Miller Creek Relocation Plan for Proposed Master Plan Update Improvements at Seattle-Tacoma International Airport

Parametrix, Inc.
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MILLER CREEK RELOCATION PLAN

FOR THE PROPOSED MASTER PLAN UPDATE IMPROVEMENTS AT SEATTLE-TACOMA INTERNATIONAL AIRPORT

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

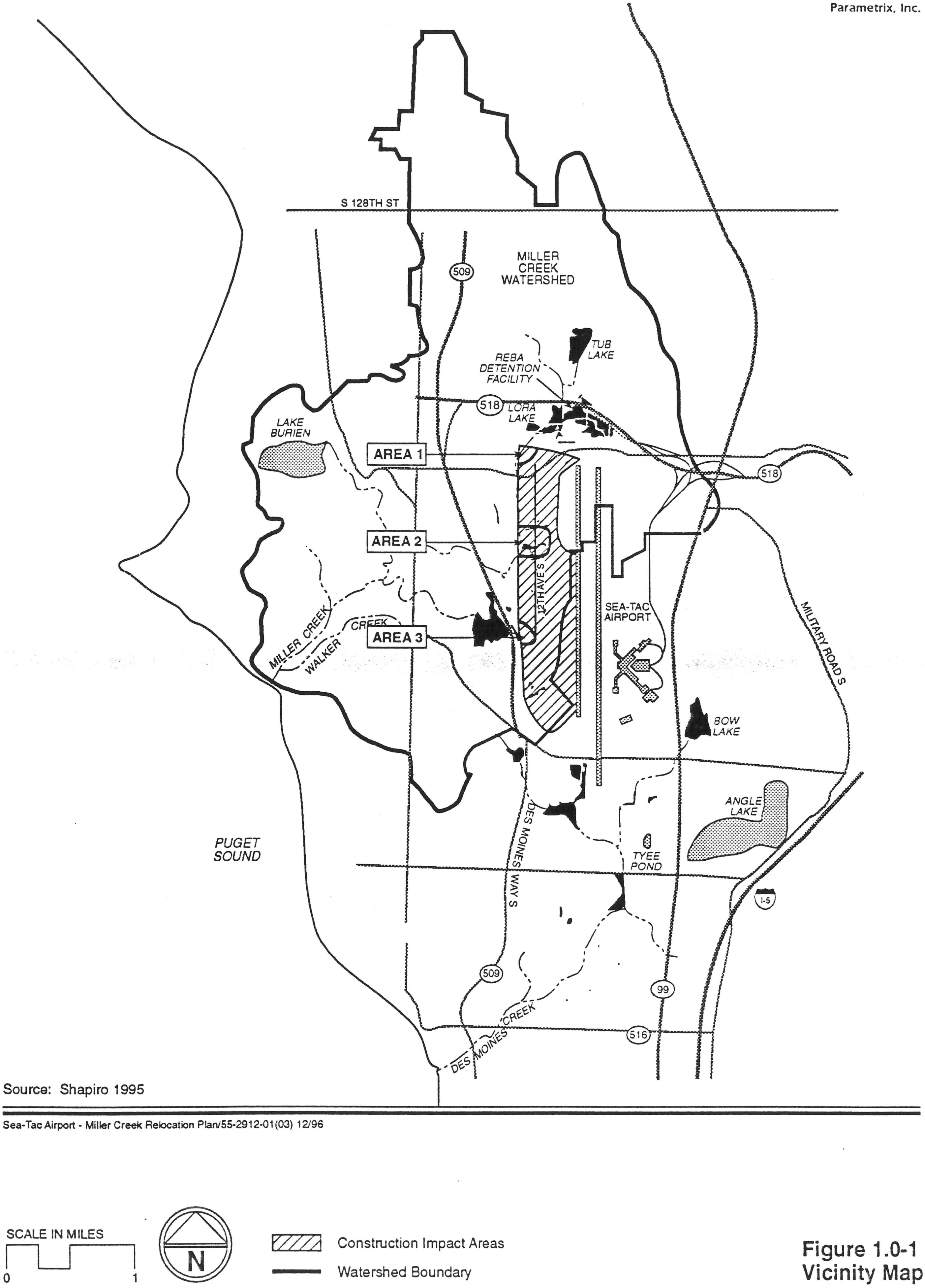
LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The Port of Seattle (Port) is proposing to update the Master Plan of Seattle-Tacoma International Airport (Airport). Implementation of the proposed Master Plan update would result in development that could cause significant, unavoidable adverse impacts to natural resources in the project vicinity, including Miller Creek (Figure 1.0-1). The proposed Master Plan Update improvements include fill activities that would directly affect three areas in the Miller Creek watershed (Shapiro 1995) due to the proposed new parallel runway embankment. Area 1 includes approximately 980 ft of Miller Creek. The affected portions extend approximately 1,000 ft south of Lora Lake. Area 2 includes Class III drainage channels, totaling 2,080 ft, that originate as seeps in the Airport Operations Area (AOA) and flow west to Miller Creek. Area 3 includes 200 ft of the Class III headwaters of Walker Creek. These waters, which originate from groundwater seepage and storm water runoff at the corner of 12th Avenue South and South 176th Street, flow northwest toward State Route 509 (SR 509).

This report discusses (1) the current resource conditions, (2) potential impacts to the resource area, (3) the goals, objectives, and performance standards of the proposed mitigation, (4) the proposed mitigation site, (5) the proposed mitigation plan, and (6) provisions for monitoring and maintaining the mitigation. It also discusses proposed contingency measures to be implemented if the established performance standards are not achieved.



Source: Shapiro 1995

Figure 1.0-1
Vicinity Map

2. ECOLOGICAL ASSESSMENT OF PROJECT SITE

The Miller Creek basin is approximately 8 mi^2 located in southwest King County. The basin includes a small portion of Sea-Tac Airport, as well as parts of the cities of SeaTac and Burien. The Airport covers an estimated 5 percent of the entire basin. The Miller Creek watershed consists of drainage channels that originate at Arbor, Burien, and Tub lakes; surface water and seep drainages from the north end of Sea-Tac Airport; and overflows from the Reba Detention Facility and Lora Lake. The creek generally flows south and southwest toward Puget Sound.

2.1 STREAM CLASSIFICATION

The lower reaches of Miller Creek are Class II salmon-bearing waters, as defined by the Washington State Department of Fish and Wildlife (WDFW). However, the upper reaches are reported to be inaccessible to anadromous salmonids (Shapiro 1995) because of road culverts and a waterfall at about 0.2 mi upstream of Southwest 160th Street. The other drainage channels that flow through or adjacent to the study area are Class III or unclassified reaches that were trenched or ditched to function primarily as surface or groundwater conveyance channels. Class III streams are classified according to their intermittent or ephemeral characteristics during normal rainfall years.

Although the watershed is generally classified by Washington Department of Ecology (Ecology) as having Class AA (extraordinary) water quality, storm water runoff from residential, commercial and agricultural properties has contributed to water quality degradation. As a result, Miller Creek fails to meet many of the state water quality standards (Landrum & Brown 1996). Water quality in the basin has degraded as a result of pollutants commonly found in urban storm water runoff. Nutrients, organics, metals, fecal coliform bacteria, and suspended solids have contributed to occasional violations of Class AA water quality standards and federal water quality criteria. In addition, occasional violations of Class AA water quality standards for pH, dissolved oxygen, and ammonia have also occurred in the basin (Landrum & Brown 1996).

2.2 PRIMARY USES/FUNCTION IN THE WATERSHED

Most of the 5,000-acre Miller Creek watershed is fully developed with residential and commercial properties. Approximately 60 percent of the land use in the basin is residential, 20 percent is commercial, and the remaining 20 percent is open space or forested. The Airport is the largest commercial facility in the watershed. Other commercial facilities are scattered along Des Moines Way, Ambaum Boulevard, and First Avenue South. Some agricultural uses are also found in the upper watershed, including the area where creek relocation would be necessary. Although urbanization has altered the stream and riparian habitat, these areas continue to support some fish and wildlife species.

2.3 EXISTING FISH HABITAT

Historically, Miller Creek supported anadromous fish runs of coho and chum salmon and sea-run cutthroat trout, as well as resident populations of pumpkinseed sunfish, sculpin, and cutthroat trout (Landrum & Brown 1996). No comprehensive fish population study has been conducted on Miller Creek. A recent (August 18, 1996) electrofishing spot-check survey reported cutthroat trout, pumpkinseed sunfish, and three-spine stickleback upstream of South 160th Street (Aquatic Resource Consultants 1996). The creek currently supports a small coho salmon run that is maintained by annual releases of hatchery-reared fingerlings raised by the Des Moines Chapter of Trout Unlimited (Shapiro 1995). The last WDFW-sponsored spawner survey in 1985 did not observe any coho spawning activity. However, the Des Moines Salmon Chapter of Trout Unlimited reported about 91 fish in a recent coho spawner survey. The August 1996 electrofishing spot-check survey reported one coho smolt captured downstream of the culvert under South 160th Street (see Figure 2.6-1) (Aquatic Resource Consultants 1996).

Residential development in the watershed has resulted in a general deterioration of fish habitat because of the removal of native riparian vegetation, stream channelization and bank armoring, filling of riparian wetlands, reduction of the availability of large organic debris, and increased non-point source pollution loading. The expansion of impervious surface area in the basin has also led to increased runoff volumes and velocities with increased bank erosion, downcutting, landslides, and debris jams. These factors have contributed to a general lack of (1) instream and overhead cover, (2) available low- and high-flow habitat or refugia, (3) available spawning habitat in the basin, (4) habitat complexity, and (5) high-quality water (King County Surface Water Management [KCSWM] 1987; Landrum & Brown 1996; Shapiro 1995).

In addition to the deteriorated habitat conditions in the basin, several natural and manmade barriers appear to limit anadromous fish access to the upper basin. The most prominent barrier on Miller Creek is an 8-ft waterfall about 0.2 mi upstream of Southwest 160th Street. Other potential barriers in the basin include several corrugated metal and concrete box culverts (Shapiro 1995). These seasonal or year-round barriers appear to limit upstream habitat use to resident fish species, including pumpkinseed sunfish, cutthroat trout, and sculpin (Shapiro 1995).

In addition to these barriers, habitat availability may be contributing to the current fish distribution pattern. Shapiro (1995) found suitable coho salmon spawning gravel limited to the area downstream of First Avenue South, while suitable cutthroat spawning habitat was scattered in small patches between South 156th Way and First Avenue South. Areas upstream of First Avenue South, however, consisted predominantly of fine silt and sand substrate, which is more suitable habitat for the non-salmonid fish species that occur there.

KCSWM (1987) reported that natural, unaltered stream reaches in the basin are essentially nonexistent and that major portions of the main stem and all associated drainage ditches are channelized or otherwise modified. The main stem section that the Port is proposing to relocate is a low-gradient, channelized stream reach, with no large woody debris, and limited habitat complexity. This reach is dominated by slow-flowing water and shows signs of excessive sedimentation, which appears to be at least partially caused by agricultural runoff. Shapiro (1995) estimated that some 10 tons of sediment are transported to the creek annually from 11 acres of adjacent agricultural land. These factors contribute to the lack of high-quality fish-rearing pools in the reach. Such pools are important over-wintering habitat that provide refuge for fish during high-flow events (Shapiro 1995).

Several small drainage channels originating from groundwater seeps under the existing runway flow west to Miller Creek. These channels are intermittent surface and groundwater conveyance ditches that do not appear to provide fish habitat at any time (Shapiro 1995). These reaches consist of a series of small, shallow, runs and riffles with occasional pocket-water. During winter flow periods, these drainage channels consist of shallow rivulets that are approximately 1- to 3-in deep and typically less than 1 ft wide.

2.4 HYDROLOGY

The addition of fill and impervious surface areas as a result of the proposed Master Plan Update improvements would decrease the amount of rainfall infiltration in soils (groundwater recharge) and increase the volume and flow rate of storm water runoff in the basin. Unless mitigated, these changes are expected to cause increased flooding, erosion, and instream habitat degradation in areas downstream of the study area. These problems already occur in the area due to previous basin development.

KCSWM (1987) estimated that 40 percent of the basin's surface area was impervious in 1986; an increase to 50 percent was predicted when the area was fully developed. Increased runoff rates and volumes resulting from urbanization and development in the watershed have contributed to erosion and downcutting in the steep ravine areas, and sedimentation and degradation in the low-gradient areas (Shapiro 1995). The Reba Detention Facility, built by King County in 1990, alleviated some of these impacts. The impervious surface areas also limit the groundwater recharge in the area, resulting in less groundwater seepage during low-flow periods.

Since 1991, KCSWM has monitored flow rates at the outlet of the Reba Detention Facility (KCSWM 1994). The available flow data provide a good record of base flows, normal wet and dry season flows, and annual peak flows. Stream flow rates are typically highest between October and April and lowest between May and September (Landrum & Brown 1996). Montgomery Water Group (1995) modeled hydrologic characteristics in the basin and found that in some years no flow occurs in the upper watershed areas during portions of the summer. They also reported that summer flows only exceed 0.5 ft^3 per second (cfs) about 10 percent of the time. A range of flow rates for channel design has been determined from these data sets (Tables 2.4-1 and 2.4-2).

Table 2.4-1. **Estimated base flow rates (cfs) at the Reba Detention Facility outlet structure.**

Base Flow Rates	Flow Rate (cfs)
Dry Season (May – September)	0.5
Wet Season (October – April)	5.0
Approximate Annual Peak	40.0

Source: KCSWM (1994)

Table 2.4-2. Flood frequency estimates - Miller Creek at the Reba Detention Facility control structure.

Return Period (years)	Peak Flow Rate (cfs)
1.01	21
1.11	40
2	75
10	125
20	141
50	161
100	175

Source: Montgomery Water Group (1995)

In addition to monitored flows, a detailed hydrologic study was prepared (Montgomery Water Group 1995) that includes a peak flow rate for flood frequencies up to the 100-year flood (see Table 2.4-2). The 2-year-flood peak flow rate is estimated at about 75 cfs (just downstream of the Reba Detention Facility), and the 100-year flow rate is about 175 cfs.

2.5 CHANNEL CONFIGURATION

Miller Creek, from the Reba Detention Facility outlet to South 156th Way, is not a natural stream; the creek has been dredged and straightened for farmland reclamation and wetland drainage. Land contours, soil types, and flat profiles indicate that the study segment was historically a poorly drained depression that overflowed to the south where Miller Creek follows a topographic incision. Ditches were constructed to connect the upper watershed, Reba Detention Facility, and Lora Lake to Miller Creek south of the study area. The channel currently overflows its banks with at least a 2-year frequency with full flow velocity of 1.7 ft per second (Shapiro 1995). Frequent flooding is primarily the result of inadequate channel capacity, in part because of the flat channel slope. A side channel in the study area runs parallel to the main channel, providing positive drainage for the farm fields. The side channel is not a true tributary, as it does not drain runoff from a distinct subbasin area nor does it provide additional channel capacity to the main channel. Rather, its function is to provide positive drainage for a portion of the relatively flat farm land located in the vicinity of the main Miller Creek channel.

In the area of the proposed creek relocation, Miller Creek is approximately 4 to 10 ft wide at the bottom and 2 ft deep below the outfall of the Reba Detention Facility. Large rocks line the banks of the creek in the upper segments near Lora Lake, and the channel has a very silty substrate.

2.6 FLOODPLAIN

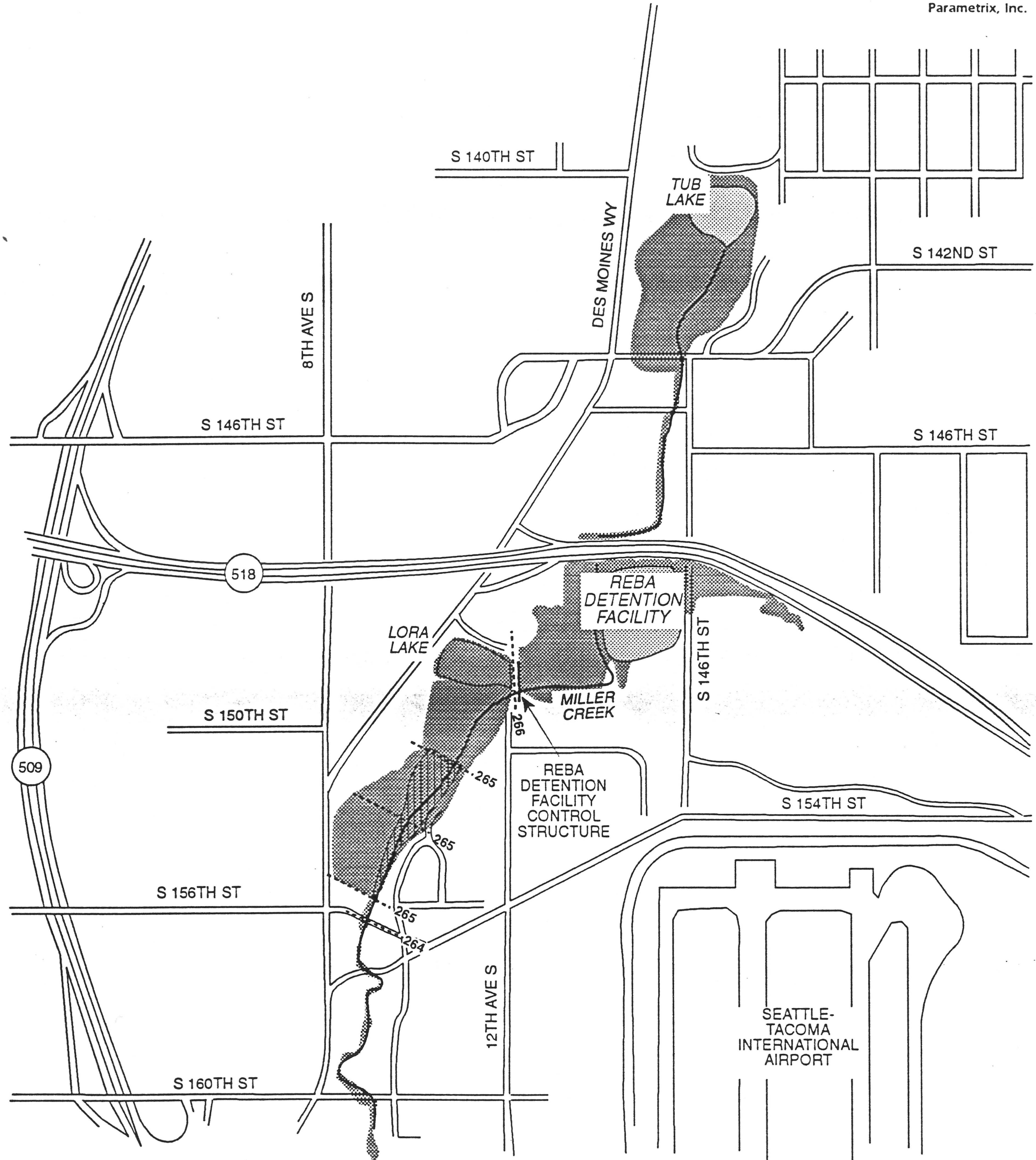
Existing floodplains have been significantly altered by urbanization and agricultural development in the Miller Creek basin. Development activities that have contributed to current floodplain conditions include filling wetlands, removing riparian vegetation, and armoring stream banks. These activities have reduced both stream channel and floodplain capacities. In addition, the construction of roads, residences, and commercial facilities have increased storm water runoff rates and volumes. These factors have contributed to an increased flooding potential in the basin (Landrum & Brown 1996).

The 100-year floodplain in the vicinity of the channel relocation is quite extensive (Figure 2.6-1). The wetland ponding area and poor drainage that existed prior to the land drainage activities are evident from the 100-year floodplain estimated by the Federal Emergency Management Agency (FEMA) (see Figure 2.6-1). The approximate 100-year flood elevations, determined by FEMA as part of its study, vary from 266 ft at the Reba Detention Facility outlet to 265 ft at the downstream end of the proposed stream relocation. A floodway has also been delineated and mapped in a portion of the floodplain.

Without mitigation, construction and operation of the proposed Master Plan Update improvements would result in significant adverse floodplain impacts, including reductions in the 100-year floodplain storage capacity, reduced floodway flow conveyance, increased storm water runoff rates and volumes, and increased flood potential in downstream areas. Floodplain development standards and floodway management requirements prohibit reductions in floodplain area or storage capacity, or significant increases in peak flow rates. Therefore, the proposed floodplain mitigation was designed to compensate for any significant floodplain or flooding impacts.

2.7 EXISTING RIPARIAN VEGETATION

In the area of the proposed channel relocation, the riparian vegetation associated with Miller Creek is typically a narrow (less than 50-ft wide) band of reed canarygrass (*Phalaris arundinaceae*), nightshade (*Solanum dulcumara*), and other introduced grass species. Scattered throughout this area are black cottonwood (*Populus tricocarpa*) and willow (*Salix*) trees and saplings. Adjacent to this band of low-quality riparian vegetation is cultivated farmland.



Source: FEMA 1995

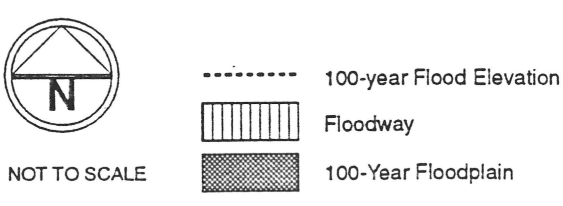


Figure 2.6-1
100-Year Floodplain On and Near Miller Creek

Downstream of the Reba Detention Facility, about 200 lineal ft of the creek is bordered by higher quality riparian vegetation. In this area, a stand of red alder (*Alnus rubra*) saplings with an understory of Douglas spirea (*Spiraea douglasii*), Himalayan blackberry (*Rubus discolor*), and field horsetail (*Equisetum arvense*) is present.

3. CONSTRUCTION IMPACTS FROM CREEK RELOCATION

Potential impacts to Miller Creek from channel construction and relocation are briefly addressed in this report. Relocation of the creek channel would affect, either temporarily or permanently, fish and wildlife, fish habitat, channel configuration, floodplain capacity and drainage, and riparian vegetation. A comprehensive discussion of impacts from construction and operations of the proposed Master Plan can be found in the Final Environmental Impact Statement (FEIS) (Landrum & Brown 1996).

3.1 IMPACTS TO FISH AND WILDLIFE

Construction activities associated with the project would displace fish and wildlife. Mammals, birds and some fish species should be able to move away from these disturbances into suitable nearby habitat. If these habitats are occupied, the displaced species would be competing for limited resources. The population density in these habitats is likely limited by available space. If no suitable habitat is available for displaced species, they would likely perish. Other wildlife may be unable to relocate to other habitats due to limited mobility. These include some small mammals, fish, amphibians, reptiles, and immature animals, which may perish during construction activities.

Construction activities in the project area would adversely affect fish and wildlife by disrupting feeding and nesting. Small mammal and amphibian species that rely on Miller Creek for foraging, breeding, and overwintering habitat would be directly impacted by the proposed stream relocation. Because of their limited mobility, these species would likely perish. After suitable stream habitat has been restored, population re-establishment would also be limited by species mobility. Much of the existing Miller Creek habitat has been degraded by increased development, non-point source pollution, instream construction, and refuse dumping (Shapiro 1995). If habitat degradation has reduced habitat suitability for sensitive species, then the carrying capacity for those species has also likely been reduced. Therefore, fish and wildlife use of Miller Creek, a degraded habitat, may not have been at capacity.

3.2 IMPACTS TO AQUATIC HABITAT

Potential construction impacts to fish and aquatic habitat would be both short- and long-term. Short-term impacts would occur during construction and continue until the new creek channel is stabilized and revegetated. These impacts could include equipment fuel and oil spills, soil compaction, erosion from clearing, sedimentation from new channel construction, etc. If not effectively mitigated, erosion of exposed surfaces at construction sites could contribute to temporary increases in total suspended solids and non-point pollutants in Miller Creek downstream of the project area. Many amphibian species are sensitive to pollutants, and further degradation of aquatic habitat and water quality in the creek may be a limiting factor for survival or reproduction. Noise disturbance related to construction activities may cause disturbance-sensitive species to avoid potential habitat in an area surrounding the construction zone.

Longer-term impacts would occur during the time required for the new riparian corridor to mature into a stable, functional habitat with a variety of aquatic plants and animals completing successional life cycles. Long-term impacts would be less direct than short-term impacts, consisting instead of limited habitat or marginal habitat quality during the establishment of the riparian corridor.

However, even without construction of the improvements at the Airport, fish and aquatic habitat and biota will continue to be adversely affected by existing degraded water quality, water quantity, and stream habitat conditions that result from various land uses around the Miller Creek watershed.

3.3 IMPACTS TO CHANNEL CONFIGURATION

About 1,080 ft of Miller Creek south of Lora Lake would be realigned and relocated. This section is adjacent to the Vacca Farms and is essentially a ditch with a silty bottom substrate. Historically, the existing channel was straightened and most variations in the natural channel configuration were removed. No impacts would result from relocating the channel if the length is maintained. No impacts to channel configuration would occur if the mitigation plans include a more-sinuous reconstructed channel with a variety of naturalized creek features (e.g., log deflectors, root wads, small instream pools, etc.). These features have been included in the mitigation design (see Chapter 6).

3.4 IMPACTS TO FLOODPLAIN

Fill for the proposed Master Plan improvements would result in the loss of about 4.1 acres of 100-year floodplain adjacent to and downstream of Lake Lora. Encroachment on the floodplain would result in loss of flood storage capacity. Increases in flood heights in downstream areas, particularly in those susceptible to flooding, would depend on the amount of flood storage displaced and on storm water detention facility flow release rates, volumes, and timing of peak rates relative to other areas of the watershed.

Flooding impacts in the Miller Creek basin would be unlikely because of required mitigation which would include adherence to floodplain development standards and floodway management requirements of FEMA, FAA, Ecology, King County, and the city of SeaTac. Floodplain development standards prohibit any reduction in the 100-year floodplain or base flood storage volume. Compensatory mitigation is required for any proposed filling of 100-year floodplain so as to achieve no net loss in flood storage capacity and to prevent an increased risk of loss of human life or property damage.

Compensatory mitigation for floodplain impacts near the northwest corner of the proposed parallel runway has been incorporated into the stream relocation design. The creek mitigation design would create an equivalent amount of floodplain storage, so no net loss of flood storage capacity would occur. Adequate floodway capacity would be provided to limit flood flow conveyance impacts. In addition, storm water runoff detention requirements would prevent significant increases in peak flow rates.

3.5 IMPACTS TO RIPARIAN VEGETATION

The primary effect of construction on plant communities is the removal of vegetation. The loss of plant communities that offer limited habitat value, such as the managed grassland of the project site, results in less of an adverse effect than loss of more complex vegetation associations, such as mature forests, wetlands and riparian zones.

No loss of vegetation communities would be anticipated during the operational phase of the proposed Master Plan Update alternatives. Indirect impacts may occur as a result of increased local development associated with increased human use of the area.

4. CREEK MITIGATION GOALS, OBJECTIVES, AND PERFORMANCE STANDARDS

4.1 GOALS AND OBJECTIVES

The primary mitigation goal is to replace the basic characteristics and functions of the three portions of Miller Creek and its associated drainage channels (Areas 1, 2, 3) that would be affected by the proposed Airport improvements (see Figure 1.0-1). Area 1 is located northwest of the current runway at the outlet of the Reba Detention Facility. Areas 2 and 3 are drainage channels flowing west from the existing runway embankment to Miller Creek. The impacts to Area 1 require relocating approximately 1,080 ft of Miller Creek. Areas 2 and 3 would be affected by the filling of the drainage channels from the western edge of the existing fill slope to the western edge of the proposed fill slope.

Miller Creek in Area 1 is no longer a natural stream channel; therefore, the goal is to provide a new stream channel of at least the same length as the existing channel, with enhanced habitat features. Area 2 consists of two small intermittent drainage channels with an indication of minor seepage. Area 3, the headwater of Walker Creek, contains a short segment of drainage channel. All three drainage channels have been affected by existing airport drainage, perimeter road crossings, or channelization. The mitigation goal for Areas 2 and 3 is replacing the drainage function of the channels.

A drainage ditch located in the project area flows parallel to Miller Creek for approximately 800 ft. The ditch provides positive drainage for the adjacent farmland, connecting to the main channel near South 156th Way. A small segment of the side channel (approximately 250 ft) would be impacted by the fill; however, because this segment is at the upper end of the side channel, drainage and conveyance would not be affected. No habitat would be impacted, since the channel flows intermittently in response to rain, and has little riparian habitat due to farming. For these reasons, no mitigation is proposed.

4.1.1 General Mitigation Objectives

The new Miller Creek channel would be constructed near the lowest path through the broad flat trough that defines the creek floodplain in the project area, with the channel edge offset from the proposed fill a minimum of 25 ft to provide a buffer. Channel slope and minimum flow depth would influence final channel alignment. The new channel section would connect with the existing Miller Creek channel downstream at the earliest possible point to minimize stream relocation impacts. Channel relocation guidelines presented below may vary due to the limited space available between Lora Lake and the proposed fill area. High flows would be diverted through Lora Lake in the upper segments of the proposed Miller Creek channel.

Careful consideration of the benefits that Miller Creek and the three drainage channels now provide must be given when determining the required features for the post-mitigation stream. Streams and waterways can provide many important functions such as conveying surface water and storm water, including flood waters, and providing in-stream and riparian habitat for fish and other water-dependent animals.

The proposed mitigation plan must ensure that present uses are not reduced and that other beneficial uses be included or enhanced. Beneficial use criteria provide design considerations and require consistency with the overall mitigation plan. Goals are prioritized from the most critical function that the existing channel provides to enhancements that would improve channel habitat. A list of impact compensation goals describes the decision-making priorities for the proposed relocated creek. If goals conflict, the higher priority takes precedence.

Miller Creek Goals

Goal 1: The creek would continue to provide base flow conveyance.

Goal 2: The new Miller Creek channel should provide improved fish habitat.

Goal 3: The mitigation would accommodate peak flows up to the 100-year flow; no net reduction of 100-year floodplain storage or floodway conveyance.

Goal 4: Minimum flow velocity should minimize fine sediment deposition.

Goal 5: The channel would replace or increase riparian habitat.

Goal 6: The channel would not include expansive, long-standing water pools or wetlands that could potentially attract wildlife.

Goal 7: The proposed Miller Creek corridor should accommodate passive recreational uses, such as walking trails.

Beneficial uses of the three Miller Creek drainage channels include flow conveyance, base flow seepage, water quality benefits from natural filtration, and limited habitat. Mitigating fill impacts would include:

Drainage Channel Goals

Goal 1: The mitigation drainage channel would continue to provide adequate flow conveyance.

Goal 2: The mitigation drainage channel would collect seepage to maintain base flows.

Goal 3: The new drainage channel would provide an open channel of equivalent length as the existing drainage channels.

Specific Miller Creek and drainage channel design standards are described Tables 4.1-1 and 4.1-2.

4.1.2 Appropriate Habitat

Design and implementation of a mitigation program for the Airport is especially challenging because of flight safety issues. Collisions between birds and aircraft are a serious safety issue. Open-water areas, wetlands, and tall trees can attract waterfowl, small flocking birds (such as starlings), and raptors that may feed on small resident mammals. Large fish populations can also attract many birds and small mammals to places where shorelines and open-water fish habitat are accessible. The closer these habitat features are to airport runways, the greater the potential for interference with aircraft.

Performance standard for cutthroat trout were used to develop design features that would enhance fish habitat. The planned features include: shading to minimize temperature increases during the summer; higher velocity riffles to maintain oxygen levels and reduce sedimentation; and logs, rocks, or other structures to provide refuge. Native plants would be used to shade Miller Creek. Shading the creek would both enhance the stream habitat and decrease its visibility, thereby reducing the likelihood of birds of prey (e.g. herons, raptors) using the creek to collect food.

Table 4.1-1. **Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek.**

Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 1: The stream and tributaries would continue to provide base flow conveyance functions		
Provide minimum flow depth to prevent fish stranding and water quality problems	Design a natural channel assuming a gravel or stony bottom and a Manning's *n* constant of 0.035	Minimum average flow depth is 0.25 ft (at 0.5 cfs)
	Construct vertical channel side slopes from the bottom up 0.5 ft; construct side slopes of 1:1 or flatter (typical) from 0.5 to 1.0 ft to provide capacity for wet season base flow	Approximate wet season (October – April) average base flow depth is 1 ft (at 5.0 cfs)
	Set channel slope to provide minimum and maximum velocity criteria (Goal 4)	
	Adjust channel bottom width for minimum depth criteria	
Maintain existing hydrology from Lora Lake	Construct overflow structure from Lora Lake that replicates the existing lake outflow hydrology	Lora Lake outflow structure replicates the existing discharge hydrology
Miller Creek Goal 2: The new Miller Creek channel should provide enhanced fish habitat		
Provide enhanced fish habitat without fish passage barriers	Provide minimum flow depth (Goal 1)	New channel meets design criteria (Goal 1)
	Provide a natural channel configuration, 0.5 ft vertical slopes, 1:1 slopes from 0.5 ft to 1 ft depth (Goal 1)	
	Provide habitat features, including in-stream features such as deflectors and overhanging logs as needed to maximize available habitat	Stream habitat features are stable
	Provide channel substrate that enhances habitat; design channel to manage flow velocity that is consistent with substrate types (Goal 4)	
	Reduce silting, sedimentation, and scouring by meeting minimum and maximum average flow velocity standards	

Table 4.1-1. **Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek (continued).**

Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 3: The channels would accommodate peak flows up to the 100-year flow; no net 100-year floodplain storage lost		
Accommodate the 100-year peak flow	Do not confine or constrict 100-year flood flows in the new channel; flows in excess of the channel design will freely overflow the channel into the flood plain	The 100-year flood stage outside the project area is not changed by more than 0.1 ft
Allow no net 100-year floodplain storage loss in the project area	Mitigate 100-year floodplain storage by providing lost storage compensation	The 100-year flood stage outside the project area is not changed by more than 0.1 ft
Limit channel scouring for the 100-year flow	Channel velocity cannot exceed the gravel movement velocity for the 100-year flow (Goal 4)	Channel substrate present; no bare scoured channel sections in excess of 25 ft
Miller Creek Goal 4: Minimum channel flow velocity should minimize fine sediment deposition		
Minimize sedimentation with minimum flow velocity	Adjust channel slope, by channel segment, to provide minimum dry season base flow velocity that is greater than the silt transport velocity (0.7 ft/sec)	Minimal sedimentation in riffles, runs or gravel substrate
	Adjust channel bottom width to achieve minimum velocity criteria	
Minimize channel scouring with a maximum design flow velocity	Channel flow velocity cannot exceed the gravel movement velocity (4 ft/sec) for the 100-year flow	Channel substrate present; no bare scoured channel bottom sections in excess of 25 ft
	Increase channel capacity above 0.5 ft depth (up to 2 ft depth) to reduce peak flow channel velocity	
Divert high flows around channel Segment A	Construct a stream diversion structure to reduce flows in channel Segment A to peak annual flow rate (40 cfs) for the 100-year peak flow	Peak flow less than 40 cfs in Segment A during the 100-year peak flow
Miller Creek Goal 5: The channels would replace or enhance riparian habitat		
Provide riparian habitat	Provide a minimum 25-ft buffer on the airport side (east) of the channel from the edge of the proposed channel	Buffers contain minimum densities of 200 trees per acre and 300 shrubs per acre. Eighty percent of trees and shrubs are native species
	Provide a minimum 50-ft buffer on the west side of the channel that accommodates public access (Goal 7)	

Table 4.1-1. **Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek (continued).**

Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 6: The channels would not include expansive, long-standing water pools or wetlands that could potentially attract wildlife		
Provide surface drainage for depressions and pools in the replacement channel floodplain	Provide positive floodplain drainage to reduce persistent standing water	No permanent or persistent floodplain or riparian pools develop that support waterfowl habitat
Prevent long-term standing water in the Miller Creek floodplain	Provide positive floodplain drainage to reduce persistent standing water	
Miller Creek Goal 7: The proposed Miller Creek corridor should accommodate passive recreational uses, such as walking trails		
Provide for passive recreation and public access to the new channel	Provide a channel buffer that allows for pedestrian trail construction	A minimum buffer width is provided to allow for trail construction

Note: Data compiled by Parametrix

Table 4.1-2. Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek drainage channel.

Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Drainage Channel Goal 1: The tributaries would continue to provide adequate flow conveyance functions		
Provide drainage flow capacity	Provide channel capacity for the 100-year, 24-hour design storm	Maximum flow depth 2 ft in proposed channel
	Provide adequate capacity and channel slope to minimize erosion during the design storm	Maximum channel velocity 6 ft per second
Collect runway surface drainage and convey to Miller Creek	Collect runway surface drainage at the existing and proposed discharge points	Flow patterns and drainage from the proposed airport improvements are not significantly different from existing drainage discharge points
Miller Creek Drainage Channel Goal 2: The tributaries would collect seepage to maintain base flows		
Collect existing seeps from slope for maintaining base flow in Miller Creek	Collect existing slope seepage near the source in subsurface drainage systems	More than 50% of the existing observed seepage is discharged into or collected by the proposed channel
Collect drainage and seepage from the base of the proposed fill slope	Collect seepage at the base of the fill on the uphill (east) side of the proposed perimeter road	More than 50% of the existing observed seepage is discharged into or collected by the proposed channel
Miller Creek Drainage Goal 3: The new tributary would provide an open channel of equivalent length as the existing channel		
Construct new channels with equivalent length, substrate, and streamside vegetation	Construct new channels with equivalent channel lengths: 2,556 ft for Channels A and B, 300 ft for Channel C	New channels that provide conveyance with well-established vegetation and limited scouring, erosion, or bank failures.
	Minimum channel slope 1%; channel side slopes 4:1 or flatter	
	Stream banks and side slopes replanted with a native mix of plants for riparian habitat	
	Channel substrate a mix of sands and gravels; channel velocity below substrate erosion velocity	
	If steep channel slope is required, protect from downcutting with log weirs	

Note: Data compiled by Parametrix

5. PROPOSED MITIGATION SITE

5.1 SITE DESCRIPTION

The proposed Miller Creek channel would be constructed near the bottom of a broad, flat valley located south of Lora Lake. The existing 1,080-ft-long main channel of Miller Creek would be displaced approximately 200 ft to the west (Figure 5.1-1).

The Miller Creek associated drainage channels would be mitigated in the proposed new parallel runway embankment construction areas. The drainage channels would be re-constructed as one channel, adjacent to the proposed airport perimeter access road (Figure 5.1-2). The road is in a restricted access area, and a vegetated filter strip buffer would protect the proposed channel from road runoff.

5.2 OWNERSHIP

The land for the stream relocation would be purchased by the Port as part of the larger property acquisition program for the proposed Master Plan Update improvements. It would be designated in airport planning documents as a sensitive area to be protected in perpetuity, with the exception of possible future bridge crossings.

5.3 RATIONALE FOR CHOICE

The mitigation site was chosen because it is relatively close to the edge of the parallel runway embankment, therefore, requires the shortest stream relocation length. Also, extremely flat site conditions dictate that the proposed channel be as short as possible to provide the maximum possible channel slope. The proposed realigned creek would be located as close to the base of the proposed fill slope of the new parallel runway as possible. The downstream end of the channel would connect with the existing Miller Creek channel at the earliest possible point to minimize stream relocation impacts. The channel edge would be a minimum of 25 ft from the base of the slope, to accommodate a riparian buffer. However, because of the limited space between Lora Lake and the proposed embankment, narrower buffers might be required in this area. To compensate for the restrictive high flow area, flows in excess of channel capacity are planned to be diverted from the main channel of Miller Creek into Lora Lake and then reintroduced at the lake outlet channel.

The drainage channel mitigation site was selected as the only appropriate option for recreating the equivalent drainage length for the filled drainage channels. The existing channels could not be left undisturbed or reconstructed on the fill slope because of airport operation and fill stability requirements.

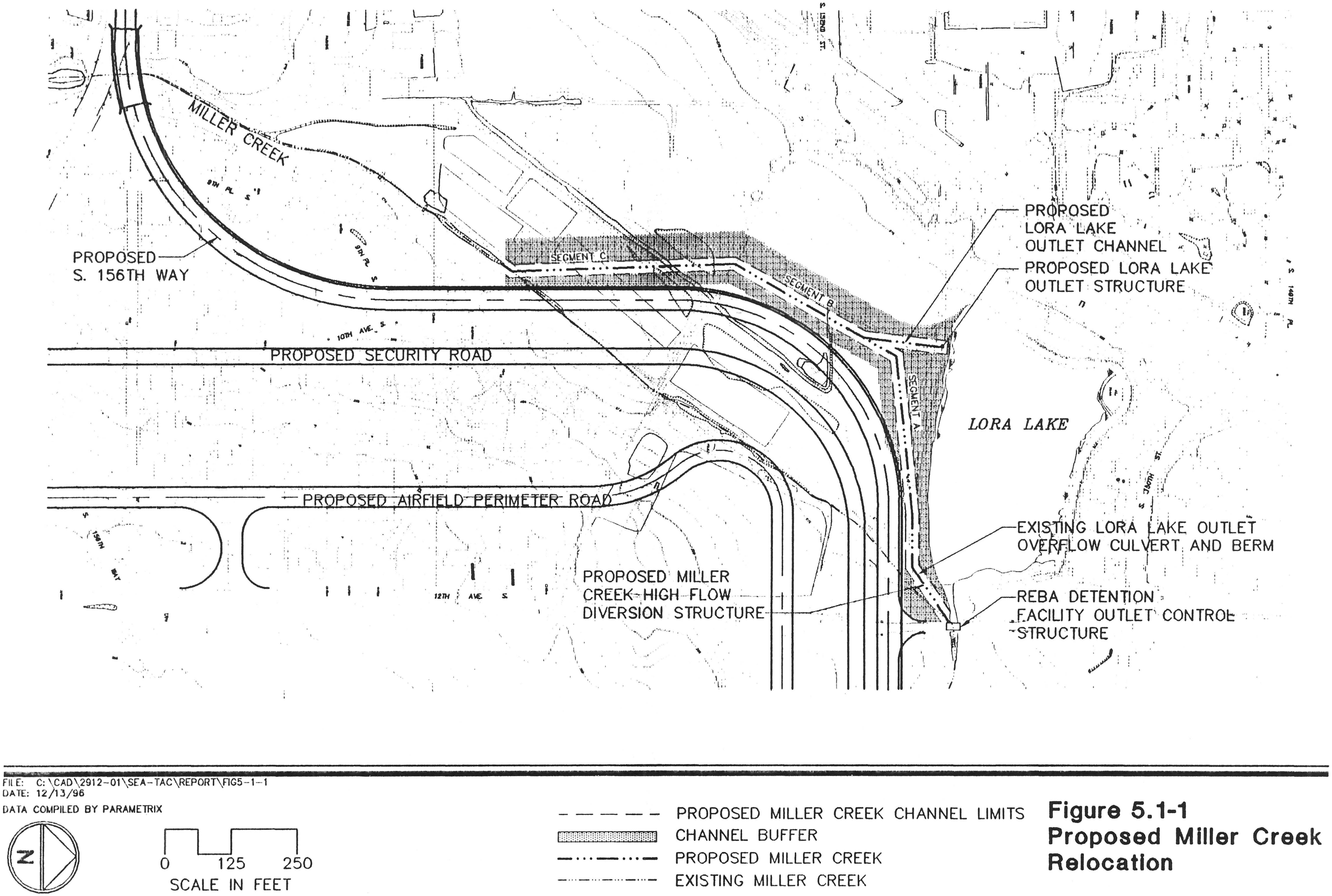
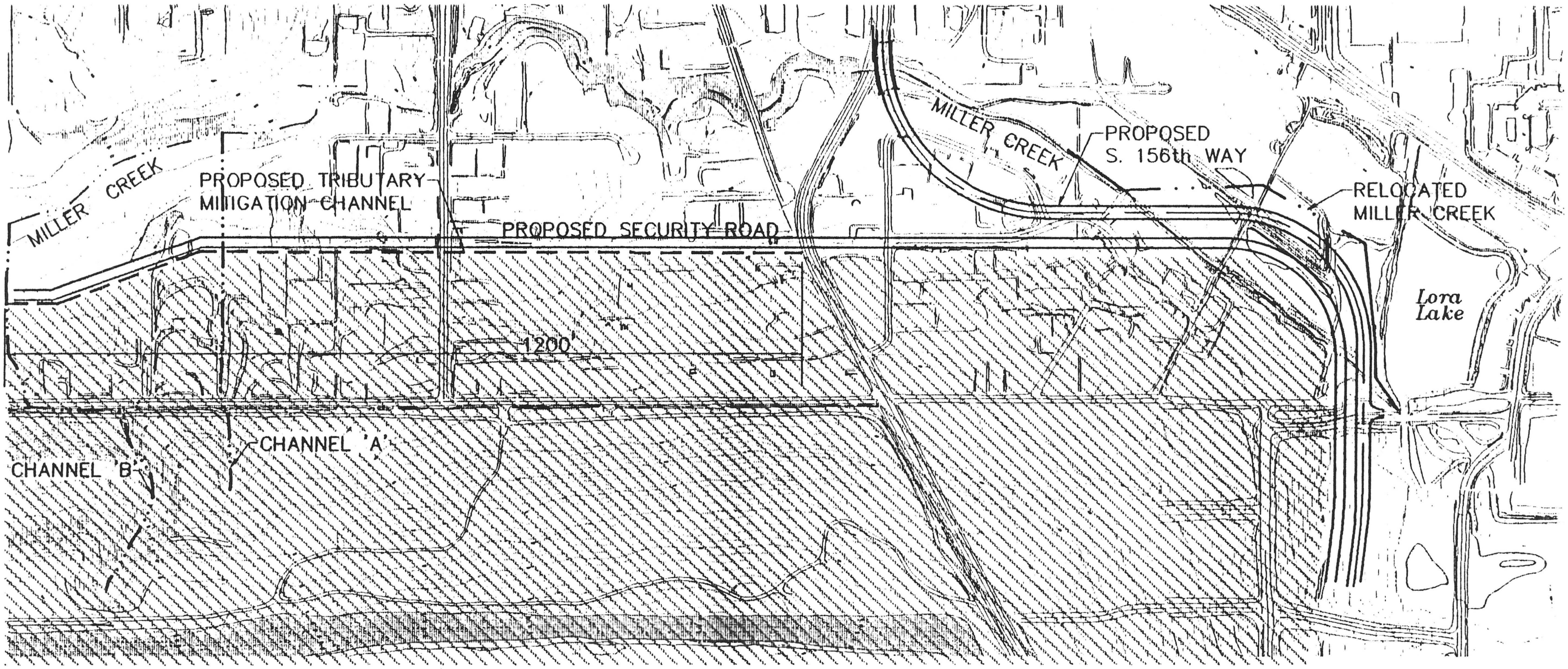


Figure 5.1-1 Proposed Miller Creek Relocation



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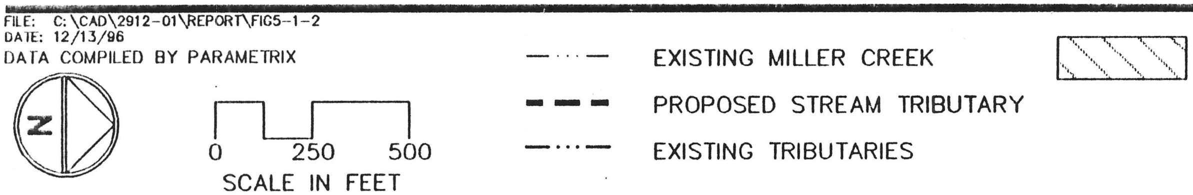


Figure 5.1-2
Area 2 Drainage Channel Mitigation

5.4 CONSTRAINTS

There are no apparent constraints outside of the Port's control that could affect the success of the stream relocation. There are no existing plans to change the Reba Detention Facility operation procedure, however, if a different control structure procedure were implemented, it would not affect the mitigation design because stream hydrology, specifically base flow and normal seasonal flow, would not be significantly modified.

The proposed drainage channels would be constructed to collect drainage from portions of the proposed and existing runways. They would also collect groundwater, which currently surfaces on the west side of the existing runway fill. The groundwater would be collected through an internal drainage system in the new fill. Additional groundwater would be collected at the toe of the proposed fill–the point where uncollected seep water is expected to surface. It may not be possible to collect all the seepage but enough should be collected to maintain the base flow of the drainage channels.

6. MITIGATION SITE PLAN

The description of the mitigation site plan is divided into two main sections: Miller Creek and Miller Creek drainage channels.

6.1 SITE GRADING

The proposed channels would be excavated and constructed as shown previously in Figures 5.1-1 and 5.1-2. Regrading is also necessary to provide floodplain mitigation. Approximately 9,630 yd^3 of floodplain storage would be lost in the proposed fill area. Approximately 10,000 yd^3 of floodplain storage and floodway conveyance would be created, not including storage for the proposed stream channel (Figure 6.1-1). Although no additional site grading is proposed, some additional grading may be required to ensure a positive drainage flow to the new channel and prevent long periods of standing water in the floodplain.

6.2 PROJECT HYDROLOGY

The hydrologic design criteria for the Miller Creek mitigation plan are listed in Table 6.2-1. KCSWM has monitored flow rates at the outlet of the Reba Detention Facility since 1988 (KCSWM 1994). Although the period of record is short, the flow data provide a good record of "normal" base flows, seasonal peak flows, and average flows by season. Design criteria for base flow and annual peak flow conditions were established from these data (see Table 6.2-1). Statistical analysis of the flow monitoring data was not conducted.

Table 6.2-1. Estimated flow rates for channel design.

Flow Regime	Flow Rate (cfs)
Dry season base flow	0.5
Wet season base flow	5
"Normal" storm flow	10
Annual peak flow	40
2-year peak flow	75
10-year peak flow	125
100-year peak flow	175

Source: Montgomery Water Group (1995);
additional data compiled by Parametrix

In addition to monitored flow rate data, a detailed hydrologic modeling study was prepared (Montgomery Water Group 1995) that calculated peak flow rates for flood frequencies up to the

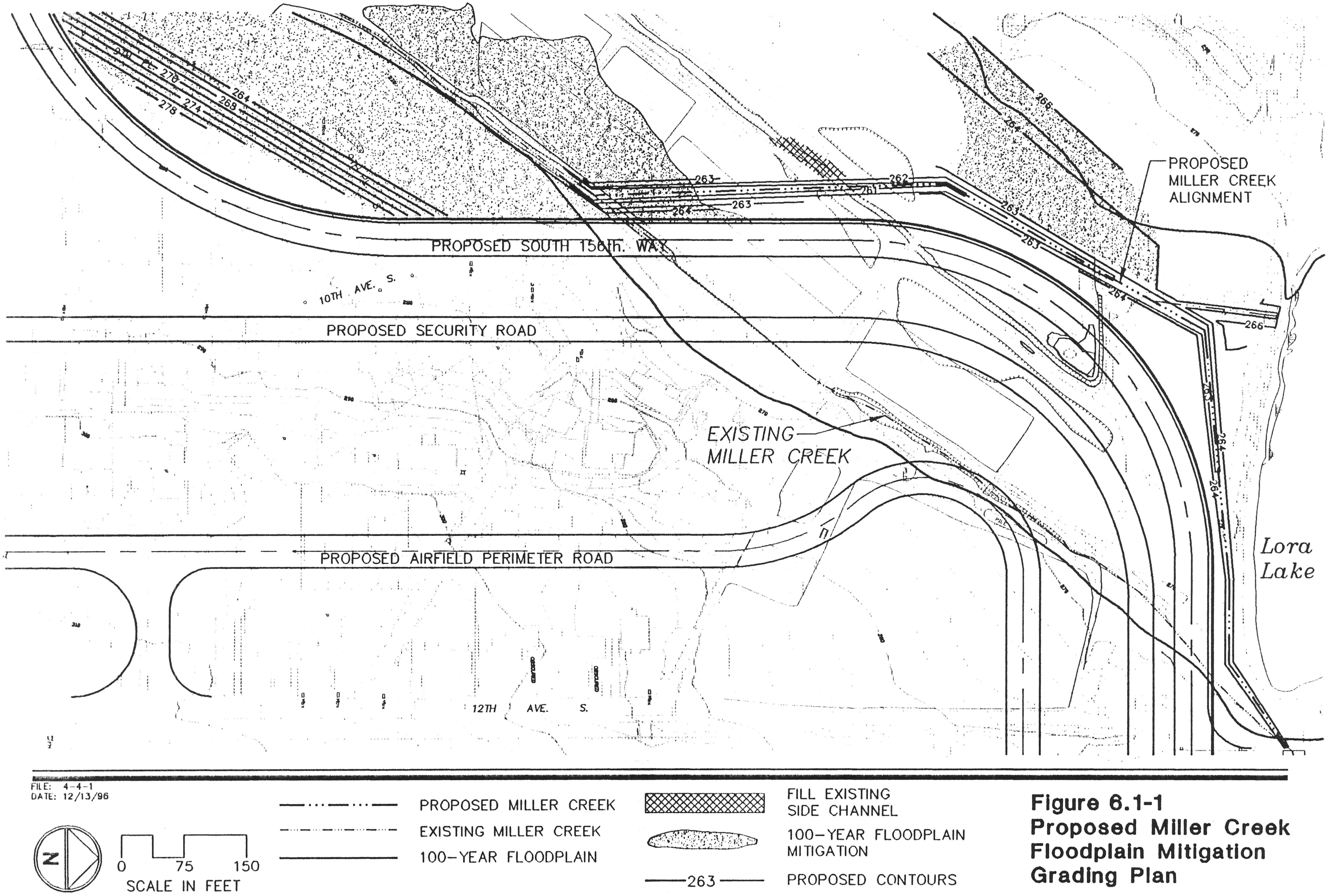


Figure 6.1-1
Proposed Miller Creek Floodplain Mitigation Grading Plan

100-year flood (see Table 2.4-2). The flood return frequencies were calculated assuming that the Reba Detention Facility detention system and control structure are in place. The calculated flow rates appear to be consistent with the flow monitoring data. The peak monitored flow rate (225 cfs) on November 24, 1990, was in excess of the predicted 100-year flood flow (approximately the 500-year flood flow). The control structure was constructed after the 1990 storm; it is likely that the peak flow rate of November 1990 would have been reduced by the detention system. Because storm water runoff would be mitigated in separate storm water management facilities, this plan does not provide for increased flows.

6.3 CREEK HYDRAULICS

Creek hydraulics are the existing or proposed physical conditions that influence the direction, depth, and flow velocity in the proposed relocated creek. Several factors influence hydraulics including: flow rates, channel slope, channel cross section, channel roughness, and flow depth. While several of these features would be designed, factors such as flow rate or average channel slope cannot generally be modified. The following sections describe the design parameters that apply to all channel segments, the design process used, and the proposed channel configuration for each segment. Channel substrate design is included in Section 6.5.2.

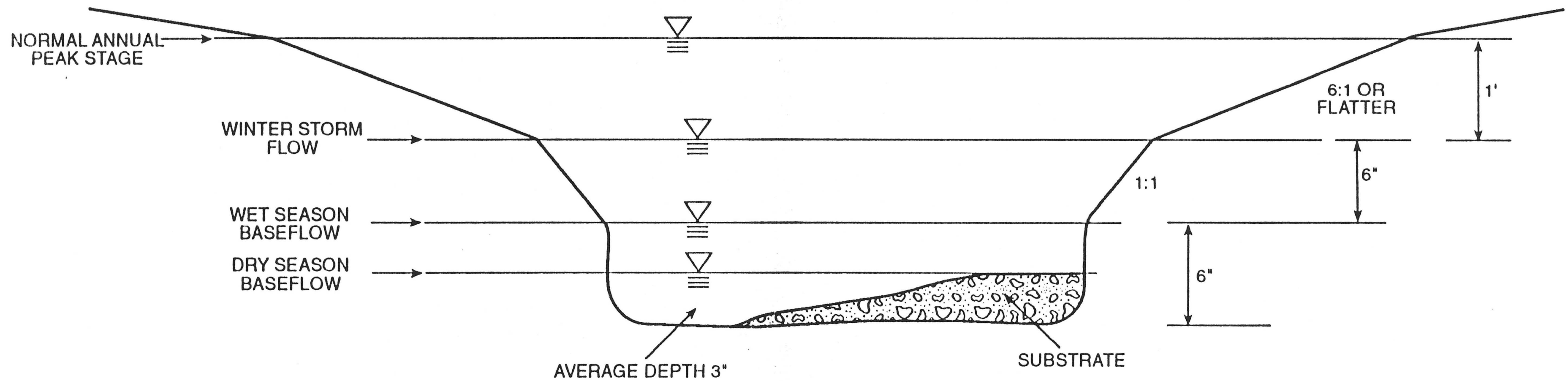
6.3.1 Channel Alignment

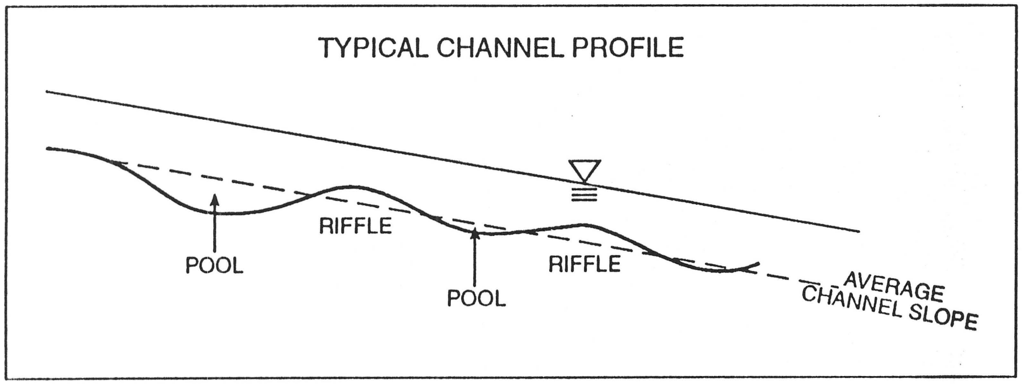
The proposed channel cross section is shown centered on the proposed alignment (see Figure 5.1-1). The channel would be constructed to meander within the limits of the stream corridor. The amount of meandering would be somewhat limited by the need to maintain a minimum channel slope to meet flow velocity goals.

6.3.2 Channel Roughness and Side Slopes

Channel roughness, a factor in determining channel capacity is described by using Manning's roughness factor, n. The assumed Manning's channel roughness for the relocated stream is 0.035; this corresponds to a natural channel with a gravel or stony bottom and limited instream vegetation.

The bottom 6 inches of the channel side slopes would be vertical (Figure 6.3-1). From 6 inches to 1 ft, channel side slopes would continue at 1:1 slopes, primarily to enhance stability, provide additional capacity, and simplify construction. From 1 to 2 ft, the side slope would be 6:1 or flatter, depending on channel capacity requirements and channel planting and buffer requirements. Above 2 ft of depth, natural grades would be used; however, if natural slopes are too flat, slope or drainage alterations would be considered to prevent ponding.





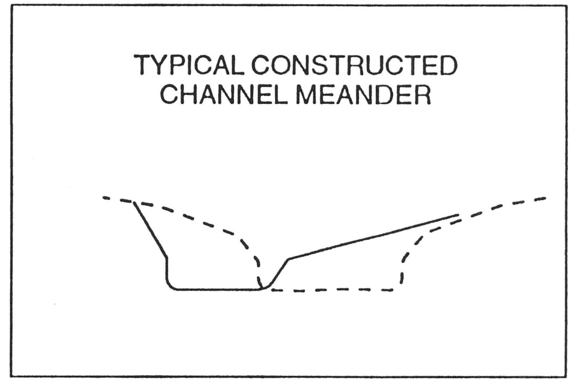


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Figure 6.3-1
Proposed Miller Creek Stream Channel

6.3.3 Channel Slope

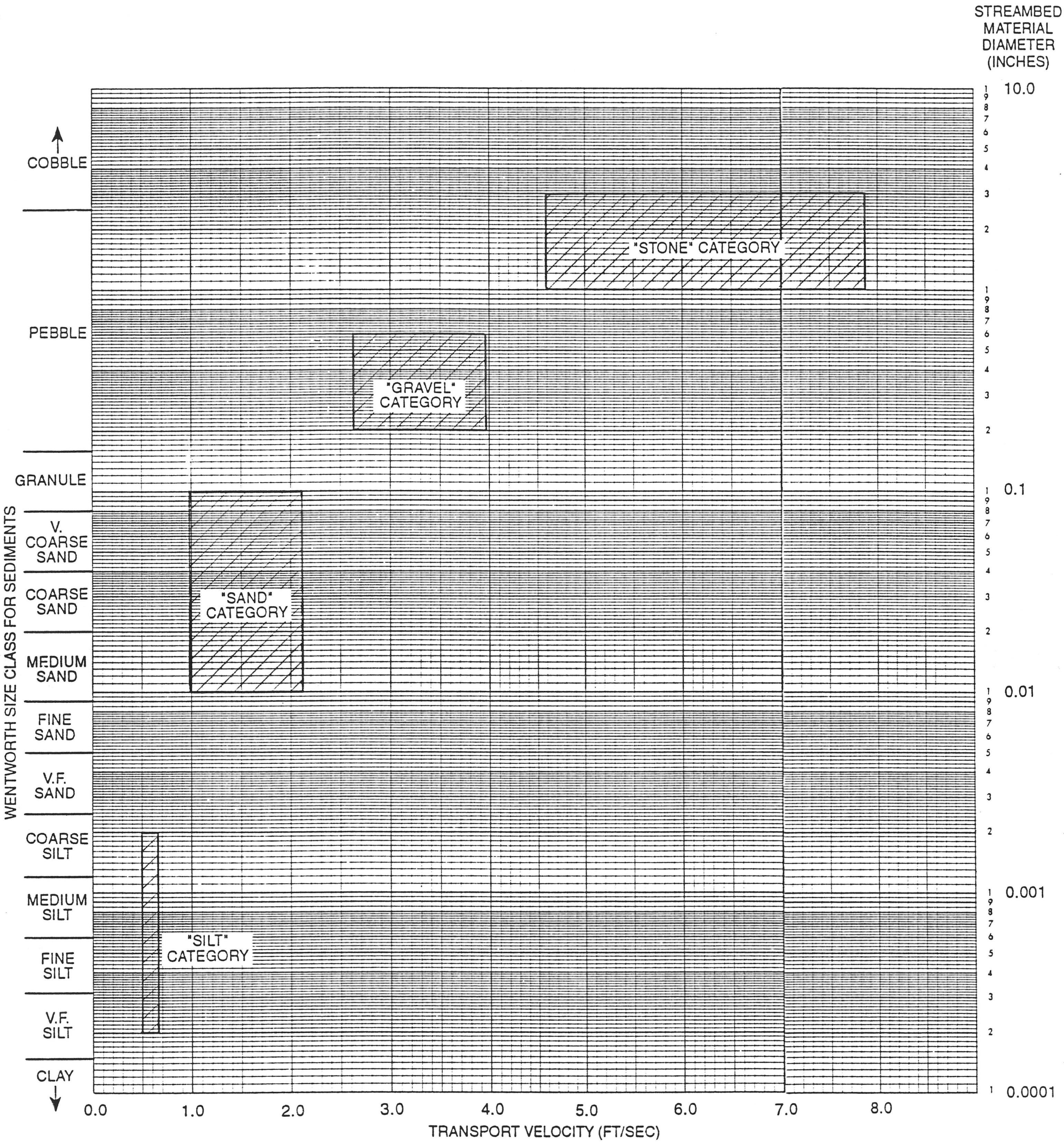
Average channel slope is determined by the physical constraints of the site. The bottom elevation at the upstream end of the proposed channel (at the control structure outlet of the Reba Detention Facility) is approximately elevation 264.0 ft. The approximate elevation at the point where the relocated creek rejoins the existing channel is 260.0 ft. With a proposed channel length of approximately 1,080 ft, the average channel slope is 0.37 percent. However, natural land slope along the proposed stream channel does not drop continuously. The proposed alignment's existing grade is approximately level at the start, then gradually slopes as the alignment turns south. The alignment moves through a shallow depression, then begins to rise slightly before rejoining the existing stream. To work with existing topography, the channel was divided into three segments (A, B, and C; see Figure 5.1-1) to determine how the slopes must vary through the proposed alignment.

Flow velocity that meets the proposed design goals is primarily a function of channel slope. Because the site offers little slope to increase flow velocity, compromises must be made for providing flows that minimize sedimentation. Slopes in segments A and B (0.3 percent and 0.4 percent, respectively) were designed to limit sand deposition at base flow, while Segment C (0.2 percent slope) was designed to prevent silt deposition at base flows. A more complete discussion of flow velocity is included in the following section.

6.3.4 Flow Velocity

Channel flow velocity is the primary variable influencing channel design. The goal is to minimize fine-grained (silt and finer) material sedimentation in all proposed channel segments during normal dry season base flows. If possible, sand deposition should also be limited. Conversely, the flow velocity at peak design flows must not exceed rates that would erode the channel and scour loose sediment and substrate larger than small gravel. With a minimum flow depth of 0.25 ft at the base flow rate, and with channel roughness and side slopes fixed, channel velocity is a function of channel bottom width and slope. Figure 6.3-2 shows the relationship between flow velocity and sediment transport velocity. If the flow velocity equals or exceeds that shown for each grain size, the sediment can be expected to move until the velocity decreases.

Channel design is a process whereby variables are adjusted until all of the design parameters are met. Initial channel slope was estimated using the available drop for Segment A. The corresponding channel bottom width was determined and adjusted until the minimum flow depth (0.25 ft) was achieved. The slope was then adjusted until the base flow velocity was strong enough to move sediments smaller than sand. Using the adjusted slope, the channel was then checked for peak flow rate velocity (in connection with maximum depths and channel configurations described in the following sections). Channel widths and flow depth were adjusted until flow velocity was less than the transport velocity for gravel. These steps were used in each alignment section.



Source: B.C. Fisheries, 1980

Figure 6.3-2
Sediment Transport Velocity vs. Sediment Diameter

6.3.5 Channel Bottom Width

The channel bottom width, within the narrow range of possible channel slopes and using the fixed side slope and roughness values, is controlled primarily by the minimum flow depth. Dry season base flow depth must average at least 0.25 ft to provide minimum depth for fish movement. To determine the channel bottom width, the base flow rate, slope, roughness, and side slopes were fixed, and the bottom width was adjusted until the flow depth was at least 0.25 ft. The results were checked to ensure that no other design criteria were changed to exceed design parameters. Results indicate that a channel bottom width, ranging from 4 to 10 ft, meet design criteria.

6.3.6 Channel Flow Depth

Several design channel flow depths are available, depending on the flow rate and the design intent. Three flow depth standards have been determined: (1) dry season base flow depth of 0.25 ft; (2) wet season base flow depth of 1 ft; (3) annual maximum flow rate depth of 2 ft. Flows greater than the annual maximum flow rate (40 cfs) will overflow into the floodplain. Figure 6.3-3 shows the approximate extent of the mean annual storm floodplain.

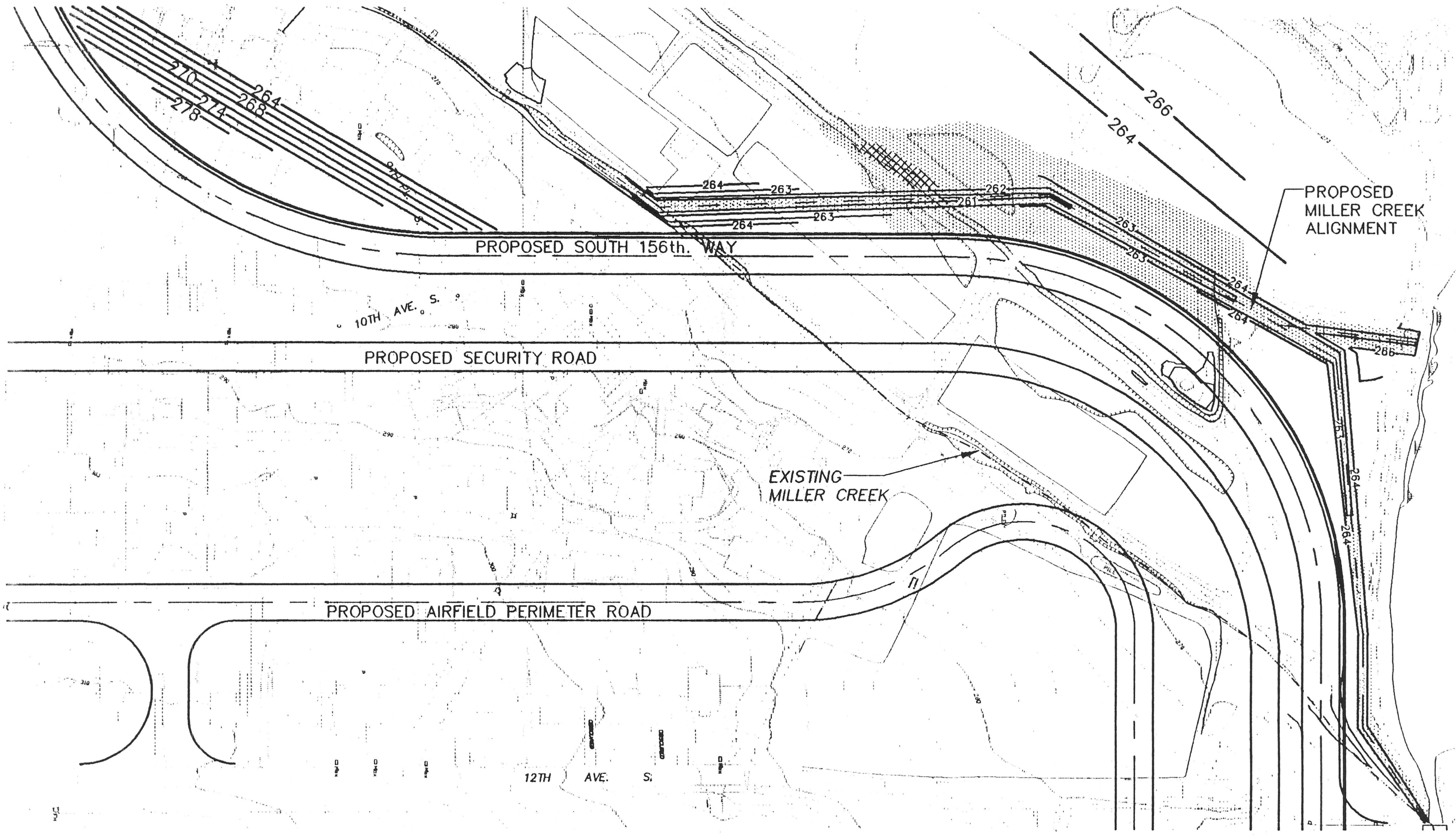
6.3.7 Maximum Design Channel Flow

Segment A, located between Lora Lake and the proposed fill, is somewhat narrower than Segments B and C. As a result, limited area is available for constructing a large channel that can convey the 100-year storm, while maintaining a minimum flow depth for dry season base flows. This mitigation plan proposes a high-flow diversion structure near the beginning of the proposed channel relocation, to divert flows in excess of the channel capacity (the 2-year storm) through Lora Lake. The lake acts as a bypass channel that buffers peak flows and releases water at a reduced rate to other segments that have adequate capacity. The proposed control structure design is shown on Figure 6.3-4.

6.3.8 Lora Lake Outlet Channel and Structure

Runoff flowing into Lora Lake overflows into Miller Creek through a 12-inch concrete culvert located in a berm that forms the south shore of the lake (see Figure 5.1-1). When inflow exceeds the lake storage and outlet pipe capacity, water flows over a low spot in the berm. In extreme conditions, it is likely that the lake becomes part of the Miller Creek floodplain and completely overwhelms the south shore berm.

The proposed Lora Lake outlet channel and structure is designed to release base flows in a manner approximating the existing outlet structure. The proposed structure has a controlled overflow feature that maximizes lake storage without adversely affecting lake stages or inflows. A 12-inch low-flow orifice and 10-ft overflow weir would be constructed. The elevations of the



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SCALE IN FEET

—·—·— PROPOSED MILLER CREEK

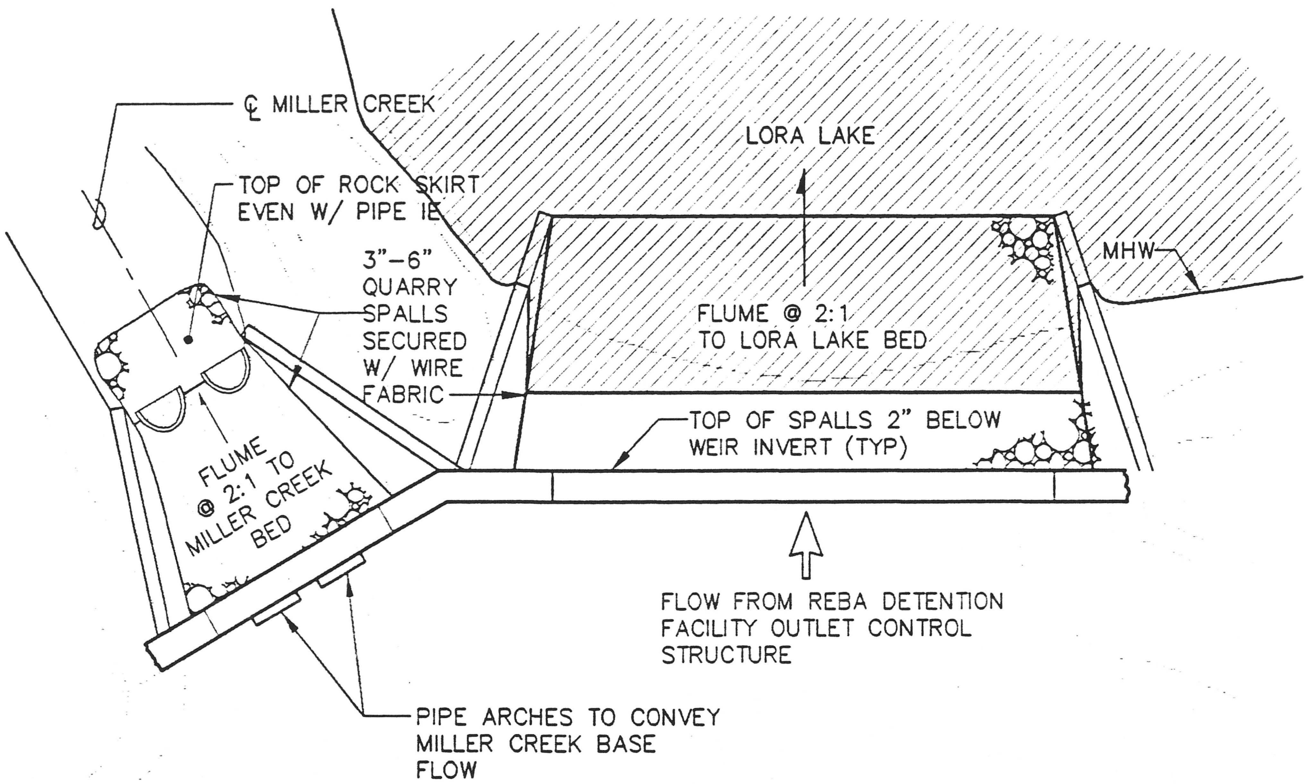
—··—··— EXISTING MILLER CREEK

FILL EXISTING SIDE CHANNEL

APPROXIMATE SEASONAL FLOODPLAIN

——263—— PROPOSED CONTOURS

Figure 6.3-3
Proposed Miller Creek Annual Peak Flow Floodplain



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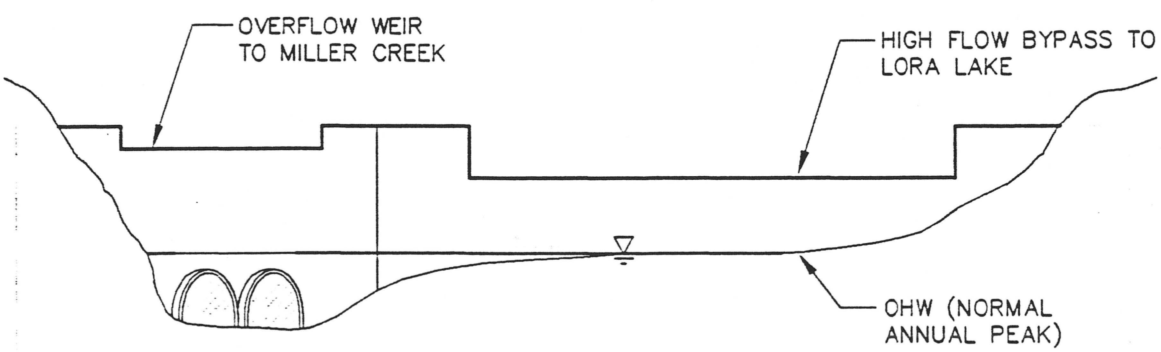

ELEVATION

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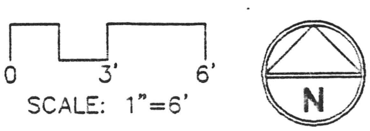


Figure 6.3-4
Miller Creek
High Flow Bypass

existing pipe and overflow basin would be used for the proposed outlet. The overflow weir would have a broad-crested overflow, approximately 5 ft wide, with erosion control such as rock and wire mesh. The existing Lora Lake outlet channel has similar design slopes to Segment A, and potentially provides stream habitat.

6.4 MILLER CREEK DRAINAGE CHANNELS

Three drainage channels associated with Miller Creek in Areas 2 and 3 would be affected by the proposed airport improvement. The three drainage channels, primarily fed by rainfall, but supplemented by groundwater seepage, flow intermittently from culverts at the airport and from seeps (no flow monitoring data are available). The proposed channel design is based on hydrologic model calculations. Portions of all three channels have been partially modified at road crossings, and Drainage Channel B has been channelized for approximately 300 ft in a roadside ditch. The primary goals of drainage channel mitigation are to provide equivalent open channel lengths, peak storm conveyance, and groundwater seepage (base flows).

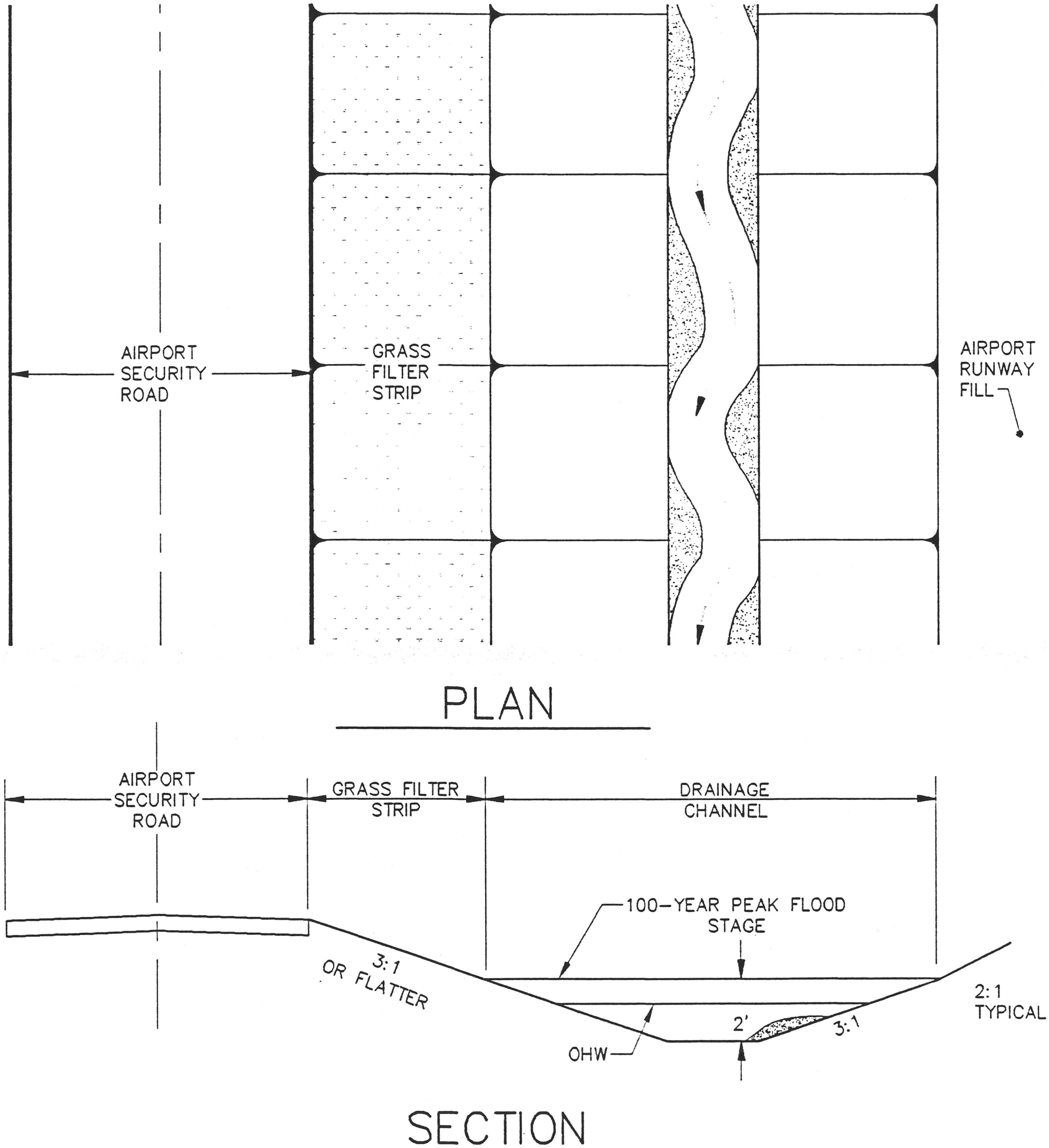
The Miller Creek drainage channel mitigation plan has three requirements: to provide adequate capacity to handle the design flow (100-year storm), provide an equivalent length of open flow channel, and maintain base flows by capturing seepage from the proposed fill slope. Mitigation for all three drainage channels would share the same design goals. The proposed mitigation channel for Drainage Channel B is shown in Figures 5.1-2 and 6.4-1.

6.4.1 Channel Configuration

The mitigation drainage channels would be constructed on the east side of the proposed airport security road. The bottom channel width may vary, but a minimum 2-ft bottom would convey the peak design flow, assuming a 1 percent slope. The proposed channel would be incorporated into the fill slope; therefore, final design parameters, such as peak flow rates and channel slope, would be used to adjust the channel configuration. Minor modifications to the preliminary design would not significantly alter the proposed mitigation channels. A vegetated filter strip would separate the security road from the mitigation channel.

6.4.2 Channel Length

Equivalent channel length would be provided for each of the disturbed drainage channels. Approximately 1,090 ft of Channel A and 1,460 ft of Channel B would be impacted. The proposed mitigation would replace the channels' primary function, which is to provide drainage. Approximately 2,550 ft of drainage channel would be constructed adjacent to the proposed security road. Seepage and drainage from the proposed fill slope would be collected and conveyed in the proposed channel. A separate 300-ft drainage channel would be constructed to mitigate Channel C impacts.



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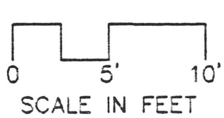


Figure 6.4-1
Typical Drainage Channel Section

6.4.3 Channel Size and Slope

The proposed channel would be designed to convey the 100-year peak flow rate. While maximum flow depth would be determined by road design considerations, it would be less than 2 ft deep. Minimum slope would be 1 percent.

6.4.4 Discharge Point

Both mitigation channels would discharge into the existing channel at the edge of the proposed fill slope. The existing channel below the Channel A mitigation would be modified to accommodate flow that may be expected from the new channel. Modifications include installing logs weirs, large woody debris, natural stream bank stabilization (live stakes, branch packs), and new channel substrate. These modifications would ensure that the new mitigation channel would not cause erosion impacts in the receiving channel prior to discharging into Miller Creek.

6.4.5 Channel Cross Section

The proposed channel cross section would have side slopes at a maximum slope of 4:1. The bottom width, to be determined in final design, would be controlled by the design depth and slope. Flow control would use check dams, log weirs, or channel widening to prevent erosion, sedimentation, scouring and downstream deposition impacts. The structures would be built to control flow and not to provide habitat.

6.4.6 Channel Vegetation

The side slopes and buffers would be planted with native vegetation to provide shade and nutrient loading to the channel. Section 6.5.1.4 includes a discussion of appropriate plant species.

6.4.7 Groundwater Seepage and Hydrology

Hydrology would be maintained by constructing a subsurface drainage system to collect the seepage from the hillside that is currently surfacing to form the existing channels. The system would consist of a field of perforated pipes packed with highly porous sand or gravel. Seepage would be collected, conveyed, and discharged to the edge of the new fill slope at the head of the proposed channels.

6.5 HABITAT

6.5.1 Instream Habitat

The instream habitat criteria used in the relocated channel design are based on general habitat requirements of salmonids. The purpose of using these criteria is to provide the highest quality habitat and environmental conditions for fish. Compared to most resident fish species, salmonids are typically very sensitive to environmental conditions such as habitat and water quality. Salmonid prey, such as aquatic insects, tend to have similar requirements. Therefore, designing the relocated stream to meet the needs of these sensitive species would help ensure that the best possible fish habitat is created. Although anadromous salmonids are currently restricted from the proposed impact areas, resident cutthroat trout are present.

In general, salmonids require cool, well-oxygenated water, spawning gravel that is free of accumulated silt, and abundant instream cover for habitat. In addition, because habitat requirements vary as life stages change, habitat complexity within the stream is also necessary. General physical habitat requirements include access to habitat, stable flows, appropriate stream substrate, and riparian and instream cover.

6.5.1.1 Habitat Access

The various habitat areas should be accessible to resident fish populations under all flow conditions. Accessible habitat should include protected areas (i.e., low-velocity pockets) during high flows and avoid features that could cause stranding problems during low-flow conditions. Adequate fish access throughout the entire relocated stream section would be provided by the minimum design depth requirements. The channel is designed to provide an average minimum depth of 0.25 ft during dry season base flows. This minimum depth requirement should allow fish access to habitat throughout the length of the channel, thus limiting stranding problems during low-flow periods.

6.5.1.2 Stable Flows

Stable flows ensure habitat access and protect the habitat against erosion or scouring; they also minimize the displacement of fish to less preferred habitats. The flow velocity criteria for the channel were set to minimize both the accumulation of fine-grained material in the channel during low-flow periods and excessive scouring of substrate materials during high flows. However, since these flow velocities are an average over the entire channel (similar to the depth criteria), sedimentation is expected to occur on the inside of bends and in deeper pools during low-flow periods. These sediments do, however, flush out again with higher flows. The channel width and bank slopes criteria have also been incorporated in the design to maintain relatively stable flow velocities throughout typical flow variations. In addition, a high-flow diversion structure has been included for Segment A to minimize erosion and fish displacement during unusually high flow periods.

6.5.1.3 Stream Substrate

Cutthroat trout require a stable gravel and sand substrate that is essentially free of accumulated silt for spawning and early rearing life stages. This substrate also contributes to the optimum production of desired prey. Substrate in the relocated channel would consist of gravel, coarse sands, and cobble material to provide stable spawning and rearing habitat. However, portions of the channel would naturally become sandier over time.

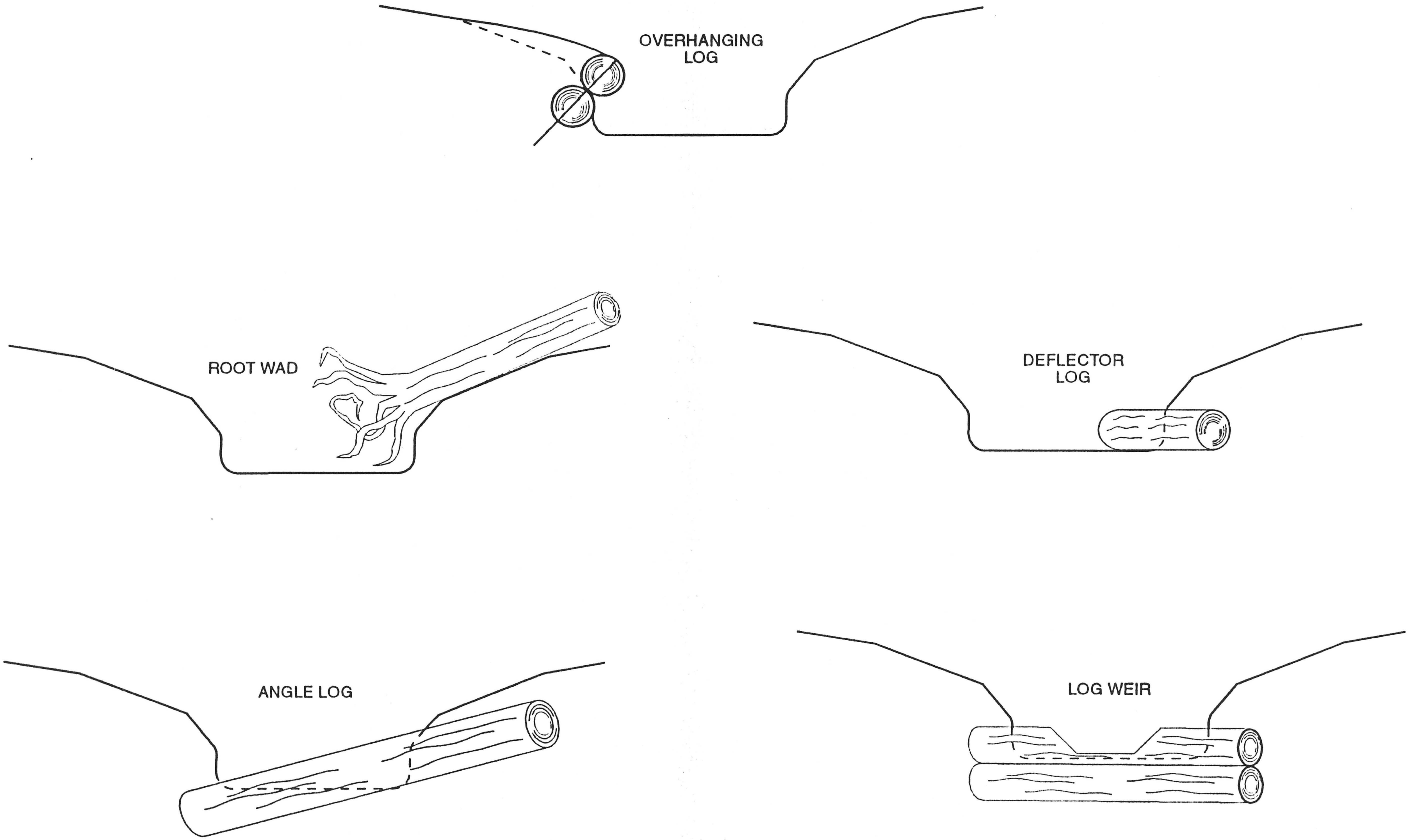
6.5.1.4 Riparian and Instream Cover

Salmonids require cover provided by such features as undercut banks, logs, boulders, deep pools, and overhanging riparian vegetation for feeding, hiding, and resting. In addition, these features help to stabilize stream banks and substrate during high-flow periods. The relocated channel, which is designed with vertical banks in the low-flow depth range, would encourage minor undercutting to provide cover habitat during low-flow periods. Large woody debris (deflector logs, angle logs, and root wads), as well as boulders would be used to stabilize the substrate, protect the upper banks from excessive erosion, and provide hiding and holding habitat for fish during higher flow periods (Figure 6.5-1).

Riparian vegetation would be used to maximize stream shade and provide overhanging cover as habitat. This type of vegetation deposits organic debris (leaves, branches, etc.) into the stream to provide a food source for aquatic insects; it also provides a mechanism for terrestrial insects to enter the stream, thereby providing valuable food sources for fish. Riparian and buffer areas would be planted with species that provide rapid development of woody plant cover to shade the stream and function as a riparian buffer, while minimizing the potential for attracting wildlife. Plants suitable for stream riparian areas are listed in Table 6.5-1. Suitable plants include red-osier dogwood, Pacific willow, and salmonberry shrubs.

Riparian buffer plantings would have a tree density of about 250 stems per acre, and a shrub density of about 400 stems per acre. Buffers would extend 25 ft from the east side of the creek and 50 ft from the west side of the creek.

Several strategies could be used to ensure rapid development of shade along the relocated stream. The landscape design concentrates plantings on the stream bank to ensure partial shading of the stream immediately following planting. Streamside plantings of fast-growing willow and red-osier dogwood should provide substantial shade within 3 years.



Data Compiled by Parametrix

Figure 6.5-1
Representative Fish Habitat Enhancement Features

Table 6.5-1. Suggested plants for riparian fringe relocation.

Scientific Name	Common Name	Streamside Zone	Upland Buffer Zone
Trees			
Acer circinatum	Vine maple	X	X
Alnus rubra	Red alder	X	X
Corylus cornuta	Western hazelnut		X
Fraxinus latifolia	Oregon ash	X	
Rhamnus purshiana	Cascara		X
Salix scoulerana	Scouler willow	X	
Shrubs			
Cornus stolonifera	Red-osier dogwood	X	
Gaultheria shallon	Salal		X
Physocarpus capitatus	Pacific ninebark	X	X
Rosa woodsii	Wood's rose		X
Salix sitchensis	Sitka willow	X	
Salix lasiandra	Pacific willow	X	
Salix hookeriana	Hooker willow	X	
Spiraea douglasii	Hardhack spirea	X	

Note: Data compiled by Parametrix

Upland buffers would include a variety of plant species, such as red alder, cascara, hazelnut, rose, and salal. Plants were selected that would be unlikely to attract large populations of birds (due to aircraft flight safety concerns). The planting design discourages human intrusion into the buffer by using thorn-bearing plants and/or split-post fencing. Exposed areas between plantings in the upland buffer would be hydroseeded with an upland grass mixture.

6.5.2 Channel Substrate

Erosion and movement of streambed sediments need to be considered when designing stream habitat features. As discharge increases in a stream channel, not only does the water level rise, but the streambed may be scoured. In general, smaller diameter particles tend to be transported at lower stream velocities relative to larger particles. The substrate criteria used in the relocated channel design are based on the general characteristics that encourage salmonid production. These criteria provide suitable spawning gravel, while minimizing the risks of scouring and transporting this material downstream during high flows.

The minimum transport velocities for various sizes of streambed particles were summarized previously in Figure 6.3-2. This figure was developed from data contained in the British Columbia Department of Fisheries and Oceans' *Stream Enhancement Guide* (Fisheries and Oceans 1980). If the maximum velocity of a specific section of a stream channel is known, an estimate of the size of the bed material that would be relatively stable can be determined. This is particularly important where gravel is being added to modify stream characteristics, such as to improve spawning conditions.

Miller Creek relocation requires a balance between a minimum base flow velocity, to prevent sedimentation, and a maximum peak flow velocity that could scour sediment. Therefore, it is desirable to have base flow velocities sufficient to transport finer-grained particles (such as silt), and peak flow velocities that do not remove coarser-grained particles such as gravel. High flows are required to initiate particle movement, and slightly lower flows have carrying power to keep the particle moving. Using Figure 6.3-2, the channel parameters were adjusted to maintain base flow velocity greater than the silt movement velocity, but less than the gravel movement velocity for peak flow. Gravel recruitment from upstream of the mitigation channel would be limited by the Reba Detention Facility.

6.6 FLOODPLAINS

6.6.1 Floodplain Storage Mitigation

The proposed channel was designed not to impede the 100-year flood; however, flood flows are not expected to be completely contained within the stream banks. One hundred-year flood storage capacity lost by the proposed fill would be approximately 9,630 yd^3. Equivalent effective floodplain storage, as shown previously in Figure 6.1-1, would provide approximately 10,000 yd^3 of floodplain storage mitigation.

6.6.2 Floodplain Conveyance

The 100-year floodplain elevation and floodway delineation in the proposed study area was determined by FEMA when the Flood Insurance Rate Maps (FIRM) were prepared. The proposed channel capacity was checked for the 100-year flow rate peak capacity. Encroachment (fill) is proposed in a portion of the 100-year conveyance area or floodway. No backwater calculations were made to estimate 100-year flood elevation impacts. However, no impacts are expected since the floodplain storage has been mitigated and the 100-year conveyance channel has adequate capacity.

6.7 IMPLEMENTATION SCHEDULE

Construction of the proposed parallel runway, which would affect Miller Creek, is currently scheduled as part of the first phase of the proposed Master Plan Update implementation. The new stream channel must be constructed and fully stabilized before stream flow is diverted from the old channel. Therefore, the stream channel would need to be constructed during the early years of runway construction.

7. MONITORING PLAN

7.1 HYDROLOGY AND HYDRAULICS

The effectiveness of the relocated stream can be measured in several ways, but fish habitat stability is an important gauge. Because erosion and sedimentation are the primary indicators of stream hydraulic conditions, they are the critical criteria to be included in the proposed monitoring plan. The following activities would be included in the stream monitoring plan:

- Inspect the constructed habitat features (log weirs, root wads, etc.) to ensure that they have not been damaged or displaced (to the extent that they are not providing habitat)

- Inspect the substrate to ensure that sedimentation and erosion prevention goals are met

- Inspect for erosion or scouring

- Inspect stream structures and channel after major storms, as monitored by the KCSWM gage

- Inspect for adverse flooding impacts and ponding water

- Inspect diversion and outlet structures for debris accumulation, scouring, and damage

7.1.1 Inspection Schedule

Table 7.1-1 includes the inspection schedule for monitoring the Miller Creek stream relocation and drainage channel enhancement. The schedule includes routine inspections and emergency inspections, in case of a major flood.

KCSWM has a control structure at the outlet of the Reba Detention Facility with an adjustable gate. Under current operating conditions this gate is not adjusted and it is unlikely that operations would be modified to allow more water to discharge from the Reba Detention Facility. However, future needs could allow higher flows under certain conditions. Since the Miller Creek diversion structure would divert most floodwater into Lora Lake, increased flow from the Reba Detention Facility would have only a modest effect on the new stream channel. If the Reba Detention Facility outlet were modified, contingency actions could include simple modifications to the diversion structure at the head of the channel to direct more flow into Lora Lake (for detention purposes) and away from the new Miller Creek channel.

Contingency measures for buffer vegetation include replanting areas if high mortality is observed. If significant plant loss occurs, site conditions would be evaluated to determine whether the conditions can support the species planted.

9. REFERENCES

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