CHAPTER 4

KEY CONCEPTS

1. **Walnut Creek is impaired by pollutants**
   Recreational uses involving direct human contact with Walnut Creek water are currently *not supported* because of high measured levels of E.coli bacteria. These levels have routinely been higher than the state's water quality standards and are the reason why the stream is listed as an impaired waterbody.

2. **The Raccoon River and Des Moines Water Works are impacted too**
   The Raccoon River is also listed as impaired due to high bacteria levels. The river is also identified as being impaired due to high levels of nitrates, which risk safe drinking water supplies. During periods of high nitrate levels, Des Moines Water Works has to activate special treatment systems which reduce nitrate levels in the treated water supply.

3. **Nutrient pollution is not just a local problem**
   Compounds containing nitrogen and phosphorus are carried downstream from the Mississippi River watershed to the Gulf of Mexico. Chemical and biological reactions increased by high levels of these nutrients can lower oxygen levels in the water to the point where fish and other animals cannot survive. This process has caused a "dead zone" to be formed in the Gulf which is over 5,800 square miles in area.

4. **Past work provides insight**
   Several past studies offer important analyses and recommendations related to the Walnut Creek Watershed.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Previous studies have identified potential risks to human health and the environment. These studies identify likely sources of pollution and the reduction of pollutant loads necessary for streams to fully support their designated uses. Strategies and best management practices are identified to address these concerns, some of which may be applicable within this plan.

Four

Background

Downstream waterbodies are:

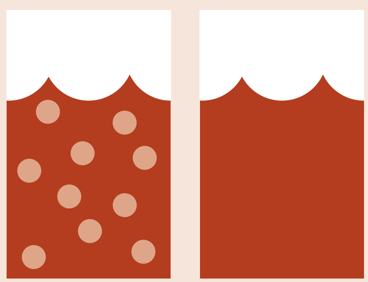
1. Des Moines River
2. Lake Red Rock
3. Mississippi River
4. Gulf of Mexico

Elevated levels of nutrients such as nitrogen and phosphorus have created a 5,500-square-mile hypoxic "*dead zone*" in the Gulf of Mexico (10% of the size of the entire State of Iowa) *

* The size of the dead zone is the five-year average size of the hypoxic zone, based on data collected by NOAA from 2011–2015.

Walnut Creek

- Currently considered an impaired waterbody due to high levels of bacteria.
- Flows into the Raccoon River which is impaired due to high levels of bacteria and nitrate.



Des Moines Water Works collects water from the Raccoon River for drinking water use. This water must be disinfected and nitrates removed through a special process when concentrations are above a certain level.

Iowa's Nutrient Reduction Strategy

Created to reduce the amount of nutrient load sent from Iowa to the Gulf of Mexico.

Past studies have been completed that broaden the understanding of Walnut Creek and where it fits within larger watersheds. The maximum allowable concentrations of certain pollutants are based on the designated uses of the stream. This influences if the stream is considered to be impaired, and the required reductions in pollutants that are needed in order to fully support the stream's desired public uses.

Designated Uses

Streams have specific designation classifications based on their use. Uses such as swimming, fishing, drinking water or maintaining aquatic life fall into different classifications. Each class has a series of rules that applies to it, known as the **IDNR water quality standards**.

The listed **designated uses** for Walnut Creek (Waterbody ID Code: IA 04-RAC-0020_1) are below:

- *Class A1 (Primary contact recreational use):* The recreation uses involve full body immersion with prolonged and direct contact with the water.
- *Class B (WW-2):* Typically smaller, perennially flowing streams capable of supporting and maintaining a resident aquatic community, but lacking the flow and habitat necessary to fully support and sustain game fish populations.

Sources:
IDNR website *"What does 'Designated Use' mean?"*
http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards/DesignatedUses.aspx
Iowa DNR 305(b) Water Quality Assessment Database – 2014 Water Quality Assessment.
Iowa Surface Water Classifications (567 Iowa Administrative Code 61.3).

Impaired Waters Status

The lowest 7.6 miles of Walnut Creek are listed on the State of Iowa's 305(b) list as an impaired waterway. Streams are added to the **impaired waters** list if conditions exist that have a negative impact on one or more of the streams' designated uses. For each stream studied, each use is categorized as being fully, partially or not supported.

Portions of Walnut Creek are listed as Category 4a , meaning that it is impaired or a downward water quality trend is evident, and a TMDL (Total Maximum Daily Load report) has been prepared.

Primary contact recreation uses (Class A1) are listed as "not supported" based on data from Iowa Geological Survey snapshot monitoring from 2004 through 2008. The levels of indicator bacteria (E.coli) at multiple sampling points were far in excess of the water quality criterion established by the State of Iowa. (These criteria for E.coli are a *geometric mean* for all samples of 126 organisms per 100 milliliters (mL) and a single sample maximum of 235 orgs/100 mL)

Aquatic life support is listed as "fully supported" based on data collected in the 1998 IDNR/UHL stream biocriteria project (Class B).

The lower Raccoon River (Waterbody ID Code: IA 04-RAC-0010_1) is listed as impaired by bacteria and nitrates. Elevated bacteria levels are the reason it is listed as "not supporting" primary contact recreation.

In addition to the uses established for Walnut Creek, the Raccoon River has the following designated uses:

Class C (Drinking water supply): Water is used as a raw water source of potable water supply.

Class HH (Human health): Waters where fish are routinely harvested for human consumption or where water is used as a drinking water supply and where fish are routinely harvested for consumption.

Source: Iowa DNR 305(b) Water Quality Assessment Database – 2014 Water Quality Assessment.

The river is also listed by the state of Iowa as a **high-quality resource**, or a water "of substantial recreational or ecological significance which possesses unusual, outstanding or unique physical, chemical or biological characteristics."

Applicable Water Quality Standards

The TMDL established for the Raccoon River set **maximum contaminant levels** (MCLs) for both nitrate and bacteria.

The Raccoon River is listed as "fully supporting" fish consumption. However, nitrate levels frequently exceeded the maximum contaminate level for nitrate of 10 mg/L, leading to this stream segment being categorized as "not supporting" use for drinking water.

Source: IDNR 305(b) Water Quality Assessment Database
https://programs.iowadnr.gov/adbnet/assessment.aspx?aid=12318

The Raccoon River TMDL report set the MCL for nitrate for single samples at 9.5 mg/L (which includes a factor of safety below the acceptable limit established by the state (10.0 mg/L)). The MCL for bacteria for single samples was established to be 200 organisms / 100 mL, which also includes a factor of safety below the state water quality standard (235 org./100mL). These standards are to be applied to major tributaries of the river (such as Walnut Creek) which have been designated as impaired by these pollutants of concern.

Previous Studies

Water Quality Improvement Plan for Raccoon River (TMDL)—2008

The federal **Clean Water Act** required the Iowa Department of Natural Resources (IDNR) to develop a Watershed Improvement Plan, also known as a Total Maximum Daily Load (TMDL), for waters that have been identified on the state's 303(d) list as impaired by a pollutant. These plans determine current pollutant loads and determine the required reductions needed to bring levels back below the desired standard. Three segments of the Raccoon River have been identified as impaired by nitrate and five segments by the **pathogen indicator bacteria** (E.coli TMDL, p.12). The segment of Walnut Creek in Polk County, downstream of I-80/35 is one of several Class A1 streams within the Raccoon River watershed which were within the report prepared for the overall Raccoon River TMDL.

Surface water from the Raccoon River is used as a drinking water source for the Cities of Des Moines and Panora. Because of this, the Class C water quality standard applies to the Raccoon River at these two locations. Between 1996 and 2005, nitrate concentrations at the Des Moines Water Works (DMWW) exceeded state water quality standards 24.0% of the time. Higher concentrations were observed during April, May and June as well as November and December. Nitrate concentrations were highest during higher flows, with an average concentration of 10.0 mg/L when flow rates were in the highest 25% of recorded levels (TMDL, p 12).

E. coli is used as the indicator bacteria for Class A waters (waters with a recreational use where human contact is likely to occur). Sampling data suggests that all Class A1 waters in the Raccoon River watershed could be considered as "not supporting" their designated uses. Therefore, the conclusion of the Raccoon River TMDL report was to assign a maximum contaminate level (MCL) to all of these streams within the watershed which had not been previously classified (TMDL, p 14).

Highest concentrations were observed during May, June and July, although concentrations above 10,000 organisms/100mL were observed in some samples collected at DMWW in all months except February and December. Highest concentrations were observed when flows were highest, with the median concentration being 665 organisms/100mL in the highest upper 25% flow range (TMDL, p 14). **Non-point sources** were expected to contribute up to 99% of the total loading, on days when observed concentrations were higher than the established standards (TMDL, p 15).

The TMDL report projects that reductions of nitrate loading of 48% would be required to reduce nitrate concentrations to 9.5 mg/L for all storm events. Loading of E.coli is projected to require more than 95% reduction to reduce levels to 200 org./100mL for all ranges of flow, with more than 99% reductions required when flows are in the upper 70% of observed levels.

For a more detailed summary about the TMDL report for the Raccoon River, refer to the technical memo on this topic included in the appendix of this management plan.

Five load reduction strategies were analyzed by computer modeling as part of the TMDL report:

1. Reducing the rate of ammonia fertilizer application.
2. Remove all cattle from the streams.
3. Remove all human waste from the watershed.
4. Convert all row crop lands located on slopes greater than 9% slopes to CRP grassland.
5. Convert all row crop lands located on floodplain soils to CRP.

Several other strategies were also listed to address nitrate and bacteria pollution:

- Strategically construct new wetlands near tile outlets.
- Implement urban stormwater **best management practices** (BMPs).
- Changing fall applications of fertilizer to spring.
- Changing fertilizer application method.
- Use **nitrification inhibitors**.
- Improved **manure management**.
- Adopt comprehensive farm **nutrient management plans** using NRCS Conservation Practice Standard 590.
- Adopt **conservation tillage**.
- **Contour planting and terracing**.
- Use **cover crops**.

Raccoon River Watershed Water Quality Master Plan—2011

This plan was prepared by Agren, Inc., funded by a grant from the Iowa Department of Natural Resources (DNR) to the Missouri and Mississippi Divide RC & D. The plan states that it "does not define specific outcome targets for water quality, nor does it prescribe a specific vision of what constitutes an environmentally and economically prosperous Raccoon River basin. Rather, it focuses on common needs that have been identified by, and are broadly supported by, multi-disciplinary experts and watershed stakeholders." (p 3-4)

The plan organized identified priorities into nine recommendations (p 5):

1. Develop a regional planning organization to guide implementation of the Raccoon River Watershed Water Quality Master Plan.
2. Conduct public education to improve awareness of water quality and instill a personal commitment to water quality improvement among all watershed residents.
3. Focus outreach and education efforts to farm operators and agricultural landowners on nutrient and drainage management strategies.
4. Aggressively pursue opportunities to facilitate private-sector conservation planning services.
5. Take full advantage of emerging technologies and LiDAR elevation data to identify areas of concern and target practices based on landscape characteristics at the field level.
6. Target implementation of agricultural best management practices to priority **subwatersheds** and **priority impairments**.
7. Enhance effectiveness of nutrient control and removal practices by encouraging a "stacked" approach to nutrient management such as reduce, trap, and treat.
8. **Monitor** water quality at the subwatershed scale to characterize existing conditions and evaluate effectiveness of watershed projects and conservation practices.
9. Continue to assess long-term water quality status and trends in the Raccoon River and enhance these efforts as resources allow.

The plan discussed the topic of **subsurface tile** drainage. "Although subsurface tile decreases runoff from the surface of a field, subsurface flow and leaching losses of nitrate are increased. This is due mostly to an increase in flow volume and the 'short-circuiting' of subsurface flow, but also in part to the increased mineralization and formation of nitrate in the soil profile (Randall, Goss, and Fausey 2010). Subsurface tile drainage provides a direct channel from farm fields into adjacent surface water streams." (page 21)

Source: Polk County SWCD

Other findings listed were as follows:

- An organization is needed to carry out a strategic mission for the entire Raccoon River watershed, however to be effective, projects would need to target smaller geographic areas (p 25).
- The Iowa Stormwater Management Manual was identified as an under-used resource for educating communities on the issue of stormwater management and low-impact development (p 31).
- Recent surveys identified a lack of awareness among agricultural landowners regarding the impact of row crop production in tile drained landscapes (p 33).
- Proper messaging regarding the priority problem and the need for action needs to be developed. The absentee landowner needs to be successfully engaged (p 36).
- Creating an effective payment or incentive program to engage agronomists is important (p 41).
- A table of agricultural best management practices that were evaluated is included (p 50).
- The Walnut Creek watershed was listed as very low priority for nitrate reduction (p 55).
- The plan also listed the Walnut Creek watershed as very low priority for pathogen reduction (p 59). (This seems to be contradicted by available monitoring data which shows extremely high pathogen levels, especially in the urbanized area of the watershed).
- Phosphorus reduction was listed as a higher priority in areas outside the Walnut Creek watershed (p 64).
- Sediment reduction within the Walnut Creek watershed was listed as a medium priority (p 66).

A nutrient reduction strategy is described on page 73 of the Raccoon River plan, stating "adequate control of nutrients will require a combination of best management practices that 1) reduce the source of nutrients; 2) trap nutrients before they enter water sources; and 3) treat tile drainage water or surface runoff to reduce nutrients." A table of nutrient BMPs categorized by source reduction, trapping and treatment is included on that same page.

Iowa Nutrient Reduction Strategy—Updated 2014

The subtitle of this report is "a science and technology based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico." It was prepared by the Iowa Department of Agriculture and Land Stewardship (IDALS) along with the IDNR and Iowa State University's College of Agriculture and Life Sciences.

It was developed following the creation of the 2008 Gulf Hypoxia Action Plan that calls for states to create strategies to reduce pollutant loadings to the Gulf of Mexico. The Action Plan set a goal of at least 45% reduction in total nitrogen and total phosphorus loads. The Iowa Nutrient Reduction Strategy outlines steps to prioritize watersheds and resources, improve current state programs and increase voluntary efforts to reduce nutrient loadings (Executive Summary).

The Nutrient Strategy assigns pollutant loadings to both **point** and **non-point sources**. It assumes that a 4% reduction in nitrogen and 16% reduction in phosphorus can be accomplished by point source reductions such as improvements at wastewater treatment plants. The remaining 41% of nitrogen and 29% of phosphorus reductions are identified as being accomplished through non-point source reductions (page 3).

The Strategy projects that nitrogen losses are a greater concern in tile drained landscapes. The largest losses are expected to occur with sustained flows occurring in the spring and at times with little evapotranspiration and nutrient uptake. In steeper, hilly areas, phosphorus losses can be greater. Surface runoff and transported sediment are common carriers of phosphorus. The largest losses can occur after rainfall events (page 9). Streambank erosion is also identified as potentially significant source of phosphorus loading (page 10).

The Strategy includes the Iowa Nonpoint Source Nutrient Reduction Science Assessment. This is based on **peer-reviewed studies** of **in-field, edge-of-field** and **watershed scale practices** and treatments to determine potential reductions in total nitrogen and phosphorus.

The framework for the Nutrient Reduction Strategy includes several major points (pages 18-26). <u>Key items relatable to the Walnut Creek watershed are underlined.</u>

1. Prioritization of Watersheds. In 2013, the Water Resources Coordinating Council (**WRCC**) selected nine priority watersheds to focus targeted conservation and water quality efforts. The North Raccoon River was listed as one of these nine priority watersheds.
2. Determine Watershed Goals. The WRCC is tasked with coordination of indicators to provide stakeholders with information to establish baselines and report progress.
3. Ensure Effectiveness of Point Source Permits. The goal is to have major **Publicly Owned Treatment Works** (POTWs) install improvements to reduce nutrient outflow. <u>Permitted animal feeding operations will continue to be monitored</u>. Iowa point sources, IDNR, IDALS and WRCC will work to develop a nutrient trading credit program, based on 2003 EPA guidance.
4. Agricultural Areas. <u>Setting priorities includes a focus on conservation, in- and off-field practices, pilot projects and implementation of nutrient trading.</u> Research and Technology will continue to identify new technologies and solutions, develop private and public support for more research and continue to gain a better understanding of the Gulf Hypoxia Zone. <u>An approach to improved outreach, education and collaboration is outlined</u>. Programs for farmer recognition and a statewide education and marketing campaign is identified as a need. Sources of potential funding are briefly described.
5. Storm Water, Septic Systems, Minor POTWs and Source Water Protection. No specific nutrient reductions are identified for urban stormwater runoff. <u>However, a focus is given to infiltration of the water quality volume (runoff from a 1.25" rainfall event). By managing this volume, reductions of 80-85% of annual runoff volumes could be achieved. Septic systems are proposed to be addressed through time of sale inspections to identify and correct leaky systems</u>. The Iowa Source Water Protection Program educates the public and local officials on the importance of protecting groundwater drinking water resources. A link to potential funding sources is provided.
6. Accountability and Verification Measures. A technical work group will define the process for providing a regular nutrient load estimate. The IDNR will track progress of implementing the reduction strategy for permitted point sources. A system for tracking non-point sources and improvements is outlined.
7. Public Reporting. WRCC will develop public annual reports. <u>Watershed management plans are expected to include strategies to assess and demonstrate progress in achieving load reductions.</u>
8. Nutrient Criteria Development. IDNR continues to review and assess water quality, with development of a suitable nutrient criteria as a long-term goal.

Section 2 of the Nutrient Reduction Strategy contains the science assessment. Some key findings of note, as related to the development of a plan for the Walnut Creek watershed:

- Key practices for nitrogen removal:
  - Nitrogen management practices, **cover crops** and **living mulches**.
  - Land use changes to energy crops, **perennial vegetation** or **extended rotations**.
  - Wetlands, drainage water management, **buffers** and **bioreactors** are edge-of-field practices with greatest potential for nitrogen reduction.
- Key practices for phosphorus removal:
  - Reducing tillage and cover crops can significantly reduce phosphorus loss.
  - Land use changes from corn-soybeans to energy crops, perennial vegetation or extended rotations.
  - Edge of field practices that settle sediment such as ponds and stream buffers.
- The Science Team will publish an updated practice list as an addendum to the Reduction Strategy,
- Table 2 (p 6) and Table 3 (p 7) have details on expected load reductions for nitrogen and phosphorus for various practices and their expected impact on corn yield.

Source: USDA

Source: USDA

CHAPTER 5

KEY CONCEPTS

1. **The streams of this watershed currently are not "natural"**
   Most of the streams within the watershed have been altered by human activity. Most streams that were present naturally have been straightened and widened. Other streams have been created by grading or tiling. Some streams which did exist have been enclosed within pipes and culverts.

2. **Stream assessments identify problems**
   Nearly half of the significant streams in this watershed were reviewed in the field. Of these, 57% had signs of moderate to severe streambank erosion. Only 1% of streams in urban areas were considered to be stable.

3. **Increases in flow make small streams act like larger rivers**
   Streams throughout the watershed are often wider and lower than they were historically. They have formed wider and deeper channels to convey larger volumes of water.

4. **Buffers wanted**
   Buffer strips along streams were either absent or were not wide enough along almost half of the smaller streams across the watershed. This means nearly 100 miles of stream length could use better buffers.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Current levels of streambank erosion and management are far above historic levels. Private property and infrastructure near streams are put at great risk. Adequate stream buffers can reduce runoff, slow velocities, resist erosion, filter pollutants and provide important habitat.

Five

Character of Streams

57%

of all field assessed streams had moderate to severe erosion

Many streams are

4-10 times

wider now than they were prior to pioneer settlement. As they widen, streambanks are eroded, displacing trees and large amounts of soil; nearby property and infrastructure is often threatened.

239

miles of streams reviewed as part of the development of this plan

48%

of smaller streams *(0 or 1st order)* have no stream buffer or have a buffer that is less than 50 feet in total width

71%

of streams *(1st order and above)* are incised or deeply incised meaning they have downcut or become lower over time

What is a buffer? Buffers slow and filter runoff before it enters the stream.

Stream Order

Stream order is an important concept to understand in watershed planning. Streams of different sizes often have different challenges and opportunities for improvements. The IDNR has created maps of streams throughout the state. They group these streams into classes by stream order using the **Strahler method**. The headwaters of a given stream, where **perennial** flow is first observed are defined as first order steams. When two first order streams meet, they join to form a second order stream. When two second order streams meet, they join to form a third order stream. Two streams of the same order must meet in order to move up to the next order. For example, at the confluence of a first and second order stream, the downstream segment remains classified as a second order stream. The second order stream does not become a third order stream, until it meets another second order stream. [1]

Stream order classification

The Walnut Creek watershed includes first, second and third order streams. Most of the perennial streams in the watershed are of the first order. Lower sections of the Little Walnut, South Walnut and North Walnut Creek are second order streams. Walnut Creek is a third order stream downstream of its confluence with Little Walnut Creek.

Throughout the watershed, there are many swales, ditches, depressions and small streams that drain significant areas, yet do not have perennial flow and are not classified as first order streams. These drainage paths are clearly visible on LiDAR topographic imaging available through the State of Iowa. To better understand the properties of key flow paths throughout the watershed, many of these features have been mapped as "zero order" streams. As part of this effort, they were studied in similar detail to the more defined stream segments within the watershed.

Most of the streams reviewed in this plan are "zero order" and "first order" streams.

Streams that have year-round continuous flow during periods of normal rainfall are called "perennial streams." "Intermittent streams" normally stop flowing for extended periods each year. "Ephemeral streams or channels" usually only have surface flow right after rainfall events. (Adapted from Wikipedia definition of "perennial stream").

Stream Order	Length Within Watershed (miles)	Proportion of All Streams
0	143	60%
1	58	24%
2	21	9%
3	17	7%

Source: Stream order 1-3 data: IDNR Natural Resources GIS Library website. Stream order "zero" data as mapped by RDG Planning & Design, using information from Iowa Geographic Map Server website.

Source:
1. State University of New York; http://www.fgmorph.com/fg_4_8.php

USGS website; http://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/NHD_Help/Introduction_to_the_NHD/Feature_Attribution/Stream_Order.htm

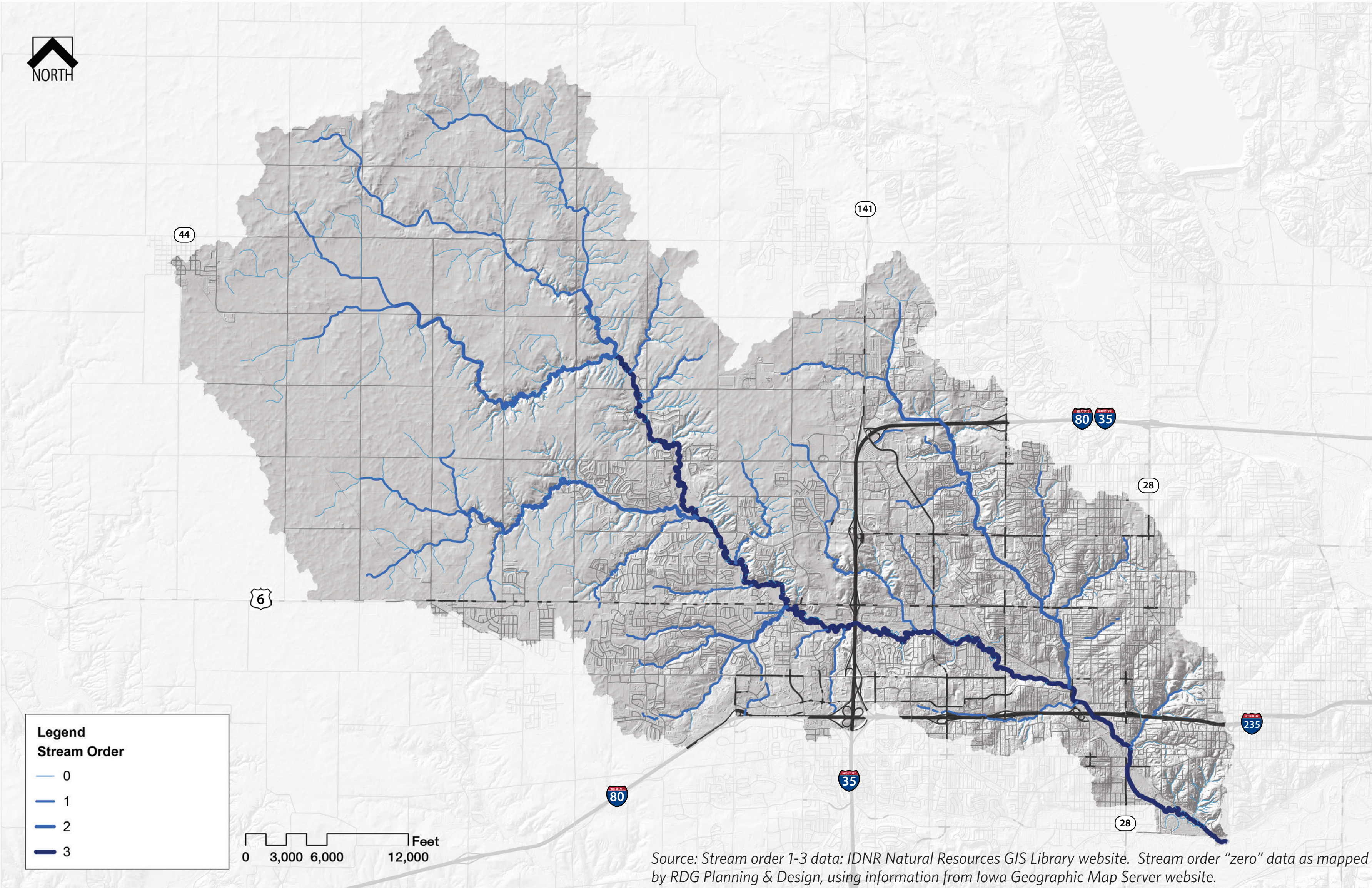
ZERO ORDER STREAM: A small "zero order" stream passes through a grass buffer in this photo.

FIRST ORDER STREAM: "First order" streams are often more defined and have constant flow.

SECOND ORDER STREAM: A "second order" stream pass through a treed buffer.

THIRD ORDER STREAM: A lower section of Walnut Creek is a "third order" stream

Source (all): RDG



Source: Stream order 1-3 data: IDNR Natural Resources GIS Library website. Stream order "zero" data as mapped by RDG Planning & Design, using information from Iowa Geographic Map Server website.

Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Stream Order

Vertical Stream Character

These basic categories were used to describe the general types of stream cross-sections that have been observed during field assessments and desktop GIS information review. They are used to evaluate the relationship of a stream to the surrounding areas and the severity of past erosion.

Larger streams are more likely to be incised or deeply incised. Ravines most commonly appear on smaller streams with steep slopes.

Vertical Stream Character by Stream Order

Stream Order	P	U	D	I	DI	R	G	V
0	3%	11%	55%	9%	8%	10%	2%	2%
1	8%	2%	28%	11%	45%	6%	0%	0%
2	4%	0%	2%	14%	73%	2%	5%	0%
3	0%	0%	0%	0%	100%	0%	0%	0%

Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.


Pond

Vertical Stream Characteristics

Character Type		Description
P	Pond	Wet ponds, usually located on zero to second order streams and usually created by an artificial dam.
U	Undefined	These are parts of zero and first order streams in agricultural lands in the flat, upper areas of the watershed. Paths of **concentrated flow** are difficult to discern from topographic information. Sometimes these paths can be determined by wet areas observed in aerial photographs. There is little or no daily flow observed between rainfall events.
D	Defined	Sections of zero to second order streams where the flow path can be seen using **LiDAR** topographic maps. Road ditches, swales and more concentrated flow paths in farm fields fall into this category.
V	Valley	Similar to a ravine, but with more gentle side slopes and with minimal active erosion. Flow passes through a narrow point. The top of the valley is most often more than 100 feet wide.
I	Incised	Erosion is visible on some portions of zero to second order streams where the stream is beginning to downcut into the soil. This "incision" usually begins on streams with moderate to higher slopes with a narrow cut of one to five feet in width and one to two feet in depth. In this condition, normal stream flow is beginning to be separated from the rest of the natural flood plain.
DI	Deeply Incised	Where downcutting has progressed past a small incision, erosion can range from three to fifteen feet (or more) in depth, at widths from 5 to more than 50 feet. The cross-section of the stream is actively deepening and/or widening to convey additional flow. Most of the higher order stream segments within the watershed fall into this category. At this stage, normal stream flow is disconnected from the surrounding flood plain.
R	Ravine	Ravines (or gullies) were considered to be smaller order stream segments, usually with steeper slopes. Active downcutting is often visible in these segments. The rate of erosion is moderate, with the stream channel cross-section forming a "V" shape with a narrow bottom and steep sides. The top of the ravine is usually 20 to 100 feet wide.
G	Gorge	Similar to a ravine, but with more rapid erosion. The channel cross-section has a wider bottom, forming a shape more similar to a "U." Depths of erosion can exceed 20 feet and the top of the gorge can be 40 to 60 feet in width.


Undefined
Source: RDG


Deeply Incised
Source: RDG


Source: RDG


Ravine
Source: RDG


Incised
Source: RDG


Gorge
Source: Greg Pierce

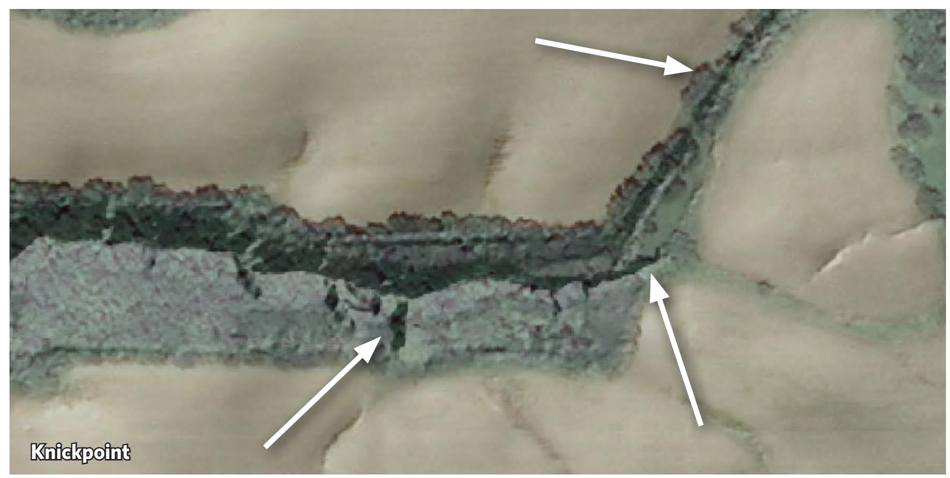
Horizontal Stream Character

These basic categories were used to describe the general types of stream alignments that have been observed during field assessments and desktop GIS information review. They are used to evaluate the relationship of a stream to the surrounding areas and the potential for movement of the stream.

Horizontal Stream Characteristics		
Character Type		Description
B	Braided	This is where the stream is divided into multiple paths, separated by islands or where multiple points of erosion have occurred.
M	Meandering	The stream weaves back and forth through a series of tight curves.
O	Oxbow	These are remnants of past channel locations. As the stream moves and meanders, low spots are left in the landscape where the stream channel used to be. They are often filled with sediment during large flood events, becoming much more subtle features over time. Since these are no longer the primary path of flow of the stream, they were catalogued as "zero order" streams, even though they usually were found alongside higher order streams.
K	Knickpoint	These are segments where a sudden drop or waterfall occurs. Below the drop, the stream is actively incising (downcutting). These knickpoints tend to work their way upstream over time, as erosion grows more significant. The downstream channel is left wider and flatter than before, able to convey larger flows at lower velocities than the stream above. These are usually located on smaller order streams. Often, the downstream alignment follows a straightened path. The knickpoint is usually at a defined point, but for the purpose of this analysis, longer segments were defined as this feature type when the knickpoint existed within them.
S	Straightened	Almost all segments have been altered, straightened or restricted from movement in the past. For this analysis, the stream was defined as straightened if it was a stream with constant flow where the alignment and general character of the original drainage ditch construction was clearly evident.
N/A	No Definition	The location and character of most of these segments have been significantly altered by human activity, but they don't clearly fall within any of the definitions above.

Horizontal Stream Character by Stream Order						
Stream Order	B	M	O	K	S	N/A
0	<0.1%	3%	3%	6%	7%	81%
1	0%	30%	0%	1%	28%	42%
2	0%	61%	0%	0%	30%	9%
3	0%	70%	0%	0%	25%	5%

Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.



Source (all): Iowa Geographic Map Server website.


Straightened Source: RDG


Straightened Aerial Source: Iowa Geographic Map Server website

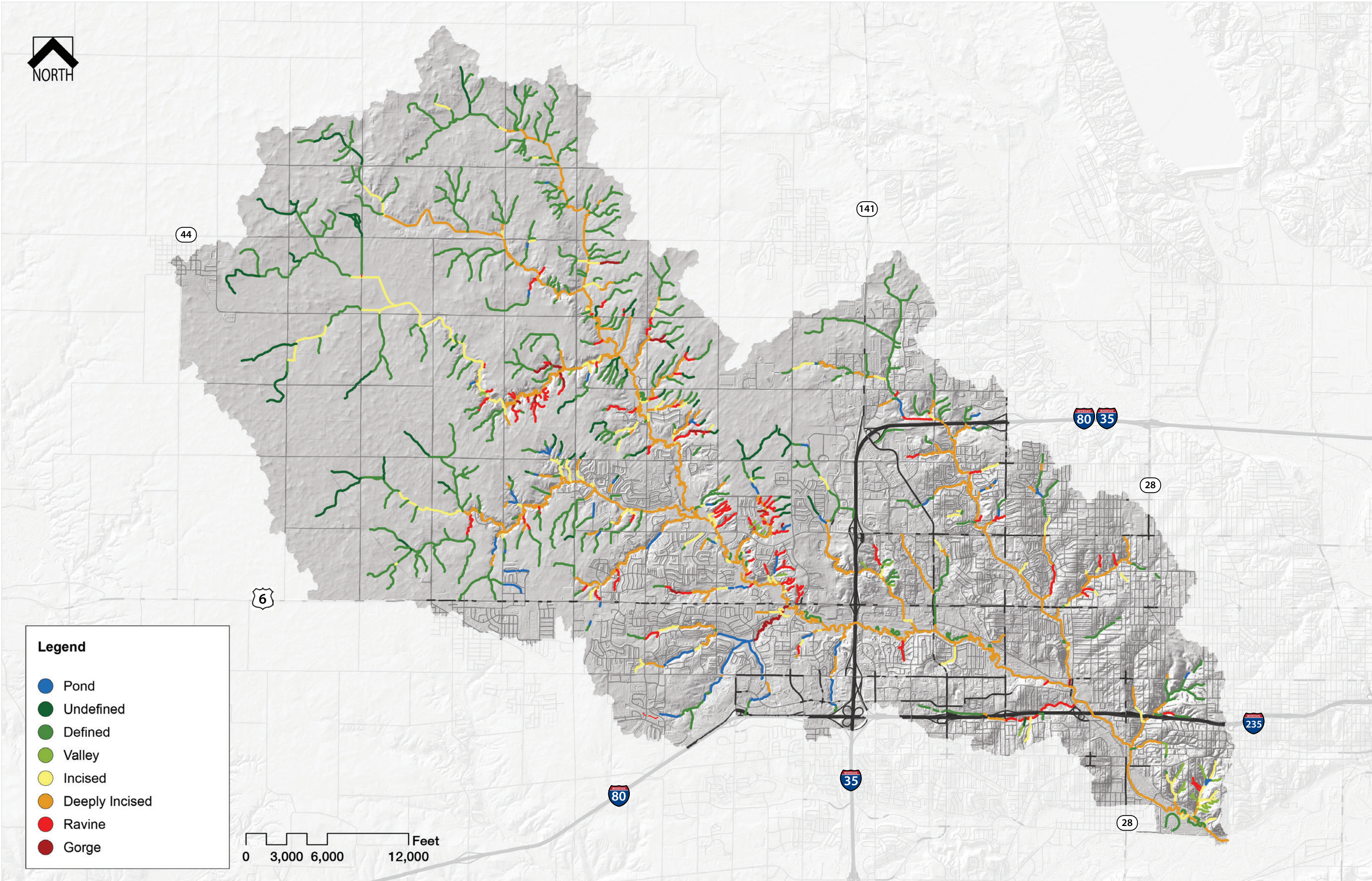

Tiled Source: RDG

Why are the horizontal characteristics of a stream important?

These characteristics tell much about the history of a stream and how it is expected to behave in the future.

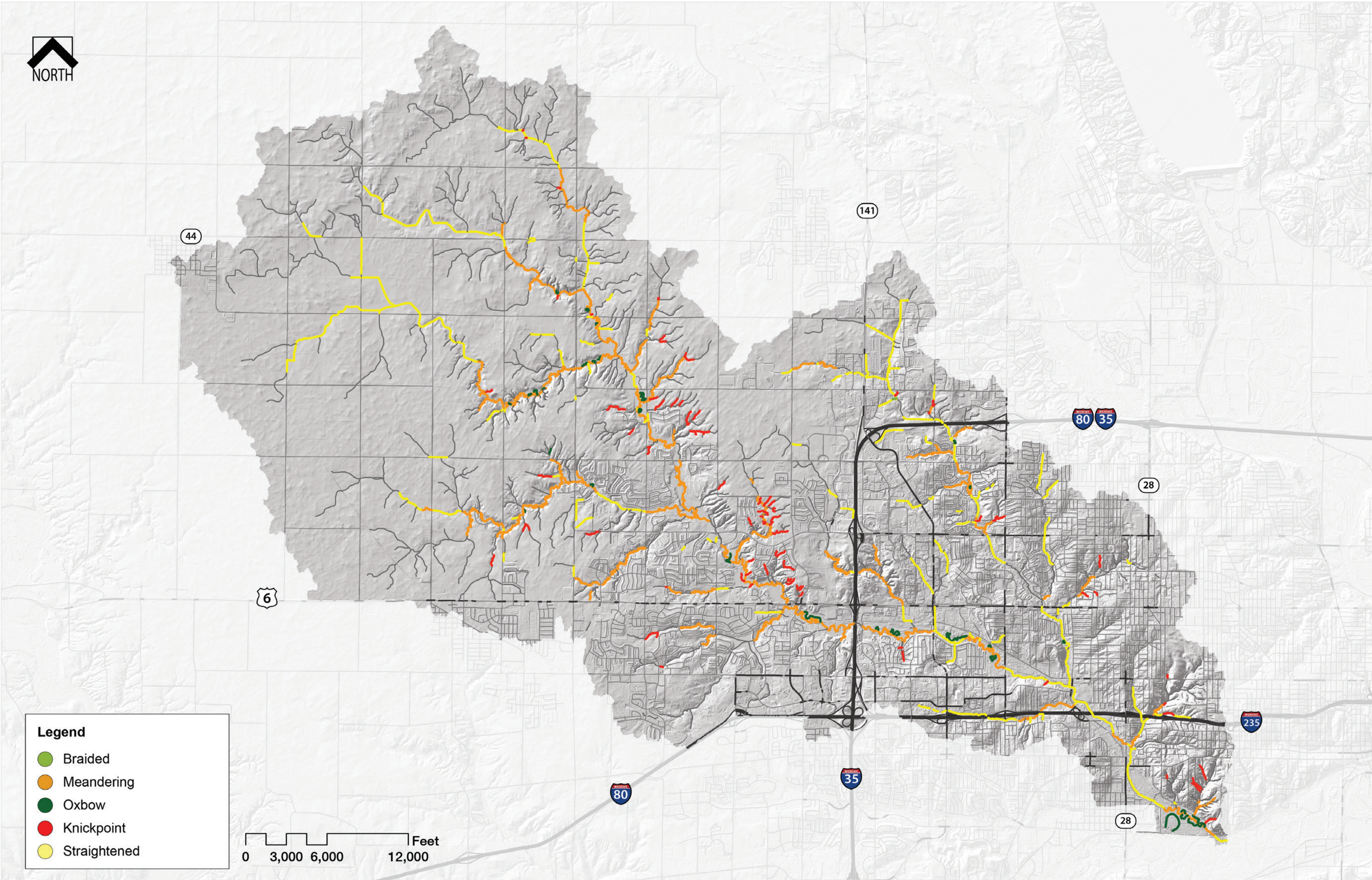
- Meandering streams are changing paths over time. The rate of change may be more rapid in areas with higher flow.
- Oxbows are past stream channels, where the main path has moved a different direction, leaving a depression or pond where the old channel used to be.
- Knickpoints indicate that there may be active erosion (downcutting) which will move upstream over time.
- Straightened streams have had their paths altered by construction of ditches, dikes or levees. They usually will push water downstream at an accelerated speed, which could lead to more significant erosion downstream.
- Some drainage paths with relatively large drainage areas (more than a square mile in some cases) may not show signs of being a stream at all. In agricultural areas, this is usually due to the installation of subsurface tile drainage lines.

Larger streams develop meanders more frequently. Stream meandering is a natural process; however, increases in streamflow and sediment load can accelerate that process far beyond natural levels.



Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Vertical Stream Characteristics



Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Horizontal Stream Characteristics

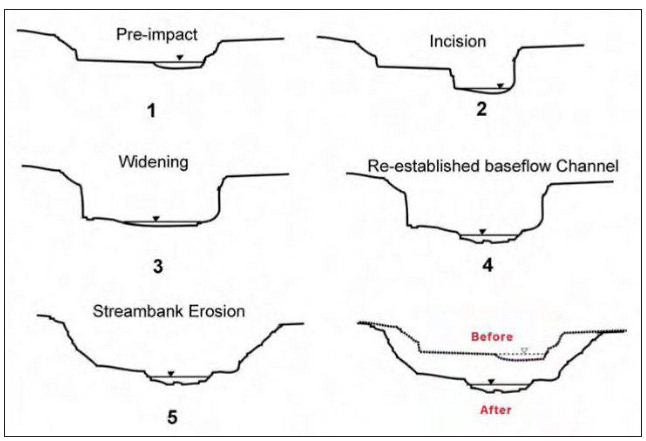
Stream Evolution

> The study of stream evolution is called **fluvial geomorphology**.

One method of stream path change involves sediment settling out of flow in areas where velocity is reduced (i.e. inside curve of stream bends, downstream of obstructions like downed trees or debris piles). As sediment collects, it piles up and can change the normal path of flow, often forcing it toward the outer banks of the stream. As this happens, stream velocity increases along the edges of the stream, leading to more streambank erosion. The sediment lost from the streambank is carried downstream until it reaches a place where velocities slow to a point where sediment can settle out. This is a cycle of erosion and deposition which repeats over time. The stream meanders, and flow paths form and disappear. In some areas along Walnut Creek, there is evidence of past meanders that are more than 500 feet from the current stream.

Changes in land use can magnify this effect to levels not seen within the native landscape. Increases in the rate and volume of runoff result in faster and deeper streamflows. These effects increase the erosive force on the bed and banks of the stream. This shear force cuts against stream banks, widening the stream. The bed of the stream begins to be incised, or downcut.

Sources of increased sediment loads, such as cropland, gullies and construction sites with insufficient controls can accelerate the cycle of stream evolution. Over a long period of time, a wider and flatter stream is created, capable of conveying higher flow volumes. The new channel is often several feet lower than the natural stream bed. This results in a stream that is disconnected from the flood plain above. When streams are disconnected from their floodplain, it is more difficult for water to spread out across the floodplain where it can flow more slowly allowing for absorption and filtration. Disconnection also changes the habitat conditions for a variety of plants, insects and animals which rely on having access to a stable boundary between stream and floodplain.



Channel Evolution: Progressive Stages of Channel Incision
Source: Schumm, 1999


Areas where sediment has deposited

Evidence of past channel locations seen in LiDAR topography


Streambank Stability Analyses

Two separate stability studies were reviewed as part of development of this plan. The first was completed within the scope of this planning process by staff from the Polk County Soil and Water Conservation District. Their efforts completed a RASCAL (Rapid Assessment of Stream Conditions Along Length) survey of more than 28 miles of streams, primarily in the rural areas of this watershed. This assessment was completed in the field during the summer months of 2015, walking along each segment using a GPS data collector equipped with the RASCAL software to gather information about a variety of characteristics of the stream.

The second was the 2014 Clive Stream Assessment Report Update. This study reviewed the stability conditions of streambanks of more than 13 miles of streams within the City of Clive. Most of these assessments were completed within the publicly owned Clive Greenbelt. This report was an update to assessments completed in 2009, which was conducted using the RASCAL protocol.

Collectively, these two studies evaluated streambank stability for nearly 42 stream miles within this watershed. This represents a current evaluation of 44% of the total length of first through third order streams in this area. Other studies have also been completed in the past by other cities, which were reviewed as part of development of this plan. In some cases, specific GIS data from these other studies was not available for analysis. In other cases, the data provided was from before 2014, so it was not considered a current evaluation of stream conditions and was not included in the statistical analysis for this plan.

	2015 RASCAL Survey		2014 Clive Assessment		Combined	
Bank Stability	**miles**		**miles**		**miles**	
Stable	5.89	20.8%	0.10	0.7%	5.99	14.4%
Minor Erosion	7.72	27.3%	4.24	31.6%	11.97	28.7%
Moderate Erosion	7.41	26.2%	5.83	43.4%	13.24	31.7%
Severe Erosion	7.26	25.7%	3.26	24.3%	10.52	25.2%
Total	28.29		13.43		41.72	

Less than 1% of urban streams assessed were categorized as stable. 68% of urban streams were seen to have moderate or severe erosion.

Source: Includes analyses by Polk County SWCD (2015) and Clive Stream Assessment Report Update (2014).

These assessments generally grouped streambank conditions into four categories:

- *Stable*—Banks were protected by natural vegetation and were not showing signs of lateral erosion.
- *Minor erosion (or moderately stable)*—Banks were mostly protected by natural vegetation, but the banks were showing signs of minor erosion.
- *Moderate erosion (or moderately unstable)*—Natural vegetation was not protecting major portions of the stream. Outer banks were often showing signs of erosion. Often there were some signs of trees and/or other vegetation falling into the stream within these segments.
- *Severe erosion (or unstable)*—Some straight reaches and inside bends were actively eroding, as well as almost all of the outer bends. Trees and vegetation were frequently falling into the stream. Little or no natural vegetation was protecting the banks of the stream.

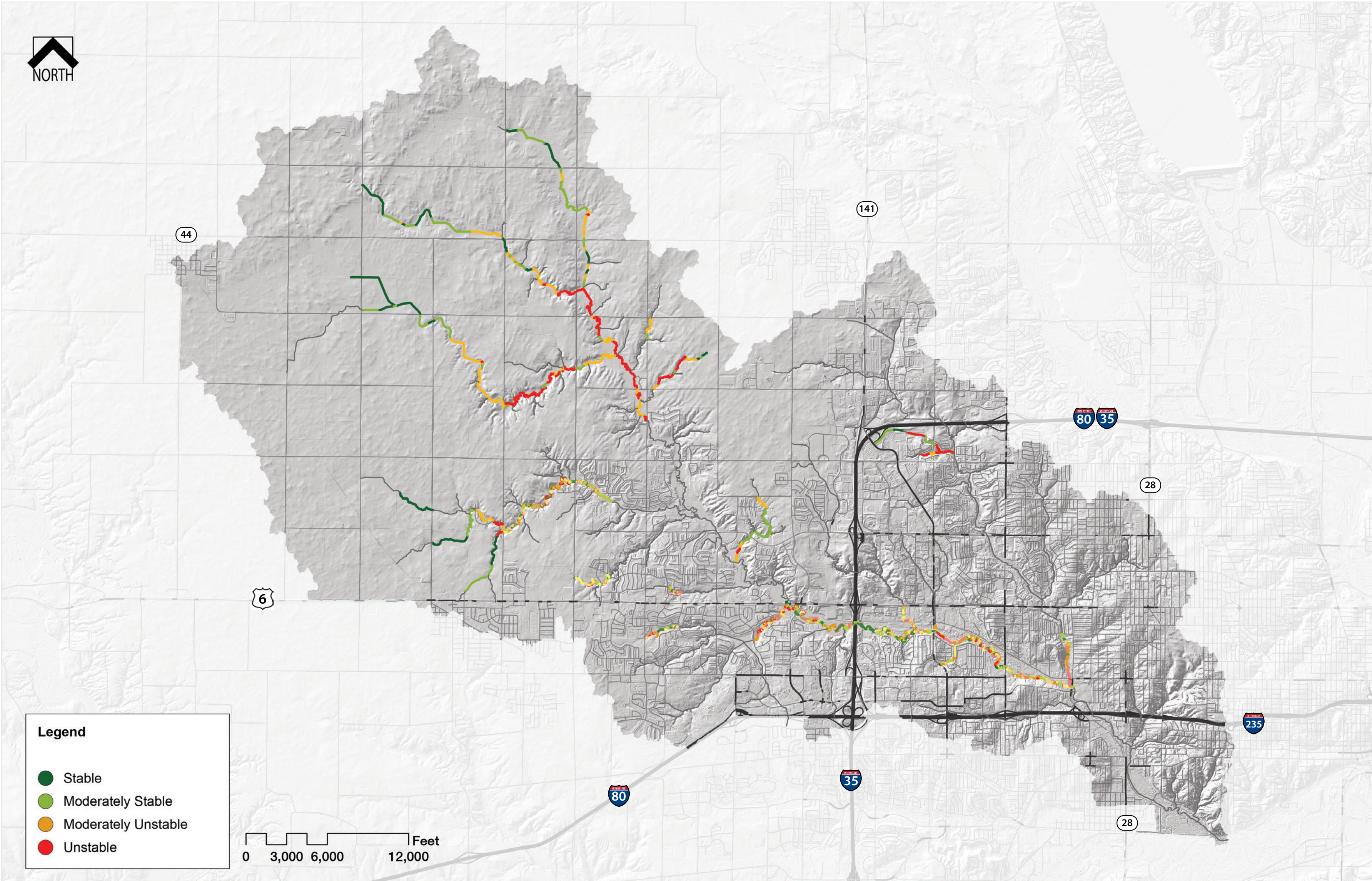
Definitions above were adapted from IDNR RASCAL protocol instructions.

What is notable from these studies is that streambanks appear to be more unstable in urban areas. Less than 1% of streams in urban areas were categorized as "stable," with 21% in this condition in the rural assessments. Moderate erosion is also much more noticeable in urban areas than in rural areas.

It is estimated that 11,300 tons of sediment loading per year may be caused by streambank erosion. Primary sources of this erosion are the 88.7 miles of stream segments that were categorized as "incised" or "deeply incised." The methods of water quality modeling that generated these estimates are explained in greater detail in Chapter 6 and in the appendices of this plan.

Sediment Load: How is it estimated?

To calculate sediment loads generated by streambank erosion, erosion rates were established for each of these four conditions. To account for loadings where streams were not assessed, the ratios above were applied to all streams which were noted as having a vertical condition as "incised" or "deeply incised," as described earlier within this plan. Ratios from the 2015 RASCAL survey were applied to non-assessed streams in rural areas. Ratios from the 2014 Clive Assessment were applied to those streams in urban areas.



Source: Includes analyses by Polk County SWCD (2015) and Clive Stream Assessment Report Update (2014).

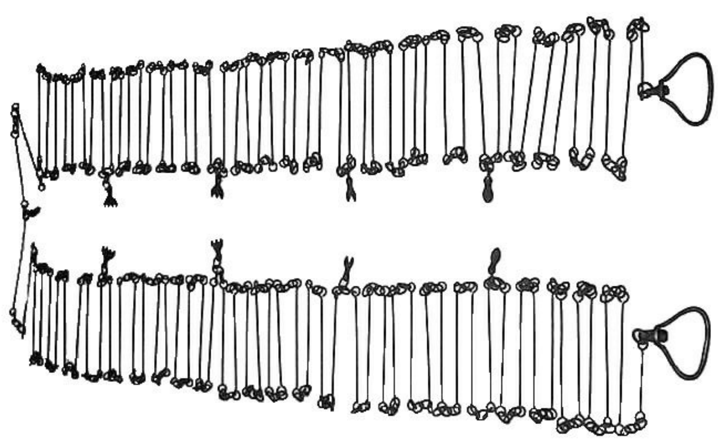
Rascal Streambank Stability

Stream Width

Streams throughout the watershed have changed significantly since pioneer settlement. The early surveyors measured the width of streams as they surveyed each section line (or the edge of each square mile of land). They would measure the width of streams by the numbers of links on their surveyor chains. Each chain had 100 links and the chain was 66 feet long. So each link in the chain was eight inches in length. By reviewing the original survey maps of this area, we can determine the width of the stream in their time (mid 1800s) and compare it today's conditions.

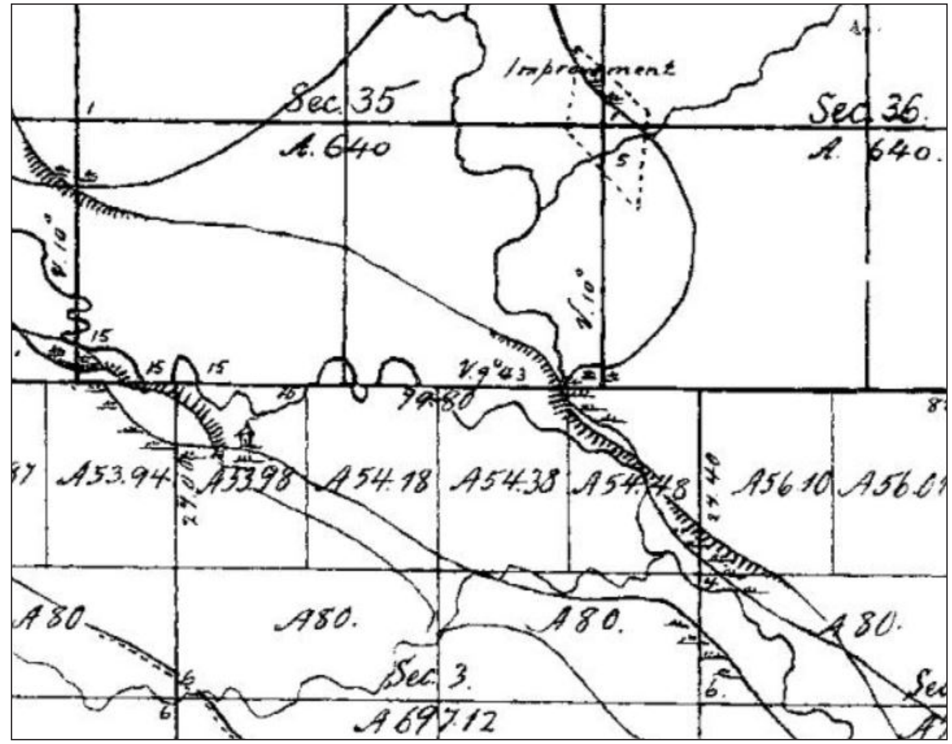
Two conclusions can be reached:

1. Fewer streams existed prior to settlement. The surveyors recorded streams as small as one foot in width. Many of the "zero" and some of the first order streams that exist today were not drawn on their survey maps and no measurement for stream width was recorded. As agricultural and urban uses have increased the portion of precipitation that is converted to surface runoff, new streams have been created. New streams were also created by draining the landscape to support agriculture during the late 1800's and early 1900's through installation of tiles and ditches.
2. The streams that did exist prior to settlement were much narrower than those we see today. The table on the following page notes changes in stream width between what was recorded by the original surveyors and what can be measured from the LiDAR survey of the state that was completed in 2007-2008.

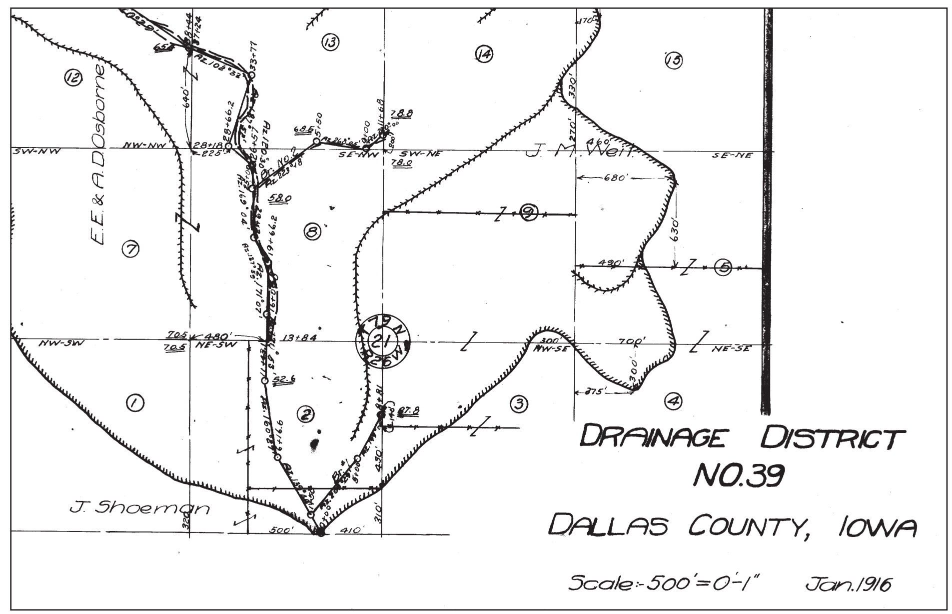


Survey Chain

Source: Williams Computer Science http://eventfuljava.cs.williams.edu/s04/labs/links/



1800s Land Survey Map

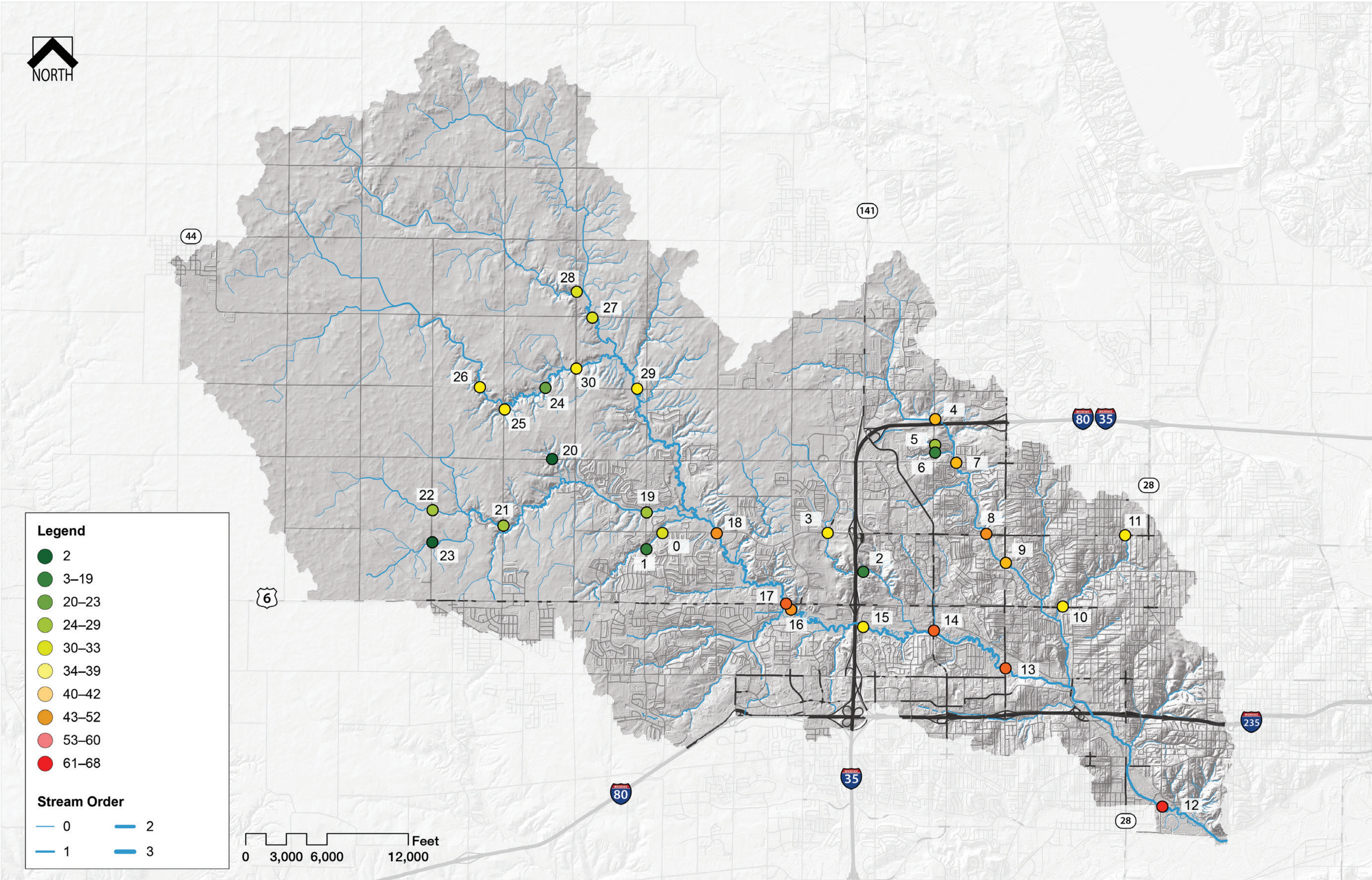


1916 Drainage District Map

ID #	Location	Microwatershed	Stream Bottom Width (in feet)		Change (in feet)	% Change
			Mid-1800's	Recent (LiDAR)		
0	Tributary to Little Walnut at Douglas Avenue	611.01	3	35	32	1067%
1	Tributary to Little Walnut at 156th Street	611.01	3	20	17	567%
2	Living History Creek at Projection of 114th Street	212.01	4	20	16	400%
3	Living History Creek at Douglas Avenue	212.01	4	40	36	900%
4	North Walnut Creek at 100th Street (Just North of I-35/80)	503.02	3	45	42	1400%
5	Tributary to North Walnut at Projection of 100th (S of Brookview)	503.22	1	30	29	2900%
6	Small Tributary to N. Walnut at Projection of 100th (N of Oakwood)	503.23	1	20	19	1900%
7	North Walnut Creek at Meredith Drive	503.01	3	45	42	1400%
8	North Walnut Creek at Douglas Avenue	502.02	4	55	51	1275%
9	North Walnut Creek at 86th Street	502.02	4	45	41	1025%
10	Rocklyn Creek at Hickman Avenue	511.01	4	40	36	900%
11	Rocklyn Creek at Douglas Avenue	511.03	1	40	39	3900%
12	Walnut Creek at Projection of 55th Street (DSM)	101.02	12	80	68	567%
13	Walnut Creek at 86th Street	201.01	10	65	55	550%
14	Walnut Creek at 100th Street	201.01	8	65	57	713%
15	Walnut Creek at 114th Street	202.01	10	45	35	350%
16	Walnut Creek at Old Alignment of 128th Street	202.02	10	60	50	500%
17	Walnut Creek at Hickman Road	203.01	10	70	60	600%
18	Walnut Creek at Douglas Avenue	203.03	8	60	52	650%
19	Little Walnut Creek at 156th Street	601.02	7	35	28	400%
20	Small Tributary to Little Walnut Creek at Meredith Dr.	601.31	4	6	2	50%
21	Little Walnut Creek at Warrior Lane	601.03	4	30	26	650%
22	Little Walnut Creek at U Avenue	602.01	3	30	27	900%
23	Tributary to Little Walnut at U Avenue	613.01	4	6	2	50%
24	Tributary to Walnut Creek at Projection of 260th (East)	701.01	7	30	23	329%
25	Tributary to Walnut Creek at V Avenue	701.01	4	40	36	900%
26	Tributary to Walnut Creek at Projection of 260th (West)	701.01	3	40	37	1233%
27	Walnut Creek at 250th Street	401.01	7	40	33	471%
28	Tributary to Walnut Creek at W Avenue	411.01	2	35	33	1650%
29	Walnut Creek at 260th Street	301.02	7	45	38	543%
30	Tributary to Walnut Creek at W Avenue	701.01	7	45	38	543%

These are 31 locations where mid-1800's surveys located and measured stream width. All are significantly wider today. Refer to Chapter 2 for more information on watershed ID numbering.

Source: Pre-settlement data from General Land Office Survey Maps from Iowa Geographic Map Server website. Recent data based on RDG measurements from LiDAR data available from Iowa Geographic Map Server website.



Stream Width

Stream Buffers

Variety of Buffer Types

Stream conditions throughout the watershed were observed and were grouped into seven general buffer descriptions, defined on the following page. The length of each type of buffer for each stream order for the entire watershed was calculated.

Several observations can be made from this analysis.

- Nearly 50% of all "zero order" streams pass through agricultural and urban landscapes without any noticeable buffer.
- Grass buffers were most common on smaller first order streams.
- Buffers along larger streams are more likely to include overstory trees, either from historically forested areas or locations where grass buffers have been allowed to evolve into a young forest.

Current Stream Buffer Widths

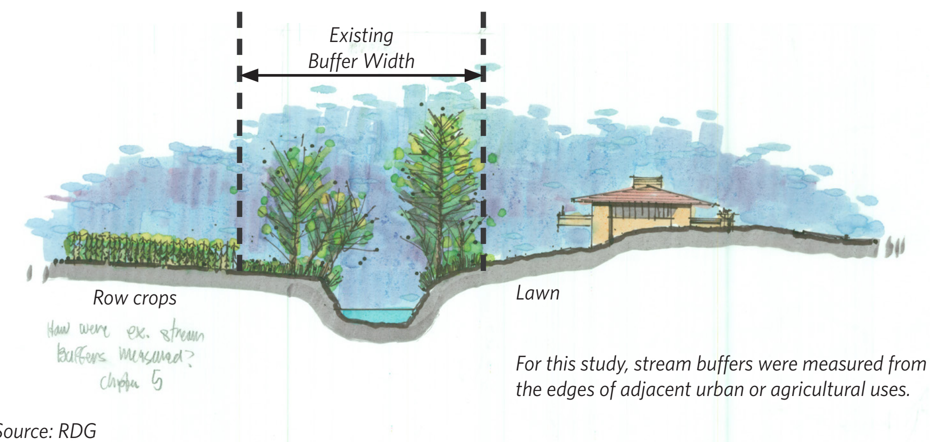
Existing buffers can generally be grouped into grass and tree buffers. Knowing the width of these buffers is important in understanding how effective each buffer will be in filtering runoff and providing important habitat. Buffer width for this study is defined as the total width measured across both sides of the stream.

Developing Overstory Aerial *Source: Iowa Geographic Map Server website*

Where they exist, grass buffers are often wider than 50 feet. However, 33% of "zero order" streams had grass buffers that are less than this width. Combining these lengths with those sections that were observed to have no buffer at all, means that 57% of all "zero order" streams in the watershed have either no buffer or grass buffers which are less than 50 feet in width. Grass buffers can be very effective in smaller order streams in capturing sediments, reducing pollutant loads and slowing runoff velocities. Their notable absence in large portions of the watershed is a concern.

Most treed buffers exceed 100 feet in width. These buffers tend to get wider along larger streams. Many of these higher order streams pass through urban areas. Their larger drainage areas lead to wider floodplains, limiting other development opportunities. Over time, many of these open spaces have developed into wider buffers of overstory trees. These areas need to be maintained through selective clearing to prevent overgrowth or development of **invasive species**.

Example of Buffer Width Measurement



Source: RDG


Grass Swale
Source: RDG


Range
Source: RDG


Overstory Aerial
Source: Iowa Geographic Map Server website


Tilled
Source: RDG


Partial Over Aerial
Source: Iowa Geographic Map Server website


Urban
Source: RDG

Generic Buffer Descriptions			
	Buffer Type		Description
No Buffer	T	Tilled	Water flows directly through row crop agricultural lands without any type of buffer.
No Buffer	R	Range	Streams pass through pastures used to support livestock operations, where they have direct access to the stream and no fencing or other buffer is present.
No Buffer	U	Urban	Streams pass adjacent to residential, commercial or other urban land uses without a discernible buffer between the land use and the stream. Manicured lawns, paved surfaces or even structures are located directly adjacent to the top of bank of the steam.
	G	Grass	A buffer of tall grasses or native vegetation (primarily without trees or shrubs) located along the stream.
Trees	D	Developing Overstory	Overstory trees are starting to establish within what was previously a grass buffer.
Trees	P	Partial Overstory	The canopy cover of trees within the buffer is generally between 40 and 70%.
Trees	O	Overstory	The buffer along the stream is more than 70% covered by a tree canopy.

Generic Buffer Types by Stream Order							
Stream Order	**T**	**R**	**U**	**G**	**D**	**P**	**O**
0	42%	2%	5%	17%	4%	4%	26%
1	6%	1%	15%	35%	2%	7%	33%
2	0%	8%	6%	12%	5%	11%	58%
3	0%	0%	0%	4%	15%	26%	55%

About 50% of zero order streams pass through a tilled field, pasture or urban area without a buffer.
Larger streams are more likely to have treed buffers.

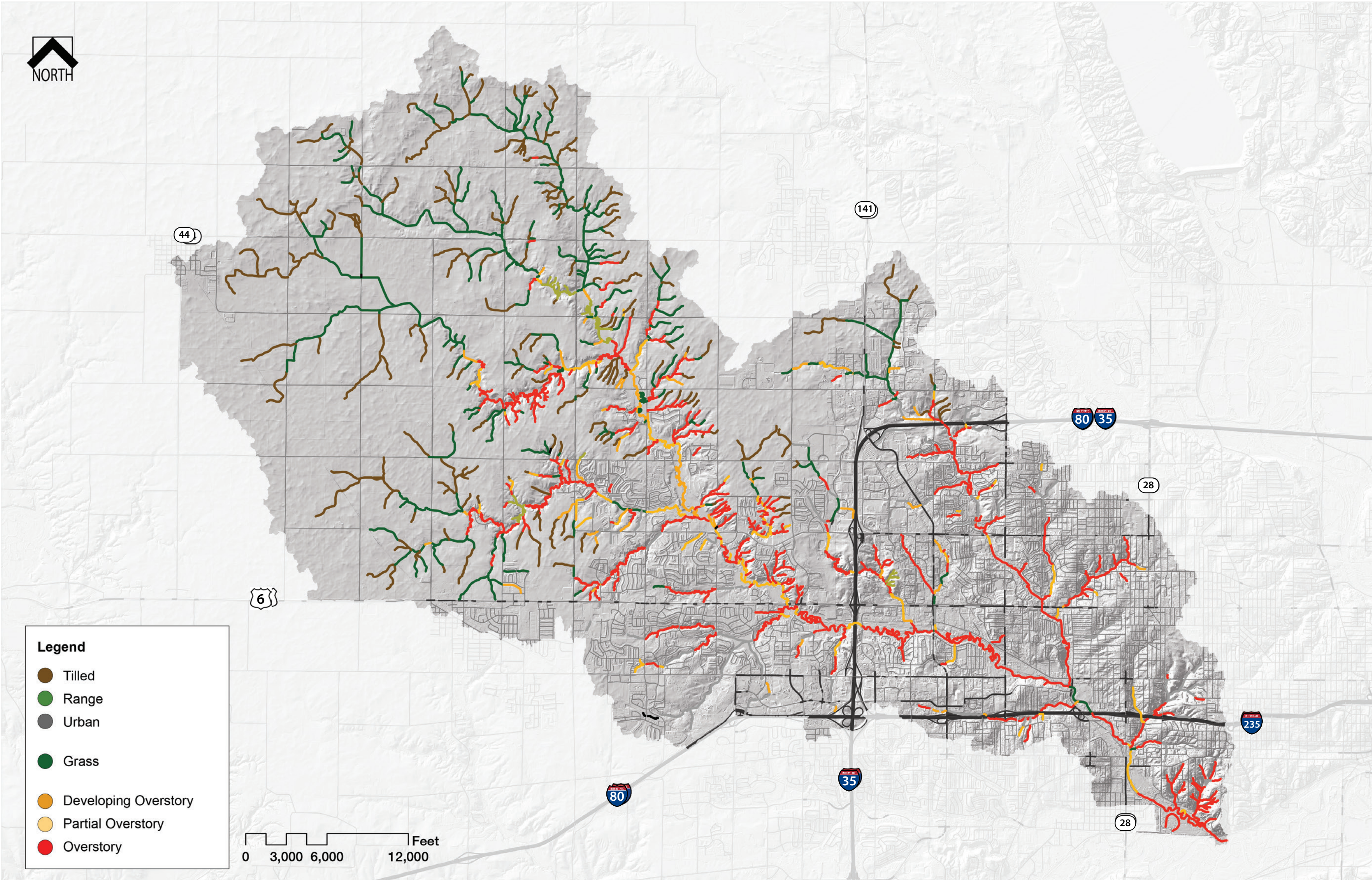
Grass Buffers					
	Buffer Width (feet)				
Stream Order	**< 10**	**11-49**	**50-99**	**100-199**	**> 200**
0	7%	26%	48%	15%	4%
1	0%	14%	16%	43%	27%
2	0%	0%	32%	12%	56%
3	0%	0%	0%	31%	69%

By combining areas with grass buffers of less than 50 feet in width with areas with no buffer, it is found that 48% of zero and first order streams have inadequate buffers.

Treed Buffers					
	Buffer Width (feet)				
Stream Order	**< 10**	**11-49**	**50-99**	**100-199**	**> 200**
0	0%	3%	20%	44%	33%
1	0%	1%	22%	36%	41%
2	0%	0%	12%	14%	74%
3	0%	0%	0%	15%	85%

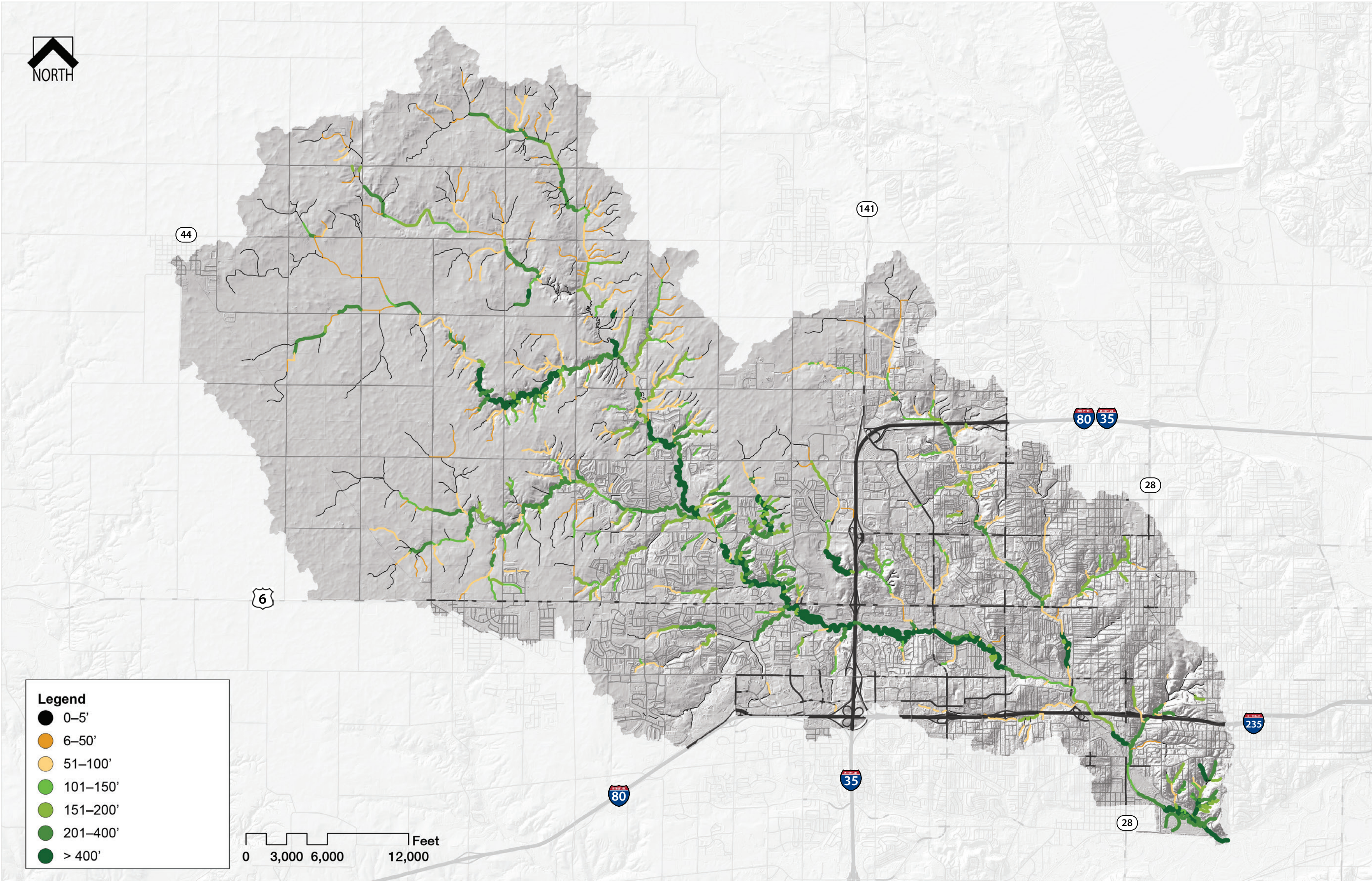
The majority of treed buffers are at least 100 feet in width.

Source (all): Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.



Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.

Stream Buffer Types



Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.

Stream Buffer Widths

CHAPTER 6

KEY CONCEPTS

1. **Key pollutants of concern have been identified**
   Nitrogen, phosphorus, sediment and pathogens have been identified as the most important pollutants to address with this plan. These pollutants pose risks to human health and the environment, which are outlined within this chapter in greater detail. Strategies to prevent increases in stormwater rates and volumes also need to be considered, as stormwater tile flow and runoff are the largest carriers of these pollutants to the receiving streams. Local flooding has also caused damage to private property and infrastructure.

2. **Water quality monitoring data is valuable**
   Data collected by the Iowa Soybean Association / Agriculture's Clean Water Alliance (ISA/CWA) and the IOWATER volunteer monitoring program has been valuable to identify pollutant loads and their potential sources.

3. **Nutrient levels appear higher in rural areas**
   Monitoring data has demonstrated that levels of nitrogen and phosphorus compounds are usually seen at higher levels in the rural areas within this watershed.

4. **Bacteria levels appear higher in urban areas**
   Observed levels of E.coli bacteria have been much higher within the urban landscape, although levels all across the watershed were consistently above the state's water quality standard.

5. **Key sources of sediment loading**
   Streambank erosion, construction sites and gully erosion are projected to be the leading current sources of sediment loading to Walnut Creek. Almost 30,000 tons of sediment per year are estimated to be delivered from the Walnut Creek watershed to the Raccoon River.

6. **Small footprint, big impact**
   Construction sites make up only 0.1% of the watershed on average each year, but contribute significantly to the overall sediment load.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

To develop targeted, effective solutions, the key pollutants posing the greatest risk need to be identified. The likely sources of these pollutants need to be identified so that effective practices can be implemented to achieve the desired load reductions.

SIX

Key Pollutants and Sources

Water Quality Monitoring Samples

- Collected by Iowa Soybean Association/Agriculture's Clean Water Alliance and IOWATER volunteers
- Collected at two sites along Walnut Creek, every other week, throughout spring and summer
- IOWATER completed sampling at over 30 locations within the watershed, but more infrequently

Key Pollutants of Concern

- Nitrogen
- Phosphorus
- Sediment
- Pathogens *(bacteria and viruses)*
- Runoff rates and volumes

Agricultural Areas
Nitrogen and phosphorus compounds have been measured at higher levels.

Urban Areas
Levels of bacteria have been at higher concentrations.

Pollutant Sources By Land Use

	N	P	Sediment
Urban	14%	26%	7%
Cropland	81%	49%	10%
Pastureland	2%	2%	0%
Forest	0%	1%	0%
Grasslands	0%	0%	0%
Gully	1%	5%	19%
Streambank	2%	10%	38%
Construction Site	1%	8%	25%

Source: Results of STEPL modeling performed by RDG

8 loading reduction goals are outlined within this chapter.

Nitrates

Highest measured concentration

22.9 mg/L

More than twice the Raccoon River Total Maximum Daily Load (TMDL) standard of 9.5 mg/L.

(from Iowa Soybean Association monitoring data)

77,010 orgs./100mL
was observed to be the maximum level of E.coli (indicator bacteria), which is more than 330 times the state's allowable average concentration of 235 orgs./100mL.

Available monitoring data within the Walnut Creek watershed was reviewed to aid in the identification of pollutants of concern, potential sources of pollution and to help inform and calibrate watershed water quality models. Several sources of information were reviewed.

Pollutants of Concern

Key **pollutants of concern** within the Walnut Creek watershed have been defined by considering the following information gathered through development of this plan:

1. Review of past studies, including the Water Quality Improvement Plan for the Raccoon River (TMDL), the Raccoon River Water Quality Master Plan and Iowa's Nutrient Reduction Strategy.
2. Review of past local and municipal watershed assessments and storm water infrastructure studies.
3. Collection of stakeholder input at WMA meetings, open houses and individual conversations.
4. An overview of the available water quality monitoring information collected from sites within the watershed.

Potential Impacts of the Identified Pollutants of Concern

This document identifies **key sources of pollution** and determines methods to reduce their impacts, both in this watershed and the downstream receiving waters. Reducing pollutant loads will require policy changes and implementation of practices requiring significant investment. To understand why such investments are necessary, it is important to realize the impact these pollutants have on health, the environment and local economic interests. [(1)]

Nutrients (Nitrogen and Phosphorus)

Nutrients like nitrogen and phosphorus exist in both surface and ground water under natural conditions. Their presence supports the growth of **algae** and aquatic plants, providing food and habitat for fish and other aquatic life within streams and lakes. Excessive algal growth can occur when the levels of these nutrients are too high. **Algal blooms** can block sunlight below the surface, clog fish gills, reduce habitat quality and diminish habitat. The death and decay of algae can lead to diminished oxygen levels, known as **hypoxia**. Oxygen levels can fall to a range where fish and other wildlife may be sickened or killed. As of 2013, there were 166 of these hypoxic "dead zones" that had been identified in and around the United States. The largest

Source:
1. http://www2.epa.gov/nutrientpollution/problem

Pollutant of Concern	Reasons
Nitrate (Nitrogen)	• The Raccoon River is listed as impaired by high nitrate levels, one of the reasons for development of the Raccoon River TMDL. • Nitrogen is one of the two key pollutants of concern listed within Iowa's Nutrient Reduction Strategy. • Levels of nitrate have routinely been observed at monitoring sites within the watershed above the State's water quality standard for the streams intended uses and above those levels established within the Raccoon River TMDL.
Phosphorus	• Phosphorus is one of the two key pollutants of concern listed within Iowa's Nutrient Reduction Strategy. • Levels of phosphorus have occasionally been observed at monitoring sites within the watershed above the State's water quality standard for the streams intended uses and above those levels established within the Raccoon River TMDL.
Sediment	• Insufficient construction site erosion control has been observed to be a significant source of sediment loading in certain locations. • Significant sediment deposition has been observed within channel areas of Walnut Creek and its tributaries. • Sediment loading has impacted the water quality and storage capacity of many ponds and lakes throughout the watershed, including Country Club Lake and Southfork Pond. • Depositing sediment has deflected and narrowed low flow paths, accelerating the horizontal movement of streams. This is leading to more significant streambank erosion, generating even higher sediment loads.
Pathogens	• The Raccoon River and lower Walnut Creek are listed as impaired by high bacteria levels, one of the reasons for development of the Raccoon River TMDL. • Levels of indicator bacteria at monitoring sites within the watershed have almost always been observed above the State's water quality standard for the stream's intended uses and above those levels established within the Raccoon River TMDL. In many cases, these levels have been well above the established standards, indicating a potential risk to public health.
Stormwater Quantity (Runoff Volume)	• While not considered a pollutant directly, volumes and rates of stormwater runoff are observed to be well above those which would have been expected prior to agricultural and urban development. These changes to the hydrology of the watershed increase the risk of flooding, streambank erosion and act as a carrier for larger pollutant loads being delivered through and out of the watershed.

of these areas was a 5,840 square mile area (approximately 10% of the size of the entire state of Iowa) in the Gulf of Mexico, largely attributed to nutrient polluted runoff received from the Mississippi River watershed (which includes the entire state of Iowa).

Excessive algal growth can also increase growth of bacteria and other human **pathogens**. In some cases, algae can form toxins which can cause rashes, stomach/liver illness, **respiratory** and **neurological** effects in humans. Direct exposure to this algae affects fish and other wildlife, with the toxic impacts being carried up the food chain if they are consumed by other animals. If toxic algae enter into the water supply stream, they can be converted into **dioxins** through the use of chemical disinfectants in the water treatment process. Risks to human health from dioxins include cancers, reproductive and developmental issues. [(1)]

Nitrate has been observed at elevated levels in stream flows within the Walnut Creek watershed. Des Moines Water Works' main intake point for surface water from the Raccoon River is located just downstream of where Walnut Creek flows into that river. Nitrates have been known to cause illness and death of human infants when at high levels.

Blue baby syndrome can affect the elderly and bottle-fed infants, with those younger than three months being most at risk. High nitrate levels in drinking water supplies can be converted by the human body into nitrite. These react with red blood cells, reducing their ability to carry enough oxygen throughout the body. The mouth, hands or feet of the affected person may appear blue. Complications can include trouble breathing, diarrhea, vomiting, lethargy, loss of consciousness and seizures. Extreme cases may be fatal. [(2)]

For this reason, Water Works employs a state of the art nitrate removal system, which is used when elevated levels of nitrate are detected in the source water. This system is expensive to operate and maintain, costing $7,000 per day to operate. From December 2014 to July of 2015, **DMWW** spent more than $1,500,000 to remove nitrate from the water. The cost of this operation is being transferred to residents and local businesses through annual water use rate increases.

Sources:
1. *World Health Organization (www.who.int/water_sanitation_health/diseases/cyanobacteria/en/)*
2. *Adapted from World Health Organization website: http://www.who.int/water_sanitation_health/diseases/methaemoglob/en/*

Possible Sources of Nutrient Pollution	
Wastewater Treatment Plant	Dallas Center's wastewater treatment facility is located within this watershed. Point sources such as these are permitted through the Iowa Department of Natural Resources and are required to provide treatment of wastewater to lower pollutant loads to acceptable levels.
Leaking Sanitary Sewer Systems	Untreated wastewater can exfiltrate, or leak out from gaps or cracks in sanitary sewer mains, structures and connection points. This most commonly occurs in older systems, if they are not regularly inspected or maintained. Communities often have a program of regular inspections to address this issue.
Septic Systems	System failures related to improper design, age or lack of maintenance can lead to overflows or leakage into shallow groundwater layers.
Confined Animal Feeding Operations	These are **point sources** and require operation permits by the State. Wastewater is collected in lagoons and applied in the surrounding area following a manure management plan.
Pastures	Loading can be higher where livestock has direct access to streams, or there is little buffer between the pastureland and the stream.
Fertilizer and Manure Applications	Pollutant loadings can be affected by application rates, season, timing of rainfall events and application close to streams where adequate buffers are absent.
Legume Fixation	Process where crops such as soybeans convert nitrogen in the atmosphere to nitrogen compounds. A portion of the amount converted often remains in the soil and can be transported into groundwater or tile drainage.
Tile Drainage	More efficiently drains shallow groundwater from agricultural fields. This groundwater often contains elevated levels of nutrients.
Lawn Fertilizer Applications	Nutrient content, irrigation, overspray onto paved surfaces or streams and rainfall events following application can influence the amount of nutrient loading from this source.
Pet and Yard Waste	Fecal matter from pets and decomposing yard waste such as lawn clippings, leaves and garden waste. These materials are sometimes not collected appropriately, or in some cases are dumped directly into the storm sewer system or streams.
Wildlife	Sources include fecal matter from ducks, geese, other birds, deer, raccoons, other rodents, feral cats and dogs.
Car wash detergents	Car wash detergents contain high levels of phosphates. Most commercial car washes have systems which collect polluted wash water, however washing of vehicles in parking lots and driveways could allow these detergents to be washed into the storm sewer system.
Atmospheric deposition	Nitrogen gas is the most common compound in our atmosphere. Deposition of nitrogen can be increased by elevated levels of air pollution, usually attributed to the burning of fossil fuels.

Source:
1. *Adapted with information from http://www2.epa.gov/nutrientpollution/problem.*

With information adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).

Pathogens

Pathogens are the most common cause for **water quality impairment** in the United States, with nearly 11,000 waterbodies listed as impaired for this cause in 2014. Pathogens are microscopic organisms which can cause disease in humans or animals. These include viruses, bacteria, protozoa and parasitic worms. The likely presence of pathogens is typically identified by measuring levels of **fecal indicator bacteria** (FIB) such as **Escherichia coli** (E. coli) or **fecal coliform**. Elevated levels of these indicator species demonstrate that conditions are favorable for pathogens at a level which could impact human health when exposures occur.

The primary concern is incidental human ingestion during recreational contact, resulting in illness. In addition, respiratory, skin, ear and eye infections are also possible. Those most at risk are the very young, those with compromised immune systems and those with no prior exposure to the pathogen. The level of exposure required to cause illness varies with each type of pathogen.

Pathogen	Symptoms
Viruses	Main symptoms from most common viruses may include diarrhea, vomiting, headache, fever and abdominal cramps.
Bacteria Salmonella	May cause diarrhea in humans.
Bacteria Campylobacter	Known to cause diarrhea, abdominal cramping, pain, fever, nausea and vomiting.
Bacteria E. coli	Most strains are harmless. A few specific strains can result in hemorrhagic colitis. Approximately 10% of cases of this disease lead to hemolytic uremic syndrome, a leading cause of kidney failure in children.
Other Bacteria	Other water related bacterial diseases include pneumonia, kidney infections and skin / wound infections.
Protozoa Cryptosporidium	This is one of the most significant causes of waterborne illness today, able to persist in the environment for months at a time in some cases. The dose required to cause infection is small. The disease is usually self-limiting, however it can be chronic and life threatening for those with compromised immune systems.
Protozoa Giardia	The dose required to cause infection is small. The disease is usually self-limiting, however it can be chronic and debilitating for those with compromised immune systems.

Source: Adapted from "Pathogens in Urban Stormwater Systems," Urban Water Resources Research Council, August 2014

Possible Sources of Pathogens	
Wastewater Treatment Plant	Dallas Center's wastewater treatment facility is located within this watershed. Point sources such as this, are permitted through the Iowa Department of Natural Resources and are required to provide treatment of wastewater to lower pollutant loads to acceptable levels.
Leaking Sanitary Sewer Systems	Untreated wastewater can exfiltrate, or leak out from gaps or cracks in sanitary sewer mains, structures and connection points. This most commonly occurs in older systems, if they are not regularly inspected or maintained. Communities often have a program of regular inspections to address this issue.
Septic Systems	System failures related to improper design, age or lack of maintenance can lead to overflows or leakage into shallow groundwater layers.
Confined Animal Feeding Operations	These are point sources and require operation permits by the State. Wastewater is collected in lagoons and applied in the surrounding area following a manure management plan.
Pastures	Loading can be higher where livestock has direct access to streams, or there is little buffer between the pastureland and the stream.
Manure Applications	Pollutant loadings can be affected by application rates, season, timing of rainfall events and application close to streams where adequate buffers are absent.
Pet and Yard Waste	Fecal matter from pets and decomposing yard waste such as lawn clippings, leaves and garden waste. These materials are sometimes not collected appropriately, or in some cases are dumped directly into the storm sewer system or streams.
Wildlife	Sources include fecal matter from ducks, geese, other birds, deer, raccoons, other rodents, feral cats and dogs.

Source:

1. Adapted with information from http://www2.epa.gov/nutrientpollution/problem

Adapted from "Pathogens in Urban Stormwater Systems," Urban Water Resources Research Council, August 2014, with information adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).

Sediment

A certain amount of sediment is naturally present and transported in streams. However, the excessive loadings observed within this watershed can have significant impacts on water quality and stream structure.

High sediment loads directly impact watershed ecology through habitat loss, reduced wetland functions and impaired water quality in ponds and lakes. Sediment impacts the physical characteristics of waterbodies through decreased floodplain volumes (increases flood risk), higher stream velocities, accelerated streambank erosion, and reduced storage in ponds and lakes. Water quality is also directly affected, as some pollutants are able to bind to sediment particles and be carried downstream.

Possible Sources of Sediment	
Tilled Agricultural Landscapes	During periods of heavy rain, wind or during the spring freeze thaw cycle, soils can be eroded from the surface of the land and transported to streams.
Paved Surfaces	Since paved surfaces absorb no rainfall, they add to the amount of water that flows to our stormwater system and increase the speed and force of the water that reaches our creeks/streams through that system. These paved surfaces often are catch-alls for a variety of pollutants including oils, fuels, other chemical mixtures and trash/litter. Minimizing paved surfaces and buffering those that do exist, can reap meaningful results in preventing erosion, other forms of pollution and in some instances, assist with flood mitigation.
Construction Sites	Surfaces that are disturbed by construction can be significant sources of sediment loading, with erosion rates commonly ranging from 35-45 tons per exposed acre.[1] Effectively installed and maintained, erosion and sediment controls are necessary to prevent the movement of soil particles or to trap displaced sediment particles if erosion does occur.
Gully and Ravine Formation	Erosion rates can be dramatic within steep, narrow stream corridors. Rates of erosion can be highest where the surface has little erosion resistant vegetation or where flow rates or volumes have been altered by land development activities.
Streambank Erosion	When stream channels widen, downcut or move laterally, the soil eroded from the bottom or the bank of the stream is directly input into the flow of the stream.
Wind Erosion	Wind erosion can remove soil from various landscapes and deposit it in other surfaces where it can be washed away during rainfall events.

Source:
1. *Developing Your Stormwater Pollution Prevention Plan; A Guide for Construction Sites—US EPA, May 2007*

Problem	Effect
Habitat Loss	• In-stream structures, such as pools and gravel beds (which are important habitat for fish and other aquatic life) can be lost when filled with sediment. • Sediment laden waters can keep fish from finding food and can interrupt spawning.
Deposition	• Sediment is more quickly deposited in lower velocity flow zones, such as inside bends of streams or near bridge columns. As sediment builds up in these areas, it can push more water outward in higher velocity zones toward banks of the stream, accelerating bank erosion and creating even higher sediment loads. • In some locations sediment deposition can reduce channel flood plain storage and clog stormwater infrastructure such as inlets, pipes and culverts. • Deposited sediment can fill wetlands, ponds and lakes; diminishing their storage depth, affecting habitat and impacting water quality within and downstream of these waterbodies.
Other Pollutants	• Sediment particles act as transport vehicles for certain pollutants, such as phosphorus and metals. • Sediments can provide refuge for pathogens from sunlight and predators, extending their lifespan and in some cases creating a medium for their reproduction.
Drinking Water	• Taste and odor problems can be developed in drinking water sources.

Source:
1. *Adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).*

Runoff Rates and Volume

Hydrology is the study of how water moves through and over the landscape. Stormwater runoff caused by rain, snowmelt and groundwater movement are the main ways that pollutants are carried from the landscape to receiving waters. As volumes of surface and subsurface runoff increase, a larger load of nutrients, pathogens and sediments are likely to be driven to the stream. Understanding the activities that increase the rates and flows of runoff can help us identify potential sources of such increases to address.

Activities that reduce the soil's ability to soak up water **(infiltration)** or restrict its ability to move through the soil **(percolation)** lead to increases in stormwater runoff volume. Both infiltration and percolation are decreased when soils are compacted. In rural areas, compaction can occur when large equipment is driven over or through the soil during agricultural activities. Tilling, fertilizing, harvesting and tile installations are all activities which can compact soils. In urban areas, soil compaction primarily occurs by use of heavy equipment during grading and construction operations as part of land development. Installation of impervious surfaces such as roofs, driveways, parking lots and streets can virtually eliminate infiltration which increases runoff volume.

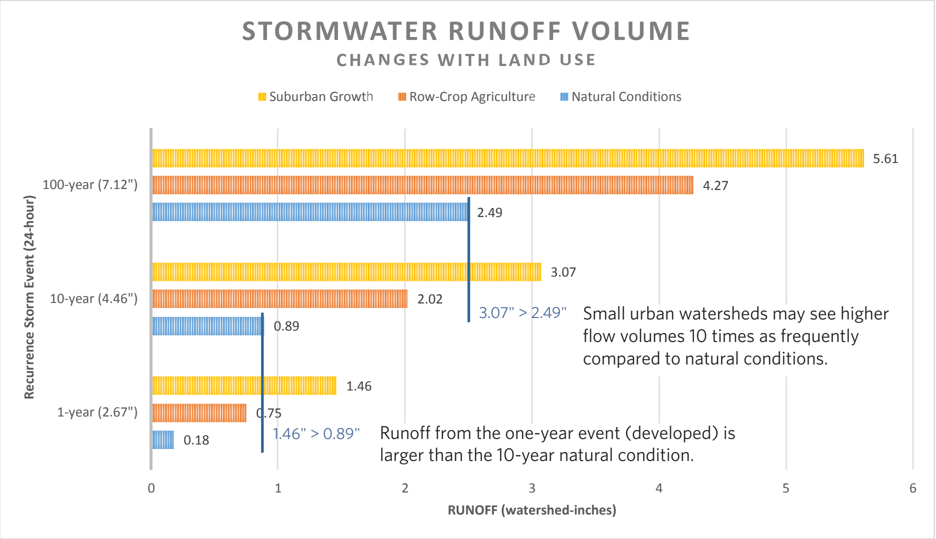
Runoff volume is also increased when native plants, trees and other vegetation are removed. Plants use water in **photosynthesis**, changing air and water into sugars for growth. They also distribute water to their leaves and release it back into the atmosphere using a process called **transpiration**. Their root structures dig deep into the soil, helping to keep it loose and porous. They provide habitat for worms, insects and burrowing animals which also increase void spaces within the soil.

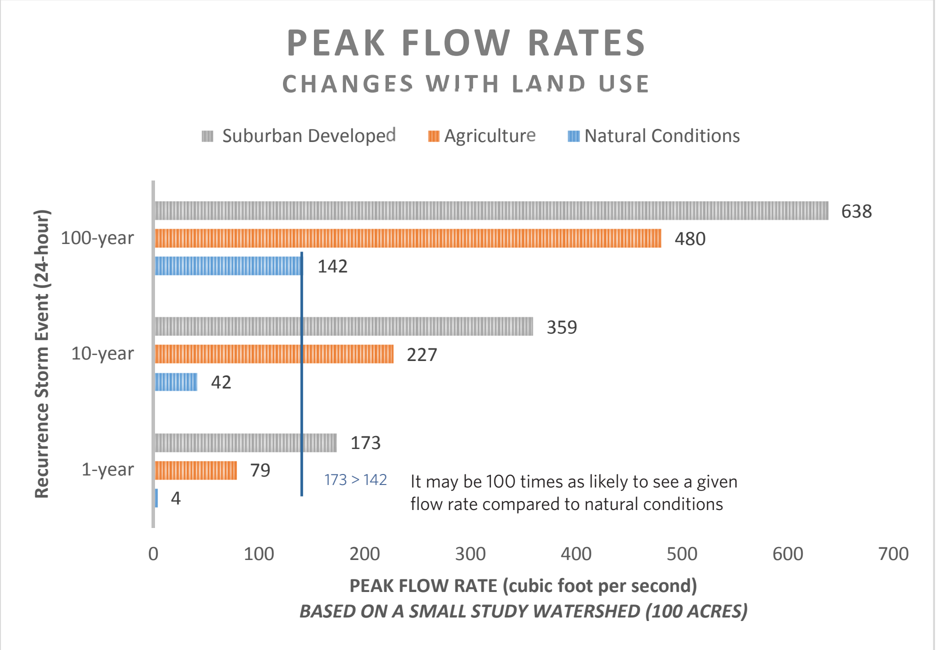
As landscapes are developed, many changes also effect the speed at which runoff is funneled to streams. This decreases the **time of concentration**, or the longest time it takes for runoff to reach the most downstream point from the extents of a given area. In agricultural areas, many ditches and tiles were constructed to drain wetlands and low lying areas. In some areas, the alignments of larger streams were straightened. Roads were installed with ditches and culverts. In urban areas, impervious areas collect runoff and quickly funnel it into gutters and storm sewers. The pipe network very quickly routes this runoff to the nearest pond or stream.

The combination of these effects results in a system which has been significantly altered from natural conditions. By modeling a case study of a developing area, the effects of these changes can be seen. Runoff volumes in both the agricultural watershed and suburban environments are likely to be several times higher than pre-settlement conditions. The proportion of increases are highest during the smaller, most frequently occurring storms. It should be noted that this comparison is based on suburban conditions (primarily single-family with some commercial growth, with a total of 40-45% impervious cover). More intense development scenarios would be expected to generate even higher runoff volumes.

Shortened time of concentrations magnify the effects of increased runoff volume. In rural areas, peak rates of flow may be nearly 20 times higher than pre-settlement levels during the most frequently occurring storms. In the suburban environment, peak rates for these events are expected to be 20-45 times more than the natural conditions. These drastic changes demonstrate how storm events of less than three inches of rain can cause rapid rises in stream levels and flash flooding. These effects are likely most dramatic in smaller streams in urban developed areas. These quick bounces account for a significant amount of streambank erosion on an annual basis, leaving the streambanks weakened and vulnerable for more significant impacts from the more rarely occurring larger events.

URBAN SMALL WATERSHED STUDY





Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see Chapter 8 and appendix resources).

Overview of Available Monitoring Data

Iowa Soybean Association / Agrculture's Clean Water Alliance (ISA/ACWA)

The **Iowa Soybean Association** in collaboration with **Agriculture's Clean Water Alliance** and the Des Moines Water Works has collected data at four separate locations along the main stem of Walnut Creek. Regular **sampling** at these sites offers the ability to evaluate conditions during a variety of flow conditions through most of the year. The limitations of this data are the small number of sites (no more than two for each year) and a lack of data during the winter, early spring and fall months of the year.

Site 40—Located near Valley Drive Bridge over Walnut Creek (Des Moines)

Data collection at this site began in April 1999 with weekly sampling through mid-November of that year. Beginning in 2000, sampling was usually conducted every other week from April through August. Data through 2014 was reviewed with the development of this plan.

This location is located less than one mile downstream of the USGS gaging station referred to in Chapter 2. Walnut Creek has received runoff from over 98% of its watershed at this location. The combination of these two factors makes this location valuable in estimating overall watershed loading and watershed scale model calibration.

Note: Water Quality data provided by the Iowa Soybean Association, the Agriculture's Clean Water Alliance and the Des Moines Water Works, supported by various grants and contracts assisting watershed management implementation in Iowa. For more information contact Roger Wolf, Director of Environmental Programs; Executive Director, Agriculture's Clean Water Alliance; Iowa Soybean Association; 1255 SW Prairie Trail Parkway; Ankeny, Iowa 50023; Tel: 515-251-8640 Fax: 515-251-8657

Information about eleven parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Discharge
- E.coli
- pH
- Fluoride
- Nitrate as N
- Nitrite as N
- Turbidity
- Orthophosphate as P
- Sulfate
- Total Coliform

Site 70.0—Located near 156th Street Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2005 with sampling occurring every other week, usually during the spring and summer months. Data through 2014 was reviewed with the development of this plan.

This location, in concert with sites 70.1 and 70.2 provide valuable information about water quality as the stream leaves the agricultural landscape in rural Dallas County and enters the developing urban area.

Information about ten parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrate as N
- Nitrite as N
- Turbidity
- Fluoride
- Sulfate
- Total Coliform
- Orthophosphate as P
- Ecoli
- pH

Site 70.1—Located near Douglas Parkway Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2002 with sampling occurring every other week through August of 2003. Both years, sampling ended in late August.

Information about nine parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrate as N
- Total Phosphorus
- Fluoride
- Sulfate
- Conductivity
- Orthophosphate as P
- Nitrite as N
- Turbidity

Site 70.2—Located near Meredith Drive Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2004 with sampling occurring every other week through August of that same year.

Information about four parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrite as N
- Nitrate as N
- Orthophosphate as P

Snapshot Monitoring Data

Water quality data was collected at 31 sites across the Walnut Creek watershed through the Polk County, Raccoon River Watershed and Walnut Creek **snapshot monitoring** events. These events were typically conducted twice annually (a spring and fall date each year) by volunteers using IDNR **IOWATER** field test kits. These kits contain test strips and other measurement methods of making a quick evaluation of water quality conditions in the field. During these events, some samples were also taken for laboratory testing. The laboratory samples measure pollutants more precisely than the test kits, which only indicate the likely concentration range for a given pollutant. Data collected and reviewed as part of this study extends from June 2004 through October 2014.

Data gathered using field test kits included the following parameters:

- Chloride
- Dissolved Oxygen
- Nitrate as N
- Nitrite as N
- pH
- Phosphate
- Water Temperature
- Transparency
- Secchi Depth (measures turbidity)

Laboratory analysis included the following parameters:

- Bromide
- Chloride
- Chlorophyll
- Nitrate + Nitrite
- Nitrite
- Nitrogen, Ammonia
- Solids, Total Suspended (TSS)
- Solids, Total Volatile Susp. (TVSS)
- Specific Conductance

- E. Coli
- Fluoride
- Nitrate
- Nitrogen, Kjeldahl
- Orthophosphate
- Solids, Dissolved
- Sulfate
- Total Coliform
- Turbidity

Data was not collected at every site during each snapshot event. Also, not all of the parameters above were analyzed for each sample collected. Since sampling was conducted less frequently, this data is less effective at measuring the patterns of pollutant loading on a monthly or seasonal basis. It is also more difficult to evaluate the effects of different flow conditions on these pollutant levels, as detailed flow data is not recorded when samples are taken. However, this data is beneficial because it has been collected over a broader area than that collected by the Iowa Soybean Association, with a greater number of pollutants measured. More data was also collected in the later months of the year than at the ISA sites. Using this information with that collected by ISA/ACWA, allows a broader evaluation into the possible sources of certain types of pollution. This provides opportunities to validate outcomes from **water quality modeling** at a subwatershed level.

USGS Water Quality Data

Water quality data was collected at USGS gaging station 05484800 located near the 1st Street / 63rd Street Bridge over Walnut Creek on the border between Des Moines and West Des Moines (same location referred to in Chapter 3). Data was collected on roughly a monthly basis between December 1971 and August 1975; October 1983 and January 2002. *Over these periods, data on the following parameters was collected:*

- Discharge
- Gage Height
- Temperature, Water
- Suspended Sediment Discharge
- Suspended Sediment Conc.
- Specific Conductance
- pH
- Temperature, Air

Des Moines Water Works

Des Moines Water Works collects nearly continuous water quality information from their intake site on the Raccoon River. This site is located less than one mile downstream of the confluence of Walnut Creek with the Raccoon River. The continuous nature of the data available makes it a valuable resource to review. However at the point of measurement, streamflow from Walnut Creek has mixed with flow from the much larger Raccoon River watershed. Given the other data sources available, it can be difficult to separate out the influence of the Walnut Creek watershed from water samples collected at this location.

Water Quality Monitoring

Water quality monitoring allows the presence of pollutants in streams to be evaluated. However, results can be effected by collection methods, timing, weather conditions, flow levels, sampling, testing methods and sampler training. Monitoring efforts rely on developing and following quality assurance plans to reduce these factors which can skew data collection. To improve the quality of collected data submitted to the state for recording, volunteer efforts must comply with requirements of Iowa Administrative Code Section 567.61.

Review of Existing Monitoring Data for Key Pollutants

Now that we have identified the key pollutants of concern, it is important to review the available **monitoring data** for these pollutants in greater detail.

Data collected by the ISA/ACWA offers the highest number of samples, typically collected every other week. Site 40 is also located just downstream of a USGS gaging station, and is less than two miles from the weather station located at the Des Moines Airport. Collectively, this information offers opportunities to understand how pollutant concentrations vary with time, streamflow and climate patterns.

IOWATER data collection does not have as many samples at each site, but has more sites distributed throughout the watershed. This data can be used in determining where higher pollutant concentrations are most likely located.

Nitrate (Nitrogen)

ISA/ACWA Monitoring

A total of 168 samples were collected and analyzed for nitrate from the ISA/ACWA site 40 between 1999 and 2014. At sites 70.0, 70.1 and 70.2; a total of 131 samples were collected between 2002 and 2014. Reviewing this data indicates that nitrate concentrations appear to be significantly higher in streams within the rural landscapes. (The site 70 locations were positioned in a primarily rural watershed, whereas site 40 received runoff from both urban and rural sources.) It appears that nitrate concentrations in urban runoff is lower, diluting nitrate concentrations as those flows enter the stream.

At both sites, concentrations were highest during the months of April through July, with peak levels occurring in May and June. This trend seems to follow the times after spring fertilization has occurred and when rainfall patterns are near their highest levels. It should be noted that concentration levels were noted to drop significantly in August, although average precipitation remains high during this month. Concentrations remained

ISA/ACWA Monitoring

	Site 40	Site 70
Average Nitrate Concentration	5.83 mg/L	9.95 mg/L
% Above Water Quality Standard	26%	49%
Maximum Recorded Level	17.6 mg/L	22.9 mg/L
Date of Maximum Recorded Level	5/20/2004	5/16/2013

Nitrate concentrations were 78% higher on average in rural areas; 49% of all samples taken at the rural ISA/ACWA site were above the state's water quality standard.

IOWATER Average Nitrate Concentrations (Laboratory)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC1A*	5	14.9	-	-	-	LWC1A*	4	5.6
WC1	3	13.1	-	-	-	WCTrib*	4	4.7
WCTrib*	6	11.3	-	-	-	WC1	5	4.5
WC8*	6	11.0	-	-	-	WC8*	4	3.9
WC3	3	10.7	-	-	-	WC5	5	3.3

* No Nitrate + Nitrite laboratory samples taken at this site during this season

Several IOWATER sites had average lab results for nitrate concentrations which exceeded the state standard.

IOWATER Average Nitrate+Nitrite Concentration (Laboratory)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC2*	2	17.5	NWC1*	2	2.9	LWC2	1	11.0
WCTrib2*	2	14.0	D11*	2	2.2	LWC1	1	7.1
LWC1*	2	13.5	POL2*	2	1.0	WCTrib2	1	6.3
WC1	6	13.1	WAVE*	2	0.5	WCTrib1	1	5.7
D11*	2	12.5	-	-	-	WC7	1	5.4

* No Nitrate laboratory samples taken at this site during this season
** Only eight total samples taken in summer months throughout the entire watershed

Several IOWATER sites had average lab results for nitrate concentrations which exceeded the state standard.

IOWATER Average Nitrate Concentrations (IOWATER test kits)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC1A	6	11.2	WC4	4	7.5	LWC1	3	5.3
D11	6	8.7	D11	4	7.3	WCTrib2	2	5.0
WCTrib	6	8.7	NWC6	6	4.8	LWC2	3	3.3
WC8	6	8.7	NWC2	2	3.5	WCTrib	5	2.4
WC1	13	8.4	WC3	2	3.5	WC7	3	2.3

Test kit data also indicated elevated nitrate concentrations in rural areas.

The maximum lab value of 31.8 mg/L is three times higher than the state water quality standard.

IOWATER Maximum Nitrate Concentrations (Laboratory)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
LWC1A*	5/8/13	31.8	-	-	-	LWC1	-	14.3
WC8*	5/8/13	21.0	-	-	-	WCTrib	-	9.8
WCTrib*	5/8/13	18.9	-	-	-	WC8	-	9.4
WC2	5/8/13	17.4	-	-	-	WC2	-	8.4
WC1	5/23/07	16.2	-	-	-	WC1	-	7.9

* No Nitrate + Nitrite laboratory samples taken at this site during this season

Some IOWATER samples indicate a fall spike in nitrate levels.

IOWATER Maximum Nitrate+Nitrite Concentration (Laboratory)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
LWC2*	4/28/07	20.0	NWC1*	7/21/07	3.9	LWC2*	9/22/07	11.0
WC1	6/2/04	18.0	D11*	7/21/07	2.3	WC1	10/16/07	8.4
NWC1	6/2/04	17.0	D11*	7/22/06	2.0	WC2	10/16/07	7.7
WC2	6/2/04	17.0	NWC1*	7/22/06	1.9	WC3	10/16/07	7.6
LWC1*	4/28/07	17.0	POL2*	7/21/07	1.8	WC4	10/16/07	7.5

* No Nitrate laboratory samples taken at this site during this season
** Only eight total samples taken in summer months throughout the entire watershed

Twenty test kit samples registered as 20mg/L.

IOWATER Maximum Nitrate Concentrations (IOWATER test kits)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
NWC1	5/8/13	20	WC4	5/8/13	20	WC8	5/8/13	20
NWC2	5/8/13	20	WC4	5/24/13	20	LWC1A	5/8/13	20
WC1	6/2/04	20	WC5	5/8/13	20	LWC1A	5/7/14	20
WC1	5/8/13	20	WC6	6/2/04	20	D11	7/4/08	20
WC2	6/2/04	20	WC6	5/9/12	20	NWC6	7/8/13	20
WC2	5/8/13	20	WC6	5/8/13	20	WC4	7/8/13	20
WC3	5/8/13	20	WCTrib	5/8/13	20			

low from September to November, although very few samples were collected during each of these months (only 5 total samples were collected in the months of Sept-Oct-Nov at site 40, and only 2 samples during those months at site 70).

At site 40, nitrate concentrations appear to be lowest during low flows, noticeably so when streamflows are in the lowest 20% of observed flow rates. They appear highest when flows are in the highest 10–50% of observed flowrates. This distribution pattern indicates that nitrate loading is most likely from non-point sources, being moved off the landscape or out of tile flows primarily during and after measurable rainfall events. In contrast, if concentrations remained high at low flow, or had spikes that appeared outside of larger rainfall events, that would indicate that the source of the pollutant was from one or more point sources, which have more constant outflows between rainfall events.

Snapshot Monitoring (Lab Samples)

IOWATER has collected data from 31 separate **sampling sites** in the Walnut Creek watershed. Nitrate was measured by 233 laboratory samples from these sites. Laboratory samples were also collected for Nitrate + Nitrite, with 189 collected for that parameter (nitrite levels when measured alone were typically low, so nitrate + nitrite may still be a good measure to approximate and compare nitrate levels).

Since significant seasonal patterns were seen at the ISA/ACWA sites, analysis of IOWATER samples has been divided into three periods: spring (April-June), summer (July-August) and fall (September-November). The sites with the highest average levels of nitrates are listed below.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to follow the pattern of the ISA/ACWA monitoring, indicating elevated levels of nitrate in the spring months, especially where runoff is being received from rural landscapes.

The IOWATER data does seem to lend some support to possibilities of spikes in nitrate concentrations in the fall. Some higher concentrations were noted on a few dates. In reviewing USGS streamflow data, it appears that these elevated values may coincide with above average flow rates. Regularly occurring late season monitoring would be needed to determine if elevated nitrate levels in the fall are a normal pattern or caused by more unique sets of circumstances.

Snapshot Monitoring (Test Kits)

IOWATER test kits use strips that read nitrate levels by changes in color. This means that readings are estimates of concentration within a given range around that number. Of the 521 samples taken, no reading above 20 mg/L was recorded. This measurement on the strip is intended to represent a range between 20 and 50 mg/L. The table on the previous page notes the different locations and dates where readings of 20 were recorded. Most of these dates coincide with elevated flow volumes measured at the USGS gaging station within the Walnut Creek watershed.

Phosphorus

ISA/ACWA Monitoring

A total of 136 samples were collected and analyzed for phosphorus from the ISA/ACWA site 40 between 2001 and 2014. At sites 70.0, 70.1 and 70.2; a total of 127 samples were collected between 2002 and 2014. This indicates that phosphorus concentrations may be higher in streams within the rural landscapes.

At site 70, average concentrations were elevated above 0.12 mg/L during all months sampled, except for August, with peak levels occurring in May and June. At site 40, highest concentrations were observed in April, with concentrations wavering after that. Seasonal trendlines are present, but do not appear as strong as those seen for nitrate concentrations. Also in contrast to nitrate levels, there appears to be much less correlation between high flow levels and elevated phosphorus concentrations. This appears to indicate that phosphorus concentrations may be more influenced by individual site actions, such as fertilizer applied soon before a storm event, which could lead to a sudden spike in phosphorus concentrations.

ISA/ACWA Monitoring		
	Site 40	Site 70
Average Phosphorus Concentration	0.083 mg/L	0.134 mg/L
Maximum Recorded Level	1.5 mg/L	0.68 mg/L
Date of Maximum Recorded Level	4/17/2004	4/18/2013
At Site 40, 110 samples were below the concentration levels which could be detected by the test. At site 70, 73 samples were below this threshold. To calculate average concentrations, tests that indicated concentrations were below the detection limit were assumed to have a value of one half of the detection limit.		

Phosphorus levels were 61% higher on average at the rural location (site 70).

IOWATER Monitoring

Average Phosphorus and Orthophosphate Concentrations (Laboratory)					
PHOSPHORUS			ORTHOPHOSPHATE		
SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L
WAVELAND GC	2	0.45	LWC1(A)	9	0.16
WC1	8	0.45	WAVELAND	7	0.14
D11	1	0.36	WCTrib	10	0.14
WCTrib1	1	0.36	WC8	10	0.12
WAVELAND	9	0.36	WAVELAND GC	3	0.11

IOWATER Monitoring

Maximum Phosphorus and Orthophosphate Concentrations (Laboratory)					
PHOSPHORUS			ORTHOPHOSPHATE		
SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L
WC1	5/18/05	2.5	NWC1	10/15/14	0.69
WAVELAND	5/18/05	1.0	WCTrib	10/15/14	0.66
WAVELAND	10/12/05	1.0	WAVELAND	10/12/05	0.64
WAVELAND GC	5/24/06	0.68	LWC1	10/15/14	0.57
WAVELAND	5/14/06	0.54	LWC1	5/8/13	0.52

Some snapshot readings indicate that runoff from Waveland Golf Course could contain elevated phosphorus levels.

Snapshot Monitoring

IOWATER has collected data from 31 separate sampling sites in the Walnut Creek watershed. Phosphorus was measured by 136 laboratory samples from these sites. Laboratory samples were also collected for Orthophospate, with 217 collected for that parameter.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to indicate elevated levels of phosphorus may be present at various locations in both rural and urban areas.

A review of maximum phosphorus concentrations also seems to indicate that the areas near Waveland Golf Course may have significant spikes in loadings. Perhaps these are associated with fertilization coinciding with certain rainfall events. It is also worthy of note, that certain dates resulted in maximum values at multiple sites. This indicates that runoff or streamflow patterns likely do influence concentrations, but it is difficult to interpret how much with the limited data available.

Bacteria (E. coli)

Iowa Soybean Association / ACWA Monitoring

A total of 62 samples were collected and analyzed for E. coli at the ISA/ACWA site 40 between 2005 and 2011. At site 70.0, a total of 46 samples were collected between 2006 and 2011. The overall average concentration for all samples at site 40 was 3126 MPN (most probable number of organisms)/100 mL, with 73% exceeding the State of Iowa's single sample water quality criterion of 235 MPN/100mL. The average concentration for samples collected at site 70 locations was 1333 MPN/100mL, with 66% of the samples exceeding the single sample criterion. Average values at site 40 were 135% higher than those observed at site 70. This indicates pathogens may be much more present in streams which receive more urban runoff.

At both sites, average concentrations over this period peaked in June, with average levels during that month at 8,122 orgs./100mL at site 40 and 1,602 at site 70. Average values showed a very high peak in June at site 40, where values were more consistent through all months at site 70.

At site 40, there appears to be a connection between high flow levels and elevated bacteria concentrations. Most of the highest concentrations were observed during the highest 30% of all flow conditions. At site 70, this connection was much less defined.

This data provides strong evidence that there is a connection between high runoff events from urban environments and high concentrations of indicator bacteria. Other seasonal factors, such as elevated temperatures may provide better environments for these bacteria and allow them to survive and multiply.

ISA/ACWA Monitoring		
	Site 40	Site 70
Average E. coli Concentration	3,126 orgs./100mL	1,333 orgs./100mL
Maximum Recorded Level	54,700 orgs./100mL	14,670 orgs./100mL
Percentage of samples exceeding water quality standard	73%	66%
Date of Maximum Recorded Level	6/26/2008	7/24/2008

Levels of E. coli were much higher at the site receiving urban runoff.

Average and Maximum E. coli Concentrations (Laboratory)					
AVERAGE			MAXIMUM		
SITE	COUNT	AVG	SITE	DATE	AVG
	#	orgs./100ML			orgs./100mL
NWCTrib1	12	9,165	NWCTrib1	10/12/2005	77,010
WC3Trib	2	7,875	WC6	5/8/2005	61,310
NWC5A	2	8,585	WAVELAND	10/12/2005	30,760
WAVELAND	10	8,585	NWCTrib2	10/18/2006	30,760
WC6	19	5,332	NWC5A	10/18/2006	16,070

The state's water quality standard for E. coli is 235 orgs./100mL for a single sample.
The maximum level observed was **more than 300 times** that level.

Snapshot Monitoring

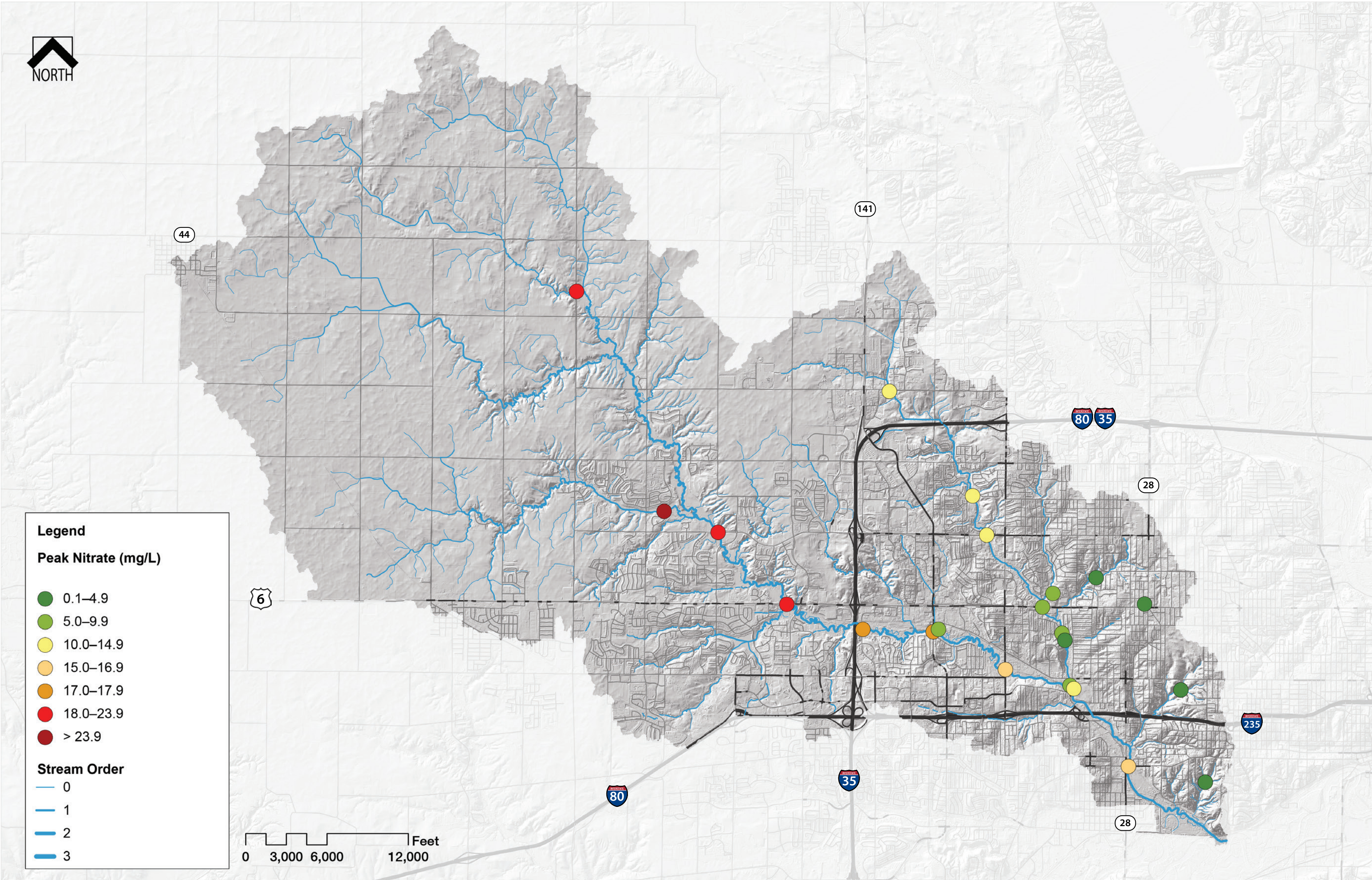
IOWATER has collected data from 31 separate sampling sites in the Walnut Creek watershed. E. coli was measured by 298 laboratory samples from these sites.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to follow the pattern of the ISA/ACWA monitoring, indicating elevated levels of indicator bacteria where runoff is being received from urbanized areas.

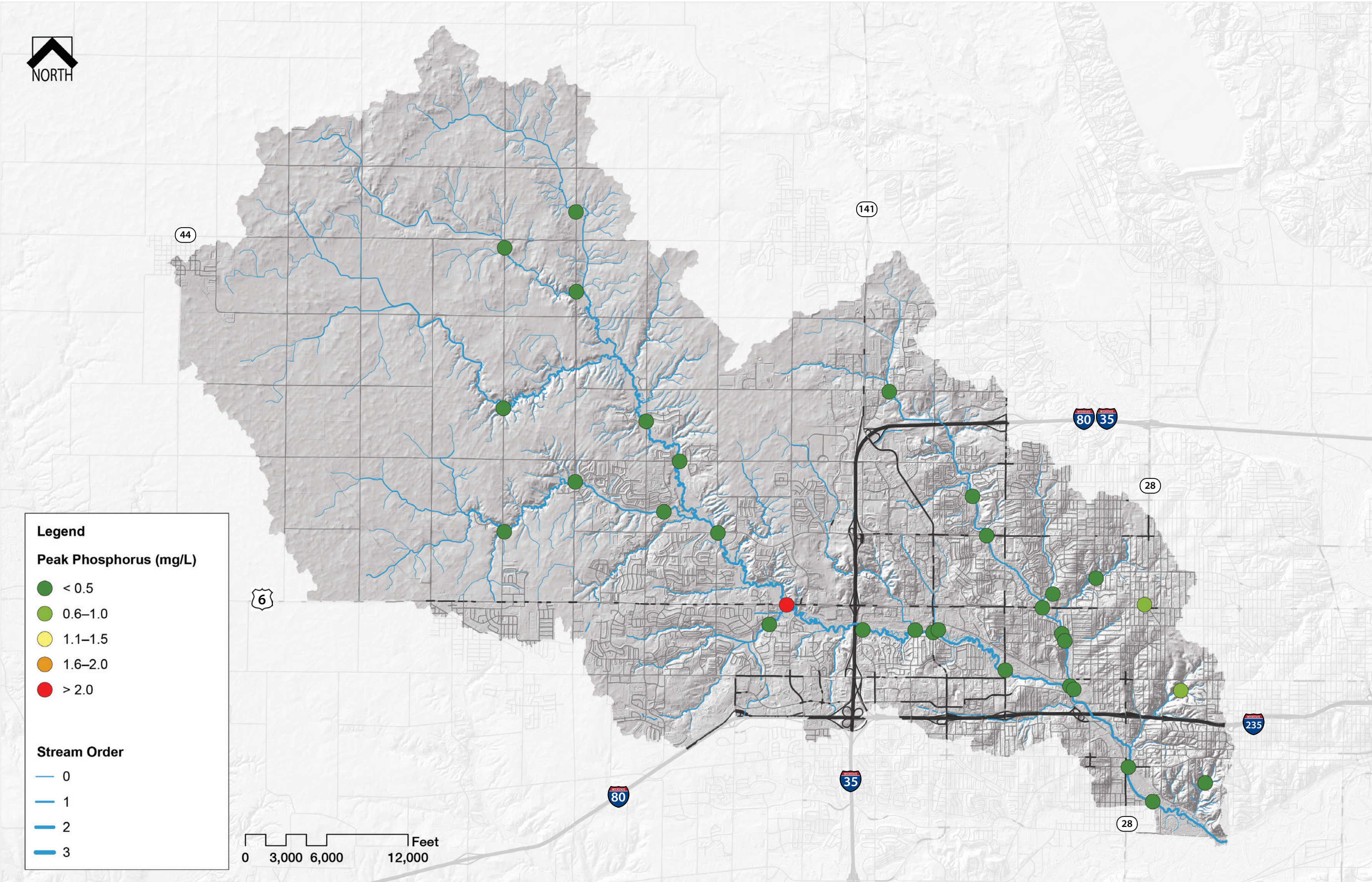
Highest concentrations appear to be in the older developed areas, lying east of I-35/80. Highest concentrations often appear in tributary streams, however high averages and maximums were noted at sites NWC5A (North Walnut Creek) and WC6 (Walnut Creek). Samples at both of these sites were collected from second or third order stream channels.

Did you know...?

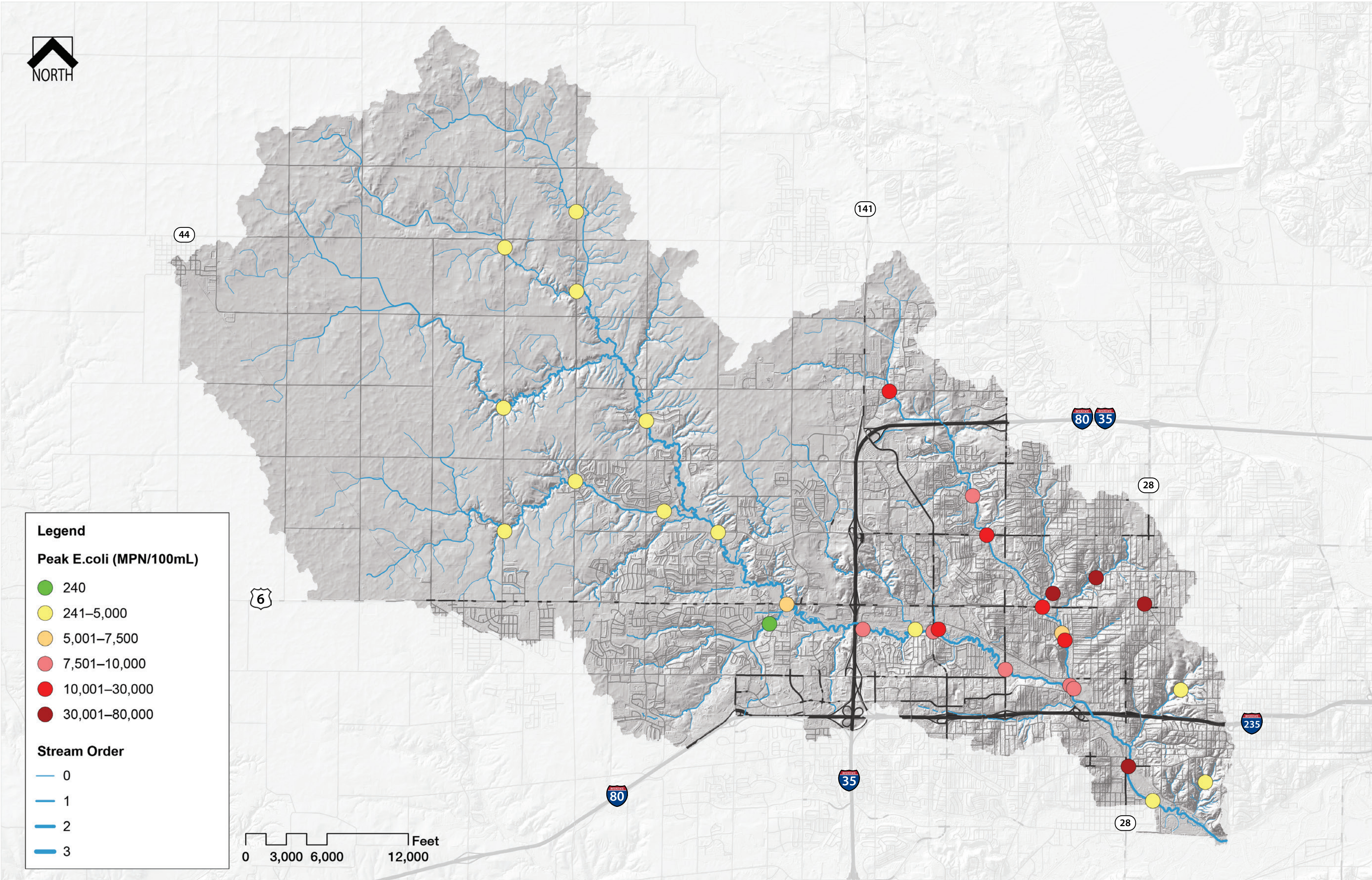
E. coli levels are usually measured by finding the most probable number (MPN) of bacteria organisms (orgs.) that are present in 100mL of water.



Nitrogen Monitoring



Phosphorus Monitoring



Bacteria Monitoring

Watershed Loading—Key Pollutants

Water quality modeling system software was used to determine the most likely sources of the key pollutants of concern. A more detailed description of this modeling effort is included as an appendix to this plan. Available **GIS land use dataset** information was used to determine the amount of different land uses in each of 33 subwatershed areas within the Walnut Creek watershed. The model accounts for other factors including local rainfall patterns, soil types, terrain, livestock, wildlife and management practices. Gully and streambank stability characteristics were also input into the modeling. The modeling software used did not account for construction site runoff. To account for this, separate calculations were completed to determine the amount of development that occurred on an annual basis over a recent ten year period. Modeling results were developed for each subarea, considering scenarios with and without this construction site loading.

Estimated Average Watershed Loading		
Pollutant	**Total Load (pounds)**	**Total Load (tons)**
Nitrogen	941,600	471
Phosphorus	61,500	31
Sediment	59,360,000	29,700

Estimated pollutant levels delivered from Walnut Creek to the Raccoon River.

Pollutant Sources By Land Use			
	N	**P**	**Sediment**
Urban	14%	26%	7%
Cropland	81%	49%	10%
Pastureland	2%	2%	0%
Forest	0%	1%	0%
Grasslands	0%	0%	0%
Gully	1%	5%	19%
Streambank	2%	10%	38%
Construction Site	1%	8%	25%

Projected source location of each pollutant.

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Existing monitoring data at Iowa Soybean Association Site 40 and streamflow data from the USGS gage located nearby were used to evaluate preliminary results. The monitoring and streamflow data was used to calculate approximations of loading rates based on the data available. The water quality model was then calibrated using this information, to bring it into better agreement with real world observations.

Expected Pollutant Sources by Land Use

Modeling results demonstrate that cropland is likely the largest source of nitrogen and phosphorus loadings. This is consistent with observations from monitoring sites, which demonstrated higher phosphorus and much higher nitrate concentrations in rural areas. Over 80% of the sediment loading in the watershed is expected from three sources—streambank, construction site and gully erosion.

Pollutant Sources by Subarea

The water quality modeling completed identifies potential sources of key pollutants at a subwatershed level. For each of these areas, the expected annual load of nitrogen, phosphorus and sediment has been calculated. These loading rates were divided by the acres of land within each subwatershed to determine the annual loading rate per acre, in order to compare loading rates of subwatershed that are different in size.

Loading rates have been calculated both with and without the expected effects of construction site sediment loads. Construction site loadings were calculated based on land development patterns that occurred between 2001 and 2011. The modeling provides a good estimate of average annual construction site loadings from each subarea which would have occurred during that period of time. As development patterns change over time, the location of these sources will be different in the years ahead. Therefore, the maps included within this chapter show the expected loading rates without construction site effects. This allows non-construction site sources to be evaluated and targeted separately. Construction site sources are best addressed with site level management techniques.

Nitrogen

Sources of nitrogen are expected to be highest in the agricultural lands that make up the headwaters of Walnut Creek. Areas west of Waukee and those between Dallas Center and Grimes appear to be the largest sources for nitrogen on a per acre basis. Elevated levels are also indicated to be present in the upper reaches of the North Walnut Creek subwatershed. These results appear to be consistent with available monitoring data.

Phosphorus

Like nitrogen, sources of phosphorus are expected to be highest in the agricultural lands in the upland areas of the watershed. However, there is less variation in phosphorus loading between the various subareas. Twenty-eight of the thirty-three subwatersheds are expected to have loading rates between 0.8-1.3 pounds per acre per year. Levels are expected to be below this range in two subwatersheds and above this range in three others. These results appear to be in agreement with available monitoring data.

Pathogens

This modeling software did not include detailed modeling of bacteria sources. Bacteria loading can be difficult to estimate, as they are driven by a variety of factors such as animal sources, temperature, precipitation, growth and lifespan. Available monitoring data for bacteria indicates levels are most elevated in the urban environment.

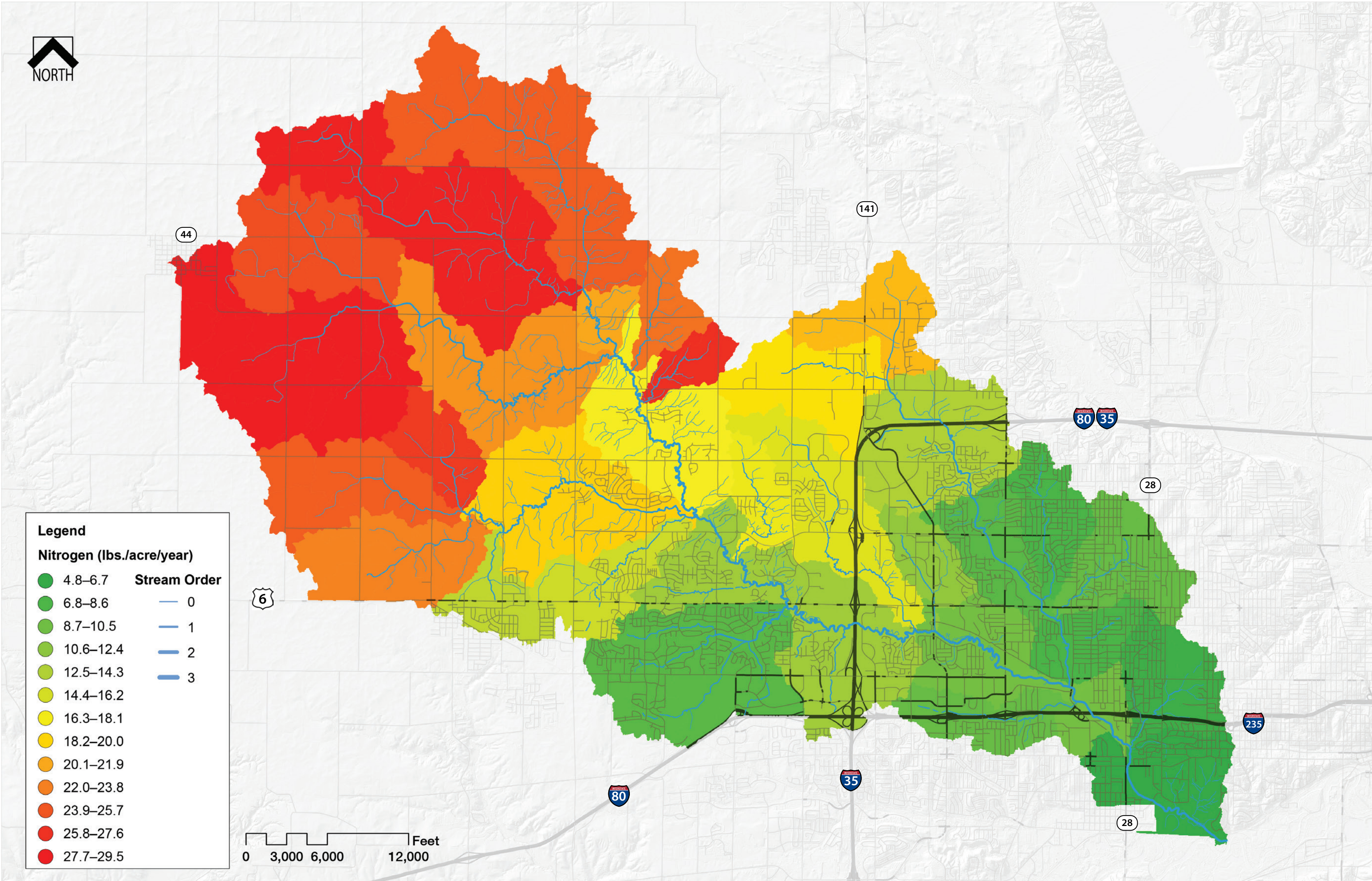
Sediment

Source loadings of sediment are expected to be highest in areas of steeper slopes and where more streambank and gully erosion has been observed. Highest levels are expected along lower Little Walnut Creek and along Walnut Creek upstream of its confluence with South Walnut Creek. There are many ravines, gullies and streams with significant slope in these areas. Please remember construction site loadings are not reflected in the maps included within this chapter.

Average Loading per Acre by Subwatershed Without Construction Site Runoff

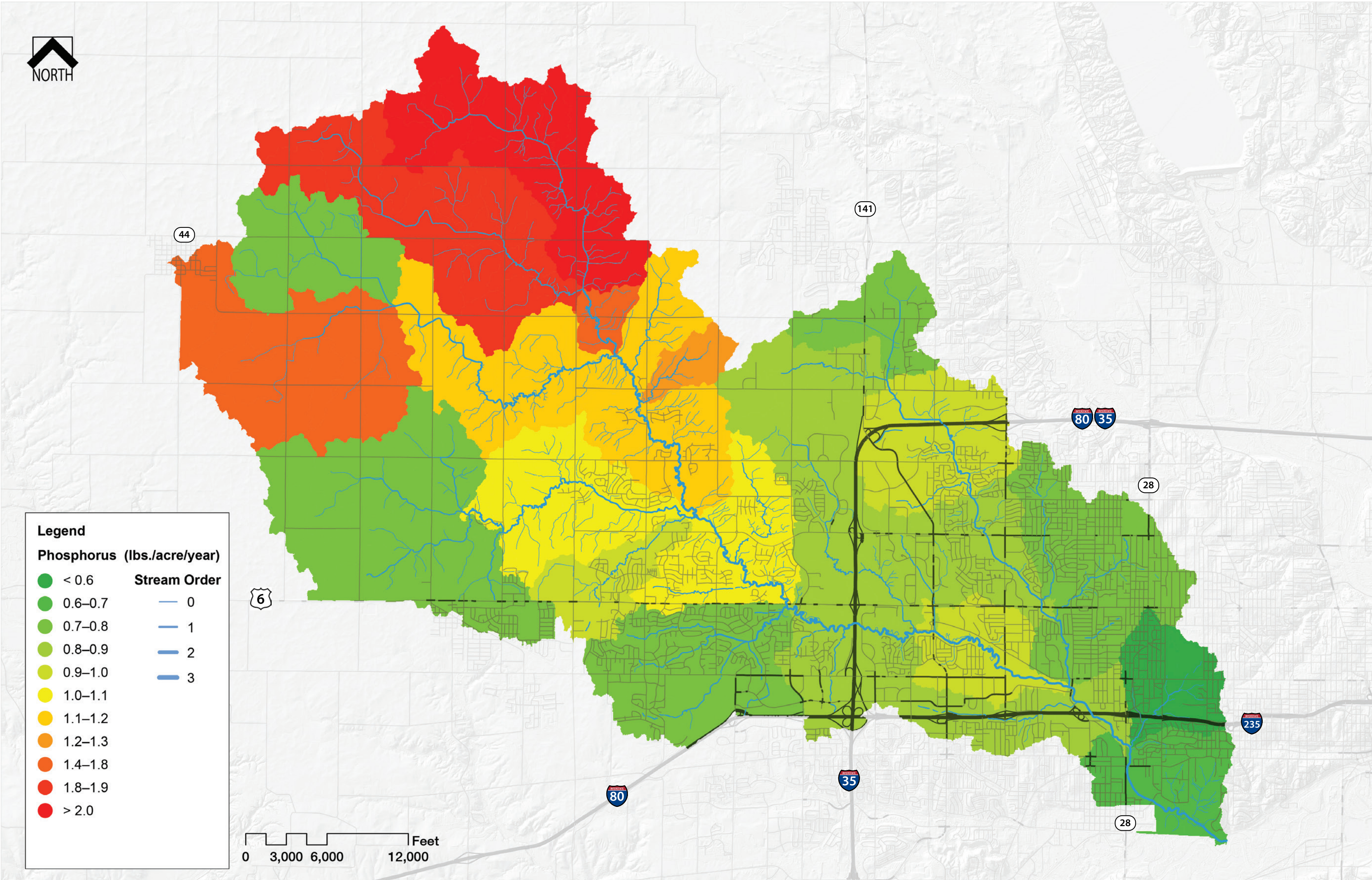
Subwatershed Site	N lb/ac/yr	P lb/ac/yr	Sediment lb/ac/yr
101	4.8	0.7	967.2
102	6.1	0.9	895.3
111	5.1	0.6	489.1
112	6.0	0.9	729.5
201	6.1	1.0	1034.2
202	6.7	0.9	911.9
203	6.7	1.1	2198.1
211	6.4	0.9	761.7
212	13.3	0.9	737.5
213	6.3	0.8	919.7
214	17.3	1.1	1810.8
301	17.7	1.2	1923.3
311	28.3	1.3	1862.8
312	27.0	1.2	1513.8
401	24.0	1.8	3823.2
402	27.4	1.0	568.4
411	28.7	1.9	520.7
501	5.5	0.8	855.7
502	5.8	0.9	1081.4
503	9.8	1.0	1001.6
504	18.0	0.9	335.7
511	6.0	0.8	799.4
512	5.5	0.8	605.6
513	19.3	0.8	201.0
601	18.6	1.1	1311.7
602	27.4	0.8	195.6
611	12.3	1.0	1051.1
612	10.8	0.8	389.6
613	26.7	0.8	254.3
614	28.2	0.8	182.5
701	25.5	1.2	1757.9
702	29.5	1.8	153.8
711	28.0	0.8	184.2
Watershed Avg.	**17.6**	**1.1**	**840.8**

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.



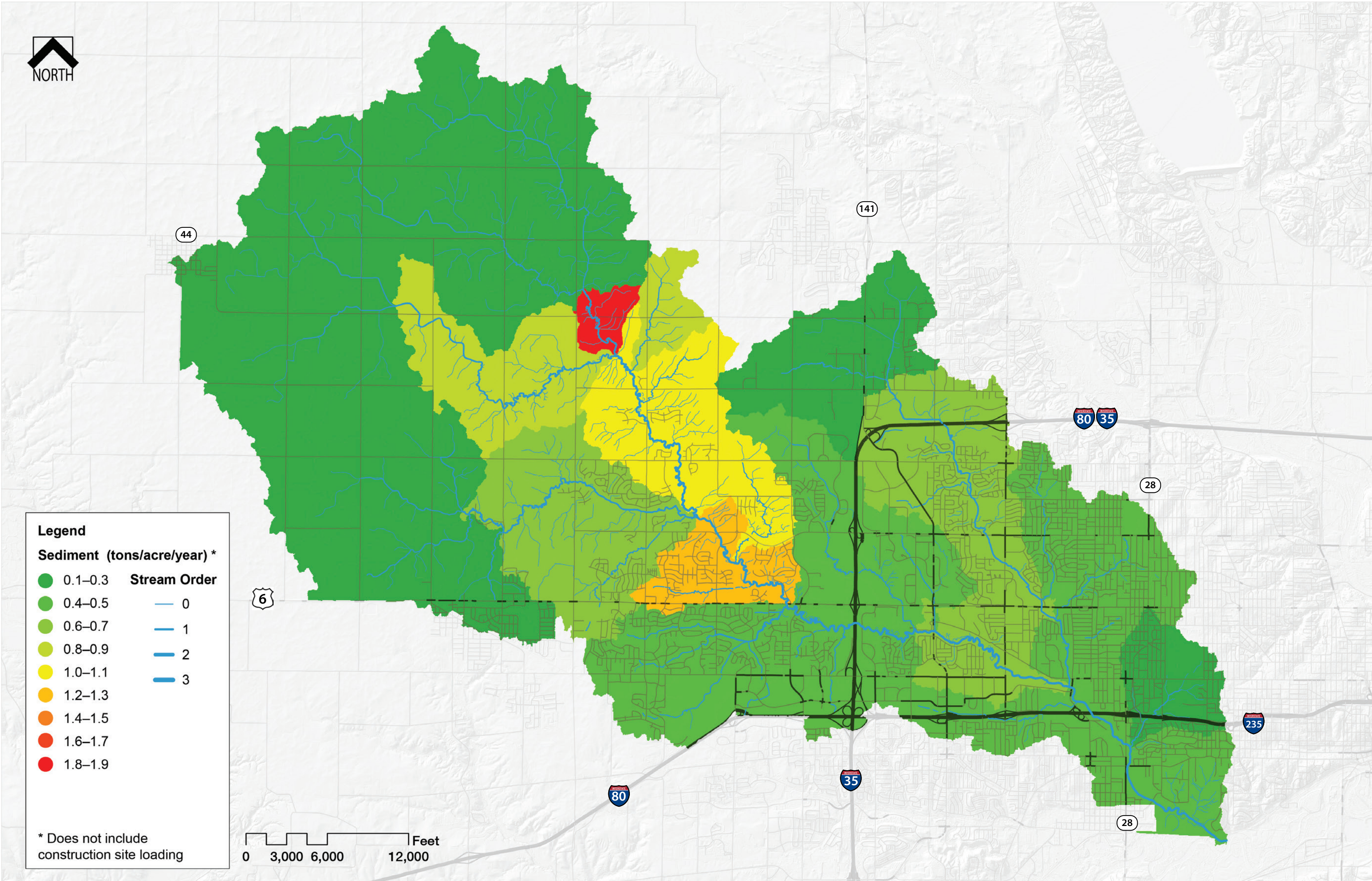
Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Nitrogen Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Phosphorus Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Sediment Loading

Projected Reduction Targets

The reduction targets within this section are intended to be long-term goals which will likely take many decades to achieve. The Watershed Action Plan (Chapters 7–10) and Implementation Plan included (Chapters 11–14) within this document will identify how to begin progress toward these goals over the next decade.

Iowa's Nutrient Reduction Strategy calls for reductions in nutrient loading from **non-point sources** in agricultural areas. These loading reductions are 41% for nitrogen and 29% for phosphorus. Using past monitoring data from the ISA/ACWA sites, loading reductions of this amount for nitrogen would be expected to limit violations of the Raccoon River watershed TMDL standard for nitrate to less than 1% of all samples collected at site 40. Many management practices which target phosphorus are also effective at reducing erosion or trapping sediment loads. Based on this, it seems reasonable to expect that sediment loadings from the agricultural areas could be reduced by a similar amount by implementing practices which aim to reduce phosphorus loading.

Did you know...?

Phosphorus is a pollutant that often binds with sediment particles.

Did you know...?

This plan estimates that 25% of the sediment load from this watershed could be attributed to construction sites. These sites cover only 0.1% of the entire watershed in a typical year. Those statistics may be difficult to imagine, however the average sediment loss estimated for construction sites is equal to only about 1/8 inch of soil across the surface of all construction sites. A more detailed discussion of how construction site loadings were calculated is included within an appendix to this plan.

The Nutrient Reduction Strategy does not establish reduction goals for nutrients within urban areas. The analysis within this plan identifies that pathogens, sediment loadings and runoff volumes and rates are more critical pollutants to address within the urban environment.

Loading Reduction Goal #1:

Reduce nitrogen loading from non-point sources within rural areas by at least 41%.

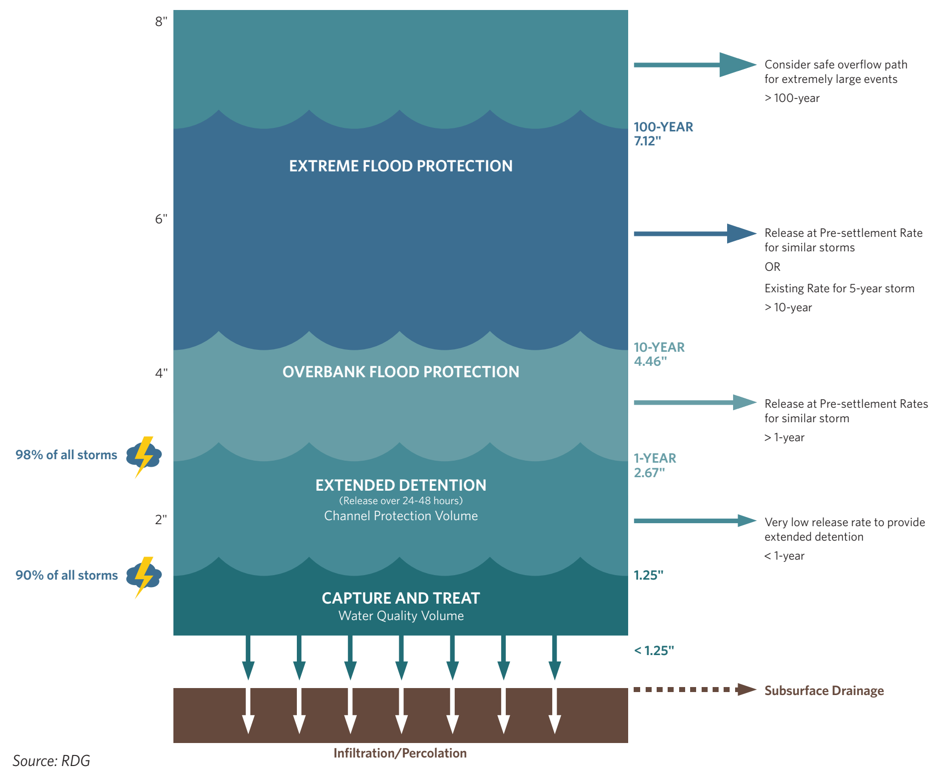
Loading Reduction Goal #2:

Reduce phosphorus loading from non-point sources within rural areas by at least 29%.

Loading Reduction Goal #3:

Reduce sediment loading from non-point sources within rural areas by at least 29%.

Levels of Stormwater Management Using ISWMM's Unified Sizing Criteria



Source: RDG

The Raccoon River TMDL established a target single sample maximum concentration of E.coli bacteria at 200 MPN/100mL. Based on monitoring sites, load reductions of more than 99% would be necessary to meet this criterion. This appears to be an impractical goal, given the level of existing urban development throughout the watershed and the amount of retrofits that would be necessary to meet this standard. For this reason, the following load reduction goals are proposed:

Loading Reduction Goal #4:

In newly developing areas, employ **best management practices** (BMPs) to capture and treat runoff from the 1.25" rainfall event (**Water Quality event**). Select practices such as **bioretention, wet detention ponds** and **constructed wetlands** which have been demonstrated to be most effective at reducing bacteria loading. (1) Refer to the International Stormwater BMP Database (bmpdatabase.org) for updated information.

Loading Reduction Goal #5:

In existing developed areas, develop a program to employ stormwater retrofits where practical to reduce pathogen loading to the maximum extent possible.

There is no established statewide criteria governing sediment loadings or water quantity volumes. This plan has identified that these items have a significant impact related to both water quality and stream corridor stability. Therefore, the following goals related to sediment and runoff water quantity are proposed:

SEDIMENT

Loading Reduction Goal #6:

Implement and/or enforce effective construction site pollution prevention management practices in developing areas. Controls should reduce total suspended solids (TSS) from site runoff by 80% (as compared to no controls). (2) Could reduce watershed sediment load by 15%.

Loading Reduction Goal #7:

Complete streambank stabilization and restoration projects as needed to reduce sediment loading attributed to streambank erosion by 50% by 2040.

RATES AND VOLUMES

Loading Reduction Goal #8:

In developing areas, provide stormwater management practices which achieve the following:

- Capture and treat runoff from the Water Quality Event (treat 100% of runoff from precipitation events of less than 1.25 inches). 90% of all rainfall events in Central Iowa fall into this category. (2)
- Provide extended detention of the 24-year, 1-year return period event; with slow release over a period of not less than 24 hours. This should reduce peak runoff rates from newly developing areas by more than 95% for these types of storm events. (3)
- Limit runoff rates for events equal to or smaller than the 24-hour, 1% annual exceedance probability (100-year return period storm) to levels similar to natural (pre-settlement) conditions.

Loading Reduction Goal #9:

In developed areas, evaluate opportunities and implement practices to reduce runoff rates and volumes by the maximum extent possible.

- Develop education and outreach incentives to increase use of best management practices on existing developed areas.
- Install practices that are intended to maximize reduction in rates and volumes from a one-year storm event.

Source:

1. *Iowa Stormwater Management Manual*
2. *Iowa's NPDES General Permit Number 2*
3. *Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see Chapter 8 and appendix resources)*