# Biosorption Activated Media (BAM) Analysis for the Primary Springs Protection Zone (PSPZ)

## for

# City of Tallahassee, Florida

**Prepared by:**
Tetra Tech, Inc.
1558 Village Square Blvd, Suite 2
Tallahassee, Florida 32309
Phone: (850) 536-8115

**Prepared for:**
City of Tallahassee
Water Resources Engineering
408 N. Adams Street
Tallahassee, FL 32301

Purchase Order: COTLH-0001057824

## August 2017

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# List of Acronyms and Abbreviations

| | |
|---|---|
| BAM | Biosorption Activated Media |
| BMAP | Basin Management Action Plan |
| BMP | Best Management Practice |
| City | City of Tallahassee |
| EMC | Event Mean Concentration |
| FDEP | Florida Department of Environmental Protection |
| FDOT | Florida Department of Transportation |
| $ft^2$ | Square Feet |
| Kimley-Horn | Kimley-Horn and Associates, Inc. |
| lbs/yr | Pounds per Year |
| mg/L | Milligrams per Liter |
| NSILT | Nutrient Source Inventory and Loading Tool |
| PSPZ | Primary Springs Protection Zone |
| ROC | Runoff Coefficient |
| SESF | Southeast Sprayfield |
| Tetra Tech | Tetra Tech, Inc. |
| TMDL | Total Maximum Daily Load |
| TN | Total Nitrogen |
| TP | Total Phosphorus |

# Executive Summary

The City of Tallahassee (City) requested that Tetra Tech, Inc. (Tetra Tech) analyze the potential benefits of adding biosorption activated media (BAM) to dry retention stormwater facilities within the primary springs protection zone (PSPZ). The PSPZ is the area within the City and Leon County with elevated aquifer vulnerability and is part of the Upper Wakulla River and Wakulla Springs contributing area. The goal of adding BAM to the dry retention facilities would be to increase nutrient removal to the ground water to benefit the river and springs.

Tetra Tech's analysis considered the benefits of retrofitting existing City-owned/maintained stormwater facilities with BAM, retrofitting the existing retention facilities at the Tallahassee International Airport with BAM, and adding BAM to future dry retention stormwater facilities in the PSPZ. The analysis included two BAM options: (1) Bold and Gold®, which is a proprietary mixture of sand, clay, and tire crumb; and (2) a local BAM mixture that would be created using readily available materials. Both options were evaluated for 1-foot and 2-feet of material added as a liner to the retention facility. This evaluation found that there are minimal nutrient removal benefits in increasing the BAM layer to 2-feet from 1-foot. Therefore, only 1-foot of BAM is recommended, if any facilities are retrofitted.

The City owns and/or maintains 16 dry retention stormwater facilities within the PSPZ. Tetra Tech estimated that the total nitrogen (TN) loading from runoff entering these existing facilities is 1,439 pounds per year (lbs/yr). This estimate was then compared to the total estimated loading to the Upper Wakulla River and Wakulla Springs from the Florida Department of Environmental Protection's Nutrient Source Inventory and Loading Tool (NSILT) to determine the relative benefit to the river and springs through BAM retrofits at these facilities. The total load to the existing facilities is 0.07% of the total TN input to the ground water from the entire contributing area.

If these facilities were to be retrofit with BAM, a reduction in loading to ground water between 45% and 60% can be achieved for a resulting TN load to ground water that is between 0.03% and 0.04% of the total load. The TN loading from these existing facilities to the Upper Wakulla River and Wakulla Springs is negligible; therefore, the nutrient reductions that could be achieved by retrofitting these facilities with BAM is also negligible. Since the potential load reductions from BAM retrofits are not large enough to justify the costs, retrofitting the existing City-owned/maintained dry retention stormwater treatment facilities with BAM is not recommended.

Tetra Tech also evaluated reports for the existing dry retention facilities at the Tallahassee International Airport and a statewide Florida Department of Transportation (FDOT) study. These reports noted that approximately 84% of the airport property is pervious/undeveloped lands and stormwater runoff associated with operational areas of airports have low nutrient concentrations. Therefore, the nutrient loading to the dry retention facilities is minimal and retrofitting those facilities would have minimal benefits to the ground water loading. Therefore, retrofit of the existing airport retention facilities is also not recommended.

In addition, Tetra Tech calculated the potential future loading from the City's portion of the PSPZ, based on Leon County's future land use coverage, to be 8,765 lbs/yr of TN. When compared to the NSILT estimated loading, the potential future loading is 0.4% of the load to ground water from

the entire contributing area. If these facilities were to be retrofit with BAM, a reduction in loading to ground water between 45% and 60% can be achieved for a resulting TN load to ground water that is between 0.17% and 0.23% of the total load. The potential future load from the City's portion of the PSPZ to the river and springs would be very small and the benefits from adding BAM to future dry retention stormwater treatment facilities is not large enough to justify the costs. Therefore, implementing changes to stormwater treatment standards within the PSPZ to require the addition of BAM in future dry retention facilities is not recommended.

# Section 1. Introduction

The City of Tallahassee (City) and Leon County identified the primary springs protection zone (PSPZ) as the area within the county with elevated aquifer vulnerability (see **Figure 1**), and additional regulations were established in the City's Comprehensive Plan to minimize the adverse impacts from development on ground water recharge quality and quantity. The PSPZ is part of the Upper Wakulla River and Wakulla Springs Basin, which was identified as impaired for excess nutrients, specifically nitrate-nitrogen, by the Florida Department of Environmental Protection (FDEP). To address this nutrient impairment, FDEP adopted a total maximum daily load (TMDL) in March 2012 to set the allowable nitrate concentration for the Upper Wakulla River and Wakulla Springs. FDEP and the stakeholders developed a basin management action plan (BMAP) to implement projects to achieve the TMDL, and the BMAP was adopted by FDEP in October 2015.

The City requested that Tetra Tech, Inc. (Tetra Tech) analyze the potential benefits of adding biosorption activated media (BAM) to dry retention stormwater facilities with significant vertical infiltration within the PSPZ to increase nutrient removal to the ground water to benefit the Upper Wakulla River and Wakulla Springs. BAM mixtures are designed to meet site specifications, but in general create an environment with denitrification and sorption rates higher than native soils, which increases total nitrogen (TN) and total phosphorus (TP) removal.

A popular choice for BAM mixtures is Bold & Gold®, which is a proprietary BAM mixture developed by the University of Central Florida Stormwater Academy. Bold & Gold® is composed of a patented blend of sand, clay, and tire crumbs/chips. The mixture uses a low percentage of organic material, which helps the media to not lose volume or shrink over time (http://www.boldandgoldmedia.com). Environmental Conservation Solutions, LLC is an authorized vendor of Bold & Gold®, and provided Tetra Tech with the recommended mixture and cost (personal communication on January 30, 2017) for this type of project. The Bold and Gold® mixture applicable to this project is CTS, which is a mixture of sand, clay, and tire crumb (http://www.boldandgoldmedia.com). This media is estimated to be effective for approximately 30-40 years. A local BAM mixture could also be created using readily available materials including leaf litter, wood chips, and local clay. Since the local mixture would have a larger percentage of organic material, it would break down faster than Bold & Gold® and would likely need to be replaced in about 10-20 years.

Tetra Tech's analysis considered the benefits of retrofitting existing City-owned/maintained stormwater facilities with BAM (see **Section 2**), as well as including BAM in stormwater facilities associated with future development (see **Section 3**).

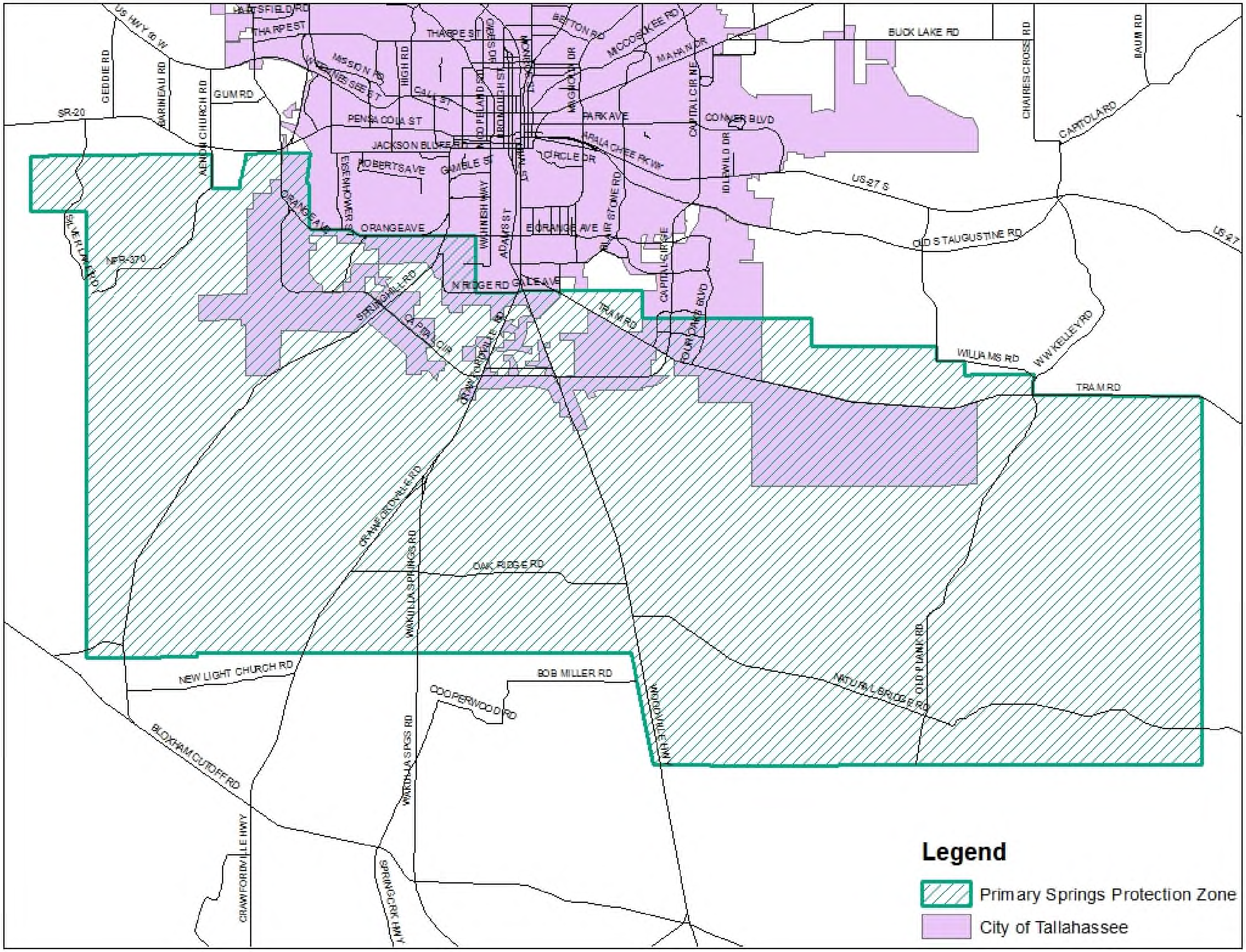


**Figure 1: PSPZ Location**

## 1.1. Literature Review

Tetra Tech conducted a literature review to compile information on studies that evaluated the addition of BAM in dry retention facilities. The studies that were conducted within Florida focused on the application of Bold and Gold®.

BAM can be used in a variety of stormwater best management practices (BMPs). Several examples and the associated efficiencies are summarized in **Table 1** (Wanielista 2015). The last example in the table is using the CTS mixture in a retention BMP, which is similar to this study of adding BAM to the dry retention facilities in the PSPZ.

**Table 1: TN and TP Removal Efficiencies for BAM**

| Location in BMP Treatment Train | Material | TN Removal Efficiency | TP Removal Efficiency |
|---|---|---|---|
| Bold & Gold as a first BMP, ex. Up-flow filter in baffle box and a constructed wetland | Expanded Clay<br>Tire Chips | 55% | 65% |
| Bold & Gold in up-flow filter at wet pond and dry basin outflow | Organics<br>Tire Chips<br>Expanded Clay | 45% | 45% |
| Bold & Gold in inter-event flow using up-flow filter at wet pond and down-flow filter at dry basin | Expanded Clay<br>Tire Chips | 25% | 25% |
| Bold & Gold down-flow filters 12” depth at wet pond or dry basin pervious pavement, tree well, rain garden, swale, and strips | Clay<br>Tire Crumb<br>Sand & Topsoil | 60% | 90% |

Note: From Wanielista 2015

One study included two retention basins in Marion County that were constructed in two different types of soils. For the South Oak retention basin, the bottom soils were found to remove nitrogen before it entered the deeper ground water system. The Hunters Trace retention basin did not remove nitrogen; therefore, the study focused on adding soil amendments to replicate the conditions in the South Oak retention basin. The Hunters Trace basin has a 56-acre watershed, which was made up of 3.4 acres of curb-and-gutter roadway, 34.9 acres of residential lots, and 17.7 acres of undeveloped conservation land. The design for the basin was to divide it into two approximately equal sub basins for pollution control and flood control. The Bold and Gold® mixture used in this project was a 1:2:4 mixture (by volume) of tire crumb to clay to sand. Monitoring was conducted for the basin, which found that there was reduction of 70–90% in total dissolved phosphorus median concentrations from pre-construction to post-construction. There was also a reduction of about 70% in nitrogen median concentrations from pre-construction to post-construction (Wanielista et. al. 2011).

Hossain et al. (2009) conducted a study to determine the additional nutrient removal that could be achieved from stormwater dry ponds with the addition of filter media. In this study, a mixture of 50% sand, 20% limestone, 15% sawdust, and 15% tire crumb was used. The study found that the removal efficiency for nitrogen was 95.36%, 81.34%, and 65.68% after five hours of hydraulic retention time for influent waste loads of 0.5 milligrams per liter (mg/L), 2.5 mg/L, and 5.0 mg/L, respectively. The study found that the BAM mixture is efficient and effective for removing nitrogen at the lower influent concentrations, which is similar to what most stormwater management systems receive in the real world. The study also determined that most stormwater dry ponds achieve between 10% and 20% TN removal efficiencies without BAM. Therefore, the addition of BAM could effectively and efficiently remove most of the TN within an appropriate hydraulic retention time through both adsorption and absorption.

Wanielista et al. (2008) evaluated the use of Bold and Gold® exfiltration media in an exfiltration trench on East Lake Brantley Drive in Seminole County, Florida. Ground water samples were collected before and after the media was added to the trench. The nitrate + nitrite reductions from the addition of the BAM ranged from 47% to 88%, and the TN reductions ranged from 32% to 56%.

# Section 2. Existing Dry Retention Stormwater Facilities

There are several existing City-owned/maintained dry retention stormwater facilities located within the PSPZ, and Tetra Tech evaluated the cost-effectiveness of retrofitting these facilities with BAM (see **Section 2.1**). In addition, there are existing dry retention facilities at the Tallahassee International Airport, and these ponds were analyzed for potential retrofits (see **Section 2.2**). Tetra Tech estimated the nutrient loading from the existing City-owned/maintained facilities in the PSPZ. This estimate was then compared to the total estimated loading to the Upper Wakulla River and Wakulla Springs from FDEP's Nutrient Source Inventory and Loading Tool (NSILT) to determine the relative magnitude of benefit that can be achieved for the river and springs (see **Section 2.3**) through implementation of BAM retrofits at these facilities.

## 2.1. City-Owned/Maintained Facilities

In the PSPZ, the City owns and/or maintains 16 dry retention stormwater facilities. These retention BMPs have almost a 100% nutrient removal efficiency for both TN and TP in the treatment of surface water. However, the treatment mechanism of retention BMPs is infiltrating the surface runoff, which relies on the soils in the area. The soils in the PSPZ are sandy, excessively drained soils that are inefficient in treating nitrogen before the infiltrated water enters the ground water. Therefore, the current stormwater facilities have limited nitrogen removal to the ground water, which is the focus of protection in this area. Retrofitting the existing facilities to add BAM would improve reductions to the ground water and, ultimately, to the Upper Wakulla River and Wakulla Springs.

To determine the current nutrient loading to these 16 facilities in the PSPZ, Tetra Tech used the land use of the area surrounding each facility with the associated event mean concentration (EMC) derived from City land use specific monitoring and the Florida Department of Transportation (FDOT) airport study (see **Section 2.2**), runoff coefficient (ROC) from the *Evaluation of Current Stormwater Design Criteria within the State of Florida: Final Report* (Harper and Baker 2007), and average annual rainfall value from the *Draft Stormwater Quality Handbook* (FDEP and Water Management Districts 2010). The TN and TP load in pounds per year (lbs/yr) for each of the dry retention facilities is shown in **Table 2**. The locations of these facilities are shown in **Figure 2** through **Figure 5**.

**Table 2: City-Owned/Maintained Dry Retention Stormwater Facilities in the PSPZ**

| Parcel ID | Location | Stormwater Facility Bottom Area ($ft^2$) | Land Use | Drainage Area (Acres) | TN Load (lbs/yr) | TP Load (lbs/yr) |
|---|---|---|---|---|---|---|
| 412425 0002 | Crawfordville Trace | 87,481 | Medium & High Density Residential | 1.60 | 8 | 2 |
| 412425 0002 | Crawfordville Trace | 9,435 | Medium & High Density Residential | 15.30 | 79 | 22 |
| 412425 0002 | Crawfordville Trace | 4,293 | Medium & High Density Residential | 5.40 | 28 | 8 |
| 3121200030000 | Southwood | 32,808 | Commercial & Government | 13.50 | 123 | 26 |
| 4115500000260 | Entrepot Industrial | 35,454 | Industrial | 21.00 | 222 | 24 |
| 4113206020000 | Wilson Green | 108,928 | Medium & High Density Residential | 52.76 | 273 | 74 |
| 3123200200000 | Southwood | 18,748 | Commercial & Government | 20.80 | 189 | 40 |
| 412321 0002 | Pine Forest | 45,321 | Medium & High Density Residential | 5.46 | 28 | 8 |
| 412321 0002 | Pine Forest | 8,530 | Medium & High Density Residential | 5.13 | 27 | 7 |
| 412321 0002 | Pine Forest | 538 | Medium & High Density Residential | 5.24 | 27 | 7 |
| 412321 0002 | Pine Forest | 924 | Medium & High Density Residential | 4.26 | 22 | 6 |
| 412321 0002 | Pine Forest | 707 | Medium & High Density Residential | 20.15 | 104 | 28 |
| 412422 0001 | Landmark | 2,727 | Medium & High Density Residential | 5.25 | 27 | 7 |
| 412422 0001 | Landmark | 2,649 | Medium & High Density Residential | 5.84 | 30 | 8 |
| 412426 0001 | Oak Ridge Place | 5,145 | Medium & High Density Residential | 19.77 | 102 | 28 |
| 3122208010000 | Southwood | 20,925 | Commercial & Government | 16.50 | 150 | 31 |
| | | | ***Total*** | ***217.96*** | ***1,439*** | ***326*** |

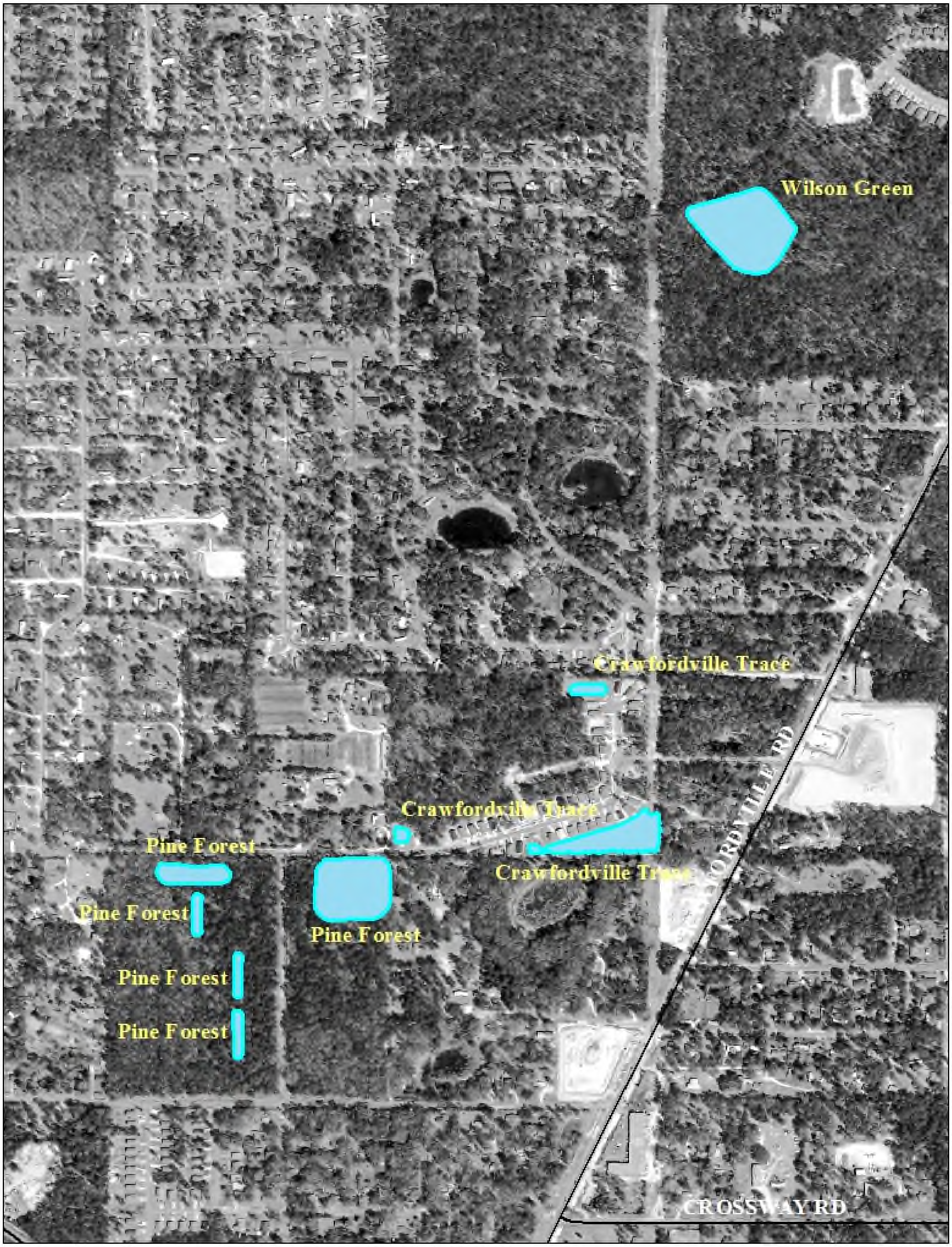


**Figure 2: Locations of the Wilson Green Crawfordville Trace, and Pine Forest Dry Retention Facilities**


**Figure 3: Location of the Entrepot Industrial Dry Retention Facility**


**Figure 4: Locations of the Southwood Dry Retention Facilities**


**Figure 5: Locations of Oak Ridge Place and Landmark Dry Retention Facilities**

Retrofits of these facilities were evaluated for both the Bold and Gold® CTS mixture and a local BAM mixture. These mixtures were analyzed for 1-foot and 2-feet of material as a liner in the retention BMP. The efficiencies for each mixture at each depth are shown in **Table 3**. The efficiencies for the CTS mixture are from the Bold and Gold® website at http://www.boldandgoldmedia.com/engineers.html. The efficiencies for the local BAM mixture were estimated by Tetra Tech using information from the literature review in **Section 1.1**.

**Table 3: Removal Efficiencies for Bold & Gold® and Local BAM Mixture**

| Depth | Bold and Gold® CTS TN Removal Efficiency (%) | Bold and Gold® CTS TP Removal Efficiency (%) | Local BAM Mixture TN Removal Efficiency (%) | Local BAM Mixture TP Removal Efficiency (%) |
|---|---|---|---|---|
| 1-foot | 60% | 90% | 45% | 45% |
| 2-feet | 75% | 95% | 55% | 65% |

The cost of the CTS mixture is approximately \$150/cubic yard, which includes delivery (Environmental Conservation Solutions, LLC personal communication on January 30, 2017). For the purposes of this evaluation, Tetra Tech estimated that the cost of a local mixture would be approximately \$50/cubic yard; however, this cost may be lower or higher depending on what materials are available to the City. The amount of BAM necessary was determined by multiplying the bottom area of each retention facility by either 1-foot or 2-feet of BAM. The cost of construction of the retrofit was determined based on pond area for ponds less than 10,000 square feet ($ft^2$) and for ponds greater than 10,000 $ft^2$. The construction costs include the following items:

- Dewatering, in case of rain that requires water to be pumped out of the facilities.
- Excavation of topsoil to allow placement of the BAM.
- Backfill of the area after the BAM has been added.
- Seeding of the facility.
- Erosion control measures during construction.
- Labor.
- Temporary construction roads/access to the facilities.

The construction costs also include a 25% contingency. In addition, the cost to retrofit each facility includes mobilization. The mobilization cost is $5,000 for the smaller ponds less than 10,000 $ft^2$ where a backhoe would be used for excavation and backfill. The mobilization cost is $12,000 for the larger ponds greater than 10,000 $ft^2$ where excavators and bulldozers would be used for excavation and backfill. Some of the ponds are in the same area and, if retrofits were conducted for these ponds in coordination, the mobilization costs could be reduced.

The total cost per pound of TN removal for each of the BAM options is summarized in **Table 4** for Bold and Gold® and **Table 5** for the local BAM mixture. There are minimal TN removal benefits in increasing the BAM layer to 2-feet from 1-foot. Therefore, only 1-foot of BAM mixture is recommended, if the facilities are retrofitted.

**Table 4: Cost per Pound of TN Removal for Bold and Gold®**

| Parcel ID | Location | TN Load (lbs/yr) | 1-Foot of Bold and Gold® | | | | 2-Feet of Bold and Gold® | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Estimated Total Cost | TN % Reduction | TN Load Reduction (lbs/yr) | Cost per lb of TN | Estimated Total Cost | TN % Reduction | TN Load Reduction (lbs/yr) | Cost per lb of TN |
| 412425 0002 | Crawfordville Trace* | 8 | $575,000 | 60% | 5 | $115,000 | $1,107,000 | 75% | 6 | $184,500 |
| 412425 0002 | Crawfordville Trace | 79 | $97,000 | 60% | 47 | $2,064 | $169,000 | 75% | 59 | $2,864 |
| 412425 0002 | Crawfordville Trace | 28 | $48,000 | 60% | 17 | $2,824 | $81,000 | 75% | 21 | $3,857 |
| 3121200030000 | Southwood | 123 | $226,000 | 60% | 74 | $3,054 | $425,000 | 75% | 92 | $4,620 |
| 4115500000260 | Entrepot Industrial | 222 | $242,000 | 60% | 133 | $1,820 | $458,000 | 75% | 167 | $2,743 |
| 4113206020000 | Wilson Green | 273 | $711,000 | 60% | 164 | $4,335 | $1,373,000 | 75% | 205 | $6,698 |
| 3123200200000 | Southwood | 189 | $136,000 | 60% | 113 | $1,204 | $250,000 | 75% | 142 | $1,761 |
| 412321 0002 | Pine Forest | 28 | $306,000 | 60% | 17 | $18,000 | $582,000 | 75% | 21 | $27,714 |
| 412321 0002 | Pine Forest | 27 | $90,000 | 60% | 16 | $5,625 | $155,000 | 75% | 20 | $7,750 |
| 412321 0002 | Pine Forest | 27 | $13,000 | 60% | 16 | $813 | $17,000 | 75% | 20 | $850 |
| 412321 0002 | Pine Forest | 22 | $17,000 | 60% | 13 | $1,308 | $24,000 | 75% | 17 | $1,412 |
| 412321 0002 | Pine Forest | 104 | $14,000 | 60% | 62 | $226 | $20,000 | 75% | 78 | $256 |
| 412422 0001 | Landmark | 27 | $33,000 | 60% | 16 | $2,063 | $54,000 | 75% | 20 | $2,700 |
| 412422 0001 | Landmark | 30 | $33,000 | 60% | 18 | $1,833 | $53,000 | 75% | 23 | $2,304 |
| 412426 0001 | Oak Ridge Place | 102 | $57,000 | 60% | 61 | $934 | $96,000 | 75% | 77 | $1,247 |
| 3122208010000 | Southwood | 150 | $150,000 | 60% | 90 | $1,667 | $277,000 | 75% | 113 | $2,451 |
| | ***Total*** | ***1,439*** | ***$2,748,000*** | ***60%*** | ***862*** | ***$10,173 (average)*** | ***$5,141,000*** | ***75%*** | ***1,081*** | ***$15,858 (average)*** |

* The cost per pound of TN removal from this facility is much greater than the other facilities and is affecting the average cost per pound of TN removal.

**Table 5: Cost per Pound of TN Removal for Local BAM**

| Parcel ID | Location | TN Load (lbs/yr) | 1-Foot Local BAM | | | | 2-Feet Local BAM | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Estimated Total Cost | TN % Reduction | TN Load Reduction (lbs/yr) | Cost per lb of TN | Estimated Total Cost | TN % Reduction | TN Load Reduction (lbs/yr) | Cost per lb of TN |
| 412425 0002 | Crawfordville Trace* | 8 | $251,000 | 45% | 4 | $62,750 | $459,000 | 55% | 4 | $114,750 |
| 412425 0002 | Crawfordville Trace | 79 | $62,000 | 45% | 36 | $1,722 | $99,000 | 55% | 43 | $2,302 |
| 412425 0002 | Crawfordville Trace | 28 | $32,000 | 45% | 13 | $2,462 | $49,000 | 55% | 15 | $3,267 |
| 3121200030000 | Southwood | 123 | $104,000 | 45% | 55 | $1,891 | $182,000 | 55% | 68 | $2,676 |
| 4115500000260 | Entrepot Industrial | 222 | $111,000 | 45% | 100 | $1,110 | $195,000 | 55% | 122 | $1,598 |
| 4113206020000 | Wilson Green | 273 | $307,000 | 45% | 123 | $2,496 | $566,000 | 55% | 150 | $3,773 |
| 3123200200000 | Southwood | 189 | $67,000 | 45% | 85 | $788 | $111,000 | 55% | 104 | $1,067 |
| 412321 0002 | Pine Forest | 28 | $138,000 | 45% | 13 | $10,615 | $246,000 | 55% | 15 | $16,400 |
| 412321 0002 | Pine Forest | 27 | $59,000 | 45% | 12 | $4,917 | $92,000 | 55% | 15 | $6,133 |
| 412321 0002 | Pine Forest | 27 | $11,000 | 45% | 12 | $917 | $13,000 | 55% | 15 | $867 |
| 412321 0002 | Pine Forest | 22 | $13,000 | 45% | 10 | $1,300 | $17,000 | 55% | 12 | $1,417 |
| 412321 0002 | Pine Forest | 104 | $12,000 | 45% | 47 | $255 | $14,000 | 55% | 57 | $246 |
| 412422 0001 | Landmark | 27 | $23,000 | 45% | 12 | $1,917 | $34,000 | 55% | 15 | $2,267 |
| 412422 0001 | Landmark | 30 | $23,000 | 45% | 14 | $1,643 | $34,000 | 55% | 17 | $2,000 |
| 412426 0001 | Oak Ridge Place | 102 | $38,000 | 45% | 46 | $826 | $58,000 | 55% | 56 | $1,036 |
| 3122208010000 | Southwood | 150 | $72,000 | 45% | 68 | $1,059 | $122,000 | 55% | 83 | $1,470 |
| | ***Total*** | ***1,439*** | ***$1,323,000*** | ***45%*** | ***650*** | ***$6,042 (average)*** | ***$2,291,000*** | ***55%*** | ***791*** | ***$10,079 (average)*** |

* The cost per pound of TN removal from this facility is much greater than the other facilities and is affecting the average cost per pound of TN removal.

## 2.2. Tallahassee International Airport Stormwater Facilities

The Tallahassee International Airport is also located within the PSPZ, and the stormwater from this site is treated by dry retention areas. In 2012, Kimley-Horn and Associates, Inc. (Kimley-Horn) prepared a stormwater analysis for the airport. This analysis found that the majority of the property is either wooded or maintained open grass field as shown in **Table 6** (Kimley-Horn 2012).

**Table 6: Land Uses at the Tallahassee Regional Airport**

| Land Use | Acres | % of Land Use |
|---|---|---|
| Pervious/Undeveloped | 2,096.7 | 84.20% |
| Runway | 352.4 | 14.15% |
| Apron | 41.1 | 1.65% |
| ***Total*** | ***2,490.2*** | ***100.00%*** |

Source: Kimley-Horn 2012

For this evaluation, Kimley-Horn developed 23 drainage basins within the airport property. Three basins had well defined low points, and most of the basins ultimately discharge stormwater to one of these low points. Only five of the basins were discharging stormwater offsite. In order to retain all the stormwater on airport property, Kimley-Horn recommended the construction of two new dry retention areas (Kimley-Horn 2012).

In addition, FDOT completed a statewide airport stormwater study for 13 airports throughout Florida, including the Tallahassee International Airport. Based on the data collected, EMCs for the different airport land uses were identified (**Table 7**) (FDOT 2007).

**Table 7: EMCs by Airport Land Use**

| Airside Type | TN EMC (mg/L) | TP EMC (mg/L) |
|---|---|---|
| Apron (composite type) | 0.398 | 0.057 |
| Runway, Air Carrier | 0.401 | 0.049 |
| Taxiway, Air Carrier | 0.569 | 0.115 |
| Pristine/Undeveloped Site | 1.150 | 0.074 |

Source: FDOT 2007

The FDOT study tested two hypotheses: (1) based on available data, airside (areas commonly allocated for aircraft operations or servicing) runoff was not likely to generate the typical constituent loading problems associated with other impervious surfaces; and (2) those constituents that are present in the pavement runoff are effectively reduced by the grassed infield area to acceptable levels. The study found that both of the hypotheses were true and that the nutrients in airside stormwater runoff are generally very low and close to values for natural land uses (FDOT 2008).

Since the Tallahassee International Airport property is 84.2% pervious/ undeveloped lands and the FDOT study found that the airside areas have very low nutrient concentrations, nutrient loading to the onsite stormwater facilities is minimal. Tetra Tech evaluated these factors and concluded that the benefits of retrofitting the airport retention facilities would result in a minimal benefit to ground water loading and the cost of retrofit is not justifiable; therefore, retrofitting the airport's dry retention facilities with BAM is not recommended.

## 2.3. Comparison to Wakulla Springs NSILT

FDEP developed the NSILT for the Wakulla Springs BMAP contributing area to identify and quantify the major nitrogen sources to the ground water. The sources evaluated in the NSLIT include atmospheric deposition, sinking streams, agricultural and nonagricultural fertilizer, livestock waste, septic systems, and wastewater application (FDEP 2014). The NSILT does not directly include loading from stormwater, although stormwater is a conveyance for some of the sources that are included (e.g. fertilizer, sinking streams). The TN loading from each source was quantified for each recharge area in the contributing basin. The recharge areas are based on permeability of the aquifer, and the categories are unconfined, semi-confined, and confined. The PSPZ is located within the unconfined portion of the BMAP contributing area. The total TN loading to the land from the sources in the NSILT is summarized in **Table 8**.

**Table 8: FDEP Wakulla Springs NSILT TN Loading to the Land (lbs/yr)**

| Recharge Category | Atmospheric Deposition (lbs/yr) | Wastewater Treatment Facilities (lbs/yr) | Septic Tanks (lbs/yr) | Farm Fertilizers (lbs/yr) | Urban Fertilizers (lbs/yr) | Livestock (lbs/yr) | Sinking Streams (lbs/yr) | Total |
|---|---|---|---|---|---|---|---|---|
| Unconfined | 748,302 | 119,532 | 431,822 | 6,241 | 60,561 | 119,817 | 101,721 | **1,587,996** |
| Semi-confined | 580,120 | 27,659 | 543,208 | 225,129 | 246,267 | 152,930 | N/A | **1,775,314** |
| Confined | 789,945 | 15,748 | 381,836 | 1,004,949 | 191,866 | 474,501 | N/A | **2,858,844** |
| ***Total Input*** | ***2,118,367*** | ***162,939*** | ***1,356,866*** | ***1,236,319*** | ***498,694*** | ***747,248*** | ***101,721*** | ***6,222,155*** |

Source: FDEP 2014

The NSILT also included an estimate of the loading to ground water as shown in **Table 9**. The loading to the ground water was calculated by applying an attenuation factor specific to each source category that accounts for the nitrogen attenuation that occurs through natural physical, chemical, or biological processes. A recharge factor was also applied to account for the different recharge categories in the basin.

**Table 9: FDEP Wakulla Springs NSILT TN Loading to Ground Water (lbs/yr)**

| Recharge Category | Atmospheric Deposition (lbs/yr) | Wastewater Treatment Facilities (lbs/yr) | Septic Tanks (lbs/yr) | Farm Fertilizers (lbs/yr) | Urban Fertilizers (lbs/yr) | Livestock (lbs/yr) | Sinking Streams (lbs/yr) | Total |
|---|---|---|---|---|---|---|---|---|
| Unconfined | 67,347 | 43,032 | 233,183 | 1684.331683 | 10,902 | 26,958 | 73,240 | **456,346** |
| Semi-confined | 23,206 | 4,425 | 130,370 | 27,015 | 19,701 | 15,293 | N/A | **220,010** |
| Confined | 7,899 | 631 | 22,910 | 30,148 | 3,838 | 11,863 | N/A | **77,290** |
| ***Total*** | ***98,452*** | ***48,087*** | ***386,464*** | ***58,848*** | ***34,441*** | ***54,115*** | ***73,240*** | ***753,646*** |

Source: FDEP 2014

As noted in **Table 2**, Tetra Tech estimated that the TN loading from the land entering the existing 16 City-owned/maintained dry retention stormwater treatment facilities in the PSPZ is 1,439 lbs/yr. This load is 0.02% of the total TN input from the land within the entire Wakulla Springs contributing area or 0.09% of the TN input from the unconfined portion of the contributing area.

To estimate the total loading from these facilities to the ground water, an attenuation factor and recharge factor were applied to match the NSILT methodology. Since the NSILT does not directly include stormwater as a source, the NSILT wastewater treatment facilities attenuation factor of 60% was used. The treated effluent from the wastewater treatment facilities is largely applied to the land surface in the basin, which would be similar to stormwater runoff infiltrating in a dry retention facility. The recharge factor for the unconfined area of 90% was also applied. With these factors, the total load from the existing facilities to the ground water is 518 lbs/yr of TN. This load is 0.07% of the total input to the ground water from the entire contributing area or 0.11% of the total input to the ground water from the unconfined portion of the basin.

If 1-foot of Bold and Gold® were added to these existing dry retention facilities, the TN load could be reduced by 60% for a total load of 576 lbs/yr. This is 0.01% of the total TN load to the river and springs from the land. When the attenuation and recharge factors are applied, the total load is 207 lbs/yr of TN or 0.03% of the total load to the ground water. If 1-foot of local BAM mixture were added to these existing facilities, the TN load could be reduced by 45% for a total load of 791 lbs/yr. This is 0.01% of the total TN load to the river and springs from the land. When the attenuation and recharge factors are applied, the total load is 285 lbs/yr of TN or 0.04% of the total load to the ground water.

As noted above, the total TN loading from these existing facilities to the Upper Wakulla River and Wakulla Springs is negligible. The load reductions that could be achieved by retrofitting these facilities with BAM is therefore also negligible. Since the potential load reductions from BAM retrofits are not large enough to justify the costs of the facility retrofits, retrofitting the existing City-owned/maintained dry retention stormwater treatment facilities with BAM is not recommended.

# Section 3. Future Development

The City provided Leon County's future land use coverage, and Tetra Tech used this coverage to evaluate the potential future loading from the City's portion of the PSPZ (see **Section 3.1**). The nutrient loading from this future land use was compared to the estimated loading to the Upper Wakulla River and Wakulla Springs from FDEP's NSILT to determine the benefits that can be achieved for the river and springs by adding BAM to future dry retention stormwater treatment facilities (see **Section 3.2**). In addition, Tetra Tech evaluated the benefits of modifying the treatment standards within the PSPZ for future development (see **Section 3.3**).

## 3.1. Potential Future Loading

Tetra Tech used the Northwest Florida Water Management District 2015-2016 land use coverage and the Leon County future land use coverage to estimate the additional nutrient loading from the City's portion of the PSPZ under the future land use condition. These land use coverages have been modified to reflect the existence of the Southeast Sprayfield (SESF), which receives treated effluent from the Thomas P. Smith Wastewater Treatment Facility. Since no land use changes are anticipated for the SESF, it has been removed from the analysis. It should also be noted that the NSILT accounts for the SESF under the category of Wastewater Treatment Facilities.

Tetra Tech calculated the loading using the acreage of each land use category with the associated EMC derived from City land use specific monitoring and the FDOT airport study, ROC from the *Evaluation of Current Stormwater Design Criteria within the State of Florida: Final Report* (Harper and Baker 2007), and average annual rainfall value from the *Draft Stormwater Quality Handbook* (FDEP and Water Management Districts 2010). If a parcel changed its land use type from the current to future land use condition, the EMC and ROC values also changed, which affected the total loading from that parcel. It is important to note that the current land use coverage (**Figure 6**) is more detailed with land uses assigned at a much smaller scale than the future land use coverage (**Figure 7**).

The estimated acres and TN load for the City's portion of the PSPZ under the current and potential future land use conditions are shown in **Table 10**.

**Table 10: Current and Potential Future Land Use Nutrient Loading in the City's Portion of the PSPZ**

| Land Use Category | Current Area (Acres) | Current TN Load (lbs/yr) | Potential Future Area (Acres) | Potential Future TN Load (lbs/yr) |
|---|---|---|---|---|
| Airport | 1,310 | 105 | 2,415 | 194 |
| Commercial & Government | 1,358 | 12,357 | 570 | 5,185 |
| Medium and High Density Residential | 767 | 7,374 | 2,156 | 20,730 |
| Industrial | 63 | 667 | 48 | 510 |
| Low Density Residential | 53 | 77 | 2,033 | 2,951 |
| Recreational – Parks – Open Space | 119 | 55 | 1,273 | 595 |
| Undeveloped | 4,825 | 765 | 0 | 0 |
| ***Total*** | ***8,495*** | ***21,400*** | ***8,495*** | ***30,165*** |
| ***Estimated Increase in Nitrogen Loading*** | ***8,765*** | | | |

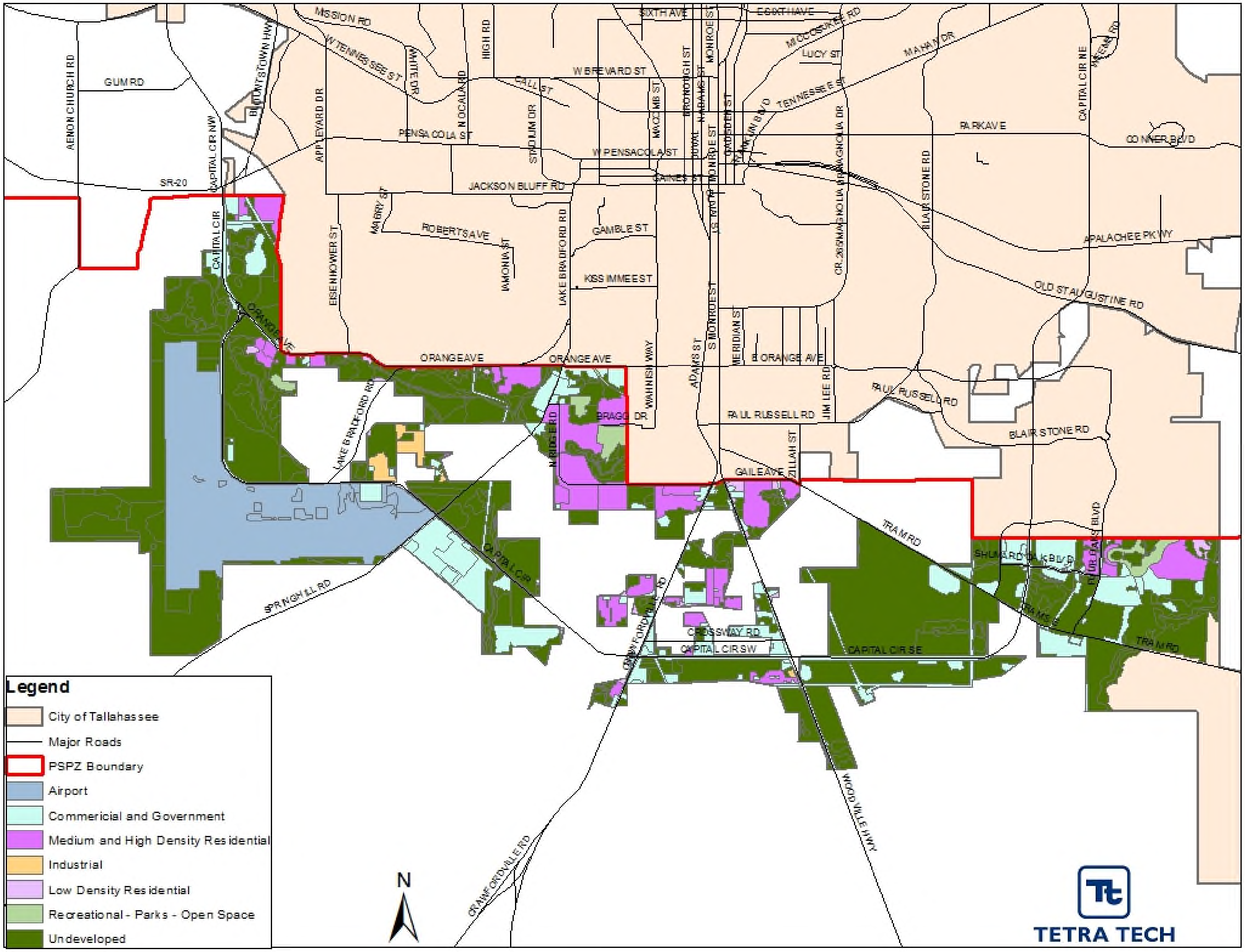


**Figure 6: Current Land Use in the City's Portion of PSPZ**

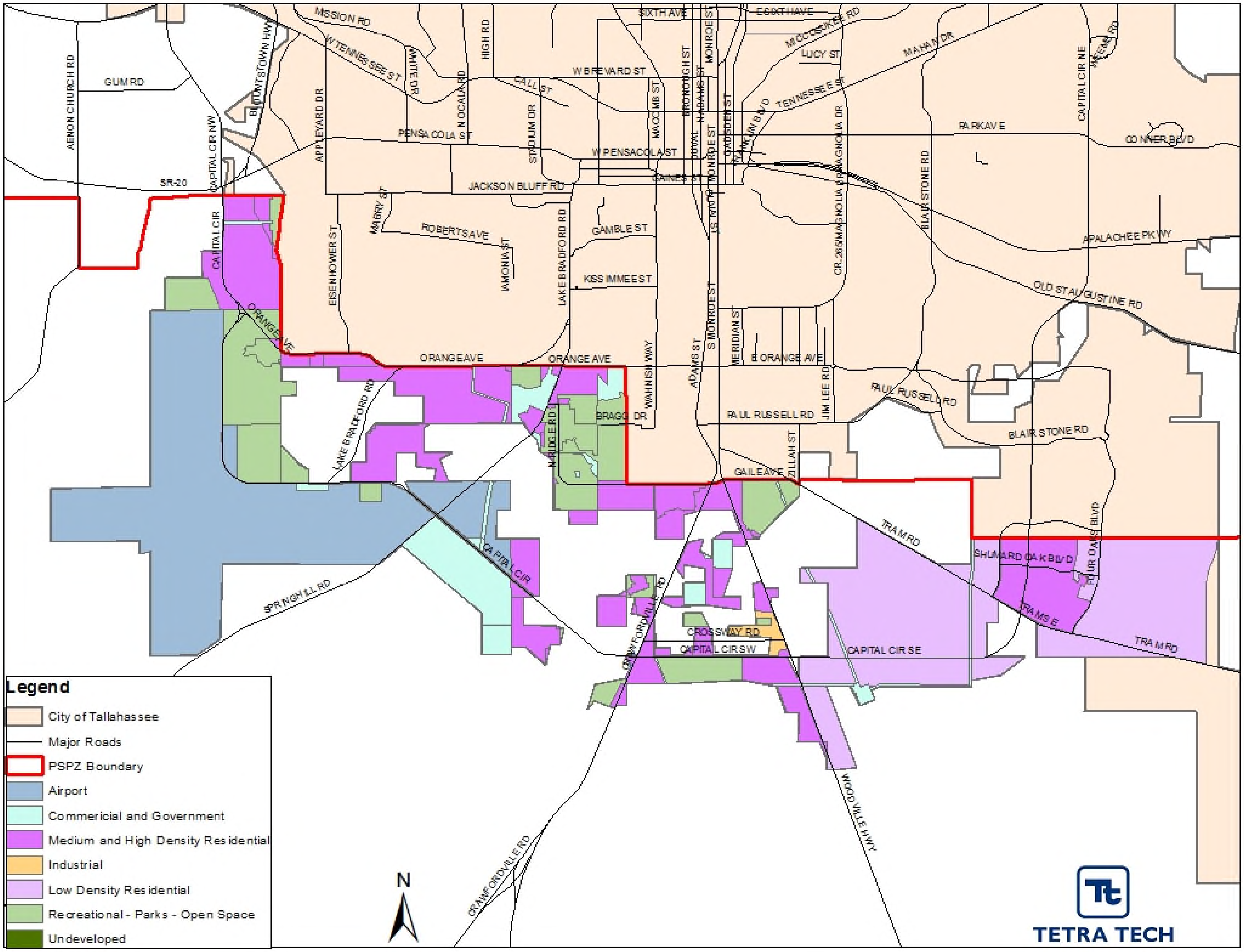


**Figure 7: Future Land Use in the City's Portion of the PSPZ**

## 3.2. Comparison to Wakulla Springs NSILT

**Table 8** shows the total TN loading to the land within the Wakulla Springs contributing area from the NSILT. Under the potential future land use condition, the additional TN load within the City's portion of the PSPZ is 8,765 lbs/yr (see **Table 10**). This is 0.1% of the total load to the land within the entire contributing area or 0.6% of the total load to the land within the unconfined portion of the basin. **Table 9** shows the total TN loading to the ground water from the NSILT. When the attenuation factor (the wastewater treatment facilities factor was used) and recharge factor are applied to the future TN load from the City's portion of the PSPZ, the total load to the ground water is 3,155 lbs/yr of TN. This load is 0.4% of the total TN load to ground water from the entire contributing area or 0.7% of the TN load to ground water from only the unconfined portion of the basin. Therefore, the contribution from the potential future land use within the City's portion of the PSPZ to the river and springs would be very small.

## 3.3. Evaluation of Treatment Standards

Although the estimated future TN loading from stormwater runoff in the City's portion of the PSPZ is relatively minor compared to the estimated total loading to the Upper Wakulla River and Wakulla Springs from the NSILT, Tetra Tech evaluated the reductions from adding BAM to future dry retention stormwater treatment facilities in this area.

For new stormwater treatment facilities, BAM could be added more cost-effectively than it could be added in a facility retrofit. As a new facility is being constructed, BAM could be added as a liner with the only additional cost being the BAM itself. **Table 11** uses the existing facilities as examples of the cost per pound of TN reduction achieved with using the cost to add Bold and Gold® or a local BAM mixture.

If 1-foot of Bold and Gold® were added in future stormwater facilities to treat the additional potential future load, the TN load could be reduced by 60% for a total load of 3,056 lbs/yr, which is 0.06% of the total TN load to the land. When the attenuation and recharge factors are applied, the total load is 1,262 lbs/yr of TN or 0.17% of the total load to the ground water. If 1-foot of local BAM mixture were added to future stormwater facilities to treat the additional future load, the TN load could be reduced by 45% for a total load of 4,821 lbs/yr, which is 0.08% of the total TN load to the land. When the attenuation and recharge factors are applied, the total load is 1,736 lbs/yr of TN or 0.23% of the total load to the ground water.

Tetra Tech determined that the load reductions that could be achieved by adding BAM to future dry retention stormwater treatment facilities is not large enough to justify the costs. Furthermore, implementing changes to stormwater treatment standards within the PSPZ to require the addition of BAM in dry retention facilities is not recommended.

**Table 11: Cost per Pound of TN Removal for Only the Addition of BAM**

| Parcel ID | Location | TN Load (lbs/yr) | 1-Foot of Bold and Gold® Estimated Cost for Material | 1-Foot of Bold and Gold® TN % Reduction | 1-Foot of Bold and Gold® TN Load Reduction (lbs/yr) | 1-Foot of Bold and Gold® Cost per lb of TN | 1-Foot of Local BAM Estimated Cost for Material | 1-Foot of Local BAM TN % Reduction | 1-Foot of Local BAM TN Load Reduction (lbs/yr) | 1-Foot of Local BAM Cost per lb of TN |
|---|---|---|---|---|---|---|---|---|---|---|
| 412425 0002 | Crawfordville Trace* | 8 | $486,000 | 60% | 5 | $97,200 | $162,000 | 45% | 4 | $40,500 |
| 412425 0002 | Crawfordville Trace | 79 | $52,000 | 60% | 47 | $1,106 | $17,000 | 45% | 36 | $472 |
| 412425 0002 | Crawfordville Trace | 28 | $24,000 | 60% | 17 | $1,412 | $8,000 | 45% | 13 | $615 |
| 3121200030000 | Southwood | 123 | $182,000 | 60% | 74 | $2,459 | $61,000 | 45% | 55 | $1,109 |
| 4115500000260 | Entrepot Industrial | 222 | $197,000 | 60% | 133 | $1,481 | $66,000 | 45% | 100 | $660 |
| 4113206020000 | Wilson Green | 273 | $605,000 | 60% | 164 | $3,689 | $202,000 | 45% | 123 | $1,642 |
| 3123200200000 | Southwood | 189 | $104,000 | 60% | 113 | $920 | $35,000 | 45% | 85 | $412 |
| 412321 0002 | Pine Forest | 28 | $252,000 | 60% | 17 | $14,824 | $84,000 | 45% | 13 | $6,462 |
| 412321 0002 | Pine Forest | 27 | $47,000 | 60% | 16 | $2,938 | $16,000 | 45% | 12 | $1,333 |
| 412321 0002 | Pine Forest | 27 | $3,000 | 60% | 16 | $188 | $1,000 | 45% | 12 | $83 |
| 412321 0002 | Pine Forest | 22 | $5,000 | 60% | 13 | $385 | $2,000 | 45% | 10 | $200 |
| 412321 0002 | Pine Forest | 104 | $4,000 | 60% | 62 | $65 | $1,000 | 45% | 47 | $21 |
| 412422 0001 | Landmark | 27 | $15,000 | 60% | 16 | $938 | $5,000 | 45% | 12 | $417 |
| 412422 0001 | Landmark | 30 | $15,000 | 60% | 18 | $833 | $5,000 | 45% | 14 | $357 |
| 412426 0001 | Oak Ridge Place | 102 | $29,000 | 60% | 61 | $475 | $10,000 | 45% | 46 | $217 |
| 3122208010000 | Southwood | 150 | $116,000 | 60% | 90 | $1,289 | $39,000 | 45% | 68 | $574 |
| | ***Total*** | ***1,439*** | ***$2,136,000*** | ***60%*** | ***862*** | ***$8,138 (average)*** | ***$714,000*** | ***45%*** | ***650*** | ***$3,442 (average)*** |

* The cost per pound of TN removal from this facility is much greater than the other facilities and is affecting the average cost per pound of TN removal.

# Section 4. Conclusions and Recommendations

Based on the evaluations in this report, Tetra Tech identified conclusions and recommendations for BAM in both existing (see **Section 4.1**) and future dry retention facilities (see **Section 4.2**) in the PSPZ.

## 4.1. Existing Dry Retention Facilities

The following conclusions and recommendations were identified for the existing 16 City-owned/maintained dry retention facilities in the PSPZ and the dry retention facilities at the Tallahassee International Airport:

- There is limited benefit for nitrogen removal in going from 1-foot to 2-feet of BAM in the dry retention facilities. Therefore, 1-foot of BAM is recommended for any retrofits.
- The total stormwater runoff loading from the 16 existing dry retention facilities is less than 0.1% of the total TN loading to the Upper Wakulla River and Wakulla Springs. The reductions achieved through retrofit of these facilities with BAM would have minimal impact on the load to the river and springs, and likely an immeasurable impact on the water quality. Therefore, and the cost of retrofits cannot be justified.
- Based on the referenced airport study, EMCs from the Tallahassee International Airport are low and similar to natural/undeveloped land uses. Therefore, it was concluded that the benefits of retrofitting the airport's retention facilities with BAM would result in a negligible benefit to ground water loading and the cost of retrofit is not justifiable.

## 4.2. Future Development

The following conclusions and recommendations were identified for future dry retention facilities in the PSPZ:

- The potential TN loading contribution from stormwater runoff from the future land uses within the City's portion of the PSPZ is minor compared to the total estimated loading to the Upper Wakulla River and Wakulla Springs from the NSILT. This potential additional stormwater runoff loading from future land uses in the City's portion of the PSPZ is less than 0.5% of the total TN loading to the Upper Wakulla River and Wakulla Springs.
- The reductions achieved by adding BAM to future dry retention stormwater facilities within the PSPZ would have a minimal impact on the TN loading to the river and springs, and likely an immeasurable impact on the water quality; therefore, requiring the addition of BAM for future dry retention facilities cannot be justified.

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