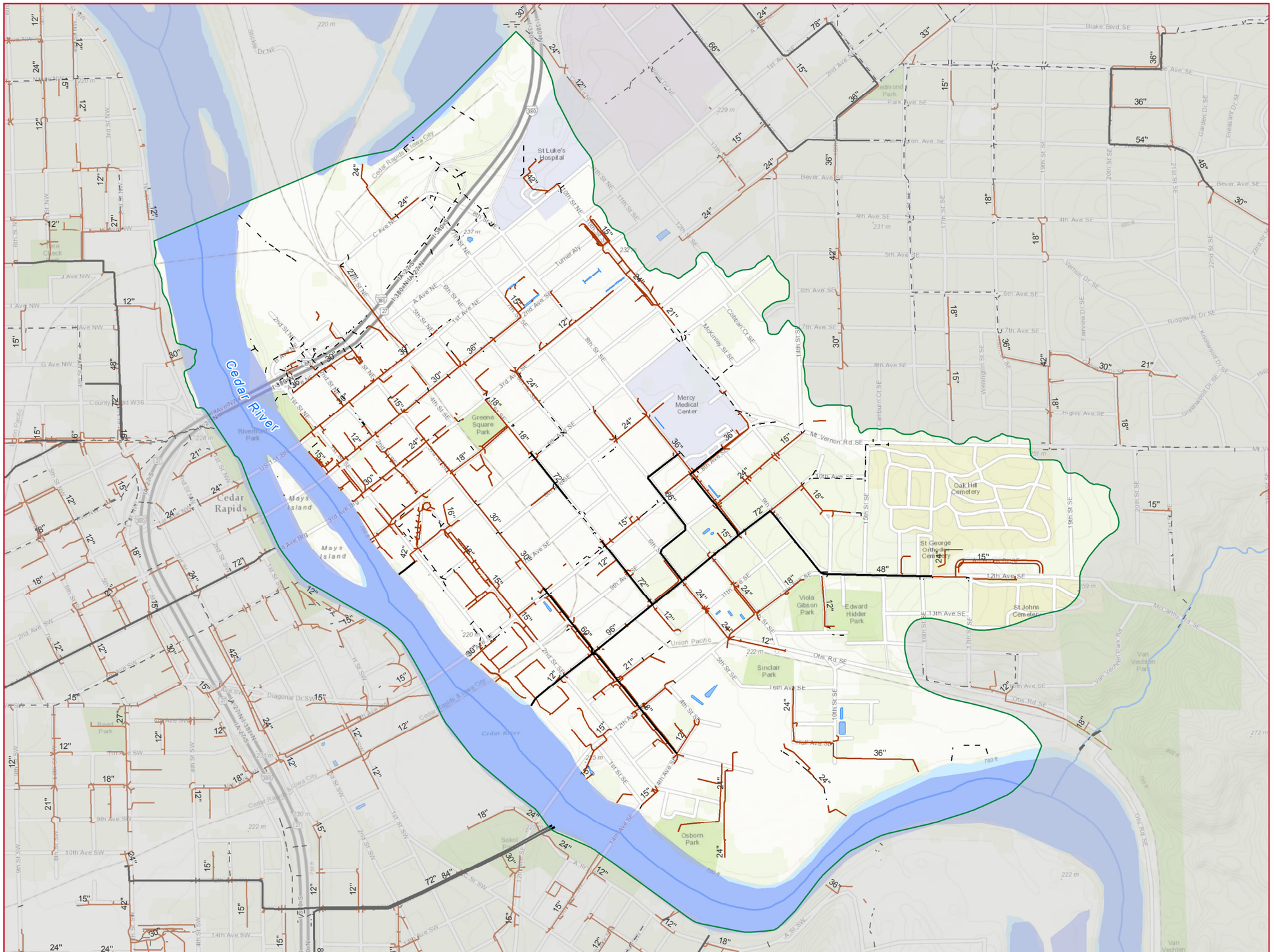


EXHIBIT 18
DOWNTOWN SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

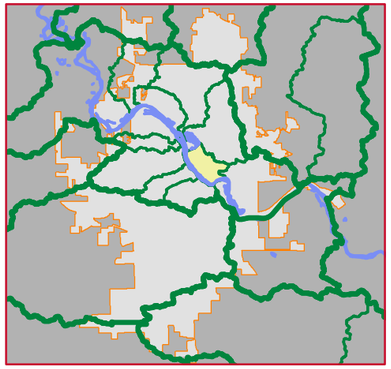
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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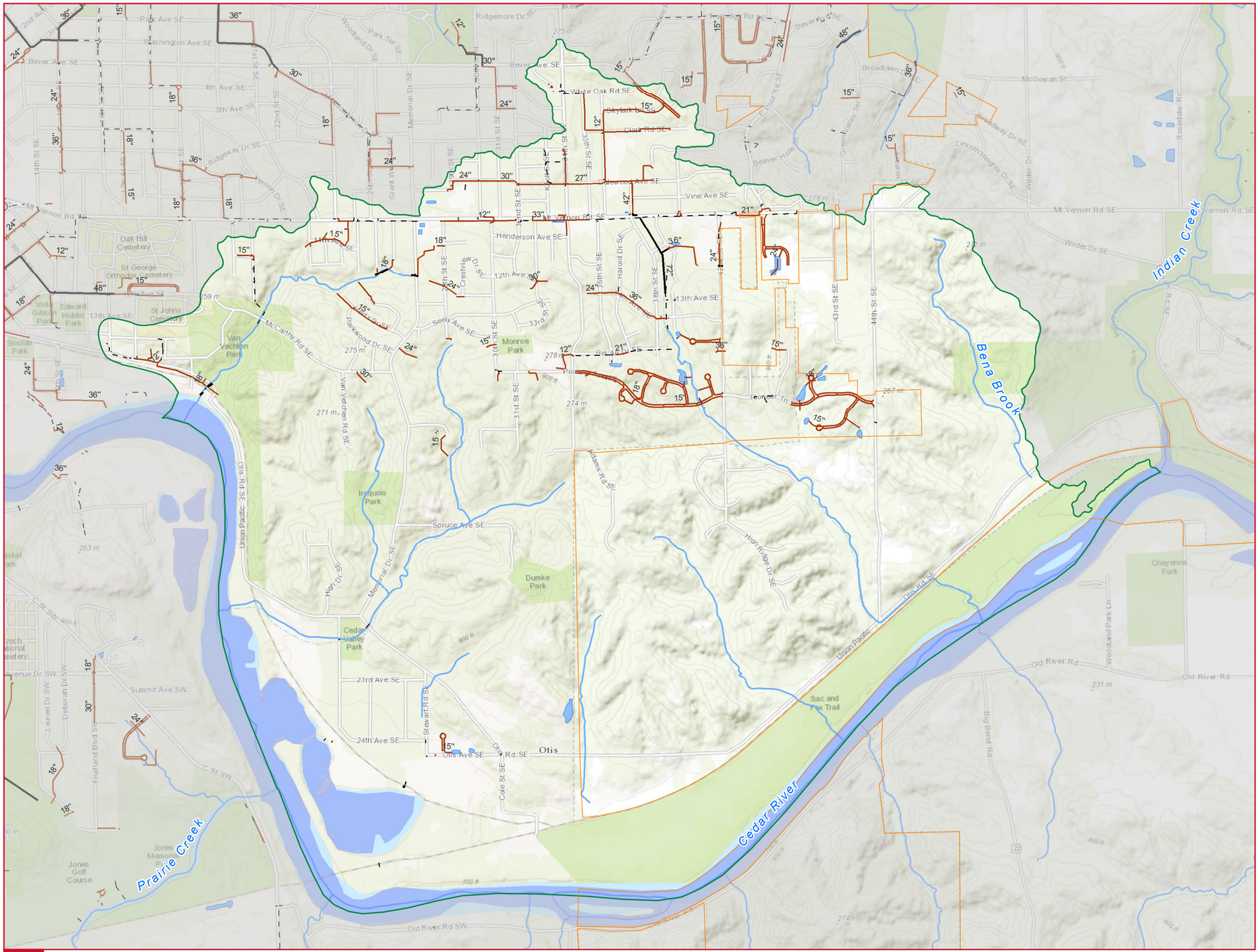


EXHIBIT 19
SE CEDAR RIVER SUB WATERSHED SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

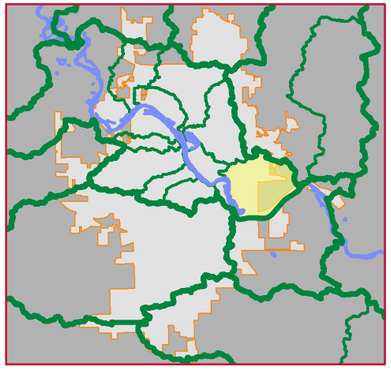
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,700

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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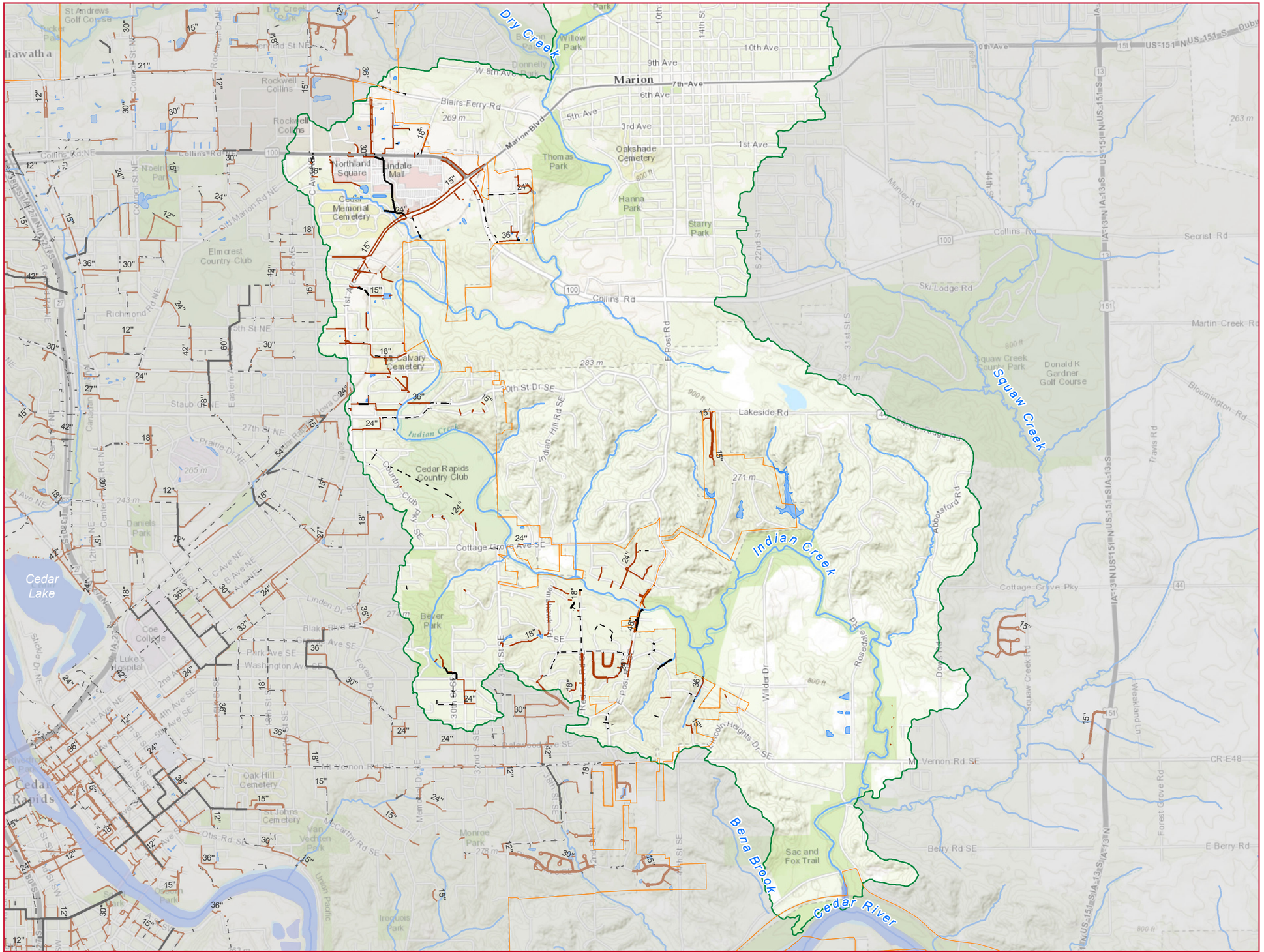


EXHIBIT 20
INDIAN CREEK SUB WATERSHED
INDIAN CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

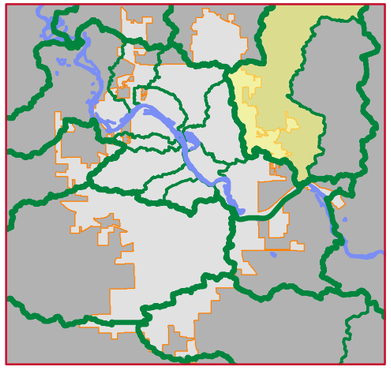
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 3,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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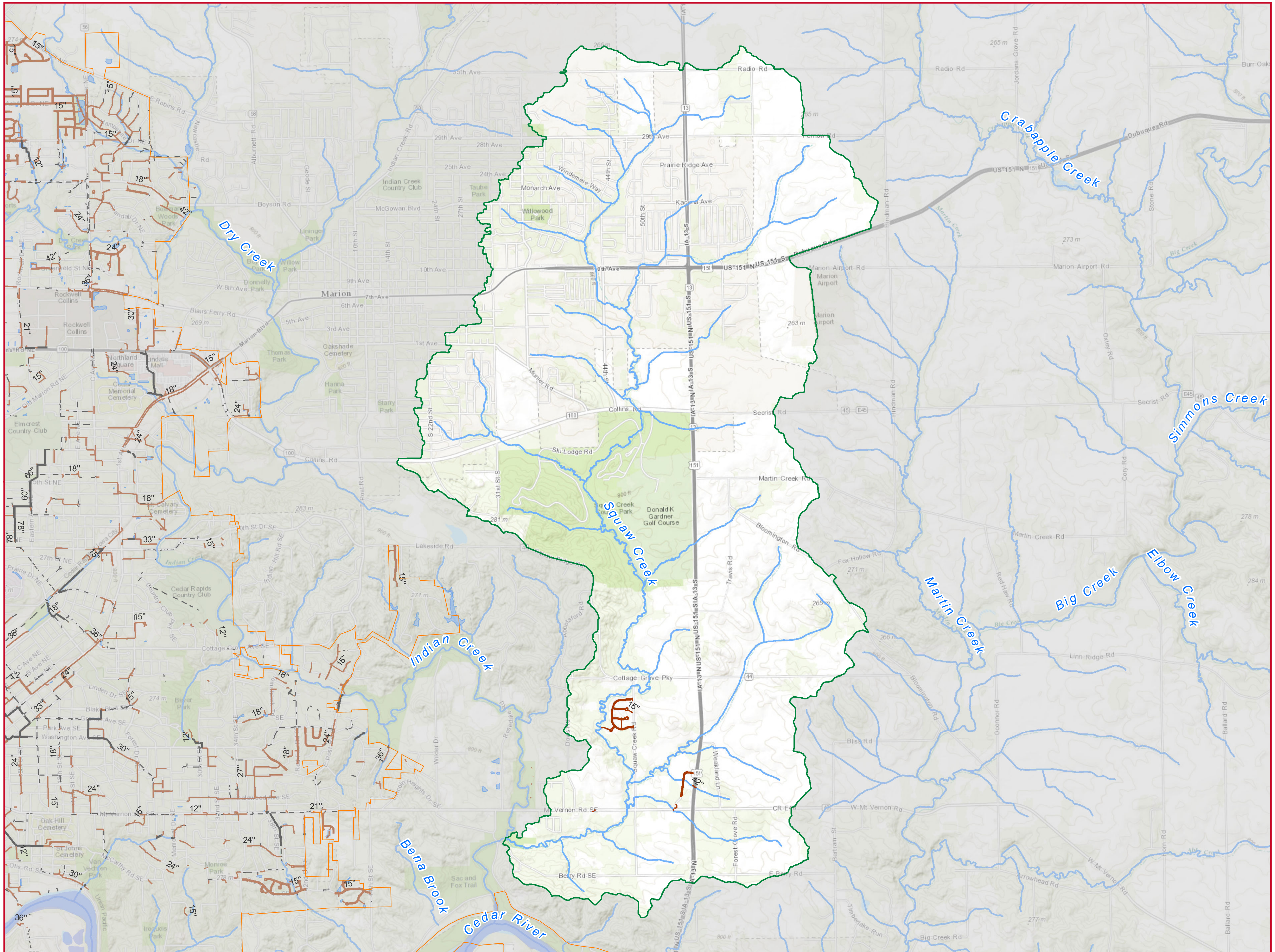


EXHIBIT 21
SQUAW CREEK SUB WATERSHED INDIAN CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

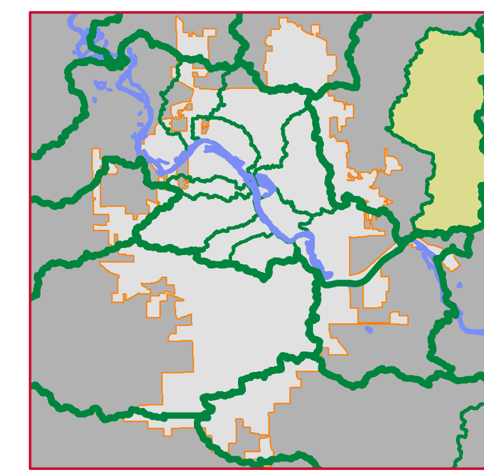
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 4,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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EXHIBIT 22
SILVER CREEK SUB WATERSHED
SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

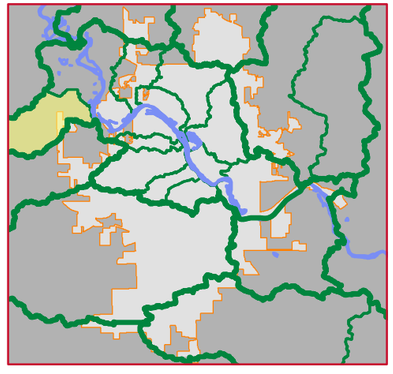
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,400

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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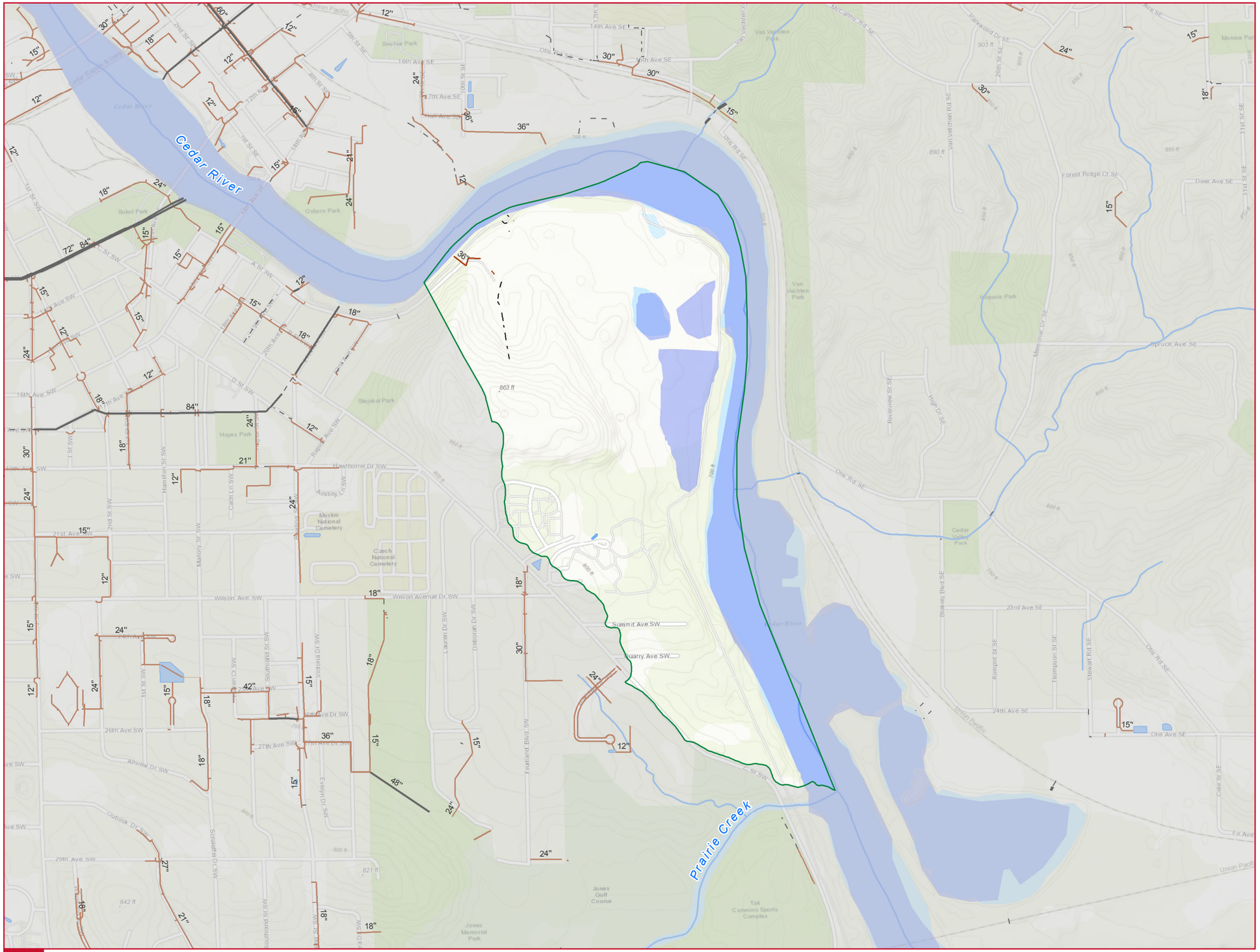


EXHIBIT 23
SW CEDAR RIVER SUB WATERSHED SILVER CREEK - CEDAR RIVER WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

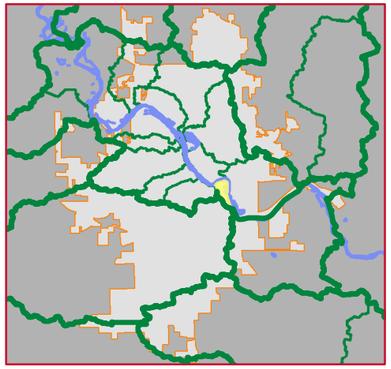
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 1,000

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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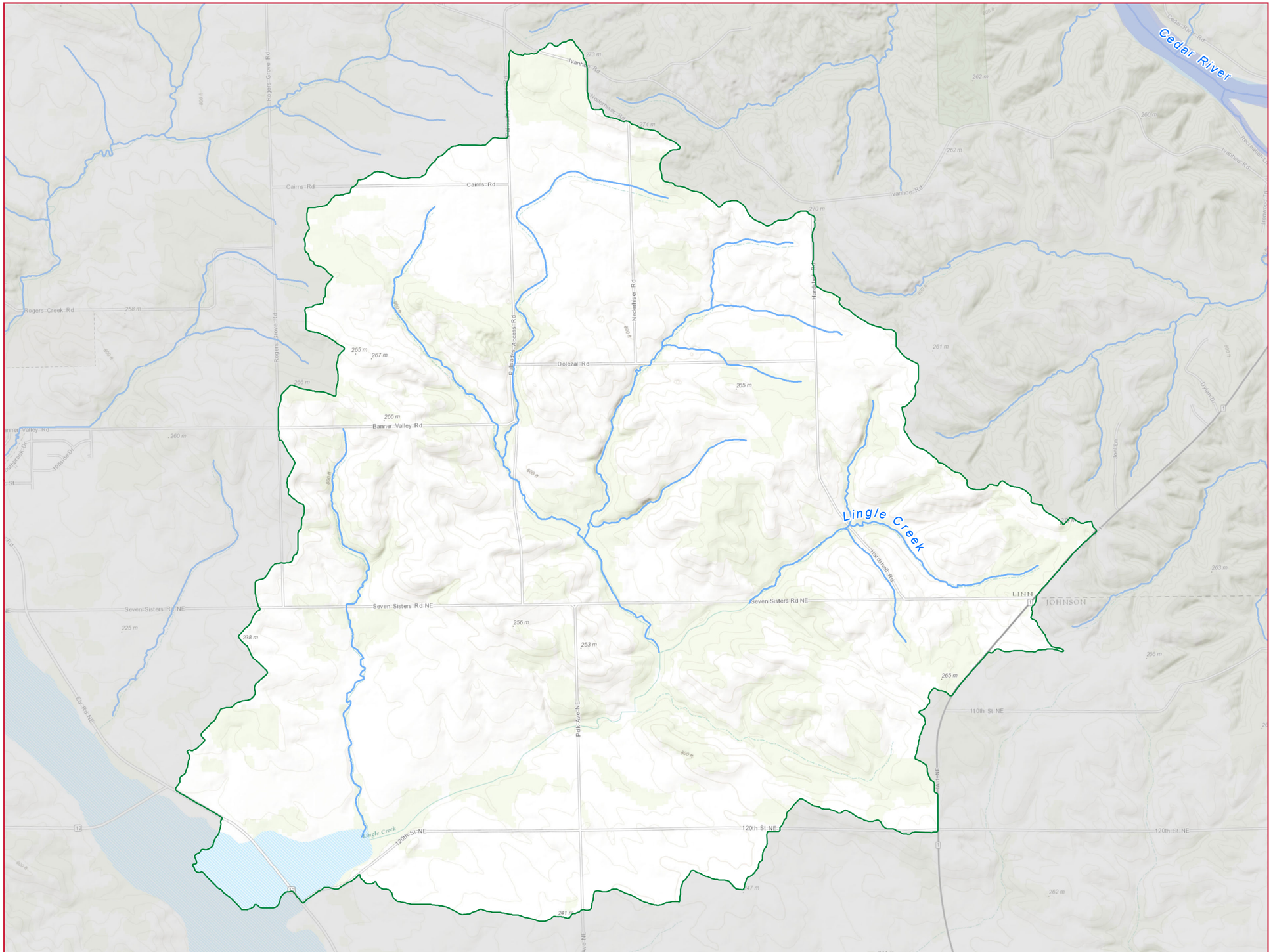


EXHIBIT 24
LINGLE CREEK SUB WATERSHED
HOOSIER CREEK WATERSHED

City Boundary

Sub Watershed

Open Channel

Cedar River

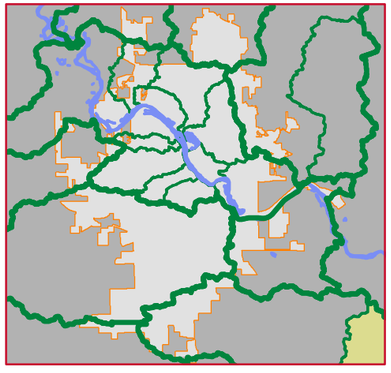
Detention

Storm Pipe Height

Missing Value

< 48"

>= 48"



0 Feet 2,200

DATA SOURCE: City of Cedar Rapids

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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