Appendix H - Floodproofing Critical Facilities

Introduction

Floodproofing critical facilities as defined in the City of Boulder's new *Critical Facility and Mobile Populations Ordinance*" was an element considered in the High Hazard Zone Mitigation Alternative. Issues of public/private ownership, varying facility type, community welfare and financial responsibility led to the conclusion that floodproofing of existing critical facilities should not be included as a component of the High Hazard Mitigation Alternative. However, basic floodproofing measures for critical facilities or government owned facilities located in the 100-year flood zone were developed as part of the mitigation plan for information purposes only.

Protection of critical facilities remains an important element in the City's overall floodplain management program. In order to provide basic information for future decision-making, measures to floodproof critical facilities or government owned facilities located in the 100-year flood zone were evaluated. Estimated costs to implement the floodproofing measures and mitigate the flood threat from South Boulder Creek were identified and are included in the mitigation master plan report for future reference. Many of these flood proofing measure could be applied across a broad spectrum of properties that are impacted by the South Boulder Creek Floodplain.

City Geographical Information System (GIS) records indicate that as many as 35 critical facilities may exist in the South Boulder Creek floodplain. These include a range of facility types, including essential services facilities, hazardous material facilities, and at-risk populations facilities. Most of the identified critical facilities are privately owned commercial/industrial operations that involve the use of hazardous materials. Under the City's recently adopted critical facilities ordinance these operations will be independently responsible for mitigating their flood threat by 2022. There is at least one essential service facility (the RTD Park 'N' Ride at US 36) and two at-risk population facilities (Friends School, and Frasier Meadows Manor) in the 100-year floodplain that don't fall into the privately owned commercial/industrial operations category.

This appendix focuses on possible options for the protection of these critical facilities and provides some definition of what infrastructure and costs may be required to floodproof these existing critical facilities. There are several primary approaches to floodproofing critical facilities that include:

1. Elevating the Structure, so that the facility is located above floodwaters and away from damage. This is not particularly practical for facilities already constructed.
2. Constructing Barriers between the Structure and Flooding, so that floodwaters cannot inundate the area around the facility. This minimizes required modifications to the structure.
3. Dry Floodproofing the Structure, so that the building's walls, floors and openings are watertight to prevent floodwaters from entering and damaging the facility. This often requires extensive modifications to the structure and may limit function during flood events.
4. Wet Floodproofing the Structure, using flood resistant construction materials and water repellant design measures, so that floodwaters that do enter the building will cause little or no damage.

Multiple references were used to analyze, recommend potential floodproofing measures, and determine reasonable cost estimates for several critical facilities in the South Boulder Creek floodplain. Primary references included:

- Local Flood Proofing Programs, US Army Corps of Engineers and the National Nonstructural/Flood Proofing Committee, February 2005
- Floodproofing Non-Residential Structures, FEMA 102, May 1986
- Selecting Floodproofing Techniques - Financial Considerations, Floodproofing Info #10, Southern Tier Central Regional Planning and Development Board
- FEMA Technical Bulletin 2, Flood Damage-Resistant Materials Requirements, August 2008
- FEMA Technical Bulletin 3-93, Non-Residential Floodproofing - Requirements and Certification
- FEMA Technical Bulleting 7-93, Wet Floodproofing Requirements
- Flood-proofing, ClimateTech Wiki, climatetechwiki.org
- Flood Proofing, UDFCD Drainage Criteria Manual, Volume 2
- UDFCD Cost Estimator for Master Planning (UD-MP Cost)
- Appendix C, Critical Facilities Flood Protection Analysis Calculations, City of Boulder Critical Facilities and Mobile Populations Ordinance Cost Analysis, The Sanitas Group, March 15, 2011

As part of the effort to evaluate floodproofing measures as an element of any proposed improvements identified in the South Boulder Creek mitigation planning study, the analysis was expanded to include an assessment and cost estimate of possible single-family residential structure floodproofing measures for dwellings with and without basements. Single-family residential structures are not defined as critical facilities and there is no regulatory requirement to protect them. These measures were not included in any of the plans.

Floodproofing of residential structures is not recognized by FEMA as an alternative to the purchase of flood insurance or as a measure to reduce required flood insurance premiums. However, floodproofing can provide a greater level of flood protection for the structure in the event of flooding. Some homeowners may want to consider these options for protecting their homes in the event of a flood.

The following pages include possible site floodproofing elements and costs analyses for the following existing critical facilities in the South Boulder Creek floodplain and for typical single-family residential structures:

- RTD Park 'N' Ride
- Frasier Meadows Manor
- Friends School
- Gasoline Service Stations at 55th and Arapahoe
- Single-family Residential Dwelling without a Basement
- Single-family Residential Dwelling with a Basement

South Boulder Creek Floodproofing Option-RTD Park & Ride Perimeter Floodwall

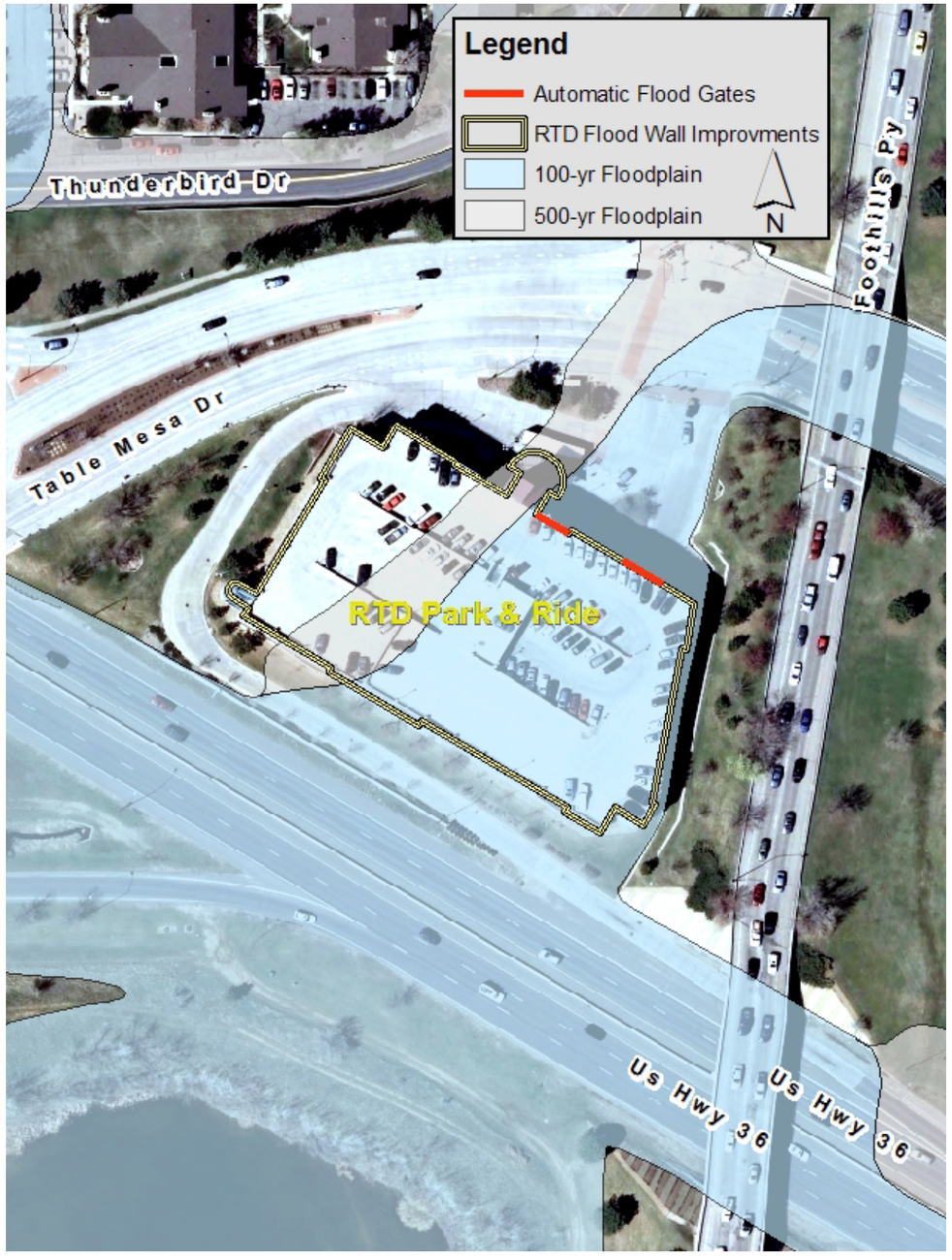
TABLE H-1
RTD Park and Ride Site Floodproofing Elements and Costs

Flood Proofing Element	Estimated 2011 Unit Cost	No. of Units	Element Costs
Increase Lower Parking Level Perimeter Wall 18"	$45.00 per square foot	1,700	$76,500
Automatic Driveway Flood Gates	$90,000	2	$180,000
Storm Sewer Check Valve	$20,000 per unit	1	$20,000
Flood Proof Concrete Walls and Seal All Field Joints	$50,000	1	$50,000
Incidentals	20% of Element Costs		$65,300
		Floodproofing Construction Sub-Total	**$391,800**
		Structural Analysis	$6,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$408,300**
		Contingency (20%)	$81,660
		Total Cost for Parking Structure	**$489,960**

Floodproofing Cost for this (50,300 square foot) Building is **$9.74 per square foot**

Assumptions:

- Max 500-year flooding depth around structure is 2.65 feet (Assuming 3 feet in depth for calculation purposes)
- Floodproofing to four feet above grade to provide 1 foot of free board
- Existing lower level of parking structure wall is approximately 30" tall
- There will need to be 1.5 feet of additional concrete added to lower parking structure wall to prevent floodwaters from entering
- Automated Flood Gates will be required at driveway entries
- It is assumed that the structure is a prefabricated concrete structure and is currently not watertight. Existing structure envelope will need to be sealed to be watertight.
- It is assumed the existing Interior Drainage System is adequately sized for areas inside the parking structure



South Boulder Creek Floodproofing Option-Frasier Meadows Manor Perimeter Floodwall

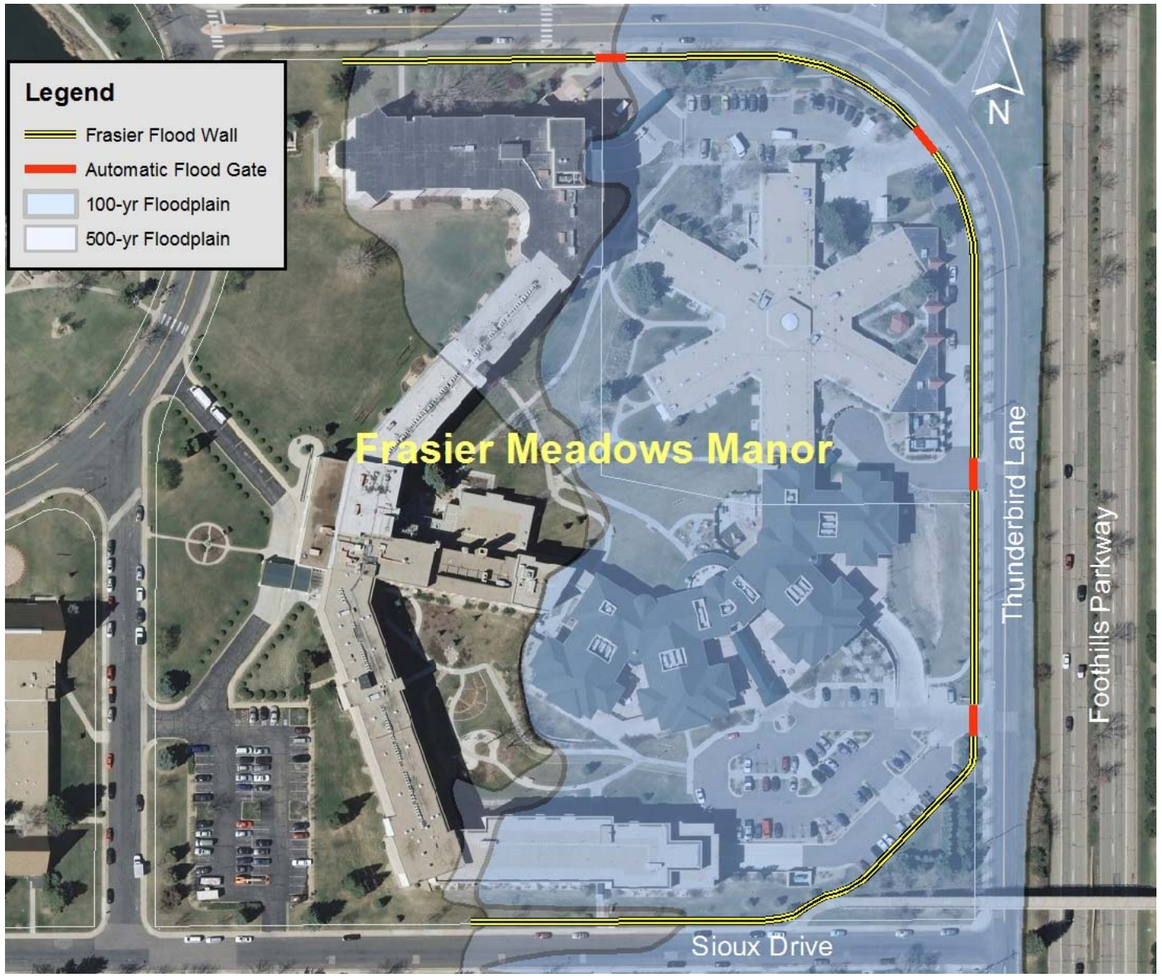
TABLE H-2
RTD Park and Ride Site Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Concrete Perimeter Floodwall	$45.00 per square foot	10,000	$450,000
Automatic Driveway Flood Gates	$90,000	4	$360,000
Sewer Main Check Valve	$20,000 per unit	1	$20,000
Site Interior Pumped Drainage System (with backup generation)	$150,000 per system	1	$150,000
Incidentals	20% of Element Costs		$196,000
		Floodproofing Construction Sub-Total	**$391,800**
		Structural Analysis	$6,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$408,300**
		Contingency (20%)	$81,660
		Total Cost for Parking Structure	**$489,960**

Floodproofing Cost for this (420,000 square foot) Building is **$3.41 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Floodproofing Involves Concrete Perimeter Floodwall Around East Property with Automated Flood Gates at Driveway Entries
- Total Height of Floodwall (to Footing) is Six Feet
- An Interior Drainage System Sized for Areas Protected by Levees is Required



South Boulder Creek Dry Floodproofing Options-Friends School

TABLE H-3
RTD Park and Ride Site Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Exterior Waterproofing and Refinish	$4.50 per square foot	1,722	$7,749
Floodproof Entry Doors	$4,000 each unit	4	$16,000
Main Entry Floodproofing	$7,000 each unit	1	$7,000
Sewer Line Check Valve	$1,200 per unit	1	$1,200
Sump Pump (w/battery backup)	$1,500 per unit	1	$1,500
Incidentals	20% of Element Costs		$6,630
		Floodproofing Construction Sub-Total	**$39,779**
		Structural Analysis	$3,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$53,279**
		Contingency (20%)	$10,656
		Total Cost for Parking Structure	**$63,935**

Floodproofing Cost for this Building is **$5.06 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Building Area = 12,634 square feet, Perimeter = 574 feet
- Three Entry Doors per Building
- Building Structurally Withstands Up to Three Feet of Flooding

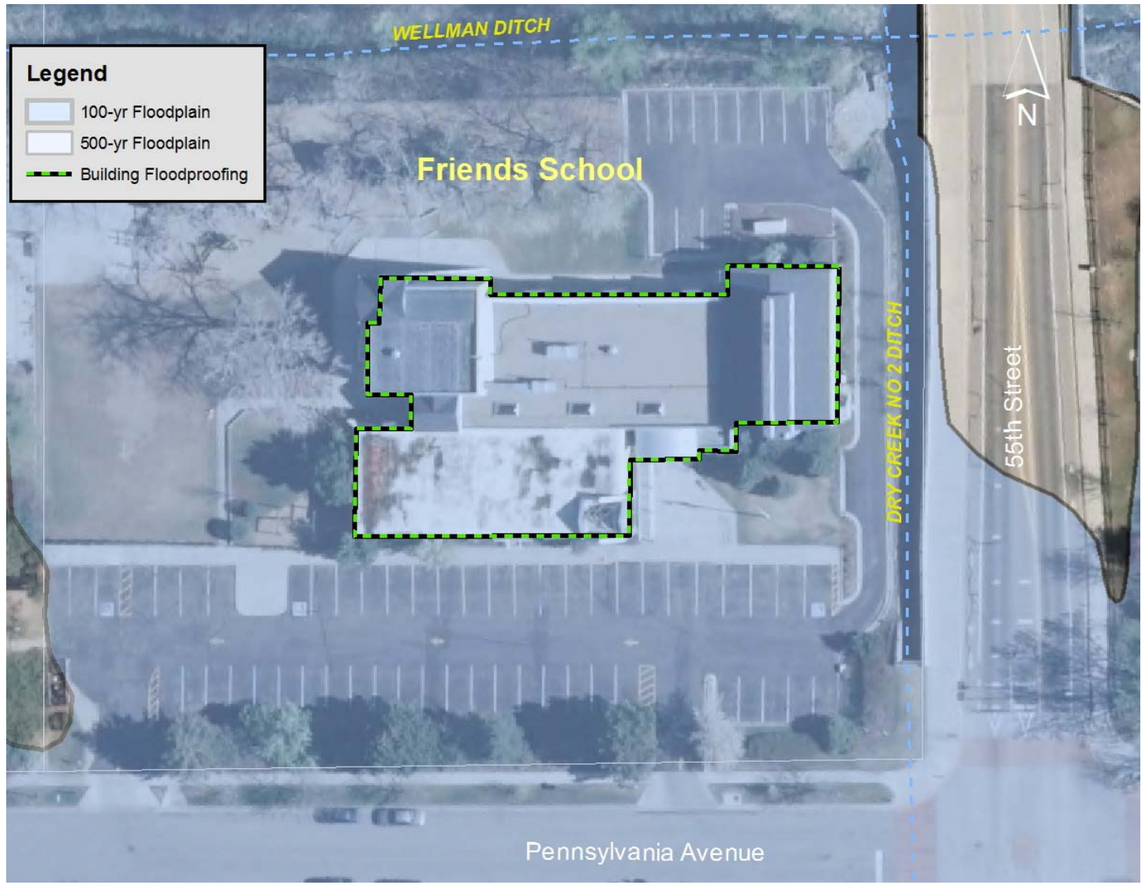


TABLE H-4
Gas Station Retail Building (1595 55th Street) Dry Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Exterior Waterproofing and Refinish	$4.50 per square foot	405	$1,823
Floodproof Entry Doors	$4,000 each unit	2	$8000
Sewer Line Check Valve	$1,200 per unit	1	$1,200
Sump Pump (w/battery backup)	$1,500 per unit	1	$1,500
Incidentals	20% of Element Costs		$2,505
		Floodproofing Construction Sub-Total	**$39,779**
		Structural Analysis	$3,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$28,528**
		Contingency (20%)	$5,706
		Total Cost for Parking Structure	**$34,234**

Floodproofing Cost for this Building is **$30.43 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Building Area = 1,125 square feet, Perimeter = 135 feet
- Three Entry Doors per Building
- Building Structurally Withstands Up to Three Feet of Flooding

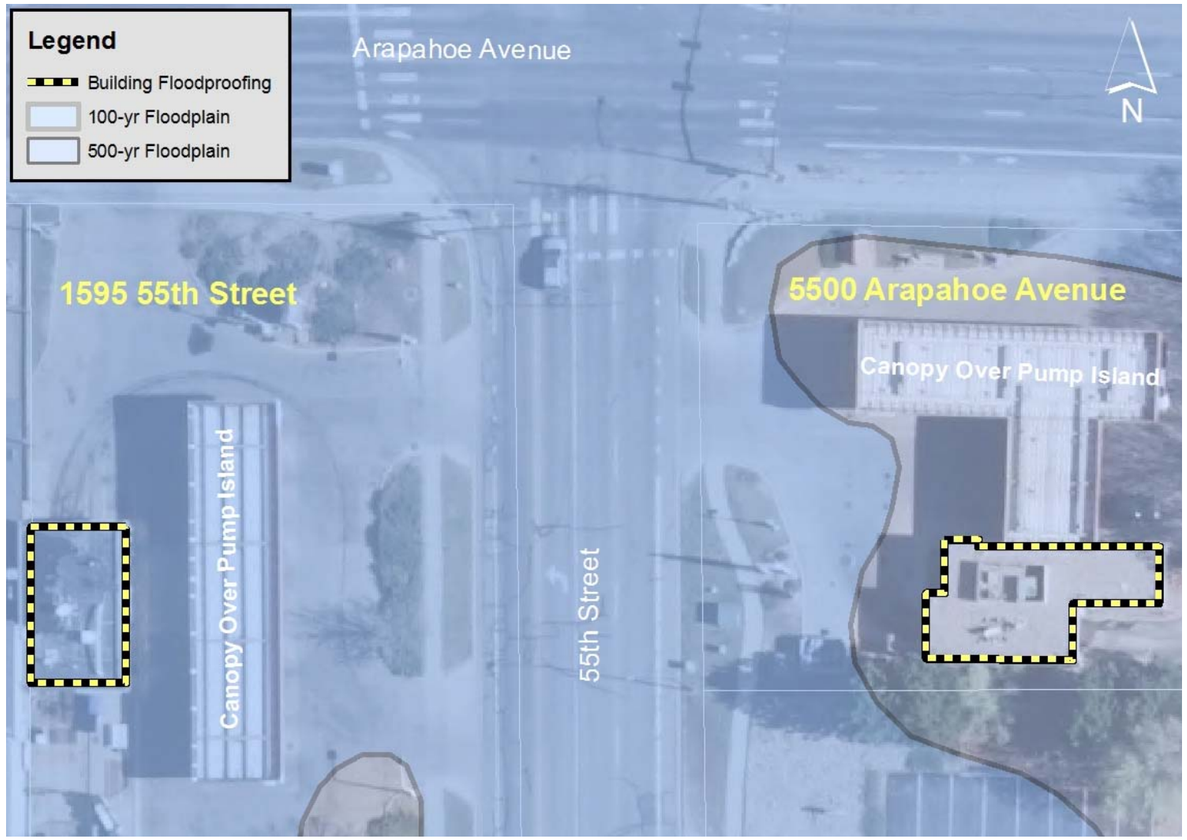
TABLE H-5
Gas Station Retail Building (5500 Arapahoe Avenue) Dry Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Exterior Waterproofing and Refinish	$4.50 per square foot	465	$2,093
Floodproof Entry Doors	$4,000 each unit	2	$8000
Sewer Line Check Valve	$1,200 per unit	1	$1,200
Sump Pump (w/battery backup)	$1,500 per unit	1	$1,500
Incidentals	20% of Element Costs		$2,559
		Floodproofing Construction Sub-Total	**$39,779**
		Structural Analysis	$3,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$28,528**
		Contingency (20%)	$5,706
		Total Cost for Parking Structure	**$34,234**

Floodproofing Cost for this Building is **$22.34 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Building Area = 1,550 square feet, Perimeter = 189 feet
- Three Entry Doors per Building
- Building Structurally Withstands Up to Three Feet of Flooding



South Boulder Creek Dry Floodproofing Options-Single Family Building - no Basement

TABLE H-6
Single-Family Residential Building - no Basement Dry Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Exterior Waterproofing and Refinish	$4.50 per square foot	480	$2,160
Floodproof Door Entry	$3,500 each unit	3	$10,500
Sewer Line Check Valve	$1,200 per unit	1	$1,200
Sump Pump (w/battery backup)	$1,500 per unit	1	$1,500
Incidentals	20% of Element Costs		$3,072
		Floodproofing Construction Sub-Total	**$18,432**
		Structural Analysis	$3,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$31,932**
		Contingency (20%)	$6,386
		Total Cost for Parking Structure	**$38,318**

Floodproofing Cost for this Building is **$25.55 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Building Area = 1,500 square feet, 50ft x 30ft, Perimeter = 160 feet
- Three Entry Doors per Building
- Building Structurally Withstands Up to Three Feet of Flooding

South Boulder Creek Dry Floodproofing Options-Single Family Building - with Basement

TABLE H-7
Gas Station Retail Building (5500 Arapahoe Avenue) Dry Floodproofing Elements and Costs

Floodproofing Element	Estimated 2011 Unit Cost	No. Units	Element Cost
Exterior Floodproof Concrete Ring wall	$45.00 per square foot	960	$43,200
Floodproof Door Entry	$3,500 each unit	3	$10,500
Sewer Line Check Valve	$1,200 per unit	1	$1,200
High Capacity Sump Pump (w/generator backup)	$4,500 per unit	1	$4,500
Incidentals	20% of Element Costs		$11,880
		Floodproofing Construction Sub-Total	**$71,280**
		Structural Analysis	$6,000
		Civil & Architectural	$4,000
		Permit Costs	$6,500
		Overall Sub-Total	**$87,780**
		Contingency (20%)	$17,556
		Total Cost for Parking Structure	**$105,336**

Floodproofing Cost for this Building is **$70.22 per square foot**

Assumptions:

- Floodproofing to Three Feet Above Grade
- Floodproofing Involves Exterior Concrete Floodwall Wrap Around Foundation
- Total Height of Floodwall (to Footing) is Six Feet
- Building Area = 1,500 square feet, 50ft x 30ft, Perimeter = 160 feet
- Three Entry Doors per Building
- Building and Basement Foundation Walls are Verified to Structurally Withstand Up to Three Feet of Flooding Above Grade