GRAND ISLAND
POST CONSTRUCTION STORMWATER BMP
MASTER PLAN

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EXECUTIVE SUMMARY

The Stormwater BMP Master Plan exists to document stormwater program requirements of new development and redevelopment projects. The City is required to maintain and enforce development standards that control urban stormwater runoff and protect local receiving water from the impacts of pollution. The City of Grand Island sends stormwater runoff to the Wood River (Segment MP2-10200) and Moores Creek. The interconnected series of gutters, inlets, pipes, channels, cells, and ponds that drain into these designated waters is the regulated Municipal Separate Storm Sewer System (MS4). The City manages stormwater conveyed through the MS4 to protect the quality of discharges into designated waters of the State.

New development and redevelopment projects within the planning jurisdiction of the City must calculate and plan for addressing minimum stormwater treatment requirements. These requirements are generally referred to as the post-construction stormwater management standards because they address common impacts to water quality that occur after development is completed. Stormwater treatment for applicable development sites must accommodate the 80% rainfall event (0.72") while redevelopment must accommodate the 70% rainfall event (0.53"). These minimum standards are also enforced by other communities in Nebraska with regulated stormwater discharges.

The first step to prepare the Post Construction Stormwater BMP Master Plan was to study local stormwater runoff characteristics and determine if the minimum criteria are practicable or if they are overly conservative of water quality. If standards could be reduced, it would mean development could plan to address a smaller amount of runoff than similar regulated communities. Grand Island generally has less impervious surface density than similar sized communities, elevated presence of sandy soils to infiltrate stormwater, generously flat topography and significant amounts of impervious surfaces that are disconnected from stormwater pipes. These criteria were considered but were determined not to affect the volume or flow rates required for stormwater treatment in Grand Island. Description of the evaluation is provided in **Section 1 - Water Quality Criteria Updates**.

The City then used the minimum criteria adopted for sizing stormwater runoff and applied it to the current land use master plan. The City used the types and amounts of land development anticipated to estimate how much treatment would be required over the next 20 years. Calculating future amounts of stormwater treatment is not a requirement before new development and redevelopment is proposed. It was done to support the Stormwater Treatment Exchange Program (STEP) and ensure that any of treatment exchanges did not result in volumetric or temporal loss of treatment when new and redevelopment projects occur. If STEP Credit does not exist when a project is proposed, then an applicable development site must accommodate stormwater treatment within the proposed project.

In 1975, the City adopted the *Moores Creek Master Plan* to coordinate drainageways and detention cells in a 17 square-mile area west and adjacent to the City. These subbasins drain to Moores Creek which flows over 65 stream miles northeast toward the Platte River (Segment MP1-20000). Moores Creek was known then to have limited hydraulic capacity that would worsen as development occurred to the west. That Master Plan envisioned a series of vegetated channels and cells that would hold stormwater for extended periods as the hydraulic head on Moores Creek decreased to allow urban stormwater runoff to flow out of the City. It identified approximately $6 Million worth of drainage way, detention cell and creek improvements that would be completed, that exist today and that are maintained by the City.

The Stormwater BMP Master Plan was completed in two phases. Phase one evaluated the same 5 Growth Area subbasins (**Figure 2-1**) studied in the 1975 Master Plan. Because of the unique hydrology described, the City anticipated that the series of vegetated channels and detention cells likely provided some or all required stormwater treatment needed by future redevelopment projects in those areas. Even though stormwater treatment is not required for existing development, minimum stormwater treatment criteria were applied to all existing and future growth in these subbasins. Calculated treatment volumes for these subbasins are listed in **Table 2-1**.

Phase two of the Stormwater BMP Master Plan evaluated the remaining 28 Existing Area subbasins of the City (**Figure 2-2**) where new and redevelopment was expected to occur. Current GIS records allowed the drainages to be delineated and field elevations were confirmed in some locations where GIS data was not available. Areas within the Grand Island Extra-Territorial Jurisdiction that were not delineated or studied are expected to remain rural. Most of the studied basins are fully or mostly developed. Redevelopment may occur in subbasins and some subbasins will receive new development as the City grows. Minimum stormwater treatment criteria was applied to land uses in these subbasins. Calculated treatment volumes are listed in **Table 2-2**.

The Post Construction Stormwater BMP Master Plan documents locations where treatment is available today for the 33 subbasins. **Section 3 – Compliance Alternatives**, describes how stormwater treatment in vegetated ditches and wet ponds was determined for Grand Island. The study returned phenomenal results, demonstrating that over 70% of all existing and future growth is currently accommodated by drainage infrastructure that treats stormwater runoff. Further review determined that the retrofit stormwater treatment projects recommended in this Plan which would increase that amount to more than 84%.

The City of Grand Island is unique among communities with regulated municipal stormwater discharges. While regulated communities are expected to enforce minimum standards that require new development and redevelopment to treat stormwater that drains from each site, this standard applied at the discharge point of each site would create redundant treatment in Grand Island. **Section 4 – Recommended Compliance Approach** documents the regional stormwater treatment available and the portion of each subbasin treated. Not only does the City maintain regional stormwater treatment for *future* growth, but most *existing* development is treated as well.

Compiling this information into the Post Construction Stormwater BMP Master Plan enables the City to implement post construction stormwater management on a regional basis to meet minimum regulatory standards. **Section 5 – Grand Island Stormwater Exchange Program**, describes how the regional strategy is applied and what limitations exist for utilizing the treatment exchange method. Through the Stormwater Treatment Exchange Program (STEP), the City may authorize an applicable development site to exchange required treatment for treatment provided elsewhere in the drainage system.

1. WATER QUALITY CRITERIA UPDATES

The City of Grand Island (City) has adopted the Final Nebraska H_2O Post-Construction Stormwater Program Design Standards and Procedures Memorandum (NE H_2O Memo) included in, prepared by Felsburg Holt & Ullevig (FHU) in August of 2015. This document (Appendix B) defined the City's post-construction storm water management program (post-construction program) design standard, which meets their MS4 permit general conditions as required by the NDEQ. The NE H_2O Memo provided the framework and guidance that all Nebraska H_2O Communities can use to satisfy part of the post-construction program requirements for individual development projects. Because this document was written for all Nebraska H_2O Communities, it remained general in nature and did not address unique characteristics of individual communities. The City has asked FHU to review the water quality control volume (WQCV) and water quality volume discharge rate (Q_{WQ}) design criteria sections of the NE H_2O Memo to ensure that they are appropriate for the unique geography in Grand Island.

1.1 WQCV Influences & Alternatives

The City of Grand Island defines the WQCV as the runoff from a specified percentile rainfall event (70th percentile for redevelopment and 80th percentile for new development) applied across the treatment drainage area. The WQCV is influenced by several naturally occurring and artificial factors. FHU performed a literature review to identify the influences that affect the WQCV and alternatives that could be used to calculate the WQCV for the City of Grand Island's post-construction program. Influences and alternatives are listed below and described in the following sections.

- Influences
  - Impervious Cover
  - Connection/Disconnection of Impervious Cover
  - Hydraulic Soil Group (HSG)
  - Land Surface Slope
- Alternatives
  - NE H_2O Method
  - Small Storm Hydrology Method
  - Reduction Factor for Disconnected Impervious Areas
  - Reduction Factor for Flat Land Surface Slope

1.1.1 NE H_2O Method

The City of Grand Island currently calculates the WQCV using the NE H_2O method, which is sometimes described as the shortcut method. This method is commonly used throughout the country because of it's simplicity and ability to produce reasonable results. The equation used by this method is shown below. In an effort to more easily compare this method with others, the term (0.05 + 0.009 x %Imp) has been replaced with the volumetric runoff coefficient (R_v).

$$WQCV = P \times R_v \times A \times 1/12 \times 43{,}560$$

WQCV = water quality control volume, cu ft

P = rainfall depth, in

R_v = (0.05 + 0.009 x %Imp) = volumetric runoff coefficient

A = treatment drainage area, ac

1/12 x 43,560 = conversion factor

R_v in this equation is an empirical term based only on impervious cover in the treatment drainage area. The NE H_2O method does not consider any other factors that could affect runoff, such as soil type or slope.

1.1.2 Small Storm Hydrology Method

Because the NE H_2O method does not consider all the influences that affect the WQCV, alternative methods were investigated to understand the impacts of the additional influences. The small storm hydrology method is an alternative method that is also commonly used throughout the country. Since soil type can have a large impact on the runoff potential for an area, this method was chosen to evaluate the impact of soil type on the WQCV.

The small storm hydrology method uses the same equation as the NE H_2O method but defines R_v differently. In this method, R_v is based on the characteristics of the treatment drainage area, considering both impervious cover and HSG. The R_v for each surface type in the treatment drainage area is selected from a table, then a composite R_v is calculated to determine the WQCV. For Grand Island, values for R_v would need to be extrapolated for both the 80^{th} and 70^{th} percentile rainfall events.

Table 1-1. Small Storm Hydrology Method R_v Values

Impervious Area	Precipitation			
	0.75"	1.00"	1.25"	1.50"
Flat roofs and large unpaved parking lots	0.82	0.84	0.86	0.88
Pitched roofs and large impervious areas (large parking lots)	0.97	0.97	0.98	0.98
Small impervious areas and narrow streets	0.66	0.70	0.74	0.77
Sandy Soils (HSG-A)	0.02	0.02	0.03	0.05
Silty Soils (HSG-B)	0.11	0.11	0.13	0.15
Clayey Soils (HSG-C and D)	0.20	0.21	0.22	0.24

Source: Iowa Storm Water Management Manual

1.1.3 Reduction Factor for Disconnected Impervious Areas

Disconnecting impervious areas from drainage infrastructure can have a number of benefits on water quality. It encourages infiltration by routing runoff over pervious surfaces, filters runoff through vegetation and increases the time of concentration of runoff, which in turn reduces peak flows and increases the effectiveness of in-line treatment facilities. Reduction factors for disconnected impervious areas were chosen to evaluate the impact that they can have on the WQCV.

The small storm hydrology method allows for a reduction factor to R_v for disconnected impervious areas based on the land use in which it is located. Literature suggests that impervious area should be disconnected by at least twice that amount of pervious area (Claytor & Schueler, 1996). This means if runoff sheet flows across 100 feet of parking lot, it should continue to sheet flow across at least 200 feet of grassed area before concentrating in a ditch or storm sewer for the reduction factor to be applied. For Grand Island, values for reduction factors would need to be extrapolated for both the 70th and 80th percentile rainfall events.

Table 1-2. Reduction Factors for Disconnected Impervious Areas

Impervious Area	Precipitation			
	0.75"	1.00"	1.25"	1.50"
Strip commercial shopping center	0.99	0.99	0.99	0.99
Medium to high density residential with paved alleys	0.27	0.38	0.48	0.59
Medium to high density residential without alleys	0.21	0.22	0.22	0.24
Low density residential	0.20	0.21	0.22	0.24

Source: Iowa Storm Water Management Manual

This reduction factor is typically applied to the R_v for each individual impervious area prior to the composite R_v being calculated in the small storm hydrology method. In theory, a composite reduction factor for disconnected impervious areas could be calculated for a treatment drainage area and applied to the NE H_2O method as well.

1.1.4 Reduction Factor for Flat Land Surface Slope

Land surface slope is known to affect runoff coefficients and the time of concentration used in hydrologic methods. The changes to these factors may, in turn, affect the volume and/or rate of runoff. Land surface slope was evaluated to understand the impact it can have on the WQCV.

With Grand Island being within the floodplain of local rivers, the land surface slope is much flatter than many cities in the country. Since the methods previously discussed were developed on a national scale, a reduction factor for flat land surface slopes may be appropriate to be used locally.

1.2 Evaluation of WQCV Criteria Update Alternatives

All WQCV criteria update alternatives were evaluated to determine if they would be appropriate for Grand Island. Sample calculations for the NE H_2O method and the small storm hydrology method were compared with each other to determine if the soil types in Grand Island aid in treatment of storm water. A desktop review of aerial imagery in existing neighborhoods was performed to determine if they are generally constructed in a way that a reduction factor for disconnected impervious areas would be appropriate. Sample calculations were also performed to determine if the flat land surface slopes in Grand Island warrant a reduction factor. All hydrologic calculations for the evaluation of WQCV criteria updates can be found in the BMP Master Plan Technical Reference - Appendix A.

1.2.1 NE H_2O Method vs. Small Storm Hydrology Method

R_v values were calculated for the NE H_2O method and the small storm hydrology method for percent imperviousness ranging from 0% to 100%, in 10% increments. Since soils in the undeveloped areas of Grand Island predominately have a hydrologic soil group (HSG) of C per the Natural Resources Conservation Service (NRCS) Web Soil Survey, with lesser amounts of A and B, HSG-C soils were assumed for all small storm hydrology method calculations. The soil survey for Grand Island can be found in BMP Master Plan Technical Reference - Appendix D.

Also, for small storm hydrology calculations, for percent impervious values that would represent residential areas (0-50%) an R_v of 0.97 was used for 50% of the impervious area to resemble pitched roofs and an R_v of 0.66 was used for the other 50% of the impervious area to resemble small impervious driveways & streets. For percent impervious values that would represent commercial or industrial areas (50-100%) an R_v of 0.82 was used for 50% of the impervious area to resemble flat roofs and an R_v of 0.97 was used for 50% of the impervious area to resemble large parking lots.

Table 1-3. R_v Values for the NE H_2O Method vs. the Small Storm Hydrology Method

Max Ground Coverage (% Impervious)	NE H_2O Method	Small Storm Hydrology Method
0%	0.05	0.20
10%	0.14	0.26
20%	0.23	0.32
30%	0.32	0.38
40%	0.41	0.45
50%	0.50	0.51
60%	0.59	0.62
70%	0.68	0.69
80%	0.77	0.76
90%	0.86	0.83
100%	0.95	0.90

This comparison shows that, when compared to the NE H_2O method, the small storm hydrology method over-estimates the value of R_v in the lower range of percent impervious (0-30) and slightly under-estimates the value of R_v in the upper range of percent impervious (90-100). In the middle range of percent impervious, the NE H_2O method and the small storm hydrology method provide very similar results.

1.2.2 Reduction Factor for Disconnected Impervious Areas

A desktop review of existing residential neighborhoods in Grand Island showed a mixture of neighborhoods that were built with and without disconnected impervious areas. Many newer neighborhoods have streets that are built with curb and gutter that drain directly to storm sewers. These areas would not qualify for a reduction factor for disconnected impervious areas.

Many older neighborhoods have streets with no curb and gutter, allowing runoff to sheet flow into roadside ditches. Some impervious areas in these neighborhoods like driveways and rooftops may drain over enough pervious area to be considered disconnected, however most roadside ditches are too close to the streets to consider the streets disconnected. Because not all impervious areas in these existing neighborhoods are fully disconnected, it will be difficult to justify the full reduction factor shown in Table 1-2 for these areas. However, a smaller reduction factor could be considered in some of the older neighborhoods in Grand Island with roadside ditches.

Commercial and industrial areas have very large impervious areas and it is typically not feasible to provide enough pervious area before runoff is concentrated to consider them disconnected. Even if a commercial or industrial area can be shown to be disconnected, the typical reduction factor, shown in Table 1-2, is so small that it provides little relief from WQCV requirements.

1.2.3 Reduction Factor for Flat Land Surface Slope

Hydrologic calculations were performed by modeling a sample 10-acre parcel in Autodesk Storm & Sanitary. All modeling was done using the SCS Method with the 24-hour precipitation depth equal to the 80th percentile event for new development in Grand Island (0.72"). In an effort to maximize runoff and make trends the most obvious, HSG-D soils were used for all calculations. The sample parcel was modeled with three different amounts of percent impervious (0%, 50% and 100%) with six different surface slopes, ranging from 0.5% to 20%. A summary of the results of the modeling is shown in Table 1-4.

Table 1-4. Summary of Modeling for Land Surface Slopes

% Impervious	SCS Method Runoff Volume (Cu Ft)					
	0.5% Slope	1.0% Slope	2.5% Slope	5.0% Slope	10% Slope	20% Slope
0%	646	657	630	666	646	606
50%	4748	4833	4629	4896	4748	4451
100%	18958	19296	18484	19550	18958	17773

The modeling showed that runoff volume is not dependent on land surface slope, it is only dependent on the drainage area, percent impervious and soil type of the contributing basin. Time to peak (earlier) and peak flow rate (higher) are the only output from the modeling that changed as land surface slope increased.

1.3 Q_{WQ} Influences and Alternatives

The City of Grand Island defines the Q_{WQ} as the peak runoff from the design water quality volume rainfall event (70th percentile for redevelopment and 80th percentile for new development) applied across the treatment drainage area. Like the WQCV, the Q_{WQ} is influenced by several naturally occurring and artificial factors. FHU performed a literature review to identify the influences that affect the Q_{WQ} and alternatives that could be used to calculate the Q_{WQ} for the City of Grand Island's post-construction program. Influences and alternatives are listed below and described in the following sections.

- Influences
  - Impervious Cover
  - Hydraulic Soil Group
  - Time of Concentration
    - Land Surface Slope
    - Connection/Disconnection of Impervious Cover
- Alternatives
  - NE H_2O Method
  - Small Storm Hydrology Method

1.3.1 NE H_2O Method

The City of Grand Island currently calculates the Q_{WQ} using the NE H_2O method. Using this method, the Q_{WQ} is calculated using the Natural Resources Conservation Service (NRCS) Curve Number procedure. The calculation is based on the 80th percentile rainfall event (0.72 inches for Grand Island), a 24-hour duration storm event and a time of concentration of 5 minutes. In an effort to avoid underestimating the volume and rate of runoff for rainfall events less than two inches that the NRCS Curve Number Procedure can produce, the area used is the impervious surface only within the treatment drainage area.

Because only the impervious surface area is used and the time of concentration is assumed to be 5 minutes, neither the hydrologic soil group, land surface slope nor connection/disconnection of impervious cover are considered using the NE H_2O method.

1.3.2 Small Storm Hydrology Method

Because the NE H_2O method does not consider all the influences that affect the Q_{WQ}, an alternative method was investigated to understand the impacts of the additional influences. The small storm hydrology method is an alternative method that is also commonly used throughout the country. Since soil type and time of concentration can have a large impact on the runoff potential for an area, this method was chosen to evaluate the impact of the additional influences on the Q_{WQ}.

Similar to the NE H_2O method, the small storm hydrology method uses the NRCS Curve Number Procedure to calculate the Q_{WQ}, but with a few modifications. In an effort to avoid underestimating the volume and rate of runoff for rainfall events less than two inches that the NRCS Curve Number Procedure can produce, the small storm hydrology method modifies the Curve Number by considering the rainfall depth for the 80th percentile storm and the Q_{WQ} produced by the 80th percentile storm using the equation below.

$$CN = \frac{1000}{(10 + 5 \times P + 10 \times WQD) - 10(WQD^2 + 1.25 \times WQD \times P)^{1/2}}$$

$$P = 80th\ Percentile\ Rainfaill\ Depth\ (0.72")$$

$$WQD = P \times R_v = \ Water\ Quality\ Runoff\ Depth\ (Inches)$$

Because the curve number is appropriately modified, the entire contributing area is used in the NRCS Curve Number Procedure for the small storm hydrology method. This means, if the small storm hydrology method is also used to calculate the WQCV, the HSG of the soil is considered for the Q_{WQ} calculation as well. The small storm hydrology method recommends calculating a unique time of concentration for each basin that is analyzed. Because of this, the land surface slope and connection/disconnection of impervious cover will also be reflected in the Q_{WQ} calculation.

1.4 Evaluation of Q_{WQ} Criteria Update Alternatives

All Q_{WQ} criteria update alternatives were evaluated to determine if they would be appropriate for Grand Island. Sample calculations for the NE H_2O method and the small storm hydrology method were compared with each other to determine if the local conditions in Grand Island impact the peak flow rate of runoff. All hydrologic calculations for the evaluation of Q_{WQ} criteria updates can be found in BMP Master Plan Technical Reference - Appendix B.

1.4.1 NE H_2O Method vs. Small Storm Hydrology Method

Q_{WQ} values were calculated for the NE H_2O method and the small storm hydrology method for percent imperviousness ranging from 0% to 100%, in 10% increments. For these calculations, the basin size was assumed to be 10 acres and slopes for time of concentration calculations were chosen to represent the typical geography in Grand Island.

Table 1-5. Q_{WQ} for the NE H_2O Method vs. the Small Storm Hydrology Method

Max Ground Coverage (% Impervious)	NE H_2O Method (CFS)	Small Storm Hydrology Method (CFS)
0%	0.00	0.08
10%	0.78	0.67
20%	1.57	1.39
30%	2.35	2.06
40%	3.14	2.76
50%	3.92	3.49
60%	4.72	4.15
70%	5.49	4.75
80%	6.29	5.30
90%	7.06	5.74
100%	7.85	5.99

The modeling showed that the NE H_2O method and small storm hydrology method produce similar results for Q_{WQ}, with the results from the NE H_2O method being 12% to 15% higher through most of the percent impervious range. However, at the higher end of percent impervious (>70%), the NE H_2O method became increasingly conservative compared to the small storm hydrology method.

One factor to keep in mind when considering the NE H_2O method is the time of concentration. Since the NE H_2O method was developed primarily for small developments using the distributed method of storm water treatment, the time of concentration was assumed to be five minutes to simplify the design process. This is an appropriate assumption for small developments, however five minutes may become unrealistic for larger developments or when considering regional treatment. To understand the implications of time of concentration, an additional analysis was completed using similar assumptions as the previous analysis, but holding percent impervious at 50% and varying the basin size for both methods.

Table 1-6. Q_{WQ} (Various Basin Sizes) for the NE H_2O Method vs. the Small Storm Hydrology Method

Basin Size (Acres)	NE H_2O Method T_c (Min)	NE H_2O Method Q_{WQ} (CFS)	Small Storm Hydrology Method T_c (Min)	Small Storm Hydrology Method Q_{WQ} (CFS)
10	5.0	3.92	24.7	3.49
50	5.0	19.7	36.8	13.7
100	5.0	39.2	45.2	24.1
200	5.0	78.7	54.4	42.6
500	5.0	196	69.1	89.6
1,000	5.0	392	85.0	154

The modeling showed that, when holding the time of concentration for the NE H_2O method to five minutes, the Q_{WQ} increases drastically as the basin size increases. For a 1,000 acre basin, the Q_{WQ} for the NE H_2O method is over twice that of small storm hydrology method. These high Q_{WQ} values for large or regional treatment facilities are unrealistic and over-estimate the peak flow rates that should be expected.

1.5 Recommended Water Quality Criteria Updates

1.5.1 WQCV Recommendations

After carefully evaluating all WQCV criteria update alternatives, FHU recommends that the City of Grand Island continues to use the NE H_2O method to calculate the WQCV with no reduction factors applied to it. The NE H_2O method provides very similar results to the small storm hydrology method, which considers local soil types, but has an approach that is very simple and is consistent with other MS4 communities in the state. A reduction factor for the flat land surface slopes in Grand Island cannot be justified because runoff volume is not dependent on slope. A partial reduction factor for disconnected impervious areas could be justified for some residential neighborhoods in Grand Island, however there are other ways that the City can show benefit from their local development practices as described in the following section.

1.5.2 Q_{WQ} Recommendations

After carefully evaluating all Q_{WQ} criteria update alternatives, FHU recommends that the City of Grand Island continues to use the NE H_2O method to calculate the Q_{WQ} with an adjustment to the time of concentration used in the calculations. The NE H_2O method provides similar, but slightly more conservative values for Q_{WQ} than the small storm hydrology method for small developments. However, since the NE H_2O method overestimates Q_{WQ} for large developments, FHU recommends using the actual time of concentration for basins with contributing drainage areas over 10 acres in size instead of assuming five minutes. This will provide more realistic values for Q_{WQ} when considering large developments or regional treatment facilities.

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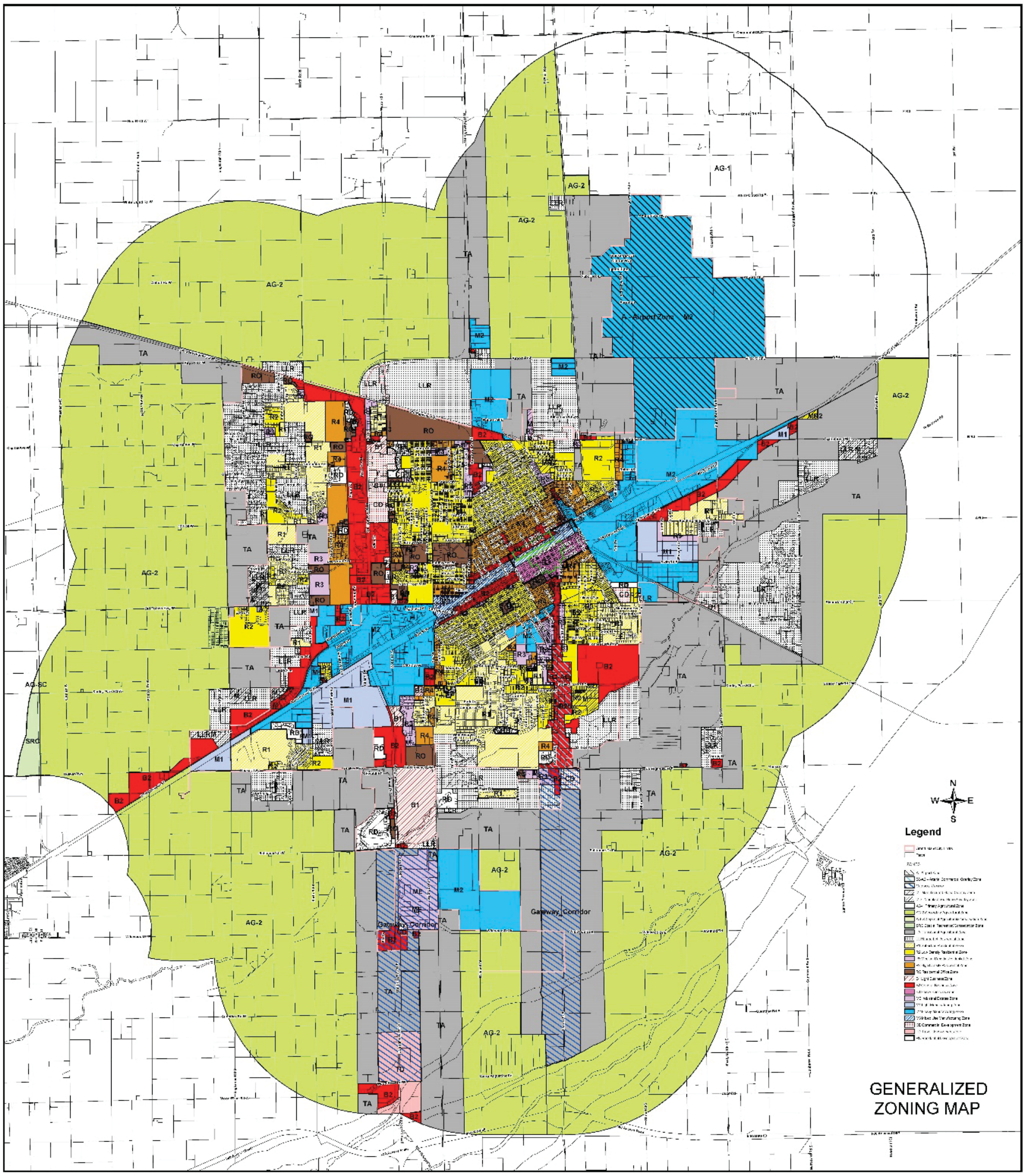
2. TREATMENT NEEDS

To develop the WQCV and Q_{WQ} requirements for Grand Island, the land use for Grand Island and typical maximum impervious coverage for those land uses were used to estimate the maximum percent impervious of the sub-basins. Future land use projections are consistent with the current Zoning and accurate until revised with a Comprehensive Plan update. The NE H_2O method, as described in Section 1, was then used to calculate the WQCV required to be treated for each sub-basin using the 80th percentile rainfall event.

Figure 2-1. Grand Island Generalized Zoning Map



For storm water treatment facilities that are designed based on a flow rate, the Q_{WQ} was calculated for each sub-basin using Autodesk Storm & Sanitary and the methodology described in the NE H_2O Memo. All hydrologic calculations can be found in BMP Master Plan Technical Reference - Appendix C.

2.1 Growth Area

The City of Grand Island's growth area is located west of Highway 281 and consists primarily of residential neighborhoods and agricultural ground with smaller amounts of commercial and manufacturing areas. The growth area is bounded on the east by Highway 281, on the north by Highway 2 & Silver Creek, on the west by 60th Road and on the south by Highway 30. The Growth area is regarded as prime development land in Grand Island because of the availability of utilities and is the most likely area to develop around the City. It has been split up into five sub-basins, which are each drained by constructed drainage ditches.

Example of Highlands Park Drainage

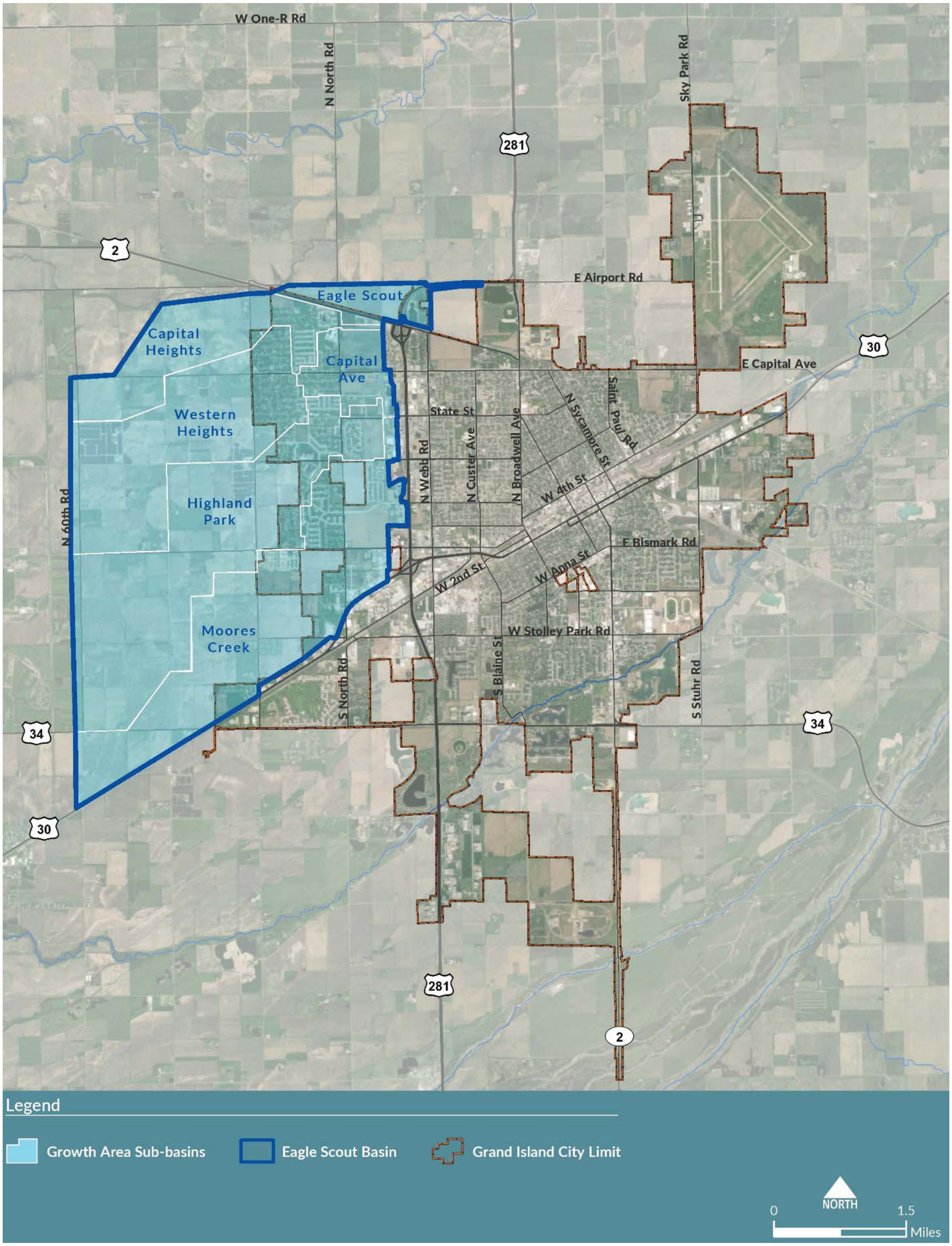
Example of Eagle Scout Drainage

Together, along with a small area along and north of Highway 2, these five sub-basins make up the Eagle Scout Basin, which drains to the lake at Eagle Scout Park.

Table 2-1. Summary of Treatment Needs for the Growth Area (80th Percentile)

Sub-Basin	Area (Ac)	Max Percent Impervious	WQCV (Ac-Ft)	Q_{WQ} (CFS)
Moore's Creek	2,978	50.6%	90.2	101
Highland Park	3,175	22.8%	48.6	52.4
Western Heights	2,207	19.1%	29.4	49.1
Capital Heights	1,252	24.0%	20.0	24.0
Capital Avenue	480	63.6%	17.9	67.8
Eagle Scout (Composite)	10,508	34.0%	225	211

Figure 2-2. Growth Area Sub-basins



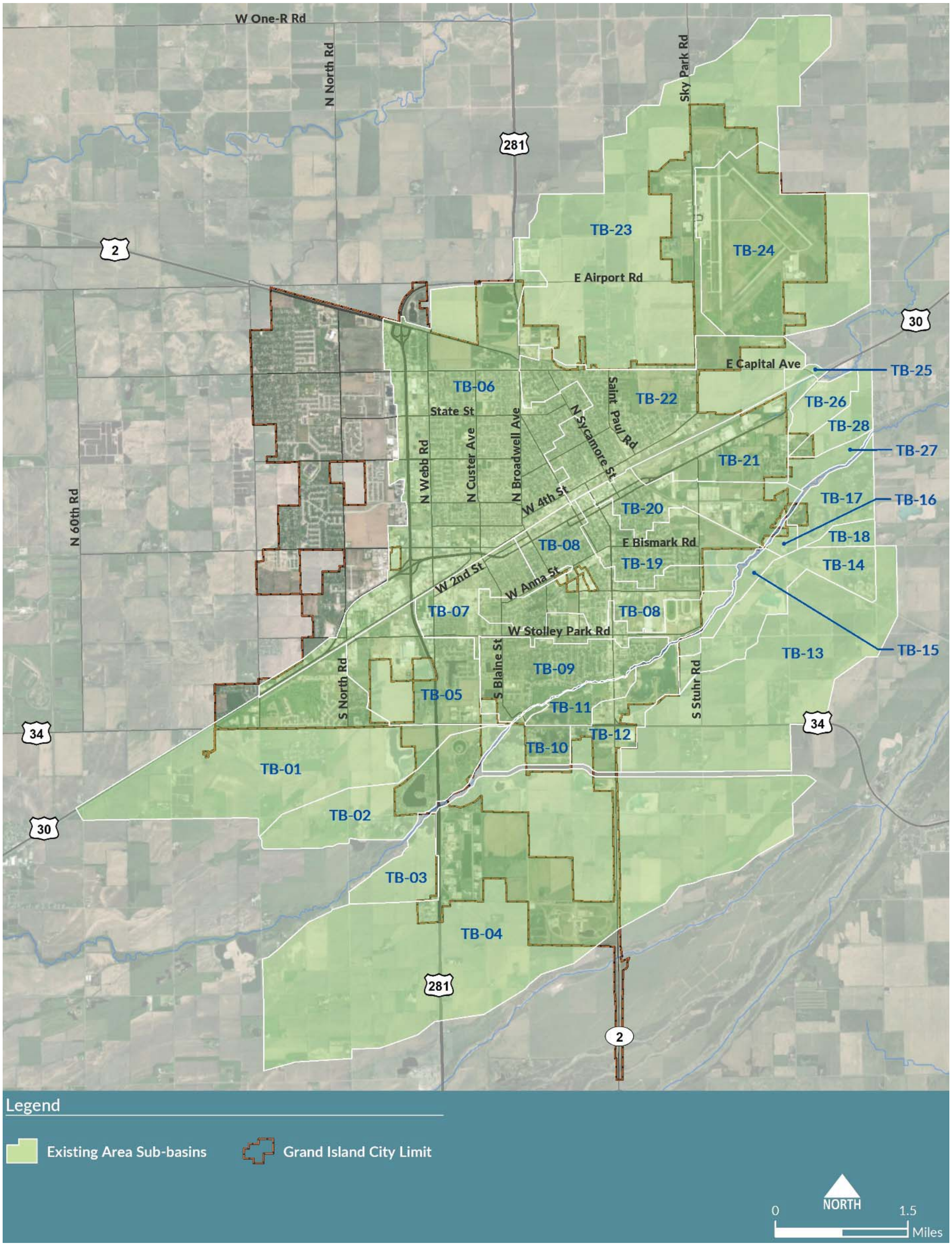
2.2 Existing Area

The City of Grand Island's existing area is generally located east of Highway 281 and consists of a mixture of agricultural, residential, commercial and manufacturing areas. The existing area is bounded on the west by Highway 281, except for a small area south of Highway 30 that extends further west and includes most of the developed area of Grand Island as well as some of the adjacent undeveloped land that could develop in the future. It has been split up into 28 sub-basins, which are each drained by constructed drainage ditches and/or storm sewer, eventually draining to the Wood River, the Platte River or Warm Slough.

Table 2-2. Summary of Treatment Needs for the Existing Area (80th Percentile)

Sub-Basin	Area (Ac)	Max Percent Impervious	WQCV (Ac-Ft)	Q_{WQ} (CFS)
TB-01	2,526	40.5%	62.8	61.6
TB-02	913	38.3%	21.6	34.0
TB-03	349	51.6%	10.8	15.5
TB-04	6,563	46.8%	186	103
TB-05	976	79.8%	45.0	78.3
TB-06	3,670	75.4%	161	192
TB-07	922	65.0%	35.1	53.2
TB-08	1,125	58.9%	39.2	88.6
TB-09	773	56.5%	25.9	44.5
TB-10	279	54.4%	9.0	21.9
TB-11	217	37.8%	5.1	14.9
TB-12	482	77.1%	21.5	57.3
TB-13	2,281	34.0%	48.7	65.8
TB-14	679	46.7%	19.1	30.0
TB-15	146	47.4%	4.2	12.9
TB-16	57	55.0%	1.8	10.7
TB-17	385	55.0%	12.6	30.7
TB-18	106	55.0%	3.5	11.3
TB-19	684	64.3%	25.8	119
TB-20	710	80.9%	33.2	75.9
TB-21	721	82.0%	34.1	104
TB-22	1,827	69.9%	74.5	161
TB-23	4,173	66.9%	163	270
TB-24	2,147	52.6%	67.4	159
TB-25	44	79.6%	2.0	7.0
TB-26	226	87.7%	11.4	28.6
TB-27	139	55.0%	4.6	9.7
TB-28	223	73.3%	9.5	23.7

Figure 2-3. Existing Area Sub-basins



3. COMPLIANCE ALTERNATIVES

Three treatment alternatives were considered as part of this study; distributed treatment, treatment in vegetated drainage ditches and treatment in detention ponds. These alternatives are described below.

3.1 Distributed Treatment

Distributed treatment, which is described in the NE H_2O Memo, is currently required by the City's post-construction program. Distributed treatment requires developers to provide treatment of storm water for new development and re-development of sites one acre or larger. Treatment facilities for new development must be sized to treat runoff from the 80th percentile rainfall event and treatment facilities for re-development must be sized to treat runoff from the 70th percentile rainfall event. This method gives developers the flexibility to decide where and how they want to treat storm water runoff as long as the treatment facility meets the sizing requirements of the NE H_2O Memo.

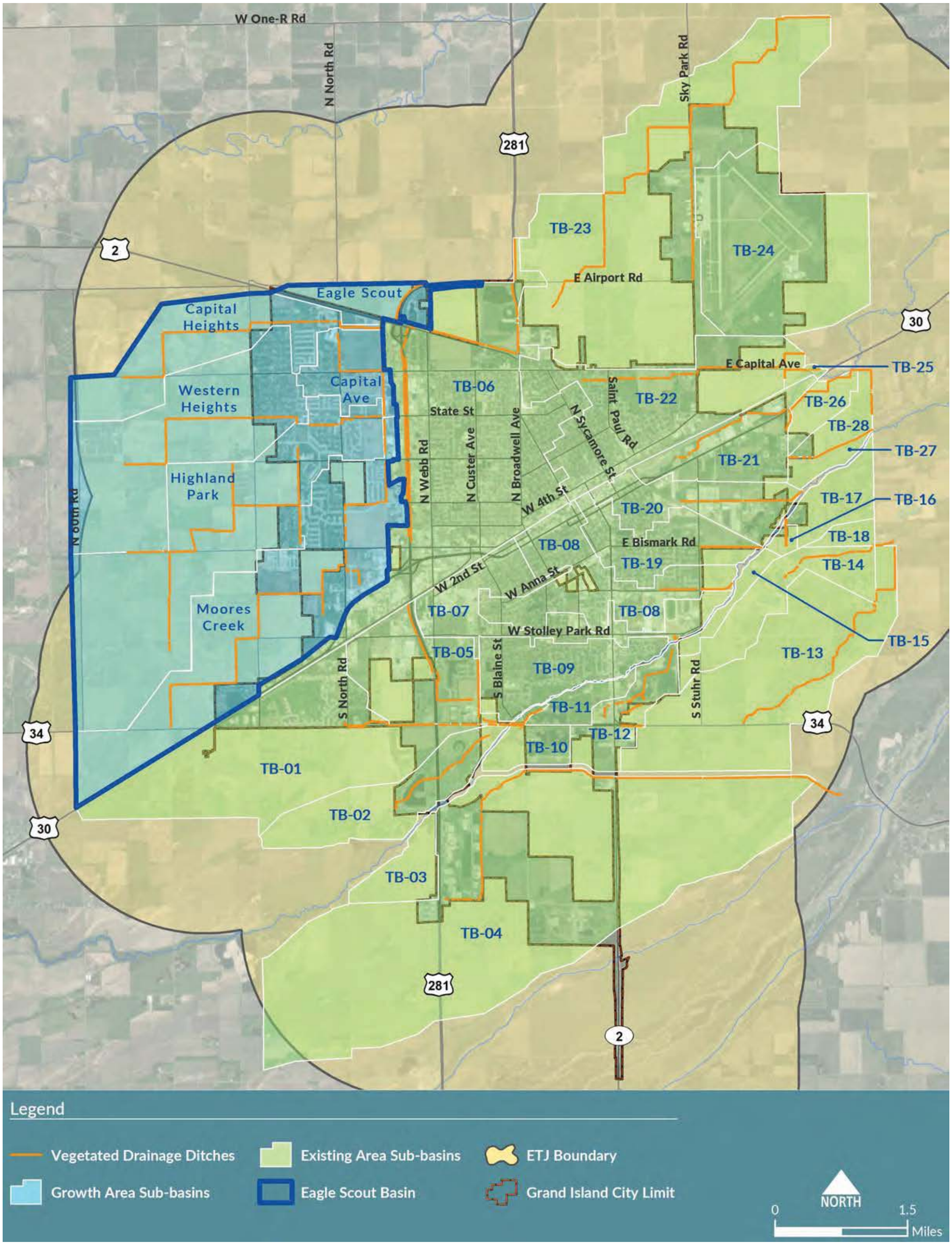
3.2 Treatment in Vegetated Drainage Ditches

Treating storm water in vegetated drainage ditches (also referred to as grass swales) is a concept that is recommended by many regional and national storm water manuals including the NDOT Drainage Design and Erosion Control Manual, the Omaha Regional Stormwater Design Manual, the Iowa Storm Water Management Manual, the Maryland Stormwater Design Manual and technical documents published by the Chesapeake Research Consortium. Treatment in these ditches relies on infiltration, filtration through vegetation and settlement of suspended solids. Some literature suggests that vegetated drainage ditches have limited ability to remove nutrients from storm water (Claytor & Schueler, 1996), however it is well documented that nutrients commonly attach to suspended solids which can be removed by these treatment facilities.

Most manuals simplify the design process for vegetated drainage ditches by placing constraints on their use to ensure that suspended solids have time to settle through the water column. These constraints commonly include the contributing drainage area being limited to 5 acres, the depth being limited to four inches and a residence time of 10 minutes being required. In many communities in the region and country, these constraints make sense because in ditches receiving higher flows from larger areas, suspended solids do not have adequate time to settle and velocities are too high to prevent resuspension of sediment. However, the local geography of Grand Island makes it an exception to these generalized constraints.

Much of Grand Island is currently drained through vegetated drainage ditches that were constructed as the City was developed. As development continues, these ditches will be extended to drain the newly developed areas. Because of Grand Island's proximity to local rivers and their floodplains, the City is very flat and has a high ground water table. The average longitudinal slope of the larger existing ditches is approximately 0.1%. Because of the flat slopes and high ground water, the drainage ditches are forced to be relatively shallow (typically around 6') and wide (up to 35') trapezoidal channels, in which vegetation establishes very easily. The natural geography of the area also lends itself to sub-basins that are generally long and narrow. All of these factors combine to create very long vegetated drainage ditches with shallow, slow moving flow, creating excellent conditions for infiltrating storm water, settling suspended solids and establishing thick vegetation to filter storm water.

Figure 3-1. Vegetated Drainage Ditches in Grand Island



3.2.1 Demonstrating Compliance

Filtration through vegetated channels and infiltration of storm water are expected to improve water quality, although these treatment methods are difficult to quantify. By comparison, settlement of suspended solids, to which contaminates and nutrients are known to attach, also provides storm water treatment in vegetated ditches. Settlement of suspended solids can be quantified by comparing the settling velocity of the solids with the flow depth and velocity in the ditches during a rainfall event.

The settling velocity of suspended solids in storm water can be calculated by dividing flow depth by residence time. A review of regional and national design manuals shows that most manuals limit flow depth to four inches and require five to ten minutes of residence time. Dividing 0.33 feet by 600 seconds derives a settling velocity of 0.00056 feet per second.

Since the terms used to derive the settling velocity are general in nature, checking this settling velocity compared to local soil types is an appropriate next step. Stoke's Law can be used to determine the settling velocity of a suspended solid for a known particle size and density, or in this case, can be used to determine the particle size for a known settling velocity and assumed particle density. Using Stoke's Law with this settling velocity (0.00056 ft/s) provided a particle size of 17.2 micrometers, which is consistent with a medium silt particle. Any particle larger than 17.2 microns will, in theory, settle faster than 0.00056 ft/s. This check using Stoke's Law is reasonable considering most soils around Grand Island are sand, sandy loam, silt loam or loam according to a search using the NRCS Web Soil Survey. The soil survey for Grand Island can be found in BMP Master Plan Technical Reference - Appendix D.

The Manning formula can be used to determine the depth and velocity of flow for the 80th percentile rainfall event in a typical ditch cross section for the various vegetated drainage ditches in Grand Island. With the settling velocity of suspended solids, flow velocity and flow depth known, the required treatment length can be calculated for each ditch using the equation below. The derivation of this equation can be found in BMP Master Plan Technical Reference - Appendix C.

$$Treatment\ Length = \frac{Flow\ Depth \times Flow\ Velocity}{Settling\ Velocity}$$

3.2.2 Resuspension of Sediment

Treating storm water in vegetated drainage ditches that are also used to drain larger rainfall events would not be effective if the sediment that was settled during the water quality rainfall events was then resuspended during large storms. To check the potential for resuspension of sediment, the maximum applied shear stress on a ditch under bank full conditions can be compared to the permissible shear stress for the ditch material. Since vegetation is a key component for treatment in ditches and the stability of ditches, the permissible shear stress of a vegetated lining should be used for this comparison. Applied shear stress is dependent on longitudinal slope and flow depth, so bankfull conditions are the most conservative to use for this evaluation. The methodology for vegetative lining design in Chapters 2 and 4 of the Federal Highway Administration's Hydraulic Engineering Circular No. 15 – Design of Roadside Channels with Flexible Linings (HEC-15) can be used for this analysis.

3.3 Treatment in Ponds (Gravel Pits)

Treating storm water in ponds (wet ponds and wet extended detention ponds) is a concept that is recommended by many regional and national storm water manuals including the NDOT Drainage Design and Erosion Control Manual, the Omaha Regional Stormwater Design Manual, the Iowa Storm Water Management Manual and the Maryland Stormwater Design Manual. Wet ponds contain a permanent pool of water equal to at least the WQCV, which is displaced during a rainfall event. Storm water is then treated during the dry period by allowing particles and associated contaminates to settle as well as through biological uptake around the perimeter of the pond. Wet extended detention ponds are similar to wet ponds but also include storage volume above the permanent pool which can store part of or the entire WQCV. The volume above the permanent pool is then treated through settling and released over an extended period of time, while the volume in the permanent pool is retained and treated through settling and biological uptake until it is displaced by the next storm.

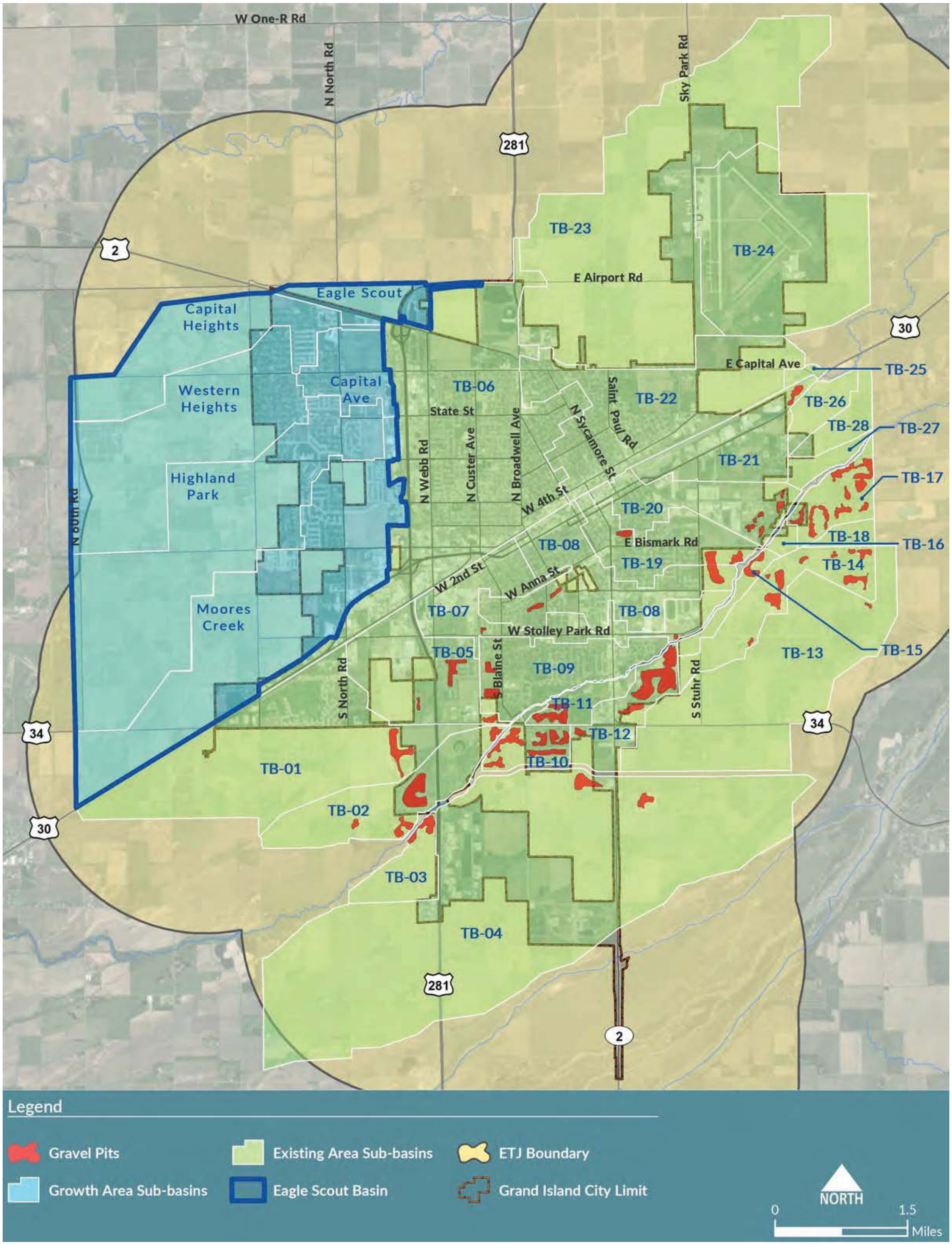
There are currently many gravel pits that line both sides of the Wood River throughout Grand Island. These gravel pits are left from mining operations to collect gravel that was used as a construction material and are typically filled with water. The water surface elevation of these pits is dictated by and fluctuates with the surrounding ground water elevation. Because of the size of the gravel pits and because the ground water elevation is typically several feet below the ground elevation, there is typically enough storage volume both above & within the permanent pool to contain the WQCV. The gravel pits also have very sandy banks that promote rapid infiltration of storm water that runs into them. All these factors combine to make the existing gravel pits in Grand Island great candidates for wet basins or wet extended detention basins to treat the storm water flowing into them.

3.3.1 Demonstrating Compliance

To demonstrate compliance of existing gravel pits acting as wet ponds, adequate storage must exist in the permanent pool to contain the WQCV. Because the water surface elevation of the permanent pool fluctuates with the surrounding ground water elevation, the water surface elevation of the permanent pool can be conservatively assumed to be the average ground water elevation during the spring months (April, May and June), before irrigation typically draws down the ground water elevation in July. The top area of the permanent pool can be measured using contours of the area and the required depth below the water surface can be calculated, while considering an average bank slope. Since bathymetric contours are not readily available for the gravel pits in Grand Island, the actual depth of the pits is unknown; however, knowledge of typical gravel pit depths suggest that adequate depth most likely exists.

To demonstrate compliance of existing gravel pits acting as wet extended detention ponds, adequate storage must exist within the permanent pool as well as above the permanent pool to contain the WQCV. To do so, the same procedure can be followed as for wet ponds but the required depth above the permanent pool should also be calculated while considering an average bank slope. If the required depth above the permanent pool is less than the vertical distance from the water surface elevation of the permanent pool to the over flow elevation of the gravel pit, then the gravel pit can be considered a wet extended detention pond. Because the gravel pits in Grand Island rely on infiltration into the sand bottom instead of an extended release to a downstream water body, wet extended detention ponds should be extremely effective at treating storm water for the City of Grand Island.

Figure 3-2. Gravel Pits in Grand Island



3.4 Additional Treatment Alternatives

In addition to distributed treatment, treatment in vegetated drainage ditches, treatment in wet ponds and treatment in wet extended detention ponds, there are several alternatives for treatment that were not considered feasible for various reasons.

3.4.1 Dry Swales

Dry swales are similar to vegetated drainage ditches but utilize filter media and an underdrain in the bottom of the ditch to filter storm water (Iowa Storm Water Management Manual). They are sized to capture the entire WQCV so they would likely need a series of check dams to pond storm water. Dry swales are not considered feasible in Grand Island because of the cost and maintenance requirements of the filter media and underdrain as well as the loss of ditch conveyance due to the installation of check dams. High ground water may also impact the functionality of the underdrain system for dry swales.

3.4.2 Wet Swales

Wet swales are similar to dry swales but do not rely on filter media or an underdrain to filter flow (Iowa Storm Water Management Manual). Instead, they store the WQCV behind check dams, slowly releasing it over 24 to 40 hours. They are typically not recommended in residential areas because of long term standing water and mosquito concerns. Wet swales are not considered feasible in Grand Island because of the loss of ditch conveyance due to the installation of check dams.

3.4.3 Bioretention Systems

Bioretention systems treat storm water by storing the WQCV and allowing infiltration into layers of plant roots and growing medium to remove contaminates. The contributing area for bioretention systems is typically small (<4 acres), so there may be potential to incorporated them into the distributed method, but it would be difficult to use these systems on a large scale.

3.4.4 Dry Detention and Extended Dry Detention Basins

Dry detention and extended dry detention basins treat storm water by storing the WQCV, allowing particles and associated contaminates to settle, and releasing the WQCV over an extended period of time, reducing peak storm water runoff rates and the effective shear stress on downstream channels. Because these treatment basins are intended to remain dry in between rainfall events, it would be difficult to incorporate them into Grand Island because of the seasonably high groundwater and tailwater that could frequently fill these basins. If incorporated throughout the community, they could also locally increase (or give the perception of increasing) the ground water elevation, which could impact adjacent structures.

4. RECOMMENDED COMPLIANCE APPROACH

4.1 Growth Area

The City of Grand Island's growth area, located west of Highway 281, consists of five long, narrow sub-basins that are drained by vegetated drainage ditches. These ditches are already constructed in the developed areas of the sub-basins and will be extended as development continues. Because of the local geography, described in Section 3.2, these ditches are long, shallow, have flat longitudinal slopes and contain dense vegetation, making them perfect candidates to effectively treat the storm water that drains through them.

The ditches in each sub-basin of the Growth Area were evaluated using the methods described in Section 3.2.1 to determine their effectiveness at treating storm water. Although the City is not obligated to treat storm water from areas that have been previously developed, these areas were still considered in the evaluation because sediment must settle through the entire water column, regardless of the treatment obligation.

Table 4-1 summarizes the capability of vegetated drainage ditches in the Growth Area to treat storm water through settlement of suspended solids. In this evaluation, the required treatment length was first calculated for each ditch. The length was then traced along each ditch to determine the extent required to settle suspended solids from the top of the water column to the bottom of the ditch. Any storm water entering the ditch in the treatment length cannot be completely treated in the ditch. The treated area was then delineated for each sub-basin. The treated area is defined as the area in the sub-basin that contributes storm water to the ditch upstream of the treatment length. Please see Section 4.1.1 for the treated area in each basin of the Growth Area.

Table 4-1. Growth Area Ditch Summary (80th Percentile)

Sub-Basin	Treatment Ditch	Q_{WQ} (CFS)	Flow Depth (Ft)	Flow Velocity (Ft/Sec)	Required Treatment Length (Ft)
Moore's Creek	Moore's Creek	101	4.27	0.94	7,245
Highland Park	Highland Park	*88.9	*3.54	*1.13	7,215
Western Heights	Highland Park & Western Heights	*88.9	*3.54	*1.13	7,215
Capital Heights	Capital Heights	24.0	1.74	1.06	3,329
Capital Avenue	Capital Ave	67.8	3.07	1.36	7,495
Eagle Scout (Composite)	Individual Ditches	Varies	Varies	Varies	Varies
Eagle Scout (Composite)	Eagle Scout	*196	*5.02	*0.95	8,606

*For treatment ditches with multiple cross sections, the statistics that produce the governing (highest) required treatment length are reported.

All ditches were evaluated to understand the risk of resuspending sediment during large storms that had previously been settled from the storm water. To do this, the permissible shear stress of the vegetative liner was compared to the maximum applied shear stress in the ditches at bankfull conditions, as discussed in Section 3.2.2. A summary of the results from this evaluation can be found in Table 4-2 and shows that sediment will not be resuspended in the ditches during large storm events.

Table 4-2. Growth Area Sediment Resuspension Summary

Sub-Basin	Treatment Ditch	Flow Depth (Ft)	Flow Velocity (Ft/Sec)	Permissible Shear Stress, Vegetated (Lb/Ft^2)	Max Applied Shear Stress (Lb/Ft^2)	Risk of Sediment Resuspension
Moore's Creek	Moore's Creek	6.00	1.31	3.43	0.25	No
Highland Park	Highland Park	*6.00	*1.83	*2.53	*0.37	No
Western Heights	Highland Park & Western Heights	*6.00	*1.83	*2.53	*0.37	No
Capital Heights	Capital Heights	6.00	3.39	1.47	0.75	No
Capital Avenue	Capital Ave	2.50	1.11	3.47	0.24	No
Eagle Scout (Composite)	Eagle Scout	*8.00	*1.44	*3.32	*0.24	No

*For treatment ditches with multiple cross sections, the statistics that produce the governing (highest) required treatment length are reported.

4.1.1 Summary of Results

The evaluation discussed in Section 4.1 showed that, except for the Capital Avenue sub-basin, over 80% of each sub-basin can be treated by the vegetated drainage ditch within the sub-basin. As a whole, 81% of the area in the sub-basins can be treated by the individual ditches in each sub-basin. In addition to the individual ditches, the Eagle Scout ditch drains all five sub-basins to the lake at Eagle Scout Park, with very little contributing area coming from elsewhere. The Eagle Scout ditch can treat 95% of the area in the five sub-basins, leaving out only a small area north and just south of Highway 2. Table 4-3 and Figures 4-2 and 4-3 summarize the treatment available in the Growth Area through vegetated drainage ditches. Cut sheets providing treatment statistics for the Growth Area sub-basins can be found in Appendix A.

Table 4-3. Growth Area Treatment Summary (80th Percentile)

Sub-Basin	Sub-Basin Area (Ac)	Treated Area (Ac)	Percent of Basin Treated
Moore's Creek	2,978	2,485	83%
Highland Park	3,175	2,635	83%
Western Heights	2,207	1,814	82%
Capital Heights	1,252	1,219	97%
Capital Avenue	480	0	0%
Eagle Scout (1) (Composite)	10,090	8,152	81%
Eagle Scout (2) (Composite)	10,508	10,032	95%

(1) Treatment in individual ditches in each sub-basin.
(2) Treatment in combined Eagle Scout Ditch.

Figure 4-1. Growth Area Treatment Summary (80th Percentile)

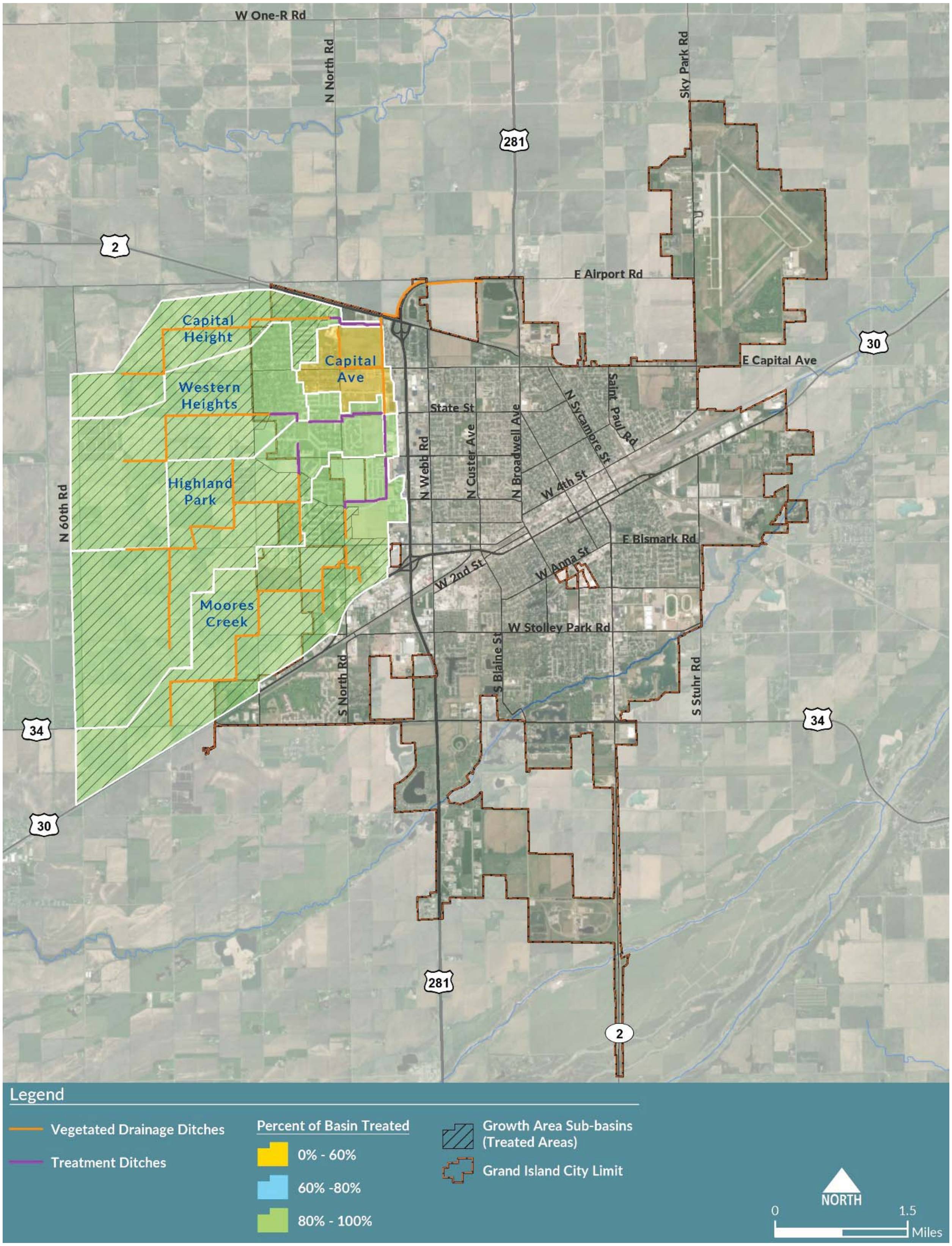
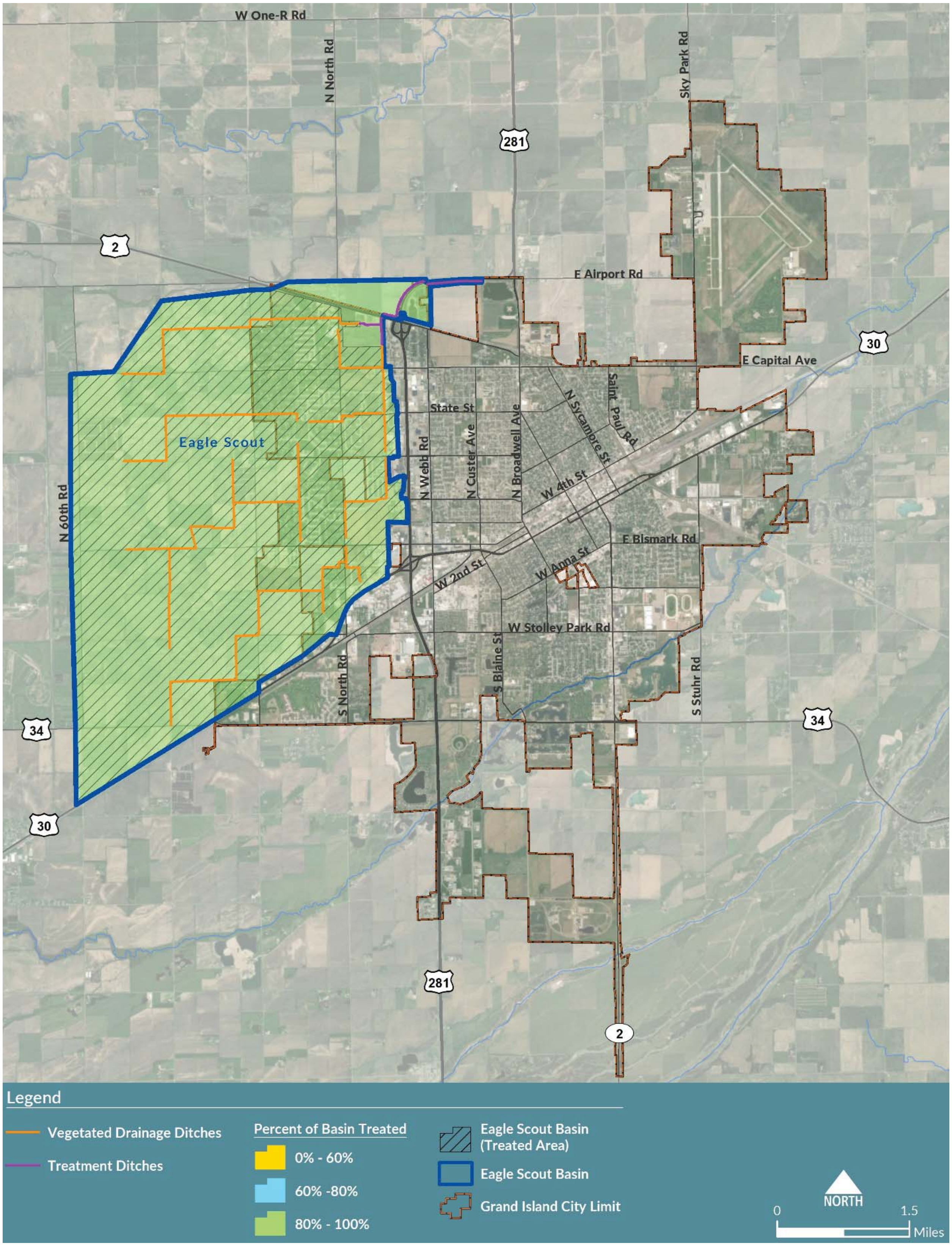


Figure 4-2. Eagle Scout Basin Treatment Summary (80th Percentile)



4.2 Existing Area

The City of Grand Island's Existing Area, located east of Highway 281, consists of 28 sub-basins of various shapes and sizes that are drained by storm sewer or vegetated drainage ditches, often draining through existing gravel pits. Because of the local geography, described in Section 3.2, these ditches are long, shallow, have flat longitudinal slopes and contain dense vegetation, making them perfect candidates to effectively treat the storm water that drains through them. Because of the size of the existing gravel pits, the fact that they are filled with water, their sand bottoms promote infiltration and they have storage above the permanent pool, the gravel pits in these sub-basins are perfect candidates for wet ponds or wet extended detention ponds.

4.2.1 Treatment in Vegetated Drainage Ditches

Sub-basins TB-01, TB-04, TB-06, TB-13, TB-16, TB-20, TB-22, TB-23 and TB-25 all drain through vegetated drainage ditches. The ditches in each sub-basin were evaluated using the methods described in Section 3.2.1 to determine their effectiveness at treating storm water. Although the City is not obligated to treat storm water from areas that have been previously developed, these areas were still considered in the evaluation because sediment must settle through the entire water column, regardless of the treatment obligation.

Table 4-4 summarizes the capability of vegetated drainage ditches in the Existing Area to treat storm water through settlement of suspended solids. In this evaluation, the same method used for the ditches in the Growth Area was used for the ditches in the Existing Area.

Table 4-4. Existing Area Ditch Summary (80th Percentile)

Sub-Basin	Q_{WQ} (CFS)	Flow Depth (Ft)	Flow Velocity (Ft/Sec)	Required Treatment Length (Ft)
TB-01	61.6	2.19	1.25	4,907
TB-04	103	2.31	1.01	4,190
TB-06	*192	*4.65	*1.75	*14,642
TB-13	*65.8	*3.11	*0.77	*4,331
TB-16	10.7	2.11	0.28	1,067
TB-20	75.9	2.65	0.94	4,474
TB-22	*161	*4.43	*1.53	*12,211
TB-23	270	5.36	1.51	14,534
TB-25	7.0	1.03	0.83	1,549

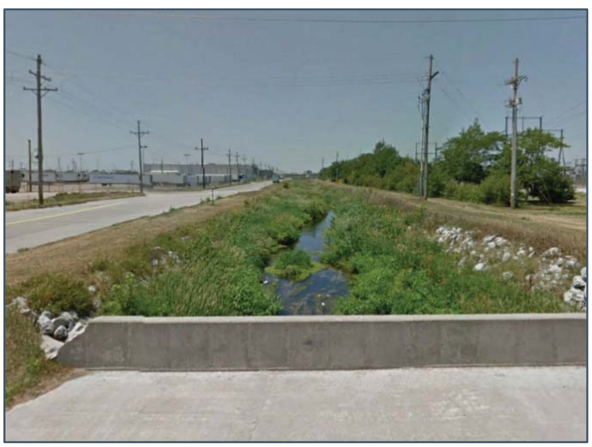
*For treatment ditches with multiple cross sections, the statistics that produce the governing (highest) required treatment length are reported.

All ditches were evaluated to understand the risk of resuspending sediment during large storms that had previously been settled from the storm water. To do this, the permissible shear stress of the vegetative liner was compared to the maximum applied shear stress in the ditches at bankfull conditions, as discussed in Section 3.2.2. A summary of the results from this evaluation can be found in Table 4-5 and shows that sediment will not be resuspended in the ditches during large storm events.

Table 4-5. Existing Area Sediment Resuspension Summary

Sub-Basin	Flow Depth (Ft)	Flow Velocity (Ft/Sec)	Permissible Shear Stress, Vegetated (Lb/Ft²)	Max Applied Shear Stress (Lb/Ft²)	Risk of Sediment Resuspension
TB-01	4.0	2.14	2.13	0.40	No
TB-04	3.0	1.79	3.32	0.19	No
TB-06	*5.0	*1.89	*2.40	*0.41	No
TB-13	*4.0	*0.97	*4.28	*0.17	No
TB-16	3.0	0.41	8.48	0.09	No
TB-20	6.0	1.89	2.50	0.33	No
TB-22	*9.0	*3.00	*1.71	*0.64	No
TB-23	6.0	1.69	2.76	0.32	No
TB-25	2.0	1.55	2.51	0.36	No

*For treatment ditches with multiple cross sections, the statistics that produce the governing (highest) required treatment length are reported.




Examples of Existing Area Vegetated Treatment Ditches

4.2.2 Treatment in Wet Ponds or Wet Extended Detention Ponds

Sub-basins TB-02, TB-03, TB-05, TB-10, TB-12, TB-14, TB-17 and TB-21 all drain through existing gravel pits. The gravel pits in each sub-basin were evaluated using the methods described in Section 3.3.1 to determine their effectiveness at treating storm water. All calculations are based on the 80th percentile rainfall event. Table 4-6 summarizes the capability of gravel pits in the Existing Area to treat storm water as a wet pond or a wet extended detention pond.

Table 4-6. Existing Area Pond Summary (80th Percentile)

Sub-Basin	WQCV (Ac-Ft)	Top Area of Permanent Pool (Ac)	Required Depth of Permanent Pool (Ft)	Required Depth Above Permanent Pool (Ft)	Available Depth Above Permanent Pool (Ft)	Pond Type
TB-02	21.6	7.7	3.0	2.7	7.4	Wet ED Pond
TB-03	10.8	18.0	0.6	0.6	8.4	Wet ED Pond
TB-05	45.0	5.8	11.8	6.6	1.3	Wet Pond
TB-10	9.0	67.9	0.1	0.1	3.7	Wet ED Pond
TB-12	21.5	81.6	0.3	0.3	*Unknown	Wet ED Pond
TB-14	19.1	24.0	0.8	0.8	*Unknown	Wet ED Pond
TB-17	12.6	76.2	0.2	0.2	*Unknown	Wet ED Pond
TB-21	34.1	8.9	4.9	3.3	*Unknown	Wet Pond

*This gravel pit is outside of the ground water rasters provided. The pond is assumed to be a wet extended detention pond if the required depth above the permanent pool is less than one foot.

Examples of Existing Area Treatment Ponds

4.2.3 Summary of Results

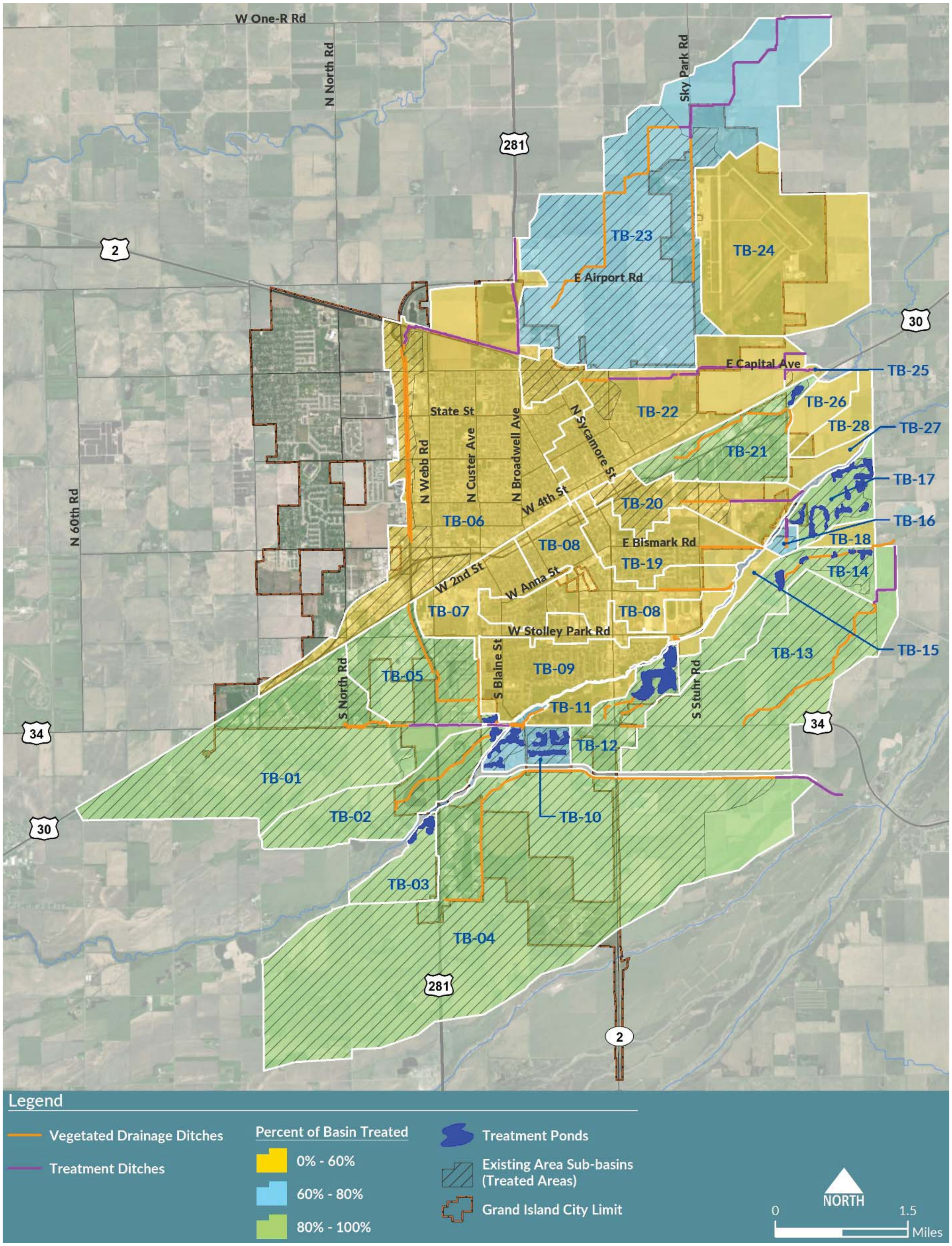
The evaluation showed that there is mixed ability to treat storm water in the Existing Area with existing regional infrastructure in Grand Island. Some sub-basins have very good treatment (up to 100%) while others have no treatment available, although there is likely some treatment occurring throughout the sub-basin as described in Section 4.3. As a whole, 64% of the Existing Area can be treated by the vegetated ditches, wet ponds and wet extended detention ponds identified throughout the individual sub-basins. Table 4-7 and Figure 4-3 summarize the treatment available in the Existing Area. Cut sheets providing improvement and treatment statistics for the Existing Area sub-basins can be found in Appendix A.

Table 4-7. Existing Area Treatment Summary (80th Percentile)

Sub-Basin	Treatment Type	Sub-Basin Area (Ac)	Treated Area (Ac)	Percent of Basin Treated
TB-01	Vegetated Ditch	2,526	2,379	94%
TB-02	Wet ED Pond	913	910	100%
TB-03	Wet ED Pond	349	348	100%
TB-04	Vegetated Ditch	6,563	6,078	93%
TB-05	Wet Pond	976	968	99%
TB-06	Vegetated Ditch	3,670	891	24%
TB-07	No Treatment Available	922	0	0%
TB-08	No Treatment Available	1,125	0	0%
TB-09	No Treatment Available	773	0	0%
TB-10	Wet ED Pond	279	212	76%
TB-11	No Treatment Available	217	0	0%
TB-12	Wet ED Pond	482	482	100%
TB-13	Vegetated Ditch	2,281	2,123	93%
TB-14	Wet ED Pond	679	616	91%
TB-15	No Treatment Available	146	0	0%
TB-16	Vegetated Ditch	57	37	65%
TB-17	Wet ED Pond	385	332	86%
TB-18	No Treatment Available	106	0	0%
TB-19	No Treatment Available	684	0	0%
TB-20	Vegetated Ditch	710	425	60%
TB-21	Wet Pond	721	714	99%
TB-22	Vegetated Ditch	1827	296	16%
TB-23	Vegetated Ditch	4,173	3,065	73%
TB-24	No Treatment Available	2,147	0	0%
TB-25	Vegetated Ditch	44	10	23%
TB-26	No Treatment Available	226	0	0%
TB-27	No Treatment Available	139	0	0%
TB-28	No Treatment Available	223	0	0%
*Composite	Multiple	*31,196	*19,886	*64%

*The composite results do not include Sub-Basin 24, which includes only the airport and agricultural land. Storm water from this sub-basin can be easily treated by the airport, using the distributed method of treatment as needed.

Figure 4-3. Existing Area Treatment Summary (80th Percentile)



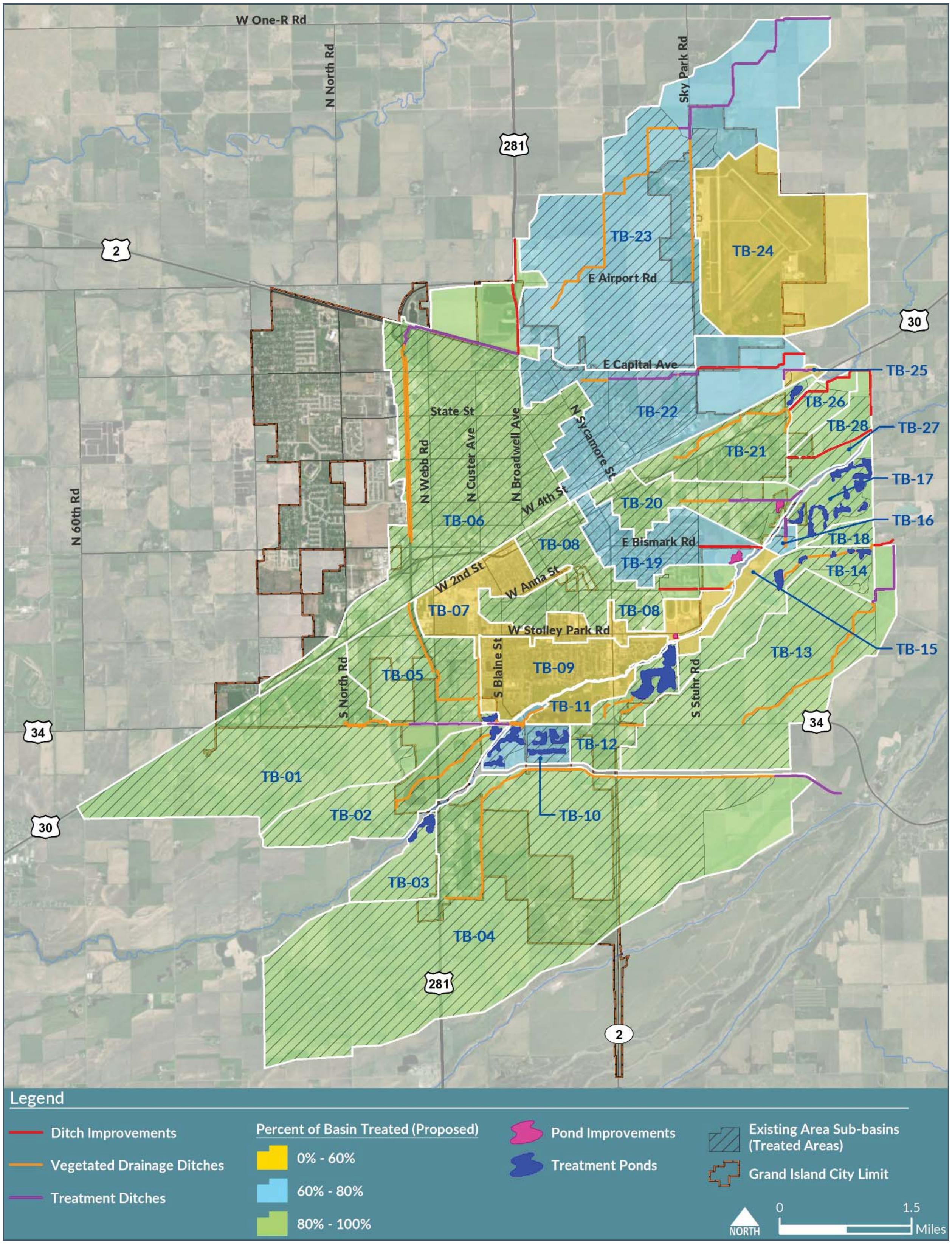
As shown in Table 4-7, about 64% of the Existing Area can be treated by existing infrastructure, however there are several improvements available that could help increase the treated area. The most obvious improvements consist of widening vegetated ditches to decrease the depth and velocity, therefore reducing the required treatment length, and constructing wet ponds or wet extended detention ponds to treat the WQCV at the downstream end of the sub-basins. There are likely additional treatment opportunities throughout the Existing Area that could increase the treated area, however they would take additional analysis and/or modeling that was beyond the scope of this study. Potential improvements that offer the most treatment benefit for the City of Grand Island are summarized in Table 4-8 and Figure 4-4. With these improvements completed, up to 82% of the Existing Area could be treated.

Table 4-8. Available Improvements Summary

Sub-Basin	Proposed Improvement	Sub-Basin Area (Ac)	Treated Area w/ Improvement (Ac)	Percent of Basin Treated w/ Improvements
TB-06	Widen ditch to 35' from Railroad to outfall to Moore's Creek.	3,670	3,190	87%
TB-07	Construct wet pond just upstream of outfall to the Wood River (35.1 ac-ft of storage required but only 7.8 ac-ft is likely available).	922	205	22%
TB-08	Widen ditch to 35' from Pleasant View to curve upstream of outfall to the Wood River.	1,125	944	84%
TB-18	Widen entire ditch to 15'.	106	106	100%
TB-19	Widen entire ditch to 55' (difficult to maintain) or route storm water through existing gravel pit (25.8 ac-ft of storage required and likely available).	684	521	76%
TB-20	Route storm water to and expand gravel pit east of the wastewater treatment plant (33.2 ac-ft of storage required and likely available).	710	592	83%
TB-22	Widen ditch to 30' from Sky Park to 3060 Capital Ave and to 35' from 3060 Capital Avenue to end of sub-basin.	1,827	1,186	65%
TB-26	Construct 12' wide trapezoidal ditch along north side of sub-basin (0.1% maximum slope).	226	185	82%
TB-27	Construct 5' wide trapezoidal ditch along Seedling Mile Road (0.1% maximum slope).	139	121	87%
TB-28	Construct 12' wide trapezoidal ditch along Gunbarrel Rd (0.1% max slope).	223	189	85%
*Composite	Multiple	*31,196	*25,513	*82%

*The composite results do not include Sub-Basin 24, which includes only the airport and agricultural land. Storm water from this sub-basin can be easily treated by the airport, using the distributed method of treatment as needed.

Figure 4-4. Available Improvements



4.3 Additional Justification for Compliance

In addition to treating storm water in vegetated drainage ditches, wet ponds and wet extended detention ponds, the City of Grand Island has been and will continue to be developed in ways that promote storm water treatment upstream of designated treatment locations. Many existing residential neighborhoods are drained internally using grassed swales. These swales slow the storm water down, allowing sediment to settle out, filter contaminates and promote infiltration. These grass swales, as well as larger vegetated ditches also promote storm water treatment and nutrient removal in the hyporheic zone. The hyporheic zone is the area immediately below and adjacent to a stream bed which is effective at providing biological nutrient processing.

Detention cells that are maintained by the City but studied for this Plan have been constructed throughout the City and promote storm water treatment in several ways. First, they allow storm water to spread out and fill the cell. This forces the velocity to approach zero, maximizing the potential for sediment to settle and infiltration to occur. The detention of storm water also reduces the flow depth and velocity in the vegetated drainage ditches, benefiting the treatment performance of the ditches. Because the detention cells were not modeled as part of this study, the actual performance of the downstream treatment ditches will likely be greater than what is illustrated in this report, reducing the required treatment length, increasing the treated area and further reducing risk of sediment resuspension.

Example of Disconnected Stormwater Runoff in Residential Development

Example Vegetated Detention with no Low-Flow Liner in Commercial Development

In addition to detention cells benefiting the performance of the vegetated treatment ditches, the City commonly experiences backwater effects from the high level of downstream receiving waters that act similarly. These backwater effects force residence time to be extended in the detention cells as well as the vegetated drainage ditches, again maximizing sediment settlement and infiltration.

Although the amount of storm water treatment from these additional justifications has not been quantified, it helps to illustrate the redundant nature of treatment currently available in the City of Grand Island. Because of the local geography and hydraulic conditions of receiving waters, the City demonstrates that they have been treating storm water well before their MS4 permit requirements were established and will continue to do so within existing and new infrastructure throughout the City.

5. GRAND ISLAND - STORMWATER TREATMENT EXCHANGE PROGRAM (GI-STEP)

5.1 STEP Overview

The Grand Island Stormwater Treatment Exchange Program operates as an equivalency standard. Equivalent treatment is provided to offset the stormwater impact caused by a new development or redevelopment project within the City. GI-STEP is made available for new development and redevelopment projects to satisfy their post construction stormwater program requirements. Individual project requirements to provide stormwater treatment may be exchanged for treatment provided elsewhere in the MS4 if the conditions described in this section are satisfied. Projects that <u>cannot</u> use GI-STEP exchange credits, will follow the Nebraska H_2O Memo (Appendix B) to size stormwater treatment and submit designs for review and approval by the City. In most situations, equivalent stormwater treatment is available throughout the MS4 and may be used to satisfy the treatment required at an applicable development site. The regional stormwater treatment (WQCV or Q_{WQ}) facility must meet the requirements, oversight, recordkeeping and maintenance standards described in this section.

5.2 Regional Stormwater Treatment Facility Applicability

All regional stormwater treatment facilities must satisfy the following requirements for STEP Applicability:

1. Water bodies listed by name in surface water quality classifications and standards regulations (NDEQ Title 117) shall not be considered regional stormwater treatment facilities.
2. Regional stormwater treatment facilities must be designed and maintained for 100% WQCV or Q_{WQ} for the **treatment** drainage area.
3. Regional stormwater treatment facilities must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices.
4. Regional stormwater treatment facilities must have capacity to accommodate the drainage from applicable development sites in the treatment drainage area.
5. Regional stormwater treatment facilities must be designed and built to comply with all assumptions for the development activities planned within its treatment drainage area, including the imperviousness of its drainage area and the applicable development sites.
6. Evaluation of the minimum drain time or equivalent flow through velocity shall be based on the pollutant removal mechanism and functionality of the regional stormwater treatment facilities. Consideration of drain time shall include maintaining vegetation necessary for operation of the stormwater treatment facility.
7. Regional stormwater treatment facilities must be subject to municipal authority necessary to effectively enforce requirements and actions for selection, design, and construction.

5.3 Regional Stormwater Treatment Facility Oversight

New and retrofit regional stormwater treatment facilities must include the following implementation for STEP Oversight:

1. <u>Plan Requirements</u> shall include preparation and submittal of:
    a. Stormwater treatment facility design plans, details and construction specifications
    b. Operation and maintenance procedures to ensure long term observation, maintenance, and operation

c. Documentation regarding easements or other legal means for access for operation, inspection and maintenance

2. Plan Review shall include consideration of minimum municipal requirements for:
    a. Stormwater treatment facility design standards
    b. Stormwater treatment facility design criteria
    c. Stormwater treatment facility operation and maintenance
3. Plan Approval shall be provided by the Director of Public Works or their authorized representative only after it has been determined that stormwater treatment facility design standards, criteria, operation and maintenance requirements will be satisfied and are enforceable by the City.
4. Construction Inspection and Acceptance shall be documented with records of inspections conducted during construction and the City's written acceptance of each completed and operational stormwater treatment facility.
5. Long-Term Operation and Maintenance and Oversight shall ensure stormwater treatment facilities are functioning as designed by:
    a. Enforcing requirement for owner or operator to implement and maintain control measures when necessary.
    b. Inspecting field conditions and control measures to confirm conformity with design plans and identify any deficiencies in implementation and operation or items requiring routine maintenance.
    c. Regional stormwater treatment facilities that are not subject to municipal authority to enforce maintenance actions, shall not receive STEP funds for maintenance actions without an approved maintenance agreement in force with the City.
6. Enforcement Response shall follow written procedures and actions to return an approved stormwater treatment facility to approved operational conditions. The procedures shall include escalation of enforcement as necessary based on the severity of the required construction, operation or maintenance action.

5.4 Regional Stormwater Treatment Facility Recordkeeping

The City will maintain a STEP tracking workbook as necessary to demonstrate program implementation over time and to support annual reporting to regulatory officials. Tracking for all applicable development sites must satisfy the following requirements for STEP Recordkeeping:

1. New Development and Redevelopment Projects: The City will review each proposed development and redevelopment project to determine if stormwater treatment requirements must be addressed. Projects that disturb one acre of soil or more or that may as part of a larger common plan of development must address post construction stormwater treatment standards. If stormwater treatment standards cannot be satisfied according to STEP 1, 2 or 3 described below, the project must incorporate stormwater treatment within the applicable development site design prior to approval.

2. STEP 1 – Pre-existing Treatment Credit: If an applicable development site is proposed to be located within the pre-existing treatment portion of a subbasin, additional stormwater treatment will not be required with the design of the project. The Stormwater BMP Master Plan documents pre-existing stormwater treatment in 22 of 33 subbasins. New development and redevelopment projects located in treated portions of these subbasins use **STEP 1 Credits** and will not be required to provide redundant stormwater treatment. A total of 26,042 acres (40.7 square miles) STEP 1 Credits are available in this Plan.

3. STEP 2 – Retrofit Treatment Credit: If an applicable development site is proposed to be located within a retrofit treatment portion of any subbasin and the stormwater treatment retrofit is complete or under construction when the project is approved, stormwater treatment will not be required with the design of the project. The Plan documents retrofit stormwater treatment in 10 subbasins. New development and redevelopment projects located in retrofit treatment areas of these subbasins use **STEP 2 Credits** and will not be required to provide redundant stormwater treatment. A total of 6,094.6 acres (9.5 square miles) STEP 2 Credits are available in this Plan.

   A stormwater treatment retrofit project may not have been initiated when a project is proposed inside the retrofit treatment portion of a subbasin. In this situation the City may exchange unused STEP 3 Credits until the stormwater treatment retrofit is completed. Once the stormwater treatment retrofit is complete, these STEP 3 Credits will be returned for use by other applicable development sites. The purpose of this exchange is to ensure there is no temporal loss in stormwater treatment provided by the Plan.

4. STEP 3 – Excess Treatment Credit: If an applicable development site is proposed outside of an existing or retrofit treatment boundary but the City authorizes use of **STEP 3 Credits**, stormwater treatment will not be required for design of the project. The City maintains records of STEP 3 Credits available and will review the proposed project to determine if the project warrants use of available credits. At the time of this study 10 subbasins provided treatment for more than 80% of the existing and/or future development area. All treated acres within a subbasin in excess of 80% are tracked as STEP 3 Credits. A total of 4,243.4 acres (6.6 square miles) of STEP 3 Credits are available in the Plan. This amount includes 2,272.3 acres available from pre-existing treatment and up to 348.6 acres of retrofit treatment if all stormwater treatment retrofit projects recommended in this Plan are completed.

5.5 Regional Stormwater Treatment Facility Maintenance

Maintenance of treatment ditches is to be completed as needed to support the functional treatment of stormwater quality flow rate Q_{WQ}. Inspections completed by staff will document any maintenance required to return the treatment ditch to minimum treatment design conditions. Structural maintenance necessary to restore side slopes, channel slopes, and in channel structures such as weirs or culverts will be documented on bi-annual inspection reports. Routine maintenances completed to remove trash and mow vegetation will be confirmed with Street Department staff once a year.

Maintenance of treatment ponds is to be completed as needed to support the functional treatment of stormwater quality capture volume (WQCV). Treatment ponds maintained by City forces or privately under maintenance agreement will be inspected to document any maintenance required to return the treatment pond to minimum design conditions. Structural maintenance necessary to restore pond depth, outlet freeboard depth, or structural inlet and outlet structures will be documented on bi-annual inspection reports. Routine maintenance completed to remove trash from the treatment pond will be confirmed with Street Department or property owner once a year.

Treatment ponds that are privately maintained but do not have a maintenance agreement in force by the City are difficult for the City to inspect. The City will work with property owners to the extent they are willing to establish maintenance agreements with owners of private treatment ponds. A cost-share program for routine maintenance could provide incentive for entering into an enforceable maintenance agreement that also enables municipal access to conduct routine stormwater inspections. Funds for cost-share of routine maintenance are recommended to be provided through stormwater utility fees and/or STEP fee in lieu of treatment if the City requires in the future.

Maintenance of MS4 infrastructure occurs on an annual basis as needed. The Street Department maintains storm sewer and inlets that accumulate sediment, excavate sediment that builds up in vegetated ditches as well as mows and maintains detention cells throughout the City. Maintenance of stormwater infrastructure upstream of treatment ditches and treatment ponds identified in this Plan improves the effectiveness of the MS4s treatment capability. This Plan does not measure the combined pollutant removal upstream of treatment ditches and ponds. The ongoing maintenance of this upstream infrastructure and removal of sediment deposits supports the annual confirmation that additional treatment is occurring beyond what is measured in treatment ditches and ponds identified by this Plan. Routine maintenances completed to remove sediment and trash from upstream MS4 infrastructure will be confirmed with Street Department staff once a year.

6. REFERENCES

1) American Public Works Association and Mid-America Regional Council, 2012. *Manual of Best Management Practices for Stormwater Quality*.

2) Bannerman, R. T. and Selbig, W. R., 2011. *Characterizing the Size Distribution of Particles in Urban Stormwater by Use of Fixed-Point Sample Collection Methods*. U.S. Geological Survey, Reston, Virginia

3) Center for Watershed Protection and Maryland Department of the Environment Water Management Administration, 2000. *Maryland Stormwater Design Manual, Volume 1*.

4) Chesapeake Bay Roadside Ditch Management Team, 2017. Technical Memo for *Draft Options for Crediting Pollutant Reduction from Roadside Ditch Management Practices (RDM) in the Chesapeake Bay Watershed*.

5) Claytor, R. A. and T. R. Schueler, 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection, Silver Spring, MD. Prepared for the Chesapeake Research Consortium with supplemental funding by the U.S. Environmental Protection Agency, Region 5

6) Comprehensive Environmental Inc and New Hampshire Department of Environmental Services, 2008. *New Hampshire Stormwater Manual, Volume 2*.

7) Federal Highway Administration, 2005. *Hydraulic Engineering Circular No. 15, Design of Roadside Channels with Flexible Linings, Third Edition*.

8) Federal Highway Administration, 2012. *Hydraulic Engineering Circular No. 18, Evaluating Scour at Bridges, Fifth Edition*.

9) Federal Highway Administration, 2012. *Hydraulic Engineering Circular No. 20, Stream Stability at Highway Structures, Fourth Edition*.

10) Felsburg Holt & Ullevig, 2015. *Final Nebraska H_2O Post-Construction Stormwater Program Design Standards and Procedures Memorandum*.

11) Iowa Department of Natural Resources, 2009. *Iowa Storm Water Management Manual*.

12) Lane, C. and T. Schueler, 2012. *Recommendation of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards*. Chesapeake Stormwater Network.

13) Minnesota Department of Agriculture, 2012. *The Agricultural BMP Handbook for Minnesota*.

14) New York State Department of Environmental Conservation, 2015. *Stormwater Management Design Manual*.

15) Rinker Materials. *Particle Size Distribution (PSD) in Stormwater Runoff*.