Northwest Corridor
A TRANSPORTATION ENVIRONMENTAL STUDY

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4.10 IDENTIFICATION OF BASE FLOODPLAINS, 100-YEAR FLOODPLAINS AND REGULATORY FLOODWAYS

INTRODUCTION

This section discusses governmental policy and guides the actions for construction in or near floodplains. *Executive Order 11988, Floodplain Management*, requires federal agencies to avoid, to the extent possible, long-term and short-term adverse impacts associated with the modification of floodplains and to avoid floodplain development wherever there is a practical alternative. Federal agencies shall: *"take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains."* The agency shall further: *"evaluate the potential effects of any actions it may take in a floodplain to ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management and to prescribe procedures to implement the policies and requirements of this Order."*

The FHWA's 23 CFR 650, Subpart A provides guidelines for floodplain and construction interaction, which includes:

- Avoiding longitudinal and major encroachments, where possible.
- Minimizing impacts of highway agency actions that adversely affect base floodplains.
- Restoring and preserving the natural and beneficial floodplain values that are adversely impacted by highway agency actions.

The base flood, which is defined as a flood that has a one percent or greater chance of occurrence in any given year (100-year flood) is the regulatory standard used by most federal and state agencies to administer floodplain management programs.

No public concerns were expressed through the public involvement process.

4.10.1 EXISTING CONDITIONS

The following discussion explains the existing floodplains, including the 100-year floodplains, and the regulatory floodways.

4.10.1.1 IDENTIFICATION OF BASE FLOODPLAINS, 100-YEAR FLOODPLAINS, AND REGULATORY FLOODWAYS

Information on the major drainage basins in the study area was obtained from Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs) for Boulder County and Jefferson County. The locations of major stream crossings within the study area, the peak flows, peak elevations, floodway data, and if the crossing is overtopped for the 100-year event are summarized in this section (see **Table 4.10-1**, **Figure 4.10-1**, **Figure 4.10-2**, and **Figure 4.10-3**). The FEMA flood zones in the study area are areas inundated by the 100-year flood. They are defined as follows:

- Zone A – No 100-year base flood elevations have been determined.
- Zone AE – 100-year base flood elevations have been determined.
- Zone AO – Average 100-year flood depths have been determined to be between one and three feet (usually sheet flow on sloping terrain).
- Floodway – Stream channel and portion of adjacent floodplain that must remain open to permit passage of 100-year base flood.

In general, the watershed basins within the study area are large and subject to high flows. The major basin areas exceed five square miles and the flows are generally 2,500 cubic feet per second (cfs) or greater. The western portions of these basins are undeveloped or have large open areas that reduce the runoff. The additional runoff from future fully developed basins will further increase the flows. The channels are incised and steep. At many of the major crossings, the culverts or bridges are undersized which leads to overtopping during the 100-year event. The floodway widths are generally wide, 200 feet wide or greater, with flood elevations two- to five-feet higher than the base flow elevations.

Table 4.10-1 Basin Summary

Stream	100-Year Storm				
	Drainage Area	Peak Discharge	Flood Elevation (NGVD 29)	Floodway Width	Does Water Flood Roadway in 100-year Storm?
Crossing	(mi^2)	(cfs)	(ft)	(ft)	
Coal Creek	**59.30**	—	—	—	—
SH 93	Zone A, No detailed study				
SH 128	Zone A, No detailed study				
McCaslin Boulevard	26.70	3770	5485.1	290	No
US 36	27.90	3820	5464	430	No
Rock Creek	**21.60**	—	—	—	—
McCaslin Boulevard	4.90	2717	5521.5	157	Yes
Indiana Street	ND	3000	5482.6	163	No
US 36	9.30	4520	5356	NC	No
Interlocken/96th Street	9.30	4520	5341.8	NC	No
Walnut Creek	**10.53**	—	—	—	—
Indiana Street	Zone A, No detailed study				
Simms Street	5.51	430	5469.8	21	No
Wadsworth Boulevard	ND	1500	5371.5	150	Yes
Woman Creek	—	—	—	—	—
Indiana Street	Zone A, No detailed study				
Alkire Street	Zone A, No detailed study				
Big Dry Creek	**41.20**	—	—	—	—
Indiana Street	ND	4930	5611	NC	Yes
Alkire Street	16.75	4930	5518.2	NC	Yes
Big Dry Creek Tributary	**5.64**	—	—	—	—
Alkire Street	Zone A, No detailed study				
Little Dry Creek	**13.30**	—	—	—	—
Alkire Street	Zone A, No detailed study				
Leyden Creek	**12.00**	—	—	—	—
SH 93	4.20	3300	5907.2	70	No
Indiana Street	9.00	2250	5561.2	220	Yes
Alkire Street	ND	2350	5490.2	200	No
Moon Gulch	—	—	—	—	—
Indiana Street	—	487	5569.3	—	No

Stream	100-Year Storm				
	Drainage Area	Peak Discharge	Flood Elevation (NGVD 29)	Floodway Width	Does Water Flood Roadway in 100-year Storm?
Crossing	(mi^2)	(cfs)	(ft)	(ft)	
Ralston Creek	**91.0**	—	—	—	—
SH 93	ND	5000	5810	90	No
Quaker Street	ND	4900	5604.3	370	No
Indiana Street	ND	4850	5537.5	340	No
Simms Street	ND	4800	5429.1	430	No
Wadsworth Boulevard	ND	9650	5313.1	111	No
Wadsworth Bypass (SH 121)	ND	9650	5307.2	442	Yes
SH 93	8.29	1570	5778.5	NC	Yes
Van Bibber Creek	**17.52**	—	—	—	—
Quaker Street	ND	1570	5632	NC	Yes
McIntyre	13.63	2850	5592	NC	Yes
Indiana Street	ND	2400	5548	720	Yes
Ward	ND	2600	5438.6	190	Yes
Van Bibber Creek Tributary	**2.57**	—	—	—	—
SH 93	0.72	540	Beyond limits of FIS		
Cressman's Gulch	**1.48**	—	—	—	—
SH 93	1.16	490	5991	NC	No
Tucker Gulch	**11.43**	—	—	—	—
SH 93	9.51	640	5925	NC	No
Clear Creek	**575.00**	—	—	—	—
US 6	325.00	12420	5698.2	224	No
Washington Avenue	ND	12420	5661.5	260	No
Ford Street	ND	13070	5658.2	130	Yes
McIntyre Street	ND	13070	5524.9	NC	No
I-70	430.00	13470	5427.5	200	No
West Fork Kinney Run Tributary #1	**1.00**	—	—	—	—
US 6	0.90	620	5848	NC	No
West Fork Kinney Run	**3.46**	—	—	—	—
US 6	1.30	1100	5857.2	NC	No

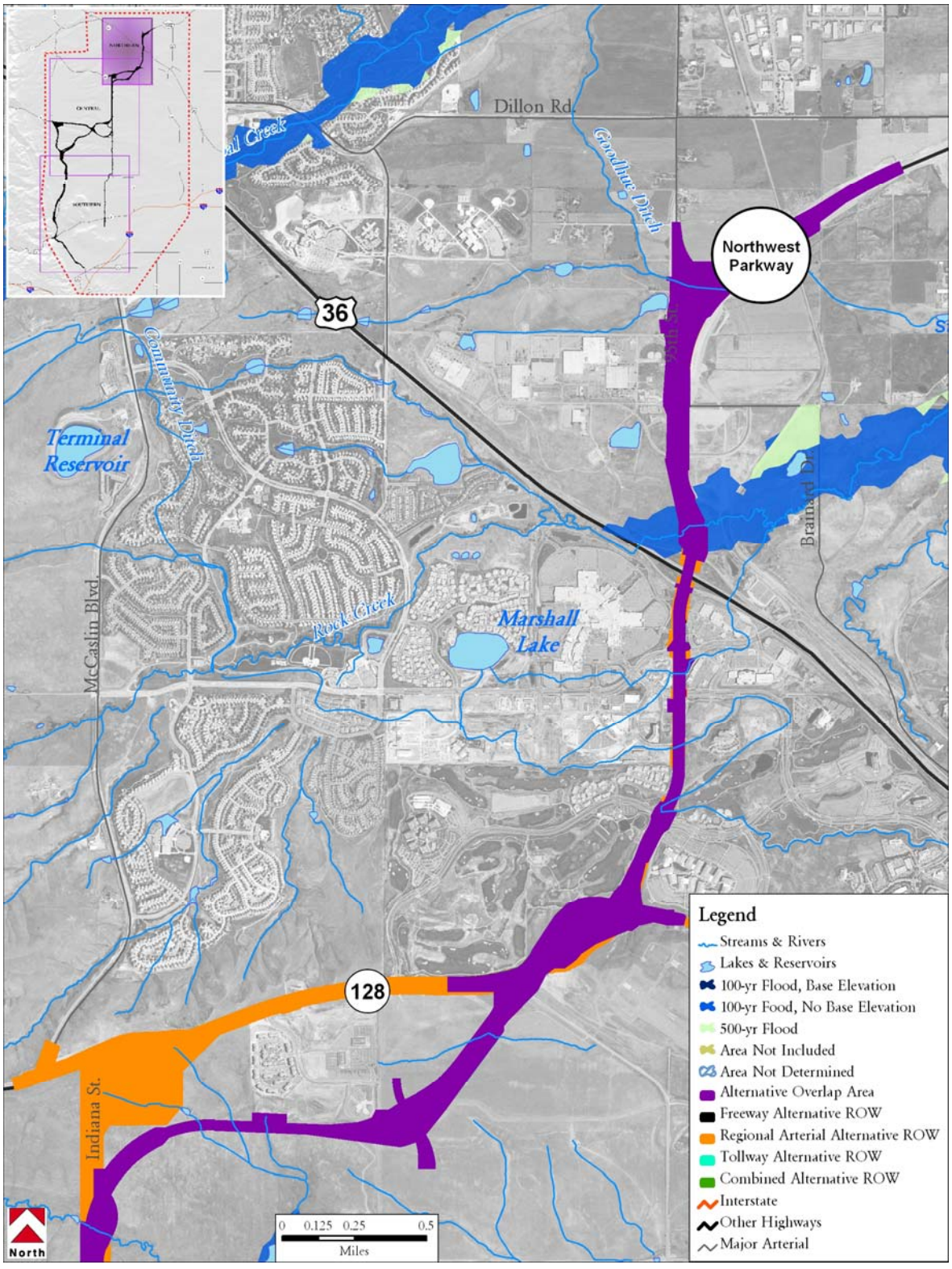
Notes: NC = flood elevation and floodway width has not been calculated
ND = no data

Sources: *Federal Emergency Management Agency (FEMA). 2002. Flood Insurance Study (FIS), Boulder County, Colorado, and Incorporated Areas, Volumes 1-5 (October 4);*

—. 2003. Flood Insurance Study (FIS). Jefferson County Colorado and Incorporated Areas, Volume 1 of 7. Flood Insurance Study Number 08059CV001 A (June 17);

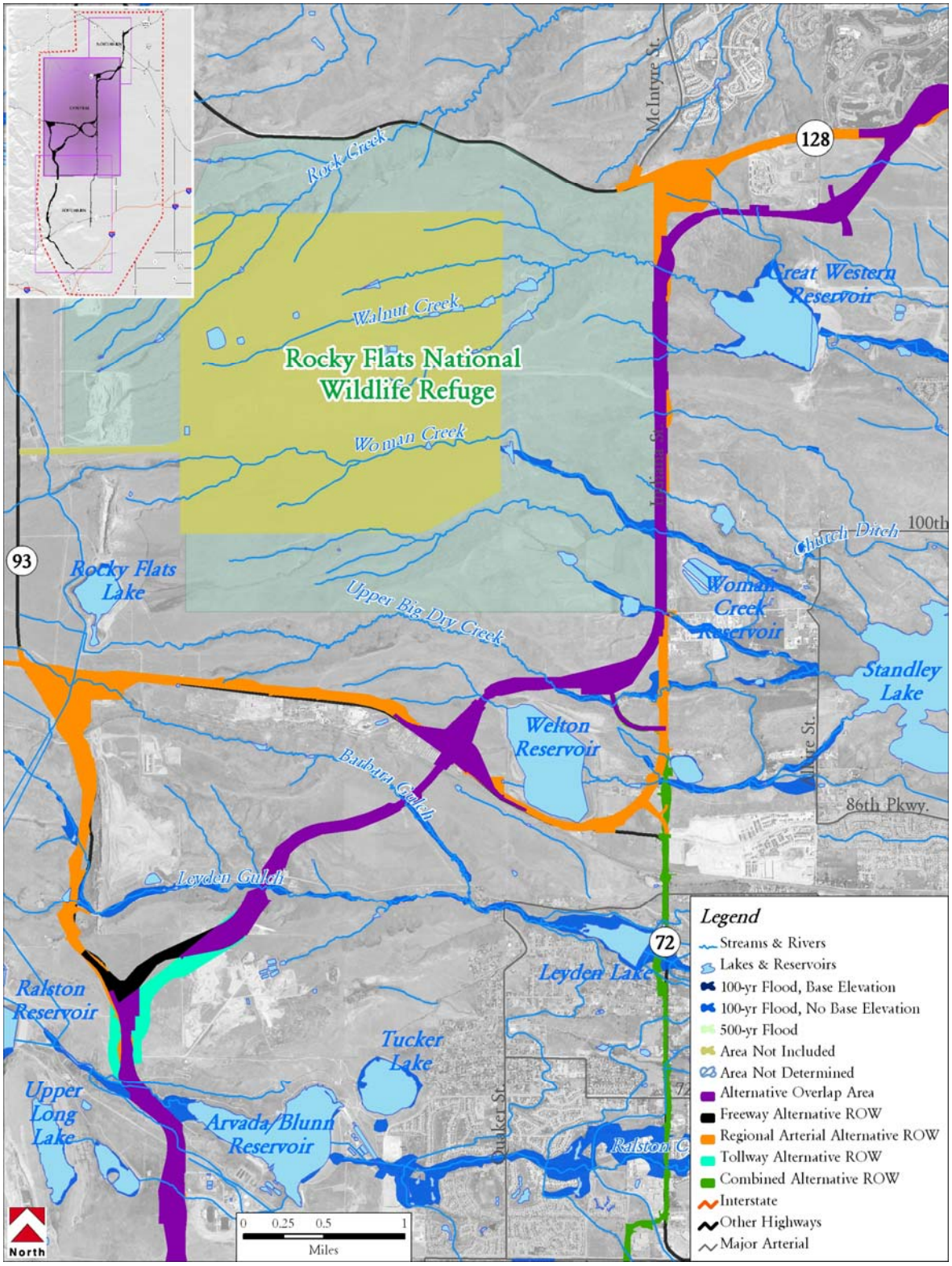
—. 2004. Flood Insurance Rate Map (FIRM), Boulder County, and Incorporated Areas (October 4).

Figure 4.10-1 FEMA Floodplain-Northern Portion



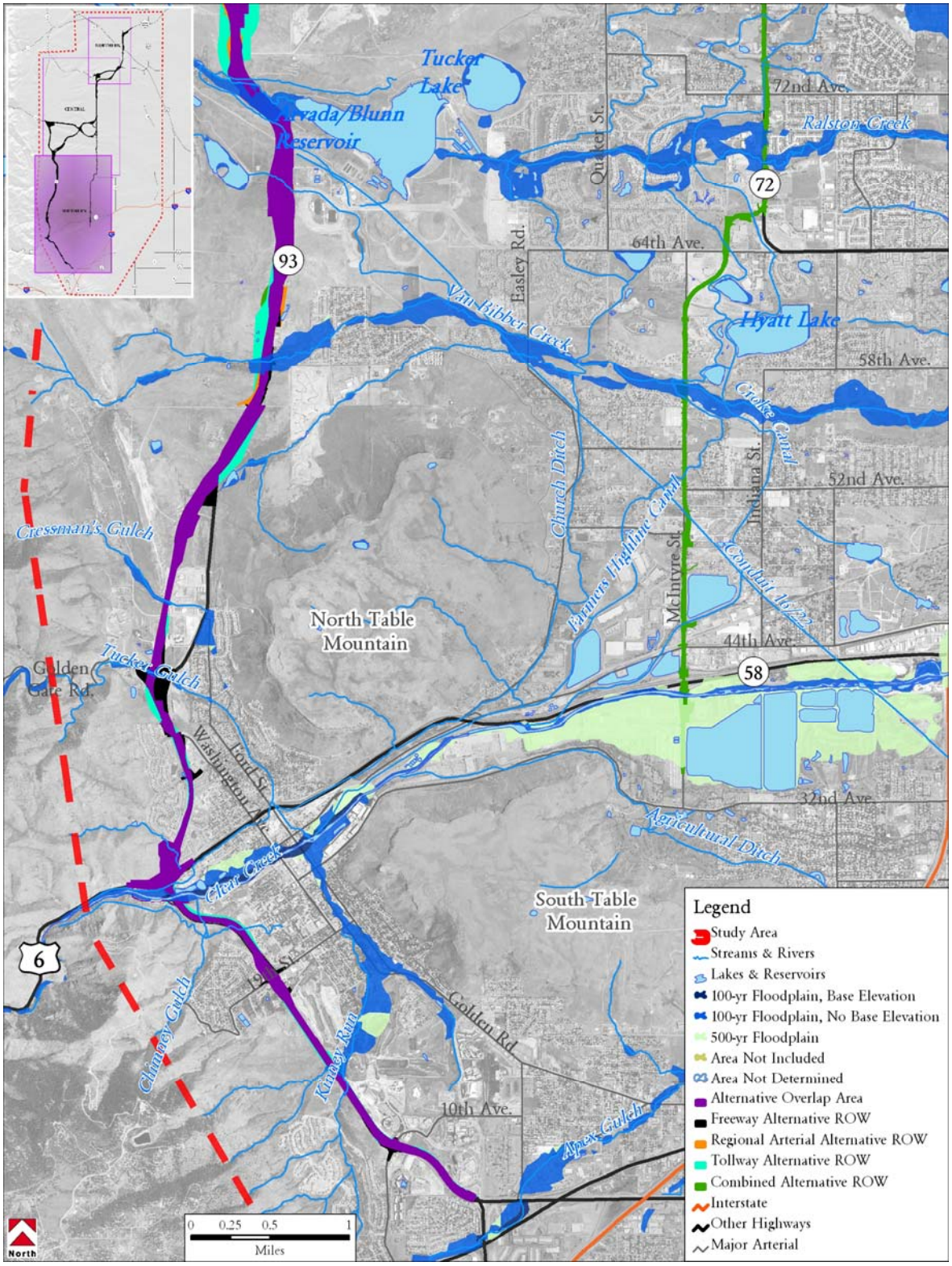
Source: Compiled by FHU, 2006.

Figure 4.10-2 FEMA Floodplain-Central Portion



Source: Compiled by FHU, 2006.

Figure 4.10-3 FEMA Floodplain-Southern Portion



Source: Compiled by FHU, 2006.

COAL CREEK

Coal Creek passes through Superior, extending southwest to just north of Coalton Drive. Coal Creek flows to the northeast, joining Boulder Creek in east-central Boulder County. Coal Creek flows primarily through agricultural land. The 100-year flows within the study area vary from 3,770 to 3,820 cfs, according to the FIS for Boulder County (FEMA, 2002). The FIRM identifies Coal Creek as Zone A from west of Plainview Road to just north of Coalton Drive and as Zone AE from just north of Coalton Drive to US 36 (FEMA, 2004).

ROCK CREEK

Rock Creek originates in the western portion of Rocky Flats National Wildlife Refuge and extends past US 36. Rock Creek is a tributary to Coal Creek, joining it just east of Lafayette. Rock Creek flows primarily through agricultural land. The FIS indicates eight cross-sections have been studied along Rock Creek. The 100-year flows within the study area vary from 2,396 to 4,520 cfs, according to the FIS for Boulder County (FEMA, 2002). The FIRM identifies Rock Creek from the uppermost reach to US 36 as Zone AE (FEMA, 2004).

WALNUT CREEK

Walnut Creek is a tributary of Big Dry Creek. It originates in the western portion of Rocky Flats National Wildlife Refuge and flows into Great Western Reservoir, then continues toward US 36. The *Flood Hazard Area Delineation, Little Dry Creek*, for the Westminster area, delineates the flooding limits for Walnut Creek (UDFCD, 1988). The upstream study limit begins at Simms Street, where there is a 100-year discharge of 430 cfs. From the uppermost reach of Walnut Creek to just west of US 36, all roads are overtopped. The 100-year discharge is not contained in any of the road culverts. The FIRM indicates two different Zones for Walnut Creek. Zone A begins at the Great Western Reservoir and ends at Simms Street, Zone AE begins downstream of Simms Street on to Dover Street, and Zone A is identified from Dover Street to US 36 (FEMA, 2004).

WOMAN CREEK

Woman Creek originates just west of Rocky Flats National Wildlife Refuge. It flows into Standley Lake and toward US 36. Although it is mentioned in the Flood Hazard Area Delineation Report for Big Dry Creek as being a tributary to Big Dry Creek, a study has not been completed for Woman Creek. The FIRM identifies Woman Creek as Zone A (FEMA, 2004).

BIG DRY CREEK

The Big Dry Creek Basin originates in unincorporated Jefferson County, west of Rocky Flats National Wildlife Refuge. The basin drains easterly from the headwaters area across Rocky Flats National Wildlife Refuge, where several tributaries begin including Walnut, Woman, and Big Dry Creeks. Land use in the upper basin above Standley Lake is presently undeveloped rangeland. The upstream study limit for Big Dry Creek indicates a 100-year flow of 1,975 cfs. Downstream of the C&S Railroad, there is a 100-year flow of 2,920 cfs, and downstream of Wadsworth Boulevard the 100-year flow is 3,220 cfs, according to *Flood Hazard Area Delineation, Little Dry Creek* (UDFCD, 1988). The FIRM identifies Big Dry Creek as having two Zones. Zone AE begins at the most upstream location to Zephyr Street, Zone A goes from Zephyr Street to Wadsworth Boulevard, Zone AE then continues from Wadsworth Boulevard to Otis Street, and Zone A continues from Otis Street to US 36 (FEMA, 2004).

LITTLE DRY CREEK

Little Dry Creek is located just south of Standley Lake in the central portion of the study area. It originates 1.5 miles southwest of Standley Lake and is a tributary of Clear Creek. The FIRM for Arvada has a special flood hazard area, Zone A, for Little Dry Creek. There are no base flood elevations determined within the study area. The floodway delineation was based on fully developed 100-year flows. The flows are 360 cfs at Alkire Street and 1,120 cfs at Wadsworth Boulevard. The FIRM shows that most of the cross streets including Alkire Street, Kipling Street, 80th Avenue, and Wadsworth Boulevard are overtopped during the 100-year storm (FEMA, 2004).

LEYDEN CREEK

Leyden Creek is a northern tributary to Ralston Creek. The drainage basin area is approximately 12 square miles. The FIRM for Jefferson County shows that Leyden Creek is located within Zones AE and AO (FEMA, 2004). In Zone AE, base flood elevations have been determined and Zone AO flood depths vary from one-foot to three-feet deep. The flows used to delineate the floodway assume a fully developed condition. The 100-year flow is 3,300 cfs at SH 93. Leyden Lake is a water supply reservoir owned and operated by Farmers Highline Canal Company. It helps reduce the 100-year flow from 3,750 cfs above the lake to 2,200 cfs below the lake. At the confluence with Ralston Creek, near Simms Street, the flow is 2,500 cfs. SH 93, Quaker Street, and Indiana Street are overtopped during the 100-year storm event. The bridge at Alkire Street is not overtopped during this event.

RALSTON CREEK

Ralston Creek lies within the west central part of the study area. It has a basin area of 91 square miles upstream of its confluence with Clear Creek. Portions of the lower reaches have been improved with grade control structures and bank protection. Runoff and storm sewer outfalls discharge developed storm waters directly into the creek without any water quality provisions. In the Arvada area, Ralston Creek has a detailed FEMA regulatory floodplain and floodway delineation based upon future 100-year flows of 4,800 cfs above the Leyden Creek confluence, 9,700 cfs above the Van Bibber Creek confluence, and 11,500 cfs at the Clear Creek confluence. The FIRM for Ralston Creek shows that much of the100-year storm inundates many developed areas. Many roads are overtopped (FEMA, 2004). The Major Drainageway Planning for this section of Ralston Creek calls for improvements, such as regional detention facilities to lower peak flows, grade control structures to stabilize the stream, and improved bridges and culverts (UDFCD, 1977a).

VAN BIBBER CREEK

Van Bibber Creek is located in the central section of the study area. It is a tributary to Ralston Creek. The South Tributary is 3.3 miles long and has a drainage basin of 2.57 square miles. The main stem of the creek is 9.1 miles long and has a drainage basin of 15.95 square miles. The total drainage area for Van Bibber Creek is 17.57 square miles. The FIRM for Jefferson County shows that the entire creek is located within Zones AE and AO (FEMA). In Zone AE, base flood elevations have been determined for both the main stem and the south tributary. Zone AO flood depths vary from one-foot to three-feet deep. The floodway is based on the existing flows for 1984. There are minor differences between the existing flows and the fully developed flows because much of the basin is already developed. Channel improvements have been constructed on Van Bibber Creek west of 58th Avenue and on some portions of the South Tributary. The 100-year flows are 1,630 cfs at SH 93 and increase to approximately 2,850 cfs at Indiana Street and McIntyre Street. SH 93, Indiana Street, and McIntyre Street are all overtopped during the 100-year storm event.

CLEAR CREEK

Clear Creek is a major drainageway that is located in the southern portion of the study area. Clear Creek flows from the Continental Divide to the South Platte River. In the study area, it flows through Golden, unincorporated Jefferson County, and Wheat Ridge. At the western limits of the study area, Clear Creek has a drainage basin area of approximately 400 square miles. An additional 50 square miles of drainage area is contained within the study area. A detailed FEMA study has been prepared for the entire reach of Clear Creek located within the study area. The 100-year flow at SH 93 is 12,420 cfs. This increases to 13,470 cfs at the downstream limits of the study area. The flows are based on fully developed basins. A number of bridges cross Clear Creek and many are overtopped during the 100-year flows. Most of these are minor pedestrian bridges in unincorporated Jefferson County. The only major bridge that is overtopped in the 100-year event is the Washington Avenue bridge over SH 58 in Golden. The stream channel has been improved in Golden and throughout Jefferson County but the floodway has not been impacted. Clear Creek has one tributary within the study area, Tucker Gulch. Tucker Gulch passes through the Golden city limits. Base flood elevations are available (FEMA, 2003).

4.10.1.2 MAJOR FLOOD EVENTS

In general, within Arvada, the streams are well defined with relatively narrow channels. Potential flooding problems along the streams can be attributed to the large developed areas that have encroached into the overbanks of these channels. Development has severely constricted the floodplain and diminished the conveyance capacity for large flood flows (FEMA, 2003).

In Golden, man-made and natural obstructions in stream channels and floodplain areas impede the flow of water, creating a backwater effect that increases flood heights. These obstructions include bridges, culverts, stream-regulating structures, channel realignments from their natural course, buildings in the floodplains, and trees and brush in the stream channels. The history of flooding in Golden indicates that the most serious flooding has been the result of cloudbursts occurring from late May to early September. Several severe floods have been recorded in Golden since 1864 (FEMA, 2003).

The streams in Westminster that flow into Standley Lake and Great Western Reservoir, along with Big Dry Creek and Little Dry Creek, are generally well defined with relatively narrow channels. Tributaries to Big Dry and Little Dry Creeks are not very well defined and, at times, are generally shallow with low banks. Industrial and residential developments exist along portions of all streams within the city, especially below the reservoirs. Generally, the streams are intermittent, having little or no flow most of the time. Flooding in the Westminster area is caused by heavy local rainstorms (FEMA, 2003).

Past flooding along many streams in the study area is not well documented. Flood magnitude or damage data are available for some larger streams in and near the area, as described below. Data on any of the small, un-gaged streams are generally not available, although it is reasonable to assume that floods occurred simultaneously on the smaller streams as well. Records are available for Clear Creek, Big Dry Creek, and the South Platte River.

CLEAR CREEK

The Clear Creek drainage basin above Golden contains some 400 square miles. The total basin area above the confluence of the South Platte River contains 575 square miles. Past floods along Clear Creek have been infrequent, but more severe in the upper reaches. Major flooding occurred in Golden in 1888 (8,700 cfs), and 1956 (5,250 cfs), and in Derby in 1965 (5,070 cfs) (FEMA, 2003).

BIG DRY CREEK

Big Dry Creek has its source west of Rocky Flats National Wildlife Refuge southwest of Boulder and is a tributary to Standley Lake. Walnut Creek begins in the western portion of Rocky Flats National Wildlife Refuge and is tributary to the Great Western Reservoir. Little Dry Creek originates just southwest of Standley Lake, passing through Arvada and Westminster to Clear Creek. The total drainage area of Big Dry Creek to I-25 is 56.84 square miles, of which 16.75 square miles are above the two reservoirs. Watershed elevations range from approximately 6,500 feet at the headwaters of the drainage area of Standley Lake to 5,160 feet at I-25 (FEMA, 2003).

SOUTH PLATTE RIVER

Although the South Platte River is not in the study area, many of the streams and creeks in the study area are tributary to the South Platte River and would possibly contribute to flooding. Large floods were reported in 1844, 1864, 1867, 1876, 1894, 1921, 1933, 1942, 1965, and 1973. The largest and most damaging of these occurred June 16 and 17, 1965, when a discharge of 40,300 cfs was computed at USGS stream gage No. 06714000, near the 19th Street Bridge in Denver. Flooding occurred throughout the South Platte River basin resulting in six drownings, two other deaths caused by flood-related activities, and damage estimated at $500 million, of which $300 million occurred in the Denver area (FEMA, 2003).

4.10.2 ENVIRONMENTAL CONSEQUENCES

4.10.2.1 HYDROLOGIC AND HYDRAULIC MODELING

Design of the drainage improvements for the build alternatives was based on current CDOT and local government criteria. These criteria are detailed in the CDOT *Drainage Design Manual* and the UDFCD *Urban Storm Drainage Criteria Manual,* Volumes 1, 2, and 3.

Preliminary drainage design was based on a minor storm event with a 20% chance occurrence, also known as the 5-year storm frequency. The major design storm event is the 100-year storm, which has a 1% annual probability. The 100-year event or 1% annual probability was used in the design of cross culverts and bridges. Bridge foundation and pier design was based on the 500-year flood frequency flows.

The CUHP computer program was used for the hydrologic modeling of the major basins, which are basins greater than 90 acres. The CUHP sub-basins have been routed using Urban Drainage Stormwater Management Model (UDSWMM). The rational model was used for on-site basins and those less than 90 acres.

4.10.2.2 NO ACTION ALTERNATIVE

The No Action Alternative would not have any direct impacts or indirect effects to the existing floodplains. It would not increase or reduce the runoff volume to the floodplains. There would be no increase or reduction in the base flood elevation. Flooding would continue to occur at the locations identified (see **Table 4-10-2**). However, with the expected increase on traffic, more vehicles will be inconvenienced by the existing flooding conditions and safety would be compromised.

Table 4.10-2 Existing Major Flood Areas

Stream	Crossing	Flood Depth for 10-Year Flood Event	Flood Depth for 100-Year Flood Event	Affected Structures/Land Use
Woman Creek	Indiana Street	No Data	1 to 2 feet of overtopping occurs	Open space, there are no structures in this area.
Big Dry Creek	Alkire Street	1.5 feet	Up to 5 feet	Large wetland area upstream of Standley Lake, there are no affected structures in this area.
Big Dry Creek	Indiana Street	1 foot	3 feet of flow across Indiana Street	Open space, there are no structures in this area.
Leyden Creek	Indiana Street	No overtopping	0.5 foot	This area is a low-density residential area comprised of ranchettes and large lot homes.
Van Bibber Creek	Indiana Street	0.5 foot	2 feet	1 ranchette upstream of crossing and 4 residences downstream on the north bank.
Van Bibber Creek	McIntyre Street	1 foot	2.5 feet	2 ranchettes located upstream of crossing and 1 outbuilding and one residence directly downstream.
Van Bibber Creek	SH 93	No flooding	0.5 foot	There is a farm directly north of the drainageway and 3 residences directly downstream.

Sources: *Federal Emergency Management Agency (FEMA). 2002. Flood Insurance Study (FIS), Boulder County, Colorado, and Incorporated Areas, Volumes 1-5 (October 4),*

—. 2003. Flood Insurance Study (FIS). Jefferson County Colorado and Incorporated Areas, Volume 1 of 7. Flood Insurance Study Number 08059CV001 A (June 17).

4.10.2.3 IMPACTS COMMON TO ALL BUILD ALTERNATIVES

Construction of any of the build alternatives would result in direct impacts and indirect effects to the floodplains in the study area. These impacts would include structural impacts, such as construction of bridges and culverts within the floodplain, and any channel improvements associated with the construction of bridges or culverts. Channel improvements could range from placing riprap for outlet protection to channel realignment and/or changes to channel cross sections. During construction, there would be temporary impacts such as bridge demolitions and flow diversion.

Any construction near or within delineated floodplains should comply with federal requirements set forth by Executive Order 11988, Floodplain Management, and applicable FHWA and FEMA requirements.

The runoff impacts to major floodplains would be minimal. There would be increases in impervious areas as a result of highway improvements and increases in drainage area because of flow routing. Both of these would result in increased flow to the floodplain. However, the impacts from increased flows to the floodplains from any of the build alternatives would be negligible. The area contributing to the increase in flow is less than one percent of the drainage basin. In addition, the flows from the highway would reach the floodplain long before the peak flows of the major drainage basin. Concentrated discharges to the floodplain would cause bank erosion.

FREEWAY ALTERNATIVE

The Freeway Alternative would have direct impacts to major floodplains (see **Table 4.10-3**).

Table 4.10-3 Floodplain Improvements and Impacts-Freeway Alternative

Location	Conveyance Improvements	Channel Improvements	Flood Impacts
Rock Creek at Interlocken Loop/96th Street	None. Roadway would be elevated above existing roadway and conveyance structure.	None.	None.
Walnut Creek at Indiana Street	150 foot bridge.	Approximately 600 feet of cross section grading and channel realignment. Riprap bridge amour.	Slight shift and narrowing floodplain due to channel work.
Woman Creek at Indiana Street	New box culvert and raised roadway profile.	Riprap inlet and outlet protection.	Narrowing of floodplain and reduction of base flood elevation due to improved conveyance capacity.
Big Dry Creek at New Alignment	New 235-foot long bridge with pier located within floodplain.	Riprap protection for piers and abutment.	None. Bridge spans floodplain.
Barbara Gulch at New Alignment	New 600-foot bridge with piers in floodplain.	Riprap protection for piers.	None. Bridge spans floodplain.
Leyden Creek at New Alignment	New 1,150-foot bridge spanning Leyden Road and Leyden Creek.	Riprap protection for piers.	None. Bridge spans floodplain.
Ralston Creek at SH 93	None. Stream would be conveyed in existing structure with 535-foot bridge above for wildlife crossing.	No direct channel improvement but existing SH 93 embankment material would be removed.	Narrowing of floodplain would occur as a result of the removal of embankment material and reduction of damming.

Location	Conveyance Improvements	Channel Improvements	Flood Impacts
Van Bibber Creek at SH 93	New 150-foot bridge to replace multicell box culvert.	Approximately 1,100 feet of cross section grading and channel realignment. Riprap bridge and pier amour.	Shifting of floodplain due to channel work. Lowering of base flood elevation due to increased conveyance area.
Cressman's Gulch at SH 93	Extended existing box culvert under Brickyard Circle.	Riprap inlet and outlet protection.	None.
Tucker Gulch at US 6	New multicell box culvert under new alignment.	Riprap inlet and outlet protection.	Increase in base flood elevation due to backwater conditions. Would not impact existing structure located upstream.
Clear Creek at US 6	1,050-foot bridge and adjacent ramp bridges to span flood plan with piers in floodplain.	Riprap protection for piers.	None. The proposed bridges would span floodway.
West Fork Kinney Run Tributary No. 1 at US 6	Existing box culvert extended.	Riprap inlet and outlet protection.	None.
West Fork Kinney Run at US 6.	300-foot bridge with bike path to replace existing bridge.	Approximately 1,600 feet of cross section grading and channel re-alignment. Riprap for bridge and pier amour and bank protection.	None.

Sources: Compiled by FHU, 2005.

TOLLWAY ALTERNATIVE

The Tollway Alternative would have the same impacts as the Freeway Alternative. The exception is where the alignment varies slightly between Leyden Creek and 58th Avenue in Golden. This difference results in a shift of the Ralston Creek Bridge to the west, causing different impacts at Ralston Creek and SH 93 (see **Table 4.10-4**).

Table 4.10-4 Floodplain Improvements and Impacts-Tollway Alternative

Location	Conveyance Improvements	Channel Improvements	Flood Impacts
Ralston Creek at SH 93	None. Stream to be conveyed in existing structure with 500-foot bridge above for wildlife crossing.	Riprap protection for piers and abutments. Fill material would be placed within the channel. Existing SH 93 embankment material would be removed.	Narrowing of floodplain would occur as a result in areas where fill is placed in floodplain. Because the existing SH 93 embankment material would be removed and thereby reduce the damming effect, the base flood elevation would decrease in the area of SH 93.

Sources: Compiled by FHU, 2005.

REGIONAL ARTERIAL ALTERNATIVE

The Regional Arterial Alternative has minimal direct impacts. The main improvements would be a widening south of SH 128. The drainage impacts would be associated with replacement of undersized facilities or the extension of existing structures. There are seven crossings associated with this alternative that differ from the Freeway Alternative (see **Table 4.10-5**).

Table 4.10-5 Floodplain Improvements and Impacts-Regional Arterial Alternative

Location	Conveyance Improvements	Channel Improvements	Flood Impacts
Big Dry Creek at Indiana Street	New box culvert and raised roadway profile.	Riprap protection for piers and abutment.	Box culvert would increase conveyance and lower base flood elevation. Upstream floodplain should narrow.
Barbara Gulch at SH 93	Extended existing box culvert or replacement with equivalent.	Riprap inlet and outlet protection.	None.
Leyden Creek at SH 93	Existing culvert replaced with box culvert.	Grading on the upstream side of highway would need to be done to mitigate encroachment on existing lake. Riprap outlet protection.	Slight shift of floodplain due to channel work.
Ralston Creek at SH 93	None.	Riprap inlet and outlet protection	None. There would be no changes to hydraulics.
Van Bibber Creek at SH 93	Extended or replacement of existing multicell box culvert.	Riprap inlet and outlet protection.	None. There would be no changes to hydraulics.
Cressman's Gulch at SH 93	Existing box culvert extended under Brickyard Circle	Riprap inlet and outlet protection.	None.
Tucker Gulch at US 6	New multicell box culvert under new alignment.	Riprap inlet and outlet protection.	Increase in base flood elevation due to backwater conditions. Will not impact existing structure located upstream

Sources: Compiled by FHU, 2005.

COMBINED ALTERNATIVE (RECOMMENDED ALTERNATIVE)

The Combined Alternative (Recommended Alternative) combines the Regional Arterial Alternative in the northern and southern portions of the alignment and the Tollway Alternative in the central portion. In addition, there are improvements on Indiana Street and McIntyre Street. There are eight crossings that differ from the Freeway Alternative (see **Table 4.10-6**).

Table 4.10-6 Floodplain Improvements and Impacts-Combined Alternative (Recommended Alternative)

Location	Conveyance Improvements	Channel Improvements	Flood Impacts
Big Dry Creek at New Alignment	New 235-foot bridge with pier located within floodplain.	Riprap protection for piers and abutment.	None. Bridge would span floodplain.
Ralston Creek at SH 93	None. Stream would be conveyed in existing structure with 500-foot bridge above for wildlife crossing.	Riprap protection for piers and abutments. Fill material would be placed within the channel. Existing SH 93 embankment material would be removed.	Narrowing of floodplain would occur as a result of the fill placed in floodplain. The base flood elevation would decrease because of the removal of existing SH 93 embankment material and reduction of damming.
Ralston Creek at Indiana Street	Replacement of existing structure with 200-foot bridge.	Riprap protection for piers and abutments. Channel opening would be increased.	Floodplain would narrow directly upstream of bridge. However, there would be beneficial impacts because the Croke Canal induces a split flow during high flow events.
Van Bibber Creek at SH 93	Extended existing multicell box culvert or replacement.	Riprap inlet and outlet protection.	None. Hydraulics would remain the same.
Van Bibber Creek at Indiana Street	Existing structure replaced with 120-foot bridge.	Riprap protection for piers and abutments.	Narrowing of floodplain and reduction of base flood elevation due to improved conveyance capacity.
Cressman's Gulch at SH 93	Existing box culvert extended under Brickyard Circle.	Riprap inlet and outlet protection.	None.
Tucker Gulch at US 6	New multicell box culvert under new alignment.	Riprap inlet and outlet protection.	Increase in base flood elevation due to backwater conditions. Will not impact existing structure located upstream
Clear Creek at US 6	1,050-foot bridge and adjacent ramp bridges would span floodplain with piers in floodplain.	Riprap protection for piers.	None. The proposed bridges would span floodway.

Sources: Compiled by FHU, 2005.

4.10.3 SUGGESTED MITIGATION

The mitigation measures discussed in the Water Quality section were developed to address many of the floodplain impacts (see **Section 4.8**). This section briefly describes the design features of the BMPs that address floodplain issues. The BMPs typically used are extended detention ponds.

The preliminary drainage design for the build alternatives is based on CDOT's *Drainage Design Manual* and Volume 3 of the UDFCD *Urban Storm Drainage Criteria Manual*. The UDFCD manual could be used to design hydraulic features. The criteria in these two manuals are designed to minimize impacts associated with highway and urban development.

All applicable permits associated with water quality should be obtained. These include, but are not limited to, FEMA Flood Map Revisions. FEMA Flood Map Revisions include both the Conditional Letter of Map Revision (CLOMR) and the Letter of Map Revision (LOMR) upon the completion of the project.

4.10.3.1 CRITICAL DESIGN FEATURES

There could be two critical design features to take into consideration in the final design of the build alternatives. One is the FEMA design requirements for floodplain development. This requires that any development within the floodplain does not increase the base flood elevation by more than a one-foot rise and does not negatively impact adjacent property owners. The other consideration is the CDOT Municipal Separate Storm Sewer System (MS4) permit.

Roadway ditches could be used to convey highway runoff and provide water quality enhancement whenever possible. Ditches could convey the minor design storm runoff and prevent adverse impacts to adjacent properties for the major design storms. The flow patterns of these ditches could follow the historical flow patterns.

4.10.3.2 DETENTION

The purpose of detention basins is to reduce the post-construction peak discharge to the pre-construction or historic discharge rate. The pond release rate and storage volume could be designed for the 100-year storm event. All designs could conform to Chapter 12 of the CDOT *Drainage Design Manual* and Volume 2, Chapter 10, of the UDFDC *Urban Storm Drainage Criteria Manual.*

4.10.3.3 BRIDGE DESIGN

All bridges could conform to FEMA regulations and design criteria set forth in Chapter 10 of the CDOT *Drainage Design Manual.* In general, the bridge should not increase the base flood elevation within floodplain more than 1 foot. The 100-year flow should to be conveyed with a minimum of 1 foot of freeboard between the water surface and the low girder. Channel degradation or aggradation plus contraction and local scour should be designed for the 500-year event. Both the hydraulic and scour analysis calculations could be performed by an approved CDOT method, such as WSPRO, HEC-RAS, HEC-18, or HEC-20.

4.10.3.4 CULVERT DESIGN

All culverts could be designed in accordance with the CDOT *Drainage Design Manual.* The cross culvert under the mainline should be designed to convey the 100-year event without overtopping the roadway. Any negative impacts to adjacent property owners as a result of backwater conditions could be avoided.

4.10.4 SUMMARY

All alternatives will have an impact to existing floodplains in the Northwest Corridor study area. While mitigation measures for the impacts to the floodplains could be required, some alternatives impact floodplains less than others. The Regional Arterial Alternative has the fewest impacts to existing floodplains. The Freeway Alternative and Tollway Alternative have very similar floodplain impacts. The Combined Alternative (Recommended Alternative) has the greatest amount of impacts, primarily because of the additional crossings along Indiana Street and McIntyre Street.

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