STORMWATER RETROFIT ASSESSMENT

FOR

INDEPENDENT SCHOOL DISTRICT 192

Prepared For:

Vermillion River watershed reflecting life

Prepared By:

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

Revised: October, 2018

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OVERVIEW

Independent School District 192 (ISD 192 or Farmington Area Public Schools) and the City of Farmington lie entirely within the Vermillion River Watershed. Sections of the river's main stem, as well as portions of three major tributaries (South Creek, Middle Creek, and North Creek) pass through Farmington from west to east. The Vermillion River main stem passes through Rambling River Park in downtown Farmington. A portion of the Vermillion River and some of its tributaries, beginning in the southeast corner of Lakeville and central Eureka Township, and stretching east through Farmington and Empire Township to a point just east of Highway 52 in Vermillion Township, have been designated as trout streams by the Minnesota Department of Natural Resources (DNR) and Class 2A waters by the Minnesota Pollution Control Agency (MPCA) and support a naturally reproducing population of brown trout. See Figures 1 and 2.

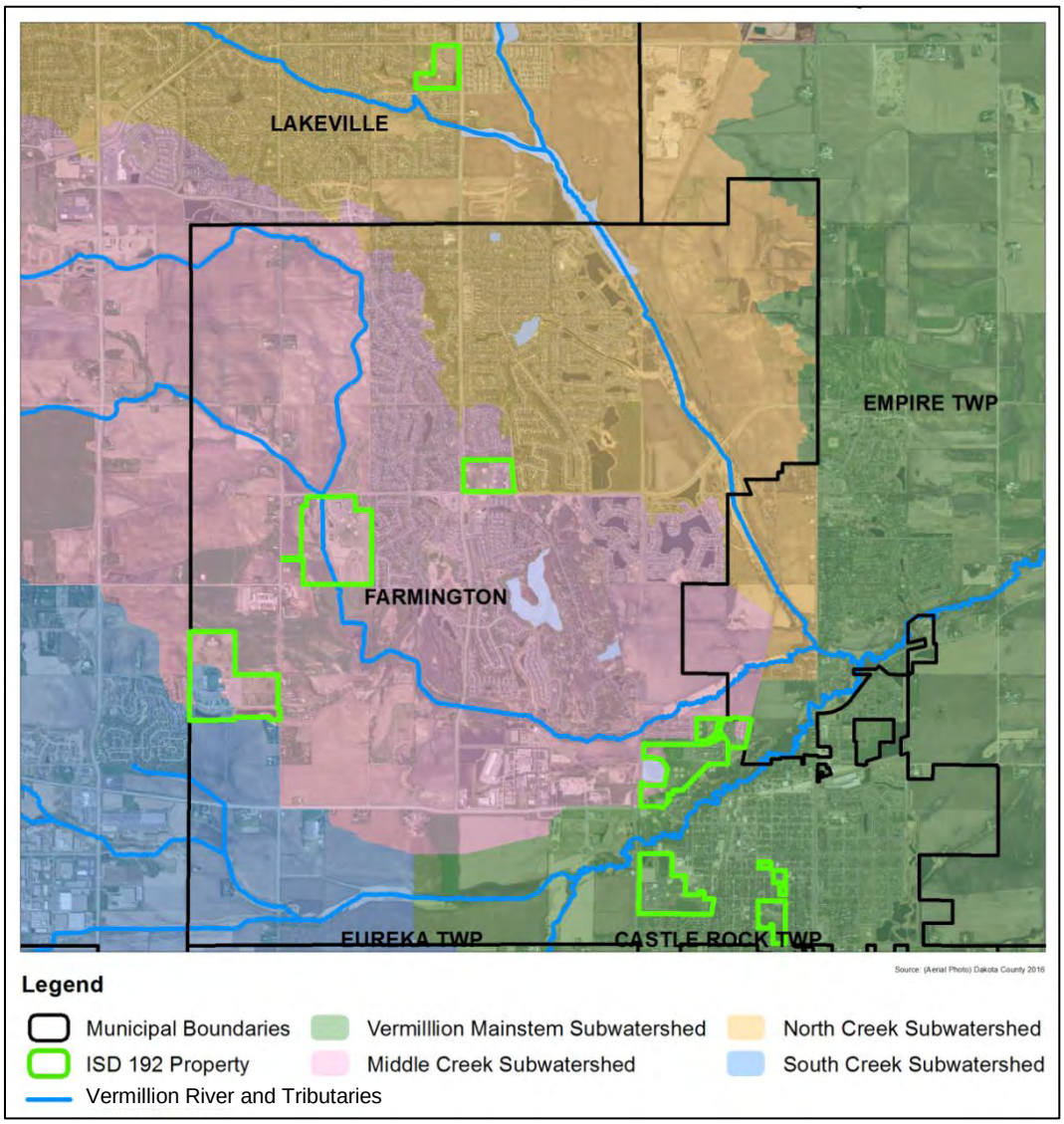


Figure 1.

Figure 2.

Water quality monitoring has revealed several pollutants that exceed the impairment thresholds set for the Vermillion River and its tributaries. Portions of the river and its tributaries within Farmington are impaired because they do not meet one or more of the state standards for turbidity, fecal coliform bacteria, dissolved oxygen, mercury, as well as fish and macroinvertebrate health. The water clarity (turbidity) impairments indicate that too much sediment is moving through the system, which impacts habitat quality and overall river health.

Many ISD 192 properties are in close proximity to the Vermillion River or its direct tributaries, as shown in Figure 2. This provides an opportunity for water quality improvement practices implemented on District 192 properties to have a direct benefit to the Vermillion River. Additionally, schools are seen as high value partners for their ability to incorporate stormwater management improvements into their curriculum.

In an effort to reduce the pollutants reaching the river and its tributaries, this report calculates sediment, phosphorus, and volume reductions provided by individual potential stormwater best management practices (BMPs) on ISD 192 property. For ranking purposes, BMPs were prioritized by

cost effectiveness with respect to sediment reduction for each stormwater BMP, then by volume reduction, and then by phosphorus reduction. Each property is unique and presents opportunities and challenges to implementing stormwater improvements. The various properties included in this report are shown in Figure 3.

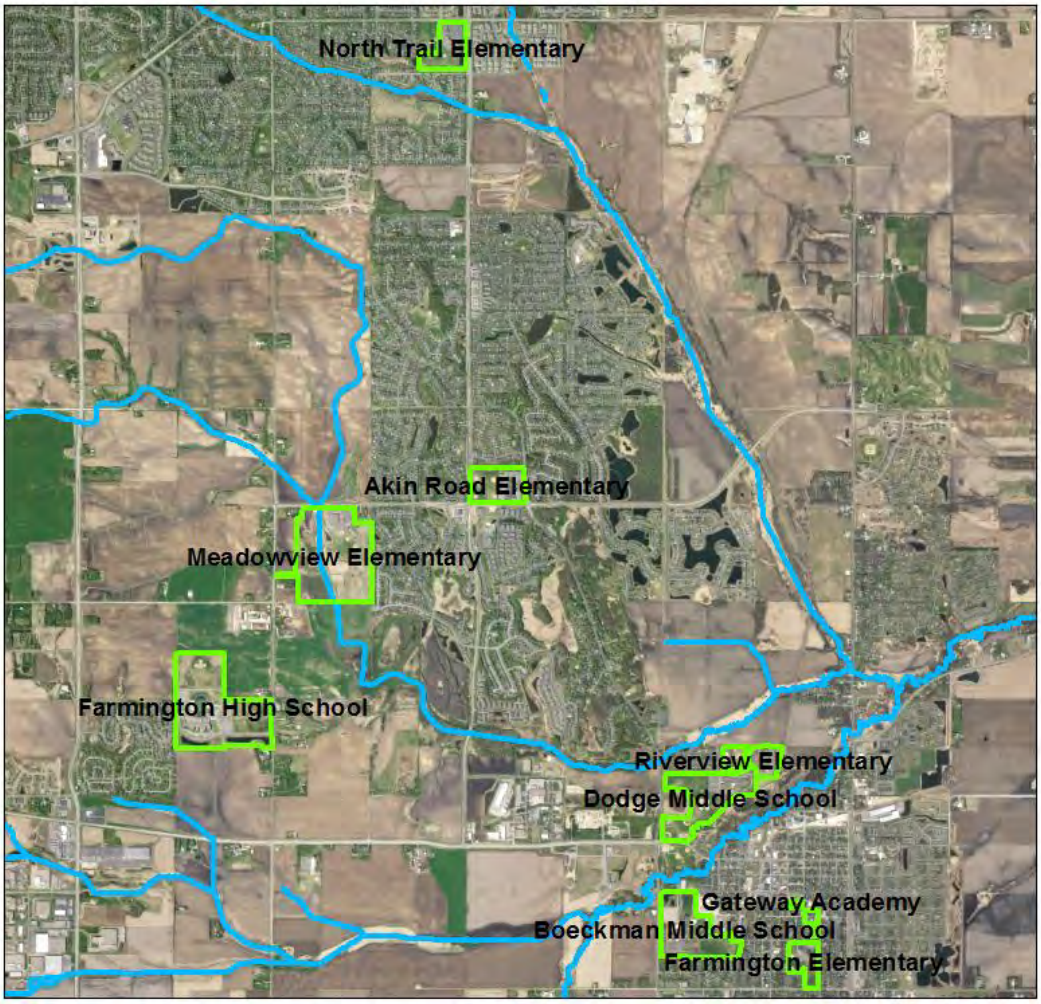


Figure 3.

ISD 192 properties were assessed to determine potential locations for structural stormwater BMPs. Maintenance issues related to stormwater facilities are noted in the report as well. Results of this assessment are based on the identification of conceptual site-specific BMPs that provide water quality treatment and water volume reductions on the landscape. Estimated final construction costs and pollutant removals will need to be refined once BMPs are selected for construction.

Constructed BMPs should be considered as one part of an overall stormwater improvement plan that also includes non-structural BMPs, such as education and outreach, upstream discharge reductions, and pollutant source control such as street sweeping and erosion control. Non-structural BMPs have the potential for substantial pollutant reduction.

The pollutant removal estimates provided in this report should be used to prioritize practices for planning purposes and grant applications but in no case should this data be used to represent actual pollutant removal until after further design and installation is complete and site-specific modeling

and/or monitoring data is available. If a specific project outlined in this report is selected for installation, site specific designs, landowner agreements, and funding sources must be secured in order to implement the BMP. The collection of projects listed in this report can be updated as new projects, opportunities, or technologies are identified.

This process is intended to assist the Vermillion River Joint Powers Organization, ISD 192, and other partner agencies in maximizing the value of funds spent implementing stormwater BMPs through a prioritized and targeted process. The process serves to identify practices that will reduce pollutants of concern in the Vermillion River, locate field-verified BMPs for implementation, prioritize those BMPs for cost effectiveness, ensure that the implemented projects provide measureable results, and facilitate the installation of projects by ISD 192 and the Vermillion River Watershed Joint Powers Organization.

METHODS

Desktop Analysis

All ISD 192 parcels were identified through Dakota County property records and using ArcMAP Geographic Information Systems (GIS) software. To streamline site assessments, individual schools were assessed as a whole campus unit rather than individual parcels (i.e. parcels were combined to form a site).

Property boundaries were overlaid with an aerial photo. Additional information including 1 foot elevation contours, wetlands and watercourses, and storm sewer information, acquired from the cities of Farmington and Lakeville, was added to determine sub-catchment areas and receiving waters. This information was used to produce a map of each school campus for drainage area delineation and field reconnaissance.

Field Reconnaissance

Using the maps created for each school as a guide, field investigations were conducted to evaluate assumptions from the desktop analysis, identify potential BMP locations, and project drainage areas, and assess site-limiting factors for BMP implementation. Site constraints were assessed to determine the most feasible BMP options as well as to eliminate sites from consideration. The field investigation also revealed BMP opportunities that could have gone unnoticed using only a desktop analysis. During the site investigation, drainage areas and other mapped data was verified. The entirety of each school site was walked on foot during this portion of the assessment.

Example of potential BMP location at Boeckman Middle School

Potential stormwater BMPs were selected from those identified in the Minnesota Stormwater Manual with a strong focus on bioretention BMPs. Bioretention was the primary focus due to its ability to provide stormwater runoff volume control and pollutant removal through infiltration, filtration, and evapotranspiration. Bioretention is also a versatile stormwater treatment practice suitable for most land uses and native soil types and is typically one of the most cost effective practices to implement. Bioretention is versatile due to its ability to easily be incorporated into landscaped areas as a stormwater retrofit.

Table 1 contains information on the BMPs considered as part of this assessment. More information on the BMP types considered for implementation can be found in Appendix 1.

Projects identified during the field reconnaissance were sited at the best locations for BMP installations to provide pollutant treatment based on existing information, professional knowledge, and past experience. The presence of existing BMPs providing stormwater treatment and the corresponding need for additional BMPs was strongly considered during this process. Following field reconnaissance, field maps and recorded notes were digitized. The locations of 43 potential BMPs were identified on ISD 192 properties.

Table 1. Best Management Practices Considered for Assessment

ID	BMP TYPE	DESCRIPTION
B	Bioretention Basin	A water quality and water quantity control process which employs a simplistic, site-integrated basin design that provides opportunity for runoff infiltration, filtration, storage, and water uptake by vegetation.
P	Retention Pond	A constructed basin that is built for the purpose of capturing and storing stormwater runoff, in order to allow for gravitational settling of particulate pollutants.
RI	Stormwater Reuse Irrigation	A constructed system that captures and retains stormwater for beneficial use at a different time or place than when or where the stormwater was generated.
IR	Impervious Reduction	Removal of asphalt, concrete, or other impervious paved surfaces which may no longer be necessary to the operation or function of site activities, such as unused parking lots.

Initial Construction Cost Estimates

After digitizing each proposed BMP location and its associated drainage area using ArcMap, the BMP size was calculated based on the drainage area and land use. In the case of bioretention BMPs, basin size refers to the size of the amended soils; in most cases the project footprint for the bioretention BMPs would be larger than the square footage shown on the project profile maps. This allows for diversions/inlets to the BMP, containment berms, or other components needed to properly treat water at the BMP. Basin size of retention ponds refers to the limits of ponded water where similarly, the project footprint would be larger.

Each project was then assigned an estimated unit cost for construction based on basin size. This was based on a compilation of average construction costs of similar projects installed in Dakota County from the most recent 5 year period as well as with values found in the referenced stormwater BMP

literature. Adjustments to individual project costs were made based on professional judgement to account for unique project conditions, such as increased difficulty in constructability, additional soil removal and disposal, required retaining walls, extensive grading, tree removal, etc. Table 2 provides the estimated construction costs for each identified BMP.

Lifecycle Costs

Lifecycle costs for each BMP were also calculated which include both initial construction costs and the cost of on-going maintenance of these projects. Descriptions of how lifecycle costs were calculated for each BMP type is below.

For bioretention basins, the lifecycle cost assumes that during the twenty year project lifespan, one minor repair (3% of the initial project cost) would occur five times. This could include potential plant replacement, mulch replacement, or erosion repair. The lifecycle cost also assumes a major repair (10% of the initial project cost) would occur one time through the course of normal maintenance. This could include repairs to the inlet, piping, or outlet.

For the stormwater retention ponds, the lifecycle cost assumes that during the twenty-five year project lifespan, one minor repair (10% of the initial project cost) would occur. This could include vegetative restoration or erosion repair. The lifecycle cost also assumes a major repair (25% of the initial project cost) would occur one time through the course of normal maintenance. This would include major removal of sediment from the retention pond.

For the reuse irrigation systems, the lifecycle cost assumes that during the twenty year project lifespan (5% of the initial project cost) would occur eight times. This assumes that the technology associated with the irrigation system requires more active maintenance compared to other stormwater BMPs, with professional technicians required to maintain operation of the system. The lifecycle cost also assumes a major repair (10% of the initial project cost) would occur one time. This accounts for repair or component replacement during the course of the project lifespan.

For the impervious reduction practices, there was no lifecycle cost included added onto the initial construction cost.

Treatment Analysis

Each bioretention basin and stormwater retention pond was modeled using WinSLAMM (Source Loading and Management Model for Windows) Version 10.1. The reported treatment levels are dependent upon optimal site selection and sizing, which would be further refined during the design phase. Not all locations and sizes will yield the same results. The pollutant removal estimates may be used to prioritize practices identified in this report and represent the best professional judgement of the modeler, however they should not be used to represent the final pollutant removal until they are modified to reflect post construction conditions. Example WinSLAMM BMP model inputs can be found in Appendix 2.

The stormwater reuse irrigation systems were modeled using EOR's Stormwater Harvesting and Reuse Model V2.0., in conjunction with WinSLAMM, to calculate pond size. Example inputs for the Stormwater harvesting Reuse Model V2.0 can be found in Appendix 2.

LIMITATIONS AND ASSUMPTIONS

Identified BMPs were selected based on available data in ArcMap as well as visible field observations. Due to limited information or potentially inaccurate information on underground storm sewer piping location, size, and depth, potential BMPs shown in this report require further investigation prior to implementation.

The location of utilities was not known during field reconnaissance and may affect the feasibility of individual BMPs included in this report. A detailed topographic survey, underground utility locates, soil borings, detailed engineering calculations, and discussion with ISD 192 facility staff are necessary before designs are completed and BMPs are implemented.

Final design may vary from what is proposed in this report. Assumptions were made on the size and depth of the existing retention ponds, which would be the source for stormwater reuse irrigation systems. Assumptions were also made on the areas to be irrigated.

This report does not include analysis of potential pollutant reductions when BMPs are used in combination with each other or when there is existing treatment between the proposed BMP and the affected water resource. During implementation of multiple BMPs on a site, pollutant reductions should be recalculated to avoid redundancies and more accurately represent actual conditions.

Cost estimates represent construction and maintenance costs for each project installed at that particular location. Depending on project complexity, additional project costs ranging from 25% to 50% of the construction cost should be considered to account for project engineering, design, outreach, and promotion. Conversely, there is a large potential for project savings due to economies of scale, should multiple projects be implemented simultaneously.

COST/BENEFIT AND PROJECT RANKING TABLE

After potential BMPs were identified, estimated pollutant reductions calculated, and preliminary cost estimates compiled, the projects were then ranked from most cost effective to least cost effective, based on cost per ton of sediment removed over the project's life-cycle. Table 2 summarizes the recommended and ranked BMPs within ISD 192 properties. Given the noted limitations and assumptions included above, the cost/benefit ranking should serve as a guide for future planning and project prioritization. Further design development will determine the feasibility, project parameters, and cost of individual projects.

Table 2. Recommended BMPs Ranked first by Sediment, then Volume, then Phosphorus Reduction Cost/Benefit

Details		Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
1	Dodge Middle School P1	$175,000	$236,250	3.11	7,632	12.97	$3,038	$1.2383	$729	No
2	Frm. Elementary B4	$13,500	$16,875	0.20	12,166	0.79	$4,293	$0.0694	$1,063	No
3	Frm. Elementary B3	$16,000	$20,000	0.23	14,429	1.15	$4,298	$0.0693	$866	No
4	Boeckman B1	$70,000	$87,500	0.95	173,733	2.35	$4,621	$0.0252	$1,860	Yes
5	North Trail B3	$12,000	$15,000	0.16	7,411	0.48	$4,826	$0.1012	$1,559	Yes
6	Boeckman B8	$25,000	$31,250	0.29	52,780	0.74	$5,402	$0.0296	$2,110	Yes
7	North Trail B6	$24,000	$30,000	0.27	48,729	0.72	$5,573	$0.0308	$2,072	Yes
8	Akin B1	$49,000	$61,250	0.55	74,900	2.40	$5,581	$0.0409	$1,277	Yes
9	North Trail B2	$49,000	$61,250	0.55	74,317	2.41	$5,607	$0.0412	$1,269	Yes
10	Dodge Middle School B4	$61,000	$76,250	0.66	115,024	1.92	$5,791	$0.0331	$1,982	No
11	Meadowview B1	$42,000	$52,500	0.43	70,711	1.47	$6,062	$0.0371	$1,781	Yes
12	North Trail B4	$16,500	$20,625	0.17	12,341	0.50	$6,192	$0.0836	$2,068	Yes
13	Akin B2	$30,000	$37,500	0.29	40,024	1.25	$6,426	$0.0468	$1,500	Yes
14	Dodge Middle School B5	$42,000	$52,500	0.40	66,572	1.40	$6,552	$0.0394	$1,869	No
15	Boeckman B9	$24,000	$30,000	0.23	41,276	0.60	$6,600	$0.0363	$2,513	Yes
16	Dodge Middle School B6	$16,000	$20,000	0.15	19,137	0.83	$6,615	$0.0523	$1,200	No
17	North Trail B1	$28,000	$35,000	0.26	35,641	1.20	$6,623	$0.0491	$1,459	Yes
18	Dodge Middle School B1	$13,500	$16,875	0.13	19,724	0.45	$6,677	$0.0428	$1,891	No
19	North Trail B7	$26,000	$32,500	0.24	43,160	0.64	$6,806	$0.0377	$2,527	Yes
20	Gateway Academy B2	$20,000	$25,000	0.18	32,727	0.48	$6,931	$0.0382	$2,630	No
21	Boeckman B4	$15,750	$19,688	0.13	18,213	0.58	$7,392	$0.0540	$1,708	Yes
22	Dodge Middle School B2	$20,000	$25,000	0.17	22,649	0.87	$7,452	$0.0552	$1,430	No
23	Frm. Elementary B2	$16,000	$20,000	0.13	23,201	0.38	$7,680	$0.0431	$2,659	No
24	North Trail B5	$10,000	$12,500	0.08	10,799	0.37	$7,764	$0.0579	$1,673	Yes
25	North Trail B8	$11,000	$13,750	0.09	11,911	0.39	$7,819	$0.0577	$1,745	Yes
26	Dist. Services Ctr. IR1	$25,000	$25,000	0.08	16,403	0.09	$7,819	$0.0381	$6,914	No
27	Frm. Elementary B1	$24,000	$30,000	0.19	34,173	0.53	$7,877	$0.0439	$2,822	No
28	Boeckman B6	$25,000	$31,250	0.20	35,542	0.51	$7,984	$0.0440	$3,043	Yes
29	Boeckman B3	$13,750	$17,188	0.10	14,136	0.46	$8,268	$0.0608	$1,869	Yes
30	Dodge Middle School B3	$54,000	$67,500	0.40	72,911	1.08	$8,369	$0.0463	$3,112	No
31	Akin B6	$16,000	$20,000	0.12	21,776	0.29	$8,437	$0.0459	$3,462	Yes
32	Boeckman B2	$20,000	$25,000	0.15	26,898	0.37	$8,497	$0.0465	$3,357	Yes
33	Akin B4	$24,000	$30,000	0.17	31,874	0.43	$8,627	$0.0471	$3,462	Yes
34	Boeckman B5	$10,000	$12,500	0.07	9,645	0.31	$8,980	$0.0648	$2,029	Yes
35	Gateway Academy B1	$30,000	$37,500	0.20	32,325	0.69	$9,357	$0.0580	$2,733	No
36	Akin B5	$14,625	$18,281	0.09	17,442	0.23	$9,629	$0.0524	$3,905	Yes
37	Boeckman B7	$16,875	$21,094	0.11	19,685	0.28	$9,744	$0.0536	$3,739	Yes
38	Akin B3	$10,000	$12,500	0.06	10,299	0.14	$11,151	$0.0607	$4,522	Yes
39	Dist. Services Ctr B1	$24,000	$30,000	0.13	23,416	0.37	$11,439	$0.0641	$4,001	No
40	North Trail RI1	$40,000	$60,000	0.00	324,554	1.95	n/a	$0.0092	$1,538	Yes
41	High School RI1	$40,000	$60,000	0.00	296,663	1.75	n/a	$0.0101	$1,714	Yes
42	Boeckman RI1	$40,000	$60,000	0.00	142,166	1.03	n/a	$0.0211	$2,913	Yes
43	Dodge Middle School RI1	$40,000	$60,000	0.00	340,782	2.05	n/a	$0.0088	$1,465	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

PROPERTY PROFILES

The following property profiles correspond to each ISD 192 school campus and include a text description of each property, the current state of stormwater management, and the site's connection to adjacent water resources.

An aerial photo is included showing the property boundaries, location of storm sewer lines and inlets, proposed BMPs, and their drainage areas. Portions of the property not shown on the aerial photo are deliberately omitted because no BMPs were identified in those areas. Each BMP has a unique identification code to coincide with the property location, project type, and project number.

Each property profile includes a table listing the BMPs specific to that property. The table shows the overall ranking of the project across all ISD 192 properties, as well as on that individual property. Just as in Table 2, the ranking is from most cost effective to least cost effective, based on cost per ton of sediment removed over the project's life-cycle.

Akin Road Elementary

Description:

Akin Road Elementary is located at the northwest corner of Akin Road and 195th Street in Farmington. The property consists of 31 acres which includes the school, athletic fields, and four baseball fields. Changes were recently made to the configuration of the north parking lot in 2015, with the east parking lot repaved at the same time.

The majority of the site drains towards the north and west to a shallow pond/converted wetland. The pond/wetland was partially open water around 2000 but has since filled in nearly completely with cattails. The site drainage enters a number of stormwater ponds and wetlands to the south of the school before entering Middle Creek and then flowing to the Vermillion River.

Identified BMPs:

Opportunities exist for bioretention BMPs near the parking lots and entrances. The Akin B1 drainage area is the only portion of the site which does not currently flow to the pond/wetland on the northwest corner of the site. The level of treatment provided by the existing pond/wetland on the northwest corner of the site is unknown however it appears to have filled in with sediment over the last 25 years. Opportunities for maintenance of existing pond to provide increased storage and treatment capacity through a modification to the pond/wetland should be investigated. Additionally, bioretention BMPs placed throughout the site (B2-B6) could help reduce the required capacity of the pond/wetland and promote infiltration of stormwater from the parking lots.

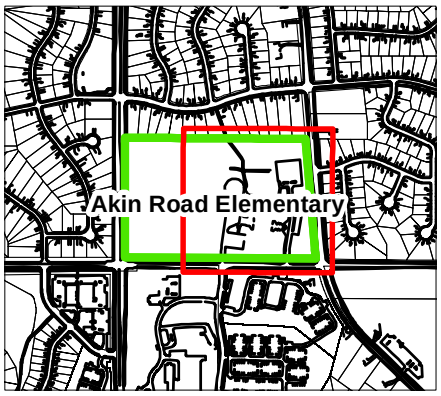
BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
8	1	Akin B1	$49,000	$61,250	0.55	74,900	2.40	$5,581	$0.0409	$1,277	Yes
13	2	Akin B2	$30,000	$37,500	0.29	40,024	1.25	$6,426	$0.0468	$1,500	Yes
31	3	Akin B6	$16,000	$20,000	0.12	21,776	0.29	$8,437	$0.0459	$3,462	Yes
33	4	Akin B4	$24,000	$30,000	0.17	31,874	0.43	$8,627	$0.0471	$3,462	Yes
36	5	Akin B5	$14,625	$18,281	0.09	17,442	0.23	$9,629	$0.0524	$3,905	Yes
38	6	Akin B3	$10,000	$12,500	0.06	10,299	0.14	$11,151	$0.0607	$4,522	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Akin Road Elementary

Source: (Aerial Photo) Dakota County Spring 2017



Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 Feet

Boeckman Middle School

Description:

Boeckman Middle School is located northeast of Denmark Avenue and 220th Street in Farmington. The entire site consists of nearly 59 acres which includes the school, four ballfields, football fields, a football stadium, and extensive parking lots. The building was previously the Farmington High School and therefore has a large north parking lot, that is often under-utilized.

The entire site drains to the north, with the majority of stormwater runoff going to a stormwater retention pond. Portions of the south and west areas of the site drain to the road ditch, which follows Denmark Avenue to a wetland on the northwest corner of the property. The existing stormwater pond also drains to this wetland which then flows directly to the Vermillion River. Infiltration BMPs currently exist on the south side of the south parking lot.

Identified BMPs:

Due to the changed use of the property from a high school to a middle school and subsequent reduced need for parking spaces, a reduction of impervious surface through removal of a portion of the north parking lot could be investigated. Multiple opportunities exist for bioretention BMPs near the parking lots. Bioretention BMPs implemented near the east, west, and north parking lots could promote infiltration and reduce the overall volume of water that is flowing to the wetland on the northwest corner of the property and then to the Vermillion River. The stormwater pond provides an opportunity to install a stormwater reuse irrigation system for the nearby football stadium.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
4	1	Boeckman B1	$70,000	$87,500	0.95	173,733	2.35	$4,621	$0.0252	$1,860	Yes
6	2	Boeckman B8	$25,000	$31,250	0.29	52,780	0.74	$5,402	$0.0296	$2,110	Yes
15	3	Boeckman B9	$24,000	$30,000	0.23	41,276	0.60	$6,600	$0.0363	$2,513	Yes
21	4	Boeckman B4	$15,750	$19,688	0.13	18,213	0.58	$7,392	$0.0540	$1,708	Yes
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29	6	Boeckman B3	$13,750	$17,188	0.10	14,136	0.46	$8,268	$0.0608	$1,869	Yes
32	7	Boeckman B2	$20,000	$25,000	0.15	26,898	0.37	$8,497	$0.0465	$3,357	Yes
34	8	Boeckman B5	$10,000	$12,500	0.07	9,645	0.31	$8,980	$0.0648	$2,029	Yes
37	9	Boeckman B7	$16,875	$21,094	0.11	19,685	0.28	$9,744	$0.0536	$3,739	Yes
42	10	Boeckman RI1	$40,000	$60,000	0.00	142,166	1.03	n/a	$0.0211	$2,913	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
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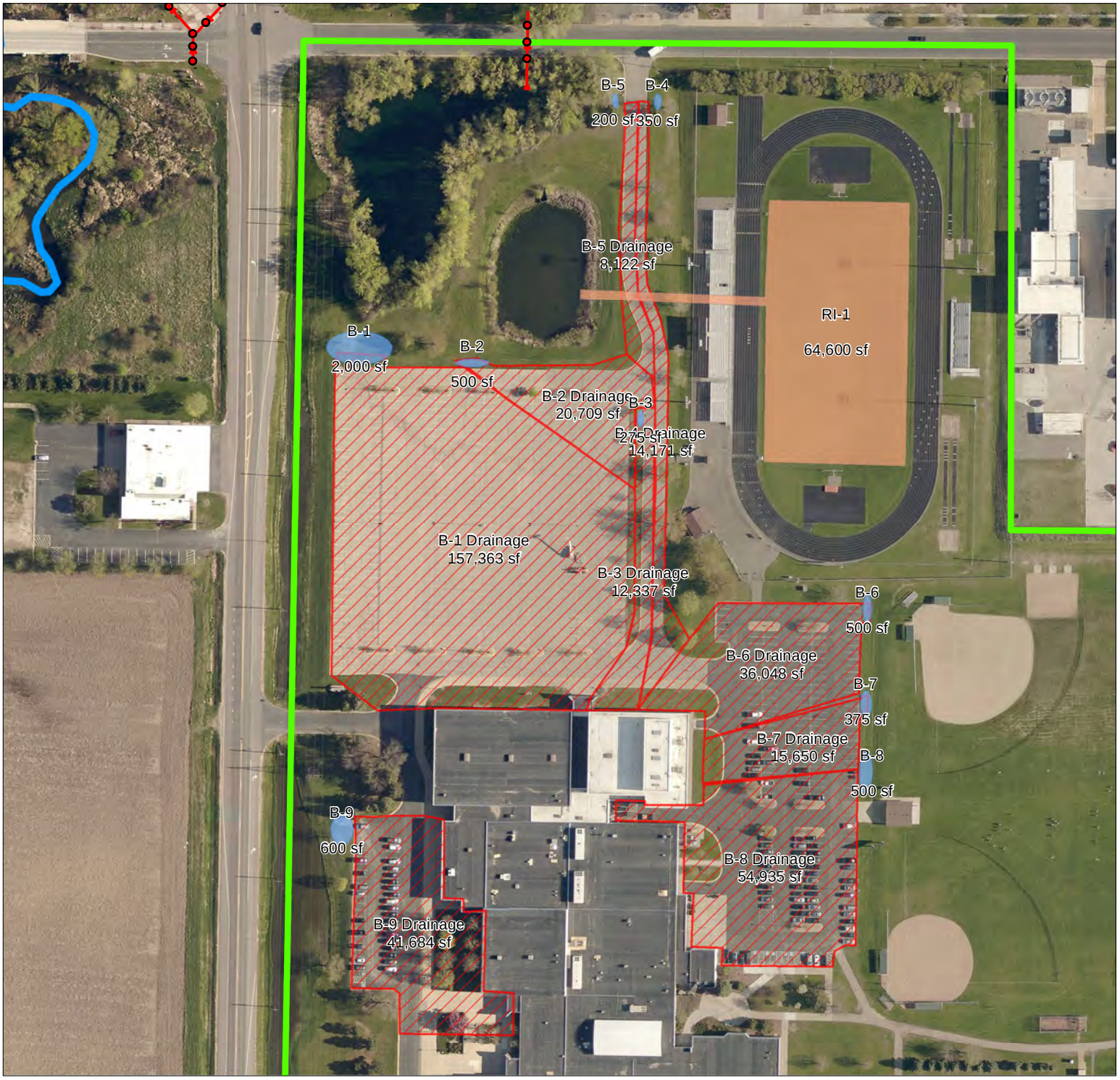
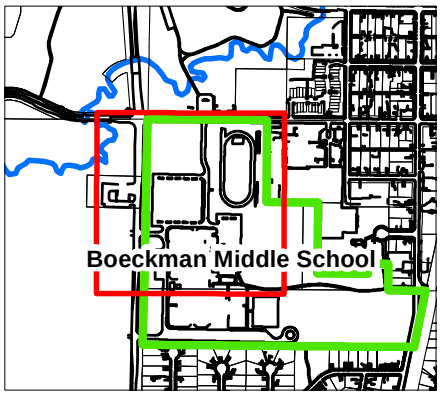
Boeckman Middle School



Source: (Aerial Photo) Dakota County Spring 2017



Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 300 Feet

District Services Center

Description:

The District Services Center property is located northwest of Walnut Street and 5th Street in Farmington. The 1.38 acre site consists primarily of the building with some landscaping and the parking lot. The building appears to be infrequently used.

The entire site drains directly to the City storm sewer system. The majority of hard surface drainage is directed towards two catch basins located in the center of the parking lot. The remainder of the site drains towards the street and alley. The site stormwater runoff ultimately drains to the north along 4th Street where it enters the Vermillion River via a 60 inch pipe.

Identified BMPs:

Two stormwater pipes which drain approximately 60 acres of residential land to the south and east of the District Services Center converge on the southwest corner of the site. If the current amount of parking is not necessary on the site, there is an opportunity to convert portions of the paved parking lot to green space. A portion of the parking lot could also be converted to a bioretention basin.

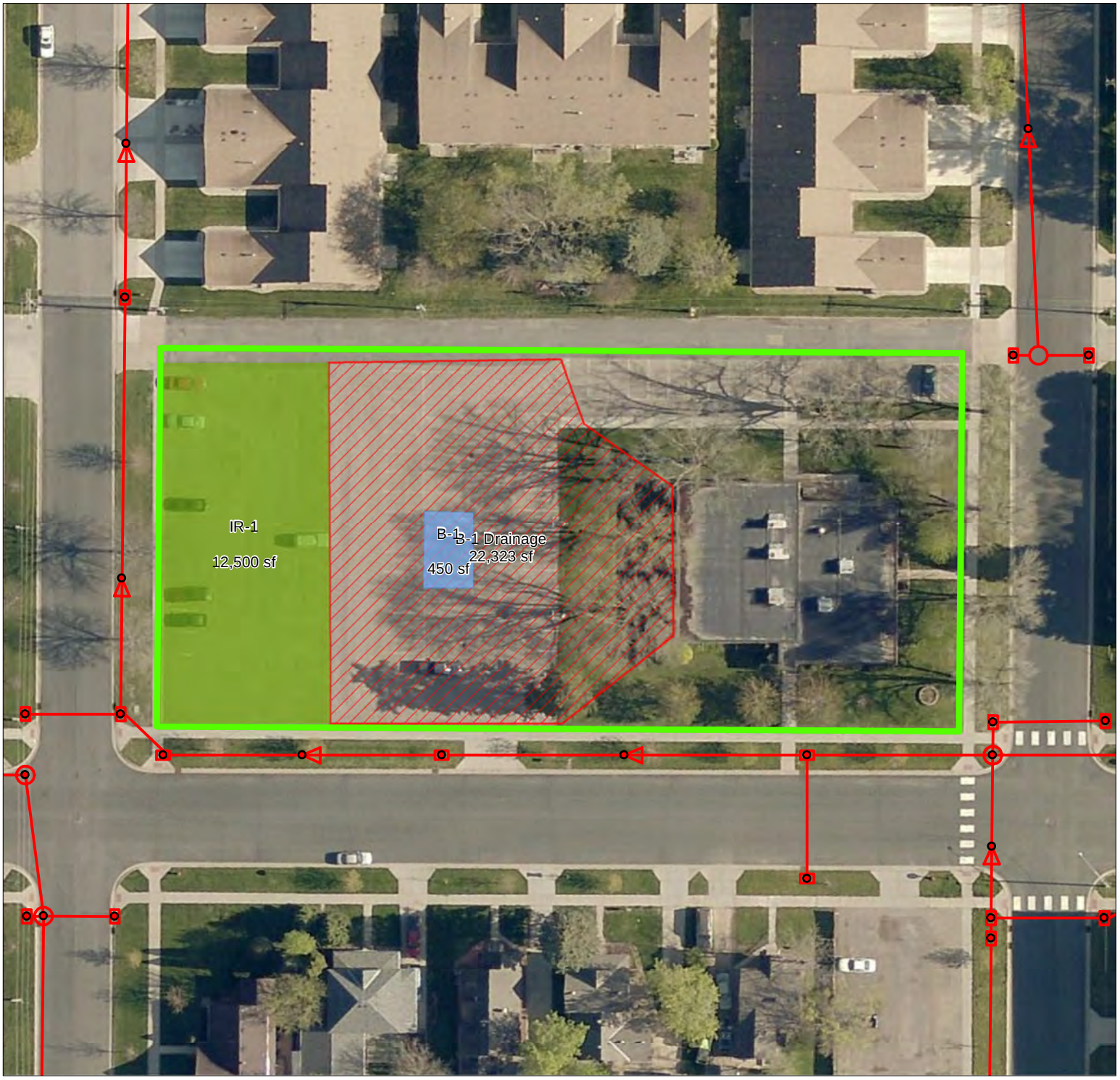
If possible, further investigation into a regional stormwater treatment pond or hydrodynamic separators located on the property could be beneficial. Costs for the installation of hydrodynamic separators could range from $200,000 to $300,000 but could remove a significant amount of sediment from reaching the Vermillion River through regional treatment of intercepted stormwater.

BMP Cost Benefit Assessment:

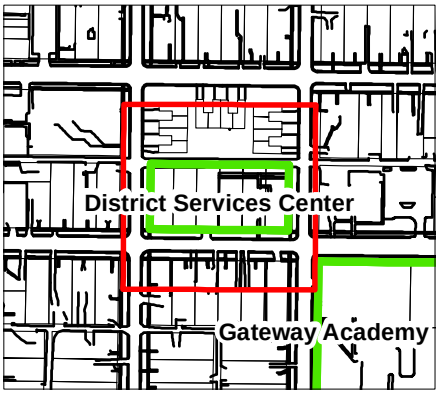
Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
26	1	Dist. Services Ctr. IR1	$25,000	$25,000	0.08	16,403	0.09	$7,819	$0.0381	$6,914	No
39	2	Dist. Services Ctr B1	$24,000	$30,000	0.13	23,416	0.37	$11,439	$0.0641	$4,001	No

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

District Services Center



Source: (Aerial Photo) Dakota County Spring 2017



Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 Feet

Dodge Middle School

Description:

Farmington Middle School is located southeast of Akin Road and 208th Street in Farmington, just north of Rambling River Park. The 60 acre site consists of large areas of athletic fields, baseball fields, softball fields, the school building, parking lots, tennis courts and two hockey rinks.

Initial construction of the Farmington Middle School did not provide any stormwater treatment. Stormwater runoff from the majority of the site enters the storm sewer system and drains directly to the south via a 54 inch pipe into a ditch, which then flows directly into the Vermillion River. Portions of the west ball fields drain to a wetland on the west side, which also then overflows to the same pipe. The parking lot on the far southwest corner of the site flows to two existing raingardens.

Identified BMPs:

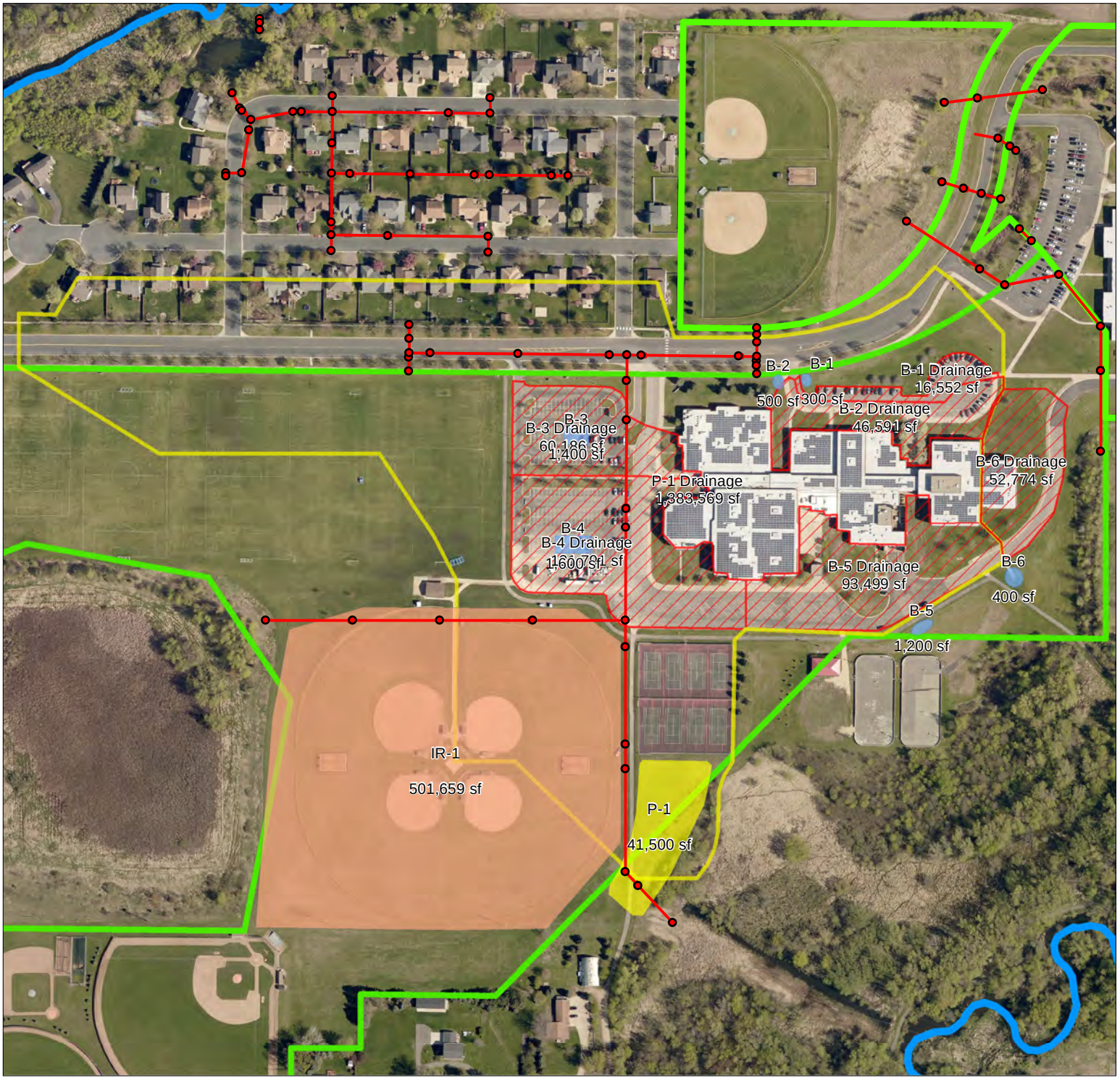
A total of 32 acres drain to a single 54 inch storm sewer pipe on the southeast portion of the property. That area encompasses nearly all of the impervious surface areas on the site as well as portions of the adjacent neighborhood and the west athletic fields. A stormwater pond on the south end of the tennis courts could potentially intercept and treat that entire 32 acre drainage area. Potential constraints include adequate pipe elevations for pond feasibility and proximity to an assumed adjacent wetland boundary. Additional bioretention BMPs to treat stormwater from the parking lots could be implemented throughout the site to provide volume control and additional pollutant reduction via infiltration of stormwater. The proposed stormwater retention pond offers an opportunity for a stormwater reuse irrigation system on the athletic fields to the southwest of the school and parking lots.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
1	1	Dodge Middle School P1	$175,000	$236,250	3.11	7,632	12.97	$3,038	$1.2383	$729	No
10	2	Dodge Middle School B4	$61,000	$76,250	0.66	115,024	1.92	$5,791	$0.0331	$1,982	No
14	3	Dodge Middle School B5	$42,000	$52,500	0.40	66,572	1.40	$6,552	$0.0394	$1,869	No
16	4	Dodge Middle School B6	$16,000	$20,000	0.15	19,137	0.83	$6,615	$0.0523	$1,200	No
18	5	Dodge Middle School B1	$13,500	$16,875	0.13	19,724	0.45	$6,677	$0.0428	$1,891	No
22	6	Dodge Middle School B2	$20,000	$25,000	0.17	22,649	0.87	$7,452	$0.0552	$1,430	No
30	7	Dodge Middle School B3	$54,000	$67,500	0.40	72,911	1.08	$8,369	$0.0463	$3,112	No
43	8	Dodge Middle School RI1	$40,000	$60,000	0.00	24,755	2.05	n/a	$0.1212	$1,465	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Dodge Middle School



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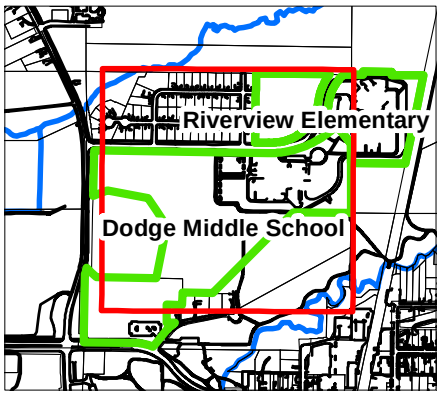


Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

0 50 100 200 300 400 Feet

Farmington Elementary

Description:

Farmington Elementary is located southwest of Maple Street and 6th Street in Farmington. The 18.3 acre site consists of a school building, parking lots, three ball fields, and an older running track. The south side of the building is a high traffic playground area.

Stormwater runoff from the entire site drains into the storm sewer system, which flows north along the Union Pacific railroad tracks in downtown Farmington and enters the Vermillion River through a 66 inch storm sewer pipe.

Identified BMPs:

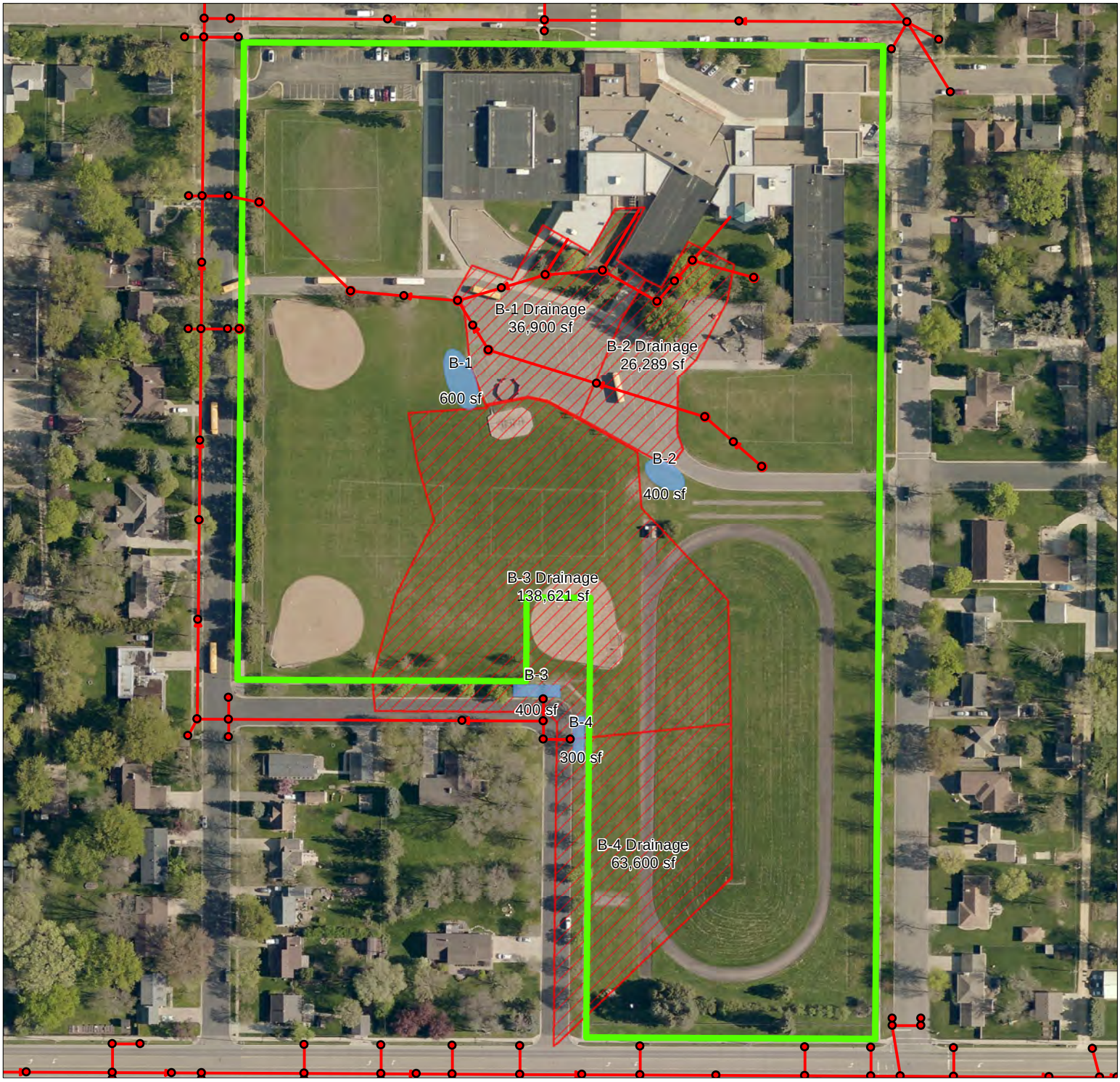
Two bioretention basins are recommended on the south and southwest sides of the school bus parking lot. Within the City Right of Way on the southwest corner of the property, there are opportunities to capture road runoff in two curb cut raingardens as well. Additional investigation should be done to determine the feasibility and benefits of an underground storage BMP in the greenspace to the west of the school.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
2	1	Frm. Elementary B4	$13,500	$16,875	0.20	12,166	0.79	$4,293	$0.0694	$1,063	No
3	2	Frm. Elementary B3	$16,000	$20,000	0.23	14,429	1.15	$4,298	$0.0693	$866	No
23	3	Frm. Elementary B2	$16,000	$20,000	0.13	23,201	0.38	$7,680	$0.0431	$2,659	No
27	4	Frm. Elementary B1	$24,000	$30,000	0.19	34,173	0.53	$7,877	$0.0439	$2,822	No

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Farmington Elementary



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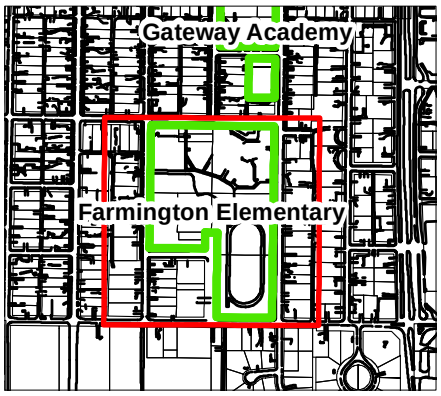


Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 300 Feet

Farmington High School

Description:

Farmington High School is located northwest of County Road 50 and Flagstaff Avenue. This is the newest campus in ISD 192, totaling 115 acres in size and consisting of the school, large athletic fields, baseball fields, softball fields, a football stadium, the school itself, and large parking lots. A large portion of the land cover on the overall site is either turf grass or un-mowed grasses.

Stormwater runoff from the entire site drains to the south via pipes into two large stormwater retention ponds. The west stormwater pond outlet flows into a ditch to the south which flows to the east branch of South Creek and then to the Vermillion River. The east stormwater pond outlet flows into a ditch to the east which flows to Middle Creek and then to the Vermillion River.

Identified BMPs:

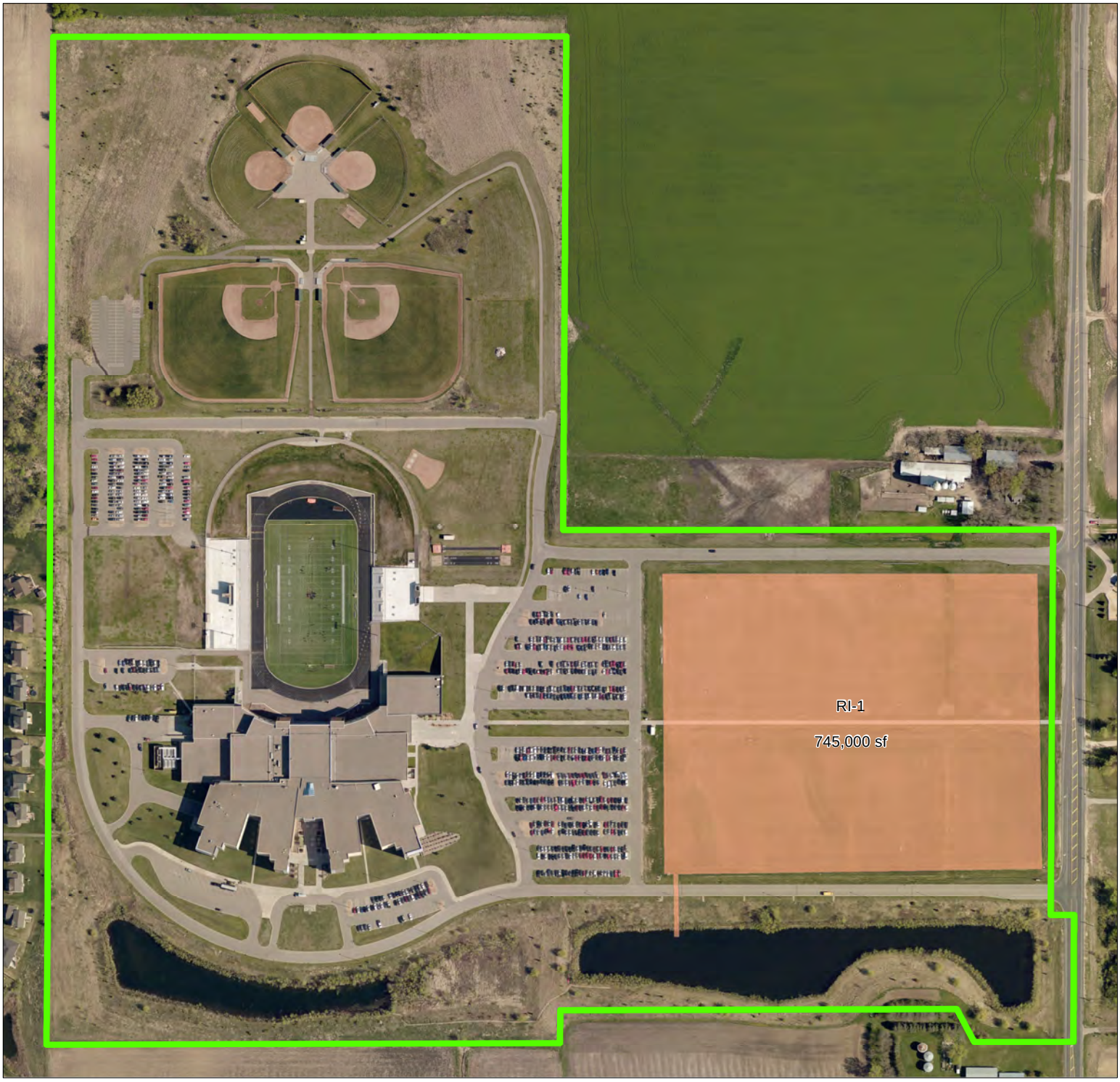
The two large stormwater retention ponds offer an opportunity for a stormwater reuse irrigation system on the athletic fields to the east of the school and parking lots.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
41	1	High School RI1	$40,000	$60,000	0.00	296,663	1.75	n/a	$0.0101	$1,714	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Farmington High School



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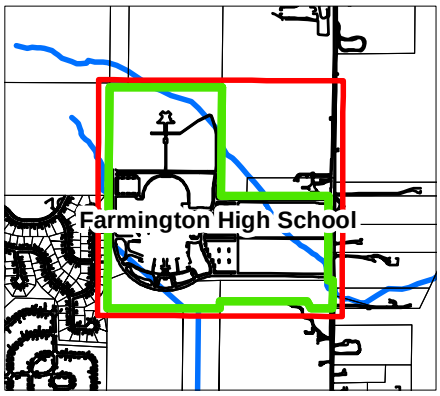

Legend

- Proposed Bioretention
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- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50100 200 300 400 Feet

Gateway Academy (Farmington Kindergarten Center)

Description:

Gateway Academy is located southwest of Walnut Street and 6th Street in Farmington. The 3.98 acre site consists of the school building, parking lots, and an athletic field across Locust Street to the south. The parking lots appear to be in need of repair in the near future.

The entire site drains to the City storm sewer with a majority of the site draining out into the street. There are two catch basins in the southeast parking lot which catch a majority of the parking area. The site stormwater runoff ultimately drains to the west and north along 4th Street where it enters the Vermillion River via a 60 inch storm sewer pipe.

Identified BMPs:

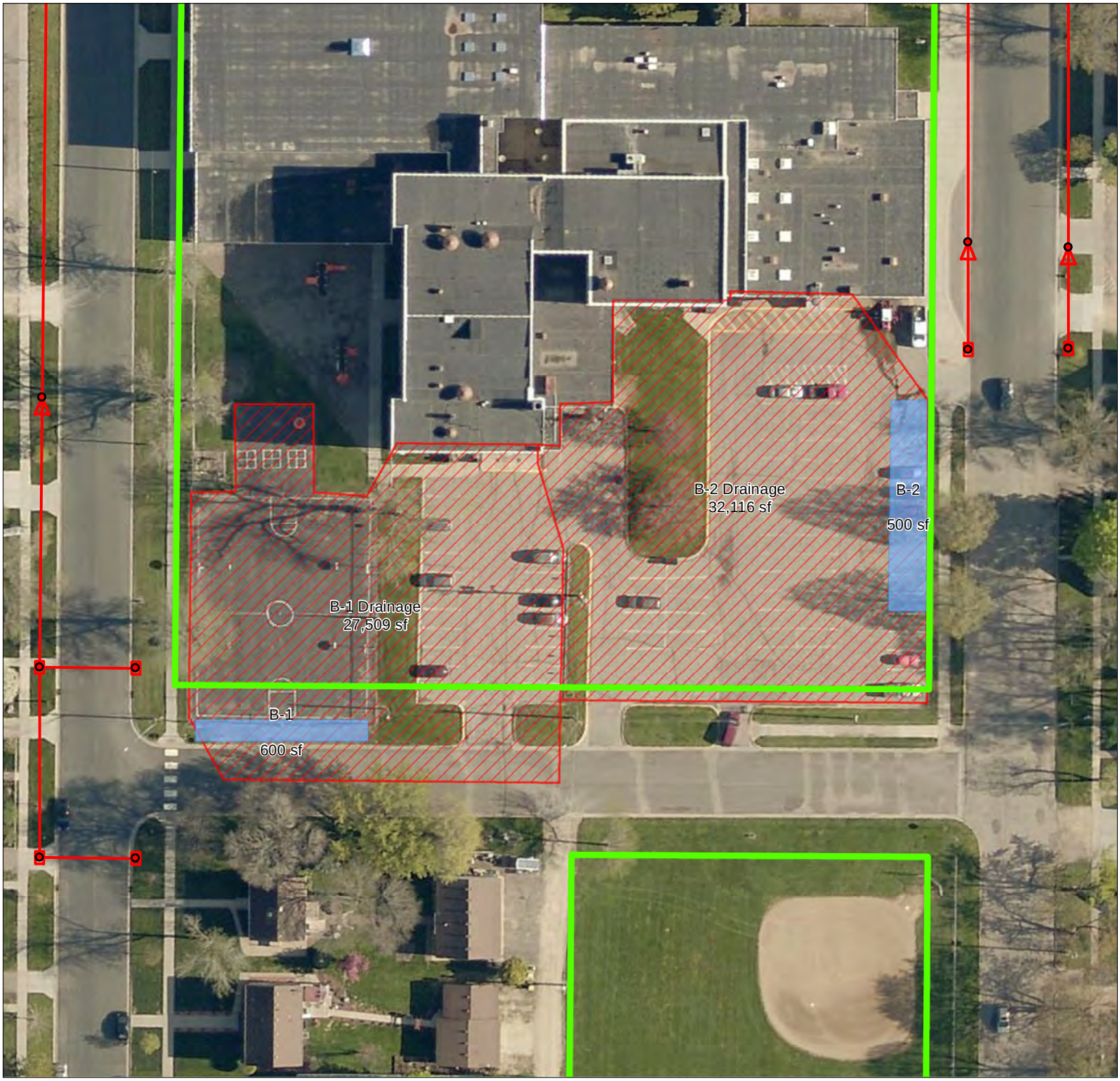
Two bioretention BMPs are recommended to treat runoff from the parking lots at Gateway Academy. One is to the south of the basketball court and would be within the right of way. The second is on the east side of the parking lot and would require the removal of 10-12 parking spaces.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
20	1	Gateway Academy B2	$20,000	$25,000	0.18	32,727	0.48	$6,931	$0.0382	$2,630	No
35	2	Gateway Academy B1	$30,000	$37,500	0.20	32,325	0.69	$9,357	$0.0580	$2,733	No

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Gateway Academy (Farmington Kindergarten Center)



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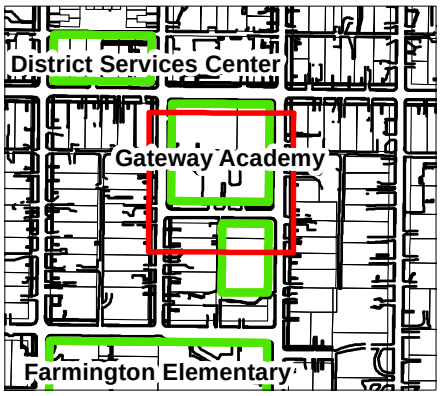

Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
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- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 Feet

Meadowview Elementary

Description:

Meadowview Elementary is located southeast of Flagstaff Avenue and 195th Street in Farmington. The combined site surrounding the school totals 115 acres. A majority of that area is natural floodplain bisected by Middle Creek with the school and two ball fields consisting of 30 acres.

Stormwater runoff from nearly the entire site drains to a retention pond on the southwest corner of the building. This pond was enlarged in 2015 to handle additional stormwater runoff from the reconstruction of 195th Street. The retention pond outlet flows to Middle Creek and then to the Vermillion River. There is a parking lot on the southeast corner of the site which drains to the southeast and is made of permeable pavers.

Identified BMPs:

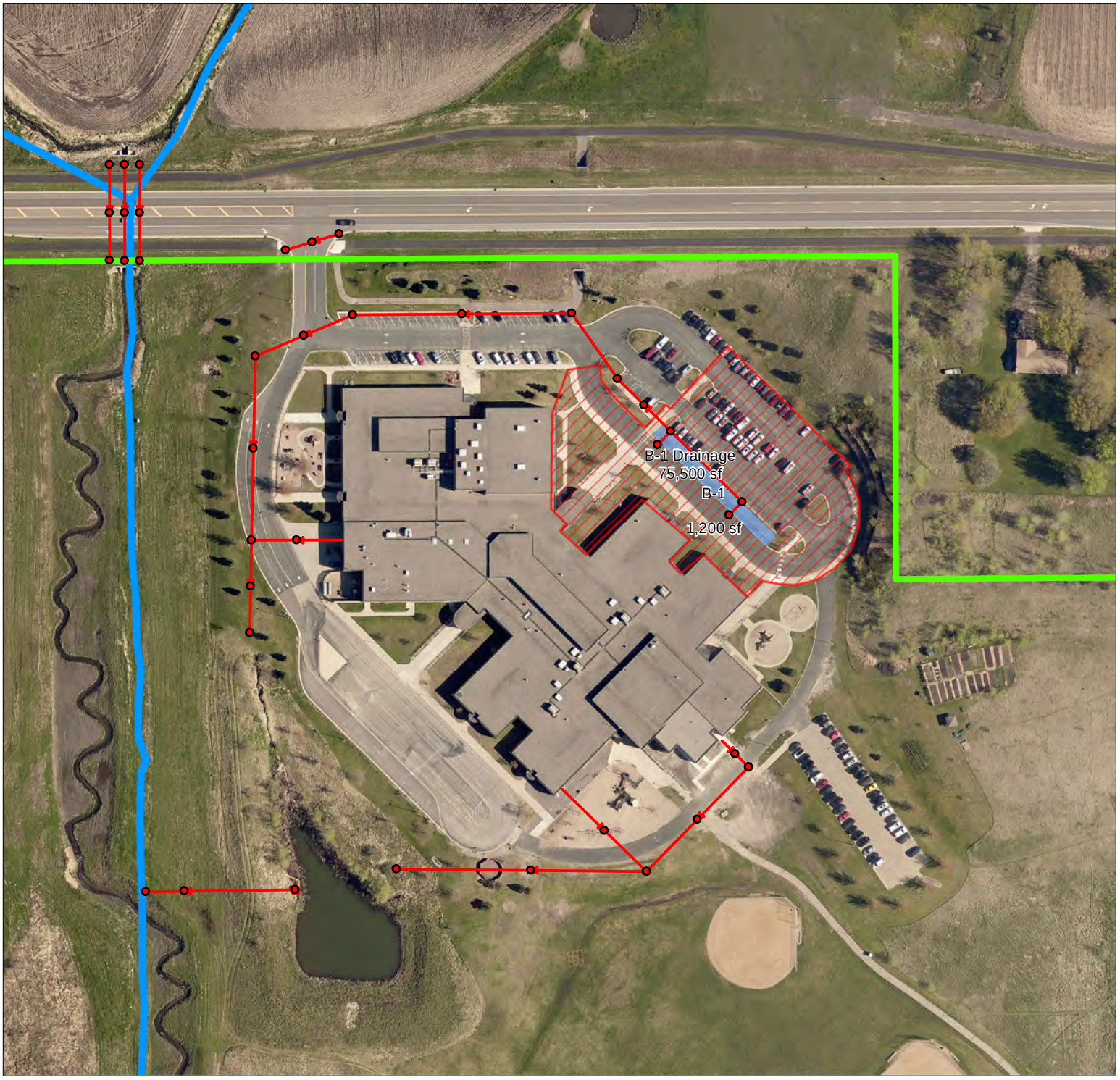
The parking lot on the northeast side of the building offers an opportunity for a linear bioretention BMP in the median between the lot and turnaround drive. The existing permeable paver parking lot is in disrepair, requiring a vacuum of the system to remove sediment and replacement of crumbling pavers.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
11	1	Meadowview B1	$42,000	$52,500	0.43	70,711	1.47	$6,062	$0.0371	$1,781	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

Meadowview Elementary



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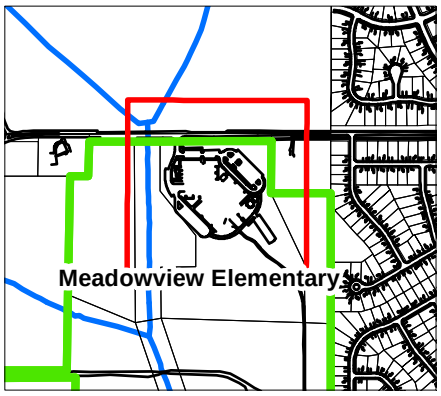


Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 300 Feet

North Trail Elementary

Description:

North Trail Elementary is located southwest of Pilot Knob road and 170th Street in Lakeville. The combined site totals 36 acres. Approximately two thirds of the site is park and athletic fields and one third is comprised of the school and parking lots.

Stormwater runoff from the entire site drains to a retention pond on the southeast corner of the site. The retention pond outlet flows to the south into North Creek and then to the Vermillion River.

Identified Structural BMPs:

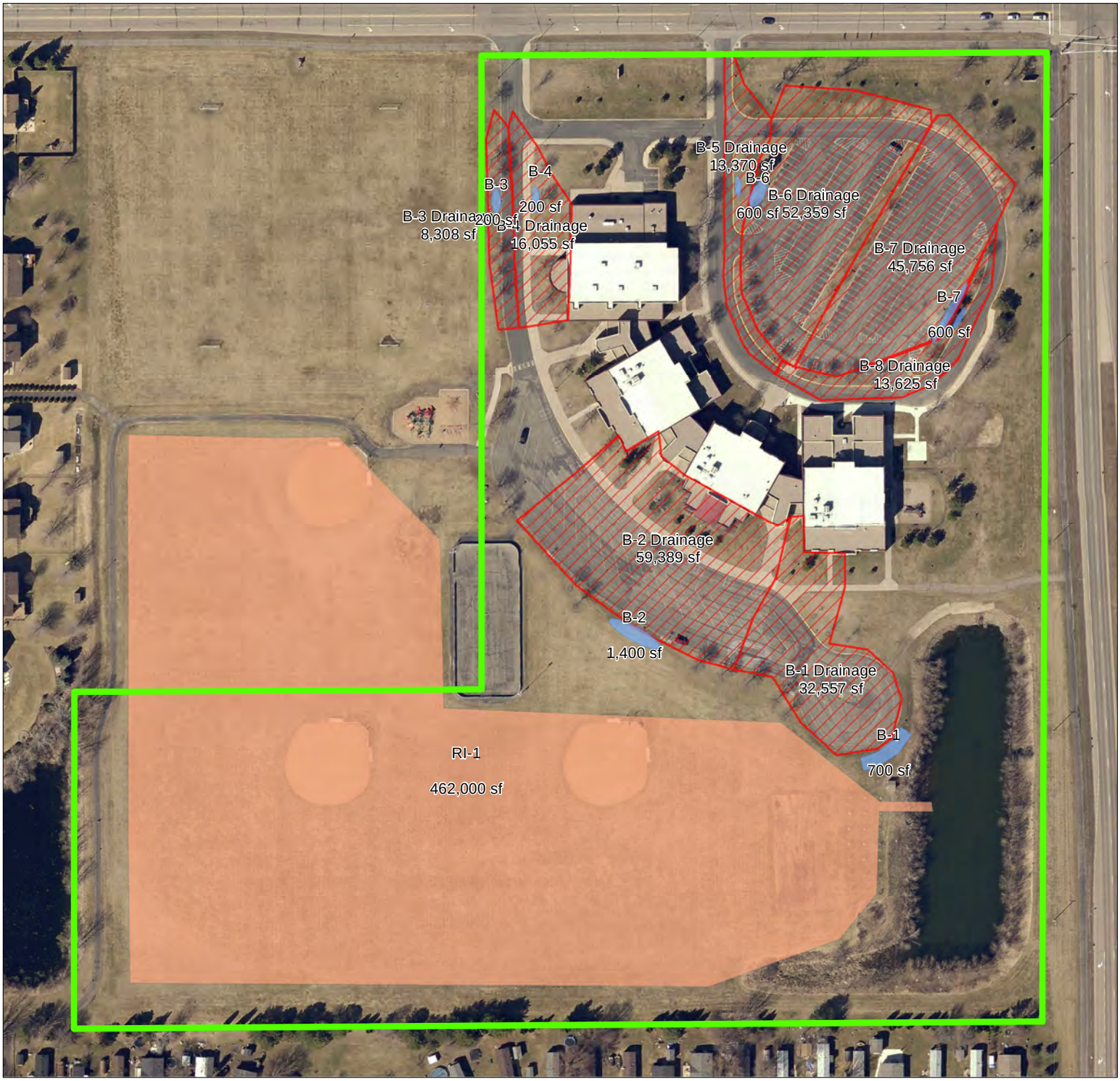
Multiple opportunities exist for bioretention BMPs near the northeast, west, and south parking lots which could provide infiltration, additional storage, and reduce the overall volume of water that is flowing to the stormwater retention pond on the southeast corner of the property. The stormwater pond provides an opportunity to install a stormwater reuse irrigation system for the nearby athletic fields. An irrigation system could also be implemented for even further benefit at an adjacent pond to the southwest of the property, which is owned by the City of Lakeville.

BMP Cost Benefit Assessment:

Details			Cost		Annual Reductions			Lifecycle Cost/Benefit			Existing Treatment
Total Rank	Site Rank	Stormwater Retrofit ID	Initial Const. Cost	Lifecycle Cost	Sediment (tons)	Volume (cubic ft)	Phosphorus (lbs)	Sediment ($/ton)	Volume ($/cf)	Phosphorus ($/lb)	Yes/No
5	1	North Trail B3	$12,000	$15,000	0.16	7,411	0.48	$4,826	$0.1012	$1,559	Yes
7	2	North Trail B6	$24,000	$30,000	0.27	48,729	0.72	$5,573	$0.0308	$2,072	Yes
9	3	North Trail B2	$49,000	$61,250	0.55	74,317	2.41	$5,607	$0.0412	$1,269	Yes
12	4	North Trail B4	$16,500	$20,625	0.17	12,341	0.50	$6,192	$0.0836	$2,068	Yes
17	5	North Trail B1	$28,000	$35,000	0.26	35,641	1.20	$6,623	$0.0491	$1,459	Yes
19	6	North Trail B7	$26,000	$32,500	0.24	43,160	0.64	$6,806	$0.0377	$2,527	Yes
24	7	North Trail B5	$10,000	$12,500	0.08	10,799	0.37	$7,764	$0.0579	$1,673	Yes
25	8	North Trail B8	$11,000	$13,750	0.09	11,911	0.39	$7,819	$0.0577	$1,745	Yes
40	9	North Trail RI1	$40,000	$60,000	0.00	324,554	1.95	n/a	$0.0092	$1,538	Yes

Stormwater Retrofit ID Key: B/P/RI/IR = Bioretention/Pond/Reuse Irrigation/Impervious Reduction
Note: Total rank determined by sorting for cost benefit of sediment removal, then volume reduction, then phosphorus removal

North Trail Elementary



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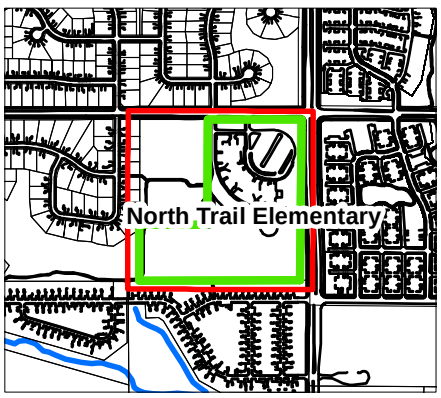


Legend

- Proposed Bioretention
- Proposed Pond
- Proposed Reuse Irrigation
- Proposed Impervious Reduction
- Pond Drainage Area
- BMP Drainage Area
- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 300 Feet

Riverview Elementary

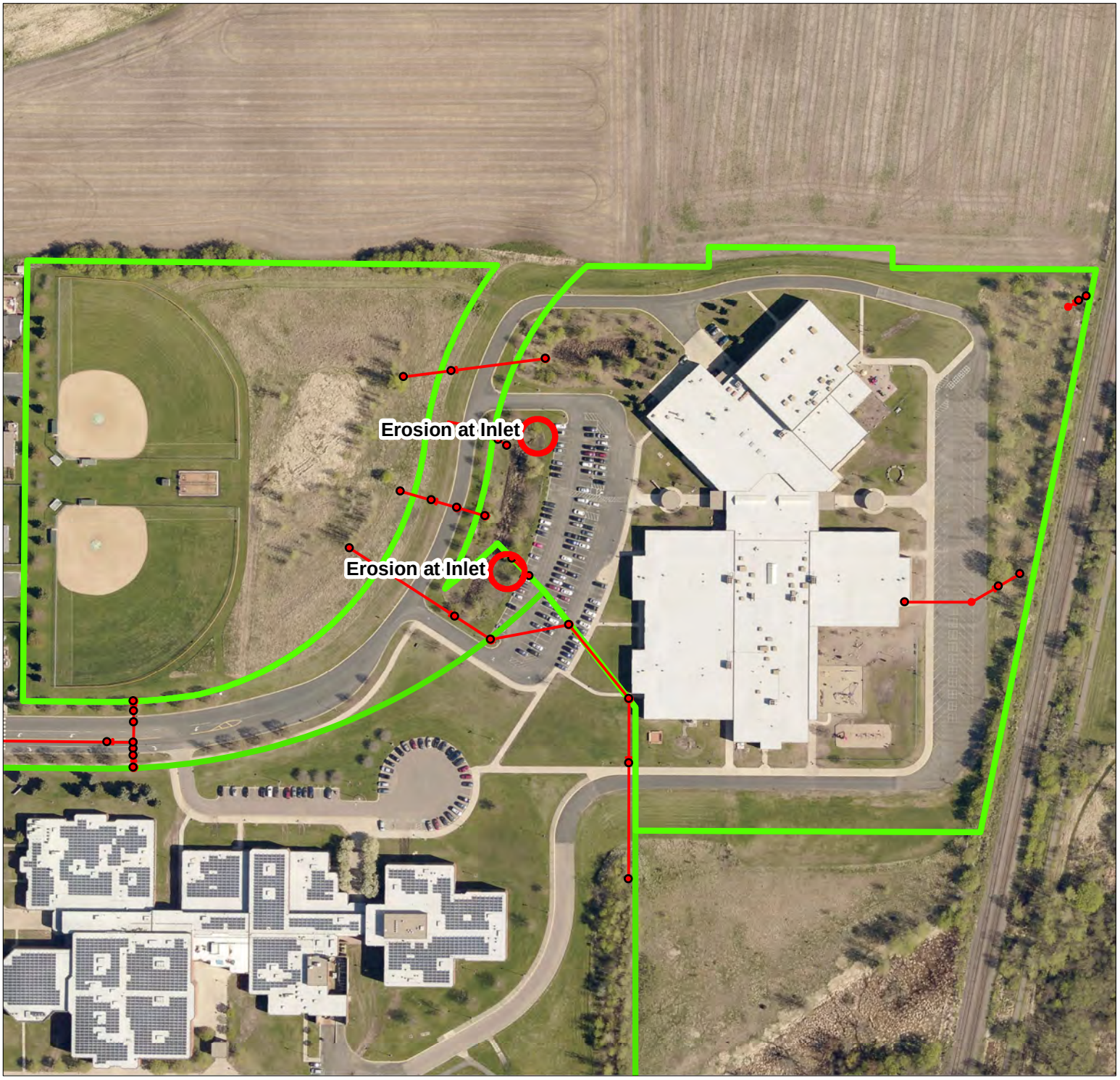
Description:
Riverview Elementary is located to the west of Akin Road on 208th Street in Farmington, just north of Rambling River Park. The 22 acre site consists of the school, parking lots, two baseball fields, and a wetland complex.

Stormwater runoff from the west side of the building and parking lots site enters two retention ponds. The water level in the ponds appears to be lower than a typical design, suggesting that the ponds are infiltrating water. These pond outlets flow to the west under the road to a wetland complex. The wetland complex has an outlet which flows to the south to a ditch connected to the Vermillion River.

Stormwater runoff from the building roof and east side bus parking lot flows to a dry retention pond/infiltration basin. This basin outlet flows to the south along the Union Pacific railroad tracks to the Vermillion River.

Identified BMPs:
No retrofit BMPs recommended. The existing BMPs on the site are providing sufficient treatment of the stormwater. Minor maintenance of the existing BMPs is needed. The inlets to the basin to the west of the west parking lot are eroding and in need of repair. The outlet on the stormwater basin located on the northeast corner of the site requires vegetation to be removed. Trees and their roots growing too close to stormwater pipe outlets can often cause cracking or separation of the concrete pipe sections and outlets.

Riverview Elementary



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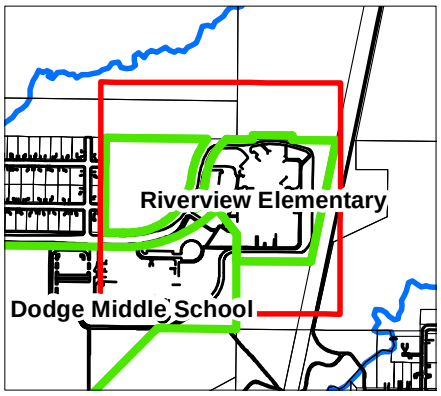


Legend

- ISD 192 Property
- Storm Sewer Lines

DAKOTA COUNTY SOIL & WATER CONSERVATION DISTRICT

0 50 100 200 300 Feet

REFERENCES

Barr Engineering Inc. 2011. Best Management Practices Construction Costs, Maintenance Costs, and Land Requirements. Prepared for Minnesota Pollution Control Agency (MPCA).

Emmons & Olivier Resources Inc. 2013. Stormwater Harvesting: Accounting of Benefits and Feasibility. MWMO Watershed Bulletin 2013 - 3. 78 pp.

Minnesota Pollution Control Agency (MPCA). Minnesota Stormwater Manual. January 2017 <https://www.pca.state.mn.us/water/minnesotas-stormwater-manual>

Schueler et. Al 2007. Urban Stormwater Retrofit Practices. Manual 2, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection. Ellicott City, MD.

APPENDIX 1 - STORMWATER TREATMENT PRACTICES

Bioretention Basin

Bioretention includes practices with localized surface depressions (typically 12 inches depth or less) which utilize amended soils and vegetation to promote infiltration where possible and provide water quality treatment. They can be located throughout a watershed drainage area and typically handle 5 acres or less of runoff. Bioretention practices are extremely versatile for different site conditions and types of soil. They can be operated as filtration systems where soils are poorly draining or where areas where infiltration of stormwater is prohibited.


Burnhaven Library, Burnsville (2011)

Impervious Reduction

Substantial runoff volume reduction can be accomplished using Low Impact Development (LID) site designs which avoid creating excessive impervious surface area and/or replace unneeded impervious areas with pervious areas. Directing the runoff from impervious surfaces onto pervious areas also effectively reduces volumes. The below photos show before and after photos of reduced impervious.


(2010)


(2011)

Retention Pond or Wet Sedimentation Pond

Wet sediment ponds are basins constructed to have a permanent pool at least 4 feet deep that provides water quality treatment by enabling the settling of the pollutants suspended in the water column. The pollutants are stored within the bottom sediment for long periods of time until the pond is cleaned out and the material can be disposed.

Northwest Bohrer Pond, Inver Grove Heights (2013)

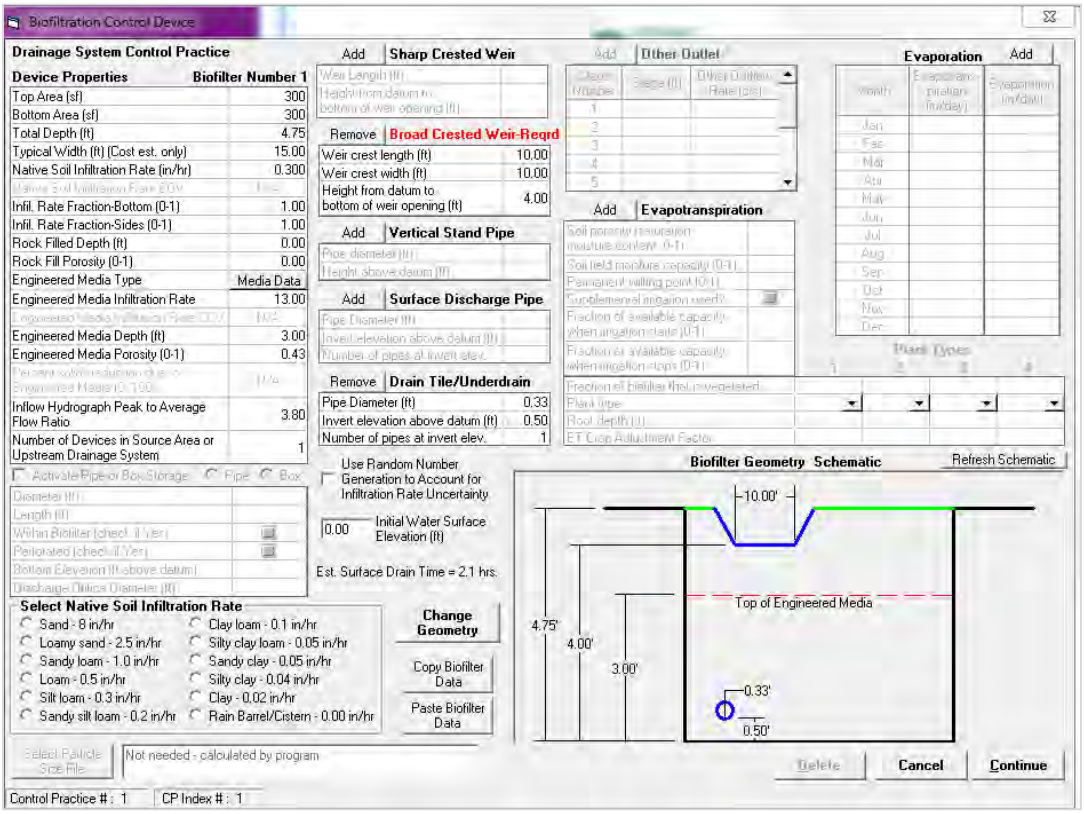
Stormwater Reuse Irrigation

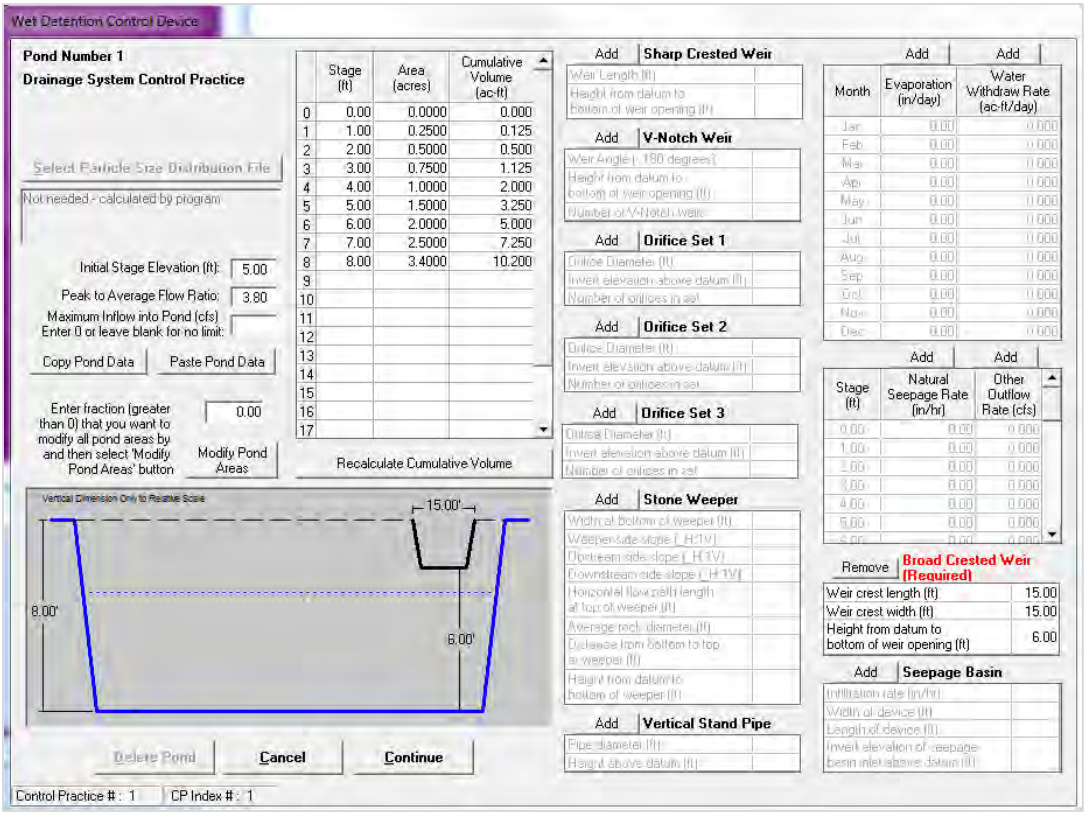
Stormwater reuse refers to collecting and re-using stormwater runoff instead of relying on potable water sources for irrigation of turf grass areas.

Small scale examples of this practice may be rain barrels and cisterns with stormwater retention ponds used to supply irrigation systems as larger scale examples.

Stormwater Reuse Pond
(Photo Courtesy of Met Council.)

APPENDIX 2 - MODEL INPUT SCREEN SHOTS





Stormwater Reuse Calculator, Version 2.0, October 2013 (Contact information: bemmons@eorinc.com or www.eorinc.com)
Developed by Emmons & Olivier Resources (EOR) with funding from Mississippi Watershed Management Organization & Minnehaha Creek Watershed District

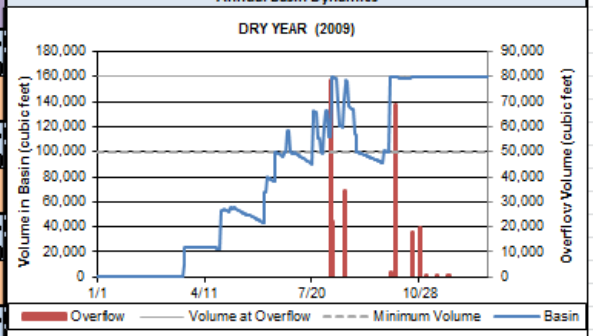
INPUTS

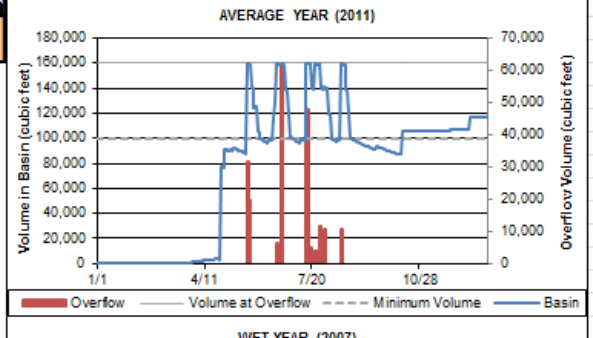
IRRIGATION	$A_{irrigation}$	460,000	ft^2
	$D_{irrigation}$	0.5	in/day
	Begin/End	5 to 9	month
WATERSHED	$A_{watershed}$	36	acres
	$\%_{imp,\ connected}$	40%	%
	Imp. disconnec	0%	%
	Imp. disconnec	0	
	$CN_{pervious}$	74	
	$C_{W\text{-}TP}$	410	ppb
	$C_{W\text{-}orthoP}$	100	ppb
STORAGE	V_{basin}	160,000	ft^3
	$V_{storage}$	100,000	ft^3
	L_{basin}/W_{basin}	425 by 100	ft
	Begin/End	1 to 12	month
	D_{basin}	6	ft
	Side slope	3	ratio
	Evaporation	1	1=on; 0=off
	$V_{basin,\ initial}$	1	ft^3

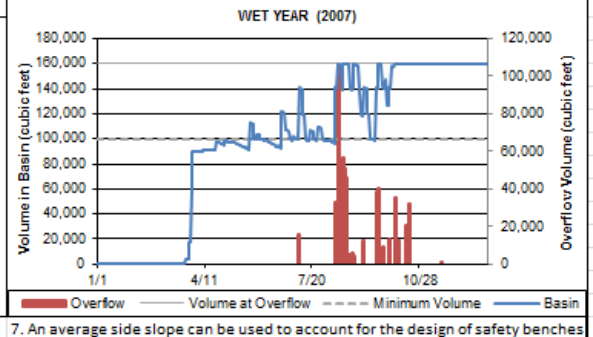
OUTPUTS

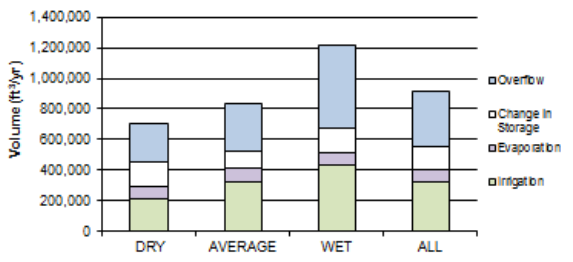
Rainfall Year	From the Watershed	To Overflow	To Irrigation	To Evaporation	To Sedimentation	Change in Storage	Units
DRY	100%	35.7%	29.8%	11.8%		22.6%	% Total Vol
	707,476	252,566	211,170	83,741		159,999	Vol (ft^3/yr)
	100%	18.6%	14.8%		54.8%	11.8%	% Total P
	8.21	1.53	1.22		4.50	0.97	TP (kg/yr)
AVERAGE	100%	36.8%	39.2%	10.0%		14.0%	% Total Vol
	836,880	307,936	328,097	83,741		117,107	Vol (ft^3/yr)
	100%	20.4%	21.4%		50.4%	7.8%	% Total P
	9.72	1.98	2.08		4.90	0.76	TP (kg/yr)
WET	100%	44.2%	35.7%	6.9%		13.2%	% Total Vol
	1,215,340	537,204	434,395	83,741		159,999	Vol (ft^3/yr)
	100%	25.8%	18.2%		50.1%	5.9%	% Total P
	14.11	3.64	2.57		7.07	0.84	TP (kg/yr)
ALL	100%	**38.9%**	**34.9%**	**9.6%**		**16.6%**	% Total Vol
	919,899	365,902	324,554	83,741		145,702	Vol (ft^3/yr)
	100%	**21.6%**	**18.1%**		**51.8%**	**8.5%**	% Total P
	10.68	2.38	1.95		5.49	0.85	TP (kg/yr)

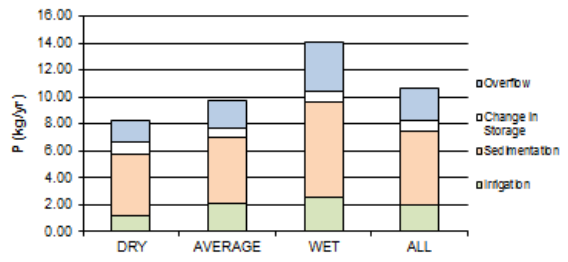
SUMMARY: Annual Basin Dynamics

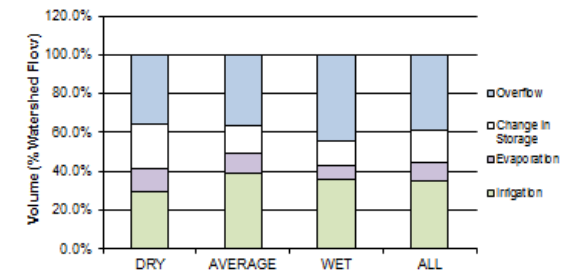


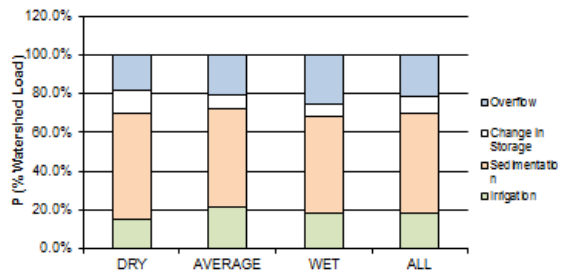












User notes:

1. The irrigation and watershed areas can be independent
2. The user must composite the CN for disconnected impervious
3. Turn off evaporation until all basin geometry is entered and valid
4. The watershed P concentrations and fractions can be set to site specific data
5. The user must define appropriate basin geometry or model results are invalid
6. The storage volume can be set to maintain any desired minimum pond depth
7. An average side slope can be used to account for the design of safety benches
8. The initial basin volume can be set by the user to account for winter dynamics
9. Model results assume regular maintenance to remove accumulated sedimen