CITY OF BOULDER
Facilities and Asset Management

New Britain and Park Central Buildings

Structural Flood Assessment

Revised - March 18, 2013

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1.0 EXECUTIVE SUMMARY

We have assessed the ability of the New Britain and Park Central buildings to resist loading and water infiltration for the 100-year flood event, and what improvements would be required to bring the structures into compliance with current structural codes. We have also investigated what improvements would be required to support the structures in the event that the existing foundations are undermined due to scour. The design criteria was based on the more stringent of the newly adopted 2012 Boulder Creek floodplain study and the preceding 1994 Boulder Creek floodplain study. The velocities utilized in the analysis range from 7.93 feet per second with a flood protection elevation of 3.24 feet above grade for the New Britain building, to 5.24 feet per second with a flood protection elevation of 3.40 feet above grade for the Park Central building. The depth of scour was determined to be approximately 1.6 feet below the footings at the New Britain building and 3.6 feet below the footings at the Park Central building. The alternative solutions investigated are site improvement solutions including providing rip rap protection around the perimeter of the structures, and permeation grouting around the perimeter of the foundations. Our solutions are described in more detail within the body of this report.

After conducting our assessment, we have concluded that the buildings as constructed are not able to withstand the 100-year flood event without improving the structures. Based on the flood and soil parameters for the site, the foundations of both buildings would be undermined due to scour, which would result in the collapse of the structures. The improvements that would be required to floodproof the existing structures excluding site improvements are approximately $31,000 for the Park Central Building and $142,000 for the New Britain Building. The costs for the site improvements that would be required to prevent the foundations from being undermined range from $115,000 to $190,000 for the Park Central Building and $72,800 to $146,000. As mentioned elsewhere in the report, there would be costs incurred in addition to the required structural improvements, including the possible relocation of underground utilities.

Since the costs for the required structural improvements do not exceed 50% of the market value of the structure, and the site improvements are not considered improvements to the building, the improvements are not considered ‘substantial improvements’ as defined in 9-16-1 of the City of Boulder Revised Code, and are therefore permitted.

2.0 INTRODUCTION

2.1 SCOPE OF SERVICES

The scope of structural services is to provide a report summarizing the results of alternate methods of preventing the undermining of the New Britain and Park Central building foundations due to scour, what improvements would need to be made to floodproof the buildings, and the approximate cost associated with improving the buildings. Floodproofing of architectural elements such as door gaskets and waterproof membranes are not included in this report. Site and utility improvements are also not included in this report.

2.2 ASSUMPTIONS AND BASIS OF ANALYSIS

Our assumptions for the analysis of the New Britain and Park Central buildings are as follows:

- The soil profile is as indicated in the existing drawing set of the Park Central Building, and sieve analysis data of a soil sample collected on site
- The water surface elevations are linearly interpolated between cross-sections
- The non-observable elements of the New Britain building are as described in Item 3.5
- Presumptive market value of the buildings is approximately $120 per square foot per the City of Boulder

The analysis is based on the information provided by the City of Boulder indicated in Item 4.0, including drawings of the Park Central Building, boring logs from the Park Central Building, floodplain data from both the newly adopted 2012 Boulder Creek floodplain study and the preceding 1994 Boulder Creek floodplain study, and photographs of the Broadway Bridge reconstruction project. Additionally, our analysis was based on our investigation of existing conditions outlined in Section 5.0.

2.3 LIMITATIONS AND EXCEPTIONS

Our analysis is limited to the information provided, and the observable elements of the structures.

3.0 SITE LOCATION AND CHARACTERISTICS

Site Location

3.1 LOCATION AND LEGAL DESCRIPTION

The Park Central Building at 1739 N. Broadway St. and the New Britain Building 1101 Arapahoe Ave. at are located immediately adjacent to each other on the northwest corner of Arapahoe Ave. and Broadway St. in downtown Boulder as illustrated below. Mustard's Last Stand, a hotdog and burger restaurant is located at the southeast corner of the Park Central Building. A playground area and Boulder Creek are directly to the north of the site, with the city's Municipal Building further north, across the creek. A parking lot and the main branch of the Boulder Public Library are directly to the west of the site with the West Senior Center further west. Across Arapahoe Ave. to the south is the Alfalfa's grocery store and across Broadway to the east are a gas station and a restaurant/office building, often referred to as the Yocum Building.

The legal descriptions for the two properties are:

New Britain Building: W 150 FT OF S 50 FT LOT 9 & W 150 FT OF N 50 FT OF S 100 FT Lot 9 SMITHS & PT E ½ VACATED 11TH ST ADJ

Park Central Building: E 160 FT OF N 50 FT OF S 100 FT AND E 150 FT OF S 50 FT LOT 9 SMITHS LESS SE 28 X 28 FT SPLIT TO ID 120058 11/94

3.2 SITE CHARACTERISTICS

The New Britain and Park Central buildings are located on fairly level ground that generally slopes away from the structures both to the north, toward Boulder Creek and to the south, toward Arapahoe Ave. Asphalt paved parking areas are located across the southern portion of the site.

The City of Boulder has recently adopted a new floodplain study for Boulder Creek, which will hereon be referred to as the 2012 Study. At this time, the study has not yet been approved by the Federal Emergency Management Agency (FEMA). Until the new study is adopted by FEMA, both the 2012 Study and the previous floodplain study, hereon referred to as the 1994 Study must be considered to determine the flooding conditions for the site. Both floodplain models indicate that the site is located within the 100-year floodplain, conveyance zone and high hazard flood zone. The 100-year flood water depths around the buildings are generally around 3 feet, with velocities ranging from approximately 5 feet per second to 8 feet per second. Floodplain maps and cross section information is included in Appendix A.

3.3 CURRENT USE OF PROPERTY

Both the New Britain Building and the Park Central Building are owned, managed and used by the City of Boulder. Within the New Britain Building are Human Resources, Housing and Human Services and Information Technology. The Park Central Building contains Public Works, Community Planning & Sustainability and Planning and Development Services. Although the property is zoned Public and allows these current uses, if the structures were substantially damaged by a 100-year flood event, they could not be rebuilt because they are located in the high hazard flood zone where structures intended for human occupancy are not allowed.

4.0 INFORMATION PROVIDED BY THE CITY OF BOULDER

4.1 DRAWINGS

- Structural, architectural and civil drawings of the Park Central building dated December 15th, 1972.
- Architectural drawing of the 2nd Floor plan for the New Britain Building Remodel, dated May 8, 2006.

4.2 BRIDGE CONSTRUCTION PHOTOS

Photos from the Broadway Bridge over Boulder Creek replacement project

4.3 FLOOD INFORMATION

- 1994 Flood Study maps and data
- 2012 Flood Study maps and data

5.0 INVESTIGATION OF EXISTING CONDITIONS

5.1 METHODOLOGY AND LIMITING CONDITIONS

The original construction drawings that were provided by the City of Boulder were reviewed to determine the existing structural configuration of the Park Central Building. These drawings also contained a soil boring log, included in Appendix C. Original construction drawings were not available for the New Britain Building, so a field investigation was performed to determine the sizes and configuration of foundation elements and structural systems. Observations were limited to visible components. No destructive investigation or soils testing were performed, other than a sieve analysis. There were no available soils reports for the site.

Additional information about the foundation elements and existing soils was provided by city personnel who had experience with construction projects in the area and had made field observations of the excavations during the construction of the adjacent Broadway Bridge.

6.0 BUILDING DESCRIPTIONS

6.1 DESCRIPTION OF NEW BRITAIN BUILDING

The New Britain building is a 3-story wood structure framed with wood joists spanning approximately 30'-0 bearing on a central steel beam spanning approximately 20'-0 to 8" diameter steel columns bearing on 12'-0 x 12'-0 x 16" concrete spread footings, and exterior bearing walls supported on 8" thick concrete stem walls, over a 72" x 12" continuous concrete spread footing. The bearing elevation of the footings is approximately 4'-6 below first floor elevation. These components were visible in the crawl space. The following components were not observable without destructive testing, but are consistent with wood framed structures:

- The walls are assumed to consist of 2x6 or 2x8 studs at 16" with exterior plywood sheathing and glazing.
- The roof structure is assumed to consist of wood mansard trusses supported by exterior bearing walls and a central line of support.

6.2 DESCRIPTION OF PARK CENTRAL BUILDING

Drawings for the Park Central building were provided by the City of Boulder. The structure is a four-story concrete structure consisting of a 4" concrete slab-on-grade, 8" thick, post-tensioned concrete floor slabs and an 8" thick, post tensioned concrete roof slab spanning 30'-0 supported by 24" deep by 16" wide exterior post-tensioned concrete spandrel beams, and an interior central concrete beam strip integral within the thickness of the slab. The spandrel beams and central beam strip are supported by concrete columns –

16" x 16", 16" x 14", 14" x 20" and 14" x 24". The concrete columns are founded on concrete spread footings. Based on the drawings, the footings bearing elevation is 5'-0" below the top of first floor elevation; however, during the Broadway Bridge over Boulder Creek replacement project, these footings were observed by city personnel to be much shallower - more on the order of 2'-6" below top of first floor elevation. There is a concrete-enclosed stair tower at the west end of the structure and a concrete and storefront enclosed combined stair tower and elevator shaft at the east end of the structure. Additionally, there is a brick-faced, one story structure at the southeast corner of the structure. Analysis of the existing restaurant at the southeast corner of the Park Central Building is not included in this report.

7.0 FINDINGS AND REQUIRED IMPROVEMENTS

7.1 FINDINGS

The flood studies were reviewed to determine flood water elevations and velocities. This information was used to determine the flood loads for the buildings. A preliminary scour analysis based on the available soils information was performed in order to determine the impacts of scouring on the existing foundation systems. The existing structures where then analyzed for flood conditions and improvements to the buildings were designed that would resist the flood conditions. Complete structural calculations are contained in Appendix B. The following are summaries of our analysis results:

TABLE 6.1 - SUMMARY OF RELEVANT ELEVATIONS

Building	FFE	WSE	FPE	Δ	BOF	DOS	Δ Ftg	Δ Flr
	[Ft]	[Ft]	[Ft]	[Ft]	[Ft]	[Ft]	[Ft]	[Ft]
New Britain	5349.00	5350.24	5352.24	3.24	5344.5	5342.92	-1.58	-6.08
Park Central	5348.37	5349.77	5351.77	3.40	5345.87	5342.29	-3.58	-5.26

Elevations are expressed in NAVD88 Datum. Abbreviations: FFE = Finished Floor Elevation, WSE = Water Surface Elevation (aka Base Flood Elevation), FPE = Flood Protection Elevation, BOF = Bottom of Footing Elevation, DOS = Depth of Scour elevation.

The forces used for our analysis are based on the more restrictive of the newly adopted 2012 Boulder Creek floodplain study and the preceding 1994 Boulder Creek floodplain study. Calculations used to determine these forces are contained in Appendix B. The following is a summary of the forces to the structure:

TABLE 6.2 - SUMMARY OF FORCES TO STRUCTURE

Building	Hydrostatic	Buoyant	Hydrodynamic	Debris Impact	Special Impact
	[PLF]	[PSF]	[PLF]	[#]	[#]
New Britain	328	202	247	2,463	100
Park Central	361	212	113	1,627	100

7.2 NEW BRITAIN

7.2.1. Site Improvements

As indicated in Table 6.1, during a 100-year flood event, scouring would cause the existing footings to be undermined by approximately 1.6 feet, thereby compromising the supporting foundations of the superstructure. In order to prevent scour from undermining the existing foundations, the site could be improved. Two methods for improving the site are providing below grade rip-rap armoring around the perimeter of the structure to a depth below the scour depth, or improve the in-situ soil by permeation grouting around the perimeter of the structure to a depth below the scour depth. Permeation grouting involves drilling and placing small diameter tubes with evenly-spaced ports, injecting a low viscosity, cementitious fluid grout, which permeates the voids in sandy soil and binds the soil together, thereby making the soil scour-resistant. Three rows of grout tubes are placed around the perimeter of the structure at 3’-0” on center, to a depth of approximately 8’-0 below grade.

7.2.2. Superstructure Improvements

As indicated in table 6.1, the flood protection elevation is 3.24 feet above the first floor elevation of the New Britain building. The storefront between the vertical brick bands

would need to be replaced with 8" concrete infill walls to flood protection elevation. The existing first floor is of wood construction, and would not be effective at resisting water infiltration. The first floor wood framing system would need to be replaced with an 8" thick structural concrete slab spanning from grade beam to grade beam to effectively resist the buoyant forces and prevent water infiltration.

The elevator shaft would need to be improved to meet the requirements of FEMA FIA-TB-4. The elevator pit would need to be waterproofed, a float switch would need to be installed, and no electronic equipment may be located below the flood protection elevation.

7.2.3. Opinion of Probable Cost for Structural Improvements

We estimate that the cost to floodproof the structural elements of the New Britain building to be approximately **$142,000**, and the cost of site improvements to prevent scour to be **$72,800** for the rip-rap solution, and **$146,000** for the permeation grouting solution. While the cost for the rip-rap solution is less, it is a much more intrusive solution than the permeation grouting. If the utilities are accurately located, the drilling for the grout tubes can be located to avoid them. This cost does not include architectural elements (such as door gaskets, membranes, elevator float switches), utility relocation, parking slabs, relocation of employees during construction, etc.

The market value of the New Britain building structure is $1,519,000 based on $120 per square foot. Since the costs for the required structural improvements do not exceed 50% of the market value of the structure, and the site improvements are not considered improvements to the building, the improvements are not considered 'substantial improvements' as defined in 9-16-1 of the City of Boulder Revised Code. Although, both structures are located in the high hazard zone based on both the 1994 study and the 2012 study, the structures are able to be improved in accordance with 9-3-5(d)(2) of the City of Boulder Revised Code.

7.3 PARK CENTRAL

7.3.1. Site Improvements

As indicated in Table 6.1, during a 100-year flood event, scouring would cause the existing footings to be undermined by approximately 3.6 feet, thereby compromising the supporting foundations of the superstructure. In order to prevent scour from undermining the existing foundations, the site could be improved. Two methods for improving the site are providing below grade rip-rap armoring around the perimeter of the structure to a depth below the scour depth, or improve the in-situ soil by permeation grouting around the perimeter of the structure to a depth below the scour depth. Permeation grouting involves drilling and placing small diameter tubes with evenly-spaced ports, injecting a low viscosity, cementitious fluid grout, which permeates the voids in sandy soil and binds the soil together, thereby making the soil scour-resistant. Three rows of grout tubes are placed around the perimeter of the structure at 3'-0" on center, to a depth of approximately 8'-0 below grade.

7.3.2. Superstructure Improvements

The west stair tower is enclosed in concrete and impermeable to the 100-year flood loads; however, the door would need to be replaced with a floodproof door and the slab-on-grade would need to be replaced with a structural slab tied into the existing concrete walls. The slab would need to be 6" thick to resist the buoyancy pressures of 212 psf (see table 6.2).

The east stair tower/elevator shaft is enclosed with concrete and storefront. The concrete walls are adequate to resist flood loading, but the storefront system would need to be replaced with either tempered glass or a concrete wall up to the flood protection elevation of 3.4 feet above first floor, and the door would need to be replaced with a floodproof door. The elevator shaft would need to be improved to meet the requirements of FEMA FIA-TB-4. The elevator pit would need to be waterproofed, a float switch would need to be installed, and no electronic equipment may be located below the flood protection elevation.

The existing columns were checked for debris impact of approximately 1,600 pounds, based on a 5,000# truck impacting the column for a duration of ½ second at the flood protection elevation. This criterion is more stringent than is what is required by the City of Boulder floodplain regulations, which is a 1,000# object impacting for a duration of 1 second. The resulting internal column reactions were loaded to approximately 12% of their capacity, as the columns are heavily reinforced (minimum of 4 - 1" diameter rebar in a 16"x16" concrete column).

7.3.3. Opinion of Probable Cost for Structural Improvements

We estimate that the cost to floodproof the structural elements of the Park Central building to be approximately **$32,000**, and the cost of site improvements to prevent scour to be **$115,000** for the rip-rap solution, and **$190,000** for the permeation grouting solution. While the cost for the rip-rap solution is less, it is a much more intrusive solution than the permeation grouting. If the utilities are accurately located, the drilling for the grout tubes can be located to avoid them. This cost does not include architectural elements (such as door gaskets, membranes, elevator float switches), utility relocation or retrofitting, parking slabs, relocation of employees during construction, etc.

The market value of the Park Central building structure is $2,430,000 based on an assumed value of $120 per square foot. Since the costs for the required structural improvements do not exceed 50% of the market value of the structure, and the site improvements are not considered improvements to the building, the improvements are not considered 'substantial improvements' as defined in 9-16-1 of the City of Boulder Revised Code. Although, both structures are located in the high hazard zone based on both the 1994 study and the 2012 study, the structures are able to be improved in accordance with 9-3-5(d)(2) of the City of Boulder Revised Code.

8.0 CONCLUSIONS

After conducting our assessment, we have concluded that the buildings as constructed are not able to withstand the 100-year flood event without improving the structures. Based on the flood and soil parameters for the site, the foundations of both buildings would be undermined due to scour, which would result in the collapse of the structures. The improvements that would be

required to floodproof the existing structures excluding site improvements are approximately $31,000 for the Park Central Building and $142,000 for the New Britain Building. The costs for the site improvements that would be required to prevent the foundations from being undermined range from $115,000 to $190,000 for the Park Central Building and $72,800 to $146,000. As mentioned elsewhere in the report, there would be costs incurred in addition to the required structural improvements, including the possible relocation of underground utilities.

Since the costs for the required structural improvements do not exceed 50% of the market value of the structure, and the site improvements are not considered improvements to the building, the improvements are not considered 'substantial improvements' as defined in 9-16-1 of the City of Boulder Revised Code, and are therefore permitted.

9.0 REFERENCES

The following published references were used in the preparation of this report:

Federal Emergency Management Agency: *Technical Bulletin 3: Non-Residential Floodproofing-Requirements and Certification for Buildings Located in Special Flood Hazard Area*, 1993

Federal Emergency Management Agency: *FEMA-102: Floodproofing Non-Residential Structures*, May 1986.

Federal Emergency Management Agency: *FEMA-114: Design Manual for Retrofitting Flood-Prone Residential Structures*, September 1986.

Federal Emergency Management Agency: *FIA-TB-4: Elevator Installation for Buildings Located in Special Flood Hazard Areas*

Colorado State University: *Colorado State University Pier Scour Equation (modified from Richardson and others)*, 1993.

Reed Construction Data: *RSMeans Online*

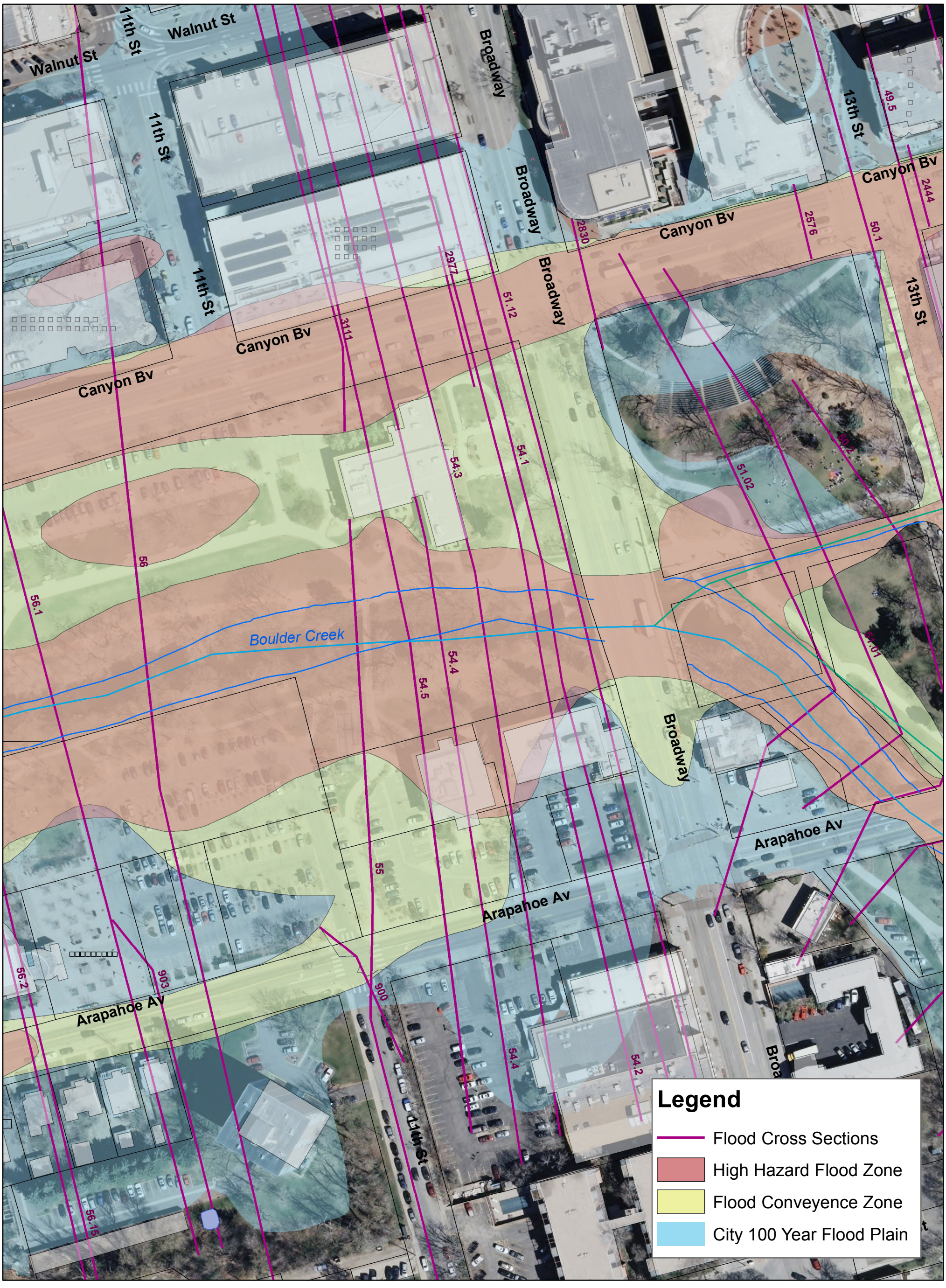
Appendix A

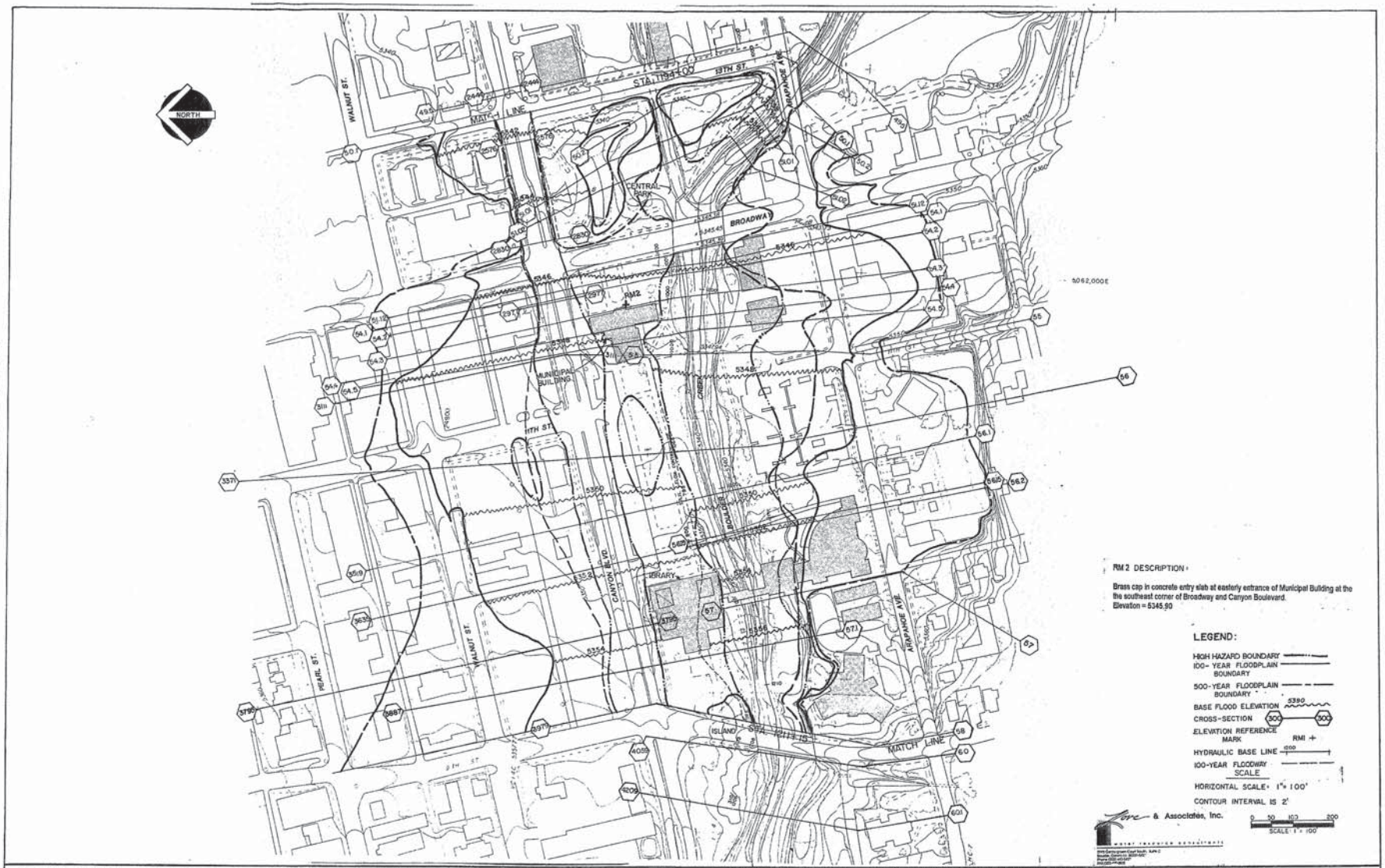
Flood Study Information

City of Boulder
1994 Boulder Creek Floodplain Study

N

160 80 0 160 Feet





PLAN
PLOTTED
PLOT BOOK
AT 100 PLOT CONTOURS

CITY OF BOULDER, COLORADO

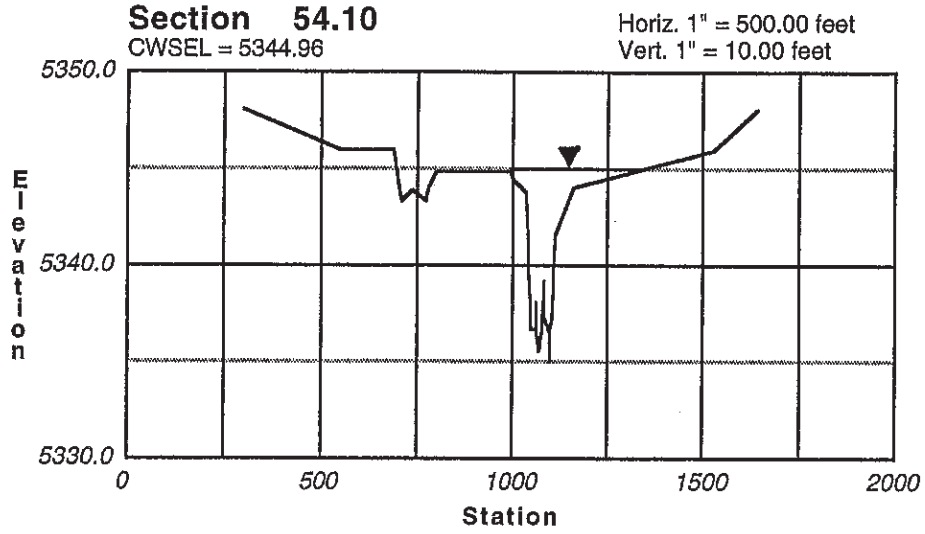
DATE	REVISION RECORD	DRW	CK'D

DESIGN	RECOMMEND FOR APPROVAL	
DRW.	WATER	DATE
CHECK	SEWER	DATE
APPROVE	FLOOD	DATE
	TRANS	DATE

FLOODPLAIN: 1194+00 TO 1211+15
Boulder Creek Physical Map Revision Request, 6th Street - 17th Street

PROJ. NO. 8912B1 | DATE 3/16/94 | SHEET 3 OF 6

Love & Associates, Inc.
2995 Centergreen Court South, Suite C.
Boulder, Colorado 80301-5421

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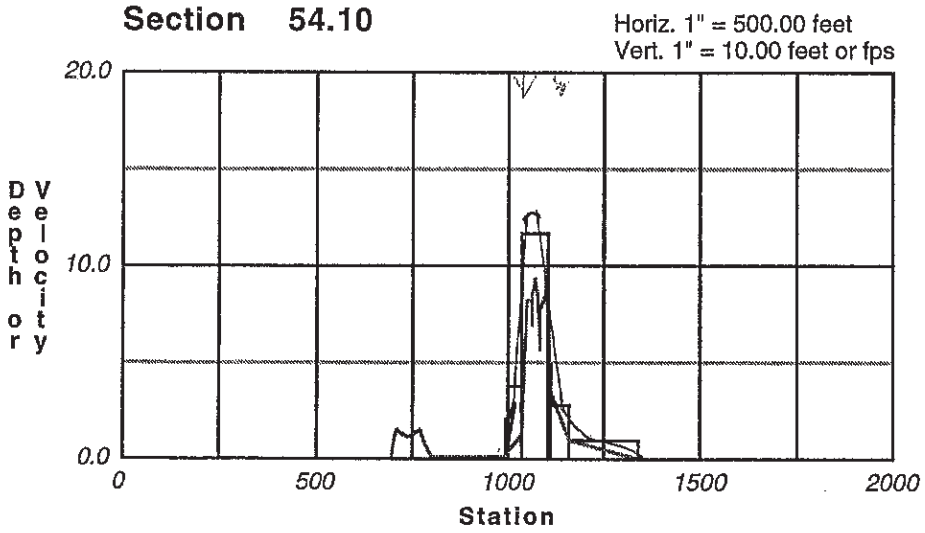
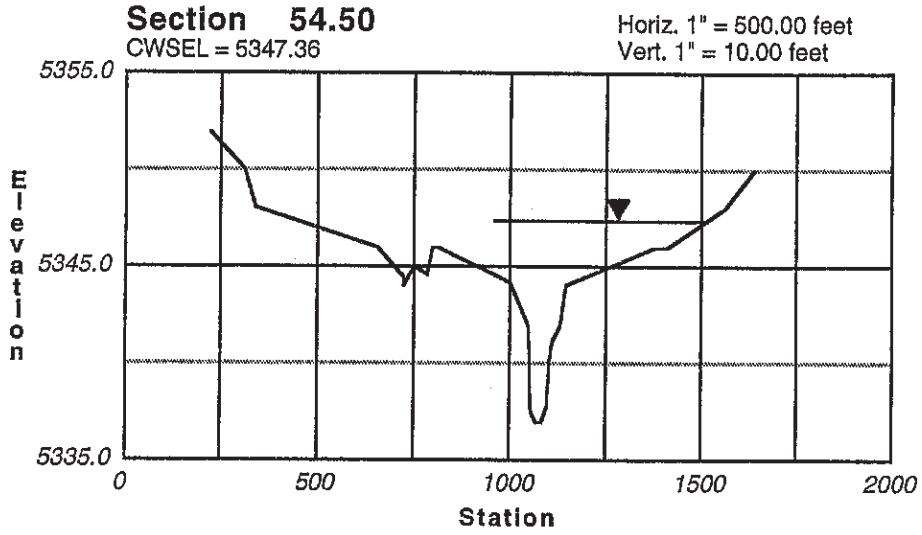


Love & Associates, Inc.
2995 Centergreen Court South, Suite C.
Boulder, Colorado 80301-5421



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9600.0	2249.8	5281.5	2068.7	338.3	532.8	902.8	98.8	30.4	5340.20
.09	6.65	9.91	2.29	.040	.050	.100	.000	5336.90	955.00
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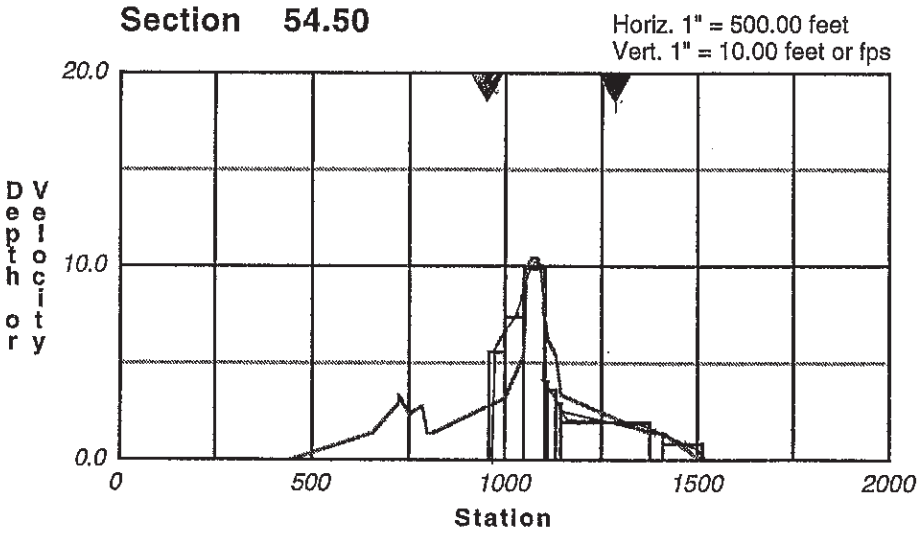
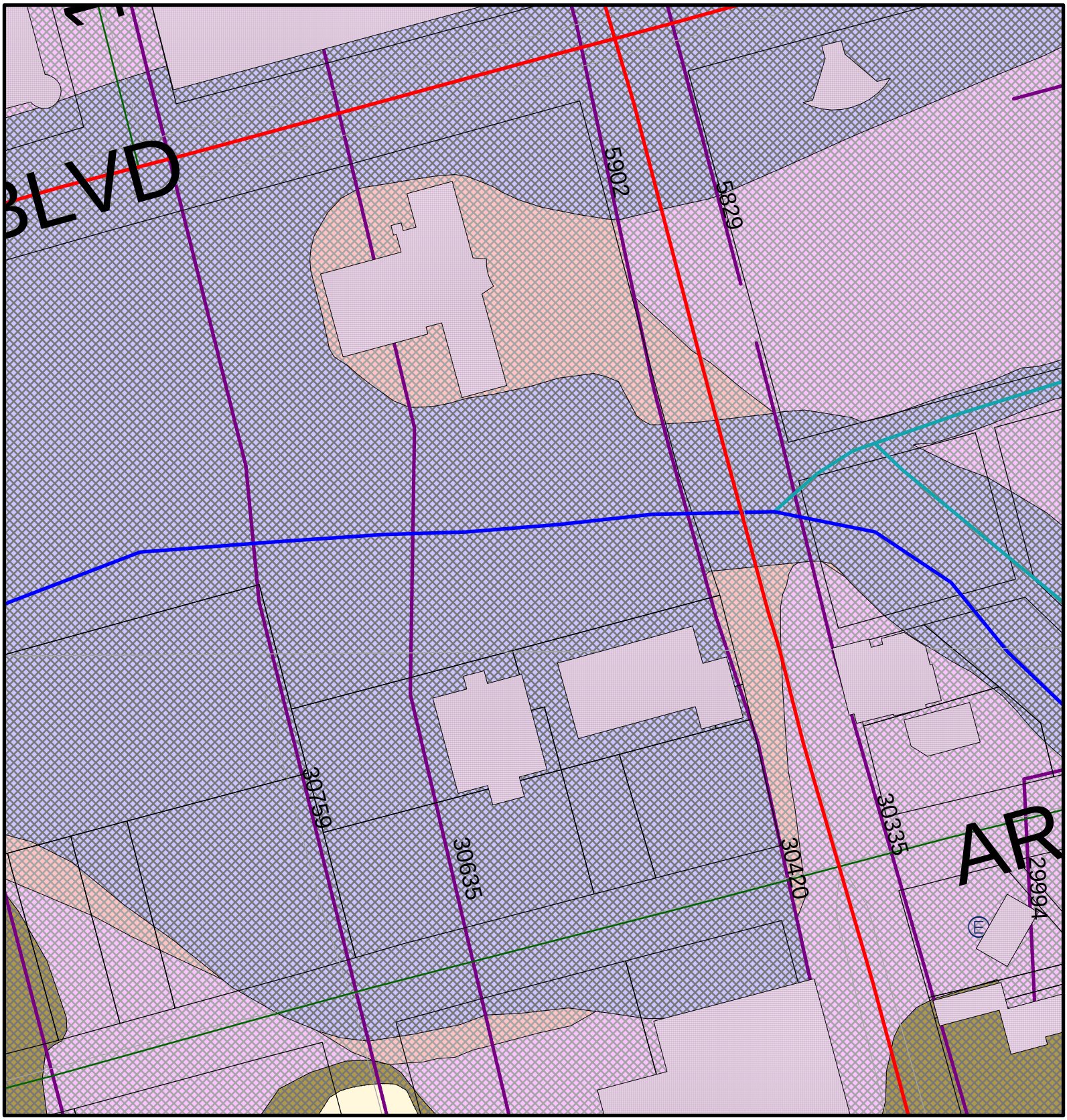


2012 Floodplain Study



LEGEND

- Street Names
- Building Footprints
- Main Roads
- Arterial
- Highway
- Street Centerlines
- Survey Polygons
- Creek & Ditches
- Creek
- Intermitent Creek
- Ditch
- Ditch Lateral
- Aqueduct
- Tailwater
- Ownership Parcels
- Flood Elevation Certificates
- Flood work in progress X Sections
- Flood work in progress High Hazard
- Flood work in progress Conveyance
- Flood work in progress 100 Year
- Flood work in progress 500 Year
- Lakes
- City Limits

N

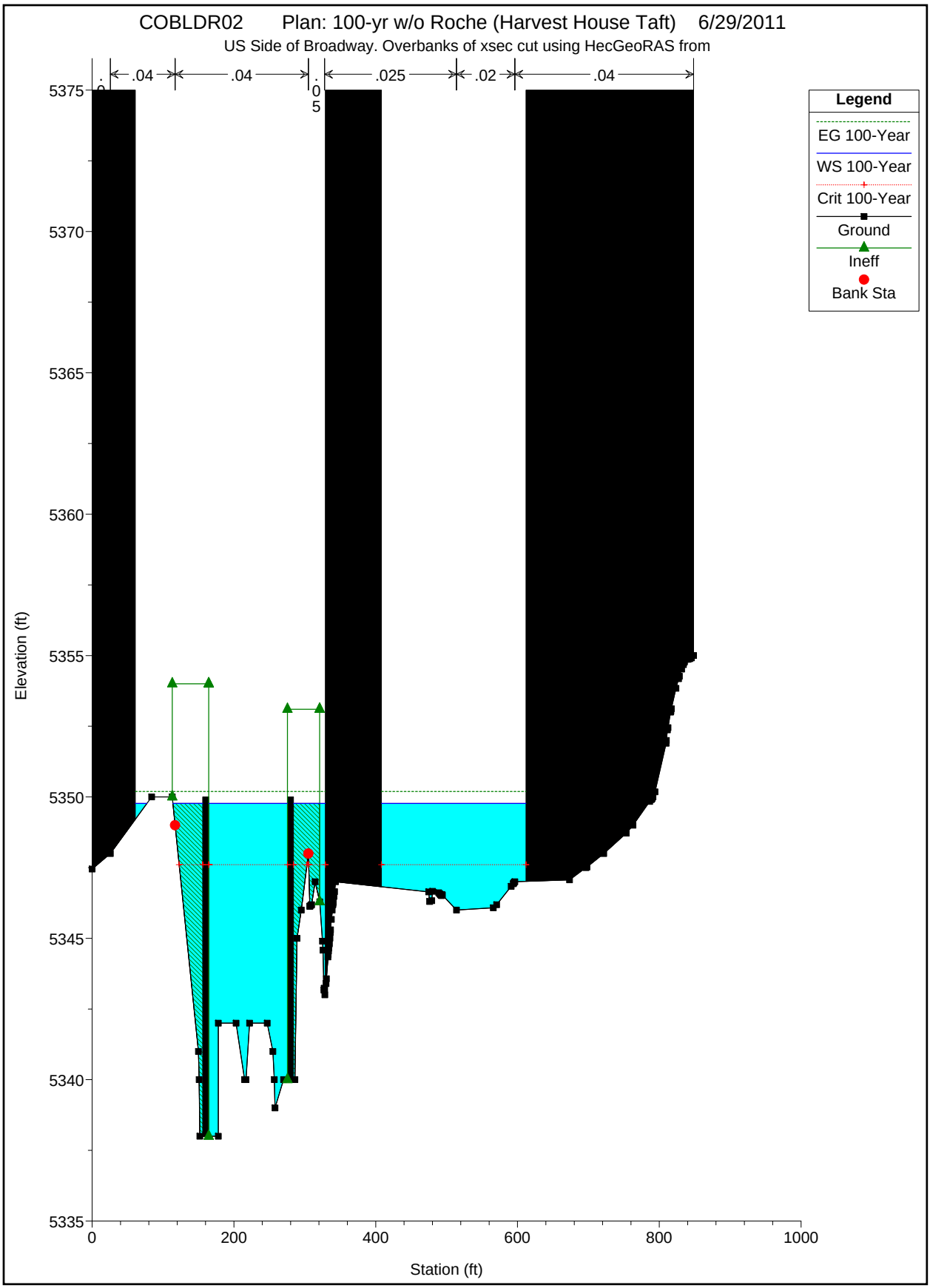
1:1200

MapLink
City of Boulder GIS

Sat 06 Oct 2012 10:29

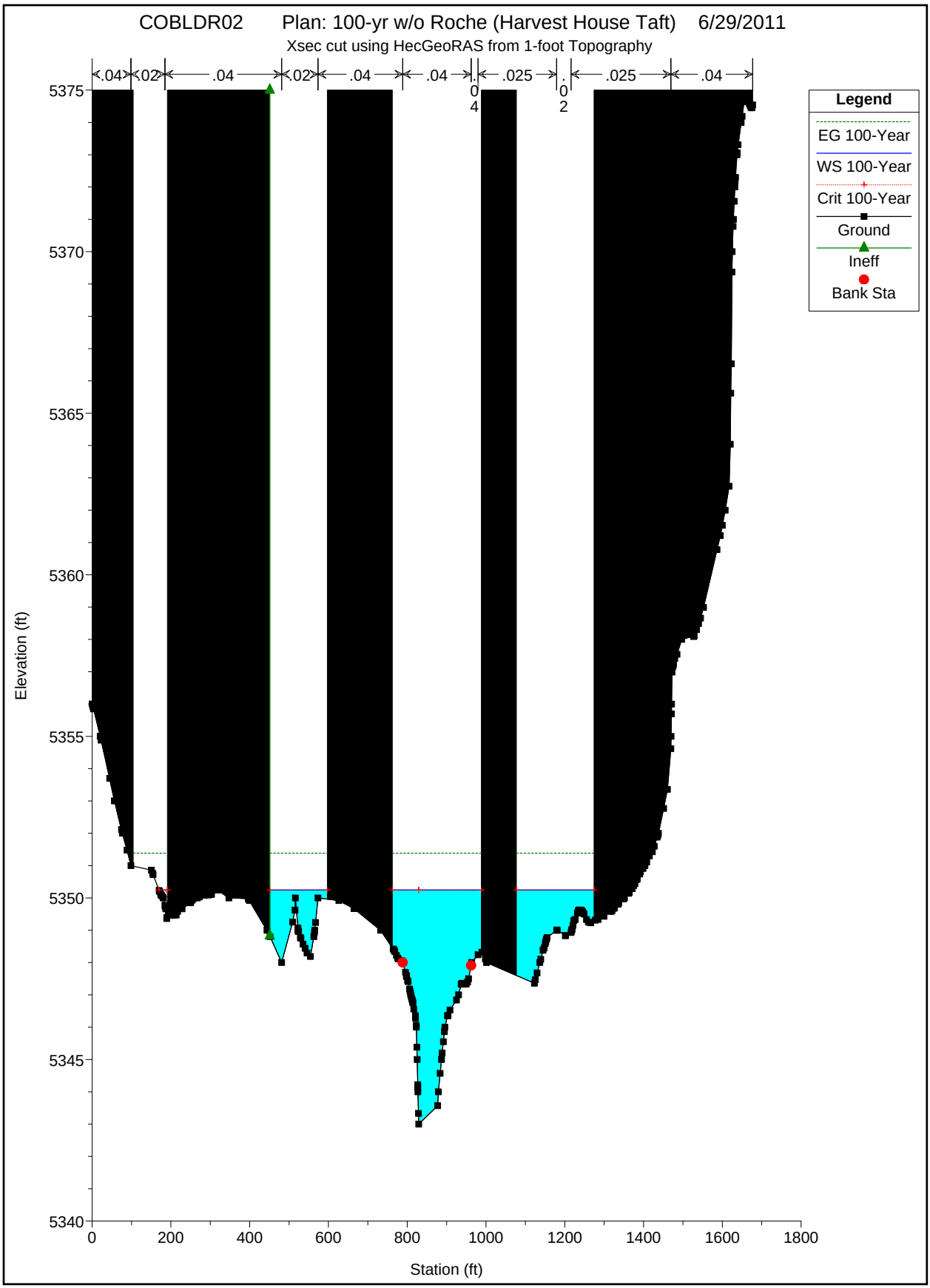
Plan: 100yr Taft Boulder Creek Broadway-Arap RS: 30420 Profile: 100-Year

E.G. Elev (ft)	5350.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.42	Wt. n-Val.	0.040	0.040	0.024
W.S. Elev (ft)	5349.77	Reach Len. (ft)	1.00	1.00	1.00
Crit W.S. (ft)	5347.60	Flow Area (sq ft)	4.56	987.92	711.86
E.G. Slope (ft/ft)	0.001430	Area (sq ft)	5.74	1307.10	762.46
Q Total (cfs)	8888.98	Flow (cfs)	2.68	5159.00	3727.30
Top Width (ft)	418.37	Top Width (ft)	19.37	171.00	228.00
Vel Total (ft/s)	5.22	Avg. Vel. (ft/s)	0.59	5.22	5.24
Max Chl Dpth (ft)	11.77	Hydr. Depth (ft)	0.28	8.90	3.36
Conv. Total (cfs)	235052.8	Conv. (cfs)	70.8	136420.3	98561.7
Length Wtd. (ft)	1.00	Wetted Per. (ft)	16.86	137.84	225.40
Min Ch El (ft)	5338.00	Shear (lb/sq ft)	0.02	0.64	0.28
Alpha	1.00	Stream Power (lb/ft s)	0.01	3.34	1.48
Frctn Loss (ft)		Cum Volume (acre-ft)	1.83	12.78	1.85
C & E Loss (ft)		Cum SA (acres)	0.43	1.24	0.43


COBLDR02 Plan: 100-yr w/o Roche (Harvest House Taft) 6/29/2011
US Side of Broadway. Overbanks of xsec cut using HecGeoRAS from
.0
.04
.04
.05
.025
.02
.04
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
5375
5370
5365
5360
5355
5350
5345
5340
5335
0
200
400
600
800
1000
Station (ft)

Plan: 100yr Taft Boulder Creek 6th-Broadway RS: 30635 Profile: 100-Year

E.G. Elev (ft)	5351.38	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.14	Wt. n-Val.	0.027	0.040	0.025
W.S. Elev (ft)	5350.24	Reach Len. (ft)			
Crit W.S. (ft)	5350.24	Flow Area (sq ft)	249.22	793.08	381.91
E.G. Slope (ft/ft)	0.008116	Area (sq ft)	256.68	793.08	381.91
Q Total (cfs)	12000.00	Flow (cfs)	1700.51	7272.42	3027.07
Top Width (ft)	590.81	Top Width (ft)	194.08	173.85	222.88
Vel Total (ft/s)	8.43	Avg. Vel. (ft/s)	6.82	9.17	7.93
Max Chl Dpth (ft)	7.24	Hydr. Depth (ft)	1.44	4.56	1.71
Conv. Total (cfs)	133199.6	Conv. (cfs)	18875.6	80723.6	33600.4
Length Wtd. (ft)		Wetted Per. (ft)	176.35	174.86	228.47
Min Ch El (ft)	5343.00	Shear (lb/sq ft)	0.72	2.30	0.85
Alpha	1.03	Stream Power (lb/ft s)	4.89	21.07	6.71
Frctn Loss (ft)	0.70	Cum Volume (acre-ft)	0.61	3.92	1.85
C & E Loss (ft)	0.36	Cum SA (acres)			


COBLDR02 Plan: 100-yr w/o Roche (Harvest House Taft) 6/29/2011
Xsec cut using HecGeoRAS from 1-foot Topography
.04
.02
.04
.02
.04
.04
.04
.025
.02
.025
.04
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
5375
5370
5365
5360
5355
5350
5345
5340
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)

Appendix B

Structural Calculations

Anthem, LLC
Structural Engineering

Project: NB & PC Structural Flood Study
Job #: 12-045 Designer: DEK
Date: October 11, 2012

Geotechnical Report:

Geotechnical Engineer	N/A
Report Number	N/A
Report Date	N/A

Soil Data:

Maximum End Bearing Pressure	25	**ksf**
Side Shear - Gravity	2.5	**ksf**
Side Shear - Uplift	2.5	**ksf**
Side Shear Minimum DL	0	**ksf**
Minimum DL End Bearing Pressure	0	**ksf**
Minimum Penetration into Bedrock	15	**ft**
Top Bedrock Penetration to be Ignored	2	**ft**
Uplift Sideshear Stress	0	**ksf**
Uplift Sideshear Length	0	**ft**
Specified Minimum Pier Length	35	**ft**
Concrete Strength: **f'c =**	4	**ksi**

Drilled Pier Properties:

Pier Diameter	**in**	**10**	**12**	**14**	**16**	**18**	**20**	**24**	**30**	**36**	**42**	**48**
End Area	**ft^2**	0.545	0.785	1.069	1.396	1.767	2.182	3.142	4.909	7.069	9.621	12.57
Surface Area	**ft^2/ft**	2.618	3.142	3.665	4.189	4.712	5.236	6.283	7.854	9.425	11	12.57
$\phi P_n/U$ (ACI 10-2)	**kips**	154.2	215.3	287.5	370.8	465.2	570.8	815.2	1265	1815	2465	3215
0.005xA	**in^2**	0.393	0.565	0.77	1.005	1.272	1.571	2.262	3.534	5.089	6.927	9.048
Bar Size	5	2	2	3	4	5	6	8	12	17	23	30

Drilled Pier Capacities (kips):

Pier Diameter (in)		**10**	**12**	**14**	**16**	**18**	**20**	**24**	**30**	**36**	**42**	**48**
$1/2\phi P_n/U$		77	108	144	185	233	285	408	633	907	1232	1607
Bedrock Penetration (ft)	**15**	99	122	146	171	197	225	283	378	483	598	723
	16	105	130	155	182	209	238	298	398	507	625	754
	17	112	137	164	192	221	251	314	417	530	653	785
	18	118	145	173	202	233	264	330	437	554	680	817
	19	125	153	182	213	244	277	346	457	577	708	848
	20	131	161	192	223	256	290	361	476	601	735	880
	21	138	169	201	234	268	303	377	496	624	763	911
	22	145	177	210	244	280	316	393	515	648	790	942
	23	151	185	219	255	292	329	408	535	672	818	974
	24	158	192	228	265	303	343	424	555	695	845	1005
												> 1/2ϕPn/U

Side Shear Capacities:

Side Shear (k/ft)	6.545	7.854	9.163	10.47	11.78	13.09	15.71	19.63	23.56	27.49	31.42
Min DL Force (kips)	0	0	0	0	0	0	0	0	0	0	0
Side Shear (min DL) (k/ft)	0	0	0	0	0	0	0	0	0	0	0
Uplift Force (kips)	20.83	25	29.17	33.33	37.5	41.67	50	62.5	75	87.5	100
Side Shear (Uplift) (k/ft)	0	0	0	0	0	0	0	0	0	0	0

Anthem, LLC
Structural Engineering

Project: NB & PC Str Flood Assessment
Job #: 12-043 Designer: DEK
Date: October 22, 2012

New Britain Building - Flood Analysis

Design Criteria (FEMA FIA-TB-3):

General:

Velocity of Water (V) =	7.93	ft/s
Specific Weight of Water (w) =	62.4	pcf
Mass Density of Water (m) =	1.94	slugs/ft^3
Equiv. Fluid Weight of Saturated Soil (S) =	0	pcf
Acceleration Due to Gravity (g) =	32.2	ft/s^2

Resultant Lateral Force Due to Hydrostatic Pressure From Freestanding Water:

Height of Freestanding Water (H) =	3.24	ft
Depth of Saturated Soil (D) =	0.0	ft
$F_h = 1/2wH^2$ =	**328**	#
$F_{sat} = 1/2SD^2 + F_h$ =	**328**	#

Buoyancy Force:

Area of Horizontal Surface (A_h) =	1.00	ft^2
Depth of Building Below Flood Protection Elevation (H) =	3.24	ft
$F_h = wA_hH$ =	**202**	#

Hydrodynamic Force:

Drag Coefficient (C_d) =	1.25	
Area of Vertical Surface (A_v) =	3.24	ft^2
$F_d = C_dm1/2V^2A_v$ =	**247**	#

Debris (Normal) Impact Force:

Weight of Object (W) =	5000	#
Duration of Impact (t) =	0.5	sec
$F_i = WV/(gt)$ =	**2463**	#

Special Impact Force:

F_{is} =	**100**	plf

Anthem, LLC
Structural Engineering

Project: NB & PC Str Flood Assessment
Job #: 12-043 Designer: DEK
Date: October 22, 2012

New Britain Building - Scour Analysis

Colorado State University Pier Scour Equation (Modified from Richardson, 1993):

$$y_s/y_1 = 2K_1K_2K_3(a/y_1)^{0.65}F_r^{0.43}$$

y_s =	**6.09**	**Feet**	Depth of Scour
y_1 =	3.24	Feet	Upstream Flow Depth
K_1 =	1		Pier Nose Shape Correction Factor (Dimensionless)
K_2 =	1		Skew Correction Factor (Dimensionless) - $(\cos\theta + L/a \sin\theta)^{0.65}$
K_3 =	1.1		Bed Form Correction Factor (Dimensionless)
a =	3	Feet	Width of Pier
F_r =	0.78		Froude Number - $(F_r = V_e/(gy_a)^{1/2})$
θ =	90	Degrees	Angle of Attack of Flow
V_e =	7.93	Ft/sec	Average Velocity of Flow

Correction Factor, K_1 For Pier Nose Shape

Shape of Pier Nose	K_1
Square Nose	1.1
Round Nose	1.0
Circular Cylinder	1.0
Group of Cylinders	1.0
Sharp Nose	0.9

Correction Factor, K_3 For Bed Form

Shape of Pier Nose	Dune Height H [Feet]	K_3
Clear Water Scour	N/A	1.1
Plane Bed & Antidun Flow	N/A	1.1
Small Dunes	10 > H > 2	1.1
Medium Dunes	30 > H > 10	1.1 to 1.2
Large Dunes	H > 30	1.3

Anthem, LLC
Structural Engineering

Project: NB & PC Str Flood Ass
Job #: 12-043 Designer:
Date: October 22, 2012

Park Central Building - Flood Analysis

Design Criteria (FEMA FIA-TB-3):

General:

Velocity of Water (V) =	5.24	ft/s
Specific Weight of Water (w) =	62.4	pcf
Mass Density of Water (m) =	1.94	slugs/ft^3
Equiv. Fluid Weight of Saturated Soil (S) =	0	pcf
Acceleration Due to Gravity (g) =	32.2	ft/s^2

Resultant Lateral Force Due to Hydrostatic Pressure From Freestanding Water:

Height of Freestanding Water (H) =	3.40	ft
Depth of Saturated Soil (D) =	0.0	ft
$F_h = 1/2wH^2$ =	**361**	#
$F_{sat} = 1/2SD^2 + F_h$ =	**361**	#

Buoyancy Force:

Area of Horizontal Surface (A_h) =	1	ft^2
Depth of Building Below Flood Protection Elevation (H) =	3.40	ft
$F_h = wA_hH$ =	**212**	#

Hydrodynamic Force:

Drag Coefficient (C_d) =	1.25	
Area of Vertical Surface (A_v) =	3.40	ft^2
$F_d = C_dm1/2V^2A_v$ =	**113**	#

Debris (Normal) Impact Force:

Weight of Object (W) =	5000	#
Duration of Impact (t) =	0.5	sec
$F_i = WV/(gt)$ =	**1627**	#

Special Impact Force:

F_{is} =	**100**	plf

Anthem, LLC
Structural Engineering

Project: NB & PC Str Flood Assessment
Job #: 12-043 Designer: DEK
Date: October 22, 2012

Park Central Building - Scour Analysis

Colorado State University Pier Scour Equation (Modified from Richardson, 1993):

$$y_s/y_1 = 2K_1K_2K_3(a/y_1)^{0.65}F_r^{0.43}$$

y_s =	**5.12**	**Feet**	Depth of Scour
y_1 =	3.4	Feet	Upstream Flow Depth
K_1 =	1		Pier Nose Shape Correction Factor (Dimensionless)
K_2 =	1		Skew Correction Factor (Dimensionless) - $(\cos\theta + L/a \sin\theta)^{0.65}$
K_3 =	1.1		Bed Form Correction Factor (Dimensionless)
a =	3	Feet	Width of Pier
F_r =	0.5		Froude Number - $(F_r = V_e/(gy_a)^{1/2})$
θ =	90	Degrees	Angle of Attack of Flow
V_e =	5.24	Ft/sec	Average Velocity of Flow

Correction Factor, K_1 For Pier Nose Shape

Shape of Pier Nose	K_1
Square Nose	1.1
Round Nose	1.0
Circular Cylinder	1.0
Group of Cylinders	1.0
Sharp Nose	0.9

Correction Factor, K_3 For Bed Form

Shape of Pier Nose	Dune Height H [Feet]	K_3
Clear Water Scour	N/A	1.1
Plane Bed & Antidun Flow	N/A	1.1
Small Dunes	10 > H > 2	1.1
Medium Dunes	30 > H > 10	1.1 to 1.2
Large Dunes	H > 30	1.3

Anthem, LLC
Structural Engineering

Project: NB & PC Flood
Job #: 12-045 Designer: DEK
Date: October 22, 2012

Concrete Beam Design:

NewBritain - Structural Slab

Internal Reactions:

Ma =	8.9	ft kips
Mu =	12.5	ft kips
Vu =	1.5	kips
Tu =	0.0	kips

Geometry:

b =	12.0	in
h =	8.0	in
d =	6.00	in
A_s =	0.66	in^2
A_v =	2.0	in^2
s =	6.0	in

[#6 @ 8"]

Material Properties:

f'_c =	4,000	psi
w_c =	145	pcf
f_y =	60,000	psi
n =	8	
β_1 =	0.85	
E =	3,644,147	psi

Mechanical Properties:

ρ =	0.0092	
ρ_b =	0.0285	
ρ_{max} =	0.0214	
x_b =	3.55	in
a_b =	2.84	in

M_{cr} =	5	ft kips
y_t =	4.00	in
I_{cr} =	208	in4
I_{gr} =	512	in4
I_e =	263	in4

Beam Capacities:

M_u =	12.5	ft kips	
ϕM_n =	16.4	ft kips	<= OK

V_u =	2	kips	
ϕV_n =	97	kips	<= OK

Anthem, LLC
Structural Engineering

Project: NB & PC Flood
Job #: 12-045 Designer: DEK
Date: October 22, 2012

Concrete Beam Design:

Park Central - 16" Square Column With Debris Impact Load

Internal Reactions:

Ma =	7.1	ft kips
Mu =	10.0	ft kips
Vu =	1.5	kips
Tu =	0.0	kips

Geometry:

b =	16.0	in
h =	16.0	in
d =	13.50	in
A_s =	1.40	in^2
A_v =	2.0	in^2
s =	6.0	in

[(2) #5]

Material Properties:

f'_c =	4,000	psi
w_c =	145	pcf
f_y =	60,000	psi
n =	8	
β_1 =	0.85	
E =	3,644,147	psi

Mechanical Properties:

ρ =	0.0065	
ρ_b =	0.0285	
ρ_{max} =	0.0214	
x_b =	7.99	in
a_b =	6.39	in

M_{cr} =	27	ft kips
y_t =	8.00	in
I_{cr} =	2,963	in4
I_{gr} =	5,461	in4
I_e =	137,679	in4

Beam Capacities:

M_u =	10.0	ft kips
ϕM_n =	80.2	ft kips

<= OK

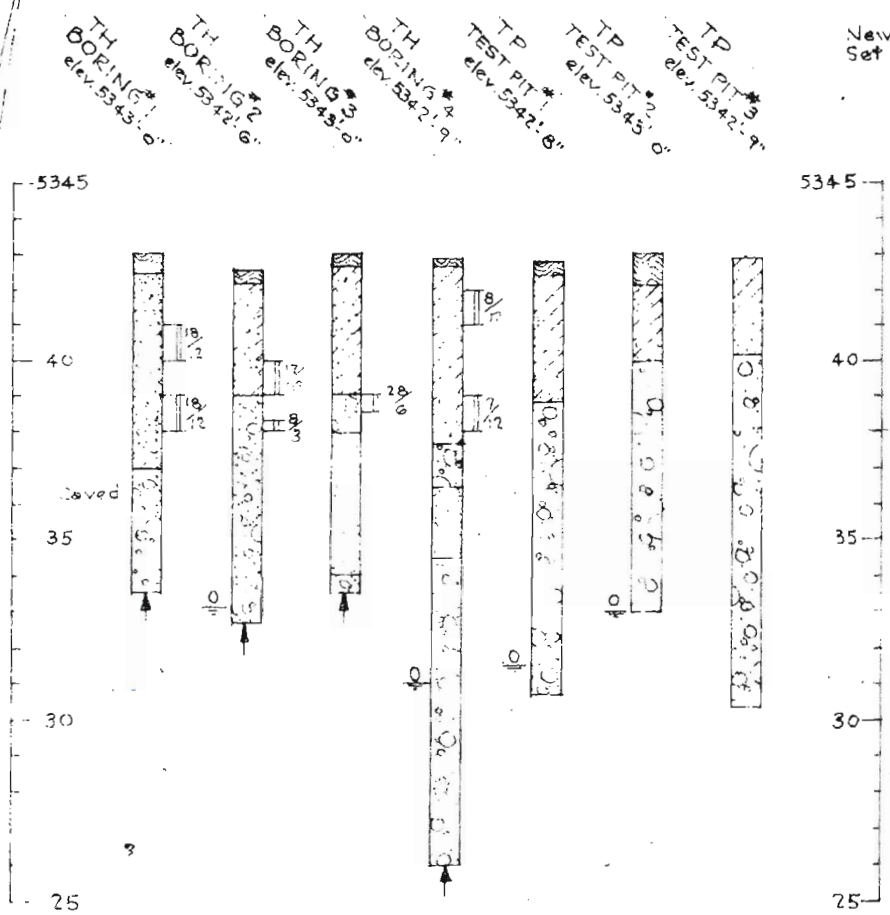
V_u =	2	kips
ϕV_n =	223	kips

<= OK

Appendix C

Historic Soil Boring Logs

LOG OF EXPLORATORY HOLES

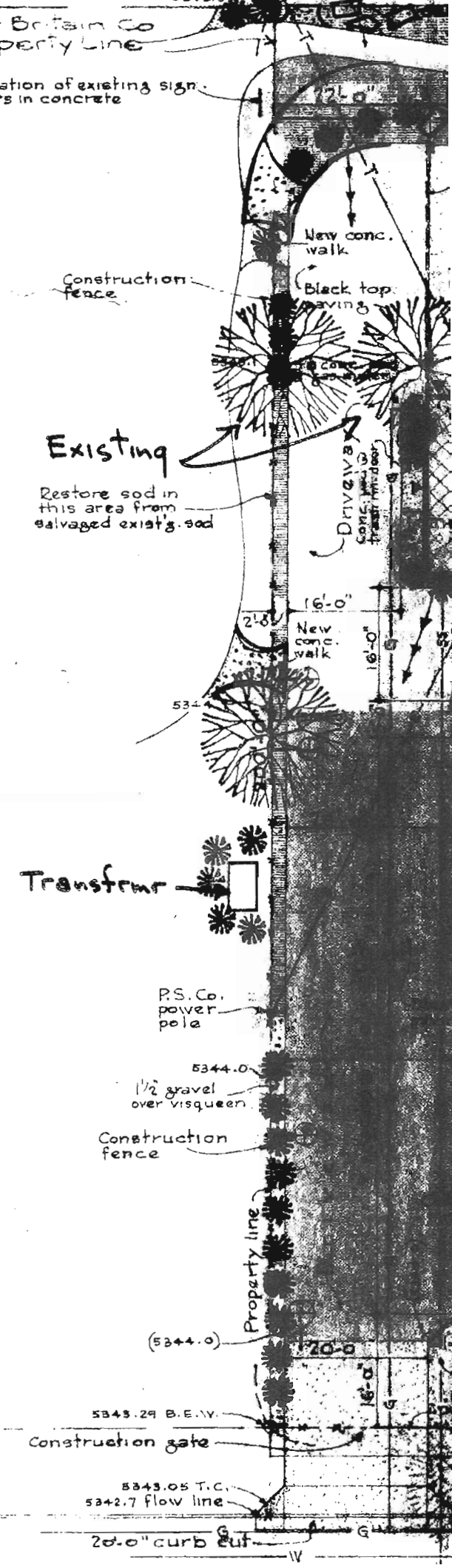


LEGEND

- Topsoil, sand, silty, contains roots & decomposing vegetation, dark brown.
- Sand, silty, gravelly, occasionally clayey, contains occasional cobble & debris, probable fill, medium brown to dark brown loose to medium dense.
- Sand, gravelly with occasional cobble, relatively clean, medium brown.
- Random mixture of gravel & cobbles in a matrix of sand, medium brown, medium dense.
- 0 ▽ Free water level & the number of days after drilling that measurement was taken.
- Indicates drilling refusal
- 18/12 Indicates that 18 blows of a 140 lb. hamer falling 30" were required to drive a 2" outside diameter sampler 12".

NOTES

1. Borings were performed December 13, 1972 with a 4"ϕ continuous flight power auger. Test pits were excavated December 7, 1972 with a tractor-mounted backhoe.
2. Elevations are approximate & were referred to a bench mark (elevation 5345.2') being a cross in the top of the sidewalk @ the southwest corner of the bridge on Broadway north of the proposed building.
3. Boring logs & test pits shown in this report are subject to the limitations, explanations & conclusions of the report.



Appendix D

Opinion of Probable Cost

Anthem, LLC
Structural Engineering

Project: NB & PC Buildings Structural Flood Assessment
Job #: 12-045 By: DEK
Date: March 18, 2013

New Britain Building - Opinion of Probable Costs for Floodproofing

Item	Qty	Unit	Unit Cost	Subtotal	GC Markup on Subs	General Conditions	GC Overhead & Profit	Total
Rip rap								
Excavating, common earth	863	BCY	$6.13	$5,290	$529	$873	$669	$7,361
Backfill, light soil, by hand	390	LCY	$24.78	$9,664	$966	$1,595	$1,223	$13,448
Hauling Rip-rap - 20 miles	473	CY	$13.60	$6,433	$643	$1,061	$814	$8,951
Rip-rap lining - machine placed	473	LCY	$57.83	$27,354	$2,735	$4,513	$3,460	$38,063
Geotextile Fabric	390	SY	$1.10	$429	$43	$71	$54	$597
Hauling excavated earth off site	473	CY	$6.60	$3,122	$312	$515	$395	$4,344
							Subtotal:	**$72,764**
Permiation Grouting 3 rows of 8 foot deep grout ports spaced at 3'-0". *Depth, spacing and costs recommended by Hayward Baker*	280	LF	$375.00	$105,000	$10,500	$17,325	$13,283	$146,108
							Subtotal:	**$146,108**
Reinforced Concrete Structural Slab	104.0	CY	$612	$63,648	$6,365	$10,502	$8,051	$88,566
							Subtotal:	**$88,566**
Concrete Wall Infill	12.7	CY	$398	$5,055	$505	$834	$639	$7,033
							Subtotal:	**$7,033**
Storefront	346.0	SF	$101	$34,946	$3,495	$3,844	$4,228	$46,513
							Subtotal:	**$46,513**
							Rip-Rap Option Total:	**$214,877**
							Permiation Grouting Option Total:	**$288,220**

Anthem, LLC
Structural Engineering

Project: NB & PC Buildings Structural Flood Assessment
Job #: 12-045 By: DEK
Date: March 18, 2013

Park Central Building - Opinion of Probable Costs for Floodproofing

Item	Qty	Unit	Unit Cost	Subtotal	GC Markup on Subs	General Conditions	GC Overhead & Profit	Total
Rip rap								
Excavating, common earth	1161	BCY	$6.13	$7,117	$712	$1,174	$900	$9,903
Backfill, light soil, by hand	303	LCY	$24.78	$7,508	$751	$1,239	$950	$10,448
Hauling Rip-rap - 20 miles	858	CY	$13.60	$11,669	$1,167	$1,925	$1,476	$16,237
Rip-rap lining - machine placed	858	LCY	$57.83	$49,618	$4,962	$8,187	$6,277	$69,044
Geotextile Fabric	910	SY	$1.10	$1,001	$100	$165	$127	$1,393
Hauling excavated earth off site	858	CY	$6.60	$5,663	$566	$934	$716	$7,880
							Subtotal:	**$114,905**
Permiation Grouting 3 rows of 8 foot deep grout ports spaced at 3'-0". *Depth, spacing and costs recommended by Hayward Baker*	366	LF	$375.00	$137,250	$13,725	$22,646	$17,362	$190,983
							Subtotal:	**$190,983**
Storefront	240.0	SF	$101	$24,240	$2,424	$2,666	$2,933	$32,263
							Subtotal:	**$32,263**
							Rip-Rap Option Total:	**$147,168**
							Permiation Grouting Option Total:	**$223,247**