CHAPTER 9

WATERSHED PLANNING AND ANALYSIS: SEQUOIA CREEK

9.1 INTRODUCTION

The Sequoia Creek headwaters originate near Chip Ross Park. The creek runs generally southeast through residential development, then turns eastward near Sycamore Avenue. The creek crosses beneath Highway 99W and the Willamette and Pacific Railroad trestle before turning to the northwest at its junction with Village Green Creek. After being joined by Village Green Creek, Sequoia Creek turns eastward, where it is known as Stewart Slough. The creek crosses beneath Highway 20 and ultimately discharges into the Willamette River.

The Sequoia Creek watershed contains 1,357 acres. The largest land use at present is low-density residential, which covers approximately 34 percent of the watershed. Fourteen percent of current use is medium- and high-density residential. City streets and rights-of-way take up approximately 14 percent of the available area. Approximately 12 percent of the land use is industrial, primarily located downstream of Highway 99W. Open spaces make up about 11 percent of the watershed. Land use in the remaining areas of the watershed includes a mixture of commercial properties, Oregon State University, and vacant land.

As future development occurs, the vacant land may be converted into low-, medium- and high-density residential areas. Other changes may include a decrease in industrial land use and an increase in commercial use. The number of acres of impervious land will increase from 543 acres to 650 acres, thus affecting the quantity and quality of stormwater runoff in the watershed.

9.2 WATERSHED FINDINGS

Information on watershed conditions was obtained by collecting public comments at open houses, working with City staff to identify maintenance and operation problems, conducting a technical stream evaluation of selected reaches, and by modeling the conveyance system for the existing and build-out scenarios. This information was compiled by stream reach and is summarized in Section 9.2.5. Figure 9-1, a map of the Sequoia Creek watershed, shows the location of the stream within the City and identifies some of the major observations made during the watershed study.

The elevation of the channel drops quickly relative to the horizontal distance, thus defining a steep gradient upstream of Walnut Boulevard. The gradient flattens out below that point, creating the potential for flooding in the transitional area between the hills and the flat area near the terminus of the creek. The gradient is flat downstream of 9th Street, thereby increasing the potential for flooding during large storm events.

Riparian conditions vary along the length of the stream. The riparian areas along Sequoia Creek are more natural (i.e., less degraded) toward the downstream end, as illustrated by Figure 9-2, Photo 1. This differs from other Corvallis streams, which are generally more degraded toward their downstream ends. Figure 9-2, Photo 2, illustrates how industrial land use encroaches on the creek near

Jack London Street. Also, a large number of debris dams in the creek downstream of Jack London Street obstruct flows, as shown in Figure 9-2, Photo 3. The recycling facility located along the north bank of the creek downstream of Highway 99W, as shown in Figure 9-2, Photo 4, is an example of industrial land use encroaching on the stream. Figure 9-2, Photo 5, shows sediment accumulation that may restrict higher flows at the culverts under 9th Street. The landscaped conditions typical of the headwater stream reaches near Antelope Place and Chipmunk Place are shown in Figure 9-2, Photo 6.

9.2.1 Public Comments

Public input, an important element of the watershed planning process, has been encouraged and facilitated through a number of public meetings. The first of these meetings was held on June 15, 1999, at Cheldelin Middle School. During that meeting, and a subsequent meeting on July 20, residents were encouraged to share their knowledge of problem areas and to identify opportunities for improving the health of the Sequoia Creek watershed. The public comments specific to each stream reach are in Section 9.2.5. Several public comments generally applicable to the Sequoia Creek watershed are provided below:

- "Sequoia Creek and south drainage areas never should have been channelized and now, if you take brush out of channel or deepen, it will speed up flow and flood downstream. Solution won't be simple—need to consider all factors."

- "City should require on-site impoundment to reduce the flooding."

- "What can you do along Sequoia if fence is right along the stream along with power poles and there is little room to modify stream to accommodate water? How wide is an adequate corridor width?"

- "Property along Sequoia with fence right near top of bank (altered). He is concerned about the stream system and if widening would improve flow, habitat, and downstream flow levels—he would support."

- "Sequoia Creek has already been developed and ditched. Will the new plan empower development reviews (staff, planning committee, etc.)? Looking at development [policies] for owners of new development, policies that create wider stream channels and corridors. Will individuals who buy and develop, who want to put house right on creek, will it force owner to develop and protect the stream functions? What has been done is done, but how do we protect the biological integrity of currently developed areas?"

- A concern of several members of the public. "Is there communication between the County and the City to integrate stormwater objectives and deal with development in the urban growth boundary? We need a liaison and ongoing communication."

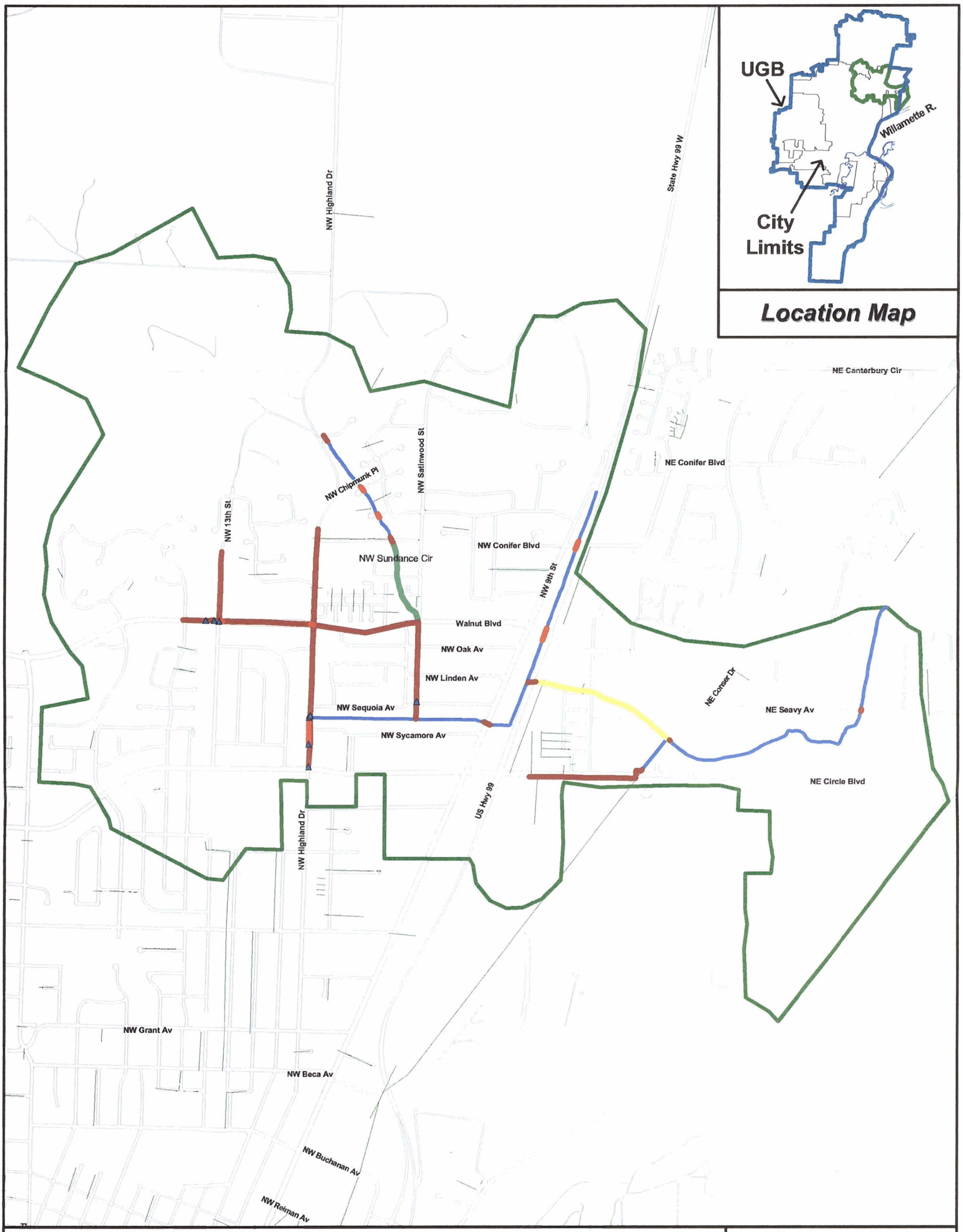

Figure 9-1 Sequoia Creek Problem Areas

LEGEND

- Pipes/Bridges
- Channels
- Basin Boundary
- Reported Problems (recorded at open house)
- Surcharged Manholes (10-year future storm)
- Flooded Manholes (10-year future storm)
- High Velocity Areas (> 4 fps, 2-year future storm)
- Undersized Conduits (10-year future storm)
- Undersized Channels (10-year future storm)

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report/figures/final/Fig9-1.wor, November 22, 2000, base data from City of Corvallis GIS Department

Figure 9-2. Watershed Photos

Photo 1. Channel conditions in the downstream reach of Sequoia Creek

Photo 2. Industrial property near Jack London Street

Photo 3. Debris in channel near Jack London Street

Photo 4. Recycling facility on Sequoia Creek stream bank

Photo 5. Culverts at Ninth Street

Photo 6. Upstream landscaping near Chipmunk Place

- "Problem is jurisdiction—Corps or DSL, County or City, State planning laws. First step—find out who has jurisdiction."

- "There were three complaints to the County recently about Sequoia Creek watershed: Highland Dell, the fill at Seavey Avenue, and various septic failures."

9.2.2 City Staff Reports

City Engineering and Utilities Operations staff is usually the first to hear from the public if problems arise. As a result of their "front-line" position, City staff members are aware of the positive and negative characteristics of the Sequoia Creek watershed. City staff helped identify known problem areas, recommended areas for stream enhancement activities, and recounted the extent and duration of flooding during major storm events. For example, the February 1996 storm caused a number of flooding problems within the watershed, including high water and road closures that occurred between Highland Drive and 9th Street.

9.2.3 Field Study Observations

Watershed Applications, a stream rehabilitation specialty firm, conducted a series of field investigations beginning in November 1997. Field personnel evaluated selected lengths of Sequoia Creek during stream walks. Their observations are included in Section 9.2.5. Detailed descriptions of the field study observations are in Appendix B.

9.2.4 Modeling Results

A computer model for the Sequoia Creek watershed identified the flow capacity of existing hydraulic structures (e.g., pipes, culverts, channels, bridge crossings) and projected existing and future flows throughout the conveyance system. The existing conditions used in the model are based on the level of development for the year 2000. Future conditions are based on the full development of the watershed (build-out) as identified in the City's Comprehensive Plan. Storm events were modeled for both the existing and future scenarios, including the 2-, 10-, 25-, and 100-year storm events. Table 9-1 lists the hydraulic structures that are undersized for the City's 10-year design storm. Modeling results for all segments over the full range of storm events are in Appendix C.

Table 9-1. Modeled Flow for Undersized Hydraulic Structures within the Sequoia Creek Watershed, cubic feet per second (cfs)

Reach/Location/Model segment	Flow capacity[1]	Existing flows 10-year storm	Future flows 10-year storm	Flooding predicted by model	Flooding reported by staff or public
Conser Street to Highway 99W/undersize channel from railroad tracks to Belvue Street (SEQ100)	230	226	234	No	Yes
Conser Street to Highway 99W/undersize channel from Belvue Street to Highway 99W (SEQ105)	102	217	225	No	No
Highway 99W to Highland Drive/culvert in Highway 99W ditch at Conifer Boulevard (SEQ145)	3.1	23.6	25.2	Yes	Yes
Highway 99W to Highland Drive/culvert in Highway 99W ditch at Walnut Boulevard (SEQ130)	5.5	28.8	30.3	Yes	Yes
Highway 99W to Highland Drive (West Branch)/ Highland Drive pipe from north (SEQ092)	57	1.4	1.4	No	Yes
Highway 99W to Highland Drive (West Branch)/ Highland Drive pipe (SEQ195)	2.1	39.6	39.6	No	Yes
Highway 99W to Highland Drive (West Branch)/ Highland Drive from south (SEQ200)	18	33.3	33.4	No	Yes
Highway 99W to Highland Drive (West Branch)/ Highland Drive from south (SEQ205)	25	13.9	13.9	No	Yes
Highway 99W to Highland Drive (West Branch)/ Walnut Boulevard west of 13th Street (SEQ250)	60	22.9	24.4	No	No
Highway 99W to Highland Drive (West Branch)/ Walnut Boulevard west of 13th Street (SEQ255)	52	22.9	24.4	No	No
Highland Drive to 13th Street (West Branch)/Walnut Boulevard east of 13th Street (SEQ245)	30	35.6	37.0	No	No
Highland Drive to 13th Street (West Branch)/Highland Drive and Walnut Boulevard pipe (SEQ231)	6.2	34.7	36.1	No	Yes
Walnut Boulevard to Headwaters (North Branch)/culvert at Chipmunk Place (SEQ335)	19	54.8	55.3	Yes	Yes
Walnut Boulevard to Headwaters (North Branch)/culvert at Antelope Place (SEQ325)	30	58.1	58.7	Yes	Yes

[1] Capacity is based on Manning's equation. It does not account for hydraulic effects from downstream backwater effects.

Most of the undersized pipes predicted by the model are in the upper reaches of the watershed, along Highland Drive. Many of the deficiencies occur where the slope of the pipe transitions from a steep gradient to the relatively flat main channel. The model shows the pipes surcharging, but not flooding during the 10-year storm event. City staff reported flooding during the 1996 storm. The channel between Conser Street and Highway 99W is shown as undersized because the capacity based on Manning's Equation is less than the projected flow, but the only reported flooding is along Conser Street at the downstream end of the stream reach.

The hydrologic/hydraulic model also estimated flow velocities. The model predicted velocities based on the 2-year storm event—the storm size most responsible for determining the channel configuration. Table 9-2 lists the modeled stream segments that exceed the 4 feet-per-second criteria.

Table 9-2. Modeled Velocities for Sequoia Creek Channel Segments Exceeding 4 fps

Reach/Model segment	2-year storm		Erosion observed	Existing bank stabilization
	Existing velocities	Future velocities		
Walnut Boulevard to Headwaters (North Branch)/ Sundance Circle to Conifer Boulevard	4.21	4.22	No	Yes
Walnut Boulevard to Headwaters (North Branch)/Satinwood culvert to Sundance Circle	4.73	4.76	No	No

9.2.5 Stream Reach Summaries

As with the other watersheds, the Sequoia Creek watershed was divided into a number of stream reaches based on physical characteristics of the stream, property ownership, and any unique characteristic that might distinguish one section of the stream from the rest. The focus of the study ranged from the headwaters to just downstream of Conser Street, where the creek reaches the city limits. The study findings are summarized in the following sections by reach description. Public comments are shown as they were recorded during public meetings or as provided by the various sources.

Downstream of Conser Street

Public Comments: "Has seen changes to downstream flows over the past years—the flashiness of it (downstream of Corvallis) at Stewart Slough."

"Culvert is too small in stretch at Highway 20."

"Man has a number of goats—2 years ago—along Stewart Slough during flooding."

"During flooding of Stewart Slough, the water was high and she (the speaker) was worried about her plantings. (She had moved the fence back and done plantings.) But, after flooding, the plants were still there and the bank was in good shape and the plantings had benefited from it. Though it takes several years to get it going."

"He owns 10 acres on Seavey Avenue along Stewart Slough and last year he picked up 2 loads of tires and other garbage. Also wood in channel."

"Lives in Seavey area near Sequoia Creek in floodplain. State (DSL) approved fill of 1,300 cubic yards (250 truckloads and they have a permit to do this). Driveway and barn are in an annual floodplain. This has been finished. An additional 1,000-1,500 cubic yards of dirt [also added]. County okayed this additional amount (no permit for this). Much of this dirt is not compacted—is loose."

City Staff Reports: Downstream property owners have made changes to the stream bank that have impacted flow capacity and stream habitat. The Walnut Boulevard Extension Project will improve the stream corridor in this area.

Field Observations: No field observations were taken for this reach.

Modeling Results: Modeling did not show any capacity or velocity deficiencies in this reach.

Conser Street to Highway 99W

Public Comments: No public comments were provided for this reach.

City Staff Reports: Low gradient stream is prone to sediment deposits that impact flow.

Field Observations: Approximately 350 feet upstream of the Willamette and Pacific Railroad tracks, the stream crosses through a 7-foot-diameter metal culvert that is about half filled with rock and silt. Downstream of Jack London Street, light industrial facilities encroach on the stream corridor. Debris and sediment from construction activities restrict the channel capacity in this reach. The stream corridor between Belvue Street and Jack London Street is a relatively high-quality riparian woodland. Some blackberry thickets are present among otherwise native species. The low-gradient stream flows through silt/clay materials with streambanks 4 to 6 feet high. A deep deposit of soft sediments has accumulated immediately downstream of Belvue Street where a dense willow thicket is crowding the channel. Raccoon tracks were present in this reach during the field survey.

The channel downstream of the railroad bridge has good canopy coverage along the south bank, but the width of the riparian buffer is confined by a trailer court along the south bank and the recycling center on the north bank. Trash in the stream is believed to be from the recycling center. The railroad bridge contains a hardened invert that has created a backwater pool upstream of the hardened area. There are substantial deposits of fine sediments immediately upstream of the box culverts at Belvue Street. The deposits have been stabilized in places by reed canarygrass. A partially silted, 36-inch-diameter culvert at Highway 99W carries the low flows, and twin box culverts positioned at a higher elevation convey water only during larger flow events. A discarded picnic table is blocking the northern box culvert under Highway 99W.
Modeling Results: The modeling showed that the stream channel was undersized from the railroad tracks near Conser Street up to Highway 99W. No reports of flooding have been received for this reach of stream. Velocities in excess of the 4 feet-per-second criteria were not predicted.

Highway 99W to Highland Drive

Public Comments: "Check out culvert in this area. [Maintenance] gate has not been locked because of blackberries at 950 NW Sequoia Street."

Nutria are a problem along Sequoia ditch, eat his lawn and chase people too. Also a large tree in the channel."

"Nutria attacked a toddler (they are territorial)."

"Citizens were involved in 1981 Drainage Master Plan and nothing was done along Sequoia ditch. Money went elsewhere—stream now 20 feet wide in 9th Street area."

"A couple of years ago, frogs on Sequoia Creek were killed and they are just now coming back."

City Staff Reports: Low gradient stream is prone to sediment deposits that impact flow. The City has little to no access to perform stream maintenance activities. Storm pipes to the south do not drain properly even during small storm events.

Field Observations: The channel between Highway 99W and 9th Street is narrow and has a sharp left bend at Highway 99W, followed by a sharp right bend underneath 9th Street. The bends, along with the berm that splits the channel, significantly decrease the channel conveyance capacity. The three box culverts under 9th Street contain large deposits of fine sediments. Directly upstream of 9th Street the creek is channelized, incised, and flat. The stream bottom is covered with fine sediments; the banks are stable and well vegetated with a mixture of native and exotic species. Man-made and woody debris block some sections of the channel.

A large, concrete, arch pipe conveys flows from the piped systems to the north and west into Sequoia Creek about 150 feet east of Fairlawn Street. The instream habitat conditions are very poor in this section of the reach. Coupled with the extensive piped systems upstream, this section has low rehabilitation potential for fish.

Modeling Results: Modeling showed capacity deficiencies along the Highway 99W ditch. A number of the pipe systems feeding into the main channel from Highland Drive are under capacity. The modeling showed no excessive velocities in this reach.

Highland Drive to 13th Street (West Branch)

Public Comments: No comments available for this reach.

City Staff Reports: No comments available for this reach.

Field Observations: No field observations were performed for this reach.

Modeling Results: The model predicted an undersized pipe at the intersection of Highland Drive and Walnut Boulevard. An undersized pipe at Walnut Boulevard and 13th Street appears responsible for surcharged manholes along Walnut Boulevard. Neither area had reports of flooding, so no action is recommended at this time. No velocity problems were reported because the modeled portion of this reach is entirely piped.

Highland Drive to Walnut Boulevard (North Branch)

Public Comments: "Why was Sequoia Creek piped over a decade ago downstream of Walnut Boulevard?"

City Staff Reports: The outlet of the arch pipe into Sequoia Creek can become partially plugged with sediment and debris.

Field Observations: No field observations were performed for this reach.

Modeling Results: The model did not predict flow capacity or velocity problems in this reach.

Walnut Boulevard to Headwaters (North Branch)

Public Comments: Sequoia [Creek] on Chipmunk [Place]: in summer sometimes a pulse of water comes down (1 or 2 times/year, a great amount of water comes down) and [its] not associated with rainfall. Reservoir overflow?"

"Chipmunk Place on Sequoia [Creek] has changed radically over past 20 years because of upstream development—some downcutting and erosion. He is concerned that if a culvert plugs, he is worried about consequences."

City Staff Reports: Culverts under Chipmunk Place and Antelope Place were designed to be undersized for the 10-year storm event and to detain water behind them.

Field Observations: No field observations were performed for this reach.

Modeling Results: Modeling showed the culverts under Chipmunk Place and Antelope Place were undersized (see City Staff Reports). Velocities exceeding the 4 feet-per-second criteria were projected for the area near Sundance Circle, between Walnut and Conifer Boulevards.

9.2.6 Watershed Summary

The downstream portions of the Sequoia Creek watershed contain some of the higher quality riparian areas observed during the overall study. Development in the lower reaches is light and has not yet encroached on the natural riparian stream buffer or on the stream itself. The mixed commercial and residential development between the Willamette and Pacific Railroad bridge and Fairlawn Street has encroached on the stream and reduced the quality of the riparian area. Also, this area is relatively flat, with a number of flow capacity deficiencies observed during the 1996 storms. The model indicates the deficiencies occur either during transitions from steep pipes to flat channels or where in-channel constrictions, such as sharp bends, exist. The water quality from the commercial areas is suspected to be low due to the absence of onsite water quality treatment facilities. Residential development in the upper reaches is low density, but vegetation management practices have reduced the quality of the riparian area and have increased the potential for water pollution, particularly from nutrients (fertilizers).

9.3 WATERSHED MANAGEMENT OPTIONS

Recommendations for the Sequoia Creek watershed are shown in Table 9-3. The short-term program elements listed in Table 9-4 include a large number of City maintenance activities. A stream stewardship program is recommended for educating and engaging the public. Such a program will help the public understand the impacts of maintenance and landscaping practices on water quality and stream health. Another recommendation is a pipe to divert flows from Fairlawn Street to the east along Linden Avenue. Detention was considered, but a lack of vacant land for off-line storage precluded this. The diversion alternative provides a direct flow path to the channel downstream of Highway 99W. It should alleviate flooding problems south of Sequoia Avenue and along 9th Street, caused in part by the existing channel configuration. The location of the diversion and other short-term projects are shown in Figure 9-3.

Additional flood protection would be provided by the recommendations listed in Table 9-5 for the long-term SWMP options. These consist of replacing several sections of undersized pipes and culverts, and improving the flood storage capacity in or along the channel. A predesign effort would be required to site and size these improvements. Figure 9-4 shows the location of the long-term projects.

Table 9-3. Sequoia Creek Options

Reach	Abridged observations	Recommended activity	Priority
Downstream of Conser Street	1) The public reported that flows have become flashier over the last few years.	a. Monitor flows to determine stream response to rain events. Use information to provide additional calibration of hydraulic model.	Short-term
	2) Culvert at Highway 20 is undersized according to public input.	a. Notify ODOT of public concern regarding capacity of culvert.	Short-term
	3) A driveway and barn were recently built in the annual floodplain according to one public observation. Also, it was noted that Benton County approved additional filling for this project without a permit.	a. Develop coordination plan with Benton County to provide review and input from City or County where project in one jurisdiction's floodplain may impact the other.	Short-term
	4) Downstream property owners have impacted flow capacity and stream habitat.	a. Develop stream stewardship program with property owners, Benton County, and City involvement with particular attention to landscaping practices impacting water quality and habitat. (Note: the Walnut Boulevard Extension Project will improve the stream corridor in this area.)	Short-term
Conser Street to Highway 99W	1) Low gradient stream is prone to sediment deposits near Belvue Street that impact flow.	a. Remove sediment near Belvue Street and work to minimize sources.	Short-term
	2) Culvert 350 feet upstream of railroad tracks is half filled with sediment.	a. Remove sediment from culvert upstream of railroad tracks and work to minimize sources.	Short-term
	3) Light industrial facilities encroach on the stream downstream of Jack London Street.	a. Develop citywide requirements for protecting remaining stream riparian areas.	Ongoing
		b. Develop citywide requirements for stormwater treatment from commercial and industrial land uses.	Ongoing
	4) Debris and sediment from construction activities restrict stream capacity downstream of Jack London Street.	a. Remove sediment downstream of Jack London Street and work to minimize sources.	Short-term
		b. Develop citywide requirements for preventing erosion from construction sites.	Ongoing
	5) Some blackberry thickets along bank between Jack London and Belvue Streets.	a. Remove non-native vegetation and replant with native species between Jack London and Belvue Streets.	Short-term

Table 9-3. Sequoia Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
Conser Street to Highway 99W (cont.)	6) The recycling center is a source of trash found in the creek.	a. Work with recycling center to adopt Best Management Practices to prevent trash and debris from entering stream.	Short-term
		b. Investigate if parking lot/storage area at recycling center can be reduced in size to allow for vegetative buffer strip and increased capacity.	Short-term
	7) A picnic table is blocking the northern box culvert under Highway 99.	a. Remove trash and debris from culvert under Highway 99 and dispose of properly.	Short-term
Highway 99W to Highland Drive	1) Culvert at 9th Street is undersized according to public comment.	a. The model did not predict flooding in this area. Monitor flows at this location to determine the extent and nature of flooding. Provide additional capacity if required. Use flow monitor information to provide additional model calibration.	Short-term
	2) The public has reported that nutria are a problem in this reach.	a. Remove nutria from area if they become a nuisance.	Short-term
	3) Low gradient stream is prone to sediment deposits that impact flow.	a. Remove sediment deposits in stream reach and work to decrease sources.	Short-term
	4) City has little to no access to perform stream maintenance activities.	a. Develop conservation easements with property owners to protect stream and provide City access for maintenance activities.	Short-term
	5) City staff reports that storm pipes to the south do not drain properly even during small storm events. Pipe systems feeding into the main channel from Highland Drive are undersized according to the model.	a. Determine if undersized pipes along Highland Drive need to be replaced after the downstream capacity is increased.	Long-term
	6) The bends and berm that split the channel near Highway 99W decrease channel capacity causing flooding along 9th Street. The model predicted inadequate flow capacity for culverts along Highway 99W.	a. Coordinate with ODOT to remove existing berm located between two ditches and replace culverts along Highway 99W to increase carrying capacity of channels.	Long-term

Table 9-3. Sequoia Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
Highway 99W to Highland Drive (cont.)		b. Install pipe along Linden Avenue between Fairlawn Street and Highway 99W to divert some flow away from Sycamore Avenue and the 9th Street/ Highway 99W stream sections.	Short-term
	7) The three box culverts under 9th Street contain large deposits of fine sediments and man-made debris blocks some sections of the channel.	a. Remove man-made debris from channel.	Short-term
	8) Instream habitat conditions are very poor in this reach.	a. Develop citywide requirements for protecting and enhancing existing riparian areas through conservation easements.	Ongoing
		b. Develop stream stewardship program with property owners, Benton County, and City involvement with particular attention to landscaping practices impacting water quality and habitat.	Ongoing
	9) Upstream of Highway 99W, the creek is channelized and incised with very flat gradient.	a. Investigate potential for laying back the streambank to improve flow regime and provide for greater flood storage.	Long-term
Highland Drive to Walnut Boulevard (North Branch)	1) Public noted that Sequoia Creek was piped downstream of Walnut Boulevard.	a. Develop citywide requirements for protecting existing stream functions.	Ongoing
	2) Outlet of arch pipe into creek can become partially plugged with sediment and debris.	a. Monitor sediment buildup at pipe and remove sediment and debris if flooding impacts are unacceptable and actions do not impact habitat value.	Short-term

Table 9-3. Sequoia Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
Walnut Boulevard to Headwaters (North Branch)	1) A pulse of water has been noted near Chipmunk Place not associated with rainfall according to one public report.	a. Investigate source and legality of non-stormwater discharges near Chipmunk Place.	Short-term
	2) One citizen noted that upstream development has caused downcutting and erosion in the stream.	a. Develop citywide requirements for preventing additional runoff volume and excessive velocities due to new or re-development.	Ongoing
	3) The model predicted velocities near Sundance Circle in excess of the velocity criterion.	a. Provide channel and stream improvements to control erosion along Sundance Circle in areas where streambed or streambank have not already been armored with riprap.	Long-term
		b. Develop citywide requirements for preventing additional runoff volume and excessive velocities due to new or re-development.	Ongoing
	4) The model predicted undersized culverts at Chipmunk Place and Antelope Place. (Note: City staff reports that the culverts were designed to retain water upstream of the culverts as part of detention system.)	a. Raise elevation of Chipmunk Place and Antelope Place to continue to allow ponding behind culvert without flooding road.	Long-term
		b. Increase storage capacity of channel directly upstream of culverts.	Long-term

Table 9-4. Sequoia Creek Short-Term Program

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Downstream of Conser Street	1) Monitor flows to determine stream response to rain events. Use information to provide additional calibration of hydraulic model.	5,000	5,800	☑
	2) Notify ODOT of public concern regarding capacity of culvert.	200	NA	≈
	3) Develop coordination plan with Benton County to provide review and input from City or County where project in one jurisdiction's floodplain may impact the other.	800	NA	≈
	4) Develop stream stewardship program with property owners, Benton County, and City involvement with particular attention to landscaping practices impacting water quality and habitat. (Note: the Walnut Boulevard Extension Project will improve the stream corridor in this area.)	1,200	NA	♠
Conser Street to Highway 99W	1) Remove sediment near Belvue Street and work to minimize sources.	NA	1,100	⚒
	2) Remove sediment upstream of railroad tracks and work to minimize sources.	NA	2,200	⚒
	4) Remove sediment and construction debris downstream of Jack London Street.	NA	4,000	⚒
	5) Remove non-native vegetation between Jack London and Belvue Streets and replant with native species.	12,000	600	♠
	6) Work with recycling center to adopt Best Management Practices to prevent trash and debris from entering stream.	400	NA	⚒
	7) Investigate if parking lot/storage area can be reduced in size to allow for vegetative buffer strip and increase channel capacity.	3,400	NA	✚
	8) Remove trash and debris from culvert under Highway 99W and dispose of it.	NA	400	⚒

Table 9-4. Sequoia Creek Short-Term Program (continued)

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Highway 99W to Highland Drive	1) The model did not predict flooding in this area. Monitor flows at this location to determine the extent and nature of flooding. Use flow monitor information to provide additional model calibration.	5,000	5,800	☑
	2) Remove nutria from area if they become a nuisance.	NA	500	⚒
	3) Remove sediment deposits in reach and work to decrease source.	NA	600	⚒
	4) Develop conservation easements with property owners to protect stream and provide City access for maintenance activities.	4,000	NA	⚒
	6) Install pipe along Linden Avenue between Fairlawn Street and Highway 99W to divert some flow away from Sycamore Avenue and the 9th Street/Highway 99W stream sections.	169,000	NA	Red line
	7) Remove man-made debris from channel at 9th Street.	NA	400	⚒
Highland Drive to Walnut Boulevard (North Branch)	1) Monitor sediment buildup at pipe and remove sediment and debris downstream if flooding impacts are unacceptable and actions do not impact habitat value.	NA	2,000	☑
Walnut Boulevard to Headwaters (North Branch)	1) Investigate source and legality of non-stormwater discharge near Chipmunk Place.	800	NA	☑
Total		**201,800**	**23,400**	

NA – Not applicable

[1]Project types are in the Figure 9-3 map legend.

Table 9-5. Sequoia Creek Long-Term Program

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Highway 99W to Highland Drive	5) Determine if undersized pipes along Highland Drive need to be replaced after the downstream capacity is increased.	166,000	NA	≈
	6) Coordinate with ODOT to remove existing berm located between two ditches and replace culverts along Highway 99 to increase carrying capacity of channels.	75,000	3,750	≈
	9) Lay back the streambank to improve flow regime and provide for greater flood storage.	120,000	6,000	≈
Walnut Boulevard to Headwaters (North Branch)	1) Provide channel and stream improvements to control erosion near Sundance Circle where streambed or streambank have not already been armored with riprap.	35,000	1,750	Green line
	2) Raise elevation of Chipmunk Place and Antelope Place to continue to allow ponding behind culvert without flooding road.	25,000	NA	≈
	3) Increase storage capacity of channel directly upstream of Chipmunk Place and Antelope Place culverts.	40,000	2,000	≈
Total		**461,000**	**13,500**	

NA – Not applicable

[1]Project types are in the Figure 9-4 map legend.

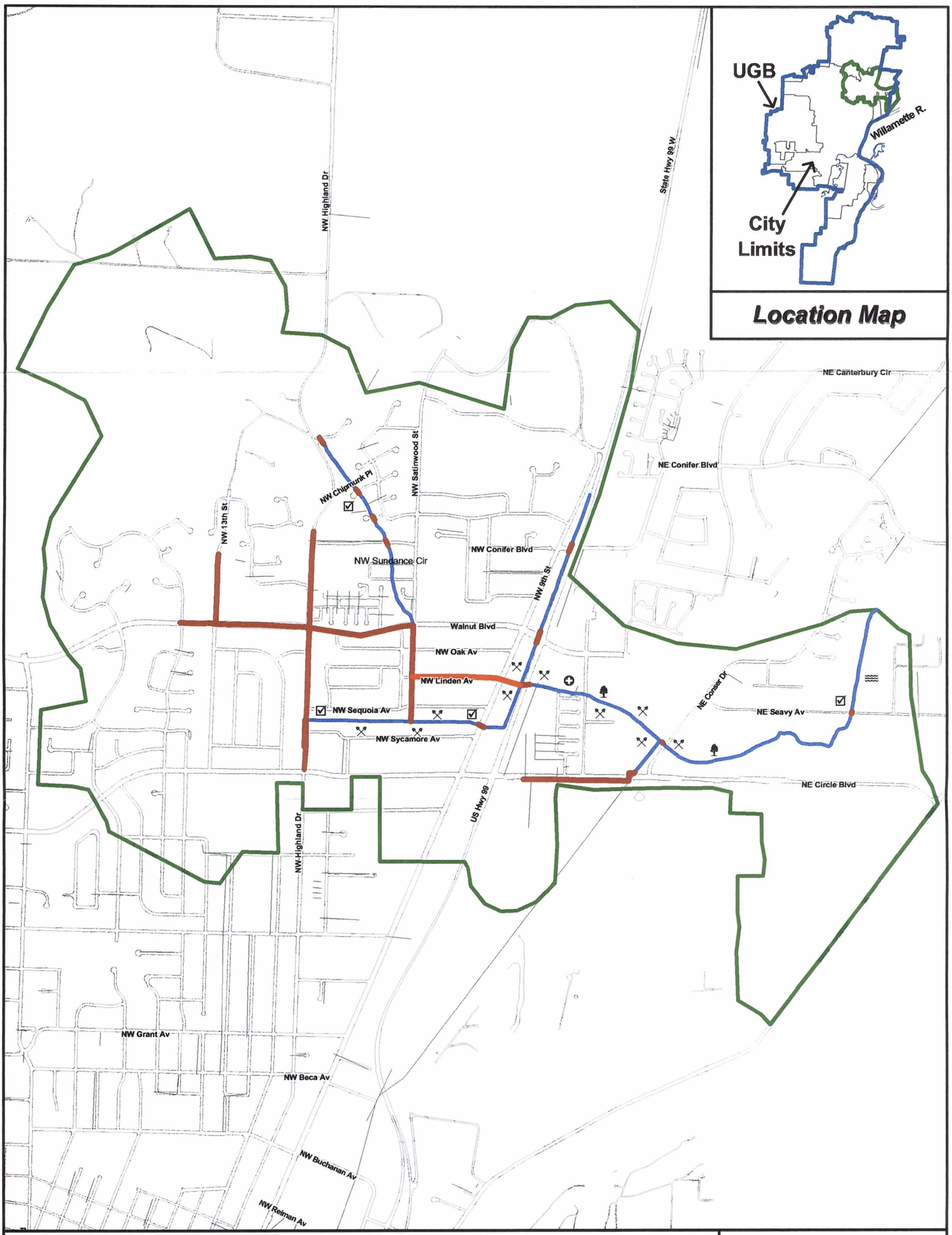

Figure 9-3 Short Term Project Locations

LEGEND

- Pipes/Bridges
- Channels
- Basin Boundary
- Bank Stabilization
- Canopy Revegetation
- Channel Improvement
- Replace Pipe/Bridge
- Fish Passage
- Buffer/Riparian Habitat
- Floodplain Reconnection
- Water Quality BMP
- Flood BMP
- Maintenance
- Monitor
- Multi-Use Facility

N

Feet 400 0 400 800 1200 1600 Feet

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report/figures/final/Fig9-3.wor, November 22, 2000, base data from City of Corvallis GIS Department