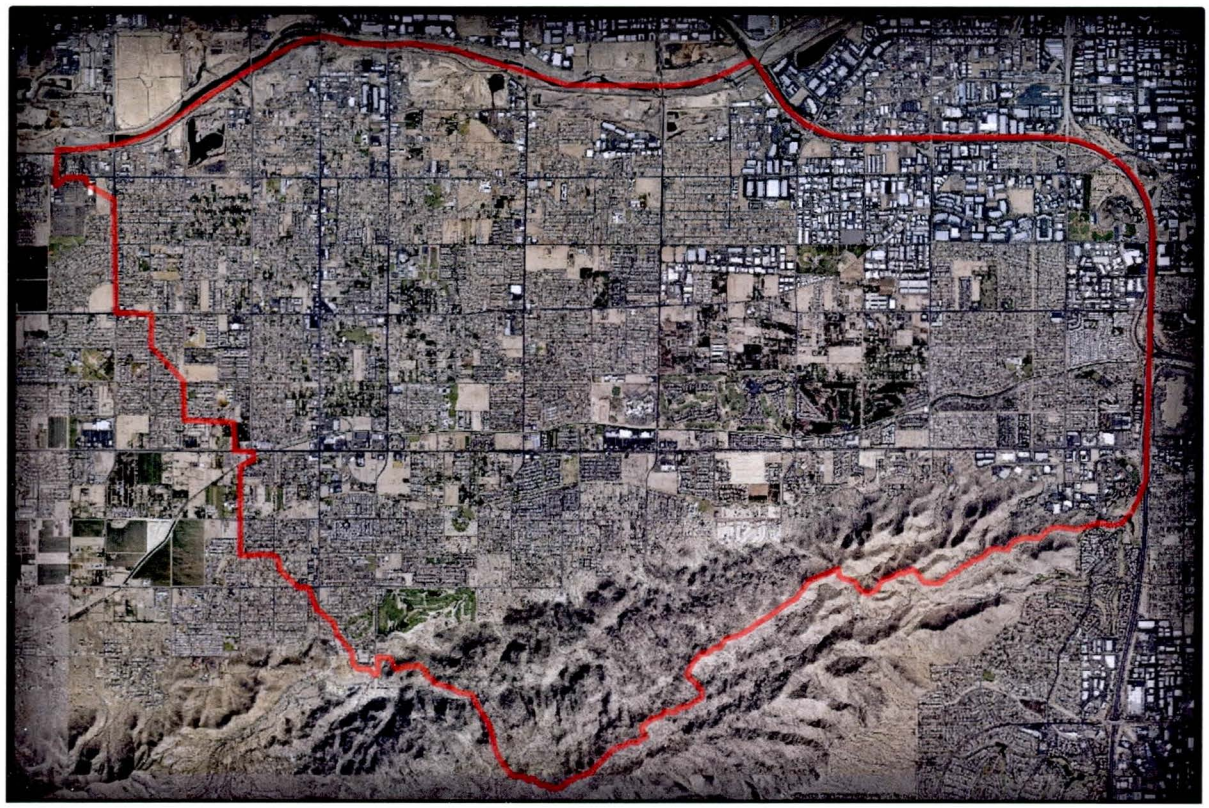
# Hohokam Area Drainage Master Plan (Phase II)
# Level 2 - Alternatives Analysis Report
## Contract FCD 2009C029

**November 2013**



**Prepared for:**

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ARIZONA, U.S.A.
EXPIRES 03/31/2015

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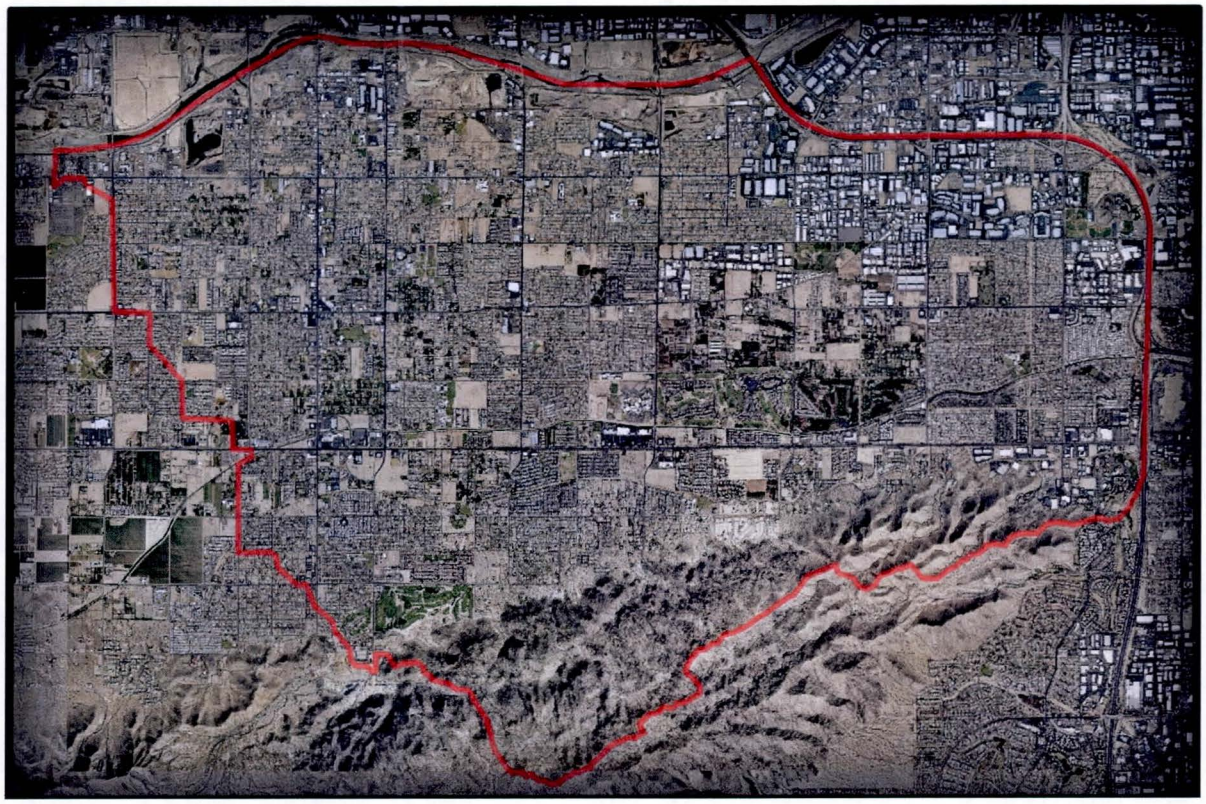

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# 1. INTRODUCTION

## 1.1 PROJECT DESCRIPTION, PURPOSE & GOALS

The Hohokam Area Drainage Master Study/Plan (ADMS/ADMP) is a two-phase regional flood control planning project to determine the nature and magnitude of existing flood hazards; develop and evaluate potential flood mitigation alternatives; provide preliminary design plans for recommended improvements; and ultimately provide a comprehensive plan to address flooding within the study area and guide future development and flood control improvements.

The Hohokam ADMS was a comprehensive data collection and investigative effort to identify and quantify existing and potential future flood hazards and document archeological, cultural, landscape, and recreational resources and opportunities that will serve as the basis to formulate and assess mitigation alternatives. The effort included development of hydrologic/hydraulic models to simulate flooding conditions; data collection and site investigations; and public outreach to gather essential information on existing flooding conditions and to incorporate the issues, concerns and values of the public into the decision making process. In addition, stakeholder involvement and participation was included to inform agency and area stakeholders, facilitate the data collection effort, and to identify potential opportunities for flood control improvements.

Phase II, the Hohokam Area Drainage Master Plan (ADMP), will utilize the results of the ADMS to formulate flood mitigation alternatives and through three levels of alternative development, analysis and evaluation, ultimately make recommendations for study area improvements. During the ADMP phase, the public outreach and involvement efforts will continue as concept plans are developed. Recommended improvements will be prioritized and a strategy for implementation prepared.

## 1.2 PROJECT AUTHORIZATION

The Flood Control District of Maricopa County (FCDMC) authorized the performance of the Hohokam ADMS/ADMP under contract FCD 2009C029 with an effective Notice-to-Proceed date of May 12, 2010.

## 1.3 PROJECT LOCATION

The Hohokam ADMS/ADMP study area is located within the corporate limits of the City of Phoenix and the City of Tempe. The area is approximately 28.1 sq. miles in size and bounded by the I-10 to the north and east, the Salt River to the north, South Mountain Park to the south and the Laveen ADMS to the west (see Figure 1-1).

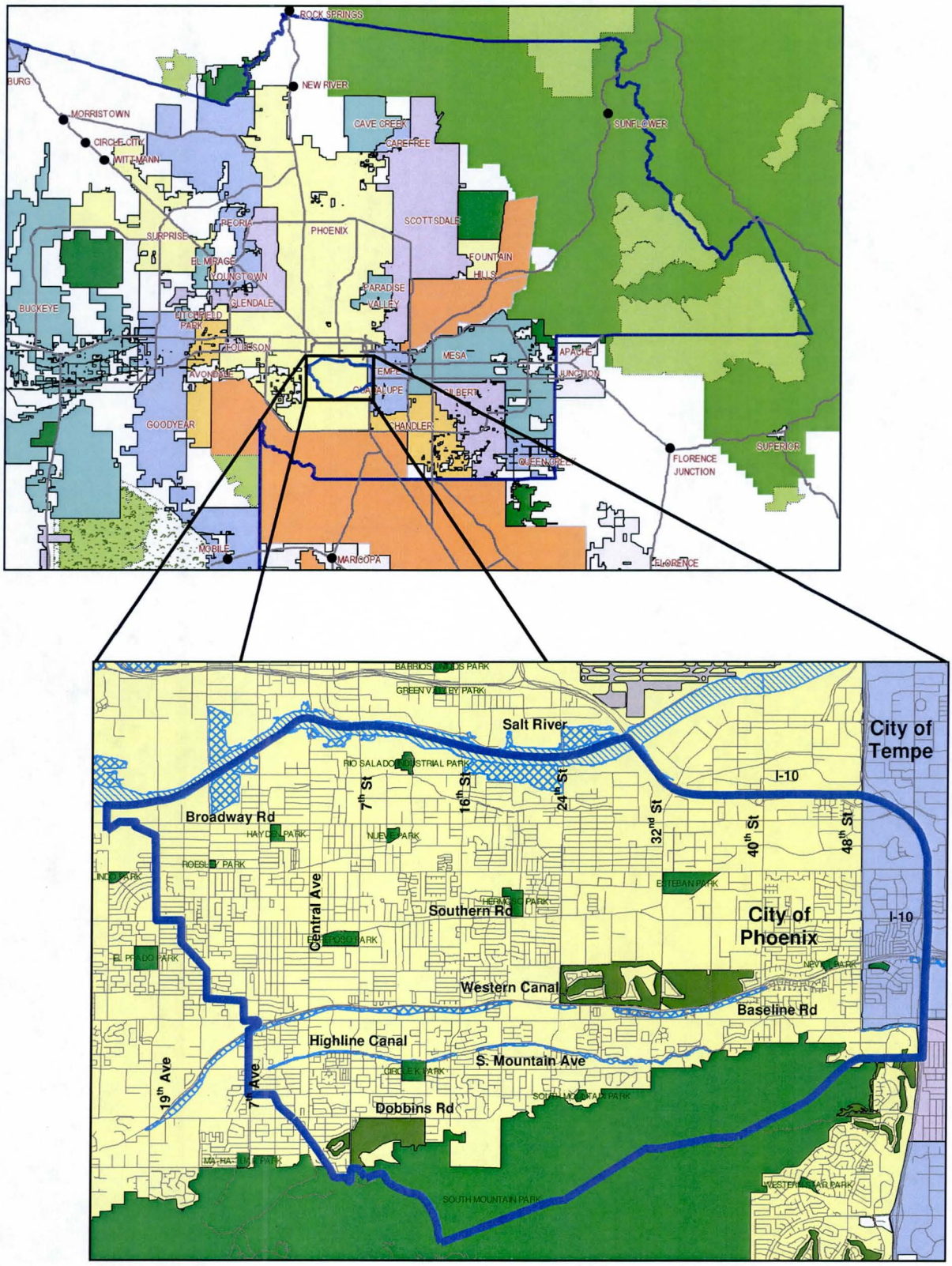



***Figure 1-1: Project Location and Vicinity Map***

## 1.4 PURPOSE OF REPORT

This report documents the process of alternative development and evaluation in Level 2 to identify recommended alternatives for development of concept plans in Level 3. In Level 2, Level 1 alternatives were further developed to determine the engineering feasibility, effectiveness and approximate costs. The alternatives were developed to the extent that potential utility impacts, Right-of-Way (ROW) requirements, potential multi-use opportunities, and environmental/cultural resource issues were identified. Based upon criteria such as public input and flood mitigation effectiveness, alternatives were evaluated and specific alternatives recommended for further development in Level 3.

## 1.5 PROJECT OVERVIEW AND HISTORY

The study area is located north of South Mountain in south Phoenix and western Tempe. Being located along the Salt River, the area has a long history of agricultural cultivation dating back to the Hohokam culture over 500 years ago. Possibly due the area's extended history of agriculture and its gradual urban conversion, no continuous natural washes remain to naturally drain the watershed to the Salt River, nor are there any continuous manmade conveyances except as provided by the City's storm drain system. Among the most significant features in the study area are the Salt River Project (SRP)'s Western and Highline Irrigation Canals. The canals are roughly parallel to each other, draining from east to west across the study area. Approximate flood hazards have been delineated along the canals due to the disruption of natural pattern of flow from South Mountain to the Salt River and the resultant ponding behind the canals.

During intense storm events, the lower portion of the study area (roughly north of the Western Canal) experiences more widespread shallow flooding in the streets and low laying areas. The steeper upper portion of the study area located along the foothills of South Mountain is directly impacted by mountain runoff and experiences more intense concentrated flooding along streets, remnant washes and historic flow paths. These flooding conditions are documented in historic complaints received by the City of Phoenix and evident from recent storm events in July 2008 and July 2010.

The lack of adequate drainage and flood control facilities was recognized in the Southeast Phoenix Storm Drainage Study conducted in 1972. This study provided conceptual design of large diameter storm drain trunk lines along north/south arterial streets and also recommended the construction of detention basins immediately upstream of the Highline Canal. While storm drain lines have been constructed along the major arterial streets from Baseline Road north to the Salt River, with the exception of a large basin located on Central Ave at the entrance to South Mountain Park, the recommended detention basins were never constructed. In 1997, the South Phoenix-Laveen Drainage Improvement Project was conducted that included the portion of the Hohokam study area west of Central Avenue. Similar recommendations were made, however, the focus of that study was primarily on drainage issues in the Laveen area and no specific recommendations were made for the Hohokam study area.

# 2. PREVIOUS STUDY REPORTS

## 2.1 HOHOKAM ADMS (PHASE I)

Several reports have previously been prepared as part of the Hohokam ADMS. These reports include:

### 2.1.1 Data Collection Report

This report documents and summarizes the data collection effort and presents pertinent data collected for the Hohokam ADMS. The report includes:

- Landscape Inventory Analysis
- Context Sensitive Flood Hazard Mitigation Planning and Approach
- Study Area General Plans and Specific Plans (summarized)
- Study Area Drainage Complaints and Site Investigations
- Study Area FIRMs
- Summary of Previous Drainage Reports for the Area
- Public Meeting Comments.

### 2.1.2 Class I Cultural Resources Inventory Survey

The Class I Cultural Resources Inventory Survey for the Hohokam Area Drainage Master Plan, Phoenix, Maricopa County Arizona documents the results of Logan Simpson Designs (LSD) literature search effort into the cultural resources within the study area and beyond its limits for 1 mile.

### 2.1.3 Pilot Study & Sensitivity Analysis Drainage Memorandum

This memorandum summarizes the results and conclusions of the FLO-2D pilot study. The pilot study consisted of hydrologic modeling of a smaller representative portion of the Hohokam ADMS study area for the purpose of determining the methodologies and approaches to be used for the development of the final study models for the entire study area. As part of the pilot study, sensitivity analyses were performed to assess the impact of various hydrologic parameters, model variables and hydraulic features. The recommendations of the pilot study were not necessarily adopted in the final study models due to further refinement of the modeling process and FLO-2D software.

### 2.1.4 Identification of Flood Hazards Report

This report documents the identified study area flood hazards and the brainstorming ideas developed as part of the Hohokam ADMS Phase I Brainstorming session. It also

provides a recommendation regarding the flood hazards that should be considered for the development of Phase II alternatives.

### 2.1.5 Hydrology & Hydraulics Report

This report documents the assumptions, approaches and results of the study area FLO-2D hydrologic models and hydraulic analyses. It includes a discussion of the model verification efforts, identification of potential problem areas, and provides an assessment of the study area storm drain system based upon the FLO-2D analyses and full-pipe capacity approach used for the study.

### 2.1.6 Hohokam ADMS Phase I Study Report

The Hohokam ADMS Phase I Study Report is a comprehensive report that consolidates and/or summarizes previous Phase I reports. It also includes the results of the Phase I Brainstorming Session that provided concept alternatives and seed ideas for consideration in Phase II.

## 2.2 HOHOKAM ADMP (PHASE II)

To date, two previous reports have been prepared as part of the development of the Hohokam ADMP (Phase II). These reports are:

### 2.2.1 Level 1: Potential Alternatives Report

This report documents the initial step of alternative formulation and evaluation for the development of the Hohokam ADMP. For Level 1, Phase I brainstorming and seed ideas were utilized to help develop potential flood mitigation alternatives for each problem area. These alternatives along with preliminary analysis information were presented to the project team and evaluated to identify the alternatives for more detailed analysis and development in Level 2.

### 2.2.2 Level 2: Technical Memorandum: Finish Floor Survey & Alternative Reduction

The *Level 2: Technical Memorandum - Finish Floor Survey and Alternative Reductions* provides the results of a survey of residential home finish floor elevations (FFE) in the study area; describes how the survey results could be used to estimate non-surveyed building structure FFEs and how FLO-2D results could be used to quantify the number of structures inundated during flooding events and to determine the beneficial impact of proposed alternatives. In addition, the memorandum discusses the rationale used for reducing the number of alternatives to be investigated in subsequent Level 2 efforts.

# 3. ADMP ALTERNATIVE DEVELOPMENT

## 3.1 OVERVIEW

The ADMP process includes three levels of alternative development:

- Level 1: Alternatives Formulations and Preliminary Analysis (also known as Potential Alternatives Analysis)
- Level 2: Alternatives Analysis
- Level 3: Recommended Alternatives Analysis

## 3.2 LEVEL 1: POTENTIAL ALTERNATIVES ANALYSIS

### 3.2.1 Description

For Level 1, Phase I brainstorming and seed ideas were utilized to help develop potential flood mitigation alternatives for each problem area. These alternatives along with potential cost estimates and right-of-way requirements were presented to the project team and evaluated based upon cost, efficiency, and effectiveness to identify the alternatives for more detailed analysis and development in Level 2. The Level 1: Potential Alternatives Report documents the initial alternative formulation and preliminary analysis and evaluation of project alternatives.

### 3.2.2 Conclusions

During Level 1, eight problem areas were identified in the study area (see Figure 3-1 ). Because factors contributing to flooding conditions in a specific problem area are not always constrained to a single source, problem area boundaries are soft and may overlap. Based upon the brainstorming and seed ideas, a total of 50 alternatives were presented to the project team for evaluation.

In the Level 1: Potential Alternative Meeting, the project team discussed the merits of each alternative. In some instances, the alternatives were combined or refined as part of the discussion. Then, as a group, the project team evaluated each alternative to come to a consensus on which alternatives should be further investigated in Level 2.

At the conclusion of the meeting, the project team identified 20 alternatives to be further investigated and studied in the Level 2. The 20 alternatives included a no action alternative for each problem area. No alternatives were chosen to be advanced to Level 2 for Problem Area 8 since most of the parcels are undeveloped and the drainage issues should be addressed upon future development of the properties.

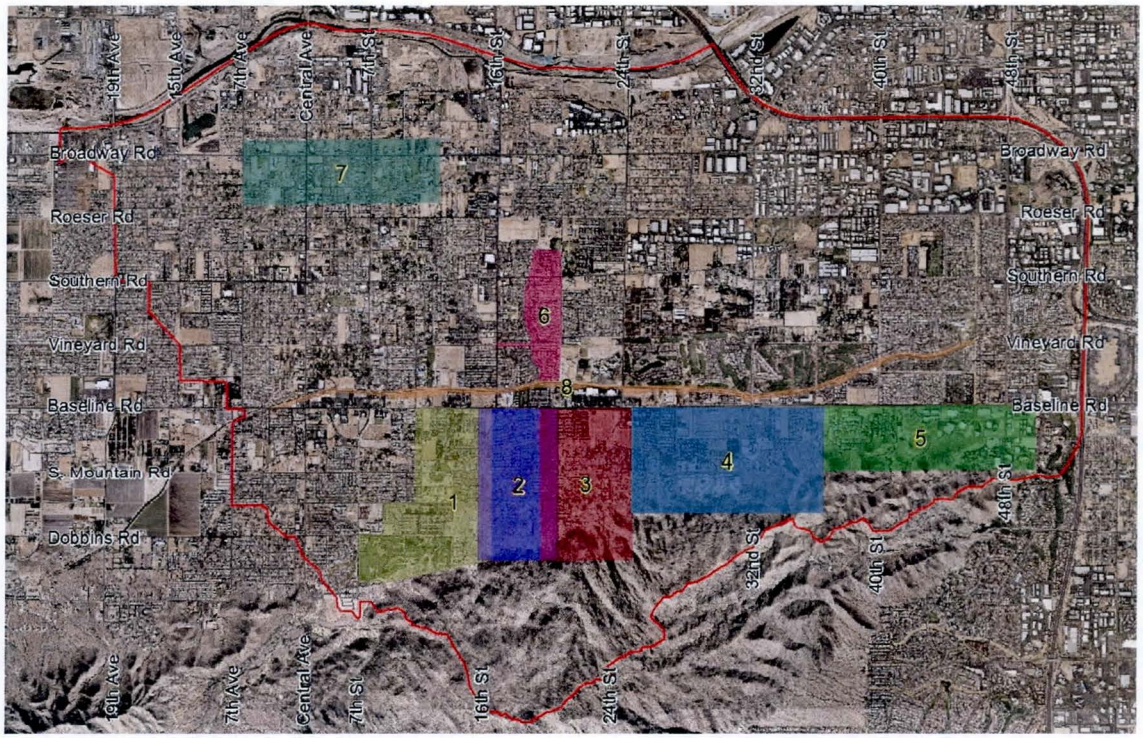



***Figure 3-1: Eight Problem Areas identified in Level 1***

## 3.3 LEVEL 2: ALTERNATIVE ANALYSIS

This report documents the Level 2: Alternatives Analysis. In Level 2, Level 2(A) alternatives were analyzed, evaluated and select alternatives (Level 2B alternatives) developed to determine the engineering feasibility, effectiveness and approximate costs. The Level 2B alternatives were developed to the extent that potential utility impacts, ROW/land acquisition requirements, potential multi-use opportunities, and environmental/cultural resource issues could be determined. To aid in the development and evaluation of alternatives, building inundation analyses were conducted to determine the potential number of structures that would benefit or be removed from the flooding hazards based upon estimated flooding depths. A discussion and the conclusions of the Level 2: Alternative Analysis is provided in Section 4.

## 3.4 LEVEL 3: RECOMMENDED ALTERNATIVES

Level 3 will develop recommended alternatives to a level at which 15% plans can be prepared. Calculations and models will be prepared to reflect the recommended alternatives. Landscape and multiple-use guidelines along with an implementation plan will be developed to guide future development and provide a strategy for implementation of the recommended plan improvements. Public meetings will be held to present the recommended alternatives.

# 4. LEVEL 2: ALTERNATIVES ANALYSIS

## 4.1 OVERVIEW

The Level 2: Alternative Analysis included multiple steps of alternative refinement, analysis and evaluation that eliminate both problem areas and alternatives prior to identification of the recommended alternatives for Level 3.

Based upon the *Phase II Level 1: Potential Alternatives Report,* 20 alternatives were selected for Level 2 analysis. The 20 alternatives included "No Action" alternatives for Problem Areas 1–7. Based upon initial building inundation assessments for multiple storm frequencies that estimated the number of buildings within each problem areas that potentially could be flooded, it was determined that problem areas 6 and 7 did not demonstrate the magnitude and extent of flooding hazard of other problem areas and, consequently, alternatives for those areas would not be included among the recommended alternatives. In addition, alternatives for Problem Area 5 were also dropped from further consideration because the impacted area was commercial or industrial and not residential. Problem Area 8 was previously eliminated at the conclusion of Level 1 as explained in sections above.

For Problem Areas 1-4, rough preliminary FLO-2D analyses were developed for the remaining alternatives. The analyses were run for multiple storm events and consisted of placing outflow nodes where improvements were proposed to remove all flow entering the outflow nodes from the model. By removing 100% of the flow, the results demonstrated the best outcome that the proposed alternatives could achieve. A building inundation analysis was also conducted to determine how effective the alternatives were in improving flooding conditions for residential structures (see Section 4.2). The building inundation results were presented to the project team along with cost estimates and right-of-way requirements to reevaluate alternatives. Alternatives recommended for further evaluation were called Level 2B alternatives.

The Level 2B alternatives were further developed to size the improvements; determine utility impacts and right-of-way requirements; and approximate construction and land acquisition costs. Detailed FLO-2D analyses were conducted to more accurately reflect proposed size and location of improvements by placing detention basins, channels, flood walls and storm drain systems within the models. As with previous Level 2A alternatives, a building inundation analysis was performed, the results presented to the project team along with land acquisition and construction costs, and the alternatives evaluated to recommend alternatives for Level 3.

# 4.2 LEVEL 2: TECHNICAL MEMORANDUM - FINISH FLOOR SURVEY & ALTERNATIVE REDUCTION

## 4.2.1 Purpose

As part of the process to better determine the extent and magnitude of actual structure flooding and possibly reduce the number of alternatives, an approach to approximate the building finish floor elevations (FFE) throughout the study area was developed. The *Level 2 Technical Memorandum: Finish Floor Survey & Alternative Reduction* report documents the survey of residential home FFE's in the study area; describes how the survey results would be used to estimate non-surveyed building structure FFEs and correspondingly how FLO-2D inundation results was used to quantify the magnitude of flood hazards, and; discussed the rationale for reducing the number of alternatives to be investigated in Level 2 efforts. A brief synopsis follows:

## 4.2.2 Process

FFEs were obtained from three sources: field survey, Grading & Drainage Plans (G&D), and the triangulated irregular network (TIN) derived from the 2-foot contour interval mapping used to construct the FLO-2D grid surface. A total of 149 structure FFEs were actually surveyed in the field.

The field survey results were compared to the G&D Plans and TIN data. Since a strong correlation could not be made between the field survey and the G&D Plans, the G&D data was not used. A better correlation was evident between the survey and TIN data. The survey data produced FFE's that were typically 0.50 feet higher than indicated by the TIN data. With this understanding, a building inundation analysis was done for all the residential buildings in the problem areas to determine how many homes would potentially be inundated (flooded). Table 4-1 summarizes the analysis results.

***Table 4-1: Summary of Building Inundation Depths by Problem Area***

| Inundation | Area 1 | | Area 2 | | Area 3 | | Area 4 | | Area 5 | | Area 6 | | Area 7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (ft) | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| D ≤ 0[1] | 566 | 59% | 467 | 52% | 227 | 38% | 388 | 52% | 66 | 31% | 564 | 74% | 975 | 69% |
| 0.0 < D[2] | 396 | 41% | 433 | 48% | 373 | 62% | 357 | 48% | 150 | 69% | 202 | 26% | 432 | 31% |
| **Total[3]** | **962** | **100%** | **900** | **100%** | **600** | **100%** | **745** | **100%** | **216** | **100%** | **766** | **100%** | **1407** | **100%** |
| 0 < D ≤ 0.5[4] | 265 | 67% | 237 | 55% | 245 | 66% | 225 | 63% | 52 | 35% | 175 | 87% | 354 | 82% |
| 0.5 < D[5] | 131 | 33% | 196 | 45% | 128 | 34% | 132 | 37% | 98 | 65% | 27 | 13% | 78 | 18% |
| **Total[2]** | **396** | **100%** | **433** | **100%** | **373** | **100%** | **357** | **100%** | **150** | **100%** | **202** | **100%** | **432** | **100%** |
| 1.0 < D[6] | 42 | 11% | 95 | 22% | 52 | 14% | 62 | 17% | 65 | 43% | 9 | 1% | 16 | 4% |

Notes:

1. Total number of buildings potentially not flooded.
2. Total number of buildings potentially flooded (to any degree).
3. Total number of buildings in area.
4. Number of buildings potentially flooded up to a depth of 0.5 ft.
5. Number of buildings potentially flooded to a depth greater than 0.5 ft.
6. Number of buildings potentially flooded to a depth greater than 1.0 ft

### 4.2.3 Reduction of Problem Areas and Elimination of Alternatives

Subsequent to the field survey and the building inundation analysis, the project team met to review alternatives recommended in Level 1 to determine if the number of alternatives could be reduced. Upon review, it was concluded that alternatives for Problem Areas 1 – 4 would be further developed in Level 2A. Alternatives for Problem Area 5 were not to be considered since the impacted area generally contained commercial or industrial building rather than residential homes. Problem Areas 6 and 7 were also not considered because of the nature, magnitude and extent of flooding did not merit a regional drainage solution. In addition, both areas had the potential to benefit from alternatives proposed for Problem Areas 1-4.

## 4.3 LEVEL 2A: ALTERNATIVES REDUCTION

### 4.3.1 Overview

Rough preliminary FLO-2D analyses were performed for the proposed alternatives by placing outlet nodes at proposed improvement locations to remove flow from the model. In order to determine the maximum level of effectiveness the proposed mitigations would have, the outlet nodes were modeled to remove all captured flow from the model. The results of the analyses were presented to the project team. Based upon the results, some alternatives were eliminated and some were revised or combined with other alternatives. Ultimately, five alternatives were then identified for more detailed analysis and investigation in Level 2B.

## 4.4 LEVEL 2B: ANALYSIS

### 4.4.1 Overview

After several rounds of alternative development, revision and evaluation, five alternatives remained in problem areas 1-4 for Level 2B analysis. These alternatives were modeled in FLO-2D with sufficient detail to estimate the size, location and capacity of alternative components. For each alternative, construction costs, right-of-way requirements and utilities impacts were also determined. In addition, a building inundation assessment was performed to evaluate the flood mitigation effectiveness of each alternative.

Detailed exhibits showing alternative improvements, utilities and right-of-way and used for the construction cost and land acquisition estimates are provided in Appendix B.

### 4.4.2 Design Event

During the Level 2 alternative development process, the project team concluded that providing flood mitigation measures for the 100-yr, 6-hr event would not be economically practical and the 10-yr, 6-hr event was subsequently selected as the design condition.

### 4.4.3 Hydrologic Modeling

The five Level 2B alternatives each one addressed specific flooding sources originating in South Mountain Park and each generally had separate flooding corridors or areas of impact. Consequently, a single FLO-2D model (run for multiple events) that incorporated all the alternatives was considered adequate to evaluate the flood mitigation effectiveness of each alternative. As opposed to the preliminary rough FLO-2D model in Level 2A, the Level 2B FLO-2D model incorporated individual alternative components (channels, basins, storm drain and floodwalls). Detention basins were modeled by lowering grid elevations for the basin footprint to provide sufficient volume to assure the 10-year events were completely retained. Similarly, channels were modeled by lowering grid elevations to simulate the incised channels. Storm drains, culverts and basin outlets were modeled in the HYSTRUC.DAT file.

Results of the FLO-2D analyses for the base condition (condition with no alternatives) and the alternatives condition are provided in Appendix A.

### 4.4.4 Hydraulic Analysis

Peak discharges derived from FLO-2D cross sections were used to estimate the required capacities and to size storm drains, culverts, and channels. Storm drain lines were sized based upon pipe full capacities and assuming pipe slopes would be equivalent to the ground slope and maximum allowable pipe velocities of 15 ft/s. Channels were sized using Manning's equation and assuming 6:1 side-slopes and maximum channel velocities of approximately 6 ft/s in flatter locations and 10 ft/s in steeper areas (assuming erosion protection would be provided). Culverts were sized using CulvertMaster.

Because the design event had not yet been decided, basins were sized to maximize the storage volume on each parcel assuming a maximum water storage depth of 6 feet, a 30-foot perimeter around each basin was not graded (to account for offsets and maintenance access roads), and the basin side-slopes were 6:1 (H:V) Upon selection of the 10-yr storm event criteria, the basin volumes were not reduced, however, basin volumes are to be refined in the Level 3 analyses for the recommended alternatives. Documentation of supporting calculations for alternatives is provided in Appendix B.

## 4.4.5 Cost Estimates

### *4.4.5.1 Cost Estimate Summary*

The evaluation of the Level 2B alternatives included the development of cost estimates. The cost estimates focused on major components of the alternatives including detention basins, storm drains, culverts, channels, right-of-way acquisition, potential utility conflicts, and landscaping. In order to develop comprehensive costs for these major components, a typical cost per unit of measurement was developed for the major element types.

The costs per unit of measurements were derived from previous District design projects, typical design project elements, and recent unit costs. A description of how each component cost was developed is provided in the following sections. Detailed cost estimates are provided in Appendix C.

### *4.4.5.2 Storm Drain Component*

Storm drain unit costs are in linear feet. A cost per foot of storm drain was used as the base price. The base price consists of the complete cost for the materials and installation of the storm drain. The cost for additional improvements such as manholes, catch basins, catch basin laterals, headwalls, and pavement replacement were then estimated for a 1000-foot section of the storm drain. A cost per linear foot was then calculated for each storm drain size.

### *4.4.5.3 Detention Basin Component*

Detention basin unit costs are based on a cubic yard measurement. The base price is an excavation cost based on recent District design projects. The total excavation quantities were increased by a factor of 1.2 to account for side slopes and variations in existing ground across the basin sites. The cost for additional improvements such as inlet structures, low flow channels, ground cover, landscaping, erosion control measures, fencing, and other items typically present in regional detention basins were estimated based on recent District regional basin projects. These costs were converted to a cost per cubic yard basis based on the sample basin size and then added to the base unit cost.

### *4.4.5.4 Channel Component*

Channel unit costs are based on a cubic yard excavation measurement. The base price is an excavation cost based on recent District design projects. The total excavation quantities were increased by 50% to account for side slopes and variations in existing ground along the channel alignments. The cost for additional improvements such as inlet structures, channel bank lining, landscaping, erosion control measures, fencing, and other items typically present in engineered channels were estimated based on

recent District channelization projects. These costs were converted to a cost per cubic yard basis based on the sample channel and then added to the base unit cost.

*4.4.5.5 Culvert Component*

Culverts identified as components in the alternatives were concrete box culverts. Therefore, the culvert unit costs were based on a cubic yards of material measurement for box culverts. Based upon FLO-2D peak discharges, a rough size and length was estimated for each box culvert and then the cubic yards of concrete required for the box culvert was calculated based on ADOT standards. This base cost was then increased to cover other items including headwalls, pavement replacement, scour protection, etc.

*4.4.5.6 Utility Relocations*

Utility relocation costs were based on proposed improvement crossings of existing sanitary sewer and potable water lines. The number of crossings was counted for each alternative and then a unit price for each crossing was applied.

*4.4.5.7 Right-Of-Way Acquisition*

Right-of-way acquisition costs were estimated for required land takes on a unit cost per square foot basis. The existing zoning of each parcel needed was determined and then a unit cost was provided by the District and applied to each zoning type.

*4.4.5.8 Landscaping*

Landscaping costs were based on a per acre basis for detention basins and per mile basis for channels. Additional costs were added to the alternatives that include improvements in Circle K Park and Francisco Highland Park to account for existing improvements at these locations that would need to be restored.

### 4.4.6 Building Inundation Analyses

To evaluate the flood mitigation effectiveness of project alternatives, it was necessary to find means to estimate the number and magnitude of potential flooding of buildings and structures in the study area. Several methods were applied and considered prior to the selection and implementation of the final method. (For a summary of other approaches considered, see Appendix E). The building inundation analysis was then performed for multiple storm events (2-yr, 10-yr and 100-yr) to help determine the magnitude and extent of flooding issues and the appropriate design frequency for future improvements.

***Table 4-2: Level 2B Building Inundation Analysis Results***

| Alt | Total Number of Buildings[1] | 2-Yr Frequency | | | 10-Yr Frequency | | | 100-Yr Frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Potentially Inundated Buildings | | Buildings Remove[4] | Potentially Inundated Buildings | | Buildings Remove[4] | Potentially Inundated Buildings | | Buildings Remove[4] |
| | | Base[2] | Alt[3] | | Base[2] | Alt[3] | | Base[2] | Alt[3] | |
| Alt 1.1 | 801 | 6 | 1 | **5** | 39 | 2 | 37 | 110 | 31 | **79** |
| Alt 2.1 | 770 | 15 | 3 | **12** | 47 | 13 | 34 | 133 | 56 | **77** |
| Alt 3.5 | 104 | 0 | 0 | **0** | 5 | 0 | 5 | 14 | 0 | **14** |
| Alt 4.1 | 217 | 8 | 2 | **6** | 14 | 10 | 4 | 29 | 17 | **12** |
| Alt 4.3 | 97 | 14 | 1 | **13** | 26 | 2 | 24 | 38 | 7 | **31** |
| **Total** | **1989** | **43** | **7** | **36** | **131** | **27** | **104** | **324** | **111** | **213** |

1. *Total number of buildings in the area that could potentially be impacted by the proposed alternative.*
2. *Buildings potentially flooded under the Future land-use conditions (adopted as the "Base" condition for analysis)*
3. *Buildings potentially flooded with implementation of all proposed alternatives*
4. *Buildings potentially removed from flooding with the implementation of all proposed alternatives.*

The building inundation analysis is based upon a comparison of the estimated building Finish Floor Elevation (FFE), to the Water Surface Elevations (WSEL) and floodplain depths adjacent to the building's footprint. The analysis used GIS applications to identify building footprints with adjacent flooding depths ($D_{max}$) greater than or equal to 0.5 ft. The buildings were then manually inspected to review the FFEs, flow depths and WSELs adjacent to the buildings. The proximity of block walls, channels, and hydraulic structures modeled within FLO-2D were also taken into consideration. Because the review was manual and required individual inspection of hundreds of structures, buildings were simply identified as potentially being flooded or not. No attempt was made to estimate the building flooding depths as was done in the previous automated process (see Section 4.2.2). To determine the effectiveness of proposed alternatives, the results of the "Base" condition (the future land-use conditions prior to any flood mitigation measures) were compared to the "Alternative" condition (condition after the implementation of all proposed alternatives for the 10-year design condition) to determine approximately the number of structures that may potentially be removed from flooding hazard. The results of the inundation analysis for the Level 2B alternatives are provided in Table 4-2.

## 4.5 LEVEL 2B: ALTERNATIVES

This section summarizes information for the Level 2B alternatives. For more detailed information on supporting calculations, construction and ROW costs, please see the appendices.

### 4.5.1 Alternative 1.1

**Flooding Issues:** Flooding conditions are mainly the result of runoff from the South Mountain Park, local street drainage and the lack of stormwater facilities. Street flooding along 16th St. results in flooding of adjacent residential properties. In addition, overtopping of the Highline Canal has caused downstream flooding of properties.

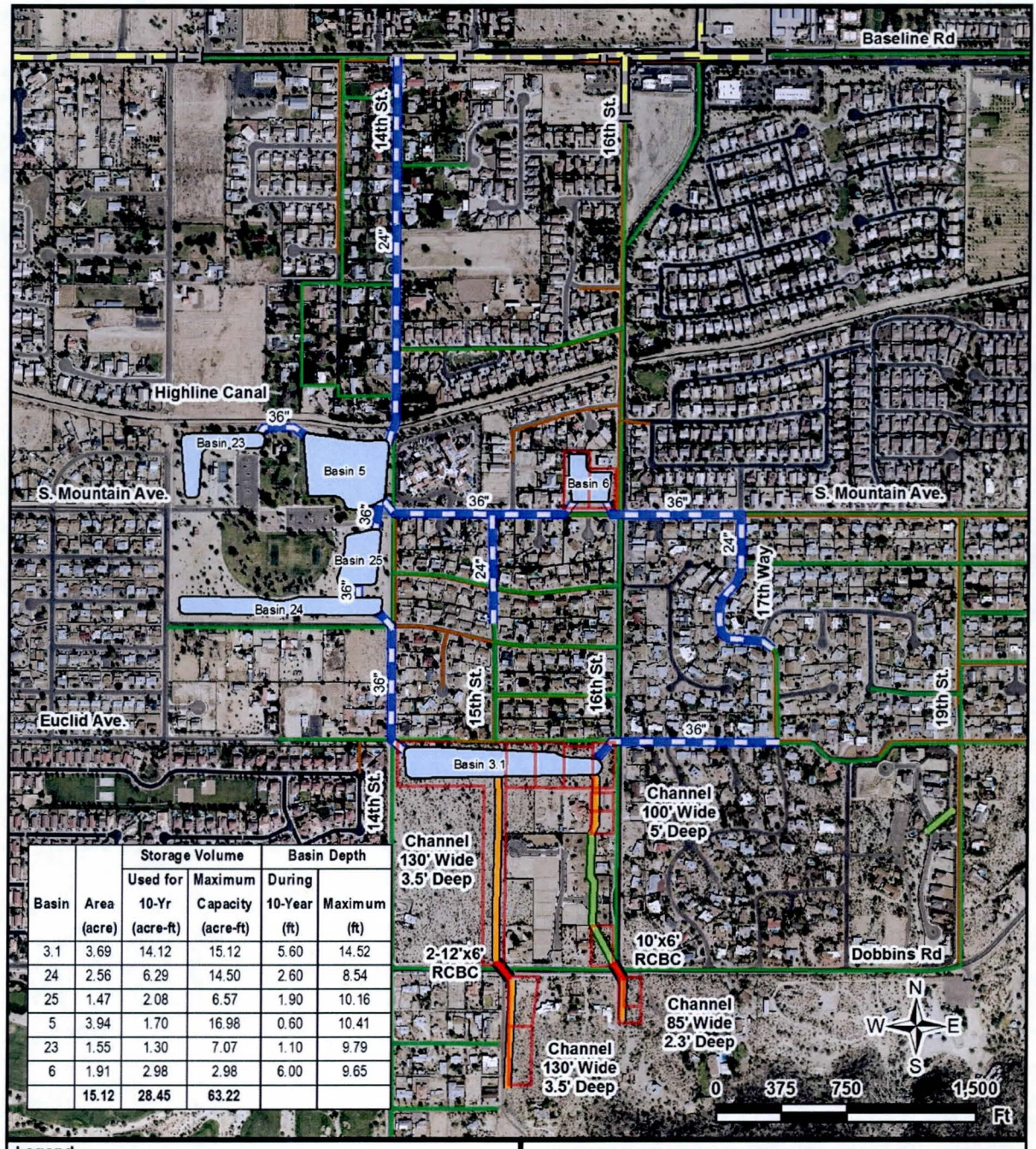
**Description:** This alternative consists of a storm drain collection system that captures runoff from the mountains and drainage runoff from the streets and conveys it to multiple proposed detention basins. The basins detain water and discharge to downstream detention basins or to an existing storm drain on Baseline Road. The alternative includes:

- 36" storm drain on S. Mountain Road and Euclid Ave
- 36" storm drain/basin outlet on 14th St from Basin 3.1 to Basin 24 and 36" culvert connections between basins in Circle K Park
- 24" storm drain on 15th St and 17th Way
- 24" basin outlet from Basin 5 to existing storm drain on Baseline Rd (this outlet has been constructed by the City)
- Channel on 15th St south of Dobbins Rd (130' wide/3.5 ft deep)
- Channel along the 15th St alignment between Dobbins Rd. and Basin 3.1(130' wide/3.5 ft deep)
- Channel from an existing channel west of 16th St that outfalls to Basin 3.1(100' wide/5 ft deep)
- Channel along 16th St south of Dobbins Rd (85' wide/2.3 ft deep)
- 2-12'x6' Reinforced concrete box culvert (RCBC) crossing Dobbins Rd at 15th St
- 1-10'x6' RCBC crossing Dobbins at 16th St
- Multiple detention basins (see Figure 4-1 and Table 4-3)
- Acquiring 16.5 acres of land from 14 parcels (not including Circle K Park)

***Table 4-3: Alternative 1.1 Basin Summary***

| Basin | Area (acres) | Storage Volume | | Basin Depth | |
|---|---|---|---|---|---|
| | | Used for 10-Year (acre-ft) | Maximum Capacity[1] (acre-ft | 10-yr WSEL (ft) | Maximum[2] (ft) |
| 3.1 | 3.69 | 14.12 | 15.12 | 5.60 | 14.52 |
| 5 | 3.94 | 1.70 | 16.98 | 0.60 | 10.41 |
| 6 | 1.91 | 2.98 | 2.98 | 6.00 | 9.65 |
| 23 | 1.55 | 13.0 | 7.07 | 1.10 | 9.79 |
| 24 | 2.56 | 6.29 | 14.50 | 2.60 | 8.54 |
| 25 | 1.47 | 2.08 | 6.57 | 1.90 | 10.16 |

*1. Basins were sized to maximize the storage volume on each parcel. (see Section 4.4.4)*
*2. Depth from the bottom of the basin to the highest basin perimeter elevation.*




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 3.1 | 3.69 | 14.12 | 15.12 | 5.60 | 14.52 |
| 24 | 2.56 | 6.29 | 14.50 | 2.60 | 8.54 |
| 25 | 1.47 | 2.08 | 6.57 | 1.90 | 10.16 |
| 5 | 3.94 | 1.70 | 16.98 | 0.60 | 10.41 |
| 23 | 1.55 | 1.30 | 7.07 | 1.10 | 9.79 |
| 6 | 1.91 | 2.98 | 2.98 | 6.00 | 9.65 |
| | **15.12** | **28.45** | **63.22** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Culvert
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Channel
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**16th St Corridor**
**Alternative 1.1**

11/4/2013

***Figure 4-1: Alternative 1.1 Proposed Improvements***

### *Landscape Aesthetics and Multi-use Considerations*

***Circle K Park - Basin 5:*** Circle K Park is a City of Phoenix community park that includes an historic administration building, shaded picnic areas, a soccer field, baseball field, children's playground, handball courts, restrooms and associated parking and trails. The City of Phoenix's Parks, Recreation, and Library staff agreed that the park is in need of updating and redesign and would be a suitable location to incorporate flood control facilities, provided that existing and future programming elements for the park are included. City staff emphasized that this should be planned as a park with drainage facilities in it. As a multiple use facility the flood control improvements within the park would provide enhanced aesthetic value and recreation opportunities as well as being consistent with local community character. The historic building and many of the mature trees would be protected in place and connections from the park to the Highline Canal trail would be enhanced.

***Structure Types and Structural Methods:*** Context sensitive soft and semi-soft structural methods, utilizing underground pipes, conveyance channels and storage basins are proposed within the park, adhering to the side slope, storage depth, and access criteria per the District's guidelines. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation. Turf athletic fields are included in the basin bottoms to provide erosion control and meet park programming needs in an integrated design solution.

***Landscape Design Themes:*** Context sensitive landscape design themes including Semi-Natural Desert, Enhanced Desert, Desert Park and Desert Oasis are proposed to achieve neighborhood compatibility and meet the City's park design requirements.

***Basins 3.1 and 6:*** These basins would be located on land acquired for the purposes of stormwater detention. Side slope requirements and inadequate volume would eliminate Basin 6 from further consideration based on flood control functional considerations. Basin 3.1 would be the deepest of the basins in this alternative, and the long narrow configuration would be problematic in implementing the District's aesthetic treatment guidelines for basins. Neither of these basins would provide multiple use opportunities. Fencing requirements around the basins would not complement or enhance the neighborhood character. Additional private property would be required to adequately incorporate necessary aesthetic treatments to mitigate the negative impacts to the neighborhood. It is strongly recommended that Basin 3.1 should be reduced in size and depth or eliminated entirely, if adequate storage capacity becomes available in the Basin 5 (Circle K Park).

**Channels:** Open channels are proposed through private properties. Due to their proximity to the 'bajada' landform near South Mountain, the design of these

channels would lend itself to a soft or semi-soft structural design approach, with some hard elements required for inlet/outlet protection and erosion and grade control. Ideally, the conveyance channels would provide enough area to maintain gentle, undulating side slopes (4:1 max.) and allow for adequate meander in the low-flow channel. Additional right-of-way would be necessary to meander the channel itself as well as to provide for the gentler side slopes. Rapid drops in elevation would be addressed using drop structures and energy dissipaters, which should be designed to mimic natural features associated with the existing landforms and native vegetation of South Mountain. These open channels are primarily located within private single-family residential areas, with limited visibility from the public rights-of-way. For this reason there may be a lower priority for vigorous application of aesthetic enhancements.

***Structure Types and Structural Methods***: Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes:*** Context sensitive themes for these two basins as well as the open channels include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

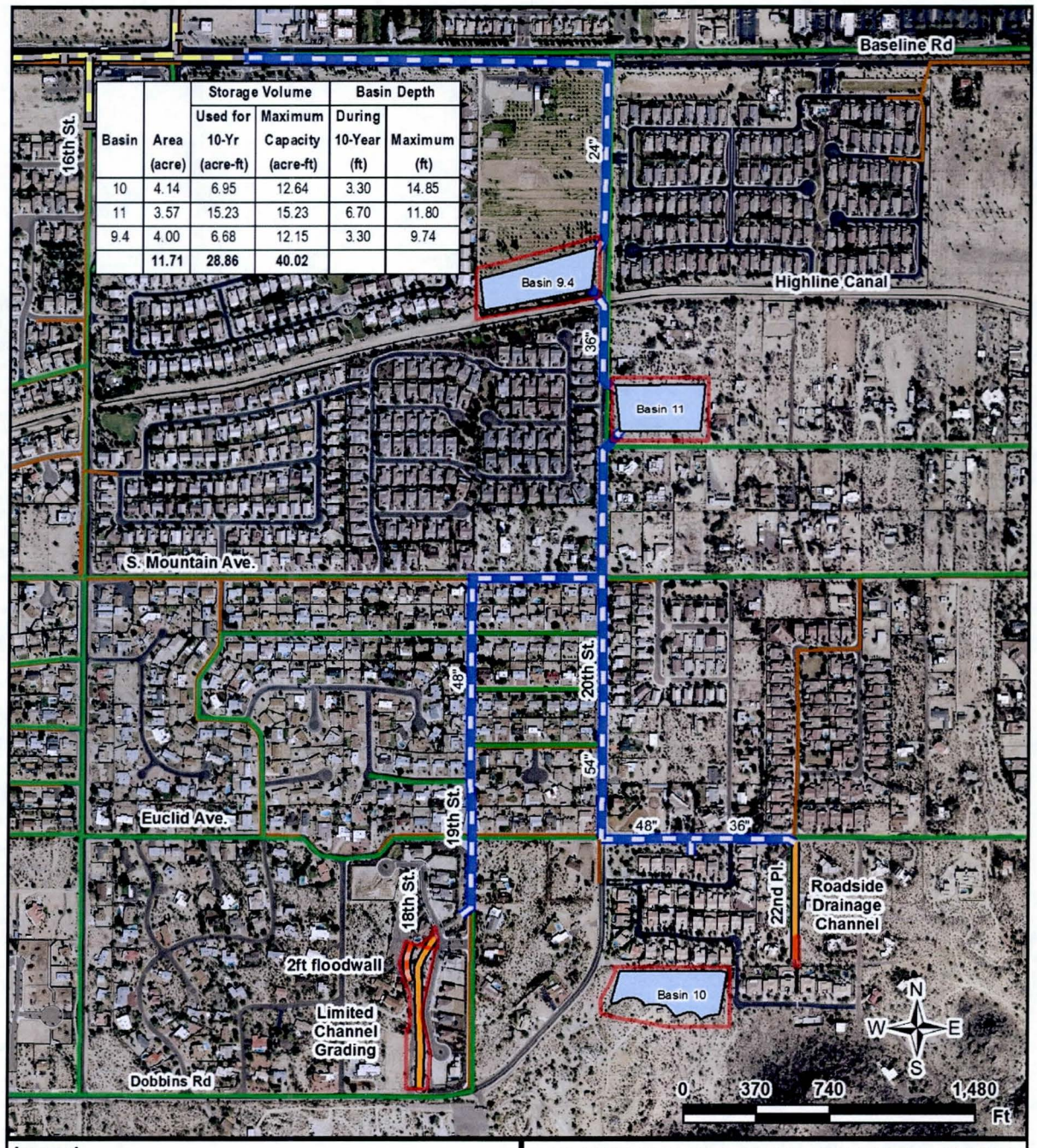
**Alternative Cost:** A summary of estimated construction and land acquisition costs are summarized in Table 4-4. Detailed information is provided in Appendix C.

***Table 4-4: Alternative 1.1 Cost Estimate***

| Description | Cost |
|---|---|
| Estimated Construction & Design Costs | $8,572,000 |
| Estimated Land, Easements & Right-of Way Acquisition Cost | $1,773,000 |
| **Total** | **$10,345,000** |

## 4.5.2 Alternative 2.1

**Flooding Issues:** West of 20th St, an existing wash from South Mountain Park is conveyed across Dobbins Rd and 18th through large culverts and ultimately discharge runoff to 19th St contributing to flooding along 19th St, Euclid Ave, and 20th St. East of 20th St., the Siesta Foothills development captures mountain runoff and discharges flow downstream of the development along historic flow paths. This flow is discharged from culverts and storm drain outlets along Euclid Ave. and west of 21st Pl. contributes to downstream flooding. Overtopping of the Highline Canal and flooding of the properties to the north are also predicted based on results of technical analysis.




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 10 | 4.14 | 6.95 | 12.64 | 3.30 | 14.85 |
| 11 | 3.57 | 15.23 | 15.23 | 6.70 | 11.80 |
| 9.4 | 4.00 | 6.68 | 12.15 | 3.30 | 9.74 |
| | **11.71** | **28.86** | **40.02** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**20th St Corridor**
**Alternative 2.1**

11/4/2013

***Figure 4-2: Alternative 2.1 Proposed Improvements***

**Description:** This alternative consists of storm drain that captures mountain and street drainage and conveys it to proposed detention basins along 20th St. adjacent to the Highline Canal (see Figure 4-2). Basin 10 is proposed to capture runoff and attenuate flows before discharging to the existing storm drain inlets in the Siesta Foothills development. The basin south of Highline Canal (Basin 11) discharges to Basin 9.4 located north of the canal. Basin 9.4 then discharges to an outlet connected to the existing storm drain on Baseline Road. The alternative includes:

- 54" storm drain on 20th St from Euclid Ave to Basin 11
- 48" storm drain on 19th Ave and S. Mountain Ave
- 36" and 48" storm drain on Euclid Ave.
- 48" and 18" connections from the proposed Euclid Ave storm drain to existing storm drain outlets located west of 20th St.
- 36" storm drain/basin outlet connection from Basin 11 to Basin 9.4
- Roadside drainage ditch along 21st Pl to help capture mountain runoff
- A wall (approx. 2 ft high) and grading improvements to the existing wash between 19th St and Dobbins Rd to contain flow within the wash channel
- Detention basins 10, 11, and 9.4 (see Figure 4-2 and Table 4-5 )
- Acquiring 13.75 acres of land from 6 parcels

***Table 4-5: Alternative 2.1 Basin Summary***

| Basin | Area (acres) | Storage Volume: Used for 10-Year (acre-ft) | Storage Volume: Maximum Capacity[1] (acre-ft | Basin Depth: 10-yr WSEL (ft) | Basin Depth: Maximum[2] (ft) |
|---|---|---|---|---|---|
| 9.4 | 4.00 | 6.68 | 12.15 | 3.31 | 9.74 |
| 10 | 4.14 | 6.95 | 12.64 | 3.30 | 14.85 |
| 11 | 3.57 | 15.23 | 15.23 | 6.70 | 11.80 |

*1. Basins were sized to maximize the storage volume on each parcel. (see Section 4.4.4)*
*2. Depth from the bottom of the basin to the highest basin perimeter elevation.*

### *Landscape Aesthetics and Multi-use Considerations*

***Basin 10 - Heard Scout Camp:*** This basin is located on a relatively steep site at the outfall of several small washes exiting South Mountain Park/Preserve. The Geronimo Trail access is located in the general vicinity of 20th Street and Dobbins Road and would need to be maintained or potentially enhanced as part of flood hazard mitigation activities in this sub-area. It is likely that the proposed basin would require the relocation of several camp structures.

***Basins 9.4 and 11:*** These basins would be located on land acquired for the purposes of stormwater detention. Context sensitive natural, soft and semi-soft structural approaches would minimize or negate the need for fencing and safety rails, keeping side slopes, storage depths, structure scale as well as public and maintenance access consistent with the criteria outlined above and in District

guidelines. Flood hazard mitigation requirements suggest that both basins may not be required. Due to its location adjacent to the Highline Canal, Basin 9.4 would be suited to support multiple uses. A multi-use pathway at the basin perimeter could connect to the existing canal-side trail with potential overlook seating areas to provide visual access and respite into the basin.

***Channels:*** Open channels are proposed along public streets and through private properties. Due to their proximity to South Mountain and its associated bajada topography, these channels would be better suited for utilization of existing natural channels or the implementation of soft or semi-soft structural methods with some hard elements required for inlet/outlet protection, and erosion and grade control. They would also require enough right-of-way to provide for gentle (4:1 max) side slopes and to allow for some meander in the low flow channel. Rapid drops in elevation would be taken up by drop structures and energy dissipation structures designed to mimic natural features in the natural desert landscape. Additional right-of-way would be required to incorporate these types of treatments.

***Structure Types and Structural Methods:*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes:*** Context sensitive landscape themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park. A recommended design approach includes: meandering channel alignment and low flow, undulating channel side slopes, adequate landscape buffer in overbank areas and landform mounding to create interest.

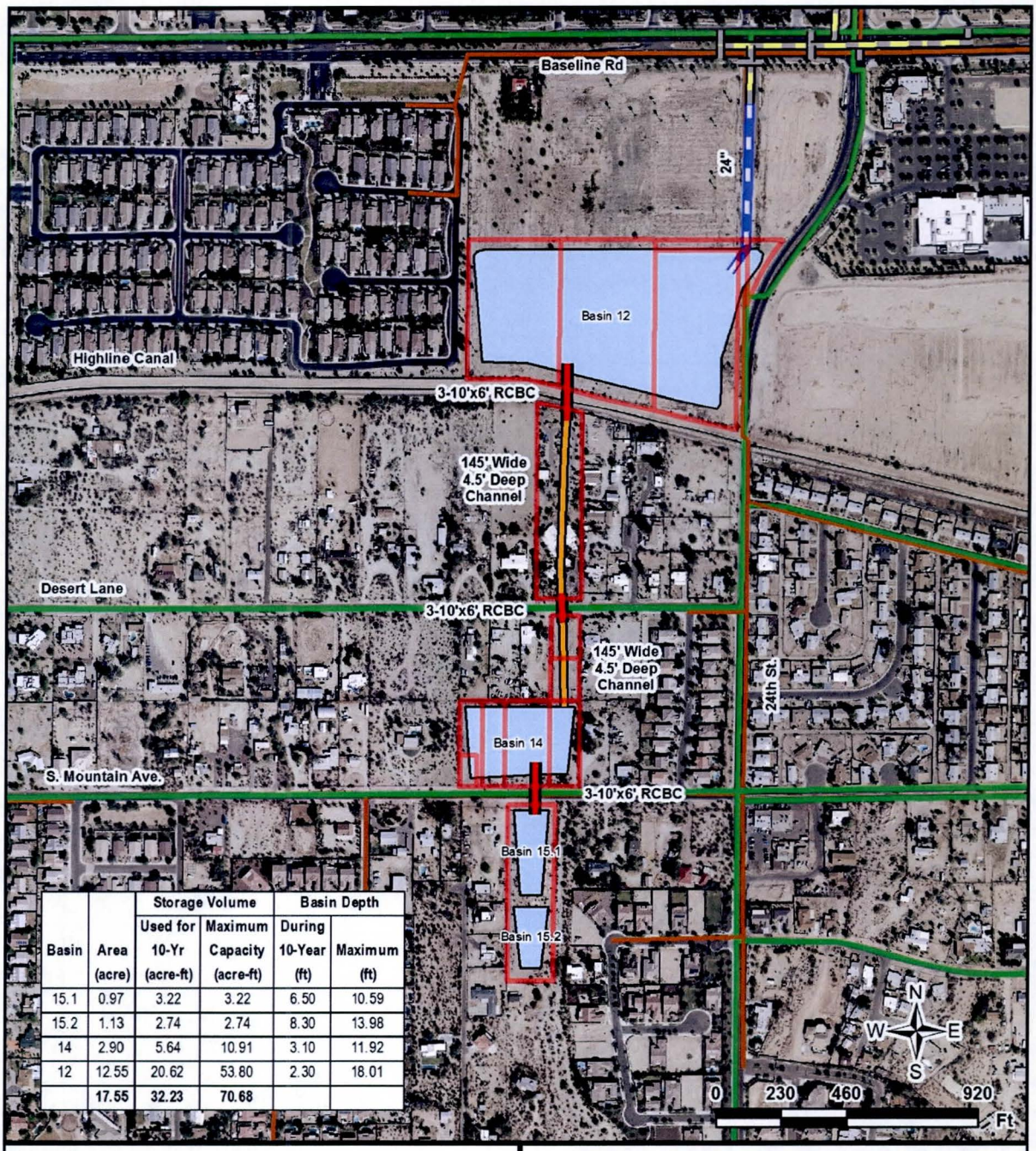
**Alternative Cost:** A summary of estimated construction and land acquisition costs are summarized in Table 4-6. Detailed information is provided in Appendix C.

***Table 4-6: Alternative 2.1 Cost Estimate***

| Description | Cost |
|---|---|
| Estimated Construction & Design Costs | $5,520,000 |
| Estimated Land, Easements & Right-of Way Acquisition Cost | $1,198,000 |
| **Total** | **$6,718,000** |

## 4.5.3 Alternative 3.5

**Flooding Issues:** A well-defined natural wash conveys mountain runoff to S. Mountain Ave. at which point the wash dissipates resulting in a wide area of shallow flooding from S. Mountain Avenue to the Highline Canal. Floodwater overtops the canal and contributes to further flooding north of the Highline Canal.




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 15.1 | 0.97 | 3.22 | 3.22 | 6.50 | 10.59 |
| 15.2 | 1.13 | 2.74 | 2.74 | 8.30 | 13.98 |
| 14 | 2.90 | 5.64 | 10.91 | 3.10 | 11.92 |
| 12 | 12.55 | 20.62 | 53.80 | 2.30 | 18.01 |
| | **17.55** | **32.23** | **70.68** | | |

**Legend**
- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Culvert
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**24th St Corridor**
**Alternative 3.5**

11/4/2013

***Figure 4-3: Alternative 3.5 Proposed Improvements***

**Description:** This alternative consists of a series of inline detention basins to attenuate and contain runoff. Two basins are located south of S. Mountain Ave, one located north of S. Mountain Ave and another basin located north of the Highline Canal. A Reinforced Concrete Box Culvert (RCBC) conveys flow across the roads and a channel is proposed to connect basins south of the Highline Canal to the basin north of the canal (see Figure 4-3). The basin north of the canal (Basin 12) is connected to an existing storm drain line on Baseline Rd. This alternative includes:

- 24" basin outlet from Basin 12 to existing storm drain on Baseline Rd
- Channel connecting Basin 14 to Basin 12 (145' wide/4.5 ft deep)
- 3-10'x6' RCBC crossing at S. Mountain Ave connecting Basin 15.1 to Basin 14
- 3-10'x6' RCBC crossing at Desert Lane
- 3-10'x6' RCBC crossing underneath the Highline Canal
- Detention Basins 12, 14, 15.1, and 15.2 (see Figure 4-3 and Table 4-7)
- Acquiring 20.9 acres of land from 13 undeveloped parcels and one developed parcel with an existing residential structure

***Table 4-7: Alternative 3.5 Basin Summary***

| Basin | Area (acres) | Storage Volume | | Basin Depth | |
|---|---|---|---|---|---|
| | | Used for 10-Year (acre-ft) | Maximum Capacity[1] (acre-ft | 10-yr WSEL (ft) | Maximum[2] (ft) |
| 12 | 12.55 | 20.62 | 53.80 | 2.30 | 18.01 |
| 14 | 2.90 | 5.64 | 10.91 | 3.10 | 11.92 |
| 15.1 | 0.97 | 3.22 | 3.22 | 6.50 | 10.59 |
| 15.2 | 1.13 | 2.74 | 2.74 | 8.30 | 13.98 |

*1. Basins were sized to maximize the storage volume on each parcel. (see Section 4.4.4)*
*2. Depth from the bottom of the basin to the highest basin perimeter elevation.*

### *Landscape Aesthetics and Multi-use Considerations*

***Basins 12, 14, 15.1, and 15.2:*** Similar to other non-park located basins, these basins would be located on land acquired for the purposes of stormwater detention. Context sensitive natural, soft and semi-soft structural approaches would minimize or eliminate the need for fencing, keeping side slopes, storage depths, structure types and public and maintenance access consistent with the District's basin aesthetic treatment guidelines. Some hard elements with aesthetic treatment may be required for inlet/outlet protection and erosion and grade control. However, Basins 15.1 and 15.2 would be relatively small basins (roughly an acre in size) with limited opportunity to increase the size of the basins without impacting residential property and would need to be fenced with significant landscape buffers required to mitigate visual impacts. These open channels are primarily located within private single-family residential areas, with limited visibility from the public rights-of-way. For this reason there may be a lower priority for vigorous application of aesthetic enhancements.

***Channels:*** Open channels are proposed through private properties and crossing the canal. These channels will require enough right of way (between 100 feet and 150 feet wide) to provide for gentle (4:1 max) side slopes and to allow for some meander in the low flow channel. Rapid drops in elevation would be taken up by drop structures and energy dissipation structures designed to mimic natural features in the landscape. There could be an opportunity to connect the Mormon Trailhead at 24th Street to the Highline Canal and vice versa using the flood control improvements as a link. The proposed open channel between Desert Lane and Basin 12 would require the relocation of one residence. Similar to other open channels, the location of this channel would not be visible from the neighborhood and minimal benefit in terms of enhancing the neighborhood character.

***Structure Types and Structural Methods:*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes***: Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

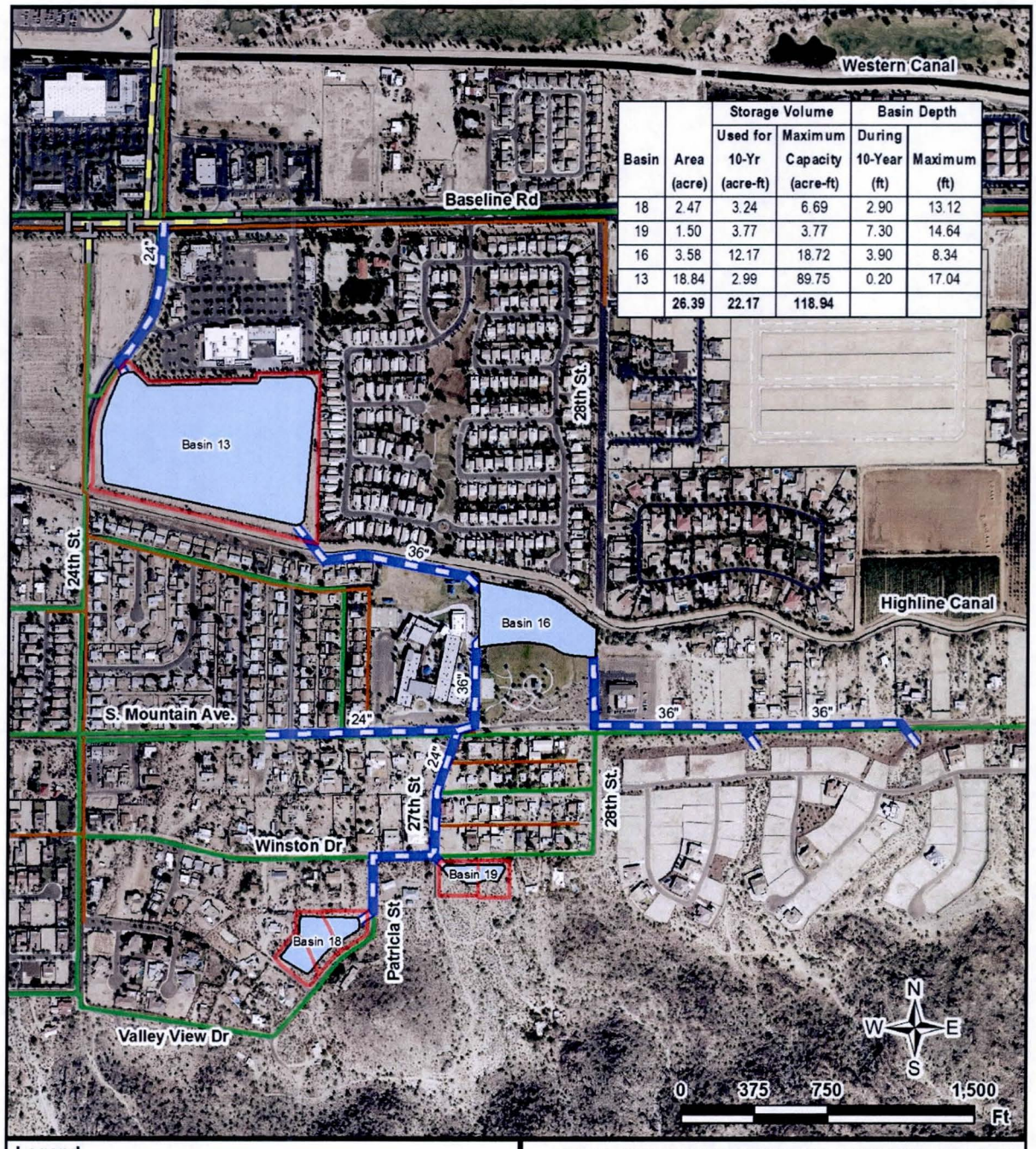
**Alternative Cost:** A summary of estimated construction and land acquisition costs are summarized in Table 4-8. Detailed information is provided in Appendix C.

***Table 4-8: Alternative 3.5 Cost Estimate***

| Description | Cost |
|---|---|
| Estimated Construction & Design Costs | $6,471,000 |
| Estimated Land, Easements & Right-of Way Acquisition Cost | $3,048,000 |
| **Total** | **$9,519,000** |

## 4.5.4 Alternative 4.1

**Flooding Issues:** Runoff from South Mountain Park results in flooding from 25th St. to 36th St. and ponds against walls behind residential homes along the Highline Canal.




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 18 | 2.47 | 3.24 | 6.69 | 2.90 | 13.12 |
| 19 | 1.50 | 3.77 | 3.77 | 7.30 | 14.64 |
| 16 | 3.58 | 12.17 | 18.72 | 3.90 | 8.34 |
| 13 | 18.84 | 2.99 | 89.75 | 0.20 | 17.04 |
| | **26.39** | **22.17** | **118.94** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

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**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**24th-36th St Corridor**
**Alternative 4.1**

11/4/2013

***Figure 4-4: Alternative 4.1 Proposed Improvements***

**Description:** This alternative includes proposed detention basins and storm drains. To capture flows from the South Mountain, two collection detention basins east of 24th St. south of Winston Dr. are proposed. Both basins will outlet to a storm drain system that also collects flows along South Mountain Ave. before discharging to a proposed detention basin placed in the northern section of Francisco Highlands Park. Another storm drain system along South Mountain Ave., east of 28th St. also drains to this detention basin. This detention basin discharges west in a storm drain along the Highline Canal to a proposed regional detention basin on the east side of 24th St. north of the Highline Canal. This basin discharges in a proposed storm drain north along 24th St. to an existing storm drain system in Baseline Rd. This alternative includes:

- 24" storm drain/basin outlets connecting Basins 18 and 19 to Basin 16
- 24" and 36" storm drain on S Mountain Ave to capture floodwater in the street
- 36" storm drain/basin outlet connecting Basin 16 to Basin 12
- 24" basin outlet draining Basin 13 to an existing storm drain on Baseline Rd
- Detention Basins 13, 16, 18 and 19 (see Figure 4-4 and Table 4-9)
- Acquiring 22.8 acres of land from 7 undeveloped parcels (does not include area modified within Francisco Highlands Park for Basin 16)

***Table 4-9: Alternative 4.1 Basin Summary***

| | | Storage Volume | | Basin Depth | |
|---|---|---|---|---|---|
| Basin | Area (acres) | Used for 10-Year (acre-ft) | Maximum Capacity[1] (acre-ft | 10-yr WSEL (ft) | Maximum[2] (ft) |
| 13 | 18.84 | 2.99 | 89.75 | 0.20 | 17.04 |
| 16 | 3.58 | 12.17 | 18.72 | 3.90 | 8.34 |
| 18 | 2.47 | 3.24 | 6.69 | 2.90 | 13.12 |
| 19 | 1.50 | 3.77 | 3.77 | 7.30 | 14.64 |

*1. Basins were sized to maximize the storage volume on each parcel. (see Section 4.4.4)*
*2. Depth from the bottom of the basin to the highest basin perimeter elevation.*

### *Landscape Aesthetics and Multi-use Considerations*

***Basins 13, 16, 18, and 19:*** Basins 18 and 19 would be relatively small basins (roughly 2.5 and 1.5 acres in size, respectively) and would need to be fenced. These basins would lack any multiple use opportunities as well as having minimal neighborhood benefits or enhancements. The vacant land that Basin 13 would be located on is currently slated for development. Basin 18 would have the potential to be incorporated into an existing park setting. It's relatively shallow depth would be conducive to incorporating the District's basin design guidelines as well as be perceived as a benefit to the park and the community at large.

***Structure Types and Structure Methods:*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of

excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes:*** Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park

**Alternative Cost:** A summary of estimated construction and land acquisition costs are summarized in Table 4-10. Detailed information is provided in Appendix C.

***Table 4-10: Alternative 4.1 Cost Estimate***

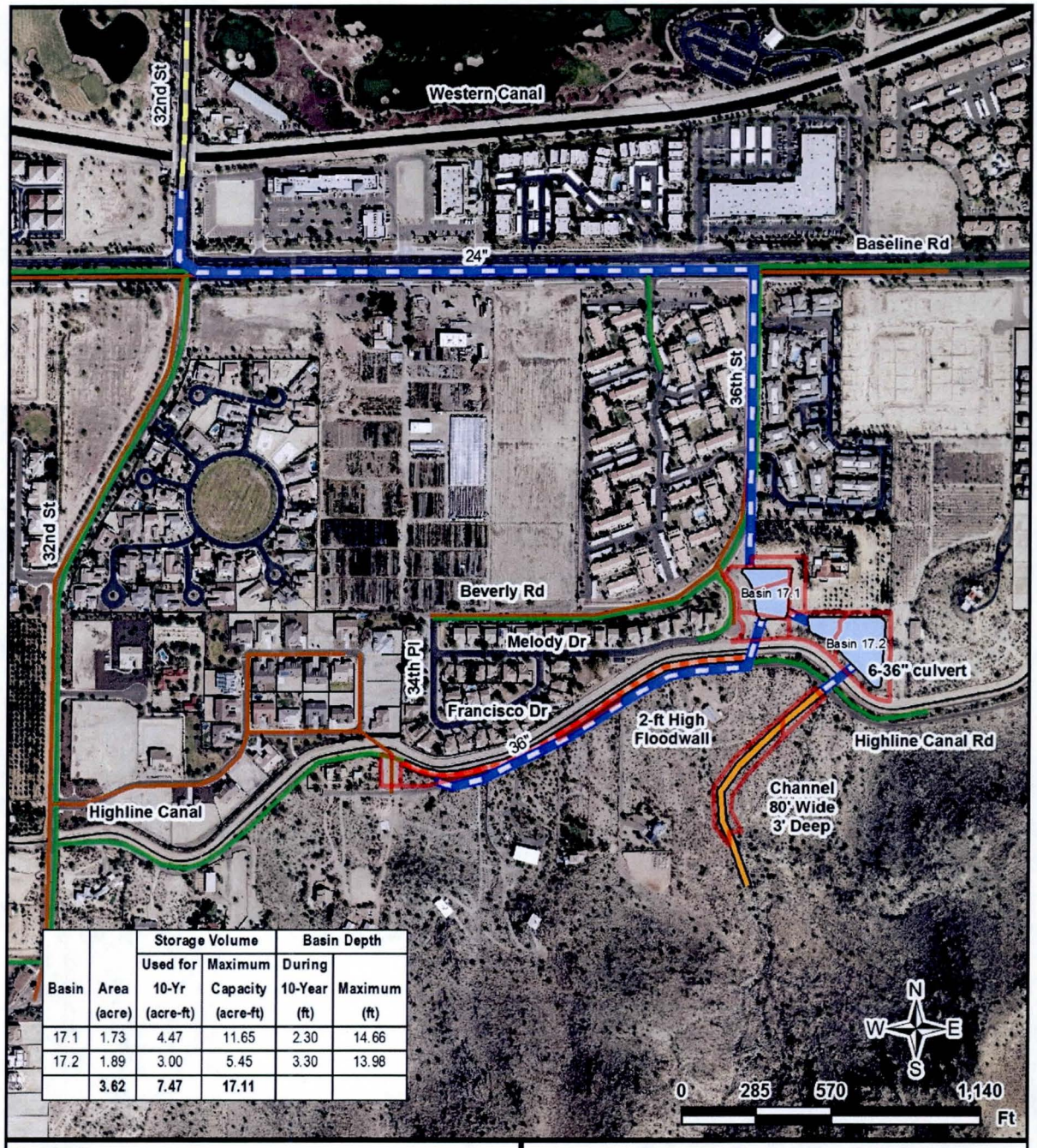
| Description | Cost |
|---|---|
| Estimated Construction & Design Costs | $9,059,000 |
| Estimated Land, Easements & Right-of Way Acquisition Cost | $3,629,000 |
| **Total** | **$12,688,000** |

## 4.5.5 Alternative 4.5

**Flooding Issues:** Runoff from South Mountain Park potentially results in flooding from 25th St. to 36th St. and ponding against block walls behind residential homes along the Highline Canal. In 2008, the ponding of water behind backyard walls near 36th St has resulted in the collapse of these block walls, flooding homes to the north.

**Description:** A proposed storm drain system collects runoff along the Highline Canal Road between 34$^{th}$ St. and 36$^{th}$ St. and discharges to one of the two proposed detention basins to be located north of the Highline Canal. A wall approximately 2-foot high along the storm drain collection system will help capture flows and reduce the amount of flow crossing the canal. A channel is also proposed east of 36$^{th}$ St. and south of the Highline Canal that would divert flows from an existing wash to a culvert crossing of the Highline Canal to the second detention basin. The two detention basins north of the Highline Canal outlet to a proposed storm drain in 36$^{th}$ St. that flows north to Baseline Rd. then west to 32$^{nd}$ St. to an existing storm drain. This alternative includes:

- 36" storm drain along Highline Canal Rd to collect floodwater
- 2'-high wall along the Highline Canal to divert floodwater to storm drain inlets
- Channel to divert mountain runoff from the Highline Canal to the proposed detention basins north of the canal (80' wide/3 ft deep)
- 6-36" culvert under the Highline Canal to convey mountain runoff (from the diversion channel to Basin 17.2)
- 36" basin connection between Basin 17.1 and 17.2
- 24" basin outlet draining Basin 17.1 to an existing storm drain on 36$^{th}$ St
- Detention Basins 17.1 and 17.2 (see Figure 4-5 and Table 4-11)
- Acquiring 5.3 acres of land from 12 parcels




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 17.1 | 1.73 | 4.47 | 11.65 | 2.30 | 14.66 |
| 17.2 | 1.89 | 3.00 | 5.45 | 3.30 | 13.98 |
| | **3.62** | **7.47** | **17.11** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan Contract FCD 2009C029**

**Preliminary Level 2B 24th-36th St Corridor Alternative 4.5**

11/4/2013

***Figure 4-5: Alternative 4.5 Proposed Improvements***

***Table 4-11: Alternative 4.5 Basin Summary***

| Basin | Area (acres) | Storage Volume: Used for 10-Year (acre-ft) | Storage Volume: Maximum Capacity[1] (acre-ft | Basin Depth: 10-yr WSEL (ft) | Basin Depth: Maximum[2] (ft) |
|---|---|---|---|---|---|
| 17.1 | 2.47 | 3.24 | 6.69 | 2.90 | 13.12 |
| 17.2 | 1.50 | 3.77 | 3.77 | 7.30 | 14.64 |

*1. Basins were sized to maximize the storage volume on each parcel. (see Section 4.4.4)*
*2. Depth from the bottom of the basin to the highest basin perimeter elevation.*

### *Landscape Aesthetics and Multi-use Considerations*

***Basins 17.1 and17.2:*** These two basins would be relatively the same size and would need to be fenced. These basins lack potential multiple use opportunities unless they could be incorporated into a link to the Highline Canal Multi-use Path.

***Channels:*** Open channels are proposed through private properties and crossing the Highline Canal. These channels would need to acquire enough right of way (approximately 100 feet) to provide for gentle (6:1 max) side slopes and to allow for some meander in the low flow channel. While having the potential to provide new link into the trail system in South Mountain Park/Preserve, the existing neighborhood is adamant that a channel would not be compatible and would not have community acceptance.

***Structure Types and Structure Methods:*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes:*** Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

**Alternative Cost:** A summary of estimated construction and land acquisition costs are summarized in Table 4-12. Detailed information is provided in Appendix C.

***Table 4-12: Alternative 4.5 Cost Estimate***

| Description | Cost |
|---|---|
| Estimated Construction & Design Costs | $2,111,000 |
| Estimated Land, Easements & Right-of Way Acquisition Cost | $460,000 |
| **Total** | **$2,571,000** |

# 5. LEVEL 3 RECOMMENDED ALTERNATIVES

## 5.1 ALTERNATIVE EVALUATION MEETING

The project team met and evaluated Level 2B Alternatives using the same evaluation matrix used in Level 1 that included several criteria: Flood Mitigation Effectiveness, Community Acceptance, Land & Resource Compatibility, and Relative Cost. For each criteria, the Alternatives as presented were rated as favorable (positive), unfavorable (negative) or neutral for each criteria. For comparison, a "No Action" Alternative was also rated for each alternative. Based upon the results of the evaluation, the project team recommended alternatives for advancement to Level 3. The project team also will consider making needed adjustments to the recommended alternatives during the Level 3 analysis.

## 5.2 RECOMMENDED ALTERNATIVE

The recommended alternatives are briefly described in this section along with suggestions made by the project team. These alternatives will be refined and analyzed in more detail in Level 3 prior to the development of concept level plans. The evaluation results for all the alternatives are in Appendix D.

### 5.2.1 ALTERNATIVE 1.1

This alternative was ranked favorably for almost all criteria except cost. The project team made several suggestions for additional consideration in Level 3 including:

- Reduce the number and/or size of basins located outside of Circle K Park.
- Extend storm drain system down 16$^{th}$ St – potentially large diameter storm drain to eliminate channelization along 16$^{th}$ St.
- Reduce or eliminate channel south of Dobbins Rd. at 15$^{th}$ St.
- Consider large diameter storm drain/box to eliminate channel north of Dobbins at 15$^{th}$ St alignment.

### 5.2.2 ALTERNATIVE 2.1

This alternative was ranked favorably mostly for flood mitigation and community acceptance. The project team made several suggestions for additional consideration in Level 3 including:

- Eliminate the basin at 20$^{th}$ St and S. Mountain Ave.
- Replace drainage ditch on 21$^{st}$ Pl with storm drain to capture flows.

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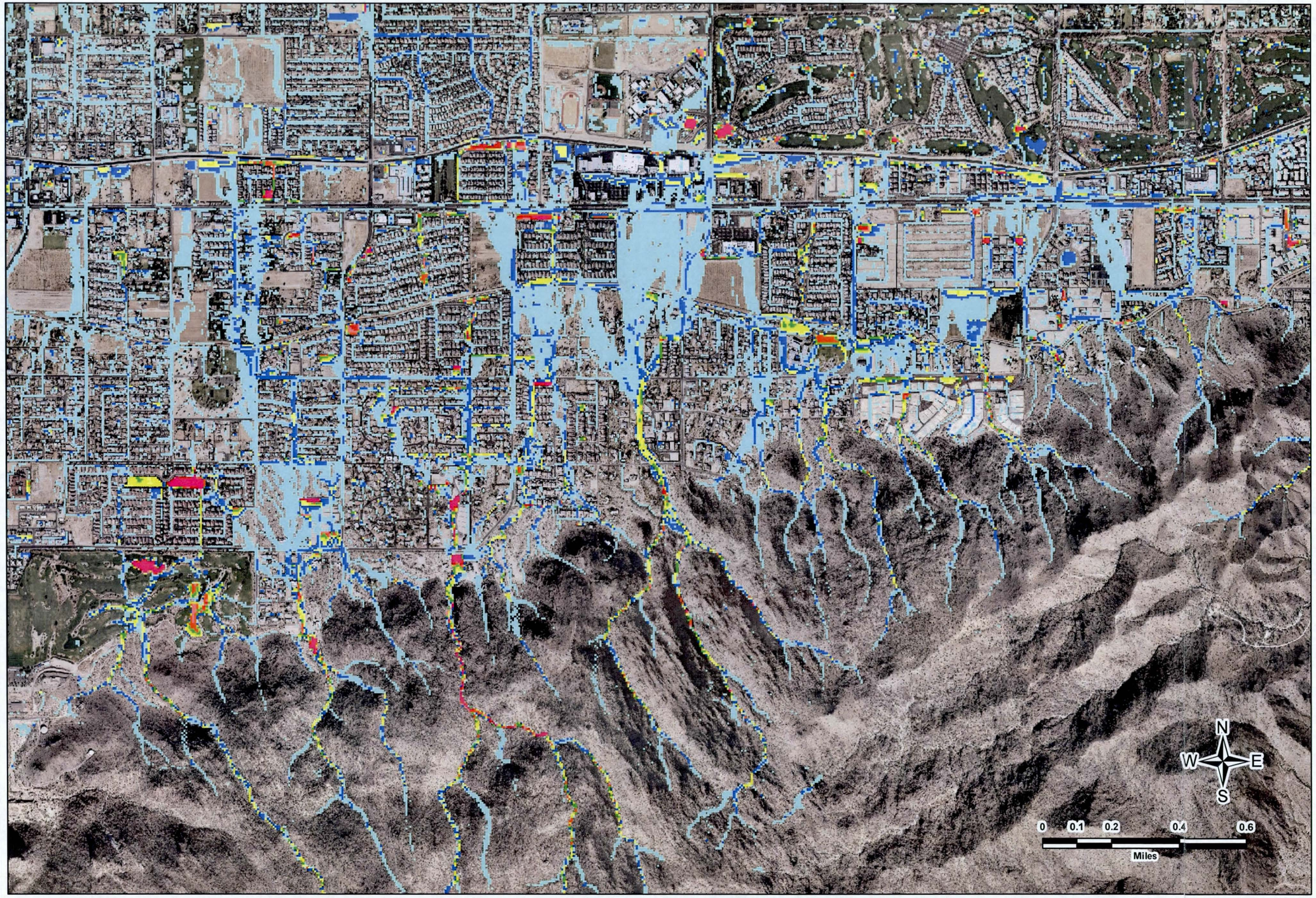
# APPENDIX A

# FLO-2D Results

# Hohokam Area Drainage Master Study/Plan

## Contract FCD209C029

**Base Condition**
**10-Yr, 6-Hr**
**Maximum Flow Depth**




**Legend**

**10-Yr Depth (ft)**

- 0.2 - 0.5
- 0.6 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 3.0
- 3.1 - 3.5
- 3.6 - 4.0
- 4.1 - 21.0

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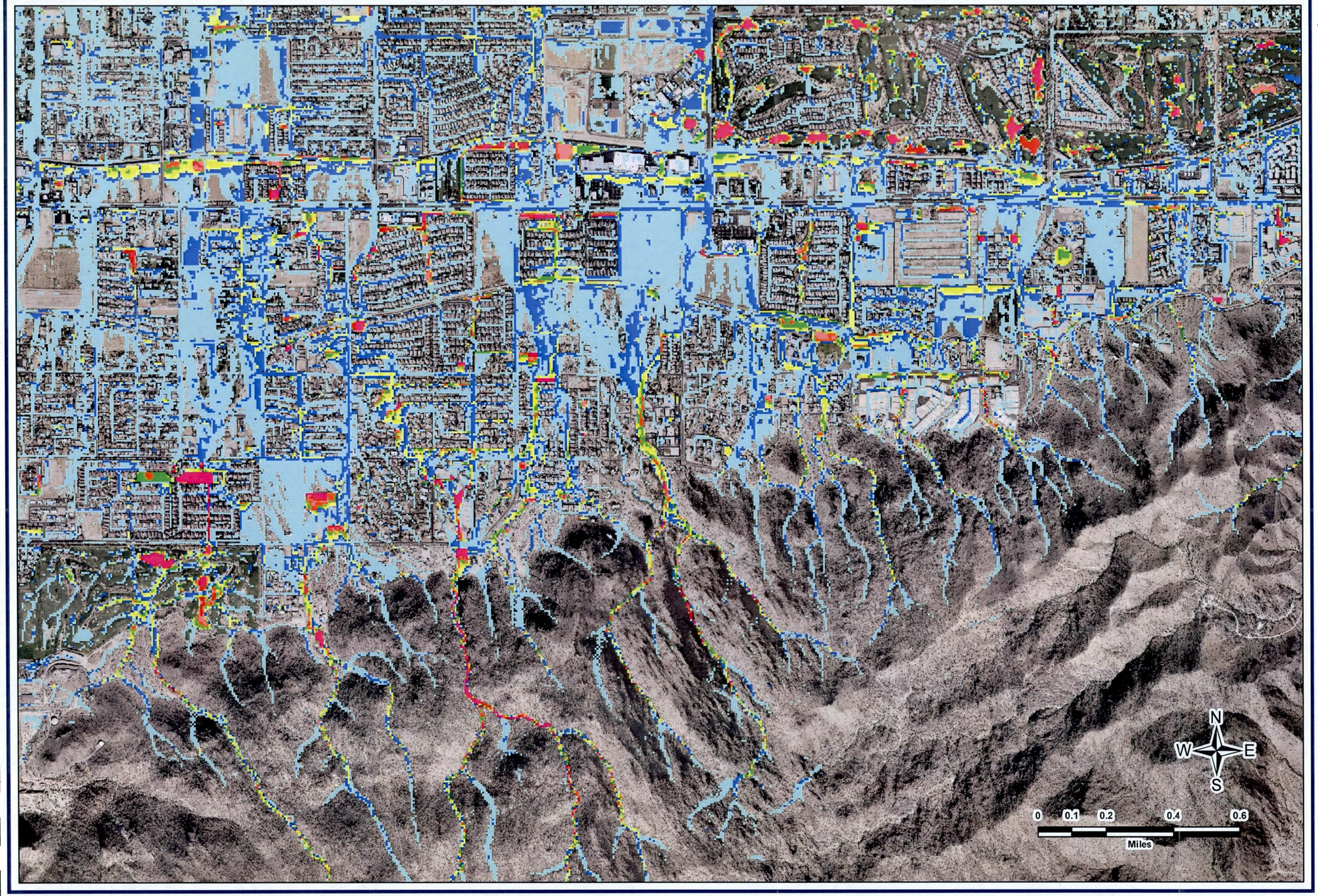
# Hohokam Area Drainage Master Study/Plan

## Contract FCD209C029

**Base Condition**
**100-Yr, 6-Hr**
**Maximum Flow Depth**




**Legend**

**100-Yr Depth (ft)**

- 0.2 - 0.5
- 0.6 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 3.0
- 3.1 - 3.5
- 3.6 - 4.0
- 4.1 - 21.0

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# Hohokam Area Drainage Master Study/Plan

## Contract FCD209C029

**Alternatives Condition**
**10-Yr, 6-Hr**
**Maximum Flow Depth**

**Legend**

**10-Yr Depth (ft)**

- 0.17 - 0.50
- 0.51 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 3.00
- 3.01 - 3.50
- 3.51 - 4.00
- > 4.00

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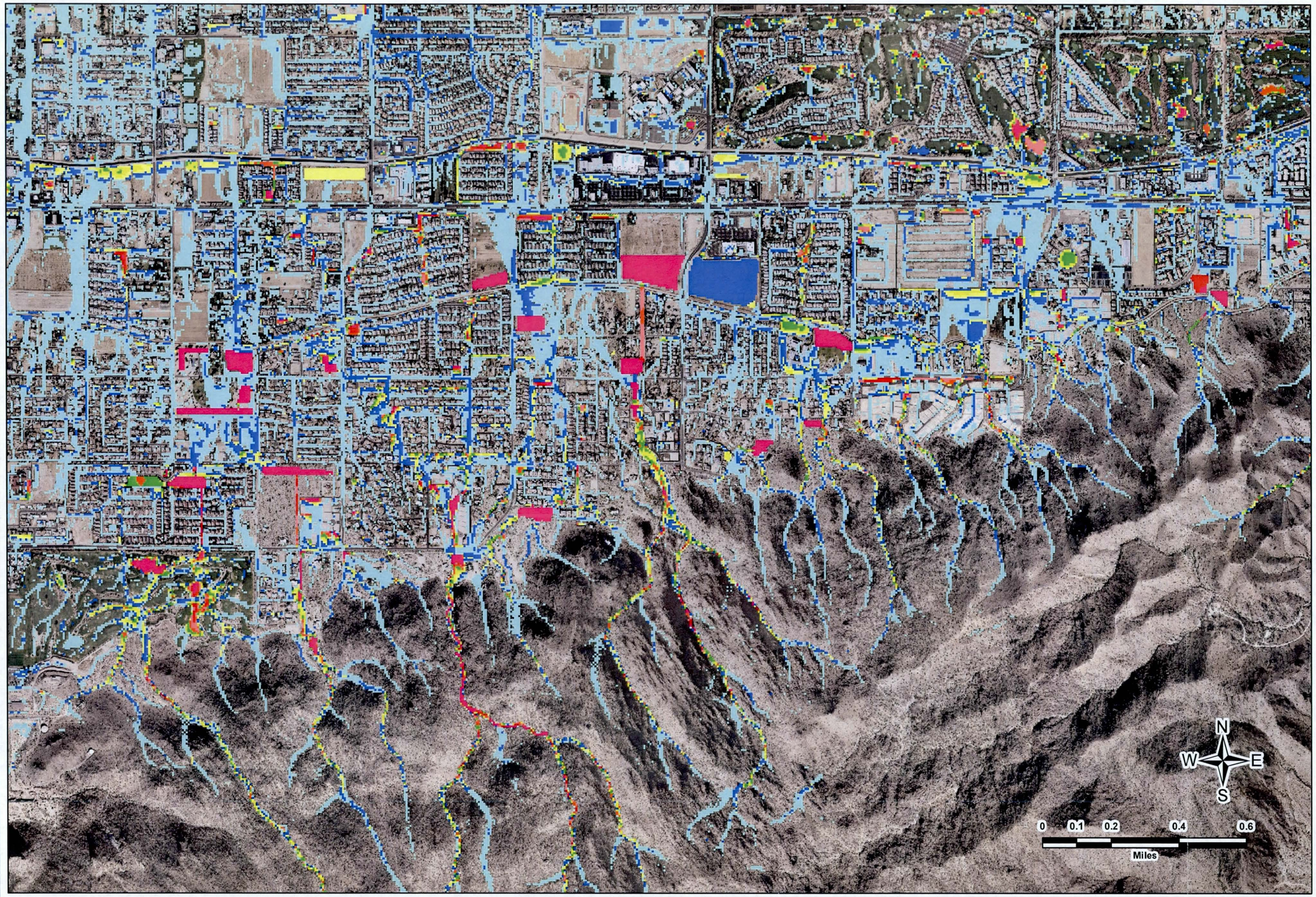
# Hohokam Area Drainage Master Study/Plan

## Contract FCD209C029

**Alternatives Condition**
**100-Yr, 6-Hr**
**Maximum Flow Depth**




**Legend**

**100-Yr Depth (ft)**

- 0.2 - 0.5
- 0.6 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 3.0
- 3.1 - 3.5
- 3.6 - 4.0
- 4.1 - 21.0

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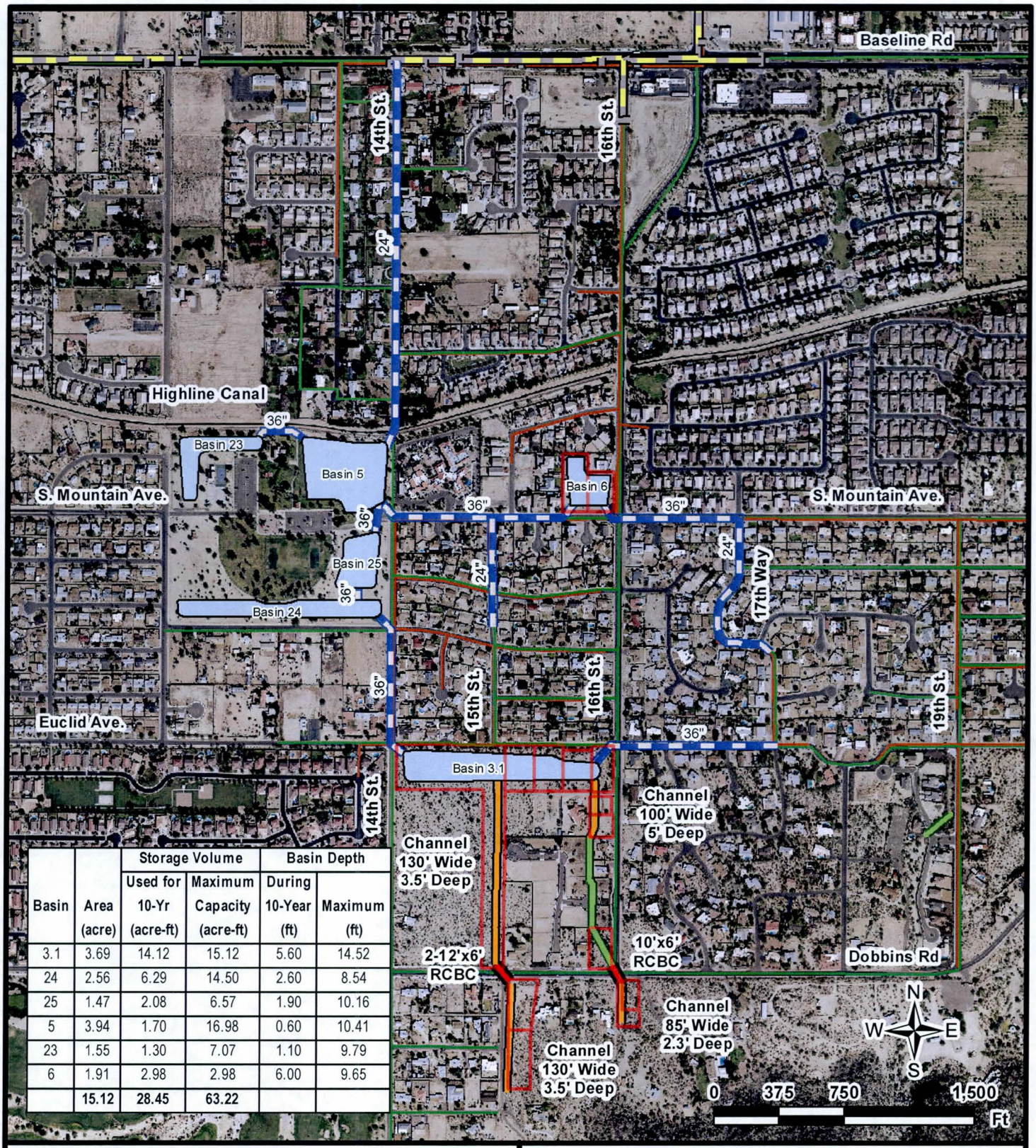
# APPENDIX B

# Alternative Exhibits
# &
# Supporting Calculations

# Alternative 1.1 Supporting Calculations




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 3.1 | 3.69 | 14.12 | 15.12 | 5.60 | 14.52 |
| 24 | 2.56 | 6.29 | 14.50 | 2.60 | 8.54 |
| 25 | 1.47 | 2.08 | 6.57 | 1.90 | 10.16 |
| 5 | 3.94 | 1.70 | 16.98 | 0.60 | 10.41 |
| 23 | 1.55 | 1.30 | 7.07 | 1.10 | 9.79 |
| 6 | 1.91 | 2.98 | 2.98 | 6.00 | 9.65 |
| | **15.12** | **28.45** | **63.22** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Culvert
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Channel
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

Flood Control District of Maricopa County

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**16th St Corridor**
**Alternative 1.1**

11/4/2013

# Culvert Designer/Analyzer Report
## Alt 1.1: 15th St & Dobbins RCB (A1.1-15S-Dobbins1 to 3)

**Overtopping Analysis**

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 2-12 x 6 ft Box | 1,800.00 cfs | 109.80 ft | 16.87 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |


SCI-Muscatine
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# Culvert Designer/Analyzer Report
## Alt 1.1: 15th St & Dobbins RCB (A1.1-15S-Dobbins1 to 3)

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev: | 109.80 | ft | Discharge | 1,800.00 | cfs |
| Inlet Control HW Elev. | 109.80 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 108.95 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 1.63 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 4.45 | ft |
| Slope Type | Steep | | Normal Depth | 3.76 | ft |
| Flow Regime | Supercritical | | Critical Depth | 5.59 | ft |
| Velocity Downstream | 16.87 | ft/s | Critical Slope | 0.003338 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Box | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 12.00 | ft |
| Section Size | 12 x 6 ft | | Rise | 6.00 | ft |
| Number Sections | 2 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 108.95 | ft | Upstream Velocity Head | 2.80 | ft |
| Ke | 0.20 | | Entrance Loss | 0.56 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 109.80 | ft | Flow Control | N/A | |
| Inlet Type | 90° headwall w 45° bevels | | Area Full | 144.0 | ft² |
| K | 0.49500 | | HDS 5 Chart | 10 | |
| M | 0.66700 | | HDS 5 Scale | 2 | |
| C | 0.03140 | | Equation Form | 2 | |
| Y | 0.82000 | | | | |

# Culvert Designer/Analyzer Report
## Alt 1.1: 16th St & Dobbins RCB (A1.1-16S-Dobbins)

**Overtopping Analysis**

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 1-10 x 6 ft Box | 800.00 cfs | 110.47 ft | 16.95 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt 1.1: 16th St & Dobbins RCB (A1.1-16S-Dobbins)

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 110.47 | ft | Discharge | 800.00 | cfs |
| Inlet Control HW Elev. | 110.47 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 109.34 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 1.75 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 4.72 | ft |
| Slope Type | Steep | | Normal Depth | 4.08 | ft |
| Flow Regime | Supercritical | | Critical Depth | 5.84 | ft |
| Velocity Downstream | 16.95 | ft/s | Critical Slope | 0.003837 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Box | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 10.00 | ft |
| Section Size | 10 x 6 ft | | Rise | 6.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 109.34 | ft | Upstream Velocity Head | 2.92 | ft |
| Ke | 0.20 | | Entrance Loss | 0.58 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 110.47 | ft | Flow Control | N/A | |
| Inlet Type | 90° headwall w 45° bevels | | Area Full | 60.0 | ft² |
| K | 0.49500 | | HDS 5 Chart | 10 | |
| M | 0.66700 | | HDS 5 Scale | 2 | |
| C | 0.03140 | | Equation Form | 2 | |
| Y | 0.82000 | | | | |

# Worksheet for Alt 1.1 100 cfs 16th Street south of Dobbins

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.02200 | ft/ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 15.00 | ft |
| Discharge | 100.00 | $ft^3/s$ |

## Results

| | | |
|---|---|---|
| Normal Depth | 0.94 | ft |
| Flow Area | 19.48 | $ft^2$ |
| Wetted Perimeter | 26.47 | ft |
| Hydraulic Radius | 0.74 | ft |
| Top Width | 26.31 | ft |
| Critical Depth | 0.97 | ft |
| Critical Slope | 0.01972 | ft/ft |
| Velocity | 5.13 | ft/s |
| Velocity Head | 0.41 | ft |
| Specific Energy | 1.35 | ft |
| Froude Number | 1.05 | |
| Flow Type | Supercritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 0.94 | ft |
| Critical Depth | 0.97 | ft |
| Channel Slope | 0.02200 | ft/ft |

# Worksheet for Alt 1.1 100 cfs 16th Street south of Dobbins

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01972 | ft/ft |

# Worksheet for Alt 1.1 300 cfs 16th St north of Dobbins

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 25.00 | ft |
| Discharge | 300.00 | $ft^3/s$ |

## Results

| | | |
|---|---|---|
| Normal Depth | 1.69 | ft |
| Flow Area | 59.27 | $ft^2$ |
| Wetted Perimeter | 45.53 | ft |
| Hydraulic Radius | 1.30 | ft |
| Top Width | 45.25 | ft |
| Critical Depth | 1.46 | ft |
| Critical Slope | 0.01713 | ft/ft |
| Velocity | 5.06 | ft/s |
| Velocity Head | 0.40 | ft |
| Specific Energy | 2.09 | ft |
| Froude Number | 0.78 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.69 | ft |
| Critical Depth | 1.46 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 1.1 300 cfs 16th St north of Dobbins

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01713 | ft/ft |

# Worksheet for Alt 1.1 500 cfs 15th St south of Dobbins

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Normal Depth | 2.50 | ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 60.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 1294.51 | $ft^3/s$ |
| Flow Area | 187.50 | $ft^2$ |
| Wetted Perimeter | 90.41 | ft |
| Hydraulic Radius | 2.07 | ft |
| Top Width | 90.00 | ft |
| Critical Depth | 2.25 | ft |
| Critical Slope | 0.01449 | ft/ft |
| Velocity | 6.90 | ft/s |
| Velocity Head | 0.74 | ft |
| Specific Energy | 3.24 | ft |
| Froude Number | 0.84 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 2.50 | ft |
| Critical Depth | 2.25 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 1.1 500 cfs 15th St south of Dobbins

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01449 | ft/ft |

# Worksheet for Alt 1.1 500 cfs 15th St north of Dobbins

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Normal Depth | 2.50 | ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 60.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 1294.51 | $ft^3/s$ |
| Flow Area | 187.50 | $ft^2$ |
| Wetted Perimeter | 90.41 | ft |
| Hydraulic Radius | 2.07 | ft |
| Top Width | 90.00 | ft |
| Critical Depth | 2.25 | ft |
| Critical Slope | 0.01449 | ft/ft |
| Velocity | 6.90 | ft/s |
| Velocity Head | 0.74 | ft |
| Specific Energy | 3.24 | ft |
| Froude Number | 0.84 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

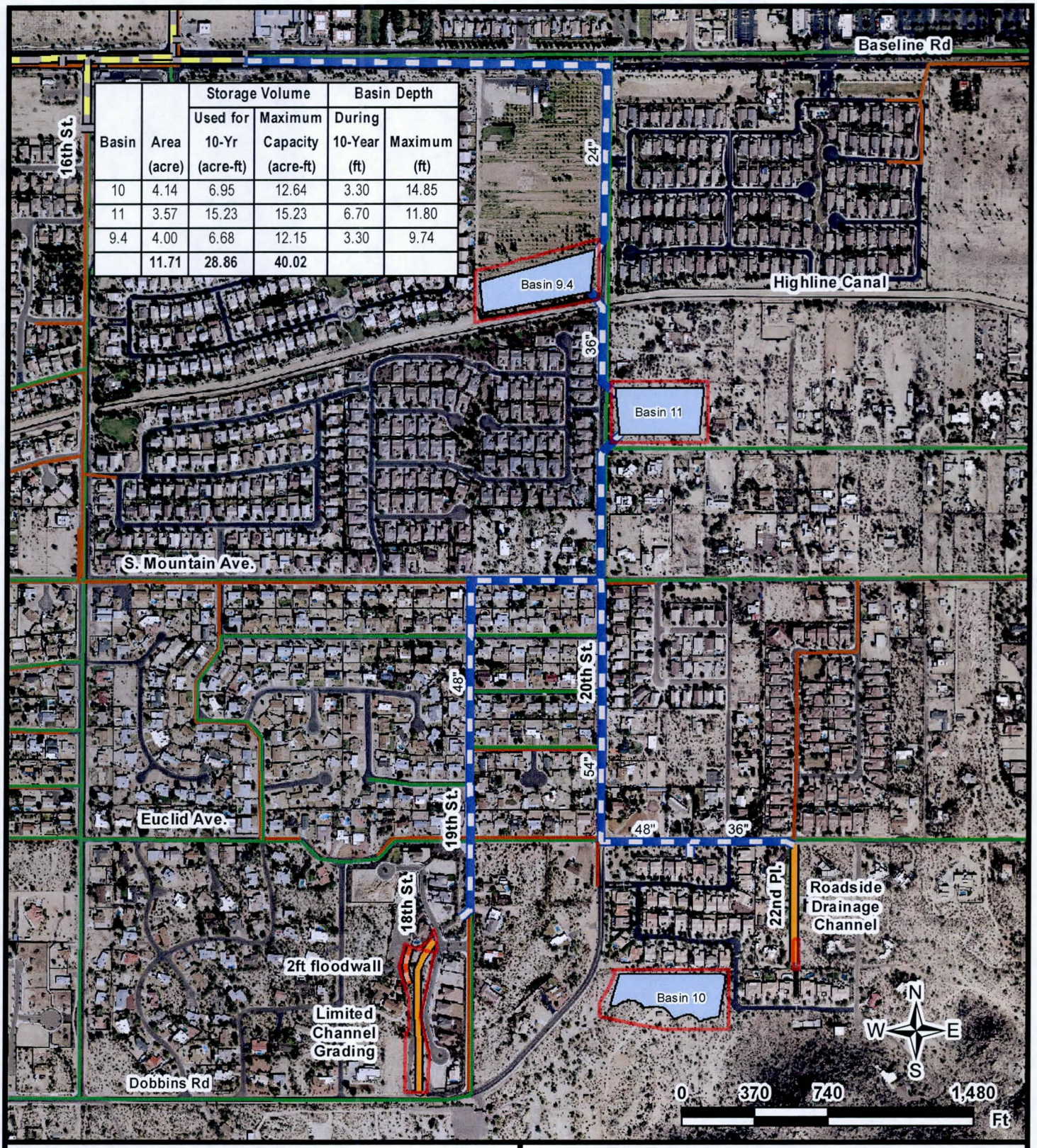
| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 2.50 | ft |
| Critical Depth | 2.25 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 1.1 500 cfs 15th St north of Dobbins

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01449 | ft/ft |

# Alternative 2.1 Supporting Calculations




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 10 | 4.14 | 6.95 | 12.64 | 3.30 | 14.85 |
| 11 | 3.57 | 15.23 | 15.23 | 6.70 | 11.80 |
| 9.4 | 4.00 | 6.68 | 12.15 | 3.30 | 9.74 |
| | **11.71** | **28.86** | **40.02** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**20th St Corridor**
**Alternative 2.1**

11/4/2013

# Worksheet for Alt 2.1 60 cfs 21st Pl south of Euclid

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 5.00 | ft |
| Discharge | 60.00 | $ft^3/s$ |

## Results

| | | |
|---|---|---|
| Normal Depth | 1.29 | ft |
| Flow Area | 16.47 | $ft^2$ |
| Wetted Perimeter | 20.71 | ft |
| Hydraulic Radius | 0.80 | ft |
| Top Width | 20.50 | ft |
| Critical Depth | 1.09 | ft |
| Critical Slope | 0.02039 | ft/ft |
| Velocity | 3.64 | ft/s |
| Velocity Head | 0.21 | ft |
| Specific Energy | 1.50 | ft |
| Froude Number | 0.72 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.29 | ft |
| Critical Depth | 1.09 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 2.1 60 cfs 21st Pl south of Euclid

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.02039 | ft/ft |

# Worksheet for Alt 2.1 600 cfs north of Dobbins west of 19th St

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 70.00 | ft |
| Discharge | 600.00 | $ft^3/s$ |

## Results

| | | |
|---|---|---|
| Normal Depth | 1.48 | ft |
| Flow Area | 116.94 | $ft^2$ |
| Wetted Perimeter | 88.03 | ft |
| Hydraulic Radius | 1.33 | ft |
| Top Width | 87.79 | ft |
| Critical Depth | 1.27 | ft |
| Critical Slope | 0.01707 | ft/ft |
| Velocity | 5.13 | ft/s |
| Velocity Head | 0.41 | ft |
| Specific Energy | 1.89 | ft |
| Froude Number | 0.78 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

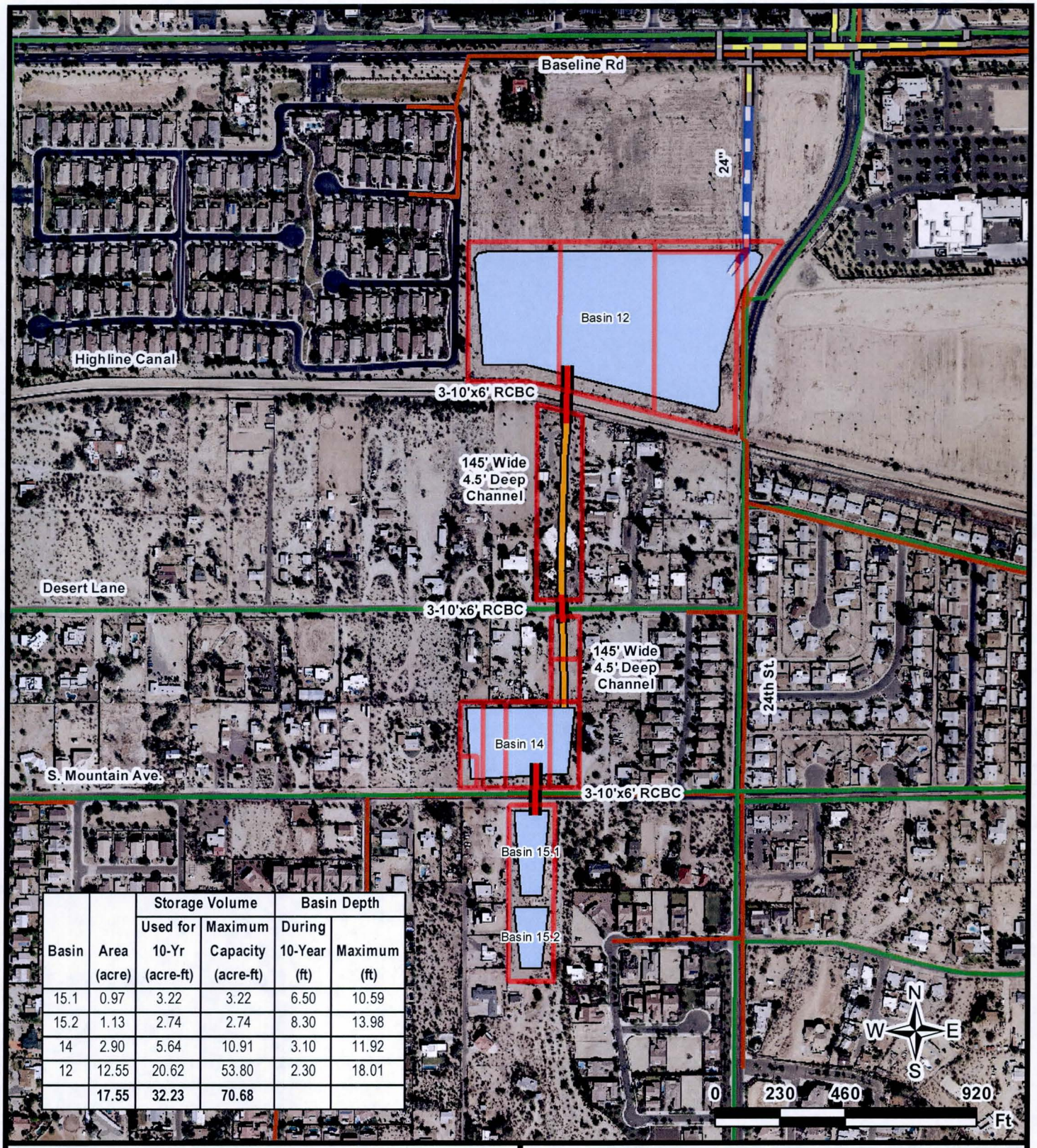
| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.48 | ft |
| Critical Depth | 1.27 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 2.1 600 cfs north of Dobbins west of 19th St

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01707 | ft/ft |

# Alternative 3.5 Supporting Calculations




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 15.1 | 0.97 | 3.22 | 3.22 | 6.50 | 10.59 |
| 15.2 | 1.13 | 2.74 | 2.74 | 8.30 | 13.98 |
| 14 | 2.90 | 5.64 | 10.91 | 3.10 | 11.92 |
| 12 | 12.55 | 20.62 | 53.80 | 2.30 | 18.01 |
| | **17.55** | **32.23** | **70.68** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Culvert
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

**Hohokam Area Drainage**
**Master Study/Plan**
**Contract FCD 2009C029**

**Preliminary Level 2B**
**24th St Corridor**
**Alternative 3.5**

11/4/2013

# Culvert Designer/Analyzer Report
## Alt 3.5: Culvert Across S Mtn Ave (A3.5-B15.1toB14)

| Analysis Component | | | |
|---|---|---|---|
| Storm Event | Design | Discharge | 2,300.00 cfs |

| Peak Discharge Method: User-Specified | | | |
|---|---|---|---|
| Design Discharge | 2,300.00 cfs | Check Discharge | 2,300.00 cfs |

| Tailwater Conditions: Constant Tailwater | |
|---|---|
| Tailwater Elevation | N/A ft |

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 3-10 x 6 ft Box | 2,300.00 cfs | 110.02 ft | 16.77 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt 3.5: Culvert Across S Mtn Ave (A3.5-B15.1toB14)

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 110.02 | ft | Discharge | 2,300.00 | cfs |
| Inlet Control HW Elev. | 110.02 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 109.08 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 1.67 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 4.57 | ft |
| Slope Type | Steep | | Normal Depth | 3.96 | ft |
| Flow Regime | Supercritical | | Critical Depth | 5.67 | ft |
| Velocity Downstream | 16.77 | ft/s | Critical Slope | 0.003795 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Box | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 10.00 | ft |
| Section Size | 10 x 6 ft | | Rise | 6.00 | ft |
| Number Sections | 3 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 109.08 | ft | Upstream Velocity Head | 2.84 | ft |
| Ke | 0.20 | | Entrance Loss | 0.57 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 110.02 | ft | Flow Control | N/A | |
| Inlet Type | 90° headwall w 45° bevels | | Area Full | 180.0 | $ft^2$ |
| K | 0.49500 | | HDS 5 Chart | 10 | |
| M | 0.66700 | | HDS 5 Scale | 2 | |
| C | 0.03140 | | Equation Form | 2 | |
| Y | 0.82000 | | | | |

# Worksheet for Alt 3.5 500 cfs basin outfall channel

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 60.00 | ft |
| Discharge | 500.00 | $ft^3/s$ |

## Results

| | | |
|---|---|---|
| Normal Depth | 1.45 | ft |
| Flow Area | 99.71 | $ft^2$ |
| Wetted Perimeter | 77.65 | ft |
| Hydraulic Radius | 1.28 | ft |
| Top Width | 77.41 | ft |
| Critical Depth | 1.24 | ft |
| Critical Slope | 0.01728 | ft/ft |
| Velocity | 5.01 | ft/s |
| Velocity Head | 0.39 | ft |
| Specific Energy | 1.84 | ft |
| Froude Number | 0.78 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

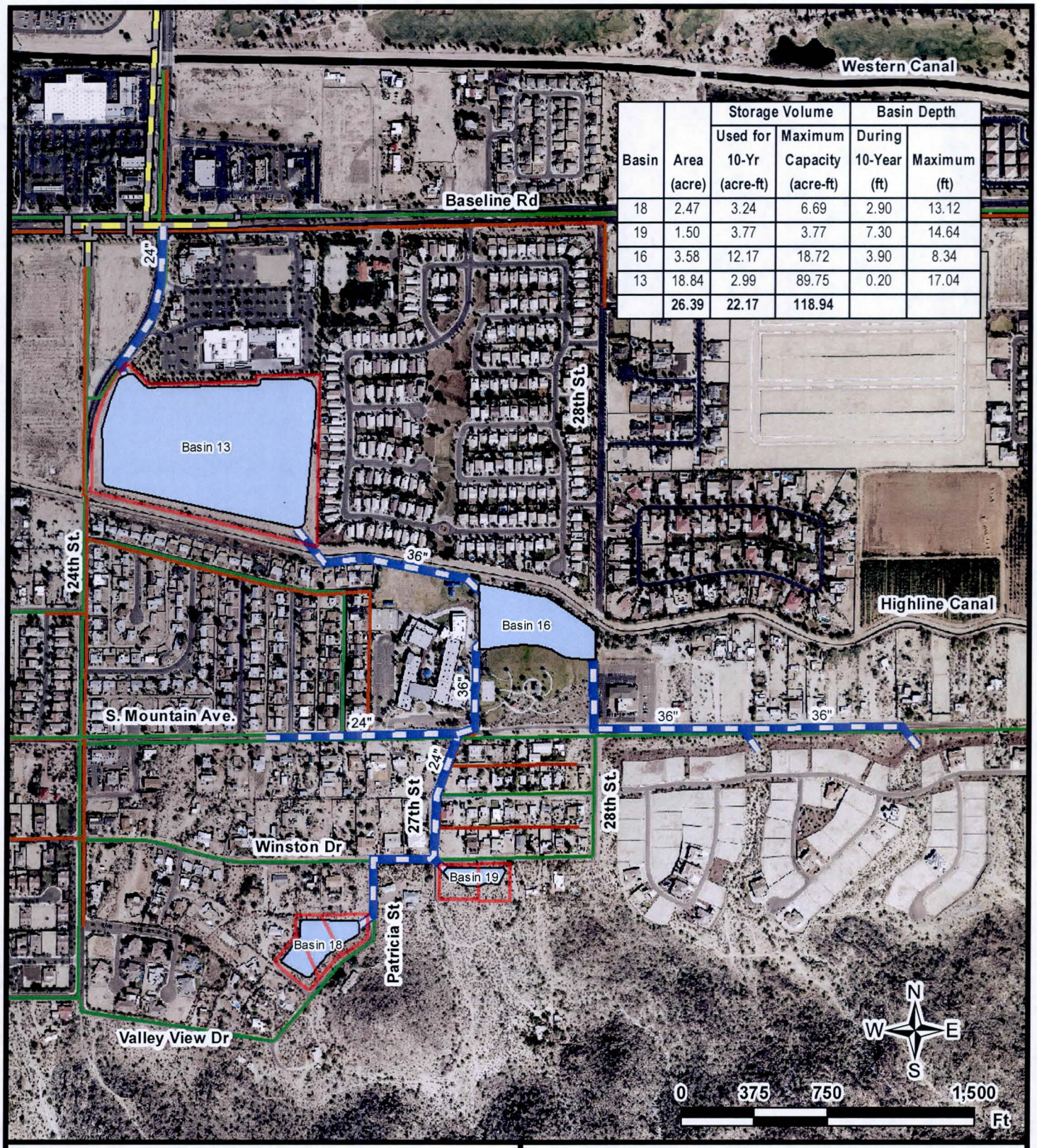
| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.45 | ft |
| Critical Depth | 1.24 | ft |
| Channel Slope | 0.01000 | ft/ft |

# Worksheet for Alt 3.5 500 cfs basin outfall channel

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01728 | ft/ft |

# Alternative 4.1 Supporting Calculations




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 18 | 2.47 | 3.24 | 6.69 | 2.90 | 13.12 |
| 19 | 1.50 | 3.77 | 3.77 | 7.30 | 14.64 |
| 16 | 3.58 | 12.17 | 18.72 | 3.90 | 8.34 |
| 13 | 18.84 | 2.99 | 89.75 | 0.20 | 17.04 |
| | **26.39** | **22.17** | **118.94** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

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**ENGINEERING DIVISION**

**Hohokam Area Drainage**
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**Contract FCD 2009C029**

**Preliminary Level 2B**
**24th-36th St Corridor**
**Alternative 4.1**

11/4/2013

# Culvert Designer/Analyzer Report
## Alt 4.1: Basin 19 Outlet & SD to Basin 16 - 24"

**Overtopping Analysis**

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 1-24 inch Circular | 50.00 cfs | 110.60 ft | 15.94 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt 4.1: Basin 19 Outlet & SD to Basin 16 - 24"

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 110.60 | ft | Discharge | 50.00 | cfs |
| Inlet Control HW Elev. | 107.81 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 110.60 | ft | Control Type | Outlet Control | |
| Headwater Depth/Height | 5.30 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.98 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.98 | ft |
| Velocity Downstream | 15.94 | ft/s | Critical Slope | 0.044995 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 110.60 | ft | Upstream Velocity Head | 3.94 | ft |
| Ke | 0.20 | | Entrance Loss | 0.79 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 107.81 | ft | Flow Control | N/A | |
| Inlet Type | Beveled ring, 33.7° bevels | | Area Full | 3.1 | $ft^2$ |
| K | 0.00180 | | HDS 5 Chart | 3 | |
| M | 2.50000 | | HDS 5 Scale | B | |
| C | 0.02430 | | Equation Form | 1 | |
| Y | 0.83000 | | | | |

# Culvert Designer/Analyzer Report
## Alt 4.1: Basin 19 Outlet & SD to Basin 16 - 36"

**Overtopping Analysis**

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 1-36 inch Circular | 50.00 cfs | 103.69 ft | 10.17 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt 4.1: Basin 19 Outlet & SD to Basin 16 - 36"

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 103.69 | ft | Discharge | 50.00 | cfs |
| Inlet Control HW Elev. | 103.69 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 103.68 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 1.23 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

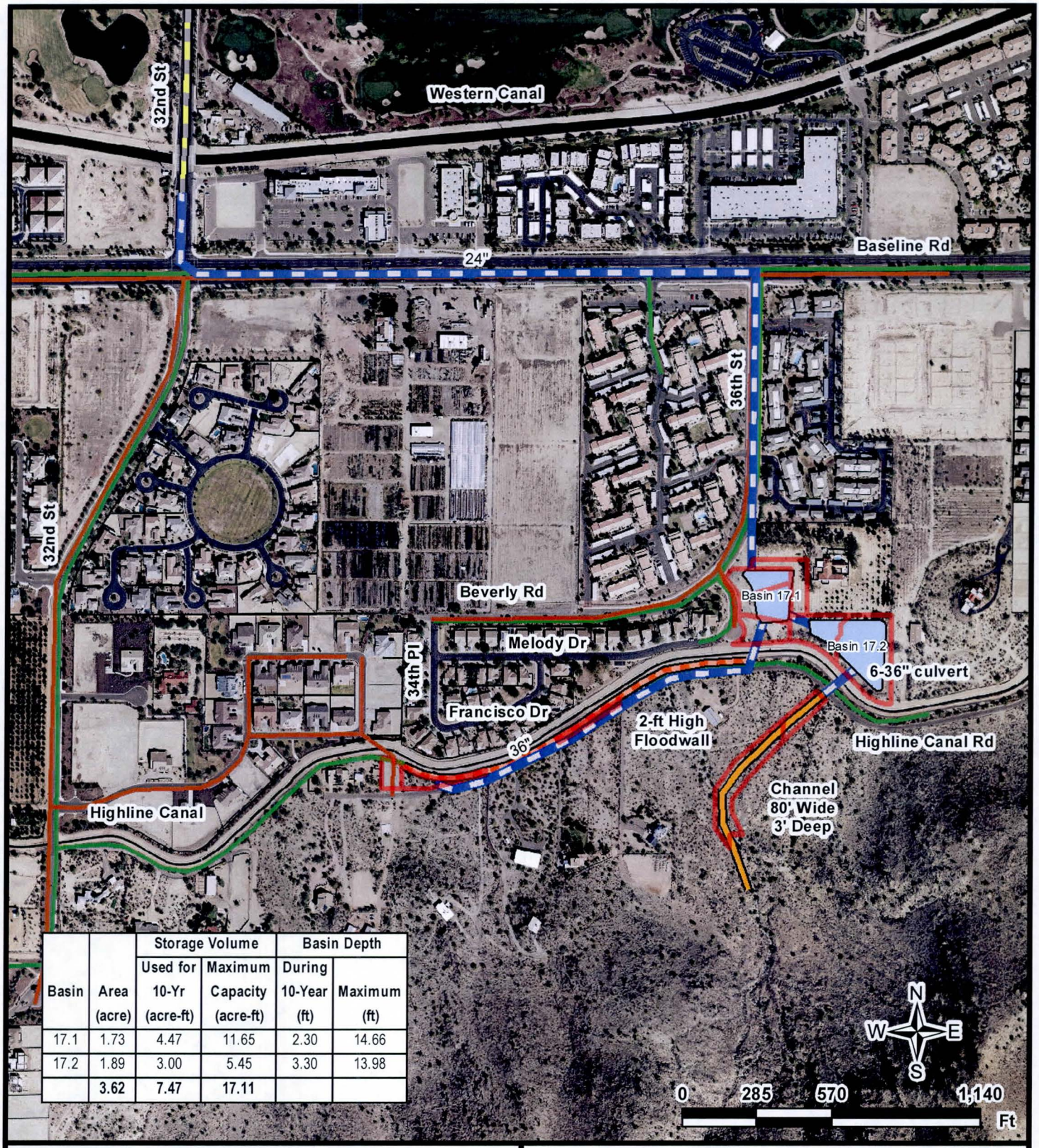
| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 1.97 | ft |
| Slope Type | Steep | | Normal Depth | 1.94 | ft |
| Flow Regime | Supercritical | | Critical Depth | 2.30 | ft |
| Velocity Downstream | 10.17 | ft/s | Critical Slope | 0.006420 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 3.00 | ft |
| Section Size | 36 inch | | Rise | 3.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 103.68 | ft | Upstream Velocity Head | 1.15 | ft |
| Ke | 0.20 | | Entrance Loss | 0.23 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 103.69 | ft | Flow Control | N/A | |
| Inlet Type | Beveled ring, 33.7° bevels | | Area Full | 7.1 | ft² |
| K | 0.00180 | | HDS 5 Chart | 3 | |
| M | 2.50000 | | HDS 5 Scale | B | |
| C | 0.02430 | | Equation Form | 1 | |
| Y | 0.83000 | | | | |

# Alternative 4.5 Supporting Calculations




| Basin | Area (acre) | Storage Volume: Used for 10-Yr (acre-ft) | Storage Volume: Maximum Capacity (acre-ft) | Basin Depth: During 10-Year (ft) | Basin Depth: Maximum (ft) |
|---|---|---|---|---|---|
| 17.1 | 1.73 | 4.47 | 11.65 | 2.30 | 14.66 |
| 17.2 | 1.89 | 3.00 | 5.45 | 3.30 | 13.98 |
| | **3.62** | **7.47** | **17.11** | | |

**Legend**

- Right-of Way Acquisition Boundary
- Proposed Detention Basin
- Proposed Storm Drain
- Proposed Channel
- Proposed Floodwall
- Existing Storm Drain
- Existing Sewer
- Existing Water

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**ENGINEERING DIVISION**

**Hohokam Area Drainage**
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**Preliminary Level 2B**
**24th-36th St Corridor**
**Alternative 4.5**

11/4/2013

# Culvert Designer/Analyzer Report
## Alt 4.5: Cortland Wash Crossing of Highlin (A4.5-CortEWash)

| Analysis Component | | | |
|---|---|---|---|
| Storm Event | Design | Discharge | 650.00 cfs |

| Peak Discharge Method: User-Specified | | | |
|---|---|---|---|
| Design Discharge | 650.00 cfs | Check Discharge | 650.00 cfs |

| Tailwater Conditions: Constant Tailwater | |
|---|---|
| Tailwater Elevation | N/A ft |

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 6-36 inch Circular | 650.00 cfs | 111.33 ft | 15.43 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt 4.5: Cortland Wash Crossing of Highlin (A4.5-CortEWash)

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 111.33 | ft | Discharge | 650.00 | cfs |
| Inlet Control HW Elev. | 111.33 | ft | Tailwater Elevation | N/A | ft |
| Outlet Control HW Elev. | 109.07 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 3.78 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.020080 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.92 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.92 | ft |
| Velocity Downstream | 15.43 | ft/s | Critical Slope | 0.023378 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 3.00 | ft |
| Section Size | 36 inch | | Rise | 3.00 | ft |
| Number Sections | 6 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 109.07 | ft | Upstream Velocity Head | 3.65 | ft |
| Ke | 0.50 | | Entrance Loss | 1.83 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 111.33 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 42.4 | $ft^2$ |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Worksheet for Alt 4.5 100 cfs diversion channel

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.02500 | ft/ft |
| Normal Depth | 2.00 | ft |
| Left Side Slope | 6.00 | ft/ft (H:V) |
| Right Side Slope | 6.00 | ft/ft (H:V) |
| Bottom Width | 20.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 548.77 | $ft^3/s$ |
| Flow Area | 64.00 | $ft^2$ |
| Wetted Perimeter | 44.33 | ft |
| Hydraulic Radius | 1.44 | ft |
| Top Width | 44.00 | ft |
| Critical Depth | 2.27 | ft |
| Critical Slope | 0.01538 | ft/ft |
| Velocity | 8.57 | ft/s |
| Velocity Head | 1.14 | ft |
| Specific Energy | 3.14 | ft |
| Froude Number | 1.25 | |
| Flow Type | Supercritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

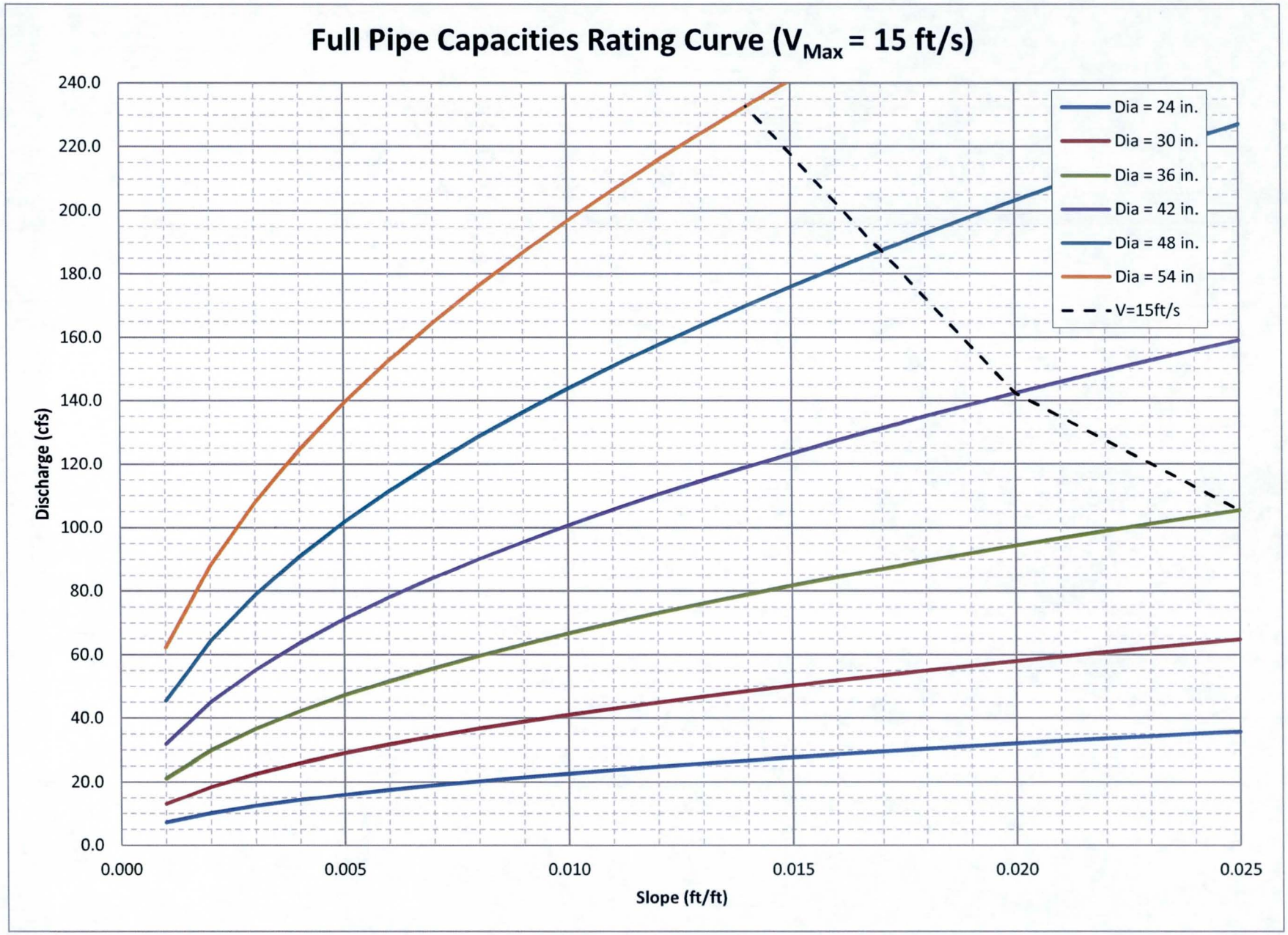
| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 2.00 | ft |
| Critical Depth | 2.27 | ft |
| Channel Slope | 0.02500 | ft/ft |

# Worksheet for Alt 4.5 100 cfs diversion channel

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.01538 | ft/ft |

# Miscellaneous Supporting Calculations




*Pipe Full Capacity Rating Table Model2.xlsx*

## Pipe Full Capacities

| n | Slope (ft/ft) | Dia = 36 in. | | | | | Dia = 42 in. | | | Dia = 48 in. | | | Dia = 54 in. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area, A (sq ft) | Perimeter, P (ft) | R = A/P (ft) | Velocity[1] (ft/s) | Discharge[2] (cfs) | Area (sq ft) | Velocity (ft/s) | Discharge (cfs) | Area (sq ft) | Velocity (ft/s) | Discharge (cfs) | Area (sq ft) | Velocity (ft/s) | Discharge (cfs) |
| 0.013 | 0.001 | 7.07 | 9.42 | 0.75 | 3.0 | 21.1 | 9.62 | 3.3 | 31.8 | 12.57 | 3.6 | 45.4 | 15.90 | 3.9 | 62.2 |
| 0.013 | 0.002 | 7.07 | 9.42 | 0.75 | 4.2 | 29.8 | 9.62 | 4.7 | 45.0 | 12.57 | 5.1 | 64.2 | 15.90 | 5.5 | 87.9 |
| 0.013 | 0.003 | 7.07 | 9.42 | 0.75 | 5.2 | 36.5 | 9.62 | 5.7 | 55.1 | 12.57 | 6.3 | 78.7 | 15.90 | 6.8 | 107.7 |
| 0.013 | 0.004 | 7.07 | 9.42 | 0.75 | 6.0 | 42.2 | 9.62 | 6.6 | 63.6 | 12.57 | 7.2 | 90.8 | 15.90 | 7.8 | 124.4 |
| 0.013 | 0.005 | 7.07 | 9.42 | 0.75 | 6.7 | 47.2 | 9.62 | 7.4 | 71.1 | 12.57 | 8.1 | 101.6 | 15.90 | 8.7 | 139.1 |
| 0.013 | 0.006 | 7.07 | 9.42 | 0.75 | 7.3 | 51.7 | 9.62 | 8.1 | 77.9 | 12.57 | 8.9 | 111.3 | 15.90 | 9.6 | 152.3 |
| 0.013 | 0.007 | 7.07 | 9.42 | 0.75 | 7.9 | 55.8 | 9.62 | 8.7 | 84.2 | 12.57 | 9.6 | 120.2 | 15.90 | 10.3 | 164.5 |
| 0.013 | 0.008 | 7.07 | 9.42 | 0.75 | 8.4 | 59.7 | 9.62 | 9.4 | 90.0 | 12.57 | 10.2 | 128.5 | 15.90 | 11.1 | 175.9 |
| 0.013 | 0.009 | 7.07 | 9.42 | 0.75 | 9.0 | 63.3 | 9.62 | 9.9 | 95.4 | 12.57 | 10.8 | 136.3 | 15.90 | 11.7 | 186.6 |
| 0.013 | 0.010 | 7.07 | 9.42 | 0.75 | 9.4 | 66.7 | 9.62 | 10.5 | 100.6 | 12.57 | 11.4 | 143.6 | 15.90 | 12.4 | 196.6 |
| 0.013 | 0.011 | 7.07 | 9.42 | 0.75 | 9.9 | 70.0 | 9.62 | 11.0 | 105.5 | 12.57 | 12.0 | 150.7 | 15.90 | 13.0 | 206.2 |
| 0.013 | 0.012 | 7.07 | 9.42 | 0.75 | 10.3 | 73.1 | 9.62 | 11.5 | 110.2 | 12.57 | 12.5 | 157.4 | 15.90 | 13.5 | 215.4 |
| 0.013 | 0.013 | 7.07 | 9.42 | 0.75 | 10.8 | 76.0 | 9.62 | 11.9 | 114.7 | 12.57 | 13.0 | 163.8 | 15.90 | 14.1 | 224.2 |
| 0.013 | 0.014 | 7.07 | 9.42 | 0.75 | 11.2 | 78.9 | 9.62 | 12.4 | 119.0 | 12.57 | 13.5 | 170.0 | 15.90 | 14.6 | 232.7 |
| 0.013 | 0.015 | 7.07 | 9.42 | 0.75 | 11.6 | 81.7 | 9.62 | 12.8 | 123.2 | 12.57 | 14.0 | 175.9 | 15.90 | 15.1 | 240.8 |
| 0.013 | 0.016 | 7.07 | 9.42 | 0.75 | 11.9 | 84.4 | 9.62 | 13.2 | 127.3 | 12.57 | 14.5 | 181.7 | 15.90 | 15.6 | 248.7 |
| 0.013 | 0.017 | 7.07 | 9.42 | 0.75 | 12.3 | 87.0 | 9.62 | 13.6 | 131.2 | 12.57 | 14.9 | 187.3 | 15.90 | 16.1 | 256.4 |
| 0.013 | 0.018 | 7.07 | 9.42 | 0.75 | 12.7 | 89.5 | 9.62 | 14.0 | 135.0 | 12.57 | 15.3 | 192.7 | 15.90 | 16.6 | 263.8 |
| 0.013 | 0.019 | 7.07 | 9.42 | 0.75 | 13.0 | 91.9 | 9.62 | 14.4 | 138.7 | 12.57 | 15.8 | 198.0 | 15.90 | 17.0 | 271.1 |
| 0.013 | 0.020 | 7.07 | 9.42 | 0.75 | 13.3 | 94.3 | 9.62 | 14.8 | 142.3 | 12.57 | 16.2 | 203.1 | 15.90 | 17.5 | 278.1 |
| 0.013 | 0.021 | 7.07 | 9.42 | 0.75 | 13.7 | 96.7 | 9.62 | 15.2 | 145.8 | 12.57 | 16.6 | 208.2 | 15.90 | 17.9 | 285.0 |
| 0.013 | 0.022 | 7.07 | 9.42 | 0.75 | 14.0 | 98.9 | 9.62 | 15.5 | 149.2 | 12.57 | 17.0 | 213.1 | 15.90 | 18.3 | 291.7 |
| 0.013 | 0.023 | 7.07 | 9.42 | 0.75 | 14.3 | 101.2 | 9.62 | 15.9 | 152.6 | 12.57 | 17.3 | 217.8 | 15.90 | 18.8 | 298.2 |
| 0.013 | 0.024 | 7.07 | 9.42 | 0.75 | 14.6 | 103.3 | 9.62 | 16.2 | 155.9 | 12.57 | 17.7 | 222.5 | 15.90 | 19.2 | 304.6 |
| 0.013 | 0.025 | 7.07 | 9.42 | 0.75 | 14.9 | 105.5 | 9.62 | 16.5 | 159.1 | 12.57 | 18.1 | 227.1 | 15.90 | 19.6 | 310.9 |

1. Flow Velocity, $V = (1.486/n)R^2S^{1/3}$
2. Discharge, Q = VA

## Summary of Pipe Capacities at Vmax = 15ft/s

| Pipe Size (in) | Velocity (ft/s) | Slope (ft/ft) | Discharge (cfs) |
|---|---|---|---|
| 24 | 15 | 0.043 | 46.91 |
| 30 | 15 | 0.032 | 73.37 |
| 36 | 15 | 0.025 | 105.46 |
| 42 | 15 | 0.020 | 142.28 |
| 48 | 15 | 0.017 | 187.29 |
| 54 | 15 | 0.014 | 232.68 |
| 60 | 15 | 0.012 | 285.30 |
| 66 | 15 | 0.011 | 352.20 |
| 72 | 15 | 0.010 | 423.51 |
| 78 | 15 | 0.009 | 497.37 |
| 84 | 15 | 0.008 | 571.39 |
| 90 | 15 | 0.007 | 642.45 |
| 96 | 15 | 0.006 | 706.49 |

# Culvert Designer/Analyzer Report
## Alt: General 24" Basin Outlet

| Analysis Component | | | |
|---|---|---|---|
| Storm Event | Design | Discharge | 32.00 cfs |

| Peak Discharge Method: User-Specified | | | |
|---|---|---|---|
| Design Discharge | 32.00 cfs | Check Discharge | 32.00 cfs |

| Tailwater Conditions: Constant Tailwater | |
|---|---|
| Tailwater Elevation | 0.00 ft |

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 1-24 inch Circular | 32.00 cfs | 110.20 ft | 10.41 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |

# Culvert Designer/Analyzer Report
## Alt: General 24" Basin Outlet

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev: | 110.20 | ft | Discharge | 32.00 | cfs |
| Inlet Control HW Elev. | 105.30 | ft | Tailwater Elevation | 0.00 | ft |
| Outlet Control HW Elev. | 110.20 | ft | Control Type | Outlet Control | |
| Headwater Depth/Height | 5.10 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.89 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.89 | ft |
| Velocity Downstream | 10.41 | ft/s | Critical Slope | 0.058982 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.024 | |
| Section Material | CMP | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 110.20 | ft | Upstream Velocity Head | 1.61 | ft |
| Ke | 0.50 | | Entrance Loss | 0.81 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 105.30 | ft | Flow Control | N/A | |
| Inlet Type | Headwall | | Area Full | 3.1 | $ft^2$ |
| K | 0.00780 | | HDS 5 Chart | 2 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03790 | | Equation Form | 1 | |
| Y | 0.69000 | | | | |

# Culvert Designer/Analyzer Report
## Alt: General 36" Basin Outlet

| Analysis Component | | | |
|---|---|---|---|
| Storm Event | Design | Discharge | 100.00 cfs |

| Peak Discharge Method: User-Specified | | | |
|---|---|---|---|
| Design Discharge | 100.00 cfs | Check Discharge | 100.00 cfs |

| Tailwater Conditions: Constant Tailwater | |
|---|---|
| Tailwater Elevation | 0.00 ft |

| Name | Description | Discharge | HW Elev. | Velocity |
|---|---|---|---|---|
| Culvert-1 | 1-36 inch Circular | 100.00 cfs | 109.96 ft | 14.30 ft/s |
| Weir | Not Considered | N/A | N/A | N/A |



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# Culvert Designer/Analyzer Report
## Alt: General 36" Basin Outlet

Component:Culvert-1

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Computed Headwater Elev | 109.96 | ft | Discharge | 100.00 | cfs |
| Inlet Control HW Elev. | 109.96 | ft | Tailwater Elevation | 0.00 | ft |
| Outlet Control HW Elev. | 108.87 | ft | Control Type | Inlet Control | |
| Headwater Depth/Height | 3.32 | | | | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.90 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.90 | ft |
| Velocity Downstream | 14.30 | ft/s | Critical Slope | 0.019679 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 3.00 | ft |
| Section Size | 36 inch | | Rise | 3.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 108.87 | ft | Upstream Velocity Head | 3.11 | ft |
| Ke | 0.50 | | Entrance Loss | 1.56 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 109.96 | ft | Flow Control | Submerged | |
| Inlet Type | Square edge w/headwall | | Area Full | 7.1 | $ft^2$ |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

## Hohokam ADMS/P

## Summary of Detention Basins Calculations

| Basin ID | Basin Volume | | | | Elevations | | | Depth | |
|---|---|---|---|---|---|---|---|---|---|
| | Excavation (cu yd) | Actual 10-Yr Provided (cu yd) | Actual 10-Yr Provided (acre-ft) | ~Max. Avail. (acre-ft) | Bottom (ft) | 10Yr WSEL (ft) | Max (ft) | Stored (ft) | Max (ft) |
| | | | | | | | | | |
| 3.1 | 40,624 | 22,773 | 14.12 | 15.12 | 1,234.00 | 1,239.60 | 1,248.52 | 5.60 | 14.52 |
| 5 | 37,554 | 2,740 | 1.70 | 16.98 | 1,202.00 | 1,202.60 | 1,212.41 | 0.60 | 10.41 |
| 6 | 6,711 | 4,800 | 2.98 | 2.98 | 1,210.00 | 1,216.00 | 1,219.65 | 6.00 | 9.65 |
| 8 | 37,376 | 37,000 | 22.93 | 22.93 | 1,166.00 | 1,172.00 | 1,173.45 | 6.00 | 7.45 |
| 9.4 | 25,707 | 10,780 | 6.68 | 12.15 | 1,197.00 | 1,200.30 | 1,206.74 | 3.30 | 9.74 |
| 10 | 33,199 | 11,220 | 6.95 | 12.64 | 1,257.00 | 1,260.30 | 1,271.85 | 3.30 | 14.85 |
| 11 | 32,222 | 24,567 | 15.23 | 15.23 | 1,210.00 | 1,216.70 | 1,221.80 | 6.70 | 11.80 |
| 12 | 173,513 | 33,273 | 20.62 | 53.80 | 1,190.00 | 1,192.30 | 1,208.01 | 2.30 | 18.01 |
| 13 | 279,820 | 4,827 | 2.99 | 89.75 | 1,190.00 | 1,190.20 | 1,207.04 | 0.20 | 17.04 |
| 14 | 27,409 | 9,093 | 5.64 | 10.91 | 1,229.00 | 1,232.10 | 1,240.92 | 3.10 | 11.92 |
| 15.1 | 6,517 | 5,200 | 3.22 | 3.22 | 1,237.50 | 1,244.00 | 1,248.09 | 6.50 | 10.59 |
| 15.2 | 5,147 | 4,427 | 2.74 | 2.74 | 1,242.00 | 1,250.30 | 1,255.98 | 8.30 | 13.98 |
| 16 | 33,129 | 19,630 | 12.17 | 18.72 | 1,207.00 | 1,210.90 | 1,215.34 | 3.90 | 8.34 |
| 17.1 | 27,475 | 7,207 | 4.47 | 11.65 | 1,198.00 | 1,200.30 | 1,212.66 | 2.30 | 14.66 |
| 17.2 | 13,616 | 4,840 | 3.00 | 5.45 | 1,200.00 | 1,203.30 | 1,213.98 | 3.30 | 13.98 |
| 18 | 15,719 | 5,220 | 3.24 | 6.69 | 1,234.00 | 1,236.90 | 1,247.12 | 2.90 | 13.12 |
| 19 | 9,741 | 6,083 | 3.77 | 3.77 | 1,232.00 | 1,239.30 | 1,246.64 | 7.30 | 14.64 |
| 23 | 13,652 | 2,090 | 1.30 | 7.07 | 1,202.00 | 1,203.10 | 1,211.79 | 1.10 | 9.79 |
| 24 | 25,241 | 10,140 | 6.29 | 14.50 | 1,216.00 | 1,218.60 | 1,224.54 | 2.60 | 8.54 |
| 25 | 13,990 | 3,357 | 2.08 | 6.57 | 1,210.00 | 1,211.90 | 1,220.16 | 1.90 | 10.16 |
| | | | | | | | | | |

## Hohokam ADMS/P
## Summary of Detention Basins by Alternative

| Alternative | Basin | Area (acre) | Basin Volume: Actual 10-Yr Provided (acre-ft) | Basin Volume: ~Max Avail. (acre-ft) | Basin Volume: Total Excavation (cu yd) | Basin Volume: Total Excavation (acre-ft) | Basin Volume: Waste Excavation (cu yd) | Basin Volume: Waste Excavation (acre-ft) | Depth: 10-Year (ft) | Depth: Max (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **1.1** | 3.1 | 3.69 | 14.12 | 15.12 | 40,624 | 25.18 | 17,851 | 11.06 | 5.60 | 14.52 |
| | 24 | 2.56 | 6.29 | 14.50 | 25,241 | 15.65 | 15,101 | 9.36 | 2.60 | 8.54 |
| | 25 | 1.47 | 2.08 | 6.57 | 13,990 | 8.67 | 10,634 | 6.59 | 1.90 | 10.16 |
| | 5 | 3.94 | 1.70 | 16.98 | 37,554 | 23.28 | 34,814 | 21.58 | 0.60 | 10.41 |
| | 23 | 1.55 | 1.30 | 7.07 | 13,652 | 8.46 | 11,562 | 7.17 | 1.10 | 9.79 |
| | 6 | 1.91 | 2.98 | 2.98 | 6,711 | 4.16 | 1,911 | 1.18 | 6.00 | 9.65 |
| **Total** | | **15.12** | **28.45** | **63.22** | **137,771** | **85.40** | **91,871** | **56.95** | | |
| | | | | | | | | | | |
| **2.1** | 10 | 4.14 | 6.95 | 12.64 | 33,199 | 20.58 | 21,979 | 13.62 | 3.30 | 14.85 |
| | 11 | 3.57 | 15.23 | 15.23 | 32,222 | 19.97 | 7,655 | 4.74 | 6.70 | 11.80 |
| | 9.4 | 4.00 | 6.68 | 12.15 | 25,707 | 15.93 | 14,927 | 9.25 | 3.30 | 9.74 |
| **Total** | | **11.71** | **28.86** | **40.02** | **91,128** | **56.48** | **44,561** | **27.62** | | |
| | | | | | | | | | | |
| **3.5** | 15.1 | 0.97 | 3.22 | 3.22 | 6,517 | 4.04 | 1,317 | 0.82 | 6.50 | 10.59 |
| | 15.2 | 1.13 | 2.74 | 2.74 | 5,147 | 3.19 | 721 | 0.45 | 8.30 | 13.98 |
| | 14 | 2.90 | 5.64 | 10.91 | 27,409 | 16.99 | 18,316 | 11.35 | 3.10 | 11.92 |
| | 12 | 12.55 | 20.62 | 53.80 | 173,513 | 107.55 | 140,240 | 86.93 | 2.30 | 18.01 |
| **Total** | | **17.55** | **32.23** | **70.68** | **212,587** | **131.77** | **160,593** | **99.54** | | |
| | | | | | | | | | | |
| **4.1** | 18 | 2.47 | 3.24 | 6.69 | 15,719 | 9.74 | 10,499 | 6.51 | 2.90 | 13.12 |
| | 19 | 1.50 | 3.77 | 3.77 | 9,741 | 6.04 | 3,658 | 2.27 | 7.30 | 14.64 |
| | 16 | 3.58 | 12.17 | 18.72 | 33,129 | 20.53 | 13,499 | 8.37 | 3.90 | 8.34 |
| | 13 | 18.84 | 2.99 | 89.75 | 279,820 | 173.44 | 274,993 | 170.45 | 0.20 | 17.04 |
| **Total** | | **26.39** | **22.17** | **118.94** | **338,409** | **209.76** | **302,649** | **187.59** | | |
| | | | | | | | | | | |
| **4.5** | 17.1 | 1.73 | 4.47 | 11.65 | 27,475 | 17.03 | 20,268 | 12.56 | 2.30 | 14.66 |
| | 17.2 | 1.89 | 3.00 | 5.45 | 13,616 | 8.44 | 8,776 | 5.44 | 3.30 | 13.98 |
| **Total** | | **3.62** | **7.47** | **17.11** | **41,090** | **25.47** | **29,044** | **18.00** | | |
| | | | | | | | | | | |

# APPENDIX C

# Cost Estimates

## Summary of Level 2 Alternatives Cost Estimates

| Alternative | Estimated Cost (rounded to $1000) | | |
|---|---|---|---|
| | Construction & Design | Land Acquisition | Total |
| | | | |
| Alternative 1.1 (Circle K Park) | $8,572,000 | $1,773,000 | $10,345,000 |
| Alternative 2.1 (BSC Area) | $5,520,000 | $1,198,000 | $6,718,000 |
| Alternative 3.5 (Natural Wash) | $6,471,000 | $3,048,000 | $9,519,000 |
| Alternative 4.1 (F.H. Park) | $9,059,000 | $3,629,000 | $12,688,000 |
| Alternative 4.5 (Cortland Pt) | $2,111,000 | $460,000 | $2,571,000 |
| | | | |
| **Total of Alternatives** | **$31,733,000** | **$10,108,000** | **$41,841,000** |
| | | | |

**Level 2 Cost Estimate** **Alternative 1.1 (Circle K Park)**

| Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|
| **Construction Costs** | | | | |
| Misc. Removals (pavement, fencing, culverts, etc...) | LS | 1 | $75,000 | $75,000 |
| Basins | | | | |
| Basin 3.1 | CY | 48,749 | $8.40 | $409,490 |
| Basin 5 | CY | 45,065 | $8.40 | $378,544 |
| Basin 6 | CY | 8,053 | $8.40 | $67,647 |
| Basin 23 | CY | 16,382 | $8.40 | $137,612 |
| Basin 24 | CY | 30,289 | $8.40 | $254,429 |
| Basin 25 | CY | 16,788 | $8.40 | $141,019 |
| Channels | | | | |
| Location 1 (Dobbins - E of 16St) | CY | 3,400 | $17.35 | $58,976 |
| Location 2 (15 St - South of Dobbins) | CY | 13,400 | $17.35 | $232,435 |
| Location 3 (15 St - North of Dobbins) | CY | 24,200 | $17.35 | $419,771 |
| Location 4 (16 St to Basin 3.1) | CY | 4,300 | $17.35 | $74,587 |
| Storm Drains | | | | |
| Basin 3.1 outlet to Basin 24 - 36" | LF | 930 | $220 | $204,600 |
| Basin 6 outlet to Basin 5 - 36" | LF | 1,210 | $220 | $266,200 |
| 17th Way/S Mtn to Basin 6 - 36" | LF | 1,900 | $220 | $418,000 |
| Euclid to Basin 3.1 - 36" | LF | 1110 | $220 | $244,200 |
| 15th Street - 24" | LF | 640 | $160 | $102,400 |
| Basin 24 outlet to Basin 25 - 36" | LF | 130 | $220 | $28,600 |
| Basin 25 outlet to Basin 5 - 36" | LF | 240 | $220 | $52,800 |
| Basin 23 outlet to Basin 5 - 36" | LF | 350 | $220 | $77,000 |
| Basin 5 outlet - 24" (constructed as part of another project) | LF | 0 | $160 | $0 |
| RCB Culvert (15 St & Dobbins) (complete) | LF | 130 | $2,200 | $286,000 |
| RCB Culvert (16 St & Dobbins) (complete) | LF | 120 | $1,200 | $144,000 |
| Utility Relocations | | | | |
| Sanitary | EA | 8 | $5,000 | $40,000 |
| Water | EA | 14 | $10,000 | $140,000 |
| Irrigation | LS | | | |
| Landscaping (Basin) | AC | 17.2 | $50,000 | $860,000 |
| Landscaping (Channels) | MI | 0.5 | $100,000 | $45,000 |
| Park Reconstruction (Circle K Park) | LS | 1 | $1,000,000 | $1,000,000 |
| **Subtotal Construction** | | | | **$6,158,312** |
| Contingency (20%) | | | | $1,231,662 |
| **Subtotal Construction (w/Contingency)** | | | | **$7,389,975** |
| Design Cost (10% incl. Contingency Cost) | | | | $738,997 |
| Construction Administration (6% incl. Contingency Cost)) | | | | $443,398 |
| **Total Construction & Design Costs (rounded to $1000)** | | | | **$8,572,000** |
| | | | | |
| **Total Estimated Cost of Land Acquisition (rounded to $1000)** | | | | **$1,773,000** |
| | | | | |
| | | | **TOTAL ALTERNATIVE COST ESTIMATE** | **$10,345,000** |

## Level 2 Cost Estimate - Land Acquisition

**Alternative 1.1 (Circle K Park)**

| Reason for Acquisition | Parcel Parcel APN | Location | Area (sq ft) | Area (acre) | Take | Parcel Status | Zoning | Unit Cost (per sq ft) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Channel along 15th St | 300-72-004Y | 15th St, S of Dobbins | 43,741 | 1.00 | Full | Vacant | Residential | $2.00 | $87,482 |
| Channel along 15th St | 300-72-004Z | 15th St, S of Dobbins | 44,635 | 1.02 | Partial | Vacant | Residential | $2.00 | $89,270 |
| Channel & Basins 3.1 | 300-39-001E | 14th St, S of Euclid | 290,625 | 6.67 | Partial | Occupied | Residential | $3.00 | $871,875 |
| Basin 3.1 | 300-39-005T | 15th-16th St, S of Euclid | 44,152 | 1.01 | Full | Vacant | Residential | $2.00 | $88,304 |
| Basin 3.1 | 300-39-005Q | 15th-16th St, S of Euclid | 43,560 | 1.00 | Full | Vacant | Residential | $2.00 | $87,120 |
| Basin 3.1 | 300-39-141 | 15th-16th St, S of Euclid | 39,435 | 0.91 | Full | Vacant | Residential | $2.00 | $78,870 |
| Basin 3.1 | 300-39-005E | 15th-16th St, S of Euclid | 33,387 | 0.77 | Full | Vacant | Residential | $2.00 | $66,774 |
| Channel from MVE to Basin 3.1 | 300-39-133 | 16th St, S of Euclid | 17,384 | 0.40 | Partial | Vacant | Residential | $2.00 | $34,768 |
| Channel from MVE to Basin 3.1 | 300-39-140A | 16th St, S of Euclid | 13,512 | 0.31 | Partial | Occupied | Residential | $3.00 | $40,536 |
| Grading for MVE culvert inlet | 300-39-005N | NW 16th St & Dobbins | 29,914 | 0.69 | Full | Vacant | Residential | $2.00 | $59,828 |
| Channel along Dobbins & culvert inlet | 301-37-005A | 16th St & Dobbins (Girl Scouts) | 17,972 | 0.41 | Partial | Occupied | Residential | $3.00 | $53,916 |
| Channel along Dobbins & culvert inlet | 301-37-001H | 16th St & Dobbins (Girl Scouts) | 15,971 | 0.37 | Partial | Occupied | Residential | $3.00 | $47,913 |
| Basin 6 | 300-23-024M | NW 16th St & S Mtn | 34,314 | 0.79 | Full | Vacant | Residential | $2.00 | $68,628 |
| Basin 6 | 300-23-024J | NW 16th St & S Mtn | 48,696 | 1.12 | Full | Vacant | Residential | $2.00 | $97,392 |
| Basins 5, 23, 24, & 25 | Multiple | Circle K Park | - | - | - | Park | Park | $2.00 | $0 |
| | | | **717,298** | **16.47** | | | | | |
| | | | | | | | | **Total Acquisition (rounded to $1000)** | **$1,773,000** |

**Level 2 Cost Estimate** **Alternative 2.1 (BSC Area)**

| Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|
| **Construction Costs** | | | | |
| Misc. Removals (pavement, fencing, culverts, etc...) | LS | 1 | $25,000 | $25,000 |
| Basins | | | | |
| Basin 10 | CY | 39,839 | $8.40 | $334,646 |
| Basin 11 | CY | 38,666 | $8.40 | $324,798 |
| Basin 9.4 | CY | 30,848 | $8.40 | $259,127 |
| Channels | | | | |
| Location 1 (21st Pl - South of Euclid) | CY | 3,900 | $17.35 | $67,649 |
| Location 2 (North of BSC) | CY | 7,700 | $17.35 | $133,564 |
| Storm Drains | | | | |
| Euclid 21st Place to Basin 10 outfall - 36" | LF | 533 | $220 | $117,260 |
| Euclid Basin 10 outfall to 20th St - 48" | LF | 539 | $270 | $145,530 |
| 19th St / S. Mountain Ave. - 48" | LF | 2,387 | $270 | $644,490 |
| 20th St to Basin 11 - 54" | LF | 2138 | $300 | $641,400 |
| Basin 11 to Basin 9.4 - 36" | LF | 622 | $220 | $136,840 |
| Basin 9.4 outlet - 24" | LF | 2812 | $160 | $449,920 |
| Utility Relocations | | | | |
| Sanitary | EA | 5 | $5,000 | $25,000 |
| Water | EA | 10 | $10,000 | $100,000 |
| Irrigation | LS | | | |
| Landscaping (Basin) | AC | 11.0 | $50,000 | $550,000 |
| Landscaping (Channels) | MI | 0.1 | $100,000 | $10,000 |
| **Subtotal Construction** | | | | **$3,965,223** |
| Contingency (20%) | | | | $793,045 |
| **Subtotal Construction (w/Contingency)** | | | | **$4,758,268** |
| Design Cost (10% incl. Contingency Cost) | | | | $475,827 |
| Construction Administration (6% incl. Contingency Cost)) | | | | $285,496 |
| **Total Construction & Design Costs (rounded to $1000)** | | | | **$5,520,000** |
| | | | | |
| **Total Estimated Cost of Land Acquisition (rounded to $1000)** | | | | **$1,198,000** |
| | | | | |

**TOTAL ALTERNATIVE COST ESTIMATE** **$6,718,000**

## Level 2 Cost Estimate - Land Acquisition

**Alternative 2.1 (BSC Area)**

| Reason for Acquisition | Parcel Parcel APN | Location | Area (sq ft) | Area (acre) | Take | Parcel Status | Zoning | Unit Cost (per sq ft) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Basin 10 | 301-36-028C | BSC (W of Main Area) | 180,447 | 4.14 | Partial | Vacant | Tax Exempt | $2.00 | $360,894 |
| Basin 11 | 301-32-026F | NE Desert Ln & 20th St | 155,683 | 3.57 | Partial | Occupied | Residential | $2.00 | $311,366 |
| Basin 9.4 | 301-33-002D | NE Highline Canal & 20th St | 174,403 | 4.00 | Partial | Occupied | Religious Use | $2.00 | $348,806 |
| Grade Wash d/s of BSC | 301-34-136A | N of Dobbins at BSC | 79,784 | 1.83 | Partial | Occupied | Religious Use | $2.00 | $159,568 |
| Grade Wash culvert inlet | 301-34-156 | Mountainside Estates HOA | 4,765 | 0.11 | Partial | Vacant | HOA Open Space | $2.00 | $9,530 |
| 22nd Pl Channel South of Euclid | 301-36-142 | SE of 22nd Pl & Euclid Ave | 3,879 | 0.09 | Partial | Vacant | Residential | $2.00 | $7,758 |
| | | | **598,961** | **13.75** | | | | | |
| | | | | | | | | **Total Acquisition (rounded to $1000)** | **$1,198,000** |

**Level 2 Cost Estimate** **Alternative 3.5 (Natural Wash)**

| Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|
| **Construction Costs** | | | | |
| Misc. Removals (pavement, fencing, culverts, etc...) | LS | 1 | $25,000 | $25,000 |
| Basins | | | | |
| Basin 15.2 | CY | 6,176 | $8.40 | $51,882 |
| Basin 15.1 | CY | 7,820 | $8.40 | $65,691 |
| Basin 14 | CY | 32,891 | $8.40 | $276,283 |
| Basin 12 | CY | 208,216 | $8.40 | $1,749,011 |
| Channels | | | | |
| Location 1 (Basin 14 to Basin 12) | CY | 23,800 | $17.35 | $412,833 |
| Storm Drains | | | | |
| Basin 12 outlet - 24" | LF | 583 | $160 | $93,280 |
| RCB Culvert (S. Mountain Ave) (complete) | LF | 184 | $2,200 | $404,800 |
| RCB Culvert (Desert Ln) (complete) | LF | 99 | $2,200 | $217,800 |
| RCB Culvert (Highline Canal) (complete) | LF | 202 | $2,200 | $444,400 |
| Utility Relocations | | | | |
| Sanitary | EA | 1 | $5,000 | $5,000 |
| Water | EA | 2 | $10,000 | $20,000 |
| Irrigation | LS | | | |
| Landscaping (Basin) | AC | 17.3 | $50,000 | $862,500 |
| Landscaping (Channels) | MI | 0.2 | $100,000 | $20,000 |
| **Subtotal Construction** | | | | **$4,648,480** |
| Contingency (20%) | | | | $929,696 |
| **Subtotal Construction (w/Contingency)** | | | | **$5,578,176** |
| Design Cost (10% incl. Contingency Cost) | | | | $557,818 |
| Construction Administration (6% incl. Contingency Cost)) | | | | $334,691 |
| **Total Construction & Design Costs (rounded to $1000)** | | | | **$6,471,000** |
| | | | | |
| **Total Estimated Cost of Land Acquisition (rounded to $1000)** | | | | **$3,048,000** |
| | | | | |
| | | | **TOTAL ALTERNATIVE COST ESTIMATE** | **$9,519,000** |

## Level 2 Cost Estimate - Land Acquisition

**Alternative 3.5 (Natural Wash)**

| Reason for Acquisition | Parcel Parcel APN | Location | Area (sq ft) | Area (acre) | Take | Parcel Status | Zoning | Unit Cost (per sq ft) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Basin 15.1 & 15.2 | 301-36-037E | S Mtn Ave W of 24th St | 99,734 | 2.29 | Full | Vacant | Residential | $2.00 | $199,468 |
| Basin 14 | 301-31-014A | N of S Mtn Ave, W of 24th St | 6,570 | 0.15 | Full | Vacant | Residential | $2.00 | $13,140 |
| Basin 14 | 301-31-014B | N of S Mtn Ave, W of 24th St | 17,471 | 0.40 | Full | Vacant | Residential | $2.00 | $34,942 |
| Basin 14 | 301-31-013 | N of S Mtn Ave, W of 24th St | 23,740 | 0.54 | Full | Vacant | Residential | $2.00 | $47,480 |
| Basin 14 | 301-31-012 | N of S Mtn Ave, W of 24th St | 47,059 | 1.08 | Full | Vacant | Residential | $2.00 | $94,118 |
| Basin 14 | 301-31-016 | N of S Mtn Ave, W of 24th St | 31,562 | 0.72 | Full | Vacant | Residential | $2.00 | $63,124 |
| Channel from Basin 14 to Basin 12 | 301-31-020F | S of Desert Ln | 15,176 | 0.35 | Full | Vacant | Residential | $2.00 | $30,352 |
| Channel from Basin 14 to Basin 12 | 301-31-020D | S of Desert Ln | 15,184 | 0.35 | Full | Vacant | Residential | $2.00 | $30,368 |
| Channel from Basin 14 to Basin 12 | 301-31-029 | N of Desert Ln | 107,177 | 2.46 | Full | Occupied | Residential | $3.25 | $348,325 |
| Basin 12 | 301-30-003E | NW Highline Canal & 24th St | 159,815 | 3.67 | Partial | Vacant | Commercial | $4.00 | $639,260 |
| Basin 12 | 301-30-002A | NW Highline Canal & 24th St | 187,792 | 4.31 | Partial | Vacant | Commercial | $4.00 | $751,168 |
| Basin 12 | 301-30-001B | NW Highline Canal & 24th St | 175,015 | 4.02 | Full | Vacant | Commercial | $4.00 | $700,060 |
| Basin 12 | 301-30-308 | NW Highline Canal & 24th St | 11,894 | 0.27 | Partial | Vacant | Commercial | $4.00 | $47,576 |
| Basin 12 | 301-30-307 | NW Highline Canal & 24th St | 12,236 | 0.28 | Partial | Vacant | Commercial | $4.00 | $48,944 |
| | | | **910,425** | **20.90** | | | | | |
| | | | | | | | | **Total Acquisition (rounded to $1000)** | **$3,048,000** |

**Level 2 Cost Estimate** **Alternative 4.1 (F.H. Park)**

| Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|
| **Construction Costs** | | | | |
| Misc. Removals (pavement, fencing, culverts, etc...) | LS | 1 | $25,000 | $25,000 |
| Basins | | | | |
| Basin 18 | CY | 18,863 | $8.40 | $158,448 |
| Basin 19 | CY | 11,689 | $8.40 | $98,189 |
| Basin 16 | CY | 39,755 | $8.40 | $333,940 |
| Basin 13 | CY | 335,784 | $8.40 | $2,820,586 |
| Storm Drains | | | | |
| Basin 18 outlet to Basin 16 - 24" | LF | 1,338 | $160 | $214,080 |
| Basin 19 outlet - 24" | LF | 113 | $160 | $18,080 |
| S. Mountain Ave (East of 28th St) - 36" | LF | 2,292 | $220 | $504,240 |
| S. Mountain Ave (West of 27th St) - 24" | LF | 981 | $160 | $156,960 |
| Basin 16 to Basin 13 - 36" | LF | 1100 | $220 | $242,000 |
| Basin 13 outlet - 24" | LF | 883 | $160 | $141,280 |
| Utility Relocations | | | | |
| Sanitary | EA | 1 | $5,000 | $5,000 |
| Water | EA | 6 | $10,000 | $60,000 |
| Irrigation | LS | | | |
| Landscaping (Basin) | AC | 26.6 | $50,000 | $1,330,000 |
| Park Reconstruction (Francisco Highland Park) | LS | 1 | $400,000 | $400,000 |
| **Subtotal Construction** | | | | **$6,507,803** |
| Contingency (20%) | | | | $1,301,561 |
| **Subtotal Construction (w/Contingency)** | | | | **$7,809,363** |
| Design Cost (10% incl. Contingency Cost) | | | | $780,936 |
| Construction Administration (6% incl. Contingency Cost)) | | | | $468,562 |
| **Total Construction & Design Costs (rounded to $1000)** | | | | **$9,059,000** |
| | | | | |
| **Total Estimated Cost of Land Acquisition (rounded to $1000)** | | | | **$3,629,000** |
| | | | | |
| | | | **TOTAL ALTERNATIVE COST ESTIMATE** | **$12,688,000** |

## Level 2 Cost Estimate - Land Acquisition

**Alternative 4.1 (F.H. Park)**

| Reason for Acquisition | Parcel Parcel APN | Location | Area (sq ft) | Area (acre) | Take | Parcel Status | Zoning | Unit Cost (per sq ft) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Basin 16 | 301-26-012D | Francisco Highland Park | - | - | - | Park | Park | | $0 |
| Basin 18 | 301-28-047 | Cactus Lane & Patricia St | 31,969 | 0.73 | Full | Vacant | Residential | $2.00 | $63,938 |
| Basin 18 | 301-28-048 | Patricia St S of Winston | 42,286 | 0.97 | Full | Vacant | Residential | $2.00 | $84,572 |
| Basin 18 | 301-28-049 | Patricia St S of Winston | 33,491 | 0.77 | Full | Vacant | Residential | $2.00 | $66,982 |
| Basin 19 | 301-26-021 | SE of Winston & Patricia | 34,932 | 0.80 | Full | Vacant | Residential | $2.00 | $69,864 |
| Basin 19 | 301-26-007 | SE of Winston & Patricia | 30,270 | 0.69 | Full | Vacant | Residential | $2.00 | $60,540 |
| Basin 13 | 301-26-694 | NE of 24th St & Highline Canal | 820,756 | 18.84 | Full | Vacant | Commercial | $4.00 | $3,283,024 |
| | | | **993,704** | **22.81** | | | | | |
| | | | | | | | | **Total Acquisition (rounded to $1000)** | **$3,629,000** |

**Level 2 Cost Estimate** **Alternative 4.5 (Cortland Pt)**

| Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|
| **Construction Costs** | | | | |
| Misc. Removals (pavement, fencing, culverts, etc...) | LS | 1 | $25,000 | $25,000 |
| Basins | | | | |
| Basin 17.1 | CY | 32,970 | $8.40 | $276,948 |
| Basin 17.2 | CY | 16,339 | $8.40 | $137,249 |
| Channels | | | | |
| Location 1 (South Highline Canal) | CY | 8,700 | $17.35 | $150,910 |
| Storm Drains | | | | |
| Highline Canal - 36" | LF | 1,528 | $220 | $336,160 |
| Highline Canal to Basin 17.2 - 6-36" | LF | 1,092 | $220 | $240,240 |
| Basin 17.2 to Basin 17.1 - 36" | LF | 129 | $220 | $28,380 |
| Floodwall | LF | 1,434 | $50 | $71,700 |
| Utility Relocations | | | | |
| Sanitary | EA | 2 | $5,000 | $10,000 |
| Water | EA | 4 | $10,000 | $40,000 |
| Irrigation | LS | | | |
| Landscaping (Basin) | AC | 3.6 | $50,000 | $180,000 |
| Landscaping (Channels) | MI | 0.2 | $100,000 | $20,000 |
| **Subtotal Construction** | | | | **$1,516,587** |
| Contingency (20%) | | | | $303,317 |
| **Subtotal Construction (w/Contingency)** | | | | **$1,819,904** |
| Design Cost (10% incl. Contingency Cost) | | | | $181,990 |
| Construction Administration (6% incl. Contingency Cost)) | | | | $109,194 |
| **Total Construction & Design Costs (rounded to $1000)** | | | | **$2,111,000** |
| | | | | |
| **Total Estimated Cost of Land Acquisition (rounded to $1000)** | | | | **$460,000** |
| | | | | |

**TOTAL ALTERNATIVE COST ESTIMATE** **$2,571,000**

## Level 2 Cost Estimate - Land Acquisition

**Alternative 4.5 (Cortland Pt)**

| Reason for Acquisition | Parcel Parcel APN | Location | Area (sq ft) | Area (acre) | Take | Parcel Status | Zoning | Unit Cost (per sq ft) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Collection Basin | 301-23-004B | S of Highline Canal at 34th Pl | 8,122 | 0.19 | Full | Vacant | Residential | $2.00 | $16,244 |
| Collection Basin | 301-23-013C | S of Highline Canal at 34th Pl | 10,633 | 0.24 | Full | Vacant | Residential | $2.00 | $21,266 |
| Inlets/Collection basins | 301-23-017Z | Between Highline Canal & Rd | 2,123 | 0.05 | Full | Vacant | Residential | $2.00 | $4,246 |
| Inlets/Collection basins | 301-23-017Y | Between Highline Canal & Rd | 2,127 | 0.05 | Full | Vacant | Residential | $2.00 | $4,254 |
| Divert & Channelize Wash | 301-23-124 | S of Highline Canal Rd | 38,140 | 0.88 | Partial | Occupied | Residential | $2.00 | $76,280 |
| Divert & Channelize Wash | 301-20-012B | S of Highline Canal Rd | 10,889 | 0.25 | Partial | Vacant | Residential | $2.00 | $21,778 |
| Basin 17.1 | 301-20-010J | 36th St & Highline Canal | 18,122 | 0.42 | Full | Vacant | Residential | $2.00 | $36,244 |
| Basin 17.1 | 301-20-220 | 36th St & Highline Canal | 18,580 | 0.43 | Full | Vacant | Residential | $2.00 | $37,160 |
| Basin 17.1 | 301-20-221 | 36th St & Highline Canal | 21,311 | 0.49 | Full | Vacant | Residential | $2.00 | $42,622 |
| Basin 17.1 | 301-20-222 | 36th St & Highline Canal | 17,295 | 0.40 | Full | Vacant | Residential | $2.00 | $34,590 |
| Basin 17.2 | 301-20-049B | 36th St & Highline Canal | 24,545 | 0.56 | Full | Vacant | Residential | $2.00 | $49,090 |
| Basin 17.2 | 301-20-050 | 36th St & Highline Canal | 57,943 | 1.33 | Full | Vacant | Residential | $2.00 | $115,886 |
| | | | **229,830** | **5.28** | | | | | |
| | | | | | | | | **Total Acquisition (rounded to $1000)** | **$460,000** |

## Summary of Basin Excavation and Retention Volume

| Basin ID | Description | Volume | | |
|---|---|---|---|---|
| | | Raw Excavation (cy) | Adjusted Excavation (cy) | Retention (acre-ft) |
| | | | | |
| 3.1 | 16 St & Dobbins | 40,624 | 48,749 | 14.12 |
| 5 | Circle K Park NE Ballfield | 37,554 | 45,065 | 1.70 |
| 6 | 16 St & S. Mtn | 6,711 | 8,053 | 2.98 |
| 8 | 16 St & Baseline | 37,376 | 44,851 | 22.93 |
| 9.4 | 20 St & Baseline | 25,707 | 30,848 | 6.68 |
| 10 | Siesta Foothills | 33,199 | 39,839 | 6.95 |
| 11 | 20 St & Desert Ln | 32,222 | 38,666 | 15.23 |
| 12 | 24th St & Highline | 173,513 | 208,216 | 20.62 |
| 13 | 24th St & Highline | 279,820 | 335,784 | 2.99 |
| 14 | 22 Pl & S Mtn | 27,409 | 32,891 | 10.91 |
| 15.1 | 22 Pl & S Mtn | 6,517 | 7,820 | 3.22 |
| 15.2 | 22 Pl & S Mtn | 5,147 | 6,176 | 2.74 |
| 16 | Francisco Highland Park | 33,129 | 39,755 | 12.17 |
| 17.1 | 36 St & Beverly | 27,475 | 32,970 | 4.47 |
| 17.2 | 36 St & Beverly | 13,616 | 16,339 | 3.00 |
| 18 | Patricia & Winston | 15,719 | 18,863 | 3.24 |
| 19 | 27 St & Winston | 9,741 | 11,689 | 3.77 |
| 23 | Circle K Park NW Basin | 13,652 | 16,382 | 1.30 |
| 24 | Circle K Park S Basin | 25,241 | 30,289 | 6.29 |
| 25 | Circle K Park SE Basin | 13,990 | 16,788 | 2.08 |

| | |
|---|---|
| **Excavation Adjustment Factor** | **1.2** |

## Summary of Channel Excavation by Alternative Based Conceptual Channels

| Alternative | Channel Description Description | Calculated Excavation Length (ft) | Width$_B$ (ft) | Width$_T$ (ft) | Depth (ft) | SS (H:1V) | Excavation (cu yd) | With Freeboard Freeboard (ft) | Width$_T$ (ft) | Excavation (cu yd) | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| **1.1** | Location 1 (Dobbins - E of 16St) | 227 | 15 | 39 | 2 | 6 | 500 | 5 | 99 | 3,400 | |
| | | | | | | | | | | | |
| | Location 2 (15 St - South of Dobbins) | 626 | 60 | 90 | 2.5 | 6 | 4,400 | 3.5 | 132 | 13,400 | |
| | | | | | | | | | | | |
| | Location 3 (15 St - North of Dobbins) | 1132 | 60 | 90 | 2.5 | 6 | 7,900 | 3.5 | 132 | 24,200 | |
| | Location 4 (16 St to Basin 3.1) | 414 | 25 | 57.4 | 2.7 | 6 | 1,800 | 2.3 | 85 | 4,300 | |
| | | | | | | | **14,600** | | | **45,300** | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| **2.1** | Location 1 (21st Pl - South of Euclid) | 595 | 5 | 32.6 | 2.3 | 6 | 1,000 | 2.7 | 65 | 3,900 | |
| | Location 2 (North of BSC) | 785 | 70 | 100 | 2.5 | 6 | 6,200 | 0.5 | 106 | 7,700 | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| **3.5** | Location 1 (Basin 14 to Basin 12) | 900 | 60 | 90 | 2.5 | 6 | 6,300 | 4.5 | 144 | 23,800 | |
| | Location 1 (Basin 14 to Basin 12) | | | | | | | | | | |
| | Location 1 (Basin 14 to Basin 12) | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| **4.1** | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| **4.5** | Location 1 (South Highline Canal) | 932 | 20 | 44 | 2 | 6 | 2,300 | 3 | 80 | 8,700 | |
| | | | | | | | | | | | |

## Estimation of Basin Cost Adjustment Factor

| Item No | Description | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 105-1 | PARTNERING ALLOWANCE | LS | 1 | $25,000.00 | $0 |
| 107-1 | AZPDES / SWPPP PERMITS | LS | 1 | $30,000.00 | $0 |
| 107-2 | PUBLIC INFORMATION AND NOTIFICATION ALLOWANCE | LS | 1 | $20,000.00 | $0 |
| 107-3 | PROJECT SIGNS ALLOWANCE | LS | 1 | $10,000.00 | $0 |
| 201-1 | CLEARING AND GRUBBING | LS | 1 | $30,000.00 | $0 |
| 202-1 | MOBILIZATION | LS | 1 | $100,000.00 | $0 |
| 220-1 | ROCK MULCH, (1"-3") | SY | 13,289 | $8.00 | $106,312 |
| 220-2 | PLAIN RIPRAP, D50=6" | CY | 907 | $60.00 | $54,420 |
| 220-3 | GROUTED RIPRAP, D50=6" | CY | 56 | $110.00 | $6,160 |
| 220-4 | 1-1/4" MINUS DECOMPOSED GRANITE INERT GROUND COVER | SY | 49,209 | $5.50 | $270,650 |
| 220-5 | 3/4" - MINUS DECOMPOSED GRANITE INERT GROUND COVER | SY | 53,973 | $3.50 | $188,906 |
| 220-6 | 1/4" - MINUS DECOMPOSED GRANITE MAINTENANCE ROAD SURFACE | SY | 6,496 | $2.50 | $16,240 |
| 310-1 | 4" ABC MAINTENANCE ROAD BASE | SY | 6,496 | $6.00 | $38,976 |
| 340-1 | DRIVEWAY ENTRANCE PER COP STD DET P1255-2 | SF | 296 | $10.00 | $2,960 |
| 350-1 | SAWCUT AND REMOVE CURB AND GUTTER | LS | 1 | $1,000.00 | $1,000 |
| 350-2 | REMOVE 60" STORM DRAIN PIPE PLUG | LS | 1 | $500.00 | $500 |
| 350-3 | REMOVE SRP CONCRETE IRRIGATION FIELD DRAIN INLET AND 18" RGRCP | LS | 1 | $2,000.00 | $2,000 |
| 350-4 | REMOVE 16" PVC PRIVATE IRRIGATION PIPE | LS | 1 | $1,000.00 | $1,000 |
| 350-5 | REMOVE AND REPLACE TRAFFIC REFLECTOR SIGN AND POST | EA | 4 | $250.00 | $1,000 |
| 420-1 | 6' CHAIN LINK FENCE AND GATES | LF | 4,116 | $20.00 | $82,320 |
| 505-1 | REINFORCED CONCRETE LOW-FLOW CHANNEL / SEDIMENT BASIN | LF | 1,581 | $130.00 | $0 |
| 505-2 | REINFORCED CONCRETE LOW-FLOW CHANNEL APRON AND TRANSITION AT BASIN OUTLET | LS | 1 | $1,700.00 | $1,700 |
| 505-3 | REINFORCED CONCRETE LOW-FLOW CHANNEL / DEBRIS BASIN ACCESS RAMP | EA | 3 | $3,250.00 | $9,750 |
| 505-4 | REINFORCED CONCRETE HEADWALL, WINGWALLS, APRON AND TRENCH DRAIN AT BASIN OUTLET | LS | 1 | $13,440.00 | $13,440 |
| 505-5 | REINFORCED CONCRETE SEDIMENT BASIN REMOVABLE SILL | LS | 1 | $1,000.00 | $1,000 |
| 505-6 | REINFORCED CONCRETE MAINTENANCE RAMP | SF | 9,107 | $12.00 | $109,284 |
| 505-7 | STORM DRAIN MANHOLE COP P1560 & MAG STD DET 522 | EA | 1 | $3,500.00 | $3,500 |
| 505-8 | MODIFIED STRAIGHT TYPE HEADWALL PER MAG STD DET 501 | LS | 1 | $2,000.00 | $2,000 |
| 505-9 | MODIFIED "L' TYPE HEADWALL PER MAG STD DET 501 | LS | 1 | $4,000.00 | $4,000 |
| 505-10 | SINGLE ADOT C-15.80 (MODIFIED) CATCH BASIN, APRON AND RAISED GRATE | LS | 1 | $3,500.00 | $3,500 |
| 505-11 | DOUBLE ADOT C-15.80 (MODIFIED) CATCH BASIN, APRON AND RAISED GRATE | LS | 1 | $5,000.00 | $5,000 |
| 505-12 | 3-DOUBLE ADOT C-15.80 (MODIFIED) CATCH BASIN, APRON AND RAISED GRATE | LS | 1 | $12,000.00 | $12,000 |
| 505-13 | 24" CONCRETE END SECTION PER MAG STD DET 545 | EA | 4 | $600.00 | $2,400 |
| 505-14 | PRIVATE IRRIGATION PLUG | EA | 30 | $350.00 | $10,500 |
| 505-15 | REINFORCED CONCRETE PRIVATE IRRIGATION OVERFLOW APRON STRUCTURE | EA | 1 | $6,000.00 | $6,000 |
| 515-1 | TRASH RACK WITH ACCESS HATCH AT BASIN OUTLET HEADWALL | LS | 1 | $6,000.00 | $6,000 |
| 520-1 | SAFETY RAIL PER COP STD DET P1173 | LF | 97 | $40.00 | $3,880 |
| 618-1 | 24" RGRCP, CLASS V | LF | 467 | $100.00 | $46,700 |
| 618-2 | 36" RGRCP, CLASS V | LF | 336 | $150.00 | $50,400 |
| 618-3 | 60" RGRCP, CLASS III | LF | 167 | $250.00 | $41,750 |
| 618-4 | 16" PVC PRIVATE IRRIGATION PIPE | LF | 86 | $50.00 | $4,300 |
| | | | | Total Cost (not incl. grading) | $1,109,547 |

| | | | | | |
|---|---|---|---|---|---|
| 215-1 | BASIN GRADING | CY | 609,545 | $6.00 | $3,657,272 |

Note: 1. Appurtenance Factor based upon ratio of Total Cost of other Appurtenances/Basin Grading Cost (rounded to 0.1).

| Cost Adjustment Factors | |
|---|---|
| Item | Factor |
| Appurtenances[1] | 0.40 |

| | |
|---|---|
| Excavation Cost ($/cy) | $6.00 |
| Appurtenances Cost ($/cy) | $2.40 |
| Total Basin Cost ($/cy) | $8.40 |

## Estimation of Channel Cost Adjustment Factor

| Item No. | Description | Unit | Quantity | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 105-1 | PARTNERING ALLOWANCE | LS | 1 | $25,000.00 | $0 |
| 105-2 | UNFORESEEN UTILITY SERVICE LINE RELOCATION ALLOWANCE | LS | 1 | $20,000.00 | $0 |
| 107-1 | AZPDES / SWPPP PERMITS | LS | 1 | $25,000.00 | $0 |
| 107-2 | PUBLIC INFORMATION AND NOTIFICATION ALLOWANCE | LS | 1 | $15,000.00 | $0 |
| 107-3 | PROJECT SIGNS ALLOWANCE | LS | 1 | $10,000.00 | $0 |
| 107-4 | WATER MANAGEMENT | LS | 1 | $50,000.00 | $0 |
| 201-1 | CLEARING AND GRUBBING | AC | 57 | $400.00 | $22,800 |
| 202-1 | MOBILIZATION | LS | 1 | $200,000.00 | $0 |
| 211-1 | LANDSCAPE GRADING | CY | 48,292 | $3.50 | $169,022 |
| 215-2 | MISCELLANEOUS CHANNEL GRADING | CY | 4,750 | $3.50 | $16,625 |
| 215-3 | TEMPORARY DITCH/BERM | LF | 4,218 | $3.50 | $14,763 |
| 220-1 | ROCK MULCH, (1"-3") | SY | 37,489 | $7.50 | $281,168 |
| 220-2 | PLAIN RIPRAP, D50=6" | CY | 36,614 | $60.00 | $1,098,420 |
| 220-3 | PLAIN RIPRAP, D50=12" | CY | 454 | $90.00 | $40,860 |
| 220-4 | 1/4"-MINUS DECOMPOSED GRANITE | SY | 2,552 | $25.00 | $63,800 |
| 310-3 | 4" ABC | SY | 9,539 | $7.50 | $71,543 |
| 309-1 | 4" LIME TREATED BASE | SY | 80 | $10.00 | $800 |
| 321-1 | 2" AC PAVEMENT | SY | 9,539 | $15.00 | $0 |
| 350-7 | REMOVE ABANDONED SRP POWER POLES | EA | 2 | $300.00 | $0 |
| 350-8 | REMOVE STORM DRAIN, INLET, OUTLET | EA | 4 | $500.00 | $0 |
| 350-9 | REMOVE FENCE | LF | 5,369 | $1.50 | $0 |
| 350-11 | REMOVE 4" NATURAL GAS LINE | LS | 1 | $500.00 | $0 |
| 420-2 | 6' CHAIN LINK FENCE | LF | 1,482 | $20.00 | $29,640 |
| 420-3 | WIRE FENCE | LF | 400 | $10.00 | $4,000 |
| 465-1A | TOQC FLAT SHEET ALUM W/DIR-APP OR SLK SCRN CHAR, TYP XI SHEET | SF | 9 | $20.00 | $0 |
| 505-1 | REINFORCED CONCRETE CUTOFF WALL (3') @ MAINT RD IN CHANNEL | LF | 1,602 | $25.00 | $40,050 |
| 505-2 | STORM DRAIN MANHOLE MAG STD DET 520 AND 522 | EA | 1 | $2,500.00 | $0 |
| 505-3 | RIPRAP SPILLWAY INLET | EA | 7 | $3,060.00 | $21,420 |
| 505-5 | STORM DRAIN INLET HEADWALL | EA | 6 | $5,000.00 | $0 |
| 505-6 | STORM DRAIN OUTLET HEADWALL | EA | 11 | $5,000.00 | $0 |
| 505-7 | CATCH BASIN PER ADOT STD DWG C-15.80 | EA | 7 | $3,000.00 | $0 |
| 505-15 | CONCRETE MAINTENANCE ACCESS RAMP | SF | 12,610 | $8.00 | $100,880 |
| 505-16 | CLSM GRADE CONTROL STRUCTURE | CY | 1,150 | $80.00 | $92,000 |
| 505-17 | CONCRETE SPILLWAY INLET | EA | 1 | $12,750.00 | $12,750 |
| 515-1 | MAINTENANCE ACCESS RD GATE AND BOLLARD | EA | 3 | $600.00 | $1,800 |
| 520-1 | VERTICAL PICKET SAFETY RAIL | LF | 336 | $30.00 | $10,080 |
| 618-2 | 18" RGRCP, CLASS III | LF | 99 | $60.00 | $0 |
| 618-3 | 24" RGRCP, CLASS III | LF | 712 | $70.00 | $0 |
| 618-4 | 30" RGRCP, CLASS III | LF | 122 | $80.00 | $0 |
| 618-5 | 36" RGRCP, CLASS III | LF | 149 | $110.00 | $0 |
| 618-6 | 48" RGRCP, CLASS III | LF | 219 | $150.00 | $0 |
| | | | | Total Cost (not incl. grading) | $2,092,420 |

| | | | | | |
|---|---|---|---|---|---|
| 215-1 | CHANNEL GRADING | CY | 242,118 | 3.5 | $847,413 |

Note:
1. Appurtenance Factor based upon ratio of Total Cost of other Appurtenances/Basin Grading Cost (rounded to 0.1).
2. Channel Excavation Factor applied to provide freeboard and to account for misc. additional grading

| Cost Adjustment Factors | |
|---|---|
| Item | Factor |
| Appurtenances | 2.47 |

| | |
|---|---|
| Excavation Cost ($/cy) | $5.00 |
| Appurtenances Cost ($/cy) | $12.35 |
| Total Channel Cost ($/cy) | $17.35 |

## Estimation of Storm Drain Unit Costs

### 24" Storm Drain 1000'

| Item | Qty | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Catch basins | 6 | ea | 3500 | $21,000 |
| Manholes | 3 | ea | 3500 | $10,500 |
| 18" Lateral | 90 | lf | 80 | $7,200 |
| Headwall | 1 | ea | 2500 | $2,500 |
| 24" Trunkline | 1000 | lf | 100 | $100,000 |
| Pavement Replacement | 490 | sy | 32 | $15,680 |
| | | | | $156,880 |
| | | | cost/LF | $160 |

### 36" Storm Drain 1000'

| Item | Qty | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Catch basins | 6 | ea | 3500 | $21,000 |
| Manholes | 3 | ea | 3500 | $10,500 |
| 18" Lateral | 90 | lf | 80 | $7,200 |
| Headwall | 1 | ea | 2500 | $2,500 |
| 36" Trunkline | 1000 | lf | 150 | $150,000 |
| Pavement Replacement | 600 | sy | 32 | $19,200 |
| | | | | $210,400 |
| | | | cost/LF | $220 |

### 48" Storm Drain 1000'

| Item | Qty | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Catch basins | 6 | ea | 3500 | $21,000 |
| Manholes | 3 | ea | 3500 | $10,500 |
| 18" Lateral | 90 | lf | 80 | $7,200 |
| Headwall | 1 | ea | 2500 | $2,500 |
| 48" Trunkline | 1000 | lf | 200 | $200,000 |
| Pavement Replacement | 715 | sy | 32 | $22,880 |
| | | | | $264,080 |
| | | | cost/LF | $270 |

### 54" Storm Drain 1000'

| Item | Qty | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Catch basins | 6 | ea | 3500 | $21,000 |
| Manholes | 3 | ea | 3500 | $10,500 |
| 18" Lateral | 90 | lf | 80 | $7,200 |
| Headwall | 1 | ea | 2500 | $2,500 |
| 54" Trunkline | 1000 | lf | 225 | $225,000 |
| Pavement Replacement | 770 | sy | 32 | $24,640 |
| | | | | $290,840 |
| | | | cost/LF | $300 |

| Summary of Unit Costs | |
|---|---|
| Size | Cost/LF |
| 24 | $160 |
| 36 | $220 |
| 48 | $270 |
| 54 | $300 |

## Summary of ROW Cost Estimate

| Zoning | Parcel Status | Unit Cost (per sq ft) | Unit Cost (per acre) |
|---|---|---|---|
| | | | |
| Residential | Vacant | $2.00 | $87,122 |
| Residential | Occupied | $3.00 | $130,683 |
| Commercial | Vacant | $3.00 | $130,683 |
| Commercial | Occupied | $3.00 | $130,683 |
| Park | Occupied | $0.00 | $0 |
| Tax Exempt | Vacant | $2.00 | $87,122 |
| Religious Use | Occupied | $3.00 | $130,683 |
| HOA Open Space | Vacant | $2.00 | $87,122 |
| | | | |

# APPENDIX D

# Evaluation Meeting Results & Landscape/Multiple-Use Considerations

## Level 2B Alternative Evaluation Matrix

| Alternative ID | Alternative Description | Flood Mitigation Effectiveness | Community Acceptance | Land & Resource Compatibility | Relative Cost | Include in Level 3 Analysis? | Comments |
|---|---|---|---|---|---|---|---|
| 1.0 | No Action: Conditions to remain as existing | - | - | = | - | No | No action was not considered an acceptable alternative |
| 1.1 | Multiple Basins and Channels: Series of retention basins connected by channels and pipes. | + | + | + | = | Yes | Modifications to alternative components warranted |
| 2.0 | No Action: Conditions to remain as existing | - | - | = | + | No | No action was not considered an acceptable alternative |
| 2.1 | Local Storm Drain System (16th & 20th St) & Basins: Storm drain system that outlet to retention basins | + | + | = | = | Yes | Modifications to alternative components warranted |
| 3.0 | No Action: Conditions to remain as existing | - | + | = | = | Yes | No action was considered an acceptable alternative. |
| 3.5 | Multiple Basins and Channels: Channelize flow & construct basins along existing drainage path. Outlet to basins along Highline Canal. | + | - | + | - | No | It was decided that the benefits of this alternative did not seem to justify the acquisition of so many properties. |
| 4.0a | No Action: Conditions to remain as existing | - | = | = | = | Yes | No Action was considered an accpetable alternative for both alternatives that addressed separate drainage issues in this area. |
| 4.1 | Multiple Basins and Local Storm Drain (S. Mtn Ave): Basins along Winston Dr and Highline Canal with a local storm drain system to connect & convey flow. | - | = | = | - | No | It was decided that the benefits of this alternative did not seem to justify the expense of this alternative. |
| 4.5 | Cortland Point Basins/Channels : Construct basins and/or channels along Highline Canal (south of Cortland Point). | + | = | - | - | No | It was decided that limited number of structures benefitted did not justify the estimated cost. In addition, the deep basins were not compatible with the residential area. They would be potential hazards and require fencing to prevent access. |

| Rating | |
|---|---|
| + | **Positive / Favorable** |
| = | **Neutral** |
| - | **Negative / Unfavorable** |

## Definition of Evaluation Criteria

| Evaluation Criteria | Factors to Consider | |
|---|---|---|
| Costs (qualitative & relative to other problem area alternatives) | Design & Construction | Costs associated with the alternative design and construction. |
| | Operation & Maintenance | Costs associated with the constructed alternative's long term operation and maintenance. |
| | Long Term Economic | Potential long term economic losses (or benefits if favorable) to the community. (via lost tax revenue, lost/improved business conditions) |
| | ROW / Land Acquisition | Costs associated with the acquiring of ROW and/or land for alternative improvements. |
| Flood Mitigation Effectiveness | Flood Mitigation | Effectiveness in eliminating and/or reducing flood hazards in both area and magnitude. |
| | Level of Protection | Ability of the alternative to achieve a 100-yr level of flood protection. |
| | Potential for Property or Economic Damage | Ability to minimize the potential for property or other economic damage |
| | Emergency Access | Ability to improve and maintain effective emergency access during flood events. |
| Community Acceptance | Community Plans | Solution is consistent or compatible with goals and objectives of adopted general and specific area plans |
| | General Public Acceptance | Level of impact to individual or community properties, resources, or amenities |
| | Stakeholder Acceptance | Level of impact to stakeholder public amenities, land values, and operational and maintenance responsibilities |
| | Agency Acceptance | Level of impact to agency public amenities, resources, land values, and operational and maintenance responsibilities |
| Land & Resource Compatibility | Multi-Use Opportunities Parks & Recreation | Value of opportunities based on neighborhood, community, and regional needs; and meeting the goals and objectives of adopted community plans |
| | Open Space | Value of open space based on neighborhood, community, and regional needs; adjacent land compatibilities, and meeting the goals and objectives of adopted community plans |
| | Landscape Aesthetic | Compatibility with existing or future landscape character |
| | Cultural/Biological Resources | Level of impact on vegetation, habitat, wildlife, geological, prehistoric and historic, and other natural resources |

**Hohokam Area Drainage Master Plan Phase II Level II Alternatives Evaluation Landscape Aesthetics and Multiple Use Considerations**

## Overview

The Flood Control District of Maricopa County District (District) continues to employ integrated design strategies for the development of flood hazard mitigation solutions in an effort to provide facilities that incorporate multiple use opportunities while protecting citizens from the effects of flooding. The District is committed to building facilities and implementing strategies to effectively reduce the risks of flooding in ways that are compatible with the environment AND acceptable to the local communities in which the facilities are located. The District's "Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects" (Aesthetic Treatment Policy, revised 3/31/09) and Landscape Aesthetics & Multiple-Use Design Guidelines for Flood Control Basins, Channels, and Flood Retarding Structure (revised December 2004), provide guidance and policy direction to staff and consultants during planning and design phases of project development for defining goals and objectives that provide for appropriate levels of aesthetic treatments and multi-use opportunities, while incorporating features and measures that will:

- Enhance/mitigate the visual appearance of flood protection facilities;
- help preserve/restore the visual character and functionality of natural Sonoran Desert landscapes;
- protect and enhance local community character, and;
- increase the aesthetic and multiple-use values of District properties.

## Context Sensitive Solutions

In Phase I of the Hohokam Area Drainage Master Study (ADMS), landscape aesthetics and multiple-use design goals and objectives were integrated using the guiding principles of the District's Context Sensitive Flood Hazard Mitigation (CSFHM) Design and Planning Approach. This process used a modified approach to CSFHM and collected data on flooding types, community character and environmental opportunities and challenges. The planning team then used the collected data to identify, structural methods and landscape design themes for structural solutions and mitigation strategies that had the potential for being context sensitive (acceptable to the community, compatible with the environment and effective in reducing flood hazards) within the study area. The results of this analysis suggests that structural solutions (with the highest potential for being context sensitive) should be constructed using natural and/or soft structural methods in areas with close proximity to the City of Phoenix South Mountain Park/Preserve, while structural solutions constructed using semi-natural and semi-soft methods would be feasible in areas north towards Baseline Road. A variety of landscape design themes are shown to be context sensitive within the study area.

However, a general rule of thumb suggests the Natural Sonoran Desert Upland theme to be context sensitive closest to South Mountain Park/Preserve, with transitions toward the Natural Lower Sonoran Desert, Enhanced Desert and Desert Park themes downstream and to the north.

## Landscape Aesthetics and Multiple-Use Considerations

In Phase II, Level II of the Hohokam Area Drainage Master Plan (ADMP), the project team developed criteria for the evaluation of the various flood control solution alternatives, which consequently will also provide the framework for the development of the conceptual design and refining the estimate of cost for the structural solutions and necessary mitigation treatments. Landscape aesthetics and multiple use considerations were part of this alternative evaluation process. For each flood hazard mitigation structural solution alternative, the general structure types, structure scale, structural methods, mitigation treatments, and applicable landscape design themes were taken into account for their level of community acceptance and support, land use and resource compatibility, as well as their effectiveness in reducing flood hazards. A summary of the evaluation of the landscape aesthetics and multiple use considerations for the Phase II alternatives by area are provided below.

## Area 1 - 16th Street Corridor

### Alternative 1.1

#### *General Description*

This alternative would consider a combination of storm drains, channels, and basins to be constructed within public rights-of-way and on private property. Storm drain lines would be constructed along 14th and 15th streets, 17th Way, South Mountain Avenue, and Euclid Avenue to collect street drainage and floodwater and discharge the storm water to detention basins. Detention basins are proposed adjacent to Euclid Avenue between 14th Street and 16th Street, at the northwest corner of South Mountain Avenue and 16th Street, and in Circle K Park. Channels with cross road culverts would collect and convey mountain runoff south of Dobbins Road to a basin along Euclid Avenue.

#### *Landscape Aesthetics and Multi-use Considerations*

***Circle K Park - Basin 5.***Circle K Park is a City of Phoenix community park that includes an historic administration building, shaded picnic areas, a soccer field, baseball field, children's playground, handball courts, restrooms and associated parking and trails. The City of Phoenix's Parks, Recreation, and Library staff agreed that the park is in need of updating and redesign and would be a suitable location to incorporate flood control facilities, provided that existing and future programming elements for the park are included. City staff emphasized that this should be planned as a park with drainage facilities in it. As a multiple use facility the flood control improvements within the park would provide enhanced aesthetic value and recreation opportunities as well as being

consistent with local community character. The historic building and many of the mature trees would be protected in place and connections from the park to the Highline Canal trail would be enhanced.

***Structure Types and Structural Methods:*** Context sensitive soft and semi-soft structural methods, utilizing underground pipes, conveyance channels and storage basins are proposed within the park, adhering to the side slope, storage depth, and access criteria per the District's guidelines. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation. Turf athletic fields are included in the basin bottoms to provide erosion control and meet park programming needs in an integrated design solution.

***Landscape Design Themes:*** Context sensitive landscape design themes including Semi-Natural Desert, Enhanced Desert, Desert Park and Desert Oasis are proposed to achieve neighborhood compatibility and meet the City's park design requirements.

***Basins 3.1 and 6.***These basins would be located on land acquired for the purposes of stormwater detention. Side slope requirements and inadequate volume would eliminate Basin 6 from further consideration based on flood control functional considerations. Basin 3.1 would be the deepest of the basins in this alternative, and the long narrow configuration would be problematic in implementing the District's aesthetic treatment guidelines for basins. Neither of these basins would provide multiple use opportunities. Fencing requirements around the basins would not complement or enhance the neighborhood character. Additional private property would be required to adequately incorporate necessary aesthetic treatments to mitigate the negative impacts to the neighborhood. It is strongly recommended that Basin 3.1 should be reduced in size and depth or eliminated entirely, if adequate storage capacity becomes available in the Basin 5 (Circle K Park).

**Channels**. Open channels are proposed through private properties. Due to their proximity to the 'bajada' landform near South Mountain, the design of these channels would lend itself to a soft or semi-soft structural design approach, with some hard elements required for inlet/outlet protection and erosion and grade control. Ideally, the conveyance channels would provide enough area to maintain gentle, undulating side slopes (4:1 max.) and allow for adequate meander in the low-flow channel. Additional right-of-way would be necessary to meander the channel itself as well as to provide for the gentler side slopes. Rapid drops in elevation would be addressed using drop structures and energy dissipaters, which should be designed to mimic natural features associated with the existing landforms and native vegetation of South Mountain. These open channels are primarily located within private single-family residential areas, with limited visibility from the public rights-of-way. For this reason there may be a lower priority for vigorous application of aesthetic enhancements.

***Structure Types and Structural Methods***: Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the

basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes:*** Context sensitive themes for these two basins as well as the open channels include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

## Area 2 - 20th Street Corridor

### Alternative 2.1

#### *General Description*

Alternative 2.1 would include inlets, channel conveyances, basins and storm drain piping from the area near the Heard Pueblo Boy Scout Camp at the base of South Mountain, along the 18th and 20th Street alignments to Baseline Road. Basin 10 is proposed to be located within the boundaries of the Boy Scout Camp, just upstream from an existing residential subdivision, and would require an easement. Basins 9.4 and 11 are located on private property that would need to be acquired by the District. Open channels were considered south of Euclid Avenue near the base of South Mountain.

#### *Landscape Aesthetics and Multi-use Considerations*

***Basin 10 - Heard Scout Camp***. This basin is located on a relatively steep site at the outfall of several small washes exiting South Mountain Park/Preserve. The Geronimo Trail access is located in the general vicinity of 20$^{th}$ Street and Dobbins Road and would need to be maintained or potentially enhanced as part of flood hazard mitigation activities in this sub-area. It is likely that the proposed basin would require the relocation of several camp structures.

***Basins 9.4 and 11***.These basins would be located on land acquired for the purposes of stormwater detention. Context sensitive natural, soft and semi-soft structural approaches would minimize or negate the need for fencing and safety rails, keeping side slopes, storage depths, structure scale as well as public and maintenance access consistent with the criteria outlined above and in District guidelines. Flood hazard mitigation requirements suggest that both basins may not be required. Due to its location adjacent to the Highline Canal, Basin 9.4 would be suited to support multiple uses. A multi-use pathway at the basin perimeter could connect to the existing canal-side trail with potential overlook seating areas to provide visual access and respite into the basin.

***Channels***. Open channels are proposed along public streets and through private properties. Due to their proximity to South Mountain and its associated bajada topography, these channels would be better suited for utilization of existing natural

channels or the implementation of soft or semi-soft structural methods with some hard elements required for inlet/outlet protection and erosion and grade control. They would also require enough right-of-way to provide for gentle (4:1 max) side slopes and to allow for some meander in the low flow channel. Rapid drops in elevation would be taken up by drop structures and energy dissipation structures designed to mimic natural features in the natural desert landscape. Additional right-of-way would be required to incorporate these types of treatments.

***Structure Types and Structural Methods***. Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes***. Context sensitive landscape themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park. A recommended design approach includes: meandering channel alignment and low flow, undulating channel side slopes, adequate landscape buffer in overbank areas and landform mounding to create interest.

## Area 3 - 24th Street Corridor

### Alternative 3.5

#### *General Description*

This alternative would include inlets, channel conveyances and basins along the 23rd Street alignment primarily across private property, from the base of South Mountain to Baseline Road. Basins 14, 15.1 and 15.2 would be located on private property that would be acquired by the District. Basin 12 would be located on a large parcel of private property that is being considered for development. Open channels were considered between Basins 14 and 12 crossing the Highline Canal.

#### *Landscape Aesthetics and Multi-use Considerations*

***Basins 12, 14, 15.1, and 15.2***. Similar to other non-park located basins, these basins would be located on land acquired for the purposes of stormwater detention. Context sensitive natural, soft and semi-soft structural approaches would minimize or eliminate the need for fencing, keeping side slopes, storage depths, structure types and public and maintenance access consistent with the District's basin aesthetic treatment guidelines. Some hard elements with aesthetic treatment may be required for inlet/outlet protection and erosion and grade control. However, Basins 15.1 and 15.2 would be relatively small basins (roughly an acre in size) with limited opportunity to increase the size of the basins without impacting residential property and would need to be fenced with significant landscape buffers required to mitigate visual impacts. These

open channels are primarily located within private single-family residential areas, with limited visibility from the public rights-of-way. For this reason there may be a lower priority for vigorous application of aesthetic enhancements.

***Channels***. Open channels are proposed through private properties and crossing the canal. These channels will require enough right of way (between 100 feet and 150 feet wide) to provide for gentle (4:1 max) side slopes and to allow for some meander in the low flow channel. Rapid drops in elevation would be taken up by drop structures and energy dissipation structures designed to mimic natural features in the landscape. There could be an opportunity to connect the Mormon Trailhead at 24th Street to the Highline Canal and vice versa using the flood control improvements as a link. The proposed open channel between Desert Lane and Basin 12 would require the relocation of one residence. Similar to other open channels, the location of this channel would not be visible from the neighborhood and minimal benefit in terms of enhancing the neighborhood character.

***Structure Types and Structural Methods.*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes.*** Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

## Area 4 - 24th - 36th Street Corridor

### Alternative 4.1

#### *General Description*

Alternative 4.1 would include a system of storm drains and basins along the 24th to 32ndstreet alignments in public rights-of-way and on private and City-owned properties, from the base of South Mountain to Baseline Road. Basins 13 and 18 are located on private property. Basin 16 is located on Francisco Highlands, a City public park adjacent the Highline Canal.

#### *Landscape Aesthetics and Multi-use Considerations*

***Basins 13, 16, 18, and 19.*** Basins 18 and 19 would be relatively small basins (roughly 2.5 and 1.5 acres in size, respectively) and would need to be fenced. These basins would lack any multiple use opportunities as well as having minimal neighborhood benefits or enhancements. The vacant land that Basin 13 would be located on is currently slated for development. Basin 18 would have the potential to be incorporated into an existing park setting. It's relatively shallow depth would be conducive to

incorporating the District's basin design guidelines as well as be perceived as a benefit to the park and the community at large.

***Structure Types and Structure Methods.*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes***. Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

**Alternative 4.5**

***General Description***

A storm drain system would collect runoff along the south side of the Highline Canal between 34th Street and 36th Street and discharge to a detention basin north of the Highline Canal. A floodwall along the storm drain collection system would help capture flows and reduce the amount of flow crossing the canal and entering the Cortland Point subdivision. A channel east of 36th Street and south of the Highline Canal would divert flows from an existing wash to a culvert crossing of the Highline Canal to a detention basin. Two detention basins 17.1 and 17.2 north of the Highline Canal discharge to a storm drain system in 36th Street that would flow north to Baseline Road, west to 32nd Street to an existing storm drain in 32nd Street.

***Landscape Aesthetics and Multi-use Considerations***

***Basins 17.1 and17.2.*** These two basins would be relatively the same size and would need to be fenced. These basins lack potential multiple use opportunities unless they could be incorporated into a link to the Highline Canal Multi-use Path.

***Channels.*** Open channels are proposed through private properties and crossing the Highline Canal. These channels would need to acquire enough right of way (approximately 100 feet) to provide for gentle (6:1 max) side slopes and to allow for some meander in the low flow channel. While having the potential to provide new link into the trail system in South Mountain Park/Preserve, the existing neighborhood is adamant that a channel would not be compatible and would not have community acceptance.

***Structure Types and Structure Methods.*** Soft and semi-soft structural methods would be utilized for Basin and Channel Conveyance structure types, including gentle side slopes and use of contour grading and mounding of excavated materials at the basins' perimeters to soften the interface with adjacent residences and streets. It will be

necessary to include some hard structural components with aesthetic treatments as require for flood hazard mitigation.

***Landscape Design Themes***. Context sensitive themes for the basins include Semi-Natural Lower Sonoran Desert, Enhanced Desert and Desert Park.

# APPENDIX E

# Background on Structure Inundation Analyses

# STRUCTURE INUNDATION ANALYSES

## OVERVIEW

To evaluate the flood mitigation effectiveness of project alternatives, a means to estimate the magnitude and extent of structure flooding in the study area was considered. Multiple approaches were performed prior to the selection of the final approach which is discussed in the main body of the report. This appendix discusses the other structure inundation analyses performed prior to the selection of the final approach. For each approach, the results of the "Base" condition (prior to any alternatives) were compared to the "Alternative" condition (after the implementation of all alternatives).

From the outset, it was determined that an estimate of building finish floor elevations (FFE) would be a critical factor in the assessing a structure's potential for being flooded. Therefore, all approaches gauge a structure's flooding potential based upon an estimate of the structure's FFE as is documented in the *Level 2: Technical Memorandum: Finish Floor Survey & Alternative Reduction* report.

## APPROACH 1: FLO-2D MAXIMUM WSEL

As part of the evaluation of approaches to estimate building FFEs, the FFEs of all the structures identified for survey were compared to the FLO-2D maximum water surface elevations (WSELs) of the grid elements adjacent to the building footprint. Because the number of surveyed structures was limited, the estimated maximum WSELs impacting each structure was determined through visual inspection of the FLO-2D results. Upon selection of the FFE approach and a review of the number and extent of buildings that were flooded, it was decided to investigate other approaches to provide a better assessment of building flooding conditions study-wide. In addition, since individual review of each of the 35,000+ structures within the study area was impractical, subsequent approaches generally focused on exploiting GIS applications to process topographic and spatial FLO-2D data.

## APPROACH 2: 5-FT WSEL RASTERS/0.15' DEPTH CRITERIA

For this approach, a 30'x30' raster of the maximum WSEL was developed from the FLO-2D output. This data was then re-sampled to create 5'x5' rasters. The value of each 5'x5' raster was interpolated from the centroids of the adjacent 30'x30' rasters to create a smoother WSEL surface. The building footprint was then draped over the 5-ft raster surface to identify the maximum WSEL for the structure.

Comparing a building's maximum WSEL to the FFE gives an indication whether the building is potentially subject to flooding, however, a WSEL higher than the FFE could also occur simply from rain falling on an adjacent grid element where the ground elevation is near, at, or possibly even higher than the structure FFE. Therefore, a depth

criterion was included such that the maximum WSEL not only had to exceed the structure FFE but the water depth (Dmax) of all the intersected grid elements also had to exceed 0.15 ft. in order for the structure to be considered inundated. The depth criterion threshold of 0.15-feet was established as follows:

1. The 100-year, 6-hour Maximum Point Rainfall is 2.635 inches
2. The average hydraulic conductivity (XKSAT) study wide is 0.30 in/hr
3. The average initial abstraction (IA) study wide is 0.26 inches
4. Subtracting the average IA from total rainfall results in 2.38 inches (0.20 feet)
5. Given that approximately 75% of the synthetic 6-hour rain falls within 1-hour, another 0.30 inches of rainfall is lost to infiltration resulting in a total excess depth of 2.08 inches (0.17 feet)
6. Rounding down to 0.15-feet is a reasonable and conservative threshold to identify structures vulnerable to flooding in the 10- and 100-year flood events.

This automated approach was initially applied study-wide. Eventually, however, only structures within the problems areas or flooding corridors were included to evaluate alternatives and for the Benefit-Cost Ratio Analysis (described below).

## APPROACH 3: BENEFIT-COST RATIO (BCR) ANALYSIS

The BCR Analysis is not a structure inundation analysis but an economic analysis that uses building flooding depths to evaluate project alternatives based upon the expected damage that would result from flooding, the improvement in flooding conditions (due to mitigation measures), and the estimated capital and long-term maintenance costs associated with the flood mitigation alternative.

For the BCR, structure flooding depths from the Approach 2 inundation analysis were used to estimate the flooding damages for multiple storm events (2-yr, 10-yr and 100-yr). A Depth-Damage table was developed to assign flood damage costs (structure damage, damage to contents, and temporary displacement or relocation costs for occupants). Then based upon the probability of the storm event occurring in any given year (e.g. 2-yr = 50% chance), the amount of damage that could occur annually was estimated as well as a life-cycle cost based upon a period of 30 years (comparable to a typical home mortgage amortization schedule).

A decrease in damages from the base condition to the alternative condition was considered the "benefit" of the alternative. This benefit was compared to the alternative costs which included construction & design costs, land acquisition, and long-term maintenance costs. The ratio of the benefit (reduction in flood damage) to the cost of the alternative provides an indication of the cost effectiveness of an alternative.

## APPROACH 4: $D_{max}$ > 0.5 ft AND MANUAL REVIEW

This approach was used to evaluate Level 2B Alternatives to identify alternatives for Level 3. A discussion of this approach is provided in the main body of the report.