Appendix B, Vol. II of II

Ruthrauff
Basin Maintenance Plan

Prepared for:

Pima County Regional Flood Control District

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Executive Summary

A properly prepared and executed maintenance program can extend the life cycle of drainage facilities, reduce the risk to public safety from the failure of those facilities and mitigate costs associated with such failures. This maintenance plan is presented in the Implementation Plan, Volume II of II, of the comprehensive Ruthrauff Basin Management Plan. The purpose of this document is to communicate an overview and preliminary cost estimates for maintenance activities, in a brief and concise form, for activities described in Volume I of the RBMP. It is intended as a guideline only for persons and entities seeking direction in developing maintenance plans and preliminary costs for drainage facilities within the Ruthrauff Basin.

The recommendations included herein should be reviewed and considered by the appropriate jurisdiction before implementation. These are recommendations only and determination of which and when recommendations get implemented is the sole responsibility of the agency or entity involved in the development of the facilities. Future planning and construction of facilities within the basin need to be formed using maintenance procedures and regulations available from the City of Tucson and Pima County. Though selections of those regulations and procedures are cited herein the authority to grant final approval of any maintenance plan lies solely with the City and the County.

Abbreviations

Units

cfs	cubic feet per second
F	degrees Fahrenheit
ft	Feet
in	Inch
lbs	Pounds
mi	Mile
sq.ft.	square feet

Agencies, Firms, misc.

ADOT	Arizona Department of Transportation
BMP	Basin Management Plan
FIRM	Flood Insurance Rate Map
FLAP	Floodprone Land Acquisition Program
FEMA	Federal Emergency Management Agency
GI/LID	Green Infrastructure/Low Impact Development
COT	City of Tucson
COTDM	City of Tucson Drainage Manual
CBC	Concrete Box Culvert
SQS	First Flush
I-10	Interstate 10
JEF	JE Fuller Hydrology and Geomorphology Inc.
LOMR	Letter of Map Revision
MMP	
MS4	Municipal Separate Storm Sewer System Permit
PCRFCD	Pima County Regional Flood Control District
RBMP	Ruthrauff Basin Management Plan
RD	Road
Stantec	Stantec Consulting Services Inc.
TSMS	Tucson Stormwater Management Study
UPRR	Union Pacific Railroad
WDG	Wheat Design Group

1.0 Introduction

In order for flood control facilities to be effective, proper routine maintenance is essential. Maintenance includes both routinely scheduled activities, as well as non-routine repairs that may be required after large storms, or as a result of other unforeseen problems. Maintenance is the responsibility of the entity owning the drainage facility; however, local governments with municipal separate storm sewer system (MS4) permits are responsible for ensuring that maintenance of privately owned facilities occurs within their MS4. Facilities should be designed with maintenance as one of the key design considerations.

2.0 Purpose

The purpose of this document is to act as a guideline to address maintenance for existing drainage facilities and supplement required maintenance plans which will be created, reviewed and approved as each project is implemented under the Ruthrauff Basin Management Plan. This document is not intended to supersede any regulatory documents or guidance issued by the City or the County. For example, in the City of Tucson channel maintenance is guided by the Tucson Stormwater Management Study (TSMS).

2.1 Defining Maintenance Responsibility

Identifying who is responsible for maintenance of a specific drainage facility and ensuring that an adequate budget is allocated for maintenance is critical to the long-term success of the overall system. Maintenance responsibility may be assigned in different ways:

- Publicly owned flood control facilities are maintained by the MS4 permittee.
- Publicly owned regional drainage facilities located within the PCRFCD service area may be maintained by PCRFCD when specific maintenance eligibility criteria are met (subject to funding limitations).
- Privately owned facilities typically are maintained by the property owner, homeowner's association, or property manager.

- Privately owned facilities may be maintained by the MS4 permittee under a written agreement with the owner, with appropriate fees assessed for maintenance services.

- Those drainage facilities located within the City limits will comply with the City of Tucson Drainage Manual and Maintenance Management Program standard work practices, as well as any other City of Tucson maintenance regulations.

MS4 permittees can utilize a variety of legal approaches to ensure maintenance of stormwater facilities. Representative measures include:

- Agreements establishing legally binding facility maintenance requirements and responsibilities.

- Permit obligations specifying facility requirements; or

- Municipal legislative action or rulemaking authority.

- Regional flood control basins constructed within the RBMP may be maintained by PCRFCD.

- Detention basins within the City limits shall be maintained by the City of Tucson.

Examples of some of the specific requirements for drainage facility maintenance suggested for legal agreements include:

- General Assurances: Identify requirements for proper operation and maintenance, conditions for modification of facilities, dedicated easements, binding covenants, operation, and maintenance plans, and inspection requirements.

- Warranty Period: Require the original developer to be responsible for maintenance and operation during a defined short-term period and identify the entity responsible for long-term operation.

- Proof of Legal Authority: Require that the entity meet certain conditions verifying its legal authority to ensure maintenance.

- Conditions for Phased Projects: Clearly specify how maintenance responsibilities are allocated over the long-term for a project that is phased in over time. This includes identifying access points during each phase.

- Remedies: Clearly define remedies in the event that the facility is not being properly maintained.

For public facilities, one of the key issues is ensuring that adequate staff and budget are provided to the department responsible for maintenance. Ponds, lakes, and wetland structures should be built only if assurances are provided that adequate maintenance staff and resources are identified in advance.

Homeowners' associations may have a lack of awareness of maintenance that is required for privately owned flood control facilities. Maintenance plans should be prepared and submitted as part of the development review/approval process and be provided to the owner(s) upon sale of the development. It is also important to educate the general public on the purpose and function of stormwater facilities. This is critical in cases where Low Impact Development (LID) or landscape-based facilities are distributed throughout multiple parcels in developments. In addition to legally binding maintenance agreements, it is also helpful to have easy-to-understand informational brochures that describe the functions and maintenance requirements for these facilities such as the PCRFCD *Drainage Maintenance for Homeowners Associations* (see References).

2.2 Maintenance Schedule and Duration

Routine maintenance is a function of both time and cost. Most drainage facilities are required to undergo certain timely maintenance activities under City and County guidelines. For example, private drainage basins and other drainage facilities located within commercial and residential subdivisions within the city limits are required to be annually inspected by a licensed civil engineer (see Appendix B). Budget constrains must be considered when scheduling maintenance activities but should not take precedence over need. Skipping crucial preventative maintenance to conserve costs can easily end up costing significantly more not only in terms money but environmental damage and public safety as well.

2.3 Record Keeping

A record keeping system for maintenance inspections in the preventative maintenance program. Clearly record the problem and the specific actions taken to correct the problem. Photos can be helpful components of such records. An annual review of these records should be conducted to evaluate the overall effectiveness of the preventative maintenance program.

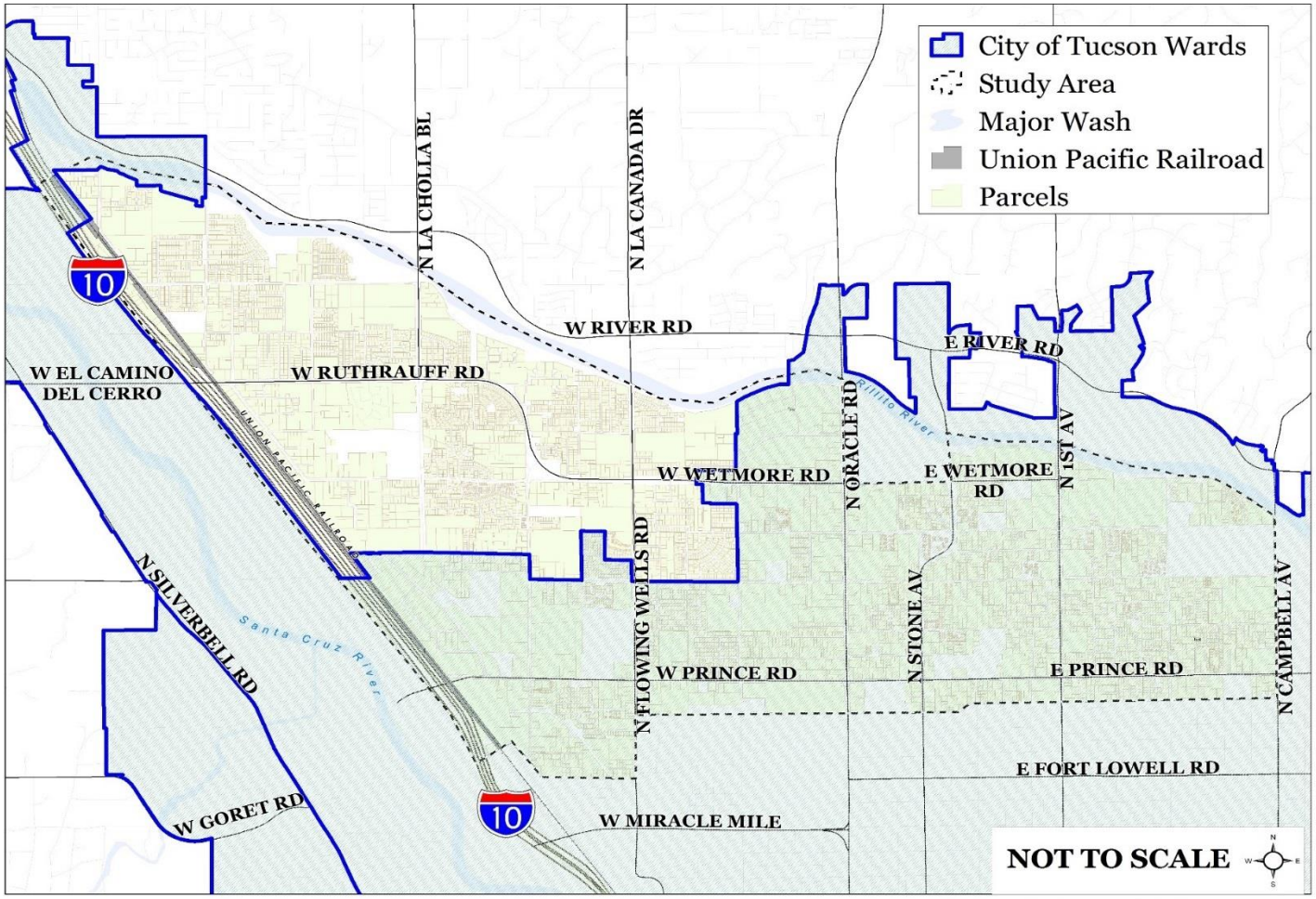
2.4 Maintenance Activities Disclaimer

Stantec has taken all necessary steps and included various assumptions that could be reasonably used without detailed discussions and/or review periods that would normally be undertaken with all necessary State and/or Federal agencies for a federally programmed project or one that requires direct coordination with all necessary State, Federal or other local agencies and/or utility owners. This document was prepared using current approaches, methodology, computations and standards of care and practice; however, the author cannot guarantee that such may be the same at a future date when funding has been established or when the final design phase commences. Therefore, at a future date this document may need to be reviewed and revised as necessary to comply with all applicable criteria at that time.

All recommendations provided within this report will require complete engineering design and other related services/efforts and approval by all appropriate agencies prior to any construction activities. This document does not serve as project approval.

Information provided to Stantec by the PCRFCD and the City of Tucson is considered appropriate for use within the nature of this study (i.e., conceptual) but will need to be reviewed and revised as necessary prior to use within any subsequent design phases.

Figure 1 – Maintenance Area with Jurisdictions



3.0 Inspections and Maintenance Activities

3.1 Culverts

Defined as a structure with a span length up to 20 ft. designed to allow the passage of water across a physical obstacle such as a roadway or railroad. Unlike bridges culverts have a floor can be circular, rectangular, elliptical or square. Culverts have low routine maintenance requirements but may need significant maintenance every 15 to 25 years depending on the material from which they are constructed.

3.1.1 Corrugated Metal Pipes (CMP)

Inspections are required for drainage facilities in the city annually to check for sediment/debris buildup, change of barrel shape, corrosion, and structural deficiencies caused by erosion. Culverts constructed around CMP's are less likely to have more permanent erosion control, such as concrete wingwalls and/or headwalls vs. backfill or riprap, and are more susceptible to corrosion than other materials therefore they will most likely require more frequent lifetime maintenance that is substantial in nature. Interior and exterior rust, reduction in metal thickness, joint separation, holes, and settlement, can all lead to the failure of the culverts. When a CMP fails during a flood, not only does the culvert cease to function as necessary, but material collapses to fill in the void which can quickly lead to a breach in the infrastructure the culvert is protecting. Because of this, you should budget for the replacement of the pipes as their design life ends. If it is noted during an inspection that a CMP culvert is Minimally Acceptable and the facility becomes damaged during a flood as a direct result of the failure of the CMP, then the Owner may deny post flood rehabilitation assistance for the repair of this damage. The maintenance and replacement of these pipes is considered to be part of the ongoing maintenance of the project and is therefore the responsibility of the owner.

3.1.2 Reinforced Concrete Pipes (RCP)

Inspections annually to check for sediment/debris buildup, excessive abrasion, cracking/spalling of concrete, exposed/corroding reinforcement, and structural deficiencies caused by erosion. The Army Corps of Engineers recommends a design life of 70 to 100 years for precast a RCP so culverts constructed around

RCP's are more likely to have reinforced concrete structural components (i.e., wingwalls, headwalls, etc.) thus reducing overall significant lifetime maintenance and the need to budget for replacement pipes. This, however, also means that they are often used to support critical infrastructure (railways, major arterial roadways, etc.) making regular maintenance essential because the associated costs of culvert failure would be significant.

3.1.3 Concrete Box Culverts (CBC)

Inspections to be performed annually to check for sediment/debris buildup, excessive abrasion, cracking/spalling of concrete, exposed/corroding reinforcement, structural deficiencies caused by erosion, and unusual/uneven settlement of the structure. Generally, CBC's are used in areas of high stormwater flow and can span more than 20 feet where minor bridges are impractical or unnecessary. Of the three types of culverts listed CBC's require the least amount of major lifetime maintenance as they are generally constructed for a 100-year lifespan and have reinforced concrete structural components and scour/erosion control.

3.2 Detention Basins

Detention basins are structures that collect stormwater and release it at surface at a controlled rate via positive gradient, bleed pipes, weir, and/or other approved control outlet. Maintenance frequency depends on the amount of construction activity within the tributary watershed sediment transport character, the erosion control measures implemented, the size of the upstream watershed, and the design of the facility. Both the City and the County have standards and regulations for detention basin construction.

3.2.1 Inspection

Inspect the basin at least twice annually, observing the amount of sediment in the base and checking for debris at the outlet structure.

3.2.2 Debris and Litter Removal

Remove debris and litter from the detention area as required to minimize clogging of the outlet.

3.2.3 Mosquito Control

Although the design provided in this manual implements practices specifically developed to deter mosquito breeding, some level of mosquito control may be necessary if the drainage facilities is located in close proximity to outdoor amenities. The most effective mosquito control programs include inspection for signs of mosquito breeding with treatment provided when breeding is found. These inspections can be performed by a mosquito control service and typically start in mid-June and extend to mid-September.

3.2.4 Sediment

Sediment transport is a natural function of most drainage systems. However, where sediment builds up, restricts conveyance, or causes clogging or other adverse impact, sediment removal shall be performed. Plunge basins may or may not need sediment removed as smaller storm events may "clean out" plunge basin areas. In the City of Tucson, a Civil Engineer's annual assessment shall evaluate sediment transport issues at sites and provide sediment removal from the bottom of the basin when accumulated sediment results in poor drainage within the basin.

3.2.5 Erosion and Structural Repairs

Repair basin inlets, outlets, trickle channels, and all other structural components required

3.3 Flap Gates

Defined as a device that allows stormwater to flow in only one direction through a pipe, or other stormwater conveyance feature, at a high-water level. All flap gates, slide gates, and other gate systems need to be inspected and lubricated at least once a year just before the flood season. If gates aren't seated properly, water will flow back through the drainage structure during high water. During the inspection, all gates should be manually operated, and any debris or obstructions removed. All gate seats should be checked and the frames readjusted if the gate is not seating properly. Cracked or damaged gates need to be replaced. The inlet and

outlet channels need to be kept free of debris, trees, brush and other vegetation, and sediment. All concrete cracks in the inlet/ outlet structure need to be repaired. Metal grates, hand wheels, and other metalwork should be secure and sound, free from rust, and regularly maintained by cleaning, painting, and greasing. If any pipe or culvert has separated from the inlet/ outlet structure headwall, this needs to be repaired as soon as possible. When high water is predicted, all flap and slide gates should again be inspected and any debris or obstructions should be removed immediately

3.4 Inlet & Outlet Structures

These are defined as structures (orifices, pipes, etc.) designed to allow the controlled movement of stormwater.

3.5 Trash Racks

Defined as a metal structure supported by masonry, or metal frame, that prevents stormwater borne debris from entering the intake of an inlet structure, pipe, or other stormwater feature. Trash racks require annual inspections to check for debris buildup and support/grate integrity. Maintenance to remove debris should be performed annually. Inspection for debris buildup may be required more than once a year due to higher than average rainfall and/or after particularly large storm events.

3.6 Green Infrastructure/Low Impact Development (GI/LID)

This defined as constructed drainage facilities that use living natural systems to provide environmentally friendly was of capturing, filtering, and infiltrating stormwater. The benefits of this approach as opposed to traditional “gray” drainage facilities are wildlife habitat, shading of buildings and streets, urban heat island effect mitigation and aesthetics. Guidance for implementing green infrastructure may be found in the *Low Impact Development and Green Infrastructure Guidance Manual* and *Green Infrastructure for Desert Communities* (see References). The following are some common green infrastructure features.

3.6.1 Stormwater Harvesting Basin

A water harvesting basin is an earthen depression, often lined with desert trees and plants, designed to collect and infiltrate stormwater. The runoff is collected in the basin through means of sidewalk scuppers, curb cores or cuts reinforced with natural rock rip rap and rock lined sediment traps. These need regular inspection for sediment build up and debris especially during the rainy season. The rip rap apron and traps should be inspected annually for erosion and sediment buildup as well.

3.6.2 Swales/Rock or Vegetated

A swale is a depressed flow feature with gently sloping sides that is long and linear in shape that can carry less than a regulatory flow and drains a watershed area of less than 25 acres. They can be flat bottomed and vegetated for infiltration or sloped and rock lined to convey flow to another infiltration feature like a stormwater harvesting basin. They require annual inspections to look for sediment buildup and clogging from debris or other obstructions. More frequent inspections may be required after particularly large storms or extended periods of rainfall.

3.6.3 Landscaping

Landscaping is defined as vegetation and hardscape, both functional and decorative. Guidance for this can be found in the Pima County *Landscape Manual*. Especially useful for GI are plants native to the Sonoran Desert that soak up large amounts of water during the rainy season in preparation for drier seasons. Effective landscaping can be used for stormwater harvesting, mitigate the urban heat island effect and stabilize soils preventing erosion and soil pollution. Maintenance of landscape should include periodic inspections for overgrowth top ensure public access and sight lines for vehicles are not encroached upon.

3.7 Channels – Lined, Unlined, & Bank Protected

A channel can be defined as any watercourse, natural or man-made, that conveys stormwater in a volume more than a regulatory flow, drains more than 25 acres, or is represented as a wash on City and County GIS maps. From a regulatory

standpoint, the inspection of channels varies from jurisdiction to jurisdiction as does a more detailed classification than is presented here. The TSMS should be consulted before any channel inspection and maintenance program within the city limits

In general, lined and bank protected channels should be inspected once a year and up to twice a year for unlined channels. Maintenance activities that may arise from these inspections include removal of trash and debris; removal of flow obstructions, both natural and artificial; vegetation control on banks; lining and bank protection repair; and grading and leveling to alleviate ponding or allow vehicle access. Regardless of the channel's classification, in general, maintenance should be performed wherever the channel's ability to convey flow is hampered or is a threat to public safety.

3.8 Road Right-or-Way

The right-of-way usually includes anything within a transportation easement owned by the City, County or State. This is defined as street inspection and maintenance. As the Ruthrauff Basin was developed out of farm land a lack of storm drains meant many streets took on the twofold task of conveying traffic and conveying stormwater. Again, the City and the County have established guidelines for street maintenance administered by their respective Departments of Transportation and any discussion of a maintenance plan should consult them.

In general, roadways should be inspected once a year. Which roads have priority for inspection, or require more frequent inspections, under constrained budgets are determined by several factors including traffic conditions, public safety, working hour limitations, and whether it is arterial or a collector. Maintenance activities that may be needed include patching, pothole repair, grading (for unpaved roads), sweeping, ditch pulling and much more. A comprehensive list of maintenance activities that may be performed can be found in Chapter 4 of the City of Tucson TSMS.

3.9 Fencing/Handrails

Fences and handrails are safety devices used to keep the public from entering or accidentally falling into drainage facilities. They should be inspected once a year. The maintenance activities that may be needed for these facilities include

replacing damaged or missing members, damaged locks, missing or loose wire, damaged post foundations, and corrosion repair.

3.10 Erosion

There are several types of erosion that effect drainage facilities. For example, the slopes of any embankment can become eroded from rain runoff or by embankment overtopping. In cases of embankment overtopping during a flood, there may be a total failure of the structure.

A second type of erosion often seen on embankments is wave wash. Under high water conditions, wave action can form long terraces along the length of the embankment slopes. If additional material or bank protection is not provided, the embankment will continue to cave as the waves work their way farther into the slope.

A third type of embankment erosion is caused by the flow of water within a river or channel. These flows can erode a channel bank or undermine other flood control structures and cause them to cave into the water. Bank caving or stream bank erosion can be a very serious threat to the stability of any drainage facility. It's critical that the riverward bank be inspected for bank caving or erosion and if observed immediate action should be taken to stabilize the banks.

3.10.1 Repair of Areas Damaged by Erosion

All erosion gullies need to be repaired to prevent further erosion and more significant damage during high water. The backfill material should generally be placed in 6 inch layers and compacted mechanically or by hand, in order to restore the original 7 shape of the levee. If erosion is typically a reoccurring problem, something should be done to improve the drainage and prevent further erosion in the area. Consideration should be given to installing drainage channels or appropriately sized rock, and areas of the levee that remain exposed should be reseeded and mulched. In extreme cases of channel/ bank erosion, a relocation or setback of the levee may be the only economical solution.

3.11 Animal Control

Close attention must be given to the presence of burrowing animals, since they may not be readily detected without a thorough inspection. Burrows created by gophers, owls, muskrats, opossums, badgers, and other animals can lead to rapid drainage facility failures during floods. For this reason, an active animal abatement program needs to be implemented to remove these animals. Rodent control techniques involving fumigation, bait stations, bait broadcasting, or trapping have proven effective in certain situations, but you should always contact Arizona Game and Fish to determine which rodent control procedures are allowable and recommended in your area. The use of chemicals shall be limited to last resort solutions in order to minimize chemical/pollutants in storm water runoff.

Inspections to detect the presence of burrowing animal activity are generally most effective immediately after the levee has been mowed. Animal burrows that are identified should be thoroughly excavated and inspected, backfilled with compacted soil that is similar to material of the levee, and reseeded. This will avoid the possibility of water piping through unfilled portions of the burrows during a flood.

3.12 Drain Down Time

Ponding water shall be addressed to minimize potential for: mosquito borne illness, mold, foundation issues, and termites. For drainage features that show slow percolation into soil, or ponding, maintenance or re-design will be required to meet 12-hr or 24-hr drain-down time for these drainage facilities in the City and 36-hrs those drainage facilities in the County.

4.0 Costs

Anytime new drainage facilities are constructed they must also be maintained and this should be budgeted for. Volume I of the RBMP presents recommended alternatives to alleviate flooding and drainage issues and promote revitalization and development in the Ruthrauff basin, especially in the Flowing well neighborhood and along Highway Drive. As part of this plan cost estimates for lifetime maintenance were calculated. The estimated costs of lifetime maintenance for the RBMP can be seen in the following Table 1.

The lifecycle for all the recommended alternatives was estimated at 50 years and the costs were estimated per year. As this is just a preliminary estimate there was no adjustment for future inflation. Inspection and maintenance activities were broken down per unit. Inspection charges were estimated by unit duration and maintenance activities were estimated to be 5% of the cost of construction per year. The unit costs include labor, equipment, fuel, permits and supplies. Each of those separate tasks would have to be broken down individually for any comprehensive maintenance plan that would follow construction of any specific alternative. The cost breakdown can be seen in Appendices C and D.

Table 1: Lifetime Cost Estimate for RBMP

Ruthrauff Recommended Alternative Inspection and Maintenance Summary

DRAFT - 3/29/2017 - Ruthrauff BMP Maintenance Items Matrix for 50-year Lifespan

	Jurisdiction	Scheduled Inspections per Year	Scheduled Maintenance per Year	Unit	# of Units	Inspection Cost per Unit	Maintenance Cost per Unit	Total Annual Cost	Total Lifespan Cost
Retention Basin	Public	2	1	Acres	61	$15.00	$2,591.17	$159,367	$7,968,343
Detention Basin	Public	2	1	Acres	-	$0.00	$2,591.17	$0	$0
Inlet & Outlet Structures	Public	1	1	Each	22	$20.00	$275.00	$6,490	$324,500
Culverts - CMP	Public	1	1	Linear Ft.	5,666	$2.00	$7.50	$53,827	$2,691,350
Culverts - RCP/CBC	Public	1	1	Linear Ft.	-	$1.00	$10.00	$0	$0
Storm Drain Pipes	Public	2	1	Linear Ft.	1,900	$5.00	$9.60	$37,240	$1,862,000
Lined Channels	Public	1	1	Sq.Yd.	15,689	$1.00	$3.00	$62,756	$3,137,800
Unlined Channels	Public/Private	2	2	Sq.Yd.	13,878	$2.00	$0.25	$62,450	$3,122,478
Bank Protection	Public	1	1	Cu.Yd.	24,050	$10.00	$4.75	$354,738	$17,736,875
Vegetation	Public/Private	2	2	Acres	61	$15.00	$75.00	$10,980	$549,000
Vegetated & Rock Swales	Public	1	1	Sq.Yd.	-	$0.00	$0.00	$0	$0
Stormwater Harvesting Basins	Public/Private	4	4	Acres	-	$0.00	$0.00	$0	$0
Road Right-of-way	Public	1	1	Linear Ft.	14,835	$2.00	$5.50	$111,263	$5,563,125
Fencing	Public	1	1	Linear Ft.	22,300	$0.50	$0.60	$24,530	$1,226,500
Handrails	Public	1	1	Linear Ft.	-	$0.50	$3.75	$0	$0
Access Roads	Public	1	1	Linear Ft.	-	$0.00	$0.00	$0	$0
							Total Plan Costs	**$883,639**	**$44,181,971**

Appendix A – References

Report on the Existing 100-year Flooding Conditions within the Gardner Lane Area: City of Tucson Contract No. 0401-81, Cella Barr Associates; November 10, 1981

Hydrologic Investigation for Gardner Lane Area: City of Tucson Contract No. 0401-81, Cella Barr Associates; June 3, 1981

Plan Tucson – General & Sustainability Plan, Resolution #22160; November 13, 2013

Alternative Design Schemes for the Gardner Lane Area: City of Tucson Contract No. 0401-81, Cella Barr Associates; June 16, 1981

I-10 mainline Reconstruction Casa Grande – Tucson Highway (I-10) Ruthrauff to Prince Road Final Drainage Report: ADOT Project No. 010 PM 252 H6241 01C, AECOM; April 2011

Hydraulic analysis program (two-dimensional modeling), FLO-2D, Pro Version (FLO-2D Software Inc., Post Office Box 66, Nutrioso, Arizona.

Hydraulic analysis program (one dimensional river analysis), HEC-RAS, version 4.1 (Hydrologic Engineering Center, 609 Second Street Davis, California, January 2010).

Hydrologic analysis program, HEC-1 (Hydrologic Engineering Center, USACOE, June 1998)

Criteria for Two-Dimensional Modeling, Technical Policy, Tech-033, Pima County Regional Flood Control District; August 1, 2013

Comprehensive Plan Update, Pima Prospers, Planning and Zoning Commission Public Hearing Draft, The Pima County Planning and Zoning Commission, File Number C07-13-10, Resolution No. 2009-63; March 25, 2015

Design Standards for Stormwater Detention and Retention, Supplement to Title 16, Chapter 16.48 Floodplain and Erosion Hazard Management Ordinance, Pima County Flood Control District; November 2015

Drainage Maintenance Guidelines for Homeowners Associations, Pima County Flood Control District Guidebook; 2015

Tucson Stormwater Management Study (including Phase III: Streets and Stormwater Management Program Phase II), City of Tucson, Simons, Li and Associates; May 22, 1995

Standards Manual for Drainage Design and Floodplain Management in Tucson, AZ, Simons, Li and Associates; Revised July 1998

Landscape Manual, Pima County; March 5 2017

Green Infrastructure for Desert Communities, Watershed Management Group; January 2017

Low Impact Development and Green Infrastructure Guidance Manual, Pima County, City of Tucson, March 2015

City of Tucson Stormwater Detention/Retention Manual, City of Tucson, 1987

Commercial Water Harvesting Ordinance, City of Tucson, Adopted Ordinance 10597; October 14, 2008

Appendix B – City of Tucson Drainage Facility Inspection Checklist

CITY OF TUCSON

Drainage Facility Annual Maintenance

Drainage basins and other drainage facilities in both commercial and residential subdivisions are **required to be inspected annually** at minimum, by a Civil Engineer hired by the HOA, or other appointed oversight group, to assure that the drainage basins and drainage facilities function to City standards and codes. (Technical Manual Section 4-04.1.5,14.3.)

Some HOA's have their annual inspection and report performed in late summer or in the fall and then use the recommendations to clean and repair damage after monsoon season.

List of maintenance requirements or guidelines specific to your subdivision are typically found in the subdivision's drainage report, on the Final Plat, and/or in the subdivision's Covenants, Conditions, and Restrictions (CC&R's).

If the HOA has not been maintaining their drainage facilities, the HOA can begin by hiring a Civil Engineer to perform an inspection of the subdivision and watershed areas. They typically will research the approved grading plan and drainage report to see if there are changes from the originally approved plans and determine which areas may need maintenance/ attention. As a suggestion, the City recommends asking your engineer to provide the HOA with clearly described options, if more than one is available, to address each correction. That way the HOA can discuss the costs and/or recommendations and vote on the options if needed. Addressing the maintenance items quickly is important as problems can compound and created increased potential for flood, erosion, or other hazards, as well as liability issues. Violation letters or other penalties may also be sent if maintenance is not being performed. (Reference: Tucson Code Chapters 11 and 26 Article I.)

List of commonly found drainage problems for basins and other subdivision drainage facilities:

- ☐ Broken/damaged scuppers
- ☐ Clogged / damaged inlet
- ☐ Clogged / damaged outlet
- ☐ Debris, contaminants, or trash
- ☐ Erosion at outlet/inlet areas
- ☐ Erosion undercutting
- ☐ Overgrown vegetation
- ☐ Sediment reducing capacity or flow
- ☐ Shopping carts
- ☐ Side bank erosion
- ☐ Sinkholes, tunneling, or piping
- ☐ Stagnant or ponding water
- ☐ Watershed change or breach
- ☐ Weeds (ie illegal buffelgrass)

In some cases the Final Plat may indicate that a certain watercourse or drainage improvement is maintained by the City of Tucson (publicly maintained drainage infrastructure), in which case the City should be contacted if there are any issues found or if there are any breaches in the watershed area of the subdivision. In other cases, Final Plats may also indicate for some subdivisions that the drainage facilities are privately maintained, which generally require maintenance by HOA management.

Except for large-scale, regional detention/retention basins, the City Tucson shall not accept small-scale, local detention/retention basins operation, maintenance, or liability. However, a basic inspection is performed by the City staff annually to see whether there are basic maintenance issues to address, and letters are sent to the HOA for those basins that are seen to have general issues. This inspection is usually not performed by a City of Tucson Civil Engineer and does not take the place of the HOA requirement to perform the annual maintenance inspection and report by their hired Civil Engineer. The City inspections typically will look for basin issues only, not at other drainage facilities. City Drainage Inspector will look for general issues such as overgrown vegetation, weeds, debris, trash, and other evident issues that may be seen by a quick inspection that may only include driving by the basin. To reiterate, City inspections do not take the place of the required annual inspection to be preformed by a civil engineer that would be hired by the property owners / HOA.

Homeowners' or Business Owners' Association shall be established for all subdivisions in order to create the authority and responsibility for maintaining private basins, small washes and private constructed channels within the subdivision.

Owner or owners of a **subdivision or any development** that have private basin(s) or private drainage facilities shall be solely responsible for operation, maintenance, and liability for these drainage structures and retention/detention basins.

Professional Civil Engineer, registered in the State of Arizona, shall be retained by the Association/Owner(s) at least once a year, and also following any damaging floods, in order to inspect and to certify compliance with the drainageway(s), detention/retention basin(s), and/or other drainage facilities, for maintenance-inspection criteria based on the approved drainage report and approved grading plans for the development or subdivision.

The owner or owners shall have an Arizona Registered Professional Civil Engineer prepare a certified inspection report for the drainage and detention/retention facilities at least once each year, and that copies of these Engineer's regular or annual inspection reports and certifications of compliance will be kept on file by the Association/Owner(s), for review by City staff, upon written request.

Per Technical Manual Section 4-04.14, City staff may periodically inspect the drainage and detention/retention facilities to verify that scheduled and unscheduled maintenance activities are being performed adequately. Owner or owners shall reimburse the City for any and all costs associated with maintaining the drainage and detention/retention facilities, should the City find the owner or owners deficient in their obligation to adequately operate and maintain their facilities.

The certified annual inspection report shall contain at minimum the following summaries:

a) A statement saying that either no maintenance work is needed at that time, or a list of repairs and work to be done to correct deficiencies, to avoid potential problems, and/or to restore the aesthetics. Also state that this work shall be followed by a Letter of Certification from an Arizona Registered Professional Civil Engineer verifying that the recommended work has been satisfactorily completed. The Engineer shall notify the City Engineer, in writing, should safety-related maintenance not be completed within a reasonable period of time.

b) A statement either indicating that watershed conditions have not changed since the previous inspection report, or stating that specific changes have occurred which alter or eliminate some of the design features - thereby affecting the level of service of the drainage and detention/retention systems. In addition, the City Engineer is to be immediately notified, in writing, if watershed conditions have changed to the extent that drainage and detention/retention systems no longer satisfy the requirements of the City Floodplain Regulations.

Other questions regarding private drainage facility maintenance requirements or researching subdivision information, may be directed to City of Tucson PDSD Engineering Division 791-5550. Come to 201 N Stone Av 1st Floor City of Tucson, Engineering Counter – go to website for office hours: https://www.tucsonaz.gov/pdsd Or contact City of Tucson Transportation Department Engineering Division on the 4th floor 201 N Stone Av for other flood/erosion questions.

Appendix C – Basin Construction Cost Estimates

RUTHRAUFF BMP - AREA 4 - ALTERNATIVE 1

Area 4 - Alternative 1 - Retention Basin - South of Rillito Street

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	3.0	$3,000	$9,000.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	26,000	$10.50	$273,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	1,350	$95.00	$128,250.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$7,500	$7,500.00
	DRAINAGE- SUBTOTAL AMOUNT				**$432,750.00**
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	L.SUM	1	$30,292.50	$30,292.50
9010001	MOBILIZATION	L.SUM	1	$51,930.00	$51,930.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$30,292.50	$30,292.50
9240010	FORCE ACCOUNT WORK	L.SUM	1	$108,187.50	$108,187.50
	LAND ACQUISITION	L.SUM	0	$268,521.00	$0.00
	DRAINAGE - TOTAL AMOUNT				**$653,452.50**

COST/ACRE **$217,817.50**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 4 - ALTERNATIVE 1

COMMENTS - 10-year solution

Basin - heavy trees and brush

complete demo of at least two homes and associated structures

Civil 3D

0.07

0.12

0.07

0.25

APNs; 104-03-200A and 104-03-203A

assumes minimal other utility conflicts as we do not have field data/potholing info

complete evaluation of demo work has not been made …no idea on any Haz Mat

RUTHRAUFF BMP - AREA 3 - ALTERNATIVE 1

Area 3 - Alternative 1 - Retention Basin - Root Lane

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	1.9	$2,500.00	$4,750.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000.00	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	21,315	$10.50	$223,807.50
2030507	EMBANKMENT	CU.YD.	500	$14.00	$7,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	1,975	$95.00	$187,625.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$12,000.00	$12,000.00
	BASIN - SUBTOTAL AMOUNT				**$450,182.50**
9010001	MOBILIZATION	L.SUM	1	$45,018.25	$45,018.25
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$31,512.78	$31,512.78
9240010	FORCE ACCOUNT WORK	L.SUM	1	$112,545.63	$112,545.63
	LAND ACQUISITION	L.SUM	0	$125,000.00	$0.00
	BASIN - TOTAL AMOUNT				**$639,259.15**

COST/ACRE **$336,452.18**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 3 - ALTERNATIVE 1

COMMENTS - 100-year solution

some mature trees within the location of the proposed basin. Assume ~0.5 acre for roadway area

26'x1400' paved road & misc structures

Civil 3D - basin

minimal amount assumed - Civil 3D reveals negligible

1345 lf + 300 lf = L, W ~ 18-ft (each) +300 basin edge protection…etc.

Testing: AC, ABC, Conc, RipRap…misc

0.10

0.07

0.25

half of APN 104-05-3510

assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 5 - ALTERNATIVE 1

Area 5 - Alternative 1 - Retention Basin - South of Pelaar Street

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	7.0	$3,000	$21,000.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1.0	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	55,000	$10.50	$577,500.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	1,200	$95	$114,000.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$5,000	$5,000.00
	DRAINAGE - SUBTOTAL AMOUNT				**$732,500.00**
9010001	MOBILIZATION	L.SUM	1	$51,275.00	$51,275.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$51,275.00	$51,275.00
9240010	FORCE ACCOUNT WORK	L.SUM	1	$183,125.00	$183,125.00
	LAND ACQUISITION	L.SUM	0	$1,013,793.10	$0.00
	DRAINAGE - TOTAL AMOUNT				**$1,018,175.00**

COST/ACRE **$145,453.57**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

COMMENTS - 10-year solution

Basin - heavy trees and brush

complete demo of developed mobile home park items including ~ 800l.ft of 20-ft roadway, end utilities

misc. work to prevent erosion of perimeter

0.07

0.07

0.25

portion of APN 106-06-023A

assumes minimal other utility conflicts as we do not have field data/potholing info

complete evaluation of demo work has not been made …no idea on any Haz Mat

RUTHRAUFF BMP - AREA 1 - ALTERNATIVE 2

Area 1 - Alternative 2 - Retention Basin & Channel system - East side of Camino de la Tierra

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	5.1	$3,000	$15,300.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1.0	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	60,000	$10.50	$630,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	700	$95.00	$66,500.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$12,000	$12,000.00
	DRAINAGE & ROADWAY - SUBTOTAL AMOUNT				**$738,800.00**
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	L.SUM	1	$51,716.00	$51,716.00
9010001	MOBILIZATION	L.SUM	1	$88,656.00	$88,656.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$51,716.00	$51,716.00
9240010	FORCE ACCOUNT WORK	L.SUM	0	$184,700.00	$0.00
	DRAINAGE & ROADWAY - TOTAL AMOUNT				**$930,888.00**

COST/ACRE **$182,527.06**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 1 - ALTERNATIVE 2

COMMENTS - 10-year solution along Camino, 100-year solution for the basin

main channel, basin, diversion channel into basin

removed paved shoulder along Camino ~50% of shotcrete area

misc. work to prevent erosion at D/S end and other work, lining of diversion channel

0.07

0.12

0.07

0.25

assumes minimal other utility conflicts as we do not have field data/potholing info

complete evaluation of demo work has not been made …no idea on any Haz Mat

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 4

Area 2 - Alternative 4 - Retention Basin and Diversion Channel - Paradise Lane

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	7.1	$2,500	$17,750.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	82,000	$10.50	$861,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	800	$95.00	$76,000.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$15,000	$15,000.00
	DRAINAGE - SUBTOTAL AMOUNT				**$984,750.00**
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	L.SUM	1	$68,932.50	$68,932.50
9010001	MOBILIZATION	L.SUM	1	$118,170.00	$118,170.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$68,932.50	$68,932.50
9240010	FORCE ACCOUNT WORK	L.SUM	1	$246,187.50	$246,187.50
	LAND ACQUISITION	L.SUM	0	$602,919.58	$0.00
	DRAINAGE - TOTAL AMOUNT				**$1,486,972.50**

COST/ACRE **$209,432.75**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 4

COMMENTS - 10-year

minor work outside roadway

remove existing conc pad and other very minor items

lined channel

0.07

0.12

0.07

0.25

APNs; 103-06-072B, 103-06-071B and 103-06-072C and portion of; 103-06-090B

assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 7 - ALTERNATIVE 1

Area 7 - Alternative 1 - Retention Basin - Don Hummel Park

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	1.2	$3,000.00	$3,600.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000.00	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	8,200	$10.50	$86,100.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	100	$95.00	$9,500.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$2,500.00	$2,500.00
	DRAINAGE - SUBTOTAL AMOUNT				**$116,700.00**
9010001	MOBILIZATION	L.SUM	1	$14,004.00	$14,004.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$8,169.00	$8,169.00
9240010	FORCE ACCOUNT WORK	L.SUM	1	$29,175.00	$29,175.00
	DRAINAGE - TOTAL AMOUNT				**$168,048.00**

COST/ACRE **$140,040.00**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 7 - ALTERNATIVE 1

COMMENTS - 100-year

minor work outside roadway

remove existing conc curb

misc edging

0.12

0.07

0.25

assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 5

Area 2 - Alternative 5 - Retention Basin - Wetmore Road

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	12.7	$2,000	$25,400.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	163,000	$10.50	$1,711,500.00
2030507	EMBANKMENT	CU.YD.	135	$14.00	$1,890.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	500	$95.00	$47,500.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$25,000.00	$25,000.00
	DRAINAGE & ROADWAY - SUBTOTAL AMOUNT				**$1,826,290.00**
9010001	MOBILIZATION	L.SUM	1	$219,154.80	$219,154.80
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$127,840.30	$127,840.30
9240010	FORCE ACCOUNT WORK	L.SUM	1	$456,572.50	$456,572.50
	LAND ACQUISITION	L.SUM	0	$1,507,000.00	$0.00
	DRAINAGE & ROADWAY - TOTAL AMOUNT				**$2,629,857.60**

COST/ACRE **$207,075.40**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 5

COMMENTS - 10-year

numerous building demo and pavement

misc edging

0.12
0.07
0.25
see memo

assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 1

Area 2 - Alternative 1 - Retention Basin - Airport Runway

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	10.5	$2,000	$21,000.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	150,000	$10.50	$1,575,000.00
2030507	EMBANKMENT	CU.YD.	120	$14.00	$1,680.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	500	$95.00	$47,500.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$25,000	$25,000.00
	DRAINAGE & ROADWAY - SUBTOTAL AMOUNT				**$1,685,180.00**
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	L.SUM	1	$117,962.60	$117,962.60
9010001	MOBILIZATION	L.SUM	1	$202,221.60	$202,221.60
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$117,962.60	$117,962.60
9240010	FORCE ACCOUNT WORK	L.SUM	1	$421,295.00	$421,295.00
	LAND ACQUISITION	L.SUM	0	$198,000.00	$0.00
	DRAINAGE & ROADWAY - TOTAL AMOUNT				**$2,544,621.80**

COST/ACRE **$242,344.93**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 1

COMMENTS - 100-year

misc fencing and pavement at crossings

misc edging

0.07
0.12
0.07
0.25
several APNs (not listed in memo), one belongs to the COT

assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 7

Area 2 - Alternative 7 - Retention Basin - Highway Drive					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**AMOUNT**
2010011	CLEARING AND GRUBBING	ACRE	9.0	$2,000	$18,000.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1.0	$15,000	$15,000.00
2030301	ROADWAY EXCAVATION	CU.YD.	1,000	$12.00	$12,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	116,000	$10.50	$1,218,000.00
2030507	EMBANKMENT	CU.YD.	2,500	$14.00	$35,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	1,200	$95.00	$114,000.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1.0	$15,000	$15,000.00
	DRAINAGE & ROADWAY - SUBTOTAL AMOUNT				**$1,427,000.00**
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	L.SUM	1	$99,890.00	$99,890.00
9010001	MOBILIZATION	L.SUM	1	$171,240.00	$171,240.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$99,890.00	$99,890.00
9240010	FORCE ACCOUNT WORK	L.SUM	1	$356,750.00	$356,750.00
	LAND ACQUISITION	L.SUM	0	$124,500.00	$0.00
	DRAINAGE & ROADWAY - TOTAL AMOUNT				**$2,154,770.00**

COST/ACRE **$239,418.89**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

COMMENTS - 10-year

existing buildings and misc work (junk yard)
assume 400'x30'x5' min

misc edge protection

0.07
0.12
0.07
0.25
APNs; too many to list

barrier system along roadway needs to be evaluated/designed
assumes minimal other utility conflicts as we do not have field data/potholing info

RUTHRAUFF BMP - AREA 2 - ALTERNATIVE 6

Area 2 - Alternative 6 - Retention Basin & Diversion Channel - Zinnia Avenue

ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
2010011	CLEARING AND GRUBBING	ACRE	4.0	$3,000	$12,000.00
2020001	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	L.SUM	1	$15,000	$15,000.00
2030401	DRAINAGE EXCAVATION	CU.YD.	28,000	$10.50	$294,000.00
9130007	RIPRAP (DUMPED)(9")	CU.YD.	950	$95.00	$90,250.00
9240170	CONTRACTOR QUALITY CONTROL	L.SUM	1	$12,000	$12,000.00
	DRAINAGE - SUBTOTAL AMOUNT				**$423,250.00**
9010001	MOBILIZATION	L.SUM	1	$50,790.00	$50,790.00
9250002	CONSTRUCTION SURVEYING AND LAYOUT (AND AS-BUILTS)	L.SUM	1	$29,627.50	$29,627.50
9240010	FORCE ACCOUNT WORK	L.SUM	1	$105,812.50	$105,812.50
	LAND ACQUISITION	L.SUM	0	$52,500.00	$0.00
	DRAINAGE - TOTAL AMOUNT				**$609,480.00**

COST/ACRE **$152,370.00**

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

COMMENTS - 10-year

minor items including ballfield

channel lining and basin spillpad

0.12
0.07
0.25
APNs; 1/2 of each of; 103-05-0300 and 103-05-031A (school). Assume easement for outlet channel

assumes minimal other utility conflicts as we do not have field data/potholing info

Appendix D – Cost Breakdown for Ruthrauff BMP Inspection and Maintenance

Ruthrauff Recommended Alternative Inspection and Maintenance Summary

DRAFT - 3/29/2017 - Ruthrauff BMP Maintenance Items Matrix for 50-year Lifespan

	Jurisdiction	Scheduled Inspections per Year	Scheduled Maintenance per Year	Unit	# of Units	Inspection Cost per Unit	Maintenance Cost per Unit	Total Annual Cost	Total Lifespan Cost
Retention Basin	Public	2	1	Acres	61	$15.00	$2,591.17	$159,367	$7,968,343
Detention Basin	Public	2	1	Acres	-	$0.00	$2,591.17	$0	$0
Inlet & Outlet Structures	Public	1	1	Each	22	$20.00	$275.00	$6,490	$324,500
Culverts - CMP	Public	1	1	Linear Ft.	5,666	$2.00	$7.50	$53,827	$2,691,350
Culverts - RCP/CBC	Public	1	1	Linear Ft.	-	$1.00	$10.00	$0	$0
Storm Drain Pipes	Public	2	1	Linear Ft.	1,900	$5.00	$9.60	$37,240	$1,862,000
Lined Channels	Public	1	1	Sq.Yd.	15,689	$1.00	$3.00	$62,756	$3,137,800
Unlined Channels	Public/Private	2	2	Sq.Yd.	13,878	$2.00	$0.25	$62,450	$3,122,478
Bank Protection	Public	1	1	Cu.Yd.	24,050	$10.00	$4.75	$354,738	$17,736,875
Vegetation	Public/Private	2	2	Acres	61	$15.00	$75.00	$10,980	$549,000
Vegetated & Rock Swales	Public	1	1	Sq.Yd.	-	$0.00	$0.00	$0	$0
Stormwater Harvesting Basins	Public/Private	4	4	Acres	-	$0.00	$0.00	$0	$0
Road Right-of-way	Public	1	1	Linear Ft.	14,835	$2.00	$5.50	$111,263	$5,563,125
Fencing	Public	1	1	Linear Ft.	22,300	$0.50	$0.60	$24,530	$1,226,500
Handrails	Public	1	1	Linear Ft.	-	$0.50	$3.75	$0	$0
Access Roads	Public	1	1	Linear Ft.	-	$0.00	$0.00	$0	$0
							Total Plan Costs	**$883,639**	**$44,181,971**

Number of Recommended Alternative Improvements by Problem Area and Type

DRAFT - 3/29/2017 - Ruthrauff BMP - Improvements Worksheet

	Units	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9	Totals
Retention Basin	acre	5	43	2	3	7		1			**61**
Detention Basin	acre										**-**
Inlet & Outlet Structures	each	2	12	2	2	2		2			**22**
Culverts - CMP	l.ft.	2,886	2,120	410	250						**5,666**
Culverts - CBC	l.ft.										**-**
Storm Drain Pipes	l.ft.	1,900									**1,900**
Lined Channels	sq.yd.	9,550			1,250		4,889				**15,689**
Unlined Channels	sq.yd.	1,079	11,841	50	907						**13,878**
Bank Protection	cu.yd.	1,475	19,100	1,975	100	1,200		100		100	**24,050**
Vegetation	acre	5	43	2	3	7		1			**61**
Vegetated & Rock Swales	sq.yd.										**-**
Stormwater Harvesting Basins	acre										**-**
Road Right-of-way	l.ft.		1,200	1,420	4,215				1,200	6,800	**14,835**
Fencing	l.ft.	2,000	14,000	1,250	1,600	2,250		1,200			**22,300**
Handrails	l.ft.										**-**
Access Roads	l.ft.										**-**

DRAFT - 3/29/2017 - Ruthrauff BMP - Inspection Effort/Maintenance Summary Worksheet

	Units	Inspection Cost	Duration (min.)	Maintenance per unit
Retention Basin*	acre	$ 15.00	15	$ 2,591.17
Detention Basin*	acre	$ -	0	$ 2,591.17
Inlet & Outlet Structures	each	$ 20.00	20	$ 275.00
Trash Racks	each	$ 20.00	20	$ 62.50
Culverts - CMP	l.ft.	$ 2.00	2	$ 7.50
Culverts - CBC	l.ft.	$ 1.00	1	$ 10.00
Storm Drain Pipes	l.ft.	$ 5.00	5	$ 9.60
Lined Channels	sq.yd.	$ 1.00	1	$ 3.00
Unlined Channels	sq.yd.	$ 2.00	2	$ 0.25
Bank Protection	cu.yd.	$ 10.00	10	$ 4.75
Vegetation	acre	$ 15.00	15	$ 75.00
Vegetated & Rock Swales	sq.yd.	$ -		
Stormwater Harvesting Basins	acre	$ -		
Road Right-of-way	l.ft.	$ 2.00	2.00	$ 5.50
Fencing*	l.ft.	$ 0.50	0.50	$ 0.60
Handrails	l.ft.	$ 0.50	0.50	$ 3.75
Access Roads	l.ft.	$ -	0.00	

Costs per instance per unit

* Maintenance costs based on % of average of alternatives scoring construction costs per unit and include all possible areas of maintenance (i.e., sediment removal, garbage removal, structural repair, etc.).

Inspection cost/hr = $ 60.00

Fence

1,700	$12.00	$20,400.00	2
3,100	$12.00	$37,200.00	2
2,600	$12.00	$31,200.00	2
4,000	$12.00	$48,000.00	2
1,200	$12.00	$14,400.00	7
2,600	$12.00	$31,200.00	2
2,000	$12.00	$24,000.00	1
2,250	$12.00	$27,000.00	5
1,600	$12.00	$19,200.00	4
1,250	$12.00	$15,000.00	3

total fence	22,300
cost	$267,600
cost per foot	$12.00
5% of cost	$0.60

	tlc		jma	
Basins	**Cost/acre**		**Cost/acre**	
Area 3 - Alt 1	$	402,242	$	336,452
Area 4 - Alt 1	$	307,325	$	217,818
Area 5 - Alt 1	$	290,281	$	145,454
Area 1 - Alt 2	$	218,743	$	182,527
Area 2 - Alt 4	$	209,433	$	209,433
Area 7 - Alt 1	$	140,040	$	140,040
Area 2 - Alt 5	$	207,075	$	207,075
Area 2 - Alt 1	$	242,345	$	242,345
Area 2 - Alt 7	$	239,419	$	239,419
Area 2 - Alt 6	$	152,370	$	152,370
Weighted Ave. Cost of Const.	$	240,927	$	207,293
% of Weighted Ave. Cost	$	12,046.36	$	2,591.17
% of Cost. =		5.0%		1.3%

Inlet/Outlet		$5,500.00	ea
	5%	$275.00	
Trash Rack		$1,250.00	ea
	5%	$62.50	
Culverts			
Round - CMP		$150.00	l.ft.
	5%	$7.50	
Box - CBC		$500.00	l.ft.
	2%	$10.00	
Storm Drain - CMP		$192.00	l.ft.
	5%	$9.60	
Lined Channels - Conc/Shot		$60.00	sq.yd.
	5%	$3.00	
Unlined Channels		$5.00	sq.yd.
	5%	$0.25	
Bank Protection		$95.00	cu.yd.
	5%	$4.75	
Vegitation		$1,500.00	ac
	5%	$75.00	
misc		$0.00	
	5%	$0.00	
misc		$0.00	
	5%	$0.00	
Road Right-of-way		$110.00	l.ft.
	5%	$5.50	
Fencing		$12.00	l.ft.
	5%	$0.60	
Handrails		$75.00	l.ft.
	5%	$3.75	