Saylorville Lake and Lake Red Rock

Sub-watershed Threat Assessment

Sustainable Rivers Project

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U.S. Army Corps of Engineers

Rock Island District

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Introduction

A Corps of Engineers reservoir project manager (lake manager) has many responsibilities for land, water, recreation, hydropower, and flood management. Their jobs are diverse, but area of responsibility (AOR) is discrete. They operate specific structures (i.e., dam gates, hydropower facilities, fish passages, etc.) in response to incoming and outgoing flow requirements and manage some surrounding lands. They are subject however, like all watersheds, to influences from upstream on mainstem rivers and from surrounding sub-watersheds. Lake managers move at an "operational pace," meaning they must plan and do work concurrently. There are seasonal events related to natural (e.g., floods, land management, etc.) and social (e.g., camping, boating, beaches, etc.) factors that must be considered and factored into operational constraints. Occasionally there are also large-scale operational reviews, such as a reservoir hydrology re-regulation study at Saylorville Lake and Lake Red Rock, that invite specific investigations.

Another driver for this study was the reservoir manager's exposure to the Sustainable Rivers Project and then to watershed studies at a Corps PROSPECT training course. Hugh Howe called Rock Island District colleagues and asked for a "watershed study". Watershed studies are typically large projects involving many partners, so a project delivery team (PDT) was formed to determine what a lake manager needs from a watershed study. The PDT determined they wanted a rapid assessment tool akin to existing USDA Rapid Watershed Assessments (USDA 2007), but tailored to the reservoir manager's AOR. The PDT considered the manager's level of control (i.e., water control, land ownership), the scale of upstream issues, and the role of the reservoir in a larger watershed management plan. The PDT imagined an analysis, toolbox, or model that would operate rapidly like other Corps tools designed for modern planning frameworks (i.e. 3X3X3 planning).

Considering Lake Red Rock and Saylorville Lakes, upstream issues are large and complex with municipal lawsuits debating National laws and policy in a Des Moines Water Works lawsuit against upstream drainage districts. The battle pits cities against agriculture and is quite controversial, so the PDT recommended that reservoir managers participate in communication, but not try to control influences on the mainstem inputs from the Des Moines River. The PDT also recommended a targeted assessment approach can help reservoir managers put their greatest operational effort into their own lands first. As a second priority they can also make significant contributions to their local environmental quality and downstream water quality by partnering in sub-watersheds draining directly to their reservoirs. It is important to show, as SRP strives to demonstrate, that reservoirs can be used to improve environmental conditions downstream through upstream land and water management.

This Rapid Sub-watershed Threat Assessment was designed to demonstrate how available spatial data layers can be efficiently integrated into a reservoir operations plan. It will help reservoir managers identify local threats to prioritize their limited management resources on their own lands first. At a slightly larger extent this approach will help reservoir managers partner in surrounding sub-watersheds and as responsible partners addressing downstream impacts.

Study Area

The study area included USACE Saylorville Lake and Lake Red Rock on the Des Moines River near Des Moines, Iowa (Figure 1). Saylorville Lake is the upstream reservoir designed to provide flood control for the City of Des Moines. Lake Red Rock is 45 miles downriver where it protects communities and agriculture in Southeast Iowa. Saylorville has 27,000 acres of land and water, while Lake Red Rock is 15,250[acres of water and 50,000 acres total project area (Figure 2). Lake Red Rock maximum project pool increases to 65,500 acres when flood easement property gets inundated (Figure 2). Both projects are multiple purpose facilities offering camping, boating, fishing, hiking, biking, etc. Wildlife, water, wetland, and land management are important to regional wildlife plans. Saylorville Lake augments Des Moines water supply and Lake Red Rock has a hydropower installation in progress.

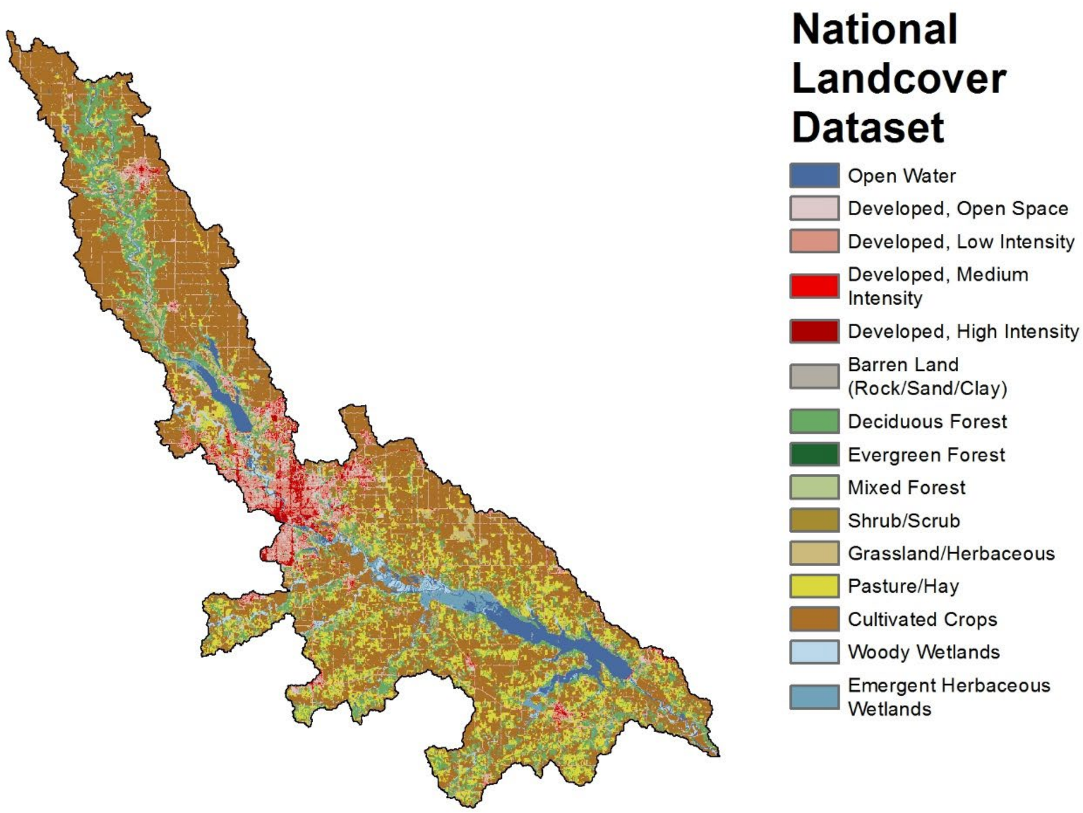


Figure 1. Saylorville Lake and Lake Red Rock reservoir sub-watershed land cover (MRLC 2011)

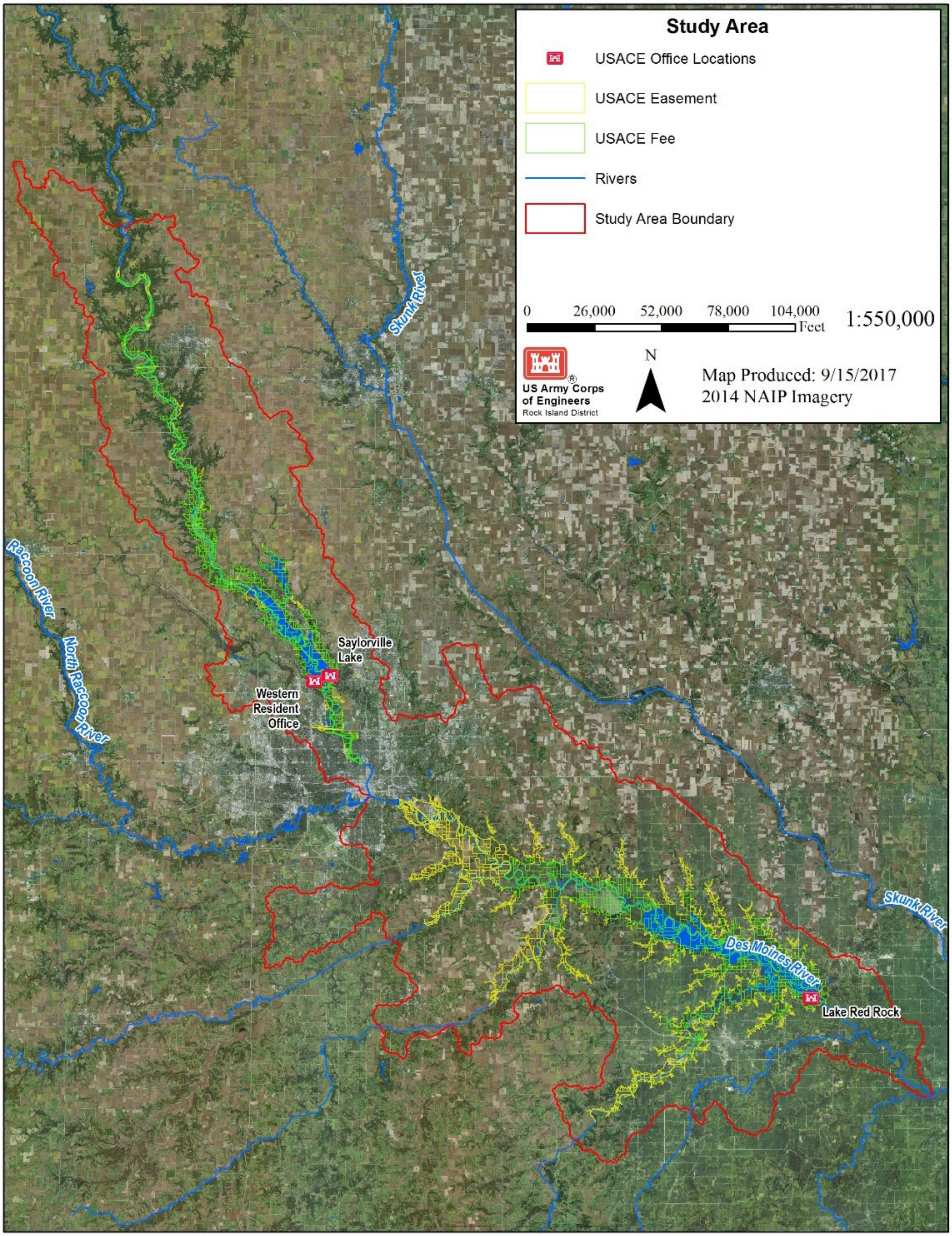


Figure 2. Saylorville Lake and Lake Red Rock reservoirs, fee title ownership, and flood easement extent

We selected 33 HUC-12 sub-watersheds that intercepted the Saylorville Lake and Lake Red Rock Project's fee and easement real estate boundary for the rapid watershed assessment (Figure 3). These are primarily ungauged tributaries with little information on physical, chemical, or biological attributes. Some sub-watersheds have local, even Federal (i.e., Whitebreast), watershed studies completed that can provide reference condition information for other parts of the sub-watershed. Nearly half of the sub-watersheds (Figure 3) are in various stages of production for Agricultural Conservation Planning Framework (ACPF) watershed BMP analysis also. Whitebreast Creek ACPF is included as an example of the advanced modeling that can be done on high-risk sub-watersheds. The ACPF analyses are catalogued and become input for the next rapid assessment and subsequent implementation.

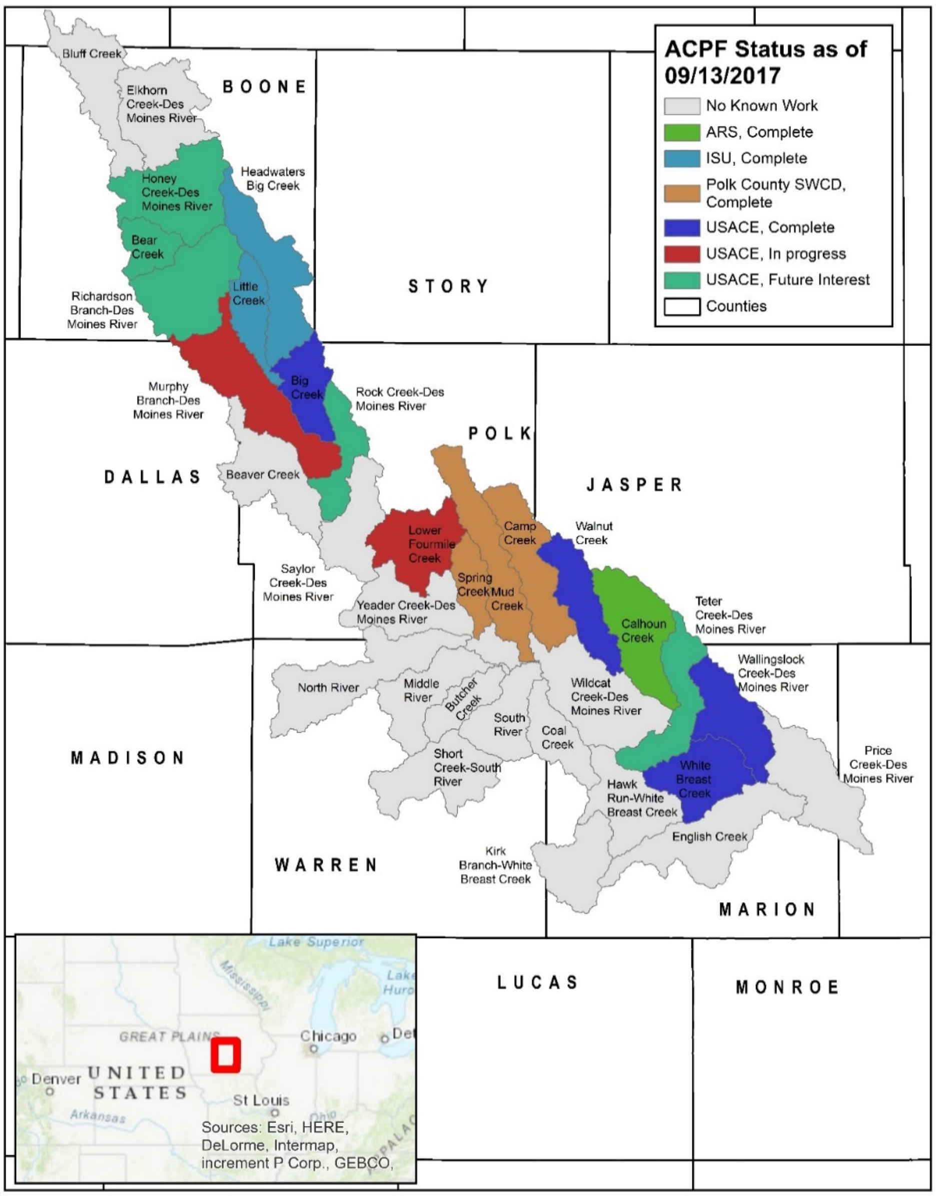


Figure 3. Sub-watershed included in Saylorville Lake and Lake Red Rock Rapid Watershed Assessment.

Methods

Rapid Watershed Threat Assessment (RWTA)

A rapid assessment of the watersheds surrounding Lake Red Rock and Saylorville Lake was undertaken loosely modeled after Natural Resource Conservation Service (NRCS) Rapid Watershed Assessment (RWA), maintaining the same intention: "to increase the speed and efficiency generating information to guide conservation implementation (Natural Resources Conservation Service n.d.)." However, a fundamental difference exists. While the typical RWA focuses on a single watershed at the HUC10 level, this study utilized multiple, thirty-three, sub-watersheds (HUC12).

The highest quality and readily available data was compiled from multiple authoritative sources covering the three main topics (social, biologic and physical) of a RWA (Natural Resource Conservation Service 2005). Variables were determined through review of the readily available datasets (Table 1). Data were then summarized to the sub-watershed scale utilizing a Geographic information System (GIS), to facilitate a more regional assessment surrounding the lakes. These summaries were conducted by clipping datasets to the extent of the study area. The gSURRGO data were not summarized to the HUC12 due to the inconsistences of data classifications across survey boundaries. A total count by sub-watershed was collected for datasets which contained point features (i.e., confined animal feeding operations, leaking underground storage tanks); for linear features (i.e., streams and roads); the total length by sub-watershed of all features in meters was computed; and for polygon (i.e., National Wetlands inventory) or raster/gridded datasets (NLCD). The total area and/or percent of total area was calculated for each class within the dataset.

Data were manually classified using data driven equal intervals. Choropleth maps were created using these classifications to assist in the identification of risk; red indicating high risk and green indicating lower risk) by variable as compared to other sub watersheds within the study area. Map outputs and data may be used to target where conservation practices may be most beneficial.

Agricultural Conservation Planning Framework (ACPF)

The ACPF is a set of software tools utilizing a GIS to identify best placement for precision conservation practices based on NRCS practices using widely available geospatial datasets, and was developed by the National Laboratory for Agriculture & the Environment, USDA-ARS (Porter, et al. 2016, Tomer, et al. 2013). The toolset utilizes a hydro-modified Digital Elevation Model (DEM), this DEM has undergone a process which eliminates barriers to water flow across the models surface. In addition to the altered DEM a database is obtained from the ARS, these serve as inputs to the tools. Potential NRCS practices identified by the toolset include underground outlets, wetland bioreactors, constructed wetland, wetland creation, water and sediment control basins, riparian forest buffers, streambank protection, and saturated buffers. Detailed information on database content and tools can be found in the User Manual provided by the ARS (Porter, et al. 2016).

Social Vulnerability Index (SVI)

In addition to the census data, Social Vulnerability Index (SVI) values were mapped for census tracts intersecting the HUC12s included in the study area, utilizing choropleth maps (red for high vulnerability to green for lower vulnerability). The Geospatial Research, Analysis & Services Program (GRASP) at the Agency for Toxic Substances & Disease Registry (ATSDR) produces the SVI in order to identify areas which will need additional assistance pre or post disaster/hazardous event (Agency for Toxic Substances and Disease Registry 2013). Each tract is ranked according to fourteen individual variables, which are then compiled and ranked for four themes (socioeconomic status, household composition and disability, minority status and language, and housing and transportation) to generate the overall ranking (Flanagan, et al. 2011). The hope is this data will assist in informing future planners of the sociodemographic composition of the areas within the study area.

Table 1: Mapped Variables

Dataset	Mapped Variable
Watershed Boundary Dataset (WBD), (NRCS, USGS 2014)	Watershed Boundaries
National Hydrography Dataset (NHD), (USGS 2015)	Road Crossing NHD Flowline Count
National Wetland Inventory (NWI), (USFWS 2014)	Total Freshwater-Forested/Shrub Wetland Area (Hectares), Total Freshwater-Emergent Wetland Area (Hectares), Total Freshwater-Forested/Shrub Wetland Area (Hectares), Total Freshwater-Pond Wetland Area (Hectares), Total Lacustrine Wetland Area (Hectares), Other Wetland Area (Hectares), Riverine Wetland Area (Hectares), Total Wetland Area (Hectares), NWI Total Disturbed Wetlands Area (Hectares)
Protected Area Database (PAD-US), (USGS n.d.)	Disturbance Allowed in Hectares, No Disturbance Allowed in Hectares, Manages for Multiple Uses in Hectares, No Mandate for Protection in Hectares
Census Blocks, (United States Census Bureau 2014)	2010 Census Population, 2010 Census Number of Housing Units
Transportation, (United States Census Bureau 2014)	Meters of Limited Use Roads, Meters of Regular Use Roads, Road Crossing NHD Flowline Count
Urban Areas, (United States Census Bureau 2014)	Urbanized Area (2013 Census) in Hectares
Social Vulnerability Index (SVI), (CDC/ASTDR/GRASP 2010)	Socioeconomic variables (Proportion of Persons Below Poverty Level, Civilian (age 16+) unemployment estimate, Per capita Income Estimate, Proportion of Persons without a high school diploma (age 25+) estimate, Percentile Ranking (Iowa) of Social Theme), Household Composition Variables (Proportion of Persons aged 17 and younger, Proportion of Persons Aged 17 and Younger, Proportion of Single Parent Households with Children Under 18, Percentile Ranking (Iowa) of Housing Composition Variables), Minority Status/Language Variables (Proportion minority (all except white, non-Hispanic) Proportion of persons (age 5+) who speak English "less than well" estimate, Percentile Ranking (Iowa) of Minority Status/Language Variables), Housing/Transportation Variables (Proportion of Housing Structures with 10 or More Units Estimate, Proportion of Mobile Homes Estimate, Proportion of households with more people than rooms estimate, Proportion of households with no vehicle available estimate, Proportion of persons in institutionalized, Percentile Rank (Iowa) of Housing/Transportation Variables), Overall Iowa Ranking
National Land Cover Dataset (NLCD), (MRLC 2011)	Proportion of: Impervious Land Cover, Open Water, Pasture, Developed Open Space, Developed Low Intensity, Developed Medium Intensity, Developed High Intensity, Barren, Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Grassland/Herbaceous, Agriculture Classes to Forest Classes, and Developed Classes to Forest Classes
gSSURGO, (Soil Survey Staff 2015)	Hydric Soil, Run Off Risk Class, National Commodity Crop Productivity Index (not summarized to watershed)
Confinement Animal Feeding Operations (CAFOs), (Iowa DNR 2016)	Confined Animal Feeding Operation Count
Open Feedlots, (Iowa DNR 2016)	Open Feed Lot Count
Animal Feeding Operations, (Iowa DNR 2016)	Animal Feeding Operation
Contaminated Sites, (Iowa DNR 2016)	Contaminated Sites Count

Leaking Underground Storage Tanks, (Iowa DNR 2016)	Leaking Underground Storage Tank Count
EPA 303d Impaired Waters, (US EPA 2014)	Impaired Waterbodies Area, Impaired Waterbodies Length
Resource Conservation and Recovery Act (RCRA) Sites, (US EPA 2012)	RCRA Site Count
Surficial Geology of Iowa (Miller 2015)	Surficial Geology of Iowa

Results

RWA results are presented with general land cover and setting information first to establish conditions relative to environmental indicators that follow. Data layers are selected mostly from national and state-wide databases so they are replicable and useful to others. Map source documentation is provided in map legends. Population metrics are presented to document human impacts. Agricultural metrics are reviewed for their impact on water quality. Biodiversity and land management are indicators of environmental quality. Environmental Protection agency (EPA) water quality impairment listings (i.e., 303d), contaminated sites and leaking underground storage tanks are indicators of non-point (listings) and point source pollutants (sites). There are many data sources remaining to be identified or mapped, but they can be added and summarized as they become available.

Land Cover

Agriculture is the dominant land use with 48 percent cultivated crops and 13 percent pasture or hay (Figure 4). Some developed sub-watersheds in Polk County have little agriculture while others in Boone County have over 80 percent cultivated crops (Figure 5). Most sub-watersheds are in the 40 to 60 percent row crop range. Deciduous forest is the third most abundant land cover class, and it is concentrated in the riparian areas above Saylorville Lake (see Figure 1). Developed open space is the fourth ranked class (6.7 percent), but three other developed classes sum to 7.3 percent, so open developed area is a mix of structures and open space. Open water is in the lakes, but grasslands are clumped at >10% area in several sub-watersheds surrounding Lake Red Rock and Saylorville Lake compared to less than 3 in most others (Figure 6). Wetlands are uncommon with less than 4 percent of the area in woody or herbaceous wetlands mostly in upper Lake Red Rock (see Figure 1).

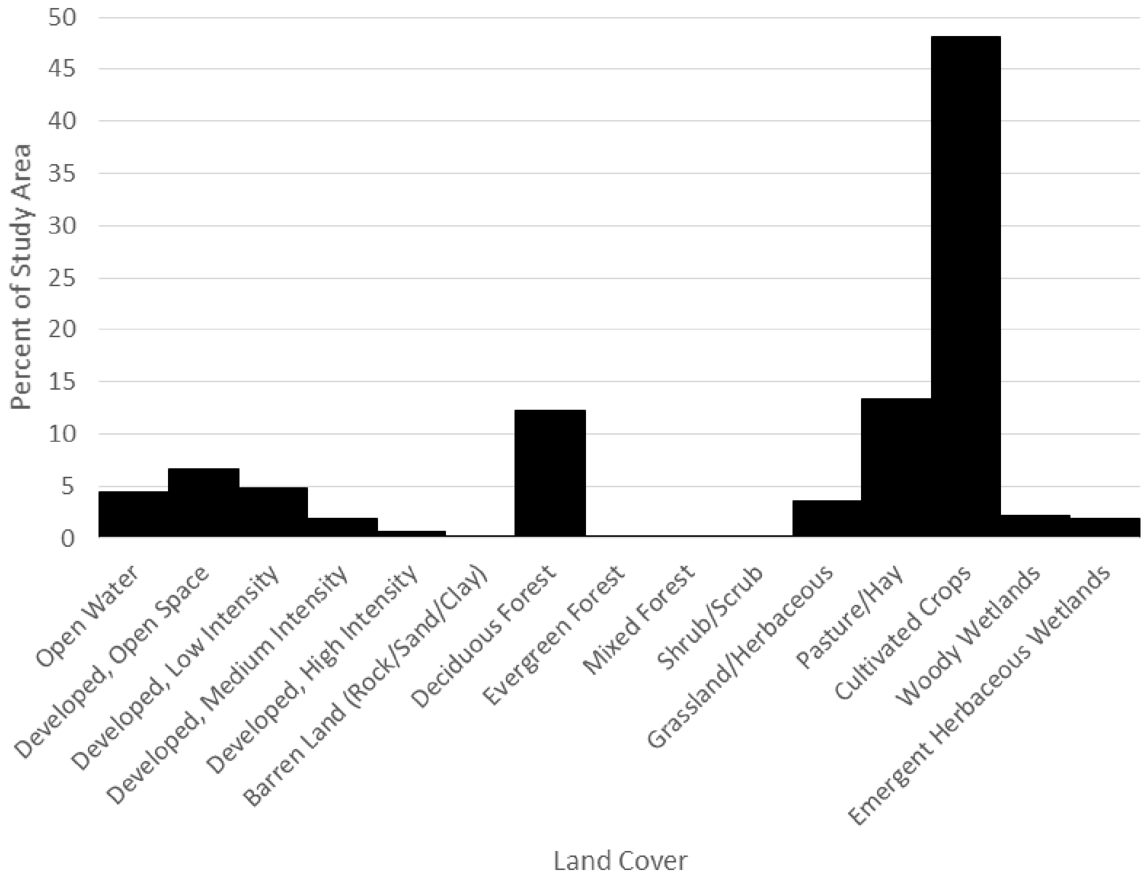


Figure 4. Saylorville Lake and Lake Red Rock sub-watershed land cover.

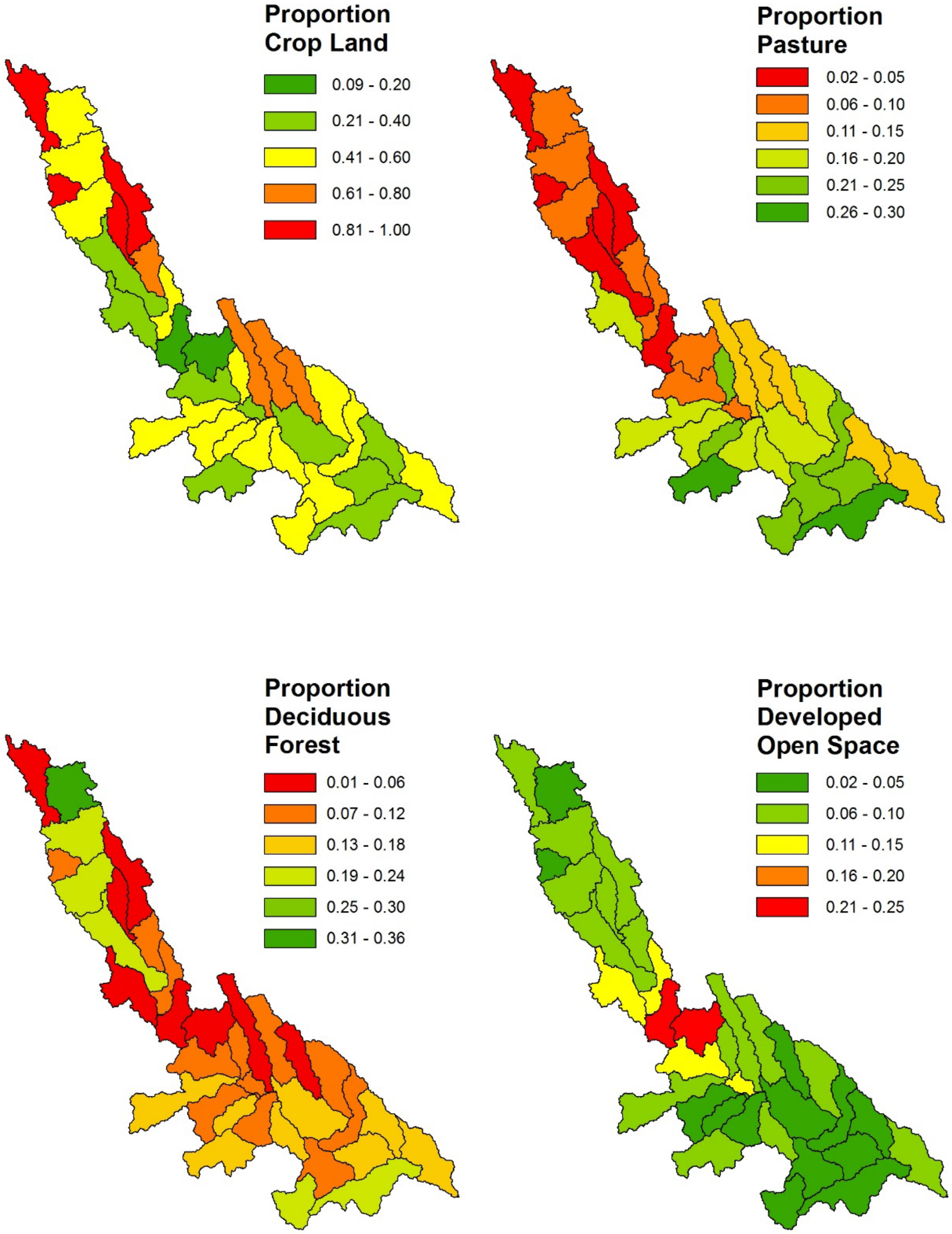


Figure 5. Dominant land cover classes in Saylorville Lake and Lake Red Rock sub-watersheds (MRLC 2011)

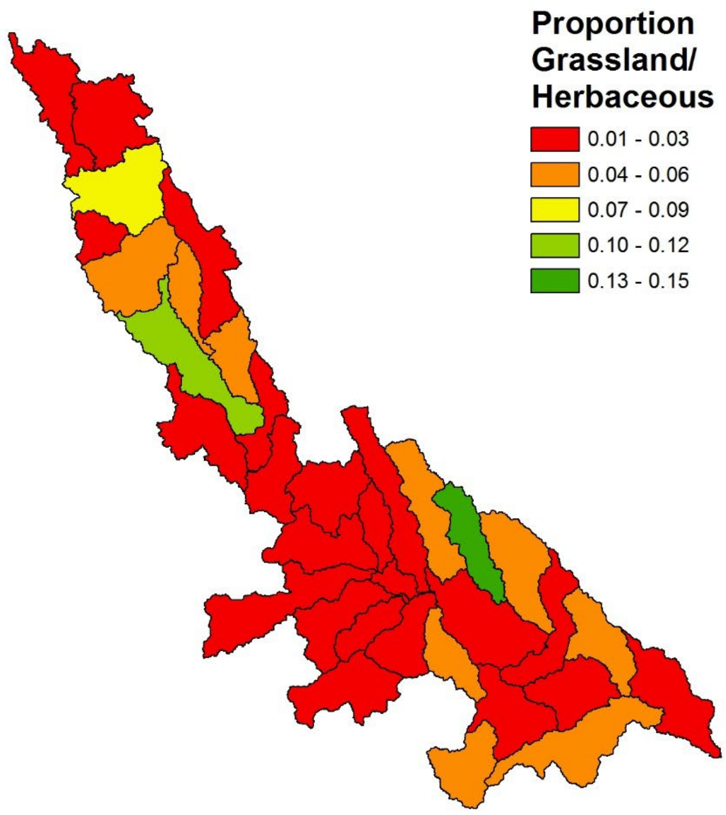


Figure 6. Grassland distribution in Saylorville Lake and Lake Red Rock sub-watersheds (MRLC 2011)

Population Indicators

Plotting census statistics helps detect patterns of high and low intensity developed areas which present different management opportunities. An urban area indicator (Figure 7) mirrors census demographic data. The Des Moines high density urban core spreads to medium and low intensity suburban development. Developed area implies structures on the landscape, some, like roads, can be isolated for impact assessment. The length of roads per unit area would estimate density, but Figure 8 only provides a relative number of the length of roads per irregular watershed, so density is not calculated; the urban core is obvious. Road crossings is a hydraulic connectivity consideration. Fish passage is often impeded at culverts and thus many road crossings. There is frequently scour at structures which could indicate high rates of sediment erosion also.

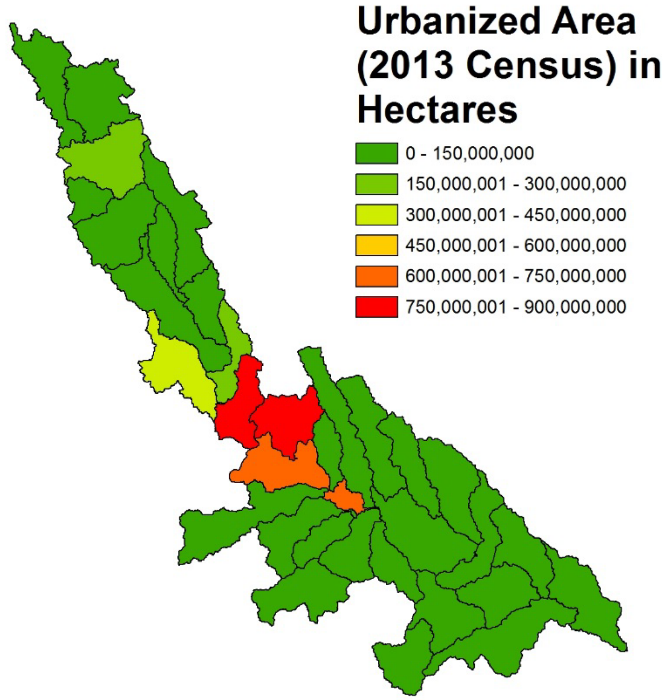
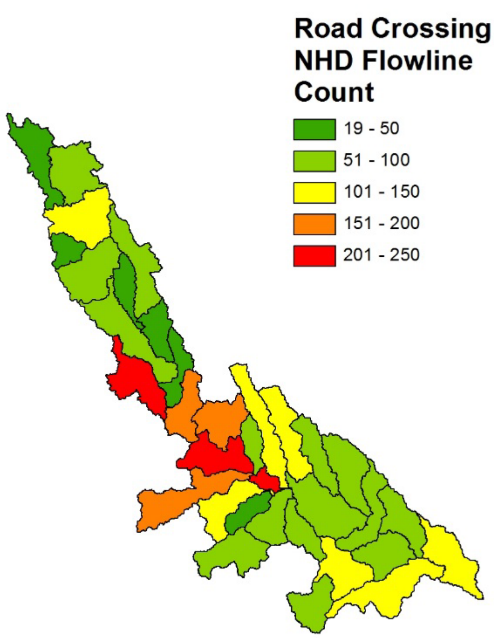


Figure 7. Urbanized area in Saylorville Lake and Lake Red Rock sub-watersheds (United States Census Bureau 2014)



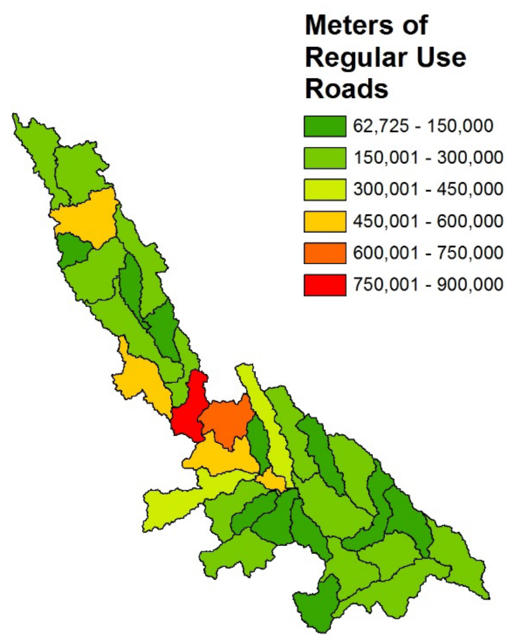


Figure 8. Road crossings and length in meters in Saylorville Lake and Lake Red Rock sub-watersheds (United States Census Bureau 2014)

Agriculture Indicators

Land cover summaries are excellent indicators of land use and associated impacts of soil, fertilizer, pesticide, and herbicide runoff potential. Livestock abundance is an indicator of additional agriculture impacts, because manure includes a multitude of nutrients limiting aquatic ecosystem production. Phosphorus enrichment is an important impact from large amounts of manure from confined animal feeding operations (CAFOs; Figure 9) on the landscape and entering streams. CAFOs imply hog operations, whereas open feed lots (Figure 10) imply cattle. Livestock are relevant because of the manure management which is regulated to minimize phosphorus inputs. Land is determined to have capacity to assimilate limited amounts of nutrients. Flat or sloped landscapes determines farm- or field-specific application rates. The sSURRGO runoff risk classification can be used to identify where manure runoff may be a concern (Figure 11). We were concerned about the high density of CAFOs in Calhoun Creek and compared that to statewide CAFO abundance to see the study area has a relatively low abundance of CAFOs compared to other parts of Iowa (Figure 12).

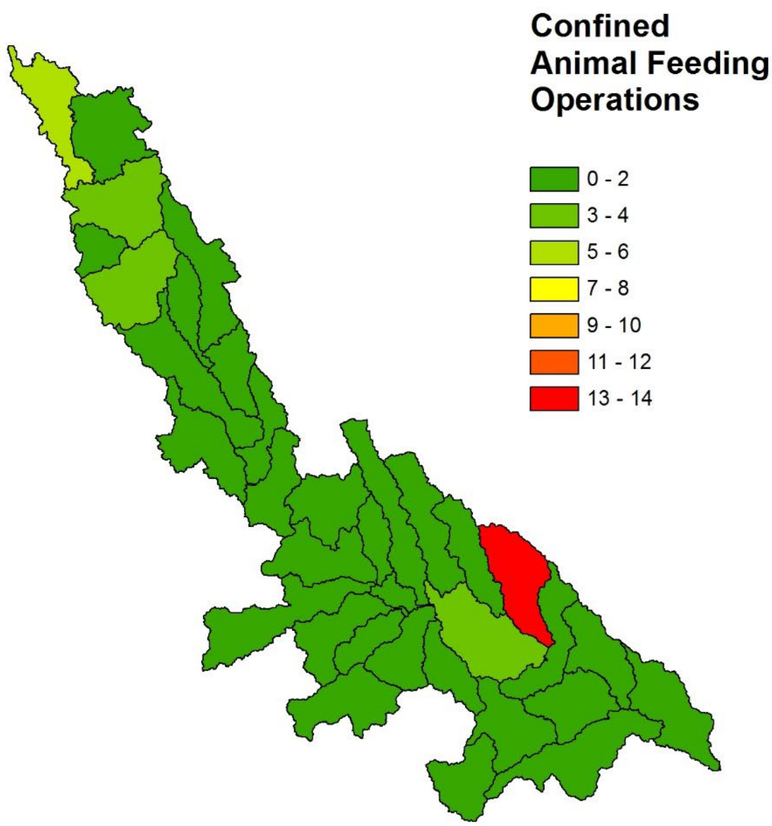


Figure 9. Confined animal feeding operations in Saylorville Lake and Lake Red Rock sub-watersheds (Iowa DNR 2016)

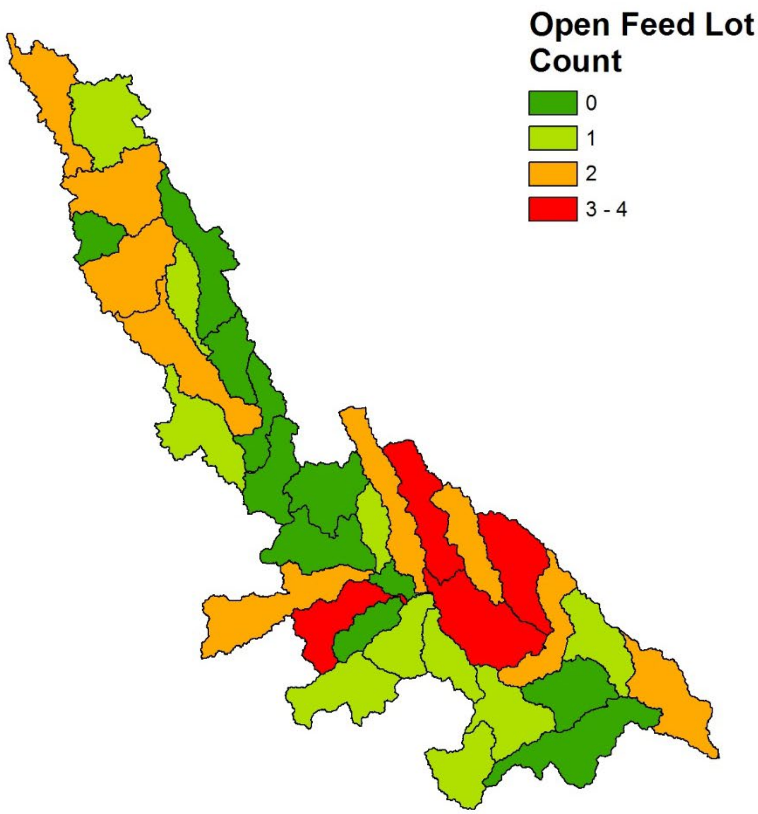


Figure 10. Open feed lots in Saylorville Lake and Lake Red Rock sub-watershed (Iowa DNR 2016)

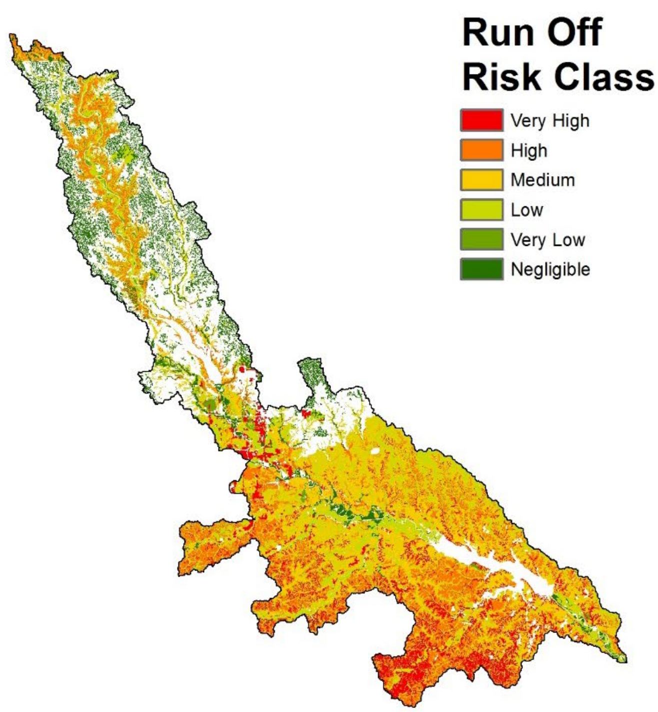


Figure 11. Runoff risk classification in Saylorville Lake and Lake Red Rock sub-watersheds gSSURGO, (Soil Survey Staff 2015)

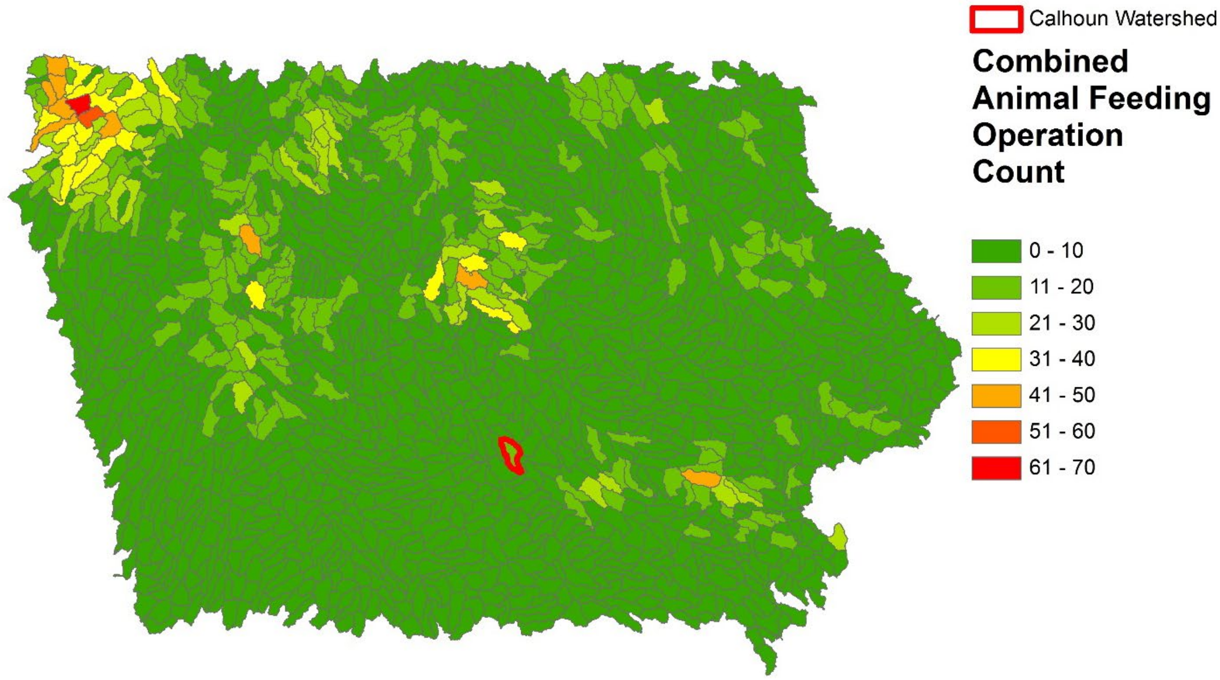


Figure 12. Iowa CAFO abundance by HUC-12 sub-watershed (Iowa DNR 2016)

Biodiversity

Land cover was presented as a general indicator of biodiversity (See Figure 1). A greater abundance of diverse natural areas provides greater opportunities for diverse and abundant fauna. With agriculture dominant on the landscape, natural landscapes are fragmented, degraded, and confined to marginal areas. Deciduous forests dominate in steeper valleys and riparian areas defined by the stream network. Natural habitats are concentrated on public land and private conservation or hunting land. The USACE ownership maps define public lands that are managed for multiple uses, but with the intent to maximize habitat benefits. USACE easement lands are more difficult to classify. The protected areas database of the US (PADUS; Appendix A) does not indicate much land in their database.

Water Quality

This water quality threat assessment is very general using nationwide databases. There are better state level information systems that have refined data and models for some locations. These are discussed later with other Corps of Engineers data and can be investigated in the future. The EPA 303d listing had one highly impaired watershed, one moderate impaired, and few others (Figure 13). Resource Conservation and Recovery Act (RCRA) sites (Figure 13) are facilities where prior releases of hazardous waste has impaired soil, surface water, ground water, sediment, or air. They are governed by the Resource Conservation and Recovery Act which compels facility owners and operators to address the investigation and cleanup of hazardous releases themselves. Sites are concentrated in urbanized areas in Des Moines and Ames. Large leaking storage tanks are in municipal areas at fuel distribution stations. Rural areas have fewer large tanks, but numerous small unregulated farm fuel tanks.

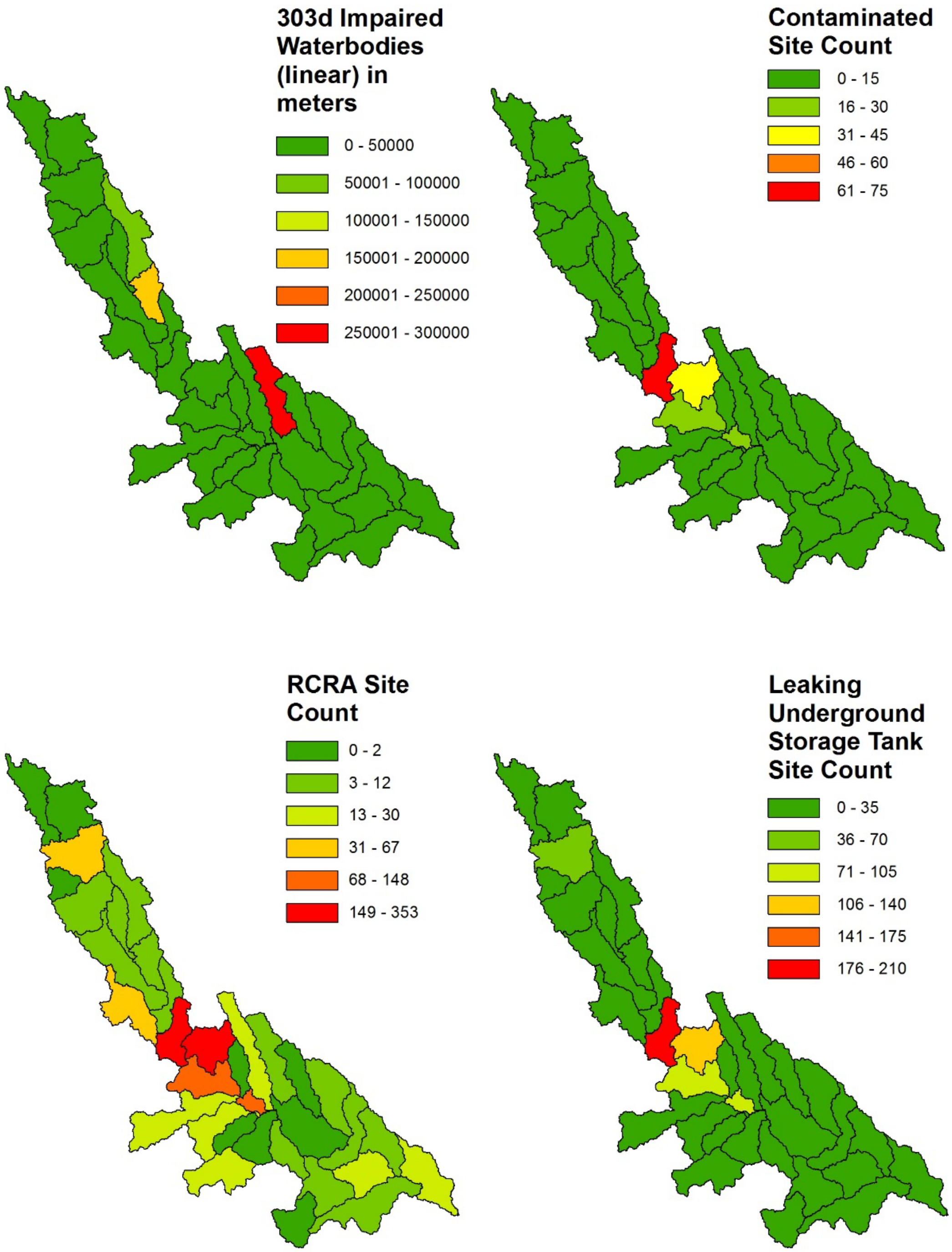


Figure 13 RCRA (US EPA 2012), Impaired waterbodies (US EPA 2014), Leaking Underground Storage Tank and Contaminate Site count (Iowa DNR 2016)

Social Vulnerability Index

The Social Vulnerability Index (SVI) is fourteen metrics in four themes: socioeconomic, housing composition and disability, minority status and language, housing and transportation. Vulnerability was concentrated in Ames, Des Moines, and Knoxville (Figure 14). The per capita income metric was lowest in the Des Moines core and highest in the surrounding statistical areas with agricultural areas in between (Figure 14).

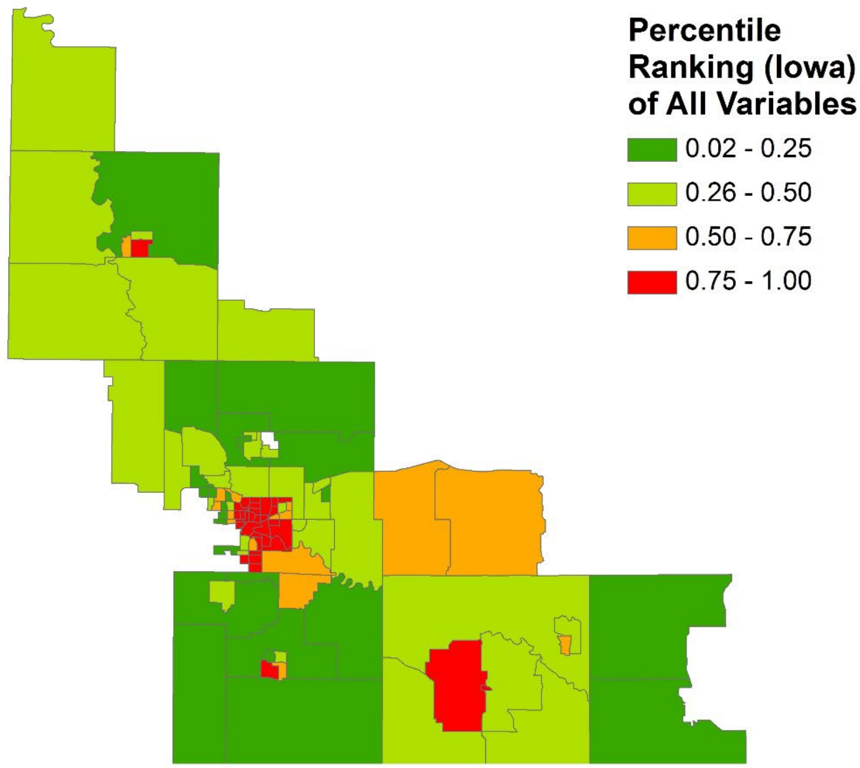


Figure 14: Social Vulnerability Index Iowa Percentile Ranking (CDC/ASTDR/GRASP 2010)

Assessment for Reservoir Management

The terrain of a landscape determines most of the physical watershed characteristics, land use practices, and social use impacts on the landscape. This study area is a glacial landscape split in half by two physiographic provinces. The Saylorville Lake watershed in the Des Moines Lobe is flat and characterized by prairie pothole wetlands, while Lake Red Rock lies in the Southern Iowa Drift Plain which has greater topographic relief and drainage. These differences translate to different types of agriculture water management and cropping practices. While there are many similarities in land use classification in watersheds surrounding the lakes, both large and small differences can be found upon closer inspection. Improved land and water management BMPs can be applied appropriately in the optimal locations using tools like the Agricultural Conservation Planning Framework (ACPF) as demonstrated below.

The Des Moines River above Saylorville Lake is entrenched in an agricultural landscape. Historically there would have been prairie land cover with little overland runoff and substantial wetland abundance away from the river valley. Wetland drainage was a large impact on native habitat and regional hydrology. Water runs off more rapidly in the highly developed agricultural landscape compared to undeveloped landscapes. The steep terrain in the river valley above Saylorville Lake, however, allowed riparian forests to persist relative to other parts of the watershed. The forest buffers would support wildlife corridors as well as help with sediment and nutrient processing.

Lake Red Rock is influenced largely from The Des Moines River upstream, as well as surrounding watersheds. The watersheds around Lake Red Rock have greater topographic relief leading to greater sediment transport potential through the watershed. Des Moines River floodplain geomorphology changes below the Skunk River as the floodplain widens into a large bottomland river. Seasonal flooding, diverse aquatic habitats, forests, and wetlands are characteristic of the natural environment, and much of that remains. Agriculture dominates the landscape, but the steeper slopes are in pasture and more evenly distributed through the watershed than the riparian corridors above Saylorville Lake. The Des Moines Metropolitan Area has a significant urban influence above Lake Red Rock.

Land productivity and water storage maps indicate important physical drivers on the watersheds surrounding Saylorville Lake and Lake Red Rock. The glacial outwash and prairie soil on the Southern Iowa Drift Plain created exceptionally productive soil (Figure 15). The Saylorville Lake and Lake Red Rock sub-watersheds are classified in the highest crop productivity categories which supports the abundant row crop agriculture. This is among the most productive farmland in the world and it will be farmed for the foreseeable future. In Corps watershed planning our rapid watershed assessment approach was able to quickly establish the existing and future without project land use which is important planning information.

The prairie soils and former wetland basins have high water retention capacity (Figure 15). Wetlands were drained a century ago, but tiling is an ongoing land management tool. High density pattern tiling has become standard practice to optimize soil moisture for crops. Tiling changes the timing and volume of runoff which may disrupt fish spawning ques or flush fish from preferred habitat. Adverse effects on water quality include increased scour with high volumes of clear water. Nitrogen fertilizers also dissolve and drain into surface waters with little retention for biological nutrient processing. There are no maps of tiling, but some stream channelization is captured in existing maps, so it is difficult to establish the existing hydrologic condition from ungauged watersheds and National Hydrography Data (NHD) maps. Lake managers can make reliable assumptions about hydrologic conditions and use local knowledge or data to supplement decision making. They can also invest in additional analysis and modeling of high priority sub-watersheds which is demonstrated below.

Targeting management efforts can be aided by seeking differences in watershed characteristics. Around Lake Red Rock, for instance, Calhoun Creek had apparently high CAFO abundance which would indicate greater phosphorus runoff potential. Under closer examination of other watersheds and other characteristics of that sub-watershed, it was seen that they are not out of the norm for the state but would be a priority in this location. Similarly, Walnut Creek has high grass abundance, but by comparison it also has high row crops and low forest. It will be important for local stakeholders to review these results and offer input. Simple interchanges project sponsors during this report identified mechanisms driving results and potential management actions.

The lake manager is subject to the regulations and land use practices upstream and in local watersheds. They must assess the existing condition and partner with neighbors to make improvements within the capacity dictated by annual budgets. This rapid watershed assessment can help classify and sort information relevant to the lake manager's mission. It can be used internally for land management decisions and externally to aid communication, understanding, and collaboration. There is much more information to be found in several watershed reports and in the significant water quality debate in Iowa. With agriculture so dominant on the landscape, ongoing CAFO and drainage district regulatory debates will have a significant effect on conditions in the lakes, but these are all outside the control of the lake manager. Using information available for this review, however, lake managers can overlay feeding operations on runoff potential maps to further refine BMP to address manure management in their operational area.

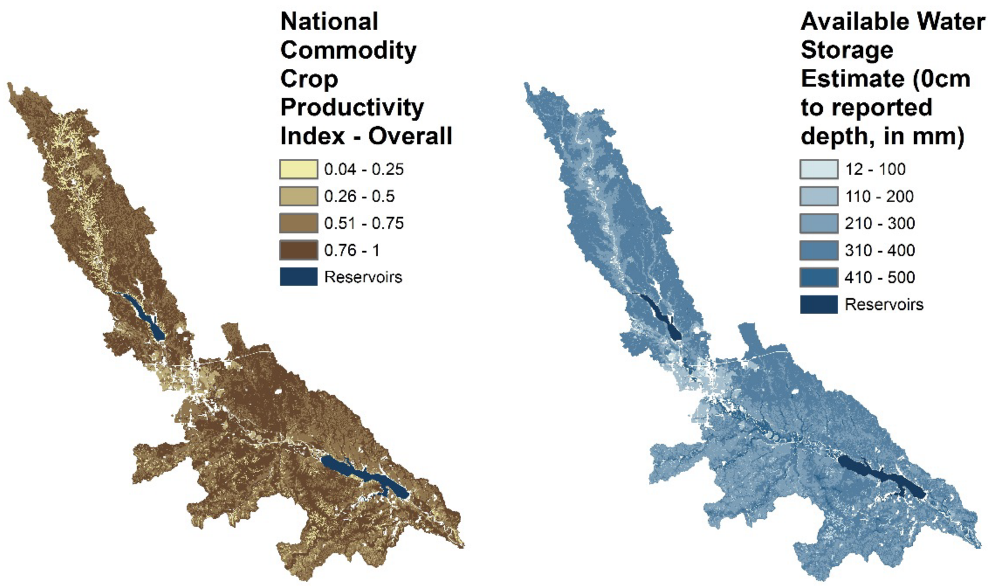
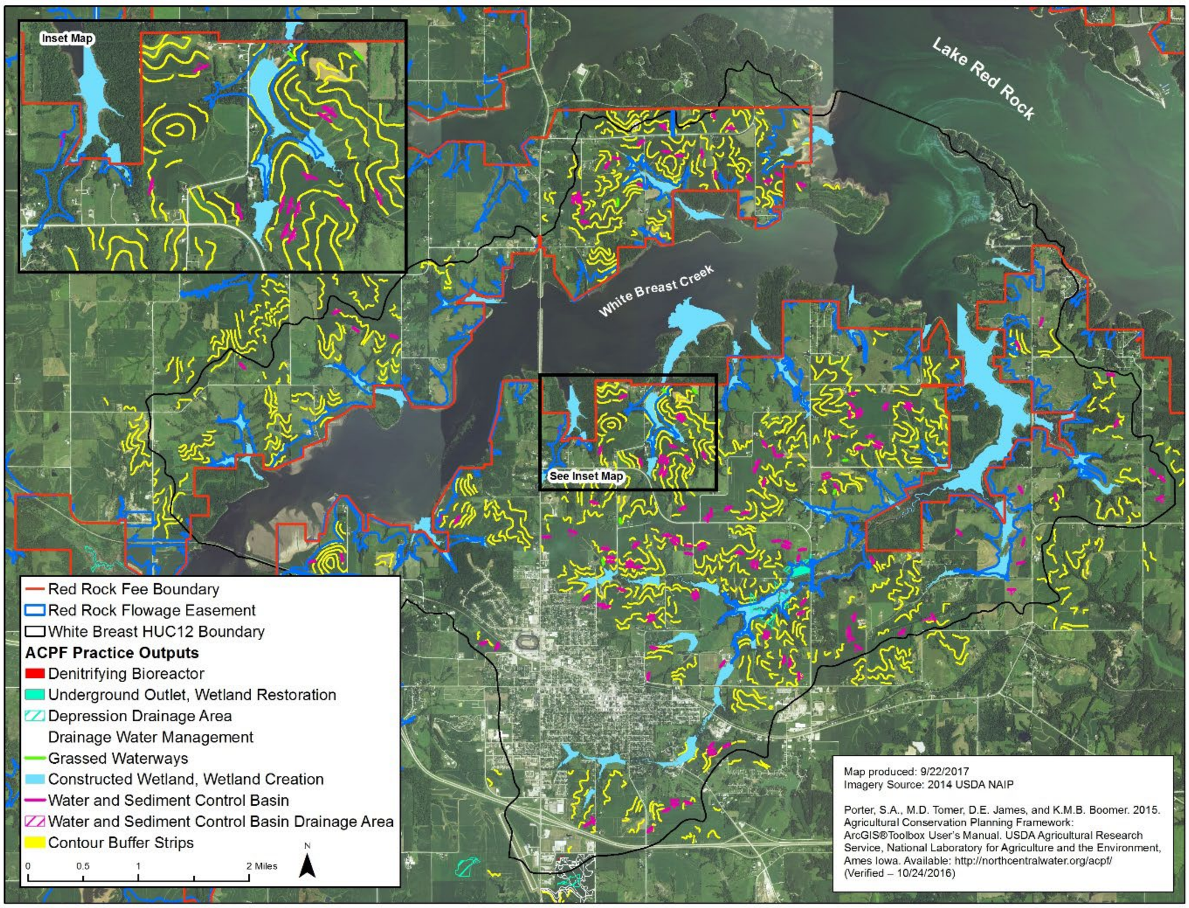


Figure 15. USDA National commodity crop productivity indices and available water storage (Soil Survey Staff 2015)

Advanced BMP Targeting

Map overlays are a straightforward analysis that can help identify threats in watersheds, but they are static representations of conditions in two dimensions. Once RWA prioritization is completed, advanced BMP targeting tools can be used to refine local watershed plans. The Agricultural Conservation Planning Framework (Tomer et al. 2013) incorporate terrains and flow accumulation in spatial models that can trace water movement and optimize the placement of water and sediment control basins (WASCOBs), contour buffer strips, tile outlet wetlands, drainage water management, nutrient removal wetlands. ACPF has been developed for several sub-watersheds and more are being completed and added to an online library. The example from White Breast Creek (Figure 16) identifies numerous potential BMP sites that must be reviewed with landowners in watershed assessments. The ACPF generates all the potential BMP sites with no constraints, whereas a watershed assessment includes considerations for replication of effort, impact on other land use, cost, and many other factors. The actual level of BMP implementation would be much less than depicted on ACPF outputs. Lake managers may have a much easier opportunity for BMP installation on their project lands, but partnerships are critical in these large geographic regions with most land in private ownership.



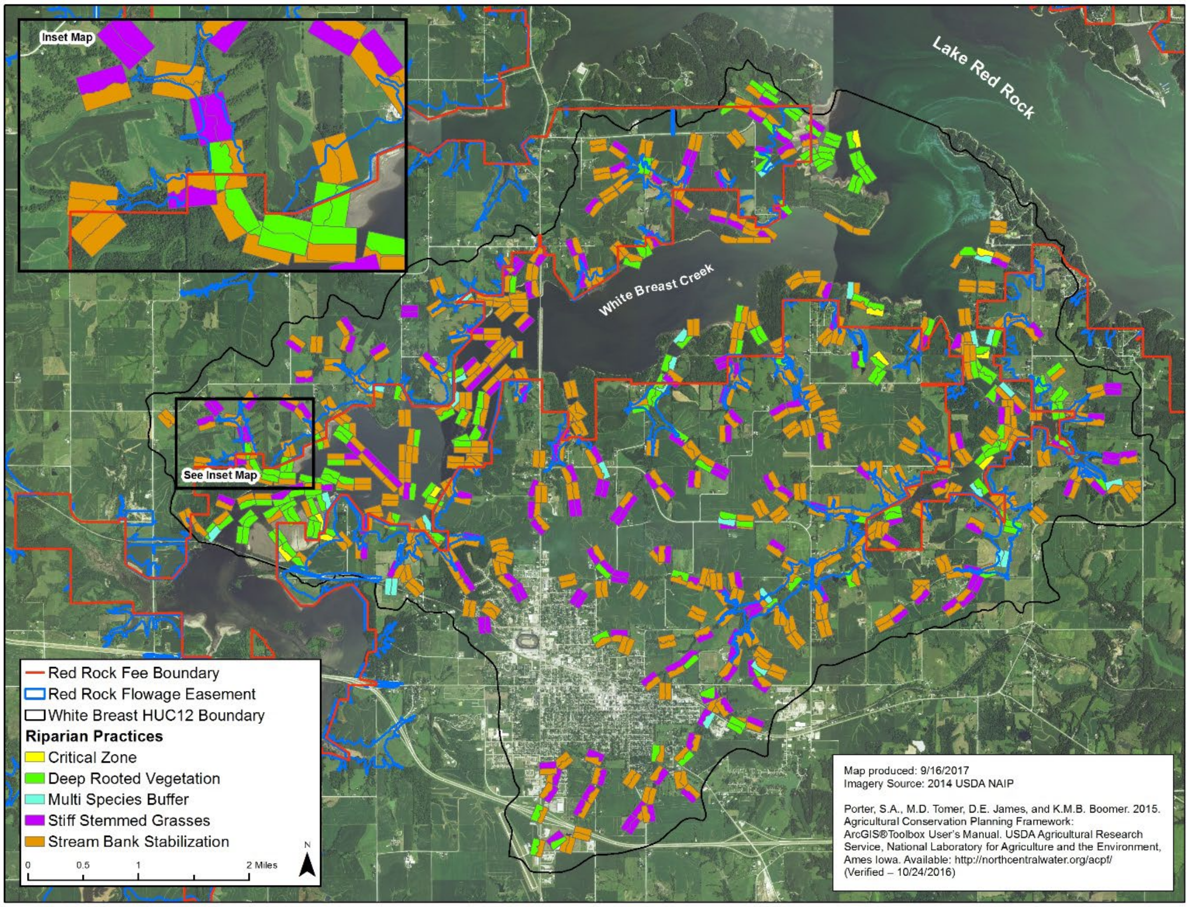


Figure 16. Agricultural Conservation Planning Framework output for BMP installation in the lower reach of the White Breast Creek sub-watershed.

Role in the Watershed

The Lake Red Rock Sustainable Rivers Project was initiated to help build a systems approach to Des Moines River management. SRP recognizes that dams and reservoirs can support more benefits when upstream and downstream factors are integrated. Several SRP studies document the increased water supply and hydropower benefits of being able to store more water in the flood control pool by increasing floodable area downstream. These factors were an important part of the re-regulation study. This analysis emphasizes the water quality functions the reservoirs support. Water quality in Saylorville Lake is particularly important because it supplements the water supply for Des Moines, Iowa. The lakes may also be serving a nutrient sequestration function that protects downstream river reaches and the Gulf of Mexico hypoxia. The carbon sequestration benefits of Corps reservoirs has been documented (USACE 2016).

Saylorville Lake is impaired for nitrates which poses a threat to human and environmental health. Nitrogen dynamics were investigated using long term water quality data records (26 years) to determine the role of the lake in removing nitrogen above the Des Moines Water Works intakes 12 miles below the dam. The lake showed an annual nitrate reduction of almost 5% between 1986 and 2011 (Stenbeck, et al. 2014). Nitrate retention was higher in low flow years where residence time was high and biological activities could process nutrients. Nutrient retention is slow in high flow years when the lake was flushed rapidly. Of particular relevance to the SRP, unpublished results suggest that dam operations could be used to reduce nitrates by an additional 1.23 mg/l during vulnerable periods (Keith Schilling, University of Iowa, Iowa City, Iowa, unpublished report).

The buffering effect of Saylorville Lake and Lake Red Rock could be assessed for other parameters using available data. Monitoring data is uncommon, but the Corps data helps understand the role of the lakes. New monitoring could also be implemented to better prioritize lake and watershed management opportunities. Local watershed groups are a potential resource for data and labor to support monitoring efforts.

There are also concerns, however, that the buffering capacity for some nutrients may be overwhelmed. Toxic algal blooms (i.e., harmful algal blooms or HABs) are becoming more common throughout Iowa and the large reservoirs are no exception. HABs have been detected on a number of occasions and caused many beach closures in 2016. HABs are an indicator of phosphorus enrichment linked to animal manure in the region. Managing local watershed inputs can increase the capacity of the reservoirs to buffer Des Moines River water.

Discussion

The reservoir RWA approach for Saylorville Lake and Lake Red Rock has been helpful to identify existing conditions, management opportunities, and the role of the reservoirs in the watershed. The assessment compiled multiple data layers to emulate USDA Rapid Watershed Assessments on a large scale. Data from 33 sub-watersheds help identify and prioritize remediation of stressors affecting water quality in the lakes. The stressors in agricultural Iowa are related to land use, sediment loading, and nutrient enrichment which are all abundant in these sub-watersheds. The location of Iowa's largest city, Des Moines, effects Lake Red Rock water quality differently than Saylorville Lake, and conversely Saylorville Lake supports water supply benefits for the city. The sediment and nutrient load from the mainstem Des Moines River is also high, but both of these stressors are somewhat outside the control of lake managers because mainstem inputs are the major water supply to reservoirs. Thus, we believed our approach helped target stressors within the operational control of the lake manager.

Considering local watershed conditions, the physiography of the sub-watersheds is considerably different, which creates different problems and opportunities. The low, flat poorly drained Des Moines Lobe, or prairie pothole region of the Saylorville Lake watershed contrasts with the topographic diversity of the Lake Red Rock sub-watersheds (Figure 17). The terrain drove channel evolution above the Skunk River toward an incised river valley with riparian forest remaining in the valleys and developed agriculture on the uplands. Lake Red Rock has much greater terrain diversity and a greater proportion of grass and pasture on slopes. These differences are important for sediment and nutrient transport management.

The SRP re-regulation study is considering a nutrient management alternative that can boost denitrification on managed mudflats in this area. Lake Red Rock nutrient reduction benefits have not been calculated like they have for Saylorville Lake. That investigation is critical to understand the functions Lake Red Rock provides for the Des Moines River downstream. Advanced sub-watershed investigations are necessary to identify available data and review ACPF outputs for implementation with partners in the watershed.

This methodology was developed to match USACE planning modernization requirements. It is a computer aided, rapid assessment of user-defined parameters available in existing databases. It is not comprehensive, but it is adaptable for lake manager's needs. We plan a future iteration of the RWA will be more public-facing as a "story map" document that can show visitors these data in a graphic illustration of watershed process and function using real data. As story map will have the following elements (ESRI web page):

1. Connect with audience,
2. Lure people in,
3. Choose user experience,
4. Make easy-to-read maps,
5. Strive for simplicity.

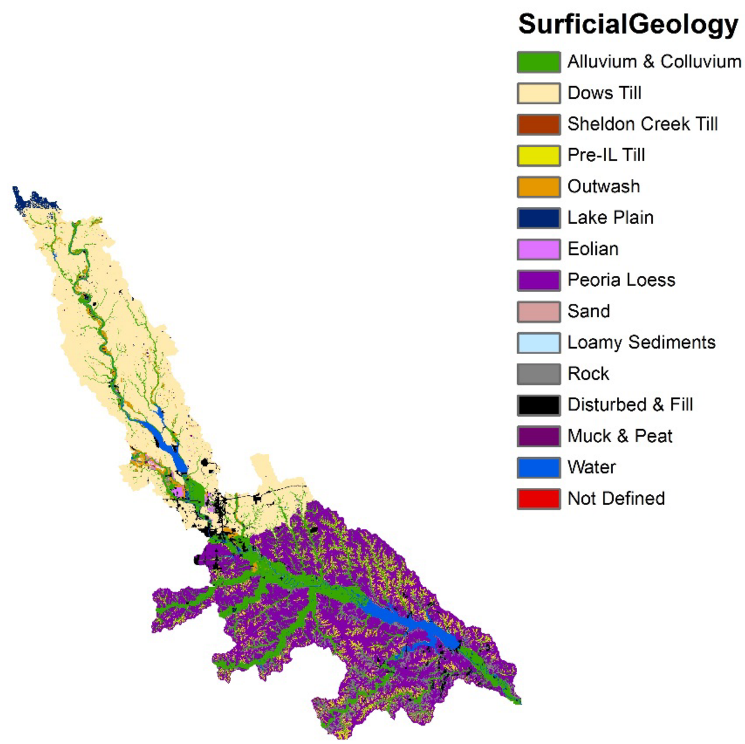


Figure 17. Surface geology of the Des Moines River watershed.

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