Spirit Lake
Source Water Protection Plan

Spirit Lake Waterworks

Dickinson County

PWSID: 3070078

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Purpose and Background

Iowa Department of Natural Resources defines source water as drinking water in its original environment, either at the surface or below ground, before being treated and distributed by a water system. Source water protection is preventing contaminants from entering public drinking water sources by managing the land which drinking water travels through, leading to improved water quality and better protection of the water itself. A community's water source is a valuable resource, which if contaminated or polluted, can impact public health, and restoration or replacement can become a large expense to the community. Preventing or reducing source water contaminants can allow public water systems to avoid costly treatment.

Potential contaminated drinking water costs can include the following:

- Providing emergency replacement water
- Paying for treatment and/or remediation
- Finding and developing new water supplies
- Litigating against responsible parties
- Conducting public information campaigns after an incident
- Reducing property value or tax revenue
- Paying health related costs from exposure to contaminated water, and
- Losing community confidence in drinking water

The benefits of source water protection include:

- Reduced costs or prevented increasing costs for treating source water
- Saved expense of finding a new water source
- Potential decrease in state regulated monitoring
- Opportunities for grants from the state
- Potential for less frequent sanitary surveys by the state

The intent of this document is to help the community to proactively address drinking water quality and quantity concerns. The plan describes the source water supply, identifies potential sources of contamination (PSC) to the water supply, determines the relative risk of the PSCs and provides information on implementation activities that will protect the source of drinking water. Source water protection activities are outlined in an Action Plan, which identifies specific actions and a timetable for implementation of each action.

As a secondary benefit, the Spirit Lake Source Water Protection Plan works to implement the Iowa Nutrient Reduction Strategy (NRS). The NRS was created in response to a 2008 Action Plan by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force that called on the 12 states within the Mississippi River watershed to reduce nutrients in surface water that feeds into the Gulf of Mexico. The NRS has set a goal to reduce 29% of phosphorus and 41% of nitrogen loading from non-point, or watershed-based, sources in order to comply with the hypoxia goals for the Gulf of Mexico. Several TMDLs also exist in the contributing watershed and in downstream lakes.

Phosphorus loading reductions needed to comply with existing TMDLs include:

- *Lower Gar Lake Turbidity TMDL* (2003) – 50% reduction in phosphorus loading
- *Upper Gar TMDL for Noxious Aquatic Plants* (2004) – 54% reduction of phosphorus loading from the watershed and in-lake recycling
- *Little Spirit Lake TMDL for Turbidity and Algae* (2004) – 74% reduction in phosphorus loading from watershed and in-lake recycling
- *Draft Missouri River Basin TMDL* (2017) – 80% reduction in phosphorus load for Loon Lake, 35% reduction for Clear Lake

Implementation of the Little Spirit Lake and Missouri Basin TMDLs will have beneficial impacts on water quality in Big Spirit Lake. Lastly, this surface water protection plan can be used in conjunction with the Iowa Great Lakes Watershed Management Plan and help to support plan implementation and the current process to update that plan. Opportunities to collaborate between projects may prove an effective use of resources.

Though voluntary in nature, SWPPs and the implementation actions are promoted and monitored in Iowa by the Source Water Protection (SWP) Program. Plans and implementation activities are submitted by the community and reviewed by technical staff at Iowa Department of Natural Resources (DNR). After technical review DNR either approves the plan or provides specific recommendations for improvement.

There are seven steps associated with an approvable Iowa Source Water Protection Plan. These are summarized below and form the basis for the organization of this document:

- Step 1: Organize a source water team
- Step 2: Identify your source water areas
- Step 3: Inventory well and contaminant sources
- Step 4: Assess and rank contaminant sources
- Step 5: Develop an action plan
- Step 6: Construct or update your emergency response plan
- Step 7: Submit and Implement your SWP Plan

System Information

The Spirit Lake Waterworks (Public Water Supply ID# 3070078) is a public community water supply serving a population of 5,578, according to the Iowa Source Water Protection Tracker. The USEPA defines a community water system as an entity that supplies water for human consumption to the same population year-round and to at least 15 service connections or an average of 25 people for at least 60 days a year. The source water for the waterworks is Big Spirit Lake, which is located in Dickinson County, Iowa, and drains a watershed of 43,959 acres. The majority of the watershed extends north into Minnesota. Land use in the watershed is predominately agricultural, specifically corn and soybean row crops. Table 1 summarizes system information and any prior source water documentation. The Big Spirit Lake watershed is shown in Figure 1.

Table 1. Summary of System Information and Prior Source Water Documentation

Administrative Office Location	1803 Hill Ave., Spirit Lake, IA 51360
Date of Most Recent Source Water Assessment	2001
Date of Most Recent Sanitary Survey	2015
Date of Most Recent Prior Source Water Protection Plan	2006
Population Served	5,578
Are There Multiple Source Water Protection Areas	No
List of Source Water Protection Areas	Big Spirit Lake

Source Water Treatment and Storage

Spirit Lake Waterworks has assessed their system capacity to provide drinking water and protect public health, including a summary of treatment capacity, storage capacity, and contingency plans. Information about treatment and storage capacity is provided in Table 2.

Table 2. Treatment and storage

Water Treatment Processes	Ozonation in an ozone contact chamber; aluminum sulfate addition at flash mixer; flocculation; two plate settlers; lime and sodium aluminate addition; recarbonation; polyphosphate addition; gravity sand and anthracite filtration; second ozone generator and contact chamber; GAC filters; gas chlorination; sodium hydroxide addition; and fluoride addition.
Current Treatment Capacity (gal/day)	2,100,000
Current Average Production (gal/day)	750,000
Maximum Quantity Treated and Produced gal/day)	2,100,000
Minimum Quantity Treated and Produced gal/day)	317,000
Average Hours of Operation	11 hours
Maximum Hours of Operation per day	24 hours
Minimum Hours of Operation per day	6 hours
Number of Storage Tanks	3
Total Gallons of Treated Water Storage	425,000 gallon chlorine contact basin storage in treatment plant; 1 MG and 1.5 MG elevated storage
Total Gallons of Raw Water Storage	Big Spirit Lake

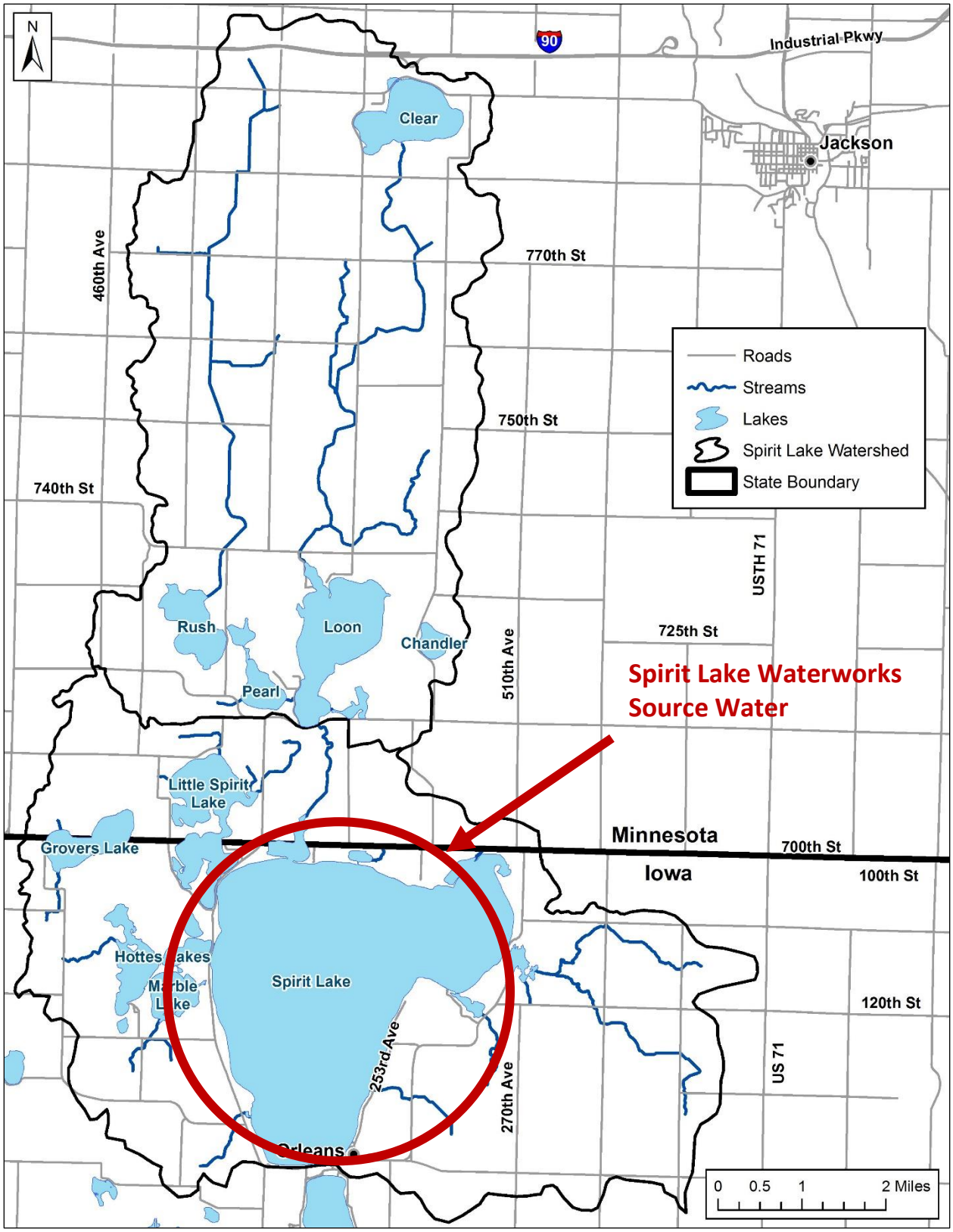

Figure 1. Big Spirit Lake Watershed in Dickinson County.

Step 1 - Source Water Team

A strong source water protection team (SWP Team) is necessary to ensure that there is an organizational structure and buy-in to implement the action plan to protect and improve source water conditions. The SWP Team was formed by contacting local agencies, organizations and individuals with a role to play in protecting source water. Table 3 provides a list of the SWP Team members, contact information and roles. Interested parties were convened to discuss the potential threats to Spirit Lake's drinking water supply as well as any concerns that the team members had on three different occasions. From these meetings a set of source water protection goals were established for Spirit Lake Waterworks. Agendas from each of the SWP Team meetings is provided in Appendix A.

Table 3. Source Water Protection Team membership

Name	Interest/Affiliation	Email	Phone #
Darin Peterson	Water Supervisor	splwater@mchsi.com	712-336-2127
Matt Welsh	NRCS District Conservationist (Acting)	matthew.welsh@ia.usda.gov	712-336-3782
Clint Hain	Dickinson County NRCS	clint.hain@ia.usda.gov	712-336-3782
Bob Waters	IDALS Watershed Coordinator	bob.waters@iowaagriculture.gov	515-306-7012
Mike Hawkins	IDNR Fisheries	6ickins.hawkins@dnr.iowa.gov	712-336-1840
Mark Gulick	IDNR Wildlife	mark.gulick@dnr.iowa.gov	712-330-2565
Julie Sievers	IDNR	Julie.sievers@dnr.iowa.gov	712-262-4177
Mary Skopec	Iowa Lakeside Labs Director	mary-skopec@uiowa.edu	712-337-3669
Steve Anderson	Iowa Great Lakes Sanitary District	iglsd@milfordcable.net	712- 338-2626
Mike Resch	Iowa Farmer	mresch@webbwireless.net	712-320-2810
John Wills	Dickinson Employee/State Representative, Dickinson County Clean Water Alliance	john.wills@ia.nacdnet.net dickinsoncwa@gmail.com	712-336-3782
Dave Kohlhaase	Dickinson SWCD Commissioner/Sanitarian	dkohlhaase@co.dickinson.ia.us	712-336-2770
Mike Ehret	Dickinson County Emergency Management	mehret@co.dickinson.ia.us	712-336-3987
Chris Bauer	Jackson County Soil & Water Conservation District	chris.bauer@mn.nacdnet.net	507-662-6682
Loren Clarke	Jackson County NRCS	loren.clarke@mn.usda.gov	507-662-6682

In addition to those SWP Team members listed above, representatives from the Minnesota Board of Soil and Water Resources, county health departments and emergency management departments, the Spirit Lake Protection Association, and Minnesota farmers are recommended for inclusion in future SWP Team meetings.

The issues and concerns identified by the SWP Team are summarized in Table 4. Each issue or concern is organized by category: water quality, water quantity, and education.

Table 4. SWP Team issues and concerns

Issue or Concern	Category		
	Quality	Quantity	Education
Challenges associated with an interstate watershed, coordination needs	X		X
Harmful algal blooms in Big Spirit Lake	X		
Nutrient loading to Big Spirit Lake • Agricultural runoff and tile discharge (nutrients, sediment, and pesticides) • Nutrient loading from upstream lakes, especially Loon Lake and Little Spirit Lake • High nitrate levels in Reed's Run • Failing septic systems and private wastewater systems • Livestock and feedlots	X		X
Erosion and sedimentation • Lake shoreline erosion • Ditch maintenance and associated erosion	X		X
Groundwater interactions –connection between shallow groundwater and Big Spirit Lake (potential for contamination). Effect of feedlots on groundwater quality.	X		
Aquatic vegetation management in lakes, weed control, potential for herbicides, mechanical vegetation removal	X		X
Zebra mussels in Big Spirit Lake	X	X	X
Impact of current and future development, need for coordination between planning efforts and updated ordinances	X		X

Goals developed based on input received from the SWP Team to address the issues and concerns include:

- Strengthen coordination between Minnesota and Iowa project partners and with various watershed planning efforts (TMDLs, Iowa Great Lakes Watershed Management Plan, etc.)
- Prevent harmful algal blooms in Big Spirit Lake
- Reduce phosphorus loading to Big Spirit Lake by 54% as provided in the Upper Gar Lake TMDL
- Reduce erosion and sediment loading to Big Spirit Lake
- Understand and manage the connection between groundwater and Big Spirit Lake
- Reduce the effect of invasive species and aquatic vegetation on the drinking water supply system and lake water quality

Step 2 - Source Water Delineation

Big Spirit Lake is part of the Iowa Great Lakes, a chain of lakes with headwaters in Jackson County Minnesota. These lakes discharge into the Little Sioux River. Big Spirit Lake is the primary source water for Spirit Lake Waterworks. There are no wells or intakes available for additional withdrawals. However, an emergency interconnect exists with the City of Okoboji. The emergency connection is sufficient for short term water supply needs. Low water levels in the lake are not common and the system has recently installed new intakes that should be sufficient to ensure the water supply. Information about the surface water source from which Spirit Lake Waterworks withdraws water is summarized in Table 5. Both intakes have recently been re-constructed to protect against zebra mussels present in the lake.

Table 5. Spirit Lake Waterworks surface water sources

Intake Name	Description	Water Source	Date Constructed / Modified	Frequency of Use	Activity Status
Big Spirit Lake Intake - lower	1,256 feet into the lake in 14 feet of water	Big Spirit Lake	2017	Primary	Active
Big Spirit Lake Intake - upper	855 feet into the lake in 11 feet of water	Big Spirit Lake	2017	Primary	Active

While the entire watershed for Big Spirit Lake constitutes the source water protection area, the primary protection area is the watershed areas closest to the intakes and is the focus of emergency response actions. A secondary protection area is delineated for areas in close proximity to the surface water supply. This secondary protection zone is defined as the ¼ mile area around the perimeter of Big Spirit Lake and its connecting lakes and wetlands. Both protection areas are provided in (Figure 2).

Characteristics of the Source Water Protection Area

Land Use

Land use in the Big Spirit Lake watershed is predominantly agricultural, with 42% of the watershed in corn, 33% in soybeans, and less than 1% in alfalfa, hay and other row crops (Figure 3). Developed areas, including residential areas and roads, make up 4.5% of the land in the watershed. The remaining portion of the watershed is grassland, pasture, forest, wetlands, barren, and open water.

Geology

The Big Spirit Lake watershed lies entirely within the Des Moines Lobe of the Wisconsin Glaciation within the Iowa Great Lakes region. The Iowa Great Lakes were formed as a result of the last major ice age to have reached this region. Lakes in the area typically have accumulation of silt, loam, and clay sediment that is nutrient rich. This area contains many shallow wetland basins and prairie potholes. Drain tiles are prevalent to foster agriculture. Dickinson County exists within an area of prominent ridges and knob and kettle terrain associated with changing ice margins. These ridges are known as end moraines[1] Bedrock in the watershed is of the Colorado and Dakota groups, which is sedimentary rock characterized primarily by sandstone and shale[2].

[1] http://agronomy.unl.edu/FarmingSystems/organic/resourcevolumes/land-forms-of-iowacari.pdf
[2] https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=IAKcd;0

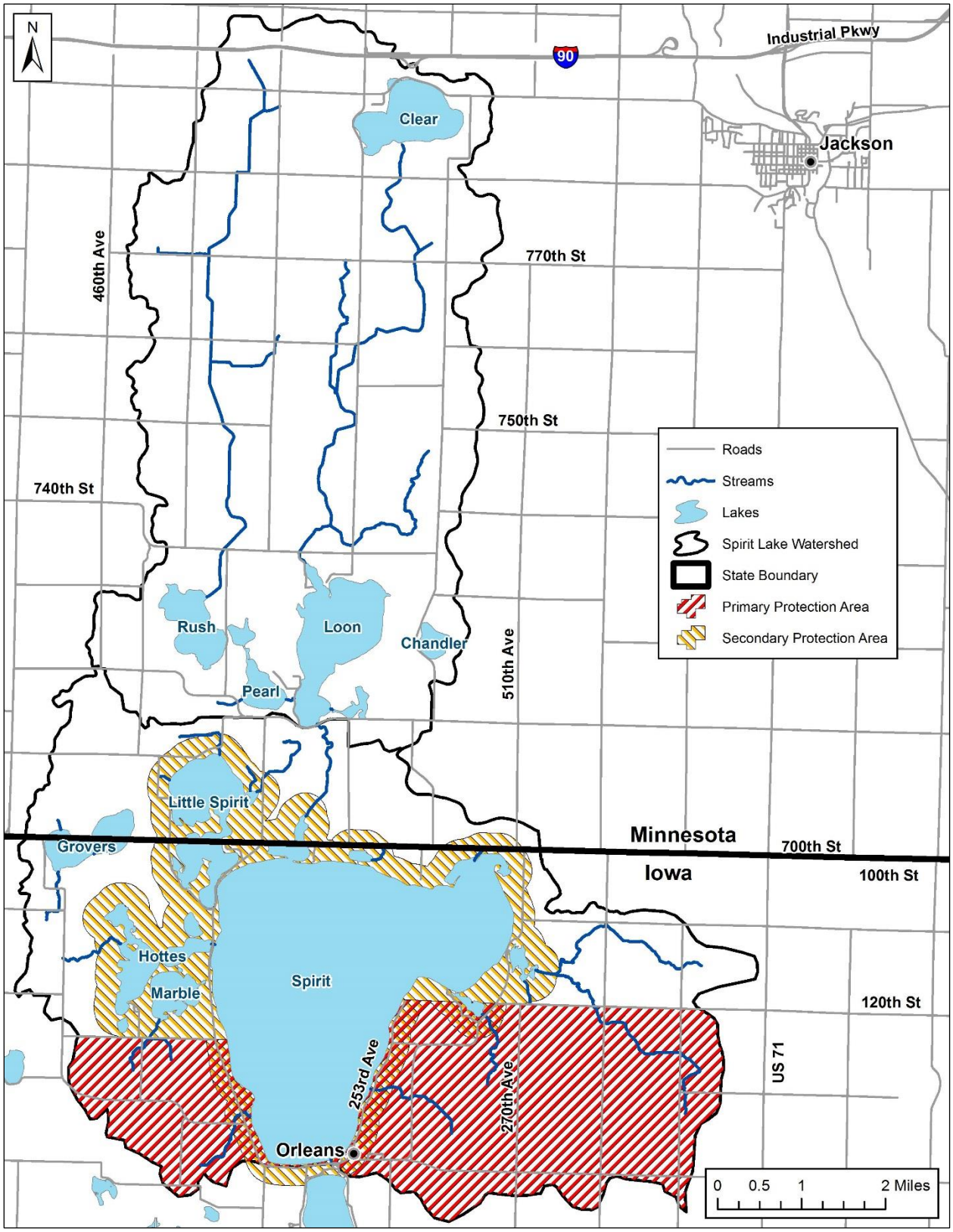

Figure 2. Big Spirit Lake watershed and protection areas.

Soils

Soil types can be important because the rate groundwater infiltrates through the soil and the type of plants grown in that soil control the amount of precipitation that reaches the groundwater. Hydrologic soils groups (HSGs) refer to the grouping of soils according to their runoff potential. Soil properties that influence the HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. There are four groups of HSGs: Group A, B, C, and Group D. Soil data were obtained from the 2014 Soil Survey Geographic Database (SSURGO) produced by the Natural Resources Conservation Service (NRCS).

The Big Spirit Lake watershed is underlain primarily by C-type soils, with some A, B, and D-type soils (Figure 4). C-type soils have low infiltration rates and are sandy clay loams (USDA 1986[3]). A-type soils are sandy gravel soils with low runoff potential and high infiltration rates. B-type soils are characterized by moderately low infiltration rates and are silt loams or loams. Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, soils with a high water table, and shallow soils over nearly impervious material.

[3] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf

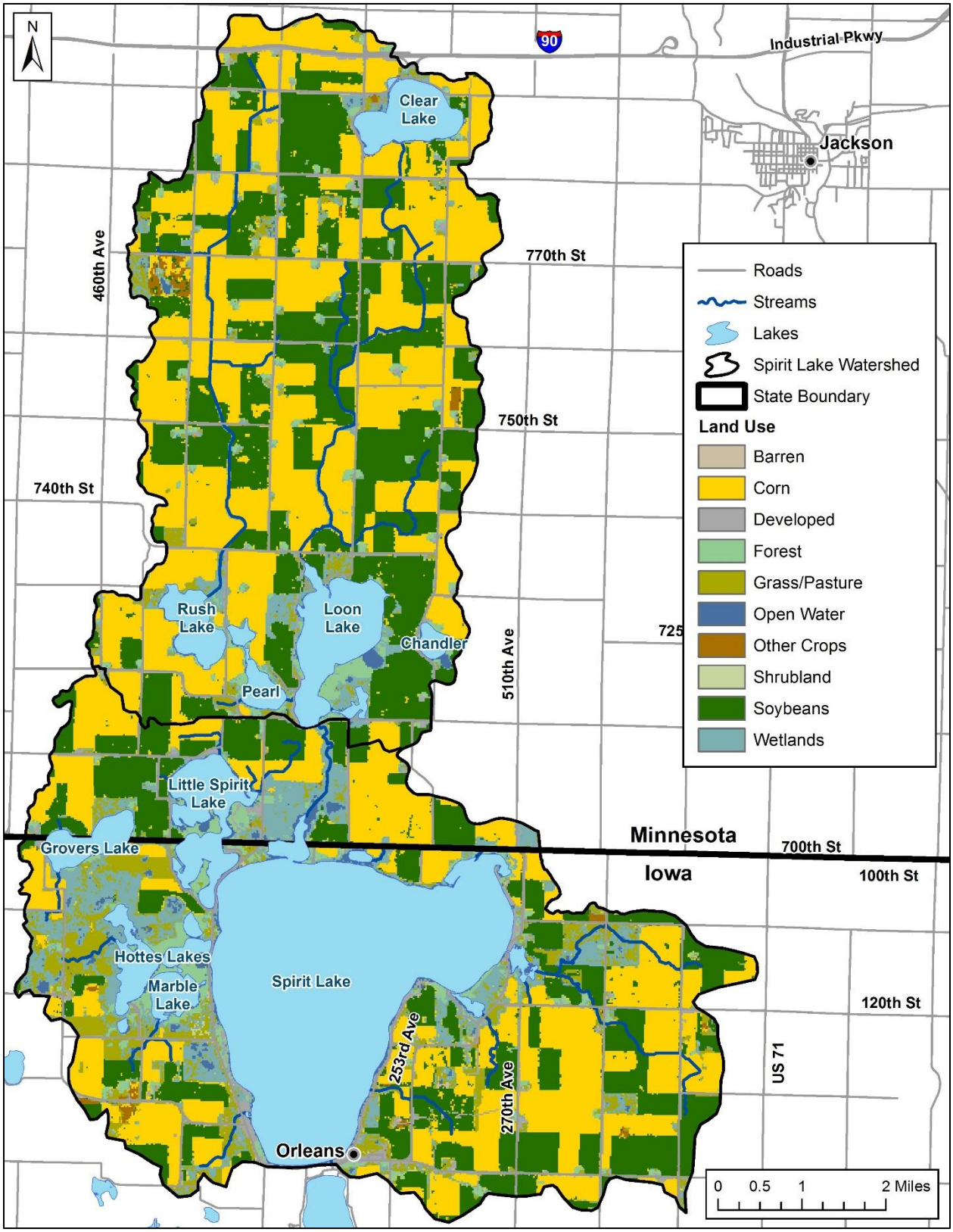

Figure 3. Land uses in the Big Spirit Lake watershed.

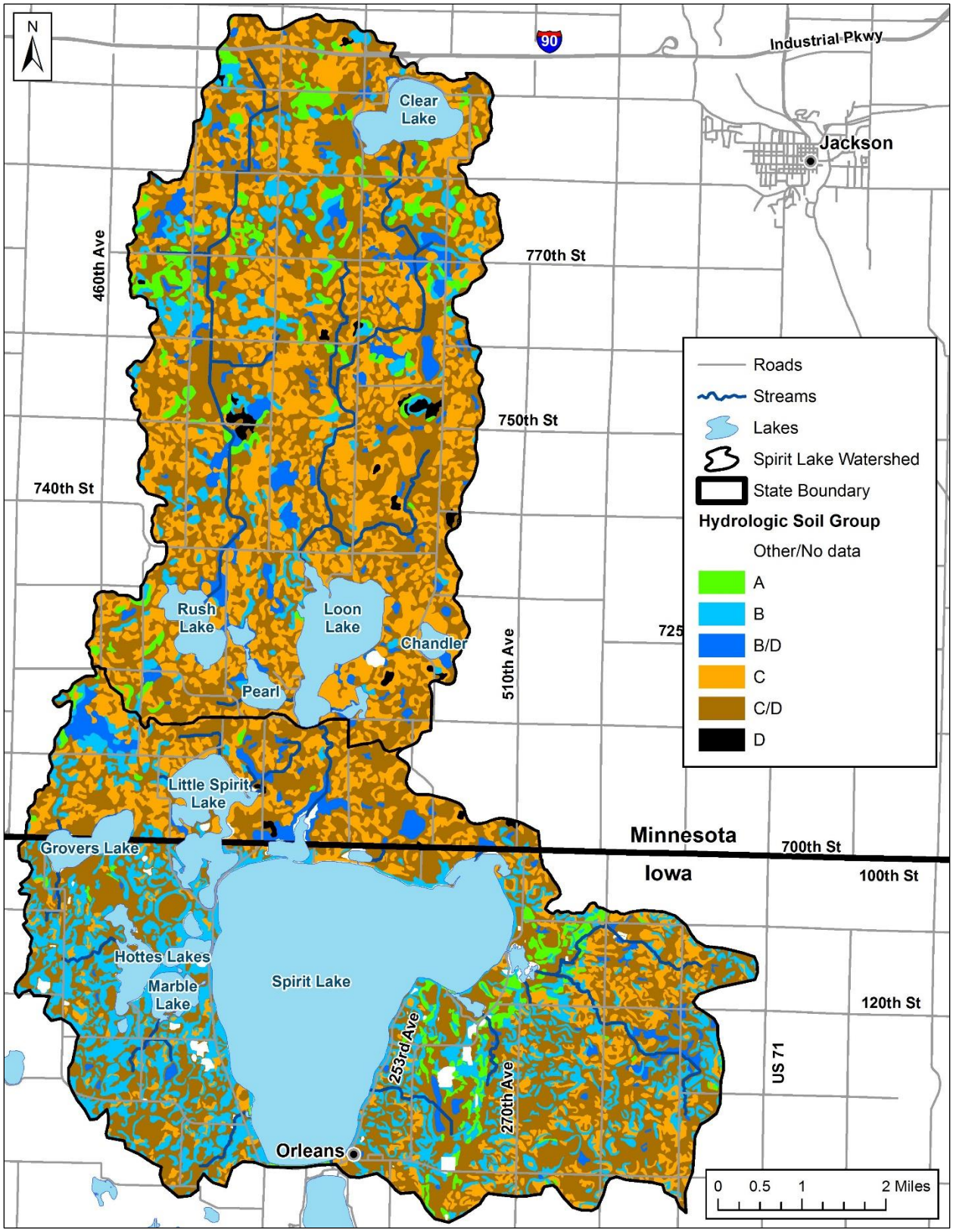

Figure 4. Soil hydrologic groups in the Big Spirit Lake watershed.

Water Quality in the Source Water Protection Area

Water quality data were collected by IDNR and by volunteers as part of the Cooperative Lakes Area Monitoring Project (CLAMP) at several locations in Iowa, including Big Spirit Lake, smaller surrounding lakes, and tributaries. In Minnesota, water quality data have been collected in Loon Lake and Clear Lake.

As summarized in Table 6, water quality data collected between 2005 and 2010 in Loon Lake and Clear Lake, as provided in the approved TMDL, report average seasonal phosphorus concentrations of 309 and 108 µg/L and chlorophyll-*a* concentrations of 104 and 52 µg/L, respectively. The Minnesota water quality standards are 90 µg/L total phosphorus and 30 µg/L chlorophyll-*a*. Water quality data collected between 1999 and 2017 in Iowa report Little Spirit Lake's phosphorus concentration is on average 248 µg/L while Big Spirit Lake is on average 50 µg/L. Chlorophyll and nitrate concentrations are also relatively low in Big Spirit Lake (33 µg/L and 0.11 mg/L, respectively). Iowa DNR's recommended phosphorus concentration for Big Spirit Lake is less than or equal to 35 µg/L. Nitrate plus nitrite concentrations in all Iowa lakes were well below the state standard of 10 mg/L throughout the monitoring period.

Total maximum daily loads (TMDLs) have been developed for turbidity and algae in Little Spirit Lake (requires a 74% reduction in phosphorus) and for phosphorus in Loon Lake (requires an 80% reduction in phosphorus); both of these lakes are directly upstream of Big Spirit Lake.

Table 6. Water quality summary for Spirit Lake and adjacent waterbodies (1999-2017)

Lake	Total Phosphorus (µg/L)	Total Phosphate-Phosphorus (µg/L)	Chlorophyll-a (µg/L)	Secchi Disk Depth (m)	Nitrate plus nitrite (mg/L)
Iowa Data (1999 – 2017)					
Little Spirit Lake	248	222	76	0.6	0.27
Big Spirit Lake	50	46	33	1.6	0.11
West Hottes Lake	-	87	27	0.7	0.05
Marble Lake	-	155	62	0.5	0.04
Minnesota Data (2005-2010)					
Loon Lake	309	-	104	0.5	-
Clear Lake	108	-	52	0.6	-

Big Spirit Lake is able to assimilate the phosphorus contributions from upstream waters on an average seasonal basis, however the risk is high that during critical summer conditions when high levels of nutrients would result in algal blooms including cyanobacteria, or blue-green algae. Microcystin, a toxin produced by cyanobacteria, was monitored by IDNR in raw influent to the Spirit Lake Municipal Waterworks drinking water treatment facility in 2016 and 2017. Within raw influent to Spirit Lake Waterworks, over half of the samples were below the detection limit of 0.3 µg/L. Microcystin was detected in 21 of the 54 samples at concentrations from 0.3 to 5.8 µg/L. The EPA health advisory levels (below 0.3 micrograms/liter for children six and under, and at or below 1.6 micrograms/liter) have been exceeded, however water treatment is currently sufficient to reduce microcystin levels below test detection.

Additional water quality data were collected at two sites representing inputs to Big Spirit Lake between 2007 and 2016 as part of the Iowa Snapshot and volunteer monitoring programs:

- Little Spirit Lake (STORET site #930055): This site discharges directly into Spirit Lake.
- Reed's Run / Site 7 (STORET site #930021): Reed's Run is a wildlife management area near the south-eastern shoreline of Spirit Lake.

Phosphate concentrations in the Little Spirit Lake outlet ranged from 200 to 600 µg/L. These concentrations are comparable to the total phosphate concentrations measured at the Little Spirit Lake mid-lake monitoring sites, which ranged from 49 to 306 µg/L in the same time period. Phosphate concentrations at the Reed's Run monitoring site ranged from 100 to 800 µg/L. Nitrate was detected in the Little Spirit Lake outlet in one of the five samples. Nitrate concentrations on average were higher in Reed's Run, ranging from 2 to 10 mg/L (Figure 5).

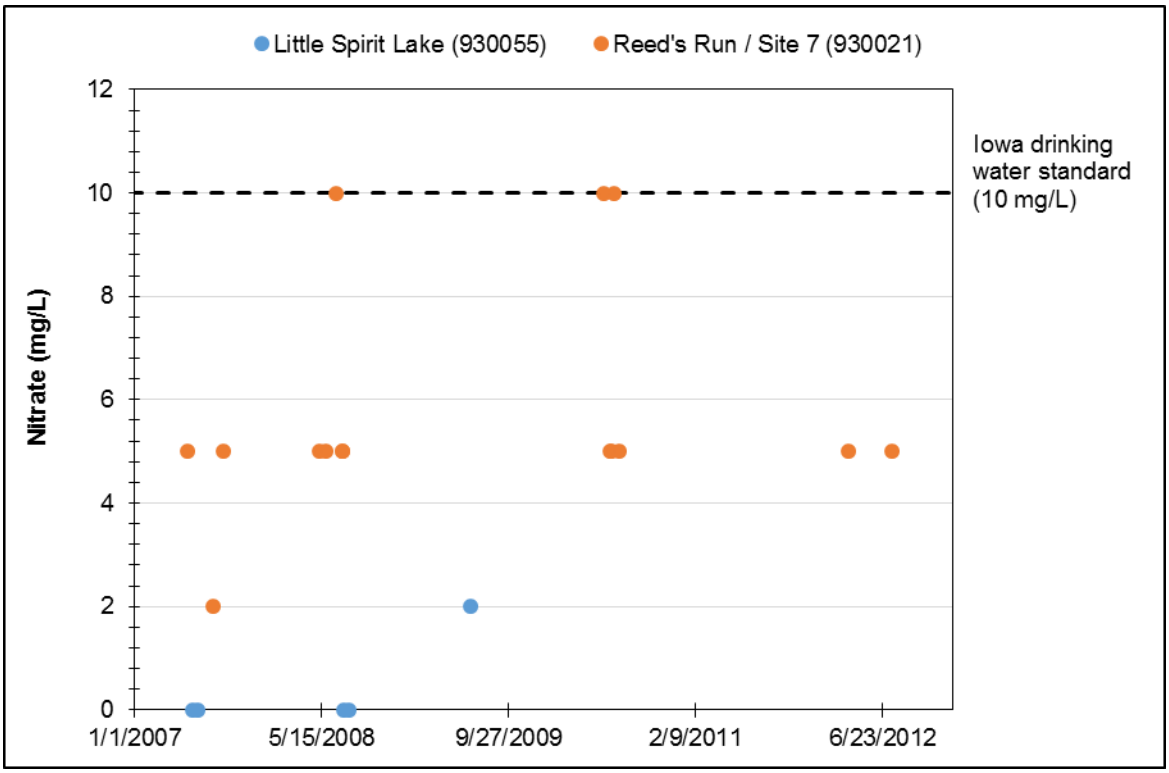

Figure 5. Nitrate concentrations at Little Spirit Lake and Reeds Run.

Susceptibility Determination

Since the source water is surface water from Big Spirit Lake, the water supply is classified as vulnerable. The City recently installed treatment protecting the intakes and raw water transmission lines from zebra mussels that are found in the lake. Additionally, high levels of microcystin, toxins produced by blue-green algae, can increase treatment costs. While the raw water tests reveal levels of microcystins above the EPA health advisory levels, treated water shows levels below the detection level of the test.

Step 3 - Inventory of Potential Contaminant Sources

SWPPs should provide a full contaminant source inventory to identify all potential contaminant sources (PCSs) within the source water area (see Appendix B for examples of PCSs). The Phase I Source Water Assessment Plan for Big Spirit Lake was developed in 2001; however, only a partially complete copy was available from the state's Source Water Protection Tracker. The missing pieces include the spatial location of potential contaminant sources, but a table listing PCSs was available. The potential contaminant sources identified in the Phase I Source Water Assessment Plan have been reviewed and included in this Source Water Protection Plan when appropriate.

In Iowa, nonpoint sources of contamination are a prevalent concern for drinking water quality. Fertilizers, chemicals and manure, all commonly used in agriculture activities, can be transported to the source water, either through surface runoff or in the shallow aquifer. PCSs, potential conduits, and land uses of concern were identified based on a review of geospatial databases from Iowa DNR and Minnesota Pollution Control Agency, land use data, findings of the 2001 Source Water Assessment, windshield survey, and input from the SWP Team. The resulting inventory is summarized in Table 7 and Figure 6.

There are several construction stormwater permits throughout the watershed. Runoff from construction sites can contain elevated levels of sediment and chemical pollutants. Currently active construction stormwater permits are identified in Table 7, but by the nature of construction sites, this list will evolve over time as construction is completed at some locations and begun at new locations.

Groundwater wells can also be considered PCSs; wells were identified from geospatial data from DNR and include wells from the Iowa Geological Survey (IGS) database, wells registered for testing, private well tracking system and registered abandoned wells. Wells are identified in the MN portion of the watershed through the state's County Well Index. Wells can serve as conduits for surface contamination to move to the groundwater more rapidly and if they are used for irrigation can also serve as a conduit for contaminated groundwater to be applied on the surface. If wells are no longer in use, it is important to properly abandon them. Groundwater well information and locations are provided in Figure 7 and Appendix C.

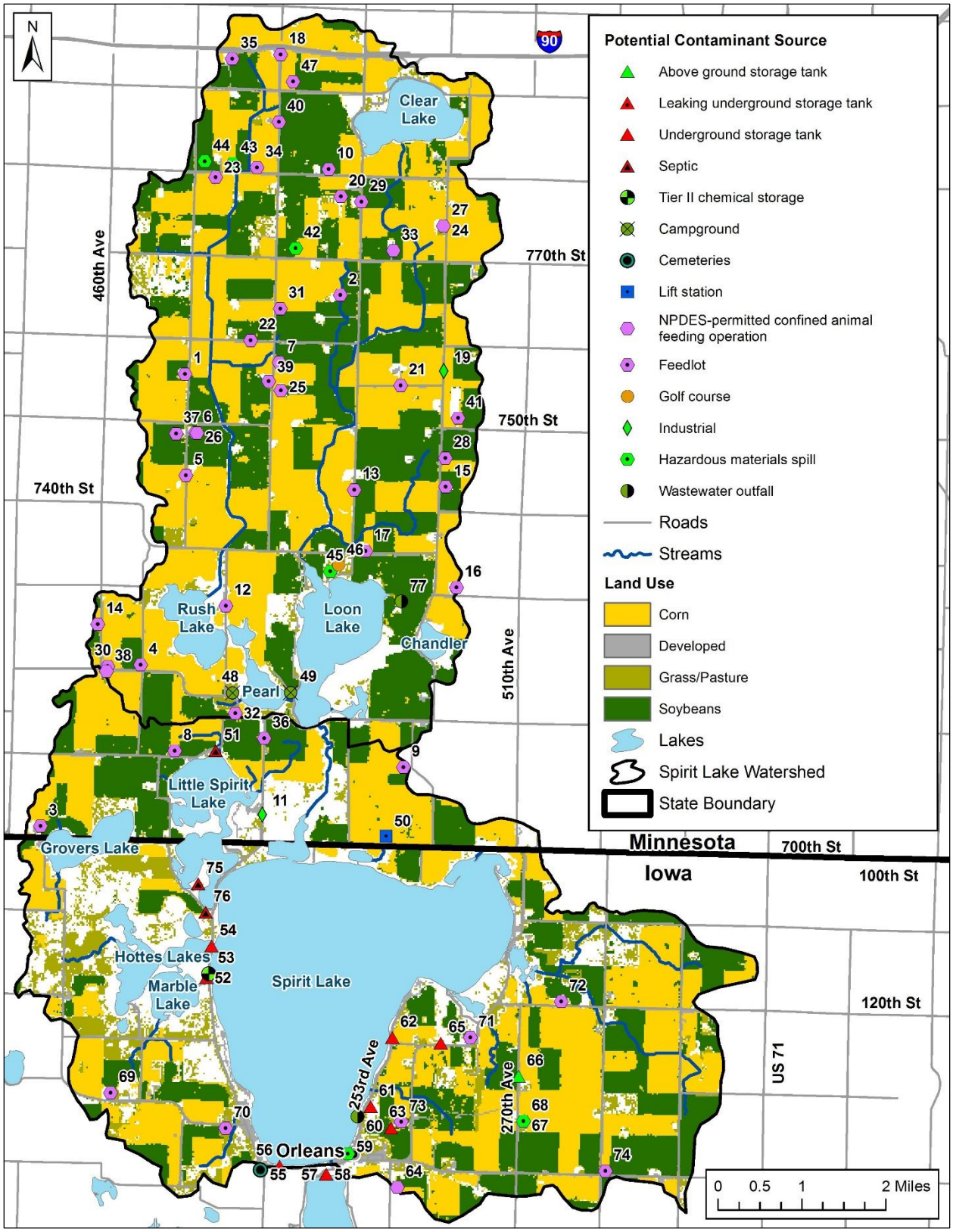

Figure 6. Potential contaminant sources and land uses of concerns. Land uses from 2015 Cropland Database.

Table 7. Inventory of Potential Contaminant Sources and Land Uses of Concern

Category (PCS, land use)	Location #	Source (database, field, etc)	Facility Type	Typical or Known Contaminants	Notes
PCS	1	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	2	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	3	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Closed
PCS	4	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Horses: Animal Units: 15
PCS	5	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Closed
PCS	6	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. 30 Feeder Cattle; 250 Swine: Animal Units: 96:
PCS	7	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Closed
PCS	8	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	9	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Swine <55 lbs: Animal Count: 4000
PCS	10	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 20: Feeder/heifer: 10: Animal Units: 13
PCS	11	Database	Industrial: Auto parts	Diesel, metals	--
PCS	12	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	13	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active
PCS	14	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Beef Cattle 30: Animal Units: 30
PCS	15	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	16	Datebase	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Bovines: 999: Animal Units: 999:
PCS	17	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active.Beef Cattle - Slaughter/Stock: Animal Units: 600:
PCS	18	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Sheep:1: Chickens: 62: Ducks: 6: Cow & calf pair: 10: Horses:10: Animal Units: 25.77
PCS	19	Database	Industrial: Drug Lab	Pharmaceuticals, hormones	--
PCS	20	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Closed
PCS	21	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Beef Cattle: 600: Animal Units: 600
PCS	22	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Calves: 70: Animal Units: 14
PCS	23	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Calves: 4: Finishers: 5: Chickens: 60: Animal Units: 2.48
PCS	24	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 1000: Animal Units: 300

Category (PCS, land use)	Location #	Source (database, field, etc)	Facility Type	Typical or Known Contaminants	Notes
PCS	25	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Nursery: 500: Finishers: 500: Animal Units: 175
PCS	26	Database	Confined animal feeding operation	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 3300: Animal Units: 990
PCS	27	Database	Confined animal feeding operation	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Swine 55-300 lbs: Animal Count: 3300
PCS	28	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	29	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 20: Sheep: 120: Horses: 2: Animal Units: 55
PCS	30	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Feeder cattle: 8: Cow & calf pair: 8: Chicken: 35: Animal Units: 15.33
PCS	31	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 330: Animal Units: 99
PCS	32	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	33	Database	Confined animal feeding operation	Nutrients, organic matter, microbes, pesticides, hormones, metals	--
PCS	34	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Feeder cattle: 15: Sows: 25: Chickens: 15: Ducks: 25: Animal Units: 20.795
PCS	35	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Cow & calf pair: 10: Animal Units: 12
PCS	36	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Horses: 5: Animal Units: 5
PCS	37	Database	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Beef Cattle: 90: Animal Units: 90
PCS	38	Database	Confined animal feeding operation	Nutrients, organic matter, microbes, pesticides, hormones, metals	Active. Finishers: 3300: Animal Units: 990
PCS	39	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	40	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	Inactive
PCS	41	Database	Feedlots	Nutrients, organic matter, microbes, pesticides, hormones, metals	--
PCS	42	Database	Petroleum Remediation, Leak Site	Petroleum	--

Category (PCS, land use)	Location #	Source (database, field, etc)	Facility Type	Typical or Known Contaminants	Notes
PCS	43	Database	Petroleum Remediation, Contaminated Soil Treatment Facility	Metals, petroleum	--
PCS	44	Database	Petroleum Remediation, Contaminated Soil Treatment Facility	Metals, petroleum	--
PCS	45	Database	Site Assessment: Dump	Waste disposal	--
PCS	46	Field	Golf Course	Fertilizers, nutrients	--
PCS	47	SWP Team	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	Closed
PCS	48, 49	Field	Campground	Waste disposal	--
PCS	50	SWP Team	Lift Station	Pumps water that normally forms wetland	--
PCS	51, 75, 76	SWP Team	Septics	Waste disposal	--
PCS	52	Database	Underground storage tank	Petroleum	--
PCS	53	Database	Tier II Chemical Storage	Unknown	--
PCS	54	Database	Underground storage tank	Petroleum	--
PCS	55	Database	Cemetery	Metals, fertilizers	--
PCS	56	Database	Underground storage tank	Petroleum	--
PCS	57	Database	Leaking underground storage tank	Petroleum	--
PCS	58	Database	Underground storage tank	Petroleum	--
PCS	59	Database	Hazardous Materials Spill	Varies	--
PCS	60	Database	Wastewater outfall	Nutrients, microbes, pharmaceuticals	--
PCS	61	Database	Underground storage tank	Petroleum	--
PCS	62	Database	Underground storage tank	Petroleum	--
PCS	63	Database	Underground storage tank	Petroleum	--

Category (PCS, land use)	Location #	Source (database, field, etc)	Facility Type	Typical or Known Contaminants	Notes
PCS	64	Database	Confined animal feeding operation	Nutrients, organic matter, microbes, pesticides, hormones, metals	--
PCS	65	Database	Underground storage tank	Petroleum	--
PCS	66	Database	Above ground fuel storage	Diesel	--
PCS	67	Database	Open feedlot	Nutrients, organic matter, microbes, pesticides, hormones	--
PCS	68	Database	Hazardous Materials Spill	Varies	--
PCS	69-74	SWP Team	Feedlot	Nutrients, organic matter, microbes, pesticides, hormones, metals	--
PCS	77	Database	Wastewater	Waste disposal	Future system
Land Use	Dark green, yellow	Land use mapping	Row crops	Pesticides, herbicides, fertilizers, nitrates	--
Land Use	Gray	Land use mapping	Developed	Nutrients, microbes, sediment, pesticides	--
Land Use	Light green	Land use mapping	Pasture	Sediment, nutrients, microbes	--

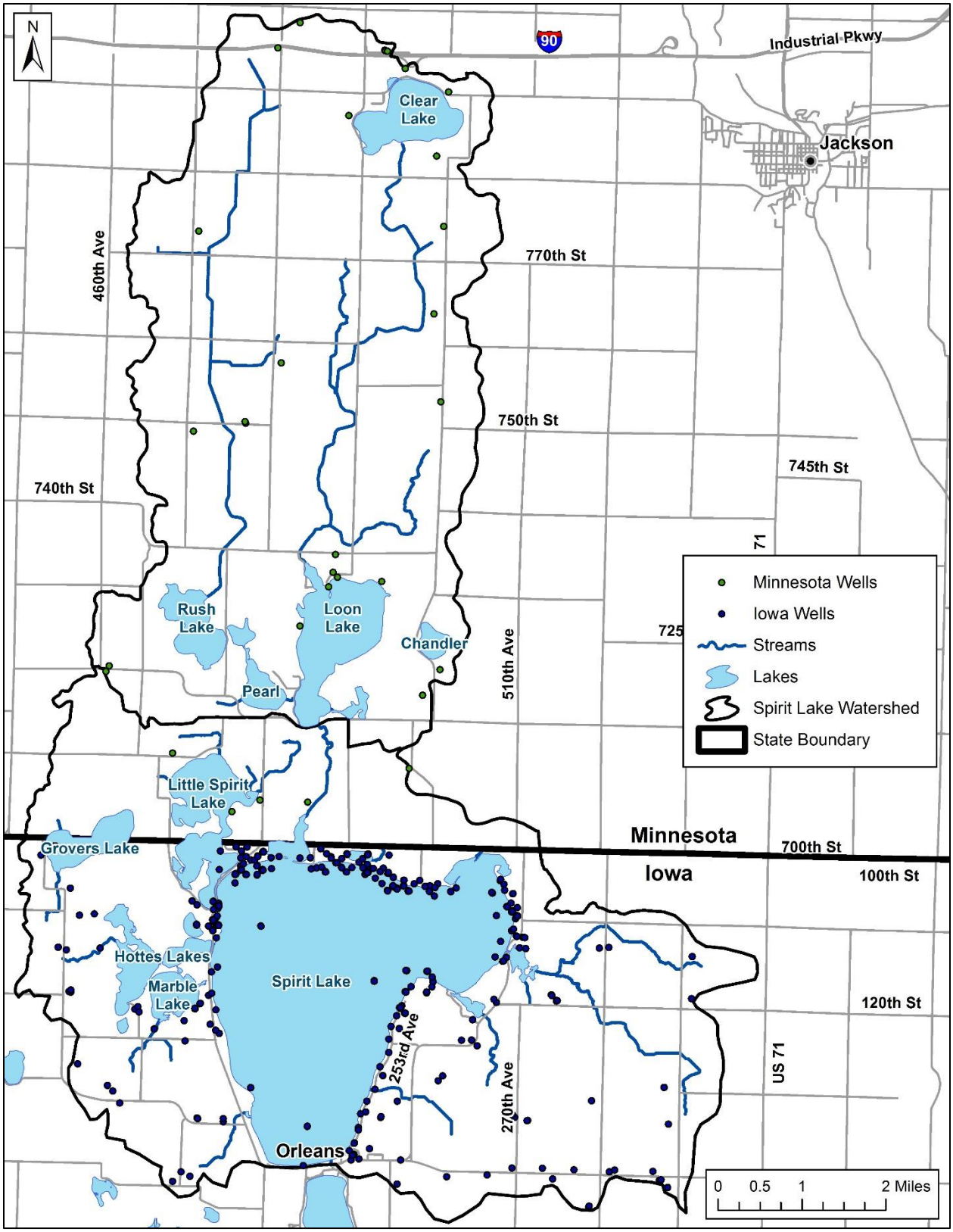

Figure 7. Groundwater wells in the Big Spirit Lake watershed. Due to scale, several wells are not visible on figure.

Step 4 - Assessment and Risk Ranking of Potential Contaminant Sources

After PCSs in the source water area are identified and inventoried, the risk each source poses to the water supply should be determined. Performing a systematic evaluation of the relative risk of contamination from each source allows the SWP Team to determine which potential threats are the greatest and can help prioritize implementation actions by focusing first on implementation strategies that impact the pollution sources of greatest risk.

The Iowa DNR Source Water Protection Program has established a statewide source water assessment and ranking system that was used in Phase I Source Water Assessment Plans and can be used in SWPPs as well. The three factors that go into the Iowa ranking system are:

- Location of the potential contaminant source
- Susceptibility
- Type of contaminant source

Risk is calculated as: Location + Susceptibility + Contaminant Risk = Source Water Risk Ranking

Points are assigned for each of the three factors and a cumulative score is calculated for each PCS. These factors have been modified, as described below, to represent a surface water source water.

Location of Potential Contaminant Source

PCSs are ranked on a scale of 1 to 5, based on their location within the surface runoff area. A higher number represents a higher risk and closer proximity to the intake. PCSs and land uses within the primary protection area would have a highest risk due to the likelihood of direct transport of pollutants to the source water intakes (Figure 2). PCSs and land uses within secondary protection area (see Figure 2) also have high risk for pollutant transport to the surface water supply (Big Spirit Lake and its connecting lakes). The remaining watershed area has lower risk based on location and is given a location risk score of 1. Table 8 summarizes the risk scores for Spirit Lake.

Table 8. Risk scores based on location of potential contaminant source

Location	Risk Score
Watershed area outside of protection areas	1
Secondary protection area	3
Primary protection area	5

Source Water Susceptibility

Since source water is limited to surface water, susceptibility risk rankings were determined by the amount of separation surface waters have from potential contaminants. Highly susceptible areas are identified as those within one quarter mile of a connected stream, wetland, or lake (Figure 8). Tile drains, by design, also create a direct connection between agricultural land and the surface water they discharge to. Therefore, the area directly surrounding a tile drain (200 feet) is also considered highly susceptible for potential contamination. Source water susceptibility rankings are summarized in Table 9. Areas of high source water susceptibility are provided in Figure 8 for PCSs and Figure 9 for groundwater wells. No data, however, were available on tile drain locations in the watershed.

Table 9. Risk scores based on source water susceptibility

Delineation	Risk Score
Greater than ¼ mile from surface water (stream or lake)	1
Greater than 200 feet from tile drain inlet	1
Less than ¼ mile from surface water (stream or lake)	5
Less than 200 feet from tile drain inlet	5

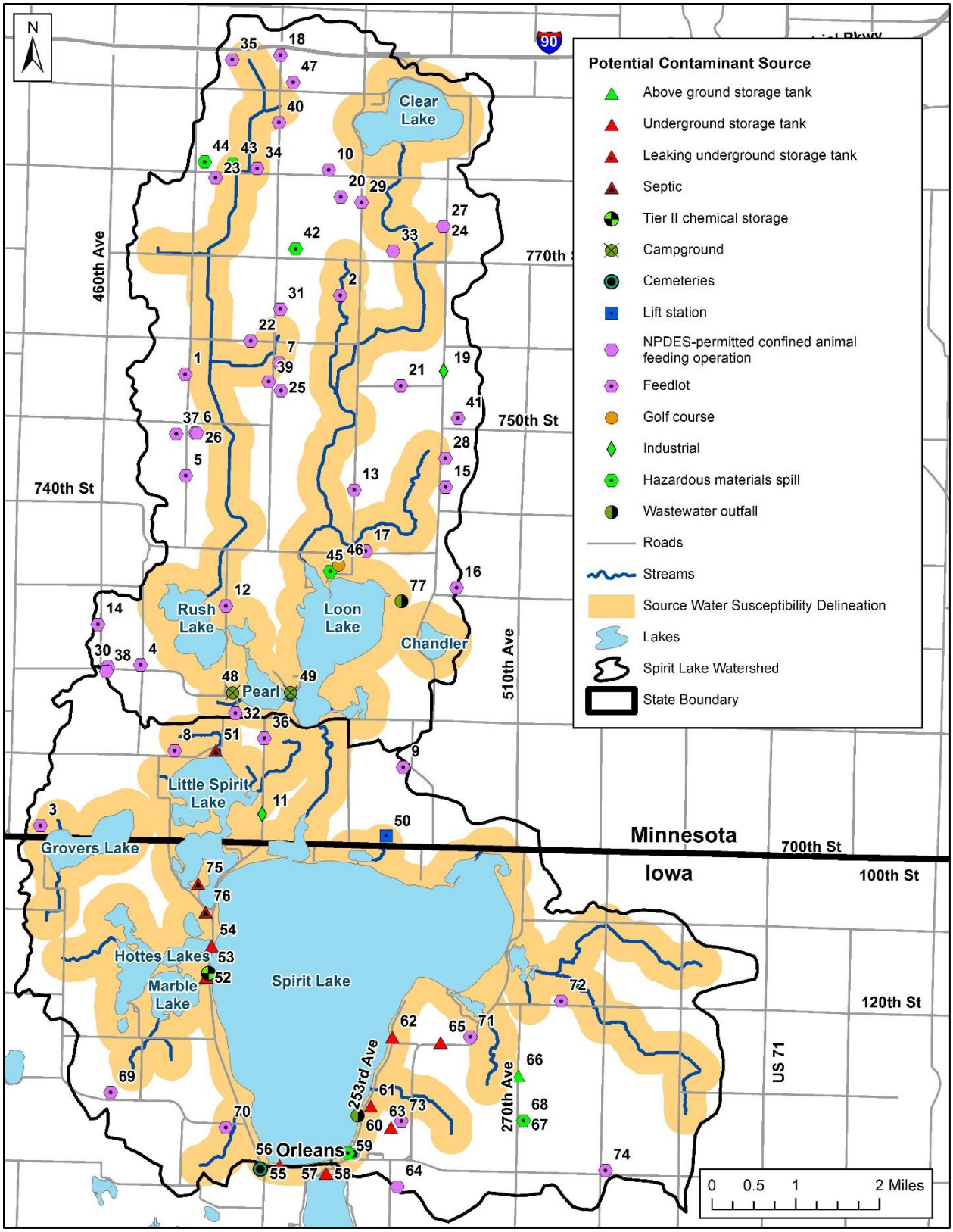

Figure 8. Source water susceptibility delineation (1/4 mile buffer) for PCSs.

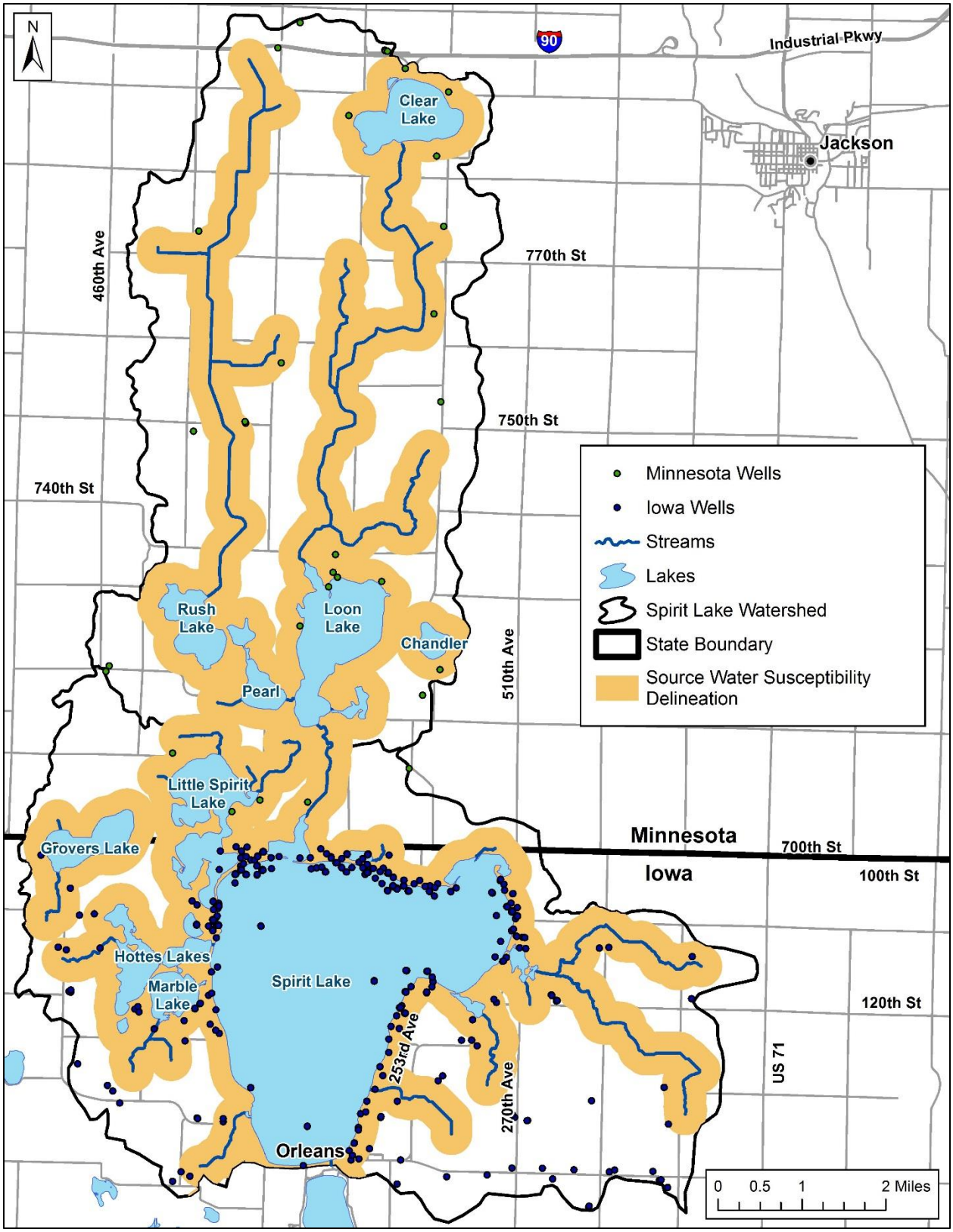

Figure 9. Source water susceptibility delineation (1/4 mile buffer) for groundwater wells. Due to scale, several wells are not visible on figure. A full list of wells can be found in Appendix C.

Contaminant Risk

Contaminant risk describes the combination of the potential to release contaminants with an estimate of the toxicity of the contaminants that may be released from a given facility or land use. Iowa DNR provides a contaminant risk guide based on land use type. As with the location of PCSs, it is appropriate to modify the risk scores to account for local water quality conditions and known issues and because the source water supply is a surface waterbody. The risk score for the field crop land use is increased to reflect the historical and potential future impacts of agricultural activities on the drinking water source supply. The risk scores also rank higher those activities that have the potential to discharge nutrients. The risk scores are relative rankings of potential for contaminant risk, not absolute risk scores. A summary of the risk scores for Spirit Lake are shown in Table 10.

Table 10. Risk scores by land use type. Higher scores are higher risk

Spirit Lake Risk Score	Land Use Type
1	Permanent open space
2	Active and properly abandoned wells
3	Municipal or private parks
3	Field crops: pasture, hay, vegetables
4	Developed land uses: residential, commercial, institutional, and areas of future development
5	Field crops: corn, soybeans, tiled fields
5	Agricultural production: dairy, livestock, poultry [a]
5	Improperly abandoned wells
5	Wastewater: sewage treatment facilities and disposal, permitted confined animal feeding operations, feedlots and manure application areas
5	Industrial: all forms of manufacturing and processing, research facilities
5	Underground storage of chemicals, petroleum
5	Waste disposal: pits, ponds, lagoons; injection wells used for waste disposal; landfills; hazardous waste treatment, storage, and disposal sites

a. A secondary ranking system could be developed to further refine the feedlot category based on input from the SWP Team. Larger feedlots and/or feedlots that are not meeting regulatory requirements could be ranked higher than smaller feedlots and/or feedlots meeting regulatory requirements. A field inspection of feedlots is needed to develop this ranking system.

Total Risk

Table 11 through Table 12 provide a summary of the PCSs and land uses with the highest risk, based on the individual location, susceptibility and contaminant risk scores. Groundwater wells located within both the primary and secondary protection areas were also identified as high priority. The total risk score for each is used to help determine implementation of the action plan. Appendix E contains the individual risk scores for all identified PCSs, groundwater wells and land use types in the watershed.

Table 11. Highest risk PCSs in the Big Spirit Lake watershed

Potential Contaminant Source	Location #	Location of PCS	Source Water Susceptibility	Contaminant Risk	Total Risk Score
Cleo Johnson Farm - Sec 2	1	1	1	5	7
Wayne & Marc Fischer	2	1	5	5	11
Jim Andersen Farm - Sec 33	3	1	5	5	11
Phyllis Johnson Farm	4	1	1	5	7
Cleo Johnson Farm	5	1	1	5	7
Vancura Investments	6	1	1	5	7
Steven Matasovsky Farm	7	1	5	5	11
David Bordwell Farm - Sec 27	8	5	5	5	15
Kabele Auto Parts	11	5	5	4	14
D & S Farms	16	1	5	5	11
Richard Klima	23	1	5	5	11
Ronald Bezdicek Farm	24	1	5	5	11
Bezdicek Finisher	27	1	5	5	11
William Tusa Farm	28	1	5	5	11
David Bordwell Farm - Sec 26	32	1	5	5	11
Brent Whisney Farm 203	33	1	5	5	11
Tony Dvorak Farm	34	1	5	5	11
Dwaine Hodnefield Farm	35	1	5	5	11
Bruce Hanson Farm - Sec 25	36	1	5	5	11
Ron Schafer Farm	39	1	5	5	11
William Jandera Farm	40	1	5	5	11
Clair O Gilmore Trust	43	1	5	5	11
Loon Lake Golf Club Dump	45	1	5	5	11
Lift station	50	1	5	5	11
Septic Locations	51	5	5	5	15
Marble Beach Marine	52	5	5	5	15
Star Energy A Division Of Growmark, Inc. - Spirit Lake Cardtrol	53	5	5	5	15
Steve Van Roekel Property	54	5	5	5	15
St. Margaret Cemetery	55	5	5	1	11
Vergie's Southside Resort	56	5	5	2	12
Department of Natural Resources	57	5	1	5	11
Department of Natural Resources	58	5	1	5	11
Handling And Storage Spill	59	5	5	5	15
Iowa Great Lakes Sanitary District Stp	60	5	5	5	15
Eric L Anderson	61	5	5	5	15
H & V Thompson Farms Ltd	62	5	5	5	15

Potential Contaminant Source	Location #	Location of PCS	Source Water Susceptibility	Contaminant Risk	Total Risk Score
Stony Point Farm	65	3	5	5	13
Iowa feedlot	69	5	1	5	11
Iowa feedlot	70	5	5	5	15
Iowa feedlot	71	5	5	5	15
Iowa feedlot	73	5	1	5	11
Iowa feedlot	74	5	1	5	11
Septic Locations	75	3	5	5	13
Septic Locations	76	5	5	5	15
Loon Lake STP	77	1	5	5	11

Table 12. Highest risk land use types in the Big Spirit Lake watershed

Land Use Type	Scores			
	Location	Source Water Susceptibility	Contaminant Risk	Total Risk Score
Crops (pasture and hay)	5	5	3	11
	3	5	3	11
Crops (corn/soy)	5	5	5	15
	3	5	5	13
	1	5	5	11
Developed	5	5	4	14
	3	5	4	12

Step 5 - Action Plan

The action plan developed in Step 5 outlines the methods for addressing the issues and concerns of the SWP Team and the threats to drinking water posed by each major PCS. The overall goal of the action plan is to reduce or mitigate the potential for contamination of the water supply from the PCSs. In addition, the action plan will provide the watershed with the tools, direction, and ability to implement pollutant load reductions set in the Iowa NRS. Step 5 includes a summary of recommended actions as well as information on a potential watershed-wide education and outreach program, monitoring, and the financial and technical resources available to support successful implementation.

A wide range of actions are necessary to address priority issues and threats to drinking water supply on a watershed-wide level. The action plan and schedule for the source water protection plan is provided in Table 13 along with the responsible entity. The action plan table is split into four categories of action items: comprehensive, watershed, land use and emergency response/spills planning actions.

The following sections provide additional information on select watershed-wide implementation actions and potential locations for implementation when available.

Table 13. Action plan and schedule

Activity	Completion Date	Responsible Entity	Comments
Management Activities			
Expand SWP Team as needed and hold semi-annual SWP Team meetings, alternating between MN and IA.	Twice per year	Spirit Lake Municipal Waterworks, SWP Team members	List of SWP Team members available in Step 1.
Formation of a watershed management authority.	2018-2019	SWCD, SWP Team members	See Programmatic and Regulatory Actions section below for further information.
Review plan on a bi-annual basis and update as needed using adaptive management framework.	Every 2 years starting in 2020	SWP Team members, Iowa DNR	See Adaptive Management section below for further information
Collect relevant data (tabular and spatial) to source water protection plan in one central location. Make available to SWP Team members and plan implementer.	Dec 2018	SWP Team members Iowa DNR	
Participate in interstate planning efforts, maintain regular communications.	Semi-annually	Iowa DNR, SWCDs, MN Board of Water and Soil Resources	
Integrate source water protection actions in other planning efforts (watershed, source water, land use, TMDLs etc.), to ensure comprehensive resource management.	On-going	SWP Team members	See Appendix D for Agricultural BMP opportunities in Okoboji watershed.
Expand SWP Team to include representative(s) from Minnesota BWSR, Spirit Lake Protection Association, Jackson County (zoning and health departments), and Minnesota farmer(s).	July 2018	SWP Team members	
Identify potential sources of funding and apply for grants.	2018-2019	SWP Team members	See Technical and Financial Assistance and Table 18 below for further information.
Watershed Implementation			
Conduct education and outreach pre-campaign survey and identify target audiences and messages. Develop state-specific messaging.	Dec 2019	Iowa Lakeside Labs, Spirit Lake Protection Association	See Watershed-Wide Education and Outreach Program section below for further information.
Conduct education and outreach activities. Promote agricultural BMPs through use of brochures, presentations, etc.	Annually by Dec.	Iowa Lakeside Labs, Spirit Lake Protection Association	See Watershed-Wide Education and Outreach Program section below for further information.
Conduct additional field and streambank assessments to determine opportunity for non-ACPF sited agricultural BMPs.	Dec 2019	Iowa and Minnesota DNR, SWCDs	See Agricultural BMP section below for further information.
Incorporate tile drain locations into source water susceptibility delineation when data obtained.	Feb 2020	SWP Team members	See Figure 8.

Activity	Completion Date	Responsible Entity	Comments
Complete field inspection of feedlots to determine compliance with regulatory requirements guidance, size, and type of operation.	Every 5 years (2020, 2025, 2030, etc.)	SWCDs, NRCS	
Develop secondary contaminant risk ranking system for feedlots in the watershed based on the field inspection. Update contaminant risk scores.	After each feedlot field inspection	SWCDs, NRCS	
Conduct farm survey to identify ownership, compliance with farm plans/nutrient management plans, and effectiveness of existing BMPs. Conduct survey every 5 years.	Every 5 years (2020, 2025, 2030, etc.)	SWCDs, NRCS	
Identify opportunity for and conduct demonstration farms within watershed.	Dec 2019	NRCS, SWCDs	See Agricultural BMPs section below for further information.
Implement three demonstration agricultural BMP project.	One project every 2 years starting in 2020	SWCDs	See Agricultural BMPs section below for further information.
Implement recommended agricultural BMPs.	On-going	SWCDs, NRCS, Iowa DNR	See Agricultural BMPs section below for further information. Prioritize and target implementation of phosphorus reducing BMPs to areas within 1 mile of confirmed feedlots.
Continue current monitoring program in Big Spirit Lake and within the watershed. Use adaptive management framework.	Annually	Iowa DNR , Cooperative Lakes Area Monitoring Project, MPCA	See Adaptive Management section below for further information.
Further investigate the interaction between Big Spirit Lake and groundwater, especially in areas with high infiltration rates, and develop guidance for land management practices. Develop a water and nutrient budget for the lake with a focus on upstream lake sources of phosphorus.	Dec 2022	Iowa DNR	See soils map for infiltration rates (Figure 4).
Conduct an erosion assessment on Big Spirit Lake, Loon Lake, and Judicial Ditch 35 and 8 to determine priority areas for stabilization and restoration.	Dec 2020	Iowa DNR	See Shoreline and Streambank Restoration section and Agricultural BMPs section below for further information.
Evaluate and implement shoreline restoration practices in priority areas identified in erosion assessment.	One project every 2 years starting in 2020	Iowa DNR, SWCDs, NRCS	See Shoreline and Streambank Restoration section and Agricultural BMPs section below for further information.
Develop and implement an aquatic plant and invasive species management plan.	Dec 2022	Iowa DNR	

Activity	Completion Date	Responsible Entity	Comments
Land Use Planning			
Consider point of sale inspection or other increased inspection program for septic systems in Iowa portion of the watershed.	2019-2028	Dickinson County Zoning and Environmental Health	See On-site Wastewater Actions section below for further information.
Identify gaps in existing ordinances and building codes and incorporate new language to protect water quality of Big Spirit Lake from pollutant loading, if necessary.	Dec 2020 – gaps analysis Dec 2022 – updated ordinances	City of Spirit Lake, Dickinson County, Jackson County, Iowa DNR	See Programmatic and Regulatory Actions section below for further information
Emergency Response and Spills			
Expand emergency response plan to address spills and other threats to Spirit Lake intakes. Identify tile inlets and outlets and inventory infrastructure upstream of lake (e.g., culverts, etc.). Ensure proper equipment and plans in place to address spill response.	June 2019	Dickinson Emergency Management	See Step 6 Emergency Response Plan and Figure 2
Determine need for source prohibitions or other action on priority PCSs, implement if necessary.	Dec 2019	Spirit Lake Waterworks	
Continue inspection and testing on identified PCSs.	On-going	Dickinson and Jackson Counties	See Table 7 and Figure 6
Field inspection of septic systems to determine compliance with regulatory requirements guidance.	On-going	Dickinson County Zoning and Environmental Health, Jackson County Department of Health	
Locate and address improperly abandoned wells, beginning with high priority wells.	Address 4 wells per year	Dickinson County Zoning and Environmental Health, Jackson County Department of Health	

Agricultural BMPs

The Big Spirit Lake watershed is largely agricultural; nutrients and sediment loading to the source water supply are a concern. Agricultural best management practices (BMPs) address many of the source water protection issues identified in Step 1.

Several types of agricultural BMPs are suitable to address source water protection concerns in the watershed. They include:

- **Nutrient removal wetlands** or treatment wetlands are engineered to mimic natural wetlands and designed to filter and treat nutrients and sediment in runoff.
- **Grassed waterways** are placed in agricultural fields where flows are concentrated and use vegetative cover to prevent erosion (IDALS et al. 2016). Reduced sediment loads of about 95% have been recorded, as have reduced water volumes and minor filtration of nutrients (Miller et al. 2012).
- **Contour buffer strips** are strips of permanent vegetation planted perpendicular to the slope of a field in between wider strips of row crops. Buffer strips can have a large impact on soil erosion reduction, but can also provide some nutrient reduction.
- **Water and sediment control basins (WASCOBs)** are embankments that restrict flow through a waterway. Placed perpendicular to flow paths, these berms slow overland flow and reduce soil erosion, suspended sediment loads, and sediment-bound particle loads, such as attached phosphorus.
- **Nutrient management strategies** such as soil testing and variable application of fertilizer can reduce the level of fertilizer applied, save application costs for the producer, and increase crop yields. Fields in close proximity to feedlots are likely areas for nutrient management.
- **Conservation tillage** is any tillage practice that results in at least 30% coverage of the soil surface by crop residuals after planting. Several types of tillage systems are commonly used:
    - No-till systems disturb only a small row of soil during planting, and typically use a drill or knife to plant seeds below the soil surface.
    - Mulch till systems are any practice that results in at least 30% residual surface cover, excluding no-till and ridge till systems.
    - Reduced till systems are any farming practice which involves fewer cultivations than used in conventional fallowing.

  Corn residues are more durable and capable of sustaining the required 30% cover. Soybeans generate less residue, the residue degrades more quickly.
- **Cover Crops** may include crops such as rye or oats. They reduce soil erosion by providing ground cover and improving soil structure, stability, and permeability with their root structures. The effectiveness of cover crops in reducing erosion is related to the soil cover achieved and cover is most important in the spring months when most runoff events occur.

- **Exclusion fencing and alternate watering systems** can limit or eliminate livestock access to a stream or waterbody. Fencing can be used with controlled stream crossings to allow livestock to cross a stream while minimizing disturbance to the stream channel and streambanks. Providing alternative water supplies for livestock allow animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (U.S. EPA 2003).

Figure 10. Livestock near stream in Big Spirit Lake watershed as a potential source of bacteria and erosion

- **Rock inlets** can provide a replacement to traditional intake risers and further reduce sediment loading to tile water. Rock inlets bury the intakes under several feet of pea sized gravel allowing for sediments to naturally settle out before reaching the tile line and drainage system. This alternative requires minimal maintenance compared with traditional systems.

- **Controlled drainage** or drainage water management systems utilize stoplogs to control water table depth under drain-tiled agricultural fields and can improve water quality by reducing water volume and nutrient transport rates. Controlled drainage has a small effect on nitrate concentrations, but the flow volume reduction they provide reduces nitrate loads with a negligible effect on crop yields (IDALS et al. 2016).

- **Saturated buffers** remove some water from tile drainage and infiltrates it into groundwater within a riparian area. Related to controlled drainage, saturated buffers use a stoplog system to create an elevated water table that allows denitrification to occur in organic soils (IDALS et al., 2016).

- **Edge-of-field bioreactors** are excavated pits that denitrify water from subsurface drainage by providing a carbon source (often wood chips) for denitrifying bacteria, which in turn convert nitrate to nitrogen.

Agricultural BMP guidance and technical notes can be found on the Iowa NRCS website. The effectiveness of agricultural BMPs to remove pollutants vary. Most of the recommended agricultural BMPs remove either nitrogen or phosphorus and sediment. Wetlands and cover crops are the only practices that significantly remove all nutrients (nitrogen and phosphorus) and sediment (Table 14). Selection of BMPs will likely require a suite of practices to meet the goals of the Source Water Protection Plan.

Table 14. Targeted pollutant(s)

BMP	BMP target pollutant(s)			
	Sediment	Phosphorus	Nitrate	Bacteria
Nutrient removal wetlands	++	++	++	++
Grassed waterways	++	++	--	--
Contour buffer strips	++	++	--	--
Water and sediment control basin	++	++	--	--
Nutrient management	--	++	++	--
Conservation tillage	++	++	--	--
Cover crops	++	++	++	--
Riparian buffer and filter strips	++	++	--	++
Exclusion fencing and alternate watering systems	++	++	--	++
Rock or alternative inlets	++	--	--	--
Controlled drainage	--	--	++	--
Bioreactors	--	--	++	--
Saturated riparian buffers	--	--	++	--

-- low level of reduction
++ high level of reduction

Existing Agricultural BMPs

Existing BMP locations were identified by the Iowa BMP Mapping Project (Figure 11) for the Iowa portion of the watershed. The Iowa BMP Mapping Project is led by Iowa State University and is making progress toward providing a complete baseline set of BMPs dating from the 2007-2010 timeframe for use in watershed modeling, historic occurrence, and future practice tracking. Tetra Tech completed a similar BMP mapping project using Iowa State University's approach for the Minnesota portion of the watershed. Iowa DNR conducted a final quality assurance check to ensure consistency.

Mapped BMPs include terraces, water and sediment control basins (WASCOB), grassed waterways, pond dams, contour strip cropping (limited mapping), and contour buffer strips. Other BMPs such as nutrient management and those practices that cannot be identified using air photography are not identified.

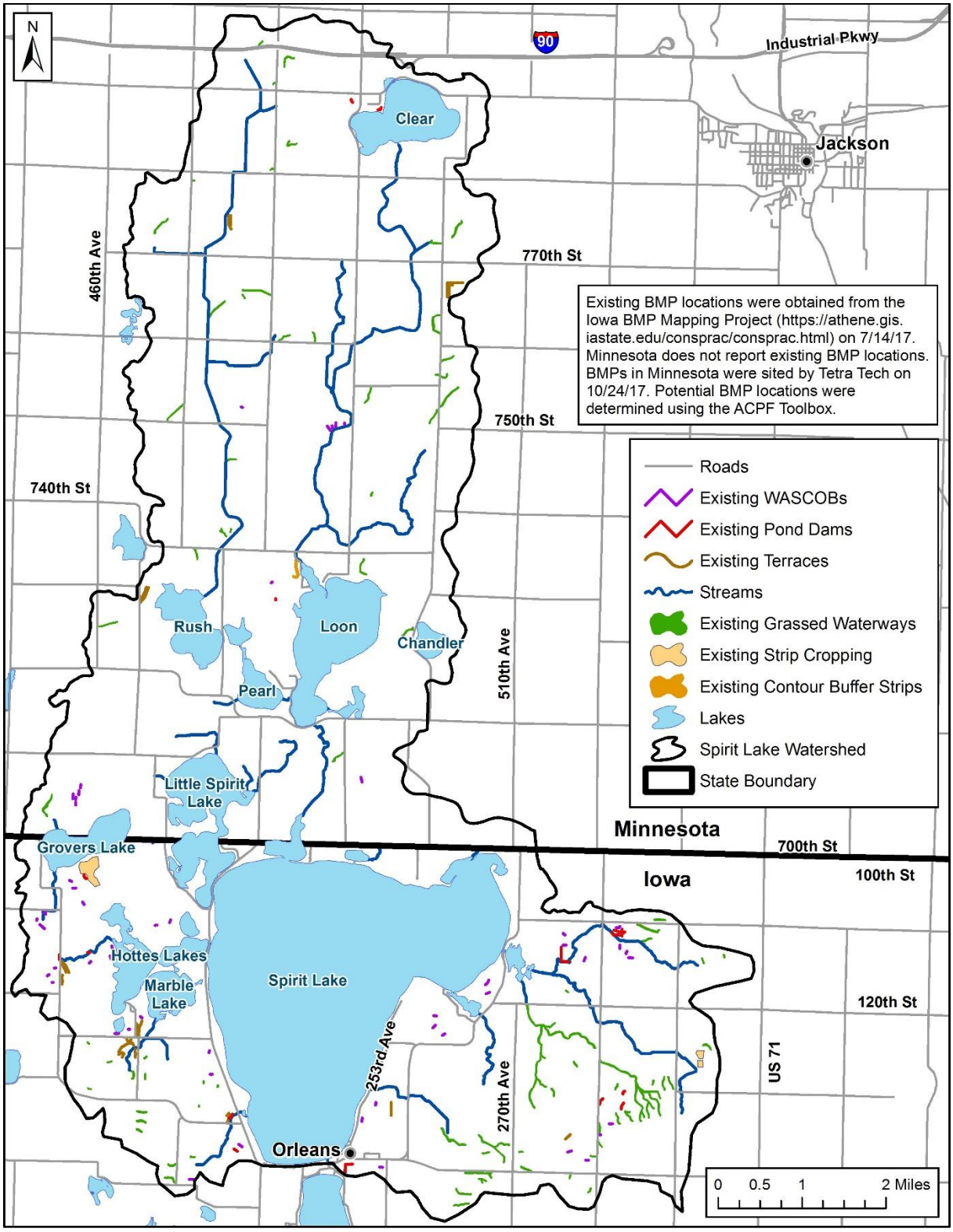

Figure 11. Existing BMPs in Spirit Lake watershed.

Agricultural BMP Opportunities

Opportunities in the watershed for implementation of agricultural BMPs were identified by using the Agricultural Conservation Planning Framework (ACPF) version 2.2 and of existing BMP locations. The ACPF Toolbox was developed by the United States Department of Agriculture's (USDA) Agricultural Research Service. It is a set of ArcGIS® tools that locate potential BMP placement in a given watershed (Porter et al., 2017). The ACPF model is able to site the following:

- Controlled drainage (drainage water management)
- Edge-of-field bioreactors
- Saturated riparian buffers
- Nutrient removal wetlands
- Grassed waterways
- Contour buffer strips
- Water and sediment control basins (WASCOB)

Figure 12 through Figure 15 provide potential location opportunities for BMPs that were sited in ACPF. ACPF results are also provided in Appendix D for the Okoboji watershed, just south of the Big Spirit Lake watershed.

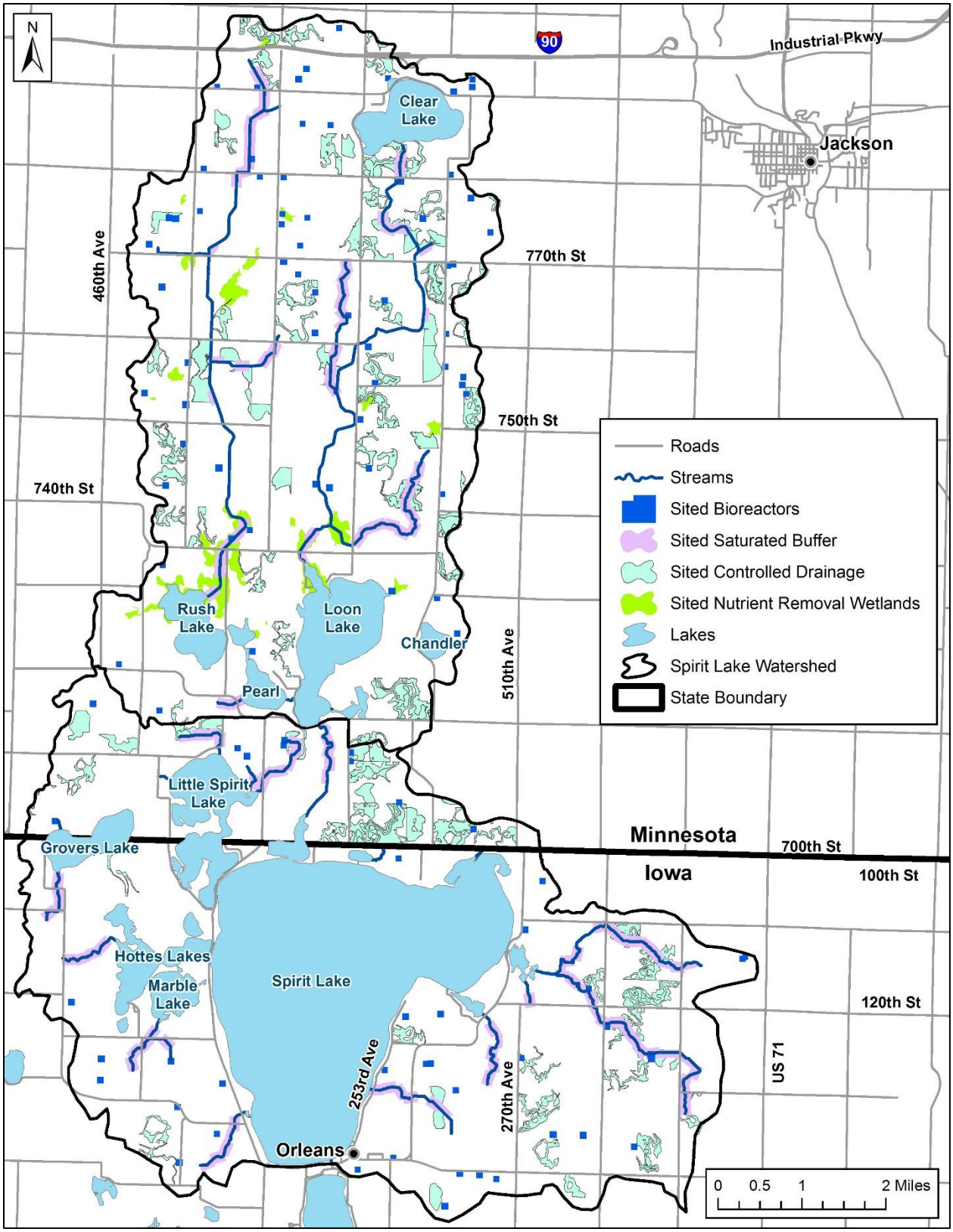

Figure 12. ACPF sited locations for saturated buffer, bioreactors, and controlled drainage BMPs in Spirit Lake watershed.

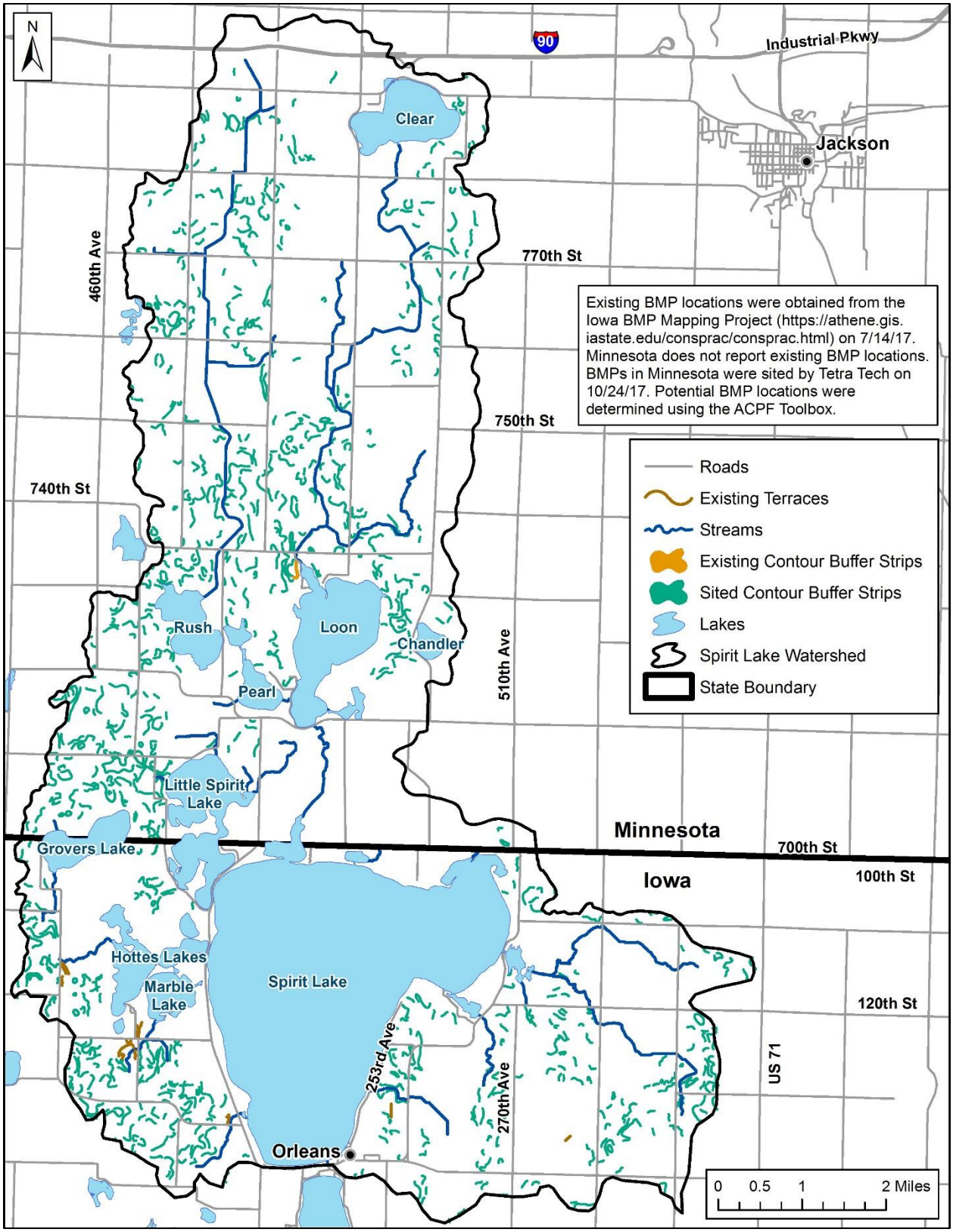

Figure 13. ACPF sited locations for contour buffer strips in Spirit Lake watershed.

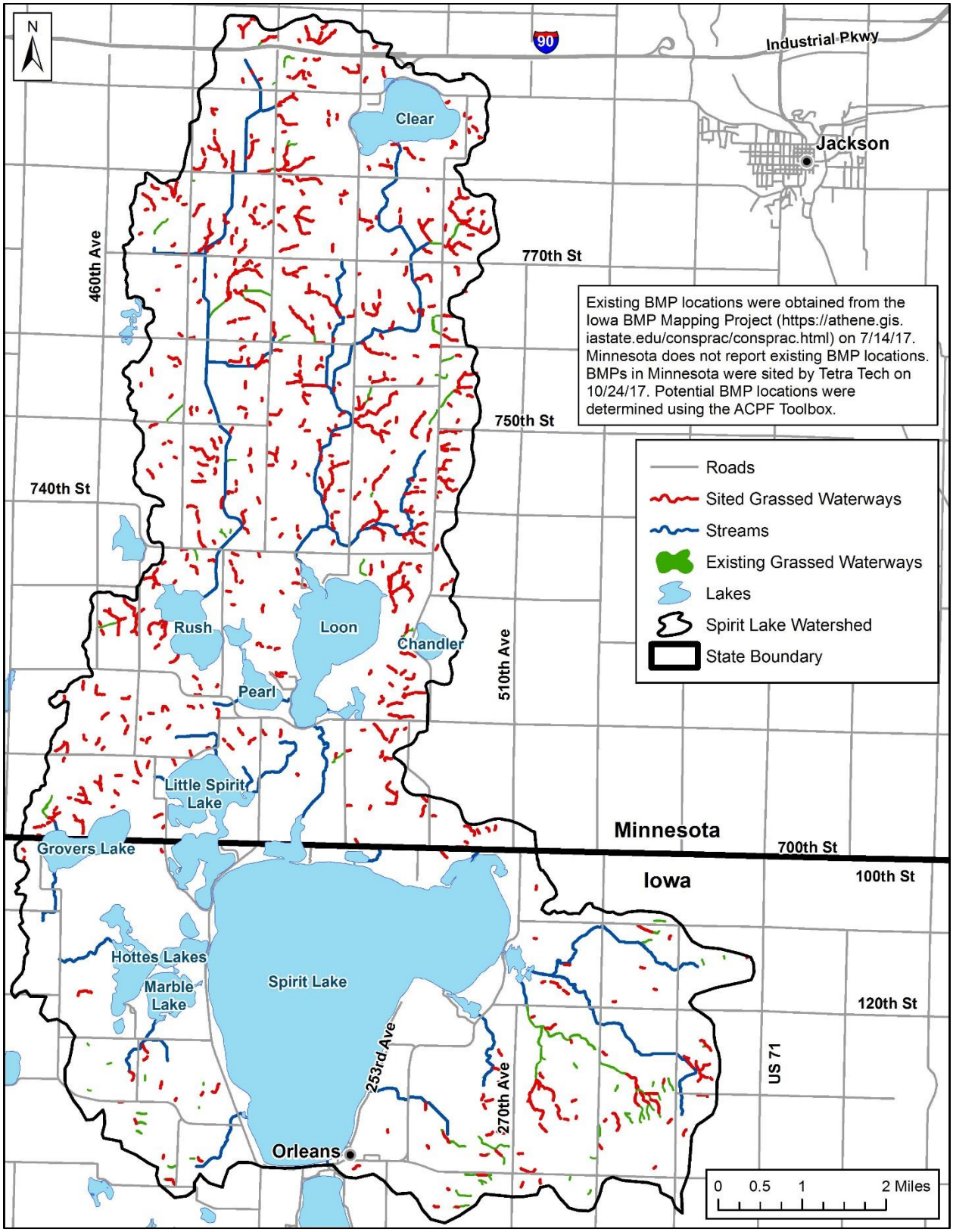

Figure 14. ACPF sites locations for grassed waterways in the Spirit Lake watershed.

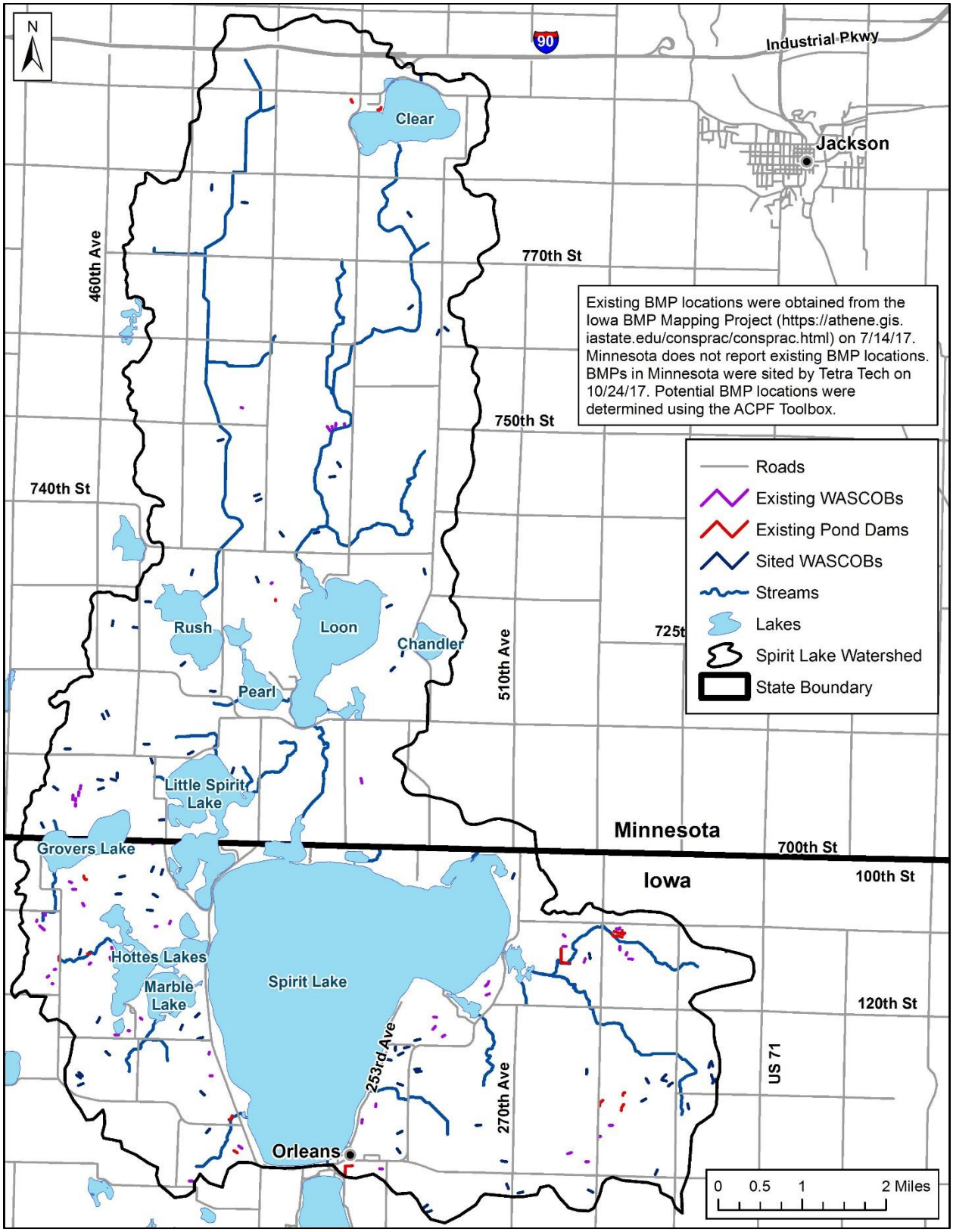

Figure 15. ACPF sited locations for WASCOBs in Spirit Lake watershed.

Agricultural BMP Scenarios

Scenarios were developed to determine the extent of agricultural BMP implementation needed to reduce phosphorus loads. The Upper Gar Lake TMDL set a goal for a 54% reduction in phosphorus in the watershed, including Big Spirit Lake. This goal is higher than the Iowa NRS phosphorus reduction goal of 29%, therefore a target reduction of 54% (566 kg P) is used to determine the extent of implementation. Existing phosphorus loading is based on a loading rate of 0.024 kg/acre/year as provided in the Iowa NRS and can be met in a variety of ways but factors such as costs, treatment opportunity, and BMP removal efficiencies should all be considered prior to selection. Table 15 summarizes these factors for select phosphorus removing agricultural BMPs. Two scenarios are provided: (1) Least cost alternative (Table 16) and (2) Balanced implementation approach (Table 17). A suite of BMPs are used in the scenarios that are more likely to remove phosphorus, actual implementation will vary depending on a variety of factors (available funds, landowner willingness, etc.).

Table 15. Costs, treatment opportunity, and removal efficiencies for select phosphorus removing BMPs

BMP	Cost/acre/ year [a]	Potential Area Draining to BMP (ac) [b]	Phosphorus removal efficiency
Nutrient Removal Wetland	$14.95	27,139	34%[b]
Phosphorus Management (Reduced Application)	$(34.00)	26,249	Varies (9% used in calculations)
Cover Crops	$32.50	26,249	29%
Conservation Tillage	$(0.95)	26,249	62%
Riparian Buffers	$13.96	2,625	58% [c]

a. Source: Iowa NRS. Cost is equal annualized cost (50-year life and 4% discount rate) factors in the cost of any corn yield impact as well as the cost of physically implementing the practice.
b. Reduction provided by Iowa CREP dataset.
c. Reduction for water that reaches the active zone of the buffer. Due to the high level of tiling that will effectively bypass the buffer, this value is small.

Table 16. Least cost alternative scenario for achieving phosphorus reduction goal in Big Spirit Lake

BMP	% Adoption on suitable acres	Acres treated	Reduction (kg P/yr)	Cost/year
Nutrient Removal Wetland	40%	10,856	88	$162,290.10
Nutrient Management	100%	26,249	55	$(892,481.51)
Cover Crops	0%	0	0	$ -
Conservation Tillage	100%	26,249	385	$(24,936.98)
Riparian Buffers	100%	2,625	36	$ 36,644.24
		Totals	**566**	$(718,484.15)

Table 17. Balanced implementation scenario for achieving phosphorus reduction goal in Big Spirit Lake

BMP	% Adoption on suitable acres	Acres treated	Reduction (kg P/yr)	Cost/year
Nutrient Removal Wetland	35%	9,499	77	$142,003.84
Nutrient Management	85%	22,312	48	$(758,609.28)
Cover Crops	42%	11,025	76	$358,305.08
Conservation Tillage	85%	22,312	330	$(21,196.44)
Riparian Buffers	95%	2,494	34	$34,812.03
		Totals	**566**	$ (244,684.77)

Shoreline and Streambank Restoration

Shoreline and streambank restoration actions address the source water protection issue of erosion and sedimentation in the watershed. Lake shoreline and streambank erosion contribute to sediment loading and associated phosphorus loading in the watershed. Lake shorelines can often be heavily managed for recreation by eliminating natural vegetation and mowing to the water surface. Similarly, row crop agriculture can also occur in riparian areas, limiting the ability of natural buffers to reduce flow and pollutant loading. Channelization of existing stream and ditch systems also contributes to poor water quality and aquatic habitat.

Priorities for streambank and lake shoreline restoration were identified by the SWP Team and include:

- Restoration of straightened segments in Judicial Ditch 35 and Judicial Ditch 8
- Big Spirit Lake

Several BMPs can be used to restore shoreline and streambanks impacted by erosion and reduce sediment loading to waterways:

- **Native emergent plants** like bulrushes, arrowhead plant, and sedges help tie down loose sediments on the lake bottoms near the shore where most stirring and re-suspension of sediment takes place. Nutrients (phosphorus and nitrogen) can be released from the sediments to the lake water column, further fueling algal growth. The re-establishment of these plants in place of invasive and nuisance plants along the lake shoreline can address shoreline erosion.

- **Engineering controls** include armoring with materials that straighten the banks and deflection of streams with rock or log structures. Example practices include stone toes and stream barbs.

- **Vegetative stabilization** and **restoration of riparian areas** can reduce peak flows from runoff areas and channel velocities directing runoff. Using vegetative controls also enhances infiltration, which reduces high flows that cause erosion. Riparian buffers are composed of vegetation that is tolerant of intermittent flooding and/or saturated soils located in the transitional zone between upland and aquatic habitats (NRCS 2003). Riparian buffers that include perennial vegetation and trees can filter runoff from adjacent cropland, provide shade and habitat for wildlife, and reinforce streambanks to minimize erosion. The root structure of the vegetation used enhances infiltration of runoff and subsequent trapping of pollutants. They are only effective in this manner, however, when the runoff enters the BMP as a slow moving, shallow “sheet”; concentrated flow in a ditch or gully, will quickly pass through the vegetation offering minimal opportunity for retention and uptake of pollutants. Similarly, tile lines can

often allow water to bypass a buffer or filter strip, thus reducing its effectiveness. In the Minnesota portion of the watershed, a statewide buffer law has been passed that requires streams and ditches to have a buffer (see Programmatic and Regulatory Actions below).

On-Site Wastewater Actions

Several on-site wastewater actions can be used to address the source water issue of failing septic systems and private wastewater systems. The most cost-effective method of managing loads from septic systems is regular maintenance. U.S. EPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household (U.S. EPA 2002). When not maintained properly, septic systems can cause the release of pathogens, as well as excess nutrients, into surface water. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would help identify those systems that are currently connected to tile drain systems or storm sewers and those that may be failing. Inspections would also help determine if systems discharge directly to a waterbody ("straight pipe"). Point of sale inspections, or inspections when a property is sold and purchased, can improve the baseline understanding of septic conditions and decrease occurrences of leaks potentially contributing to fecal loading in the watershed. These may include a soil boring to determine if the soil has adequate separation, and an examination of the inside of the tank after it has been pumped. Point of sale inspections are currently required throughout the state of Minnesota.

Education is a crucial component of reducing pollution from septic systems. Education can occur through public meetings, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

Reductions in both phosphorus and bacteria loading resulting from upgrading or replacing failing systems and improved operation and maintenance of all systems in the watershed depends on the wastewater characteristics and the level of failure present in the watershed. Upgrading or replacing failing systems will result in 100 percent reduction in bacteria loading from that system. Cluster systems, or small systems for two or more residential houses, are a potential upgrade option for residents located near surface waters. Residents around Loon Lake, for example, have begun planning for a cluster system for their neighborhood.

Programmatic and Regulatory Actions

Programmatic and regulatory actions can address the following source water protection issues: interstate coordination, and nutrient loading to Big Spirit Lake. Non-structural actions such as programmatic and regulatory actions provide formalized approaches to watershed-wide management and can provide the regulatory support behind other recommended actions.

Watershed Management Authorities

In 2010, Iowa lawmakers passed legislation authorizing the creation of Watershed Management Authorities. A Watershed Management Authority (WMA) is a mechanism for cities, counties, SWCDs, and stakeholders to cooperatively engage in watershed planning and management.

WMAs have been formed across Iowa for a variety of reasons. While the driving motivation for WMA formation may be water quality improvement and/or flood risk reduction, there are multiple benefits to cooperating with other jurisdictions within a watershed:

- Conduct planning on a watershed scale, which has greater benefits for water quality improvement and flood risk reduction
- Foster multi-jurisdictional partnership and cooperation
- Leveraging resources such as funding, technical expertise
- Facilitate stakeholder involvement in watershed management

Ordinance Development

Ordinance development and improvement can be used to prevent untreated runoff from developing areas. The City of Spirit Lake has existing ordinances and codes on erosion and sediment control however additions can be included to further prevent source water contamination. Such components include:

- Stormwater quality treatment requirements
- Stronger new development ordinances (low impact development, wetland filling, etc.)
- Provisions that encourage green infrastructure as a method of meeting runoff, volume control and stormwater detention requirements

Iowa stormwater education partnership has several model and existing city ordinances on their website (http://www.iowastormwater.org/en/resources/communities/ordinances/). Ordinance changes and improvements will be most effective in developed and areas with development pressures.

Minnesota Buffer Program

The Minnesota Buffer Law sets statewide requirements for buffers. Compliance with this law is required in the Minnesota portion of the Spirit Lake watershed but similar principles could be implemented in the Iowa portion of the watershed. The Minnesota Buffer Law requires the following:

- For all public waters, the more restrictive of:
    - A 50-foot average width, 30-foot minimum width, continuous buffer of perennially rooted vegetation, or
    - The state shoreland standards and criteria
- For public drainage systems established under M.S. Ch. 103E, a 16.5-foot minimum width continuous buffer

Alternative practices are allowed in place of a perennial buffer in some cases. Amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allow landowners to be granted a compliance waiver until July 1, 2018, when they have filed a compliance plan with the SWCD.

Watershed-Wide Education and Outreach Program

Successful implementation of the action plan will rely heavily on effective public education and outreach activities that will encourage participation and change behaviors. An education and outreach program

can address all source water protection issues in the watershed. This section presents recommendations related to developing and implementing a coordinated watershed-wide public education and outreach program.

It is imperative to raise stakeholders' awareness about issues in the watershed and develop strategies to change stakeholders' behavior in a manner that will promote voluntary participation. Changes in awareness and behavior are surrogate indicators for longer-term changes in water quality. For example, strong public education and involvement in water quality improvement actives may encourage local governments and businesses to implement BMPs to meet the desires of citizens. Fortunately, several organizations within the watershed are already conducting education and outreach on important water quality issues. While there exist multiple regional education and outreach efforts, implementation of the source water protection plan may provide the opportunity for these entities to work together to ensure a consistent and overarching marketing campaign across the watershed.

A stakeholder survey could be an initial activity related to a watershed-wide education and outreach campaign. This type of survey (e.g., a pre-campaign survey) will help to establish a baseline of public awareness and behaviors that will help watershed outreach campaign organizers to further develop tailored outreach messages. A variety of activities can be undertaken in order to reach the various stakeholders and should address each audience appropriately. The outreach and education campaign can include newspaper articles, social media campaigns, newsletters, radio spots, website content, workshops, demonstration projects and tours. Key topics for education and outreach could include:

- General watershed management principles
- Watershed friendly riparian uses and activities
- The importance of native emergent plants to stabilize lake shorelines
- Agricultural BMP demonstration field days (e.g., cover crops, conservation tillage)
- Aquatic invasive species (i.e. zebra mussels)
- Septic system maintenance and compliance
- Feedlot and livestock management
- Municipal operations
- Funding and technical assistance opportunities

Adaptive Management

In addition to continued monitoring for water quality improvements, the SWP Team may wish to use an adaptive management framework for implementing the action plan. Adaptive management is a commonly used strategy to address natural resource management that involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system. USEPA (2008) recognizes that the processes involved in watershed assessment, planning, and management are iterative.

As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process, depicted in Figure 16, enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to

better guarantee desirable results. In this way, understanding of the resource can be enhanced over time, and management can be improved.

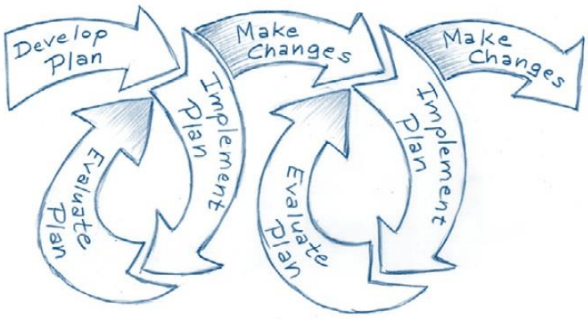

Figure 16. Adaptive management iterative process (USEPA 2008).

Evaluation for adaptive management can include a variety of evaluation components to gain a comprehensive understanding of implementation progress. An implementation evaluation determines if practices and activities have been implemented according to schedule. An evaluation can also be developed that focuses on changes to behaviors and water quality as a result of implementation actions. This type of evaluation looks at changes in stakeholder behavior and awareness, BMP performance, and changes to ambient water quality. Results from these evaluations should inform any changes or adaptations to the action plan. For example, if after engaging with local producers, one of the recommended BMPs is determined to be unfeasible for the vast majority of the watershed, implementers of the plan should revisit and re-evaluate potential BMPs for the area.

Technical and Financial Assistance

Implementing the required actions for this source water protection plan will require financial and technical support from a variety of sources. Table 18 summarizes the available funding sources. . In addition to these resources, the staff from local organizations such as Dickinson County Clean Water Alliance (http://cleanwateralliance.net/category/dickinson-swcd/), Practical Farmers of Iowa (http://www.practicalfarmers.org/), Iowa Stormwater Education Partnership (http://www.iowastormwater.org/), Pheasants Forever (http://iowapf.net/), Ducks Unlimited and the local NRCS office can provide assistance with finding funding opportunities and grants.

Table 18. Available funding sources for Action Plan implementation

Funding Program	Type of Funding	Entity	Information	More information
Regional Conservation Partnership Program	Cost share	NCRS	RCPP provides funds for producers to install and maintain conservation activities. The program is not a grant program but partners can leverage RCPP funding in their programs.	https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/farmbill/rcpp/?cid=nrcseprd1308280
Environmental Quality Incentive Program (EQIP)	Cost share	NRCS	Farmers in livestock, agricultural, or forest production who utilize NRCS approved conservation practices are eligible for cost share up to 75% of project cost. Contracts are typically 3+ years.	https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/
Environmental Education Grants Program	Grant	US EPA	Environmental education programs that promote environmental awareness and stewardship and help provide people with the skills to take responsible actions to protect the environment. This program is currently waiting on the Fiscal Year 2018 budget before issuing a request for proposals. Local, state, non-profit, noncommercial, tribal and college/university programs are eligible.	https://www.epa.gov/education/environmental-education-ee-grants
Healthy Watersheds Consortium Grant	Grant	EPA, NRCS and U.S. Endowment for Forestry and Communities	"Healthy watershed" program development projects that aim to preserve and protect natural areas, or local demonstration/trainings Conservation easements are not eligible Grants awarded are generally within three categories: 1. Short term funding to leverage larger financing for targeted watershed protection 2. Funds to help build the capacity of local organizations for sustainable, long term watershed protection 3. New replicable techniques or approaches that advance the state of practice for watershed protection.	https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/forests/
Cost share programs	cost	IDALS and local SWCD	Cost share dollars are available for temporary and permanent practices including conservation tillage, grass strips, terracing, windbreaks, tree planting, buffers, grass waterways, and diversions.	http://www.iowaagriculture.gov/FieldServices/financialAssistance.asp
Watershed protection program	Technical services and grants	IDALS	IDALS Regional Coordinators provide technical assistance and training on watershed development, planning and implementation to soil and water conservation districts and others. Grants are available to assist with watershed planning efforts that address identified environmental issues in a specific watershed.	http://www.iowaagriculture.gov/waterResources/watershedProtection.asp
Conservation Reserve		USDA Farm Service Agency	CREP is a major state/federal initiative to develop wetlands. Financial incentives are provided to private landowners to develop and restore wetlands that intercept tile drainage from agricultural	http://www.iowaagriculture.gov/waterResources/CREP.asp

Funding Program	Type of Funding	Entity	Information	More information
Enhancement Program (CREP)		and local SWCDs	watersheds. Landowners receive annual land payments for up to 15 years and reimbursement for costs of wetland and buffer establishment. Easements to maintain the wetlands and buffers are required for a minimum of 30 years with permanent easements offered as well.	
Conservation Reserve Program (CRP)	Cost share	USDA Farm Service Agency	Farmers in the program are paid a yearly rental payment for the environmentally sensitive areas they remove from agricultural production. Contracts range for 10-15 years or in perpetuity. Goals of the program are to reestablish land cover to improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.	http://www.iowadnr.gov/Conservation/Wildlife-Landowner-Assistance/Conservation-Reserve-Program
Resource Enhancement and Protection Program (REAP)	Cost share	IDNR, IDALS and others	Funded through the state's Environment First Fund and from sales of natural resource license plates.	http://www.iowadnr.gov/Conservation/REAP
Section 319 Nonpoint Source	Grant	US EPA/ IDALS	Projects are designed to reduce pollutants from nonpoint sources, typically row crop agriculture. Priority given to projects that implement cost-effective corrective and preventative BMPs on a watershed scale. Also available for BMPs on a non-watershed scale and the development of information/education nonpoint source pollution control programs. Projects that meet requirements of a NPDES permit are not eligible for 319 funding	http://www.iowaagriculture.gov/FieldServices/waterQualityLoanFund.asp
Mississippi River Basin Initiative funds.	Cost share	NRCS	MRBI offers agricultural producers in priority watersheds the opportunity for voluntary technical and financial assistance through the NRCS. A maximum score is given to applications that support the development of a Conservation Activity Plan (CAP).	https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/programs/landscape/?cid=nrcs142p2_007958
Iowa Water Quality Loan Fund (State Revolving Loan Fund)	Loan	US EPA/ IDALS	Available to assist and encourage landowners to address non-point source pollution. Applications are accepted year round for projects such as: terraces, grade stabilization structures, WASCOBs, grassed waterways and filter strips, Filed borders and buffers, waste storage facilities, and manure control structures.	http://www.iowaagriculture.gov/FieldServices/waterQualityLoanFund.asp
Drinking Water State Revolving Fund (SRF)	Low interest loan	Iowa DNR, Minnesota Department of Health	State Revolving Fund loans usually fund changes that are related to upgrades to infrastructure or new wells. However, there are also funds available for soil erosion control practices, land easements, manure management, etc.	http://www.iowasrf.com/program/drinking_water_loan_program/ http://www.health.state.mn.us/divs/eh/water/dwrf/
Iowa Water and Sewer Fund	Grant	Iowa Economic Development	Annual competitive program to assist cities and counties with sanitary sewer, water, wastewater, stormwater, and rural water systems. Funding request limits are determined by community population. Projects must benefit primarily moderate and low income persons.	https://www.iowaeconomicdevelopment.com/CDBG

Funding Program	Type of Funding	Entity	Information	More information
Minnesota Conservation Reserve Enhancement Program	Grant	Board of Water and Soil Resources	An offshoot of the CRP program that encourages implementation of buffer strips, wetland restoration, and wellhead protection areas.	http://www.bwsr.state.mn.us/crep/
Minnesota Clean Water Funds	Grant	Board of Water and Soil Resources	Part of Minnesota's Constitution, the program aims to protect drinking water sources, protect, enhance, and restore wetlands, prairies, forests, and wild life habitat, preserve arts and cultural heritage, support parks and trails, and protect, enhance, and restore lakes, rivers, streams, and groundwater.	http://www.bwsr.state.mn.us/cleanwaterfund/
Conservation Partners Legacy Grant Program	Grant	MN DNR	Habitat focused project implementation. Eligible activities include: enhancement, restoration, or protection of forests, wetlands, prairies, and habitat for fish, game, or wildlife in Minnesota. Requires a 10% match.	http://www.dnr.state.mn.us/grants/habitat/cpl/index.html
AGRI Livestock Investment Grant	Grant	Minnesota Department of Agriculture (MDA)	Minnesota livestock farmers that are (1) In good standing with the state of Minnesota, (2) Are current Minnesota residents or entity authorized to farm in Minnesota and, (3) Principle operator of the farm, are eligible. Funds can support the purchase, construction, or improvement of buildings or facilities for livestock, and fencing, feeding, and waste management.	http://www.mda.state.mn.us/grants/grants/livestockinvestment.aspx
AGRI Sustainable Agricultural Demonstration Grants	Grant	MDA	Grant provided to support innovative on-farm research and demonstrations. Eligible projects explore sustainable agricultural practices/systems. Findings will be published in the MDA's annual Greenbook. Farmers, non-profits, and educational programs are eligible to apply.	http://www.mda.state.mn.us/grants/grants/demogrant.aspx
Dairy Business Planning Grants	Grant	MDA	Cover 50 percent of cost to develop a dairy business plan. Grant encourages modernization of dairy operations in the state.	http://www.mda.state.mn.us/grants/grants/dbgrant.aspx
MAWQCP Financial Assistance	Grant	MDA	Grant designed to assist the Minnesota Agricultural Certification Program (MAWQCP). MAWQCP works to accelerate the adoption of on-farm practices that protect Minnesota's waters. Applicants must already be certified or actively seeking certification in the program.	http://www.mda.state.mn.us/protecting/waterprotection/awqcprogram/mawqcpgrant.aspx
Dairy Profitability and Enhancement Teams	Technical assistance	MDA	Result of a Minnesota state law that seeks to "expand the one-on-one educational delivery team system to provide appropriate technologies…applicable to small and medium sized dairy farms to enhance the financial success and long-term sustainability of dairy farms" (Minnesota Laws 1997, Ch. 216 Section 7.4).	http://www.mda.state.mn.us/grants/grants/diagnostics.aspx

Step 6 - Emergency Response Plan

Every approved Source Water Protection Plan (SWPP) and every community water supply serving over 3,300 people must have an Emergency Response Plan. Many systems may have generated such a document in response to the 2002 Bioterrorism Act, in which case the DNR accepts an affidavit in lieu of generating a duplicate Emergency Response Plan, Appendix F contains the affidavit attesting to its existence.

At a minimum, the Emergency Response Plan must include contact information for the following entities:

- City personnel including mayors, city clerks, and water or wastewater operators
- Industry professionals including the city's power company, a professional electrician, a professional plumber, and an equipment repair company
- Critical users including hospitals, nursing homes schools, etc.
- Local media including newspapers, radio, and television stations
- Emergency partners including certified laboratories, local emergency contacts, state and local health departments, the National Guard, DNR's 24-hour emergency contact, and the local DNR field office

Additionally, the Emergency Response Plan must include a procedure for immediate notification to identified critical users.

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Appendix A – Source Water Protection Team Meetings

Three source water protection team meetings were held during the development of the Source Water Protection Plan. Meeting dates were: November 3, 2017, December 14, 2017, and January 19, 2018. Meeting agendas are provided on the following pages.

Spirit Lake Waterworks

Source Water Protection Team Meeting

Friday, November 3, 2017 and December 14, 2017
10am
USDA Service Center, Spirit Lake

Agenda

1. Introduction (All)
2. Project purpose and role of the team (Iowa DNR)
3. Source Water Protection Planning Part 1 (Tetra Tech)
4. Small group breakout – issues and challenges and potential contaminant sources (All)
5. Source Water Protection Planning Part 2 (Tetra Tech)
6. Small group breakout – opportunities for protection and improvement (All)
7. Next steps (Iowa DNR/Tetra Tech)

Project Purpose

Provide technical assistance and support to the state of Iowa in providing needed technical assistance for communities to begin implementing Source Water Protection plans, which includes assistance in identifying resources for implementation of the Plan and coordinating partners. Specific source water protection activities will be different according to the communities and watersheds selected, but will always include nutrient reduction efforts utilizing Iowa's Nutrient Reduction Strategy, along with other potential efforts such as emergency response protocols for hazardous spills, and mitigation and understanding of harmful algal bloom outbreaks in lakes.

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Spirit Lake Waterworks

Source Water Protection Team Meeting

Friday, January 19, 2018
10 am
Waitt Water Quality Lab, Iowa Lakeside Laboratory

Agenda

1. Introductions
2. Update on Progress to Date
3. Review Steps 1-4 of Plan
4. Step 5 – Action Plan
    a. Recommended actions
    b. Schedule
    c. Responsible entities
5. Agricultural Best Management Practices
6. Review Process
    a. Additional input needed by January 26
    b. Updated plan by early February for final review

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Appendix B – List of Common Potential Contaminants

Agricultural
Row crop acreage
Agricultural drainage wells
Animal burial areas
Animal feedlots
Animal research facilities
Chemical storage areas
Chemical application (e.g., pesticides, fungicides, and fertilizers)
Grain storage
Irrigation
Manure spreading and pits
Tank loading and rinsing areas

Commercial
Agricultural chemical dealers
Airports
Auto: repair, machinery, service shops
Boat yards / marinas
Car washes
Cemeteries / funeral services
Construction areas
Dry-cleaning establishments
Educational institutions (e.g. labs, lawns, and chemical storage)
Fuel pipelines
Gas stations
Golf courses (chemical applications and storage)
Grain storage
Degreasing operations
Hardware stores
Jewelry and metal plating
Junk yards
Laundromats
Lumber yards
Material transport (trucks and railroads)
Medical facilities
Paint shops
Photography establishments
Printing / copy shops
Railroad tracks and maintenance yards
Stormwater drains and retention basins
Road maintenance depots
Storage tanks and pipes (above and below ground)

Industrial
Asphalt plants
Chemical manufacturing, warehousing, and distribution activities
Construction activities
Degreasing operations
Electrical and electronic products and manufacturing
Electroplating and metal fabrication
Foundries
Former manufactured gas plants
Lagoons, pits, holding ponds
Machine and metalworking shops
Manufacturing and distribution sites for cleaning supplies
Mining (surface and underground), mine drainage, and waste piles
Petroleum products production, storage and distribution centers
Pipelines (e.g. oil, gas, coal, and slurry)
Radioactive materials production, distribution, and storage
Storage tanks (above and below ground)
Toxic and hazardous spills
Wells, operating and abandoned (e.g. oil, gas, water, injection, monitoring, exploration)
Wood preserving facilities

Residential
Cesspools
Fuel storage sites
Furniture and wood strippers and refinishers
Hazardous products (cleaners, paint, oil)
Lawns (chemical applications)
Septic systems
Sewer lines
Stormwater drains and retention basins
Swimming pools (e.g. chlorine)
Water softeners
Waste Management
Fire training facilities
Hazardous waste management units (e.g., landfills, land treatment areas, surface impoundments, waste piles, incinerators, treatment tanks)
Leaky sewers
Municipal incinerators
Municipal landfills
Municipal wastewater and sewer lines
Open burning sites
Recycling and waste-reduction facilities

Modified from US-EPA 1989, Wellhead Protection Programs: Tools for Local Governments. EPA 440/6-89-002

Appendix C – Groundwater Well Information and Location

Table 19. Summary of private and agency-owned wells in Big Spirit Lake watershed. Location numbers align with GIS map layer provided separately.

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
55230	1	IGS well database	216	2/1/2000	Bedrock depth: 0; Well type: Livestock, Private
21793	2	IGS well database	196	6/1/1969	Bedrock depth: 0; Well type: Private
75240	3	IGS well database	0	7/23/2012	Bedrock depth: 0; Well type: Unknown
17382	4	IGS well database	125	1/1/1965	Bedrock depth: 0; Well type: Private
75239	5	IGS well database	0	7/24/2012	Bedrock depth: 0; Well type: Unknown
75279	6	IGS well database	0	11/8/2011	Bedrock depth: 0; Well type: Unknown
75241	7	IGS well database	0	7/24/2012	Bedrock depth: 0; Well type: Unknown
41597	8	IGS well database	430	10/7/1996	Bedrock depth: 408; Well type: Private
75269	9	IGS well database	0	11/4/2011	Bedrock depth: 0; Well type: Unknown
15458	10	IGS well database	366	1/1/1962	Bedrock depth: 350; Well type: Unknown
42119	11	IGS well database	227	5/23/1996	Bedrock depth: 0; Well type: Private
35924	12	IGS well database	228	7/19/1994	Bedrock depth: 0; Well type: Private
17402	13	IGS well database	72	1/4/1965	Bedrock depth: 0; Well type: Private
160	14	IGS well database	227	1/1/1934	Bedrock depth: 0; Well type: Public Supply
42580	15	IGS well database	25	unkn	Bedrock depth: 0; Well type: Municipal
42581	16	IGS well database	0	unkn	Bedrock depth: 0; Well type: Municipal
42579	17	IGS well database	0	unkn	Bedrock depth: 0; Well type: Municipal
35922	18	IGS well database	120	7/8/1994	Bedrock depth: 0; Well type: Private
29129	19	IGS well database	320	6/29/1985	Bedrock depth: 305; Well type: Private
32467	20	IGS well database	315	7/17/1991	Bedrock depth: 0; Well type: Private
48364	21	IGS well database	79	11/28/1998	Bedrock depth: 0; Well type: Livestock, Private
27471	22	IGS well database	80	6/16/1982	Bedrock depth: 0; Well type: Private
30317	23	IGS well database	428	8/19/1988	Bedrock depth: 161; Well type: Private
38501	24	IGS well database	420	5/21/1996	Bedrock depth: 192; Well type: Public Supply
46170	25	IGS well database	420	5/21/1996	Bedrock depth: 0; Well type: Public Supply
46171	26	IGS well database	50	unkn	Bedrock depth: 0; Well type: Public Supply
36948	27	IGS well database	35	unkn	Bedrock depth: 0; Well type: Public Supply
37139	28	IGS well database	22	11/1/1986	Bedrock depth: 0; Well type: Irrigation
24721	29	IGS well database	500	4/16/1977	Bedrock depth: 435; Well type: Private
46105	30	IGS well database	430	1/1/1989	Bedrock depth: 0; Well type: Public Supply
2118502	31	Private well tracking system	65	1/1/1966	Status: Active
2100171	32	Private well tracking system	100	1/1/1940	Rotary Drill Status: Plugged
2098473	33	Private well tracking system	unkn	unkn	Status: Retired
2158886	34	Private well tracking system	unkn	unkn	Status: Permitted

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
2090180	35	Private well tracking system	299	1/1/1979	Rotary Drill Status: Active
2128912	36	Private well tracking system	unkn	unkn	Status: Permitted
2116628	37	Private well tracking system	33	1/1/1960	Status: Plugged
2167063	38	Private well tracking system	35	1/1/1920	Hand Dug Status: Inactive
2167066	39	Private well tracking system	93	1/1/1940	Driven - Sand Point 2" or less Status: Inactive
2156771	40	Private well tracking system	unkn	unkn	Status: Permitted
2157114	41	Private well tracking system	unkn	unkn	Status: Permitted
2145355	42	Private well tracking system	unkn	unkn	Status: Permitted
2157437	43	Private well tracking system	24	1/1/1950	Auger, Bored or Bucket Status: Inactive
2075745	44	Private well tracking system	100	1/1/1960	Auger, Bored or Bucket Status: Active
2076392	45	Private well tracking system	unkn	unkn	Status: Retired
2100163	46	Private well tracking system	177	1/1/1975	Rotary Drill Status: Active
2187005	47	Private well tracking system	39	1/1/1950	Status: Inactive
2096733	48	Private well tracking system	43	1/1/1958	Auger, Bored or Bucket Status: Active
2162092	49	Private well tracking system	2	1/1/1960	Auger, Bored or Bucket Status: Inactive
2130988	50	Private well tracking system	54	1/1/1950	Status: Plugged
2155194	51	Private well tracking system	unkn	1/1/1970	Rotary Drill Status: Active
2080417	52	Private well tracking system	30	1/1/1964	Status: Active
2148341	53	Private well tracking system	15	1/1/1970	Auger, Bored or Bucket Status: Inactive
2091713	54	Private well tracking system	36	1/1/2003	Auger, Bored or Bucket Status: Plugged
2094667	55	Private well tracking system	26	1/1/1983	Auger, Bored or Bucket Status: Plugged
2172443	56	Private well tracking system	unkn	unkn	Status: Permitted
2086493	57	Private well tracking system	32	1/1/1987	Rotary Drill Status: Active
2104817	58	Private well tracking system	28	1/1/1978	Status: Active
2124792	59	Private well tracking system	30	1/1/1960	Status: Plugged
2131093	60	Private well tracking system	30	1/1/1970	Status: Plugged

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
2172271	61	Private well tracking system	388	1/1/1980	Rotary Drill Status: Inactive
2086440	62	Private well tracking system	388	1/1/1980	Rotary Drill Status: Active
2137744	63	Private well tracking system	5	1/1/1950	Rotary Drill Status: Inactive
2131092	64	Private well tracking system	27	1/1/1960	Status: Plugged
2171250	65	Private well tracking system	26	1/1/1980	Auger, Bored or Bucket Status: Inactive
2116246	66	Private well tracking system	53	1/1/1950	Status: Plugged
2177516	67	Private well tracking system	48	1/1/1960	Auger, Bored or Bucket Status: Inactive
2111959	68	Private well tracking system	48	1/1/1960	Status: Plugged
2080379	69	Private well tracking system	22	1/1/1940	Hand Dug Status: Plugged
2110989	70	Private well tracking system	54	1/1/1970	Status: Plugged
2146430	71	Private well tracking system	46	1/1/1960	Auger, Bored or Bucket Status: Inactive
2161664	72	Private well tracking system	unkn	unkn	Status: Permitted
2174819	73	Private well tracking system	unkn	unkn	Status: Permitted
2138128	74	Private well tracking system	unkn	unkn	Status: Permitted
2111957	75	Private well tracking system	21	1/1/1945	Status: Plugged
2091704	76	Private well tracking system	48	1/1/1970	Auger, Bored or Bucket Status: Plugged
2111980	77	Private well tracking system	32	1/1/1960	Status: Plugged
2116280	78	Private well tracking system	19	1/1/1960	Status: Plugged
2105403	79	Private well tracking system	62	1/1/1950	Status: Plugged
2122267	80	Private well tracking system	40	1/1/1960	Status: Plugged
2154629	81	Private well tracking system	25	1/1/1970	Auger, Bored or Bucket Status: Inactive
2103795	82	Private well tracking system	unkn	unkn	Status: Retired
2156089	83	Private well tracking system	unkn	unkn	Status: Permitted
2084172	84	Private well tracking system	72	1/1/1961	Auger, Bored or Bucket Status: Plugged
2133162	85	Private well tracking system	75	1/1/1970	Auger, Bored or Bucket Status: Inactive
2177249	86	Private well tracking system	310	1/1/1988	Cable Tool Drill -Driven Status: Inactive

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
2093534	87	Private well tracking system	62	1/1/1960	Auger, Bored or Bucket Status: Plugged
2086434	88	Private well tracking system	60	1/1/1968	Auger, Bored or Bucket Status: Plugged
2083178	89	Private well tracking system	482	6/1/1960	Rotary Drill Status: Plugged
2172269	90	Private well tracking system	37	1/1/1950	Auger, Bored or Bucket Status: Inactive
2160216	91	Private well tracking system	unkn	unkn	Status: Permitted
2082727	92	Private well tracking system	30	1/1/1960	Auger, Bored or Bucket Status: Plugged
2161651	93	Private well tracking system	unkn	unkn	Status: Permitted
2079343	94	Private well tracking system	60	1/1/1970	Rotary Drill Status: Active
2172272	95	Private well tracking system	100	1/1/1960	Rotary Drill Status: Active
2100510	96	Private well tracking system	unkn	unkn	Status: Retired
2004391	97	Private well tracking system	82	11/28/1998	Status: Active
2082725	98	Private well tracking system	15	6/1/2001	Driven - Sand Point 2" or less Status: Active
2075681	99	Private well tracking system	240	1/1/1980	Rotary Drill Status: Active
2078834	100	Private well tracking system	25	5/1/1992	Hand Dug Status: Active
2080392	101	Private well tracking system	15	1/1/1950	Driven - Sand Point 2" or less Status: Active
2152638	102	Private well tracking system	42	1/1/1970	Auger, Bored or Bucket Status: Inactive
2118444	103	Private well tracking system	400	4/1/1982	Status: Active
2144094	104	Private well tracking system	25	1/1/1984	Rotary Drill Status: Inactive
2140695	105	Private well tracking system	35	1/1/1940	Rotary Drill Status: Active
2118443	106	Private well tracking system	400	4/1/1982	Rotary Drill Status: Active
2143205	107	Private well tracking system	123	1/1/1950	Rotary Drill Status: Inactive
2180855	108	Private well tracking system	50	1/1/1960	Status: Inactive
2185240	109	Private well tracking system	25	1/1/1950	Status: Active
2172267	110	Private well tracking system	80	1/1/1950	Rotary Drill Status: Inactive
2151072	111	Private well tracking system	77	1/1/1950	Auger, Bored or Bucket Status: Inactive
2075609	112	Private well tracking system	52	1/1/1960	Hand Dug Status: Plugged

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
2175173	113	Private well tracking system	15	1/1/1950	Status: Active
2157983	114	Private well tracking system	70	1/1/1970	Rotary Drill Status: Active
26401	115	Permitted private wells	200	1/27/2000	Primary use: household
12171	116	Permitted private wells	180	8/12/1991	Primary use: Livestock/Agricultural
12192	117	Permitted private wells	unkn	5/10/1993	Primary use: Domestic/household
12203	118	Permitted private wells	8	5/24/1989	Primary use: Irrigation
12235	119	Permitted private wells	208	5/15/1990	Primary use: Domestic/household
12183	120	Permitted private wells	270	7/6/1992	Primary use: Irrigation
17168	121	Permitted private wells	230	7/11/1994	Primary use: Domestic/household
12240	122	Permitted private wells	140	5/17/1990	Primary use: Domestic/household
18591	123	Permitted private wells	250	unkn	Primary use: Public water supply
12197	124	Permitted private wells	25	10/5/1990	Primary use: Domestic/household
12249	125	Permitted private wells	130	8/9/1993	Primary use: Domestic/household
640	126	Permitted private wells	185	unkn	Primary use: Domestic/household
12209	127	Permitted private wells	185	1/30/1989	Primary use: Domestic/household
22136	128	Permitted private wells	unkn	unkn	Primary use: household
12179	129	Permitted private wells	28	3/6/1990	Primary use: Domestic/household
17166	130	Permitted private wells	unkn	unkn	Primary use: Domestic/household
12186	131	Permitted private wells	30	7/26/1988	Primary use: Domestic/household
12187	132	Permitted private wells	30	7/26/1988	Primary use: Domestic/household
48	133	Permitted private wells	30	unkn	Primary use: Domestic/household
47	134	Permitted private wells	30	unkn	Primary use: Domestic/household
24497	135	Permitted private wells	100	4/1/1999	Primary use: household
20374	136	Permitted private wells	18	10/4/1996	Primary use: household
12212	137	Permitted private wells	18	4/3/1989	Primary use: Domestic/household
12231	138	Permitted private wells	18	5/9/1990	Primary use: Domestic/household

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
643	139	Permitted private wells	18	unkn	Primary use: Domestic/household
12221	140	Permitted private wells	10	3/19/1991	Primary use:
12219	141	Permitted private wells	11	3/19/1991	Primary use: Domestic/household
12173	142	Permitted private wells	15	6/10/1991	Primary use: Domestic/household
12174	143	Permitted private wells	10	6/21/1991	Primary use: Domestic/household
12150	144	Permitted private wells	10	6/22/1992	Primary use: Domestic/household
12220	145	Permitted private wells	10	3/18/1991	Primary use: Domestic/household
12194	146	Permitted private wells	310	7/10/1991	Primary use: Domestic/household
12237	147	Permitted private wells	350	5/15/1990	Primary use: Domestic/household
12216	148	Permitted private wells	unkn	6/18/1990	Primary use: Domestic/household
12180	149	Permitted private wells	unkn	2/15/1990	Primary use: Recreational
12205	150	Permitted private wells	unkn	6/13/1989	Primary use: Domestic/household
23683	151	Permitted private wells	75	11/10/1998	Primary use: household
12218	152	Permitted private wells	25	3/15/1990	Primary use: Domestic/household
12184	153	Permitted private wells	375	10/20/1992	Primary use: Domestic/household
17169	154	Permitted private wells	unkn	unkn	Primary use: Domestic/household
16824	155	Permitted private wells	13	6/22/1995	Primary use: Domestic/household
12193	156	Permitted private wells	470	6/14/1993	Primary use: Domestic/household
12191	157	Permitted private wells	20	6/23/1993	Primary use: Domestic/household
12198	158	Permitted private wells	unkn	9/29/1990	Primary use: Domestic/household
36281	159	Wells registered for testing	65	unkn	Drilling method: Drilled;
34718	160	Wells registered for testing	unkn	unkn	Drilling method: Drilled; Well depth is uncertain
64108	161	Wells registered for testing	196	1969	Drilling method: Drilled; Known well depth
85505	162	Wells registered for testing	299	1979	Drilling method: Drilled; Known well depth
42470	163	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
27394	164	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
24390	165	Wells registered for testing	440	1996	Drilling method: Drilled;
6649	166	Wells registered for testing	unkn	1974	Well depth is uncertain
42427	167	Wells registered for testing	unkn	1974	Drilling method: Unknown; Well depth is uncertain
45732	168	Wells registered for testing	unkn	1974	Drilling method: Unknown; Well depth is uncertain
80769	169	Wells registered for testing	unkn	unkn	Well depth is uncertain
10151	170	Wells registered for testing	430	1993	Drilling method: Drilled; Known well depth
67566	171	Wells registered for testing	85	unkn	Drilling method: Augered; Known well depth
41995	172	Wells registered for testing	350	unkn	Drilling method: Augered; Known well depth
67565	173	Wells registered for testing	350	unkn	Drilling method: Augered; Known well depth
46792	174	Wells registered for testing	unkn	unkn	Drilling method: Bored; Well depth is uncertain
42132	175	Wells registered for testing	350	unkn	Drilling method: Augured; Known well depth
42293	176	Wells registered for testing	85	unkn	Drilling method: Augered; Known well depth
10148	177	Wells registered for testing	240	1971	Drilling method: Drilled; Known well depth
42285	178	Wells registered for testing	unkn	unkn	Drilling method: Augered; Well depth is uncertain
42140	179	Wells registered for testing	38	1960	Estimated well depth
34729	180	Wells registered for testing	43	unkn	Drilling method: Unknown; Known well depth
49122	181	Wells registered for testing	43	unkn	Drilling method: Unknown; Known well depth
73384	182	Wells registered for testing	24	unkn	Drilling method: Bored; Known well depth
42287	183	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
83813	184	Wells registered for testing	28	1965	Drilling method: Unknown; Known well depth
27397	185	Wells registered for testing	30	unkn	Drilling method: Dug; Estimated well depth
42374	186	Wells registered for testing	28	unkn	Drilling method: Bored; Estimated well depth
42582	187	Wells registered for testing	unkn	unkn	Drilling method: Bored; Well depth is uncertain
42310	188	Wells registered for testing	unkn	unkn	Drilling method: Bored; Well depth is uncertain
75522	189	Wells registered for testing	unkn	unkn	Drilling method: Drilled; Well depth is uncertain
42072	190	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
7976	191	Wells registered for testing	30	unkn	Drilling method: Dug; Estimated well depth
7975	192	Wells registered for testing	30	unkn	Drilling method: Dug; Estimated well depth
1605	193	Wells registered for testing	35	1960	Drilling method: Bored; Known well depth
76436	194	Wells registered for testing	unkn	unkn	Drilling method: Drilled; Well depth is uncertain
5143	195	Wells registered for testing	28	1974	Drilling method: Bored; Estimated well depth
21085	196	Wells registered for testing	193	1990	
42346	197	Wells registered for testing	200	1990	Drilling method: Drilled; Known well depth
42353	198	Wells registered for testing	36	1960	Drilling method: Unknown; Known well depth
10157	199	Wells registered for testing	unkn	1965	Drilling method: Bored; Well depth is uncertain
32495	200	Wells registered for testing	30	1932	
43711	201	Wells registered for testing	35	1958	Drilling method: Unknown; Estimated well depth
42632	202	Wells registered for testing	unkn	1965	Drilling method: Bored; Well depth is uncertain
42295	203	Wells registered for testing	200	1990	Drilling method: Drilled; Known well depth
24	204	Wells registered for testing	unkn	unkn	
42351	205	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
65652	206	Wells registered for testing	30	1965	Drilling method: Unknown; Known well depth
42036	207	Wells registered for testing	40	1965	Drilling method: Bored; Known well depth
54342	208	Wells registered for testing	32	1965	Drilling method: Bored; Known well depth
12933	209	Wells registered for testing	30	1965	
64109	210	Wells registered for testing	30	1965	Drilling method: Unknown; Known well depth
70268	211	Wells registered for testing	30	1960	Drilling method: Unknown; Known well depth
42334	212	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42387	213	Wells registered for testing	180	1990	Drilling method: Drilled; Known well depth
1601	214	Wells registered for testing	100	unkn	Drilling method: Drilled; Estimated well depth
42901	215	Wells registered for testing	225	1978	Drilling method: Drilled; Known well depth
42082	216	Wells registered for testing	211	1975	Drilling method: Drilled; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
85506	217	Wells registered for testing	30	1987	Drilling method: Drilled; Known well depth
11582	218	Wells registered for testing	32	1988	Drilling method: Drilled;
84778	219	Wells registered for testing	30	1987	Drilling method: Drilled; Known well depth
76798	220	Wells registered for testing	150	1986	Drilling method: Drilled; Known well depth
70930	221	Wells registered for testing	32	1987	Drilling method: Drilled; Known well depth
42900	222	Wells registered for testing	270	1992	Drilling method: Drilled; Known well depth
11190	223	Wells registered for testing	248	1994	Drilling method: Drilled; Known well depth
36279	224	Wells registered for testing	15	1963	Drilling method: Bored; Known well depth
54349	225	Wells registered for testing	30	1970	Drilling method: Drilled; Known well depth
42286	226	Wells registered for testing	15	1963	Drilling method: Bored; Estimated well depth
43726	227	Wells registered for testing	15	1963	Drilling method: Bored; Estimated well depth
42133	228	Wells registered for testing	12	1975	Drilling method: Dug; Known well depth
8631	229	Wells registered for testing	33	1992	Drilling method: Bored; Known well depth
42477	230	Wells registered for testing	14	1962	Drilling method: Augered; Known well depth
38555	231	Wells registered for testing	32	1987	Drilling method: Drilled;
31	232	Wells registered for testing	30	1964	Drilling method: Drilled; Known well depth
54350	233	Wells registered for testing	unkn	unkn	Drilling method: Augered; Well depth is uncertain
33	234	Wells registered for testing	12	1950	Drilling method: Bored; Known well depth
42120	235	Wells registered for testing	unkn	unkn	Drilling method: Augured; Well depth is uncertain
42636	236	Wells registered for testing	15	1963	Drilling method: Bored; Estimated well depth
42119	237	Wells registered for testing	30	1970	Drilling method: Drilled; Known well depth
34728	238	Wells registered for testing	30	1947	Drilling method: Dug;
34730	239	Wells registered for testing	250	1993	Drilling method: Drilled;
34731	240	Wells registered for testing	150	1955	Drilling method: Augered;
42314	241	Wells registered for testing	69	1990	Drilling method: Bored; Known well depth
11580	242	Wells registered for testing	35	1992	Drilling method: Drilled;

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
12927	243	Wells registered for testing	12	1985	Drilling method: Dug;
42367	244	Wells registered for testing	15	1963	Drilling method: Dug; Known well depth
42366	245	Wells registered for testing	30	1987	Drilling method: Bored; Known well depth
42405	246	Wells registered for testing	77	1970	Drilling method: Bored; Known well depth
50202	247	Wells registered for testing	26	1978	Drilling method: Augered; Known well depth
62577	248	Wells registered for testing	20	1950	Drilling method: Bored; Known well depth
63274	249	Wells registered for testing	unkn	unkn	Drilling method: Bored; Well depth is uncertain
63268	250	Wells registered for testing	33	1990	Drilling method: Bored; Known well depth
1849	251	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
1848	252	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
43718	253	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
42130	254	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42041	255	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
63278	256	Wells registered for testing	30	1987	Drilling method: Bored; Known well depth
42099	257	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
43717	258	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
1850	259	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
42469	260	Wells registered for testing	33	1991	Drilling method: Drilled; Known well depth
43727	261	Wells registered for testing	30	1987	Drilling method: Bored; Known well depth
85503	262	Wells registered for testing	19	1962	Drilling method: Driven; Known well depth
42381	263	Wells registered for testing	95	1913	Drilling method: Bored; Known well depth
42089	264	Wells registered for testing	12	unkn	Drilling method: Sandpoint; Estimated well depth
42088	265	Wells registered for testing	16	unkn	Drilling method: Unknown; Known well depth
42116	266	Wells registered for testing	12	1960	Drilling method: Driven; Known well depth
42090	267	Wells registered for testing	11	1960	Drilling method: Bored; Estimated well depth
12935	268	Wells registered for testing	380	1980	Drilling method: Drilled;

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
42638	269	Wells registered for testing	385	1981	Drilling method: Drilled; Known well depth
42637	270	Wells registered for testing	12	1940	Drilling method: Sandpoint; Known well depth
42379	271	Wells registered for testing	385	1981	Drilling method: Drilled; Known well depth
16664	272	Wells registered for testing	unkn	unkn	Drilling method: Driven;
17269	273	Wells registered for testing	unkn	unkn	Drilling method: Sandpoint;
16663	274	Wells registered for testing	10	unkn	Drilling method: Driven;
23	275	Wells registered for testing	220	unkn	Estimated well depth
42349	276	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42327	277	Wells registered for testing	14	unkn	Drilling method: Sandpoint; Estimated well depth
13425	278	Wells registered for testing	14	unkn	Drilling method: Sandpoint; Estimated well depth
62089	279	Wells registered for testing	9	unkn	Drilling method: Driven; Known well depth
42045	280	Wells registered for testing	12	unkn	Drilling method: Sand Point; Known well depth
17267	281	Wells registered for testing	10	unkn	Drilling method: Sandpoint;
62949	282	Wells registered for testing	35	unkn	Drilling method: Bored; Known well depth
17265	283	Wells registered for testing	unkn	unkn	
17263	284	Wells registered for testing	15	1960	Drilling method: Dug;
42080	285	Wells registered for testing	30	1960	Drilling method: Bored; Known well depth
42320	286	Wells registered for testing	30	1988	Drilling method: Augered; Known well depth
1275	287	Wells registered for testing	35	1983	Drilling method: Bored; Known well depth
42895	288	Wells registered for testing	34	1983	Drilling method: Bored; Estimated well depth
54343	289	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42079	290	Wells registered for testing	34	unkn	Drilling method: Augered; Known well depth
1274	291	Wells registered for testing	unkn	unkn	Well depth is uncertain
42376	292	Wells registered for testing	35	1983	Drilling method: Bored; Known well depth
54339	293	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
54351	294	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
42053	295	Wells registered for testing	17	unkn	Drilling method: Unknown; Estimated well depth
17260	296	Wells registered for testing	35	1980	Drilling method: Augered;
34586	297	Wells registered for testing	35	1980	Drilling method: Augered; Known well depth
42026	298	Wells registered for testing	35	1980	Drilling method: Bored; Known well depth
46793	299	Wells registered for testing	33	1980	Drilling method: Augered; Known well depth
70947	300	Wells registered for testing	33	1980	Drilling method: Augered; Known well depth
42077	301	Wells registered for testing	33	1981	Drilling method: Augered; Known well depth
42078	302	Wells registered for testing	30	1966	Drilling method: Bored; Estimated well depth
42025	303	Wells registered for testing	33	1981	Drilling method: Augered; Known well depth
65651	304	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
34720	305	Wells registered for testing	33	1981	Drilling method: Augered;
32838	306	Wells registered for testing	33	1981	Drilling method: Augered;
32506	307	Wells registered for testing	26	1973	Drilling method: Augered;
45143	308	Wells registered for testing	26	1973	Drilling method: Augered;
17266	309	Wells registered for testing	33	1980	Drilling method: Augered;
12932	310	Wells registered for testing	26	1973	Drilling method: Augered;
34713	311	Wells registered for testing	26	1973	Drilling method: Augered; Known well depth
16654	312	Wells registered for testing	33	1980	Drilling method: Augered;
58789	313	Wells registered for testing	120	1999	Drilling method: Drilled; Known well depth
17268	314	Wells registered for testing	30	1959	Drilling method: Augered;
45142	315	Wells registered for testing	unkn	unkn	Drilling method: Driven; Well depth is uncertain
42110	316	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
42433	317	Wells registered for testing	238	1981	Drilling method: Drilled; Known well depth
116	318	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
1296	319	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
7982	320	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
7981	321	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
9215	322	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
10154	323	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
42913	324	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
42394	325	Wells registered for testing	238	1981	Drilling method: Drilled; Known well depth
79	326	Wells registered for testing	32	1959	Drilling method: Bored; Known well depth
63301	327	Wells registered for testing	50	1940	Drilling method: Unknown; Known well depth
42635	328	Wells registered for testing	50	1940	Drilling method: Unknown; Known well depth
7979	329	Wells registered for testing	50	1940	Known well depth
84774	330	Wells registered for testing	60	1960	Drilling method: Unknown; Known well depth
85502	331	Wells registered for testing	250	1968	Drilling method: Drilled; Known well depth
17739	332	Wells registered for testing	250	unkn	Drilling method: Drilled;
85501	333	Wells registered for testing	250	1968	Drilling method: Drilled; Known well depth
42030	334	Wells registered for testing	65	1982	Drilling method: Drilled; Known well depth
54338	335	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42131	336	Wells registered for testing	315	1991	Drilling method: Drilled; Known well depth
42083	337	Wells registered for testing	40	unkn	Drilling method: Bored; Known well depth
42896	338	Wells registered for testing	315	1991	Drilling method: Drilled; Known well depth
60998	339	Wells registered for testing	15	unkn	Drilling method: Driven; Known well depth
42071	340	Wells registered for testing	200	1965	Drilling method: Bored; Known well depth
10153	341	Wells registered for testing	200	1960	Drilling method: Bored; Known well depth
42359	342	Wells registered for testing	300	1990	Drilling method: Drilled; Known well depth
82806	343	Wells registered for testing	60	1970	Drilling method: Drilled; Known well depth
69741	344	Wells registered for testing	60	1970	Drilling method: Drilled; Known well depth
70905	345	Wells registered for testing	60	1970	Drilling method: Drilled; Known well depth
71493	346	Wells registered for testing	60	1970	Drilling method: Drilled; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
9216	347	Wells registered for testing	67	1982	Drilling method: Bored; Known well depth
32498	348	Wells registered for testing	60	1970	Drilling method: Drilled; Estimated well depth
62091	349	Wells registered for testing	60	unkn	Drilling method: Bored; Known well depth
42301	350	Wells registered for testing	370	1990	Drilling method: Drilled; Known well depth
41994	351	Wells registered for testing	475	1990	Drilling method: Drilled; Known well depth
74387	352	Wells registered for testing	unkn	unkn	Drilling method: Dug; Well depth is uncertain
50595	353	Wells registered for testing	96	1980	Drilling method: Drilled; Known well depth
50593	354	Wells registered for testing	70	1960	Drilling method: Bored; Known well depth
42360	355	Wells registered for testing	25	1991	Drilling method: Augered; Known well depth
62141	356	Wells registered for testing	17	1993	Drilling method: Driven; Known well depth
50594	357	Wells registered for testing	270	1970	Drilling method: Drilled; Known well depth
32829	358	Wells registered for testing	45	unkn	Drilling method: Clay; Known well depth
16656	359	Wells registered for testing	unkn	unkn	
12931	360	Wells registered for testing	25	1992	Drilling method: Augered;
74386	361	Wells registered for testing	15	unkn	Drilling method: Augered; Known well depth
42409	362	Wells registered for testing	35	1950	Drilling method: Bored; Known well depth
71504	363	Wells registered for testing	25	1994	Drilling method: Augered; Known well depth
82812	364	Wells registered for testing	15	1950	Drilling method: Driven; Known well depth
42324	365	Wells registered for testing	15	unkn	Drilling method: Sandpoint; Known well depth
54341	366	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
71139	367	Wells registered for testing	14	unkn	Drilling method: Driven; Known well depth
9665	368	Wells registered for testing	15	1981	Drilling method: Sandpoint; Known well depth
45736	369	Wells registered for testing	13	1988	Drilling method: Driven; Known well depth
42479	370	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth
70899	371	Wells registered for testing	15	1990	Drilling method: Driven; Known well depth
1298	372	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
9217	373	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth
12934	374	Wells registered for testing	15	1990	Drilling method: Drive/sand;
74388	375	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
42005	376	Wells registered for testing	13	1990	Drilling method: Sandpoint; Known well depth
10146	377	Wells registered for testing	16	1981	Drilling method: Sandpoint; Known well depth
83806	378	Wells registered for testing	15	1990	Drilling method: Driven; Known well depth
71506	379	Wells registered for testing	13	1995	Drilling method: Sand Point; Known well depth
45733	380	Wells registered for testing	25	1990	Drilling method: Augered; Known well depth
84773	381	Wells registered for testing	15	2001	Drilling method: Driven; Known well depth
63315	382	Wells registered for testing	14	1991	Drilling method: Sandpoint; Known well depth
84770	383	Wells registered for testing	12	unkn	Drilling method: Driven; Known well depth
82807	384	Wells registered for testing	25	1992	Drilling method: Dug; Known well depth
63299	385	Wells registered for testing	16	1990	Drilling method: Sandpoint; Known well depth
45737	386	Wells registered for testing	45	unkn	Drilling method: Sandpoint; Known well depth
63292	387	Wells registered for testing	16	1970	Drilling method: Sandpoint; Known well depth
9657	388	Wells registered for testing	35	1950	Drilling method: Bored; Known well depth
119	389	Wells registered for testing	50	1970	Drilling method: Bored; Known well depth
42420	390	Wells registered for testing	13	1990	Drilling method: Sandpoint; Known well depth
70266	391	Wells registered for testing	45	unkn	Drilling method: Driven; Known well depth
63296	392	Wells registered for testing	13	1990	Drilling method: Sandpoint; Known well depth
16662	393	Wells registered for testing	12	unkn	Drilling method: Driven;
32489	394	Wells registered for testing	25	1991	Drilling method: Augered;
112	395	Wells registered for testing	16	1981	Drilling method: Sandpoint; Known well depth
70316	396	Wells registered for testing	15	1950	Drilling method: Driven; Known well depth
42410	397	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth
1762	398	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
63288	399	Wells registered for testing	16	1981	Drilling method: Sandpoint; Known well depth
63280	400	Wells registered for testing	14	1985	Drilling method: Sandpoint; Estimated well depth
117	401	Wells registered for testing	14	1991	Drilling method: Sandpoint; Known well depth
63258	402	Wells registered for testing	50	1970	Drilling method: Augered; Known well depth
115	403	Wells registered for testing	16	1990	Drilling method: Sandpoint; Known well depth
63257	404	Wells registered for testing	12	unkn	Drilling method: Sandpoint; Known well depth
123	405	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth
71495	406	Wells registered for testing	50	1925	Drilling method: Drilled; Known well depth
82811	407	Wells registered for testing	13	1996	Drilling method: Sandpoint; Known well depth
70317	408	Wells registered for testing	13	1970	Drilling method: Unknown; Known well depth
45741	409	Wells registered for testing	15	1980	Drilling method: Driven; Known well depth
54340	410	Wells registered for testing	16	1990	Drilling method: Sandpoint; Known well depth
42006	411	Wells registered for testing	10	unkn	Drilling method: Driven; Estimated well depth
34719	412	Wells registered for testing	15	unkn	Drilling method: Driven; Known well depth
71512	413	Wells registered for testing	15	unkn	Drilling method: Driven; Known well depth
1270	414	Wells registered for testing	10	unkn	Drilling method: Bored; Estimated well depth
42322	415	Wells registered for testing	13	1990	Drilling method: Sand Point; Known well depth
83807	416	Wells registered for testing	15	2001	Drilling method: Driven; Known well depth
9658	417	Wells registered for testing	13	1991	Drilling method: Sandpoint; Known well depth
42094	418	Wells registered for testing	15	1975	Drilling method: Drvn/sndpt; Known well depth
70265	419	Wells registered for testing	25	1992	Drilling method: Dug; Known well depth
45731	420	Wells registered for testing	15	1950	Drilling method: Driven; Known well depth
70894	421	Wells registered for testing	14	unkn	Drilling method: Driven; Known well depth
9659	422	Wells registered for testing	14	1990	Drilling method: Sandpoint; Known well depth
70261	423	Wells registered for testing	15	1990	Drilling method: Driven; Known well depth
42323	424	Wells registered for testing	13	unkn	Drilling method: Sandpoint; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
42326	425	Wells registered for testing	45	unkn	Drilling method: Dug; Known well depth
42011	426	Wells registered for testing	13	1982	Drilling method: Sandpoint; Estimated well depth
9666	427	Wells registered for testing	25	1991	Drilling method: Bored; Known well depth
122	428	Wells registered for testing	13	1990	Drilling method: Sandpoint; Known well depth
94	429	Wells registered for testing	unkn	1979	Drilling method: Sandpoint; Well depth is uncertain
1282	430	Wells registered for testing	15	1988	Drilling method: Sandpoint; Estimated well depth
32833	431	Wells registered for testing	unkn	unkn	
46789	432	Wells registered for testing	14	1955	Drilling method: Driven; Known well depth
12939	433	Wells registered for testing	15	unkn	Drilling method: Driven;
32830	434	Wells registered for testing	12	1987	Drilling method: Sandpoint; Estimated well depth
32488	435	Wells registered for testing	15	1980	Drilling method: Driven;
32503	436	Wells registered for testing	15	1980	Drilling method: Driven;
34582	437	Wells registered for testing	14	1991	Drilling method: Driven; Known well depth
46795	438	Wells registered for testing	14	1991	Drilling method: Driven; Known well depth
34585	439	Wells registered for testing	15	1980	Drilling method: Driven; Known well depth
12936	440	Wells registered for testing	15	1981	Drilling method: Driven;
16657	441	Wells registered for testing	15	1981	Drilling method: Driven;
32487	442	Wells registered for testing	15	1980	Drilling method: Driven;
32491	443	Wells registered for testing	13	1995	Drilling method: Driven;
49126	444	Wells registered for testing	70	1930	Drilling method: Bored; Known well depth
42058	445	Wells registered for testing	70	1955	Drilling method: Dug; Estimated well depth
111	446	Wells registered for testing	70	1950	Drilling method: Dug; Estimated well depth
42291	447	Wells registered for testing	70	1950	Drilling method: Dug; Estimated well depth
43716	448	Wells registered for testing	70	1950	Drilling method: Dug; Estimated well depth
71140	449	Wells registered for testing	75	unkn	Drilling method: Augered; Known well depth
49124	450	Wells registered for testing	75	unkn	Drilling method: Augered; Known well depth

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
74383	451	Wells registered for testing	75	unkn	Drilling method: Augered; Known well depth
50200	452	Wells registered for testing	75	unkn	Drilling method: Augered; Known well depth
26828	453	Wells registered for testing	75	unkn	Drilling method: Augered;
45138	454	Wells registered for testing	unkn	unkn	Drilling method: Augered;
45139	455	Wells registered for testing	35	1958	Drilling method: Augered;
42365	456	Wells registered for testing	100	1980	Drilling method: Drilled; Known well depth
1602	457	Wells registered for testing	unkn	unkn	Drilling method: Drilled; Well depth is uncertain
1604	458	Wells registered for testing	unkn	unkn	Drilling method: Drilled; Well depth is uncertain
36	459	Wells registered for testing	121	1980	Drilling method: Drilled; Known well depth
45140	460	Wells registered for testing	450	1984	Drilling method: Drilled;
74382	461	Wells registered for testing	62	unkn	Drilling method: Unknown; Known well depth
45742	462	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
46788	463	Wells registered for testing	unkn	unkn	Drilling method: Unknown; Well depth is uncertain
39341	464	Registered abandoned wells	23	n.a.	Well plugged: 12/15/1999; Well type: > 18" dia.
20012	465	Registered abandoned wells	175	n.a.	Well plugged: 9/27/1994; Well type: < 18" dia.
12343	466	Registered abandoned wells	186	n.a.	Well plugged: 9/13/1991; Well type: < 18" dia.
12342	467	Registered abandoned wells	180	n.a.	Well plugged: 9/13/1991; Well type: < 18" dia.
1703	468	Registered abandoned wells	285	n.a.	Well plugged: 7/18/1989; Well type: unkn
33539	469	Registered abandoned wells	60	n.a.	Well plugged: 8/28/1998; Well type: > 18" dia.
33540	470	Registered abandoned wells	95	n.a.	Well plugged: 8/28/1998; Well type: > 18" dia.
44374	471	Registered abandoned wells	9	n.a.	Well plugged: 9/28/2000; Well type: > 18" dia.
37903	472	Registered abandoned wells	32	n.a.	Well plugged: 8/27/1999; Well type: > 18" dia.
39337	473	Registered abandoned wells	22	n.a.	Well plugged: 6/23/1999; Well type: > 18" dia.
17982	474	Registered abandoned wells	360	n.a.	Well plugged: 2/25/1995; Well type: < 18" dia.
24199	475	Registered abandoned wells	140	n.a.	Well plugged: 4/29/1996; Well type: < 18" dia.
24200	476	Registered abandoned wells	28	n.a.	Well plugged: 4/29/1996; Well type: > 18" dia.

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
9069	477	Registered abandoned wells	40	n.a.	Well plugged: 9/25/1992; Well type: > 18" dia.
6087	478	Registered abandoned wells	45	n.a.	Well plugged: 7/6/1992; Well type: > 18" dia.
45626	479	Registered abandoned wells	30	n.a.	Well plugged: 4/17/2001; Well type: > 18" dia.
43971	480	Registered abandoned wells	45	n.a.	Well plugged: 8/17/2000; Well type: < 18" dia.
25714	481	Registered abandoned wells	72	n.a.	Well plugged: 7/24/1996; Well type: > 18" dia.
46490	482	Registered abandoned wells	83	n.a.	Well plugged: 7/12/2001; Well type: > 18" dia.
12323	483	Registered abandoned wells	58	n.a.	Well plugged: 10/17/1991; Well type: > 18" dia.
45829	484	Registered abandoned wells	32	n.a.	Well plugged: 6/7/2001; Well type: > 18" dia.
45830	485	Registered abandoned wells	9	n.a.	Well plugged: 6/4/2001; Well type: > 18" dia.
6093	486	Registered abandoned wells	175	n.a.	Well plugged: 10/28/1992; Well type: < 18" dia.
10162	487	Registered abandoned wells	50	n.a.	Well plugged: 6/16/1993; Well type: > 18" dia.
10163	488	Registered abandoned wells	450	n.a.	Well plugged: 6/16/1993; Well type: < 18" dia.
17131	489	Registered abandoned wells	65	n.a.	Well plugged: 5/8/1995; Well type: > 18" dia.
12314	490	Registered abandoned wells	36	n.a.	Well plugged: 8/21/1991; Well type: > 18" dia.
12316	491	Registered abandoned wells	40	n.a.	Well plugged: 8/21/1991; Well type: < 18" dia.
12313	492	Registered abandoned wells	73	n.a.	Well plugged: 8/14/1991; Well type: > 18" dia.
2413469	493	Public Water Supply well	334	unkn	PWSID: 3050929; Permit Status: Inactive
2410450	494	Public Water Supply well	430	5/1/1996	PWSID: 3000657; Permit Status: Inactive
2412136	495	Public Water Supply well	40	1/1/1970	PWSID: 3000657; Permit Status: Inactive
2410683	496	Public Water Supply well	35	unkn	PWSID: 3000687; Permit Status: Inactive
2407259	497	Public Water Supply well	unkn	unkn	PWSID: 3070464; Permit Status: Inactive
2411354	498	Public Water Supply well	430	5/1/1989	PWSID: 3070601; Permit Status: Acitve
00697865	499	Unknown	unkn	unkn	
00214505	500	Irrigation	87	5/1/1965	Status: Active
00172141	501	Domestic	274	7/10/1978	Status: Active
00640737	502	Domestic	183	9/19/2001	Status: Active
00136174	503	Domestic	275	9/29/1977	Status: Active
00673457	504	Domestic	128	5/1/2002	Status: Active
00165538	505	Domestic	410	7/22/1982	Status: Active

Well ID	Location #	WELL_TYPE	DEPTH	C_P_DATE	OTHER_INFO
00187009	506	Domestic	244	9/26/1985	Status: Active
00172128	507	Abandoned	70	5/27/1983	Status: Sealed
00171921	508	Domestic	100	6/24/1980	Status: Active
00110101	509	Domestic	131	4/17/1975	Status: Active
00102845	510	Domestic	530	6/30/1977	Status: Active
00171913	511	Domestic	201	5/29/1980	Status: Active
00462070	512	Domestic	90	8/7/1990	Status: Active
00112804	513	Domestic	156	10/2/1975	Status: Active
00115304	514	Domestic	304	8/2/1978	Status: Active
00174168	515	Domestic	220	52/1981	Status: Active
00171936	516	Domestic	148	5/11/1981	Status: Active
00100502	517	Domestic	372	1975	Status: Active
00174169	518	Domestic	272	5/30/1981	Status: Active
00174186	519	Domestic	315	9/14/1982	Status: Active
00640744	520	Domestic	202	11/15/2001	Status: Active
00136157	521	Domestic	460	8/18/1977	Status: Active
00136167	522	Domestic	460	9/17/1977	Status: Active
00102846	523	Domestic	530	6/30/1977	Status: Active
00136183	524	Domestic	445	5/15/1979	Status: Active
00222771	525	Domestic	110	8/6/1970	Status: Active
00214504	526	Irrigation	48	5/1/1965	Status: Active
00131184	527	Domestic	482	4/8/1977	Status: Active
00174176	528	Domestic	325	12/4/1981	Status: Active
00171940	529	Domestic	412	5/30/1981	Status: Active
00795616	530	Domestic	533	8/12/2013	Status: Active
2169431	531	Private Well Tracking System	71		Rotary Drill Status: Inactive

Appendix D – Okoboji Watershed Agricultural BMPs

Existing agricultural BMPs in the Okoboji watershed are provided in Figure 17. Figure 18 through Figure 21 provide potential location opportunities for BMPs that were sited in ACPF.

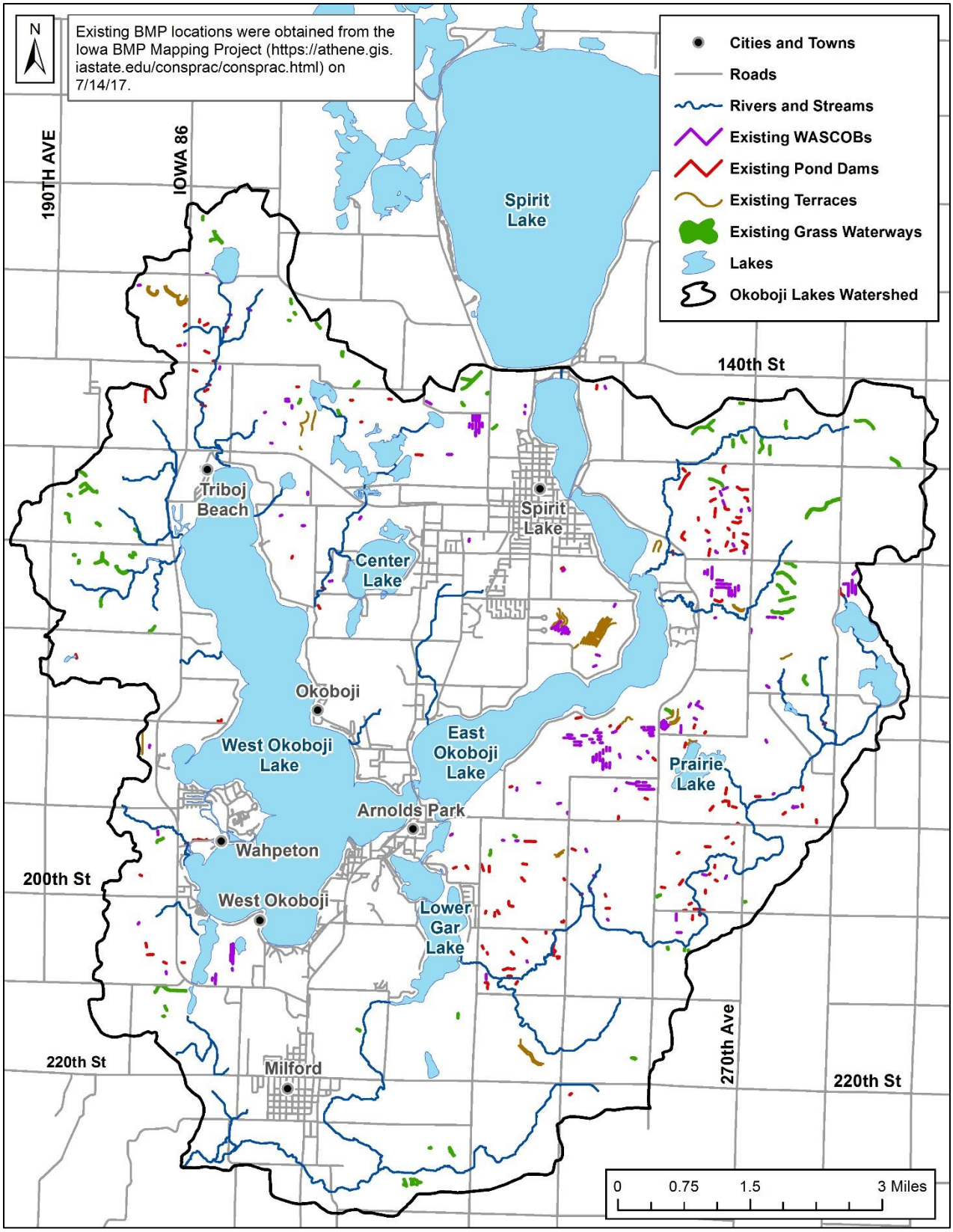

Figure 17. Existing BMPs in the Okoboji watershed.

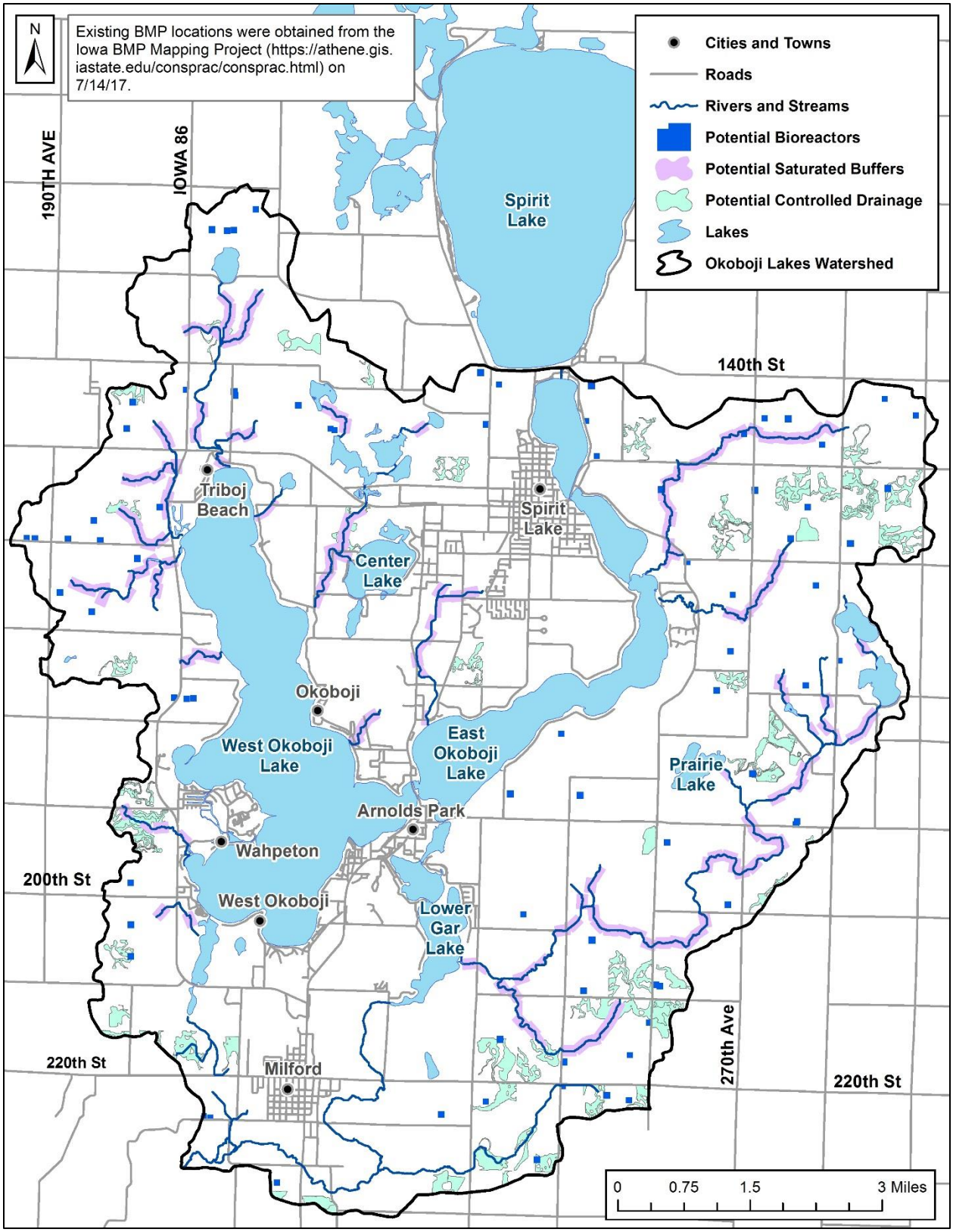

Figure 18. ACPF sited locations for bioreactors, saturated buffers, and controlled drainage in the Okoboji watershed.

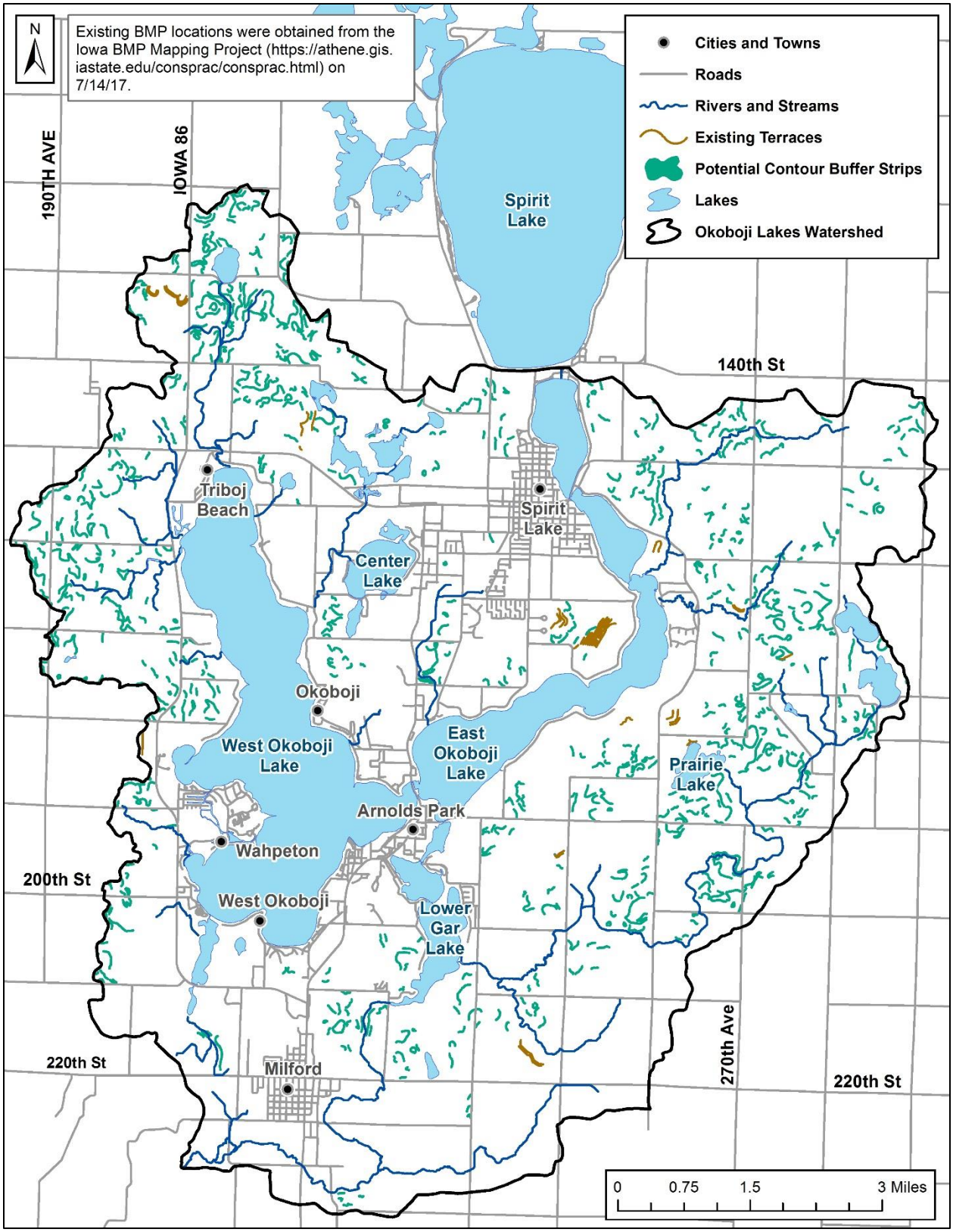

Figure 19. ACPF sited locations for contour buffer strips in the Okoboji watershed.

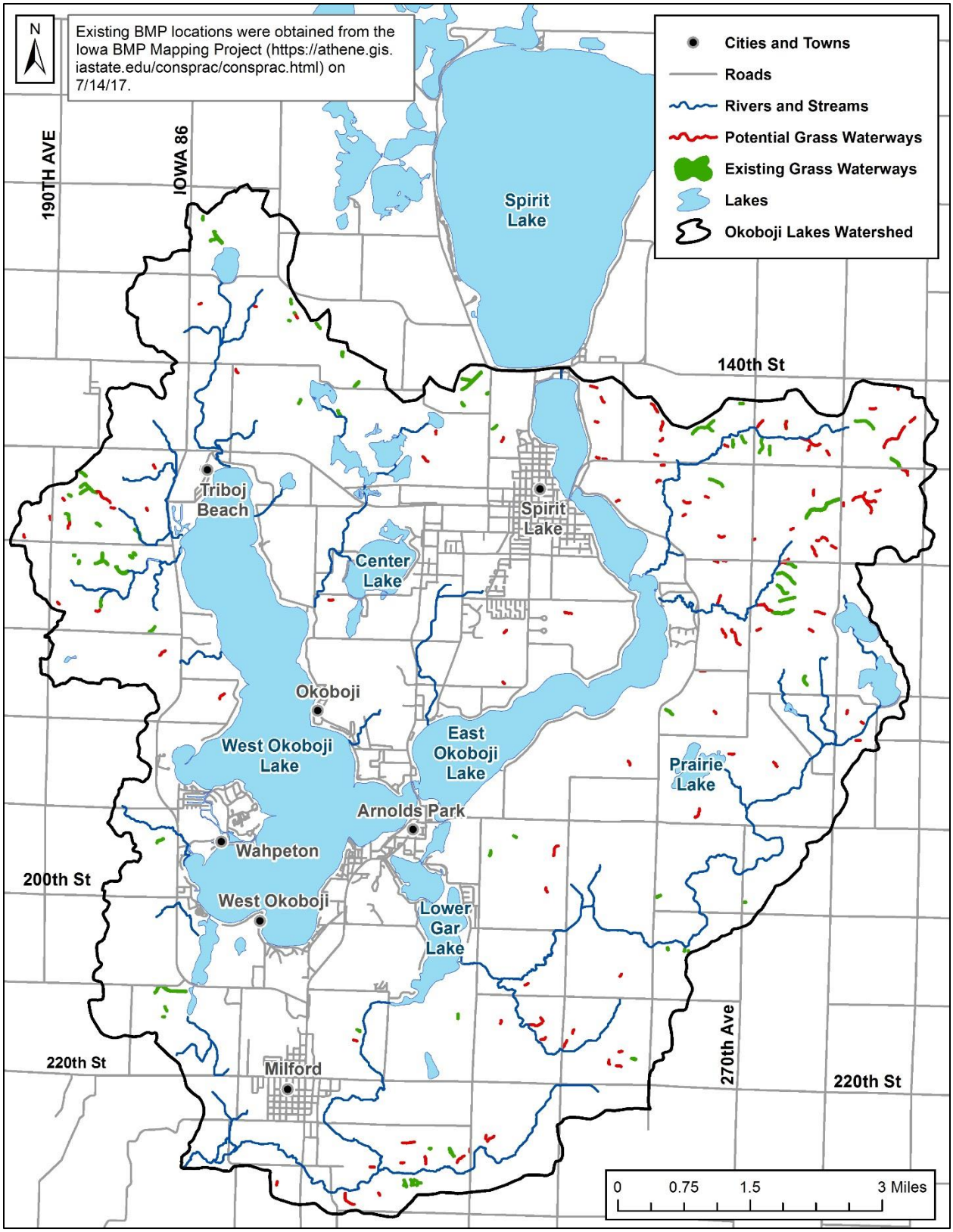

Figure 20. ACPF sites locations for grass waterways in the Okoboji watershed.

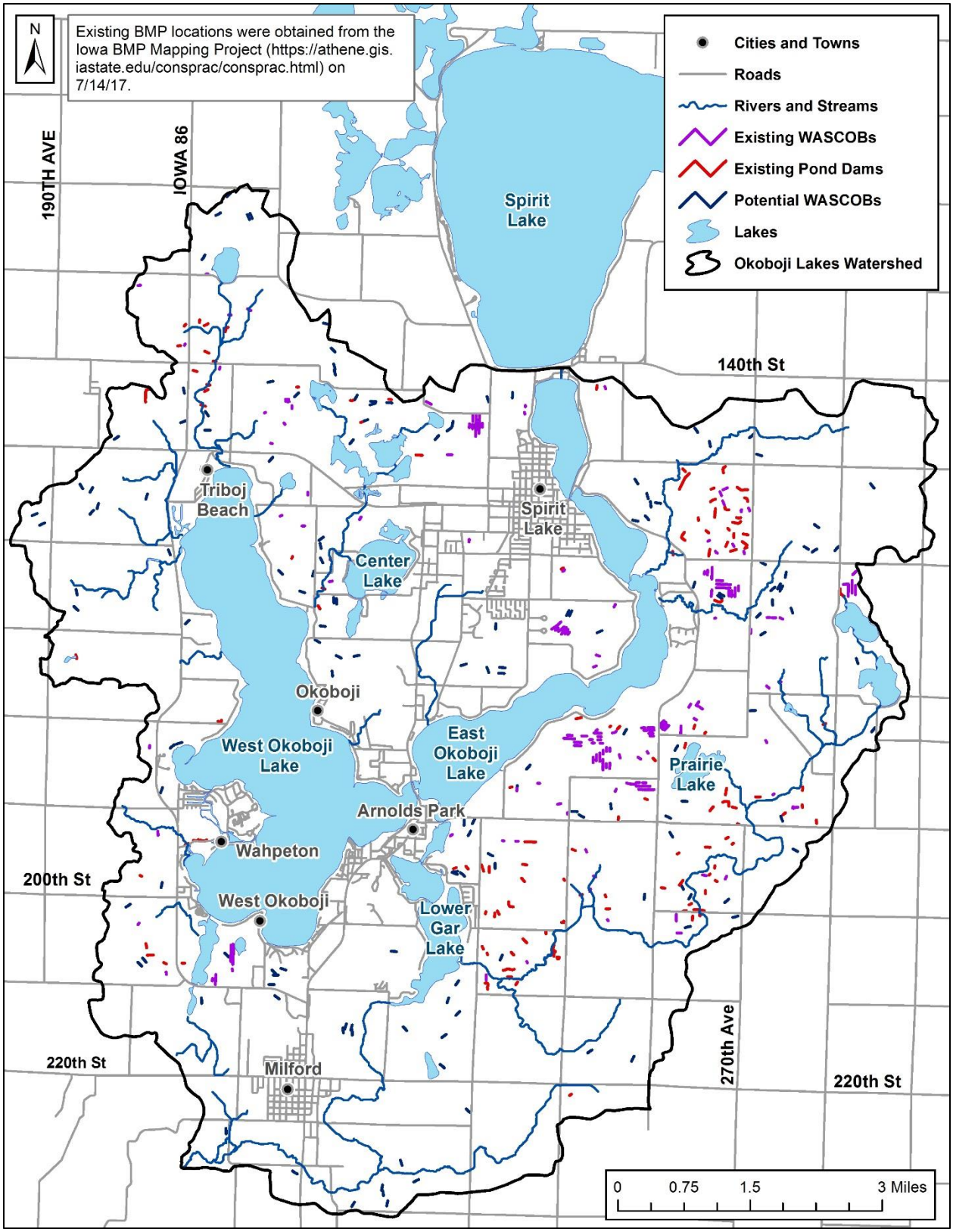

Figure 21. ACPF sited locations for WASCOBs in the Okoboji watershed.

Appendix E – Total PCS Risk Scores

Table 20 provides a summary of each PCS and the total risk score, based on the individual location, susceptibility and contaminant risk scores. Total risk summaries for land use and groundwater wells are provided in Table 21 and Table 22, respectively. The total risk score for each PCS is used to help determine the priority for mitigating the impacts of the PCS through the action plan.

Table 20. Total Risk Scores of Potential Contaminant Sources

Facility Type	Location #	Location of PCS	Source Water Susceptibility	Contaminant Risk	Total Risk Score	Priority
Feedlot	1	1	1	5	7	
Feedlot	2	1	5	5	11	High priority
Feedlot	3	1	5	5	11	High priority
Feedlot	4	1	1	5	7	
Feedlot	5	1	1	5	7	
Feedlots	6	1	1	5	7	
Feedlots	7	1	5	5	11	High priority
Feedlot	8	5	5	5	15	High priority
Feedlot	9	1	1	5	7	
Feedlot	10	1	1	5	7	
Industrial: Auto parts	11	5	5	4	14	High priority
Feedlot	12	1	5	4	10	
Feedlot	13	1	1	5	7	
Feedlot	14	1	1	5	7	
Feedlot	15	1	1	5	7	
Feedlot	16	1	5	5	11	High priority
Feedlot	18	1	1	5	7	
Industrial: Drug Lab	19	1	1	4	6	
Feedlot	20	1	1	5	7	
Feedlots	21	1	1	5	7	
Feedlots	22	1	1	5	7	
Feedlot	23	1	5	5	11	High priority
Feedlot	24	1	5	5	11	High priority
Feedlot	25	1	1	5	7	
Feedlots	26	1	1	5	7	
Confined animal feeding operation	27	1	5	5	11	High priority
Confined animal feeding operation	28	1	5	5	11	High priority
Feedlot	29	1	1	5	7	
Feedlot	30	1	1	5	7	

Facility Type	Location #	Location of PCS	Source Water Susceptibility	Contaminant Risk	Total Risk Score	Priority
Feedlot	31	1	1	5	7	
Feedlots	32	1	5	5	11	High priority
Feedlot	33	1	5	5	11	High priority
Confined animal feeding operation	34	1	5	5	11	High priority
Feedlot	35	1	5	5	11	High priority
Feedlot	36	1	5	5	11	High priority
Feedlot	37	1	1	5	7	
Feedlot	38	1	1	5	7	
Confined animal feeding operation	39	1	5	5	11	High priority
Feedlots	40	1	5	5	11	High priority
Feedlots	41	1	1	5	7	
Feedlots	42	1	1	5	7	
Petroleum Remediation, Leak Site	43	1	5	5	11	High priority
Petroleum Remediation, Contaminated Soil Treatment Facility	44	1	1	5	7	
Site Assessment: Dump	45	1	5	5	11	High priority
Golf Course	46	1	5	3	9	
Feedlot	47	1	1	5	7	
Campground	48	1	5	1	7	
Campground	49	1	5	1	7	
Lift Station	50	1	5	5	11	High priority
Septics	51	5	5	5	15	High priority
Underground storage tank	52	5	5	5	15	High priority
Tier II Chemical Storage	53	5	5	5	15	High priority
Underground storage tank	54	5	5	5	15	High priority
Cemetery	55	5	5	1	11	High priority
Underground storage tank	56	5	5	2	12	High priority
Leaking underground storage tank	57	5	1	5	11	High priority
Underground storage tank	58	5	1	5	11	High priority
Hazardous Materials Spill	59	5	5	5	15	High priority
Wastewater outfall	60	5	5	5	15	High priority
Underground storage tank	61	5	5	5	15	High priority
Underground storage tank	62	5	5	5	15	High priority
Underground storage tank	63	3	1	5	9	
Confined animal feeding operation	64	3	1	5	9	

Facility Type	Location #	Location of PCS	Source Water Susceptibility	Contaminant Risk	Total Risk Score	Priority
Underground storage tank	65	3	5	5	13	High priority
Above ground fuel storage	66	3	1	4	8	
Open feedlot	67	3	1	5	9	
Hazardous Materials Spill	68	3	1	5	9	
Feedlot	69	5	1	5	11	High priority
Feedlot	70	5	5	5	15	High priority
Feedlot	71	5	5	5	15	High priority
Feedlot	72	1	1	5	7	
Feedlot	73	5	1	5	11	High priority
Feedlot	74	5	1	5	11	High priority
Septics	75	3	5	5	13	High priority
Septics	76	5	5	5	15	High priority
Wastewater outfall	77	1	5	5	11	High priority

Table 21. Total risk scores for land uses

Land Use Type	Scores				Priority
	Location	Source Water Susceptibility	Contaminant Risk	Total Risk Score	
Crops (pasture and hay)	5	5	3	13	High priority
	3	5	3	11	High priority
	1	5	3	9	
	1	1	3	5	
Crops (corn/soy)	5	5	5	15	High priority
	3	5	5	13	High priority
	1	5	5	11	High priority
	1	1	5	7	
Developed	5	5	4	14	High priority
	3	5	4	12	High priority
	1	5	4	10	
	1	1	4	6	

Table 22. Total risk scores for groundwater wells

Scores				Priority
Location	Source Water Susceptibility	Contaminant Risk	Total Risk Score	
5	5	2	12	High priority
3	5	2	10	
1	5	2	8	
1	1	2	4	

Appendix F – Emergency Response Plan Affidavit

Emergency Response Plan Affidavit

The Safe Drinking Water Act amendments of 1986 and 1996 established the concept of wellhead protection, and subsequently the Source Water Protection Program. The program is currently overseen by the Iowa Department of Natural Resources (DNR) and attempts to prevent potential contaminants from entering source waters and prepare for situations in which drinking water may be impaired through contamination, power outage and treatment or distribution system interruptions. In order to ensure a public water supply's preparedness in such events, a Contingency/Emergency Plan has been required in every approved Source Water Protection Plan (SWPP) or Wellhead Protection Plan (WHPP). Due to recent and growing concerns over water system security and due to many systems having previously prepared such a plan under the provisions of the 2002 Bioterrorism Act, the DNR is now allowing an affidavit in lieu of including a completed Contingency/Emergency Plan within the submitted SWPP/WHPP. Although public water supplies do not need to send DNR completed plans, each must have an accessible and up-to-date plan in case a catastrophic event occurs within their system. It is necessary for the completed water supply Contingency/Emergency Plan to contain the following information, at a minimum:

- Contact information for the city's mayor, city clerk, water/wastewater operator.
- Contact information for the city's power company, a professional electrician, a professional plumber and an equipment repair company.
- System's critical users must be identified and a plan for immediate notification must be created. (i.e. hospitals, nursing homes, schools, etc.)
- Contact information for local media, including newspaper, radio and television.
- Contact information for a certified laboratory, local emergency contacts, state and local public health departments and the National Guard.
- Contact information for the DNR's 24 hour emergency contact and the local DNR field office.

I, Mark Peterson, representing City of Spirit Lake certify that a Contingency / Emergency Plan has been created for our public water supply system and that this information can be presented to the DNR upon request.

Signature: Mark Peterson

Date: 2-28-18

Modified from the Iowa Source Water Protection Program Workbook Page 19 DNR Form 542-0625