2. Existing Conditions

Introduction

This chapter is a compilation of all relevant conditions related to risk, transportation, land use, and other elements. The baseline Avalanche Hazard Index for Little Cottonwood Canyon is also discussed in detail.

Land Use

Existing Land Use

Existing land uses in Little Cottonwood Canyon are typical of a mountain resort community. Land use at the ski resorts includes high-density lodging and condominiums, restaurants, and a variety of retail uses. Surrounding the Town of Alta are numerous residences scattered among limited parcels of private property. However, the Town of Alta is essentially at build-out: there are few vacant lots available for construction, and the planning commission's last meeting was over a year ago. Residential development in the Snowbird portion of the canyon is limited to one or two residences adjacent to and immediately north of SR-210, and an abundance of lodges and condominiums associated with the resort's base facilities. Infrastructure to support these uses includes: SR-210 and local roads; sewer, which according to the Forest Service is connected to the valley sewer system via pipeline running down SR-210; culinary water, provided from local sources; and power, connected via transmission line from Brighton. Remains of historic mines are also present, though such activities are no longer operational. Non-developed land uses include a myriad recreational uses of the National Forest. These recreational uses are described in further detail later in this report.

Wilderness Area

In addition to the forest designation, some lands in Little Cottonwood Canyon are also designated as wilderness. Two wilderness areas are present in the canyon: the Lone Peak Wilderness Area and the Twin Peaks Wilderness Area. These areas are Congressionally designated as wilderness, which places certain restrictions on the activities that can occur within their boundaries. Generally, no motorized vehicles or roads are allowed in wilderness areas. If alignment of SR-210 were to penetrate the existing wilderness boundary, the wilderness boundary would need to be adjusted through an act of Congress.

Current Zoning

Zoning and the regulation of land uses in Little Cottonwood Canyon is administered by a variety of entities. Although Salt Lake County, Forest Service, and the Town of Alta are the primary agencies with jurisdiction over the development of land in Little Cottonwood Canyon, other entities such as Salt Lake City and the Salt Lake City-County Health Department have authority to regulate the types of activities that occur in the watershed. For further details on jurisdiction see the discussions of watershed and Forest Service jurisdiction below.

<u>Town of Alta Zoning Ordinance</u>

The Town of Alta Zoning Ordinance regulates land use for properties within the town's boundaries. It addresses avalanche hazards, and requires completion of an avalanche hazard report for new structures or improvements, including structural analysis of the building's ability to withstand avalanche impact. Most of Alta's zoning districts, including the Forestry-Multifamily (FM) and Forestry and Recreation zones (FR), prohibit placing structures at an "unreasonable

risk of harm" from natural hazards. These hazards may include flood, landslide, avalanche, high water table, or soil erosion. The zoning ordinance does not contain any specific controls over transportation infrastructure within existing rights-of-way. Although new roadway facilities are not specifically addressed in the Town of Alta's zoning ordinance, the town will review proposals on a case-by-case basis.

Town of Alta General Plan

The Town of Alta General Plan includes a policy statement that indicates Alta's preference for SR-210 to be open and accessible "at all times." The General Plan supports realignment of SR-210 to avoid avalanche paths, but suggests construction of avalanche galleries as a short-term measure. It also supports increased transit service and improved transit amenities as a method of decreasing congestion. The General Plan suggests constructing a municipal parking structure to relieve parking pressures in the community. Another preferred element is the construction of a facility for the Unified Fire Authority between Alta and Snowbird, which would improve emergency response times to both areas. In addition, the Town of Alta supports a ski interconnect between Alta and Snowbird and proposes further study of ski and ground connections to other resorts as well as to the Salt Lake Valley. The General Plan does not support increasing capacity on SR-210, or the implementation of toll booths at any point along the road.

Salt Lake County Zoning Ordinance

The Salt Lake County Zoning Map illustrates the county zones present in Little Cottonwood Canyon. Generally, the county zoning ordinance does not regulate highways but does regulate the local roads that stem from them. The primary county plan that addresses transportation in Little Cottonwood Canyon is the 1989 Wasatch Canyons Master Plan.

Other applicable ordinances in Little Cottonwood Canyon include the Foothills and Canyons Overlay Zone (FCOZ), and Natural Hazard Areas regulations. FCOZ establishes standards for development in the foothills and canyons, in order to preserve their natural character. FCOZ lists the following items among its goals:

- Preserve the aesthetic qualities of the foothills and canyons, including ridgelines
- Encourage design that will reduce the risk of natural hazards and maximize residents' safety
- Provide adequate vehicle and pedestrian circulation
- Minimize construction impacts on sensitive lands
- Prohibit activities that would degrade fragile soils, steep slopes, and water quality
- Preserve environmentally sensitive areas through clustering
- Protect streams, drainage channels, absorption areas, and floodplains

FCOZ applies to all County lands in Little Cottonwood Canyon, and is generally more restrictive than the underlying base zones (FR, FM). Regulations regarding Natural Hazard Areas attempt to minimize hazards to public health, safety and welfare. This ordinance requires completion of debris flow, landslide, and avalanche hazard reports for applicable areas in the County.

Regional Population Growth

The Wasatch Front has experienced notable population growth in the last 30 years. Table 2-1 compares population by county from 1980 – 2000, for the three primary counties of the Wasatch Front.

Table 2-1: Population Growth for Selected Counties, 1980 - 2000

County	*1980 Census Population*	*1990 Census Population*	*Percent Change, 1980 – 1990*	*2000 Census Population*	*Percent Change, 1990 - 2000*
Davis	146,540	187,941	28.25%	238,994	27.16%
Salt Lake	619,066	725,956	17.27%	898,387	23.75%
Utah	218,106	263,590	20.85%	368,536	39.81%
Source: Governor's Office of Planning and Budget					

While growth in previous decades has centered on Salt Lake County, the Salt Lake Valley is nearing its development potential. According to the Governor's Office of Planning and Budget, the highest rates of future population growth will be seen in the Wasatch Back (Summit County and Wasatch County) and Washington County, in southwestern Utah. Population projections for these counties and for the counties listed in Table 2-1 are shown in Table 2-2.

Table 2-2: Population Growth for Selected Counties, 2010 - 2030

County	*2010*	*2020*	*2030*	*AARC 2000 - 2030*
Davis	292,201	347,412	386,672	1.62%
Salt Lake	1,077,556	1,283,784	1,431,843	1.57%
Utah	503,039	615,480	689,586	2.11%
Washington	131,880	177,354	218,840	2.99%
Summit	41,988	56,001	68,474	2.82%
Wasatch	22,894	29,777	34,893	2.81%
Source: Governor's Office of Planning and Budget				

Jurisdiction and Ownership

Forest Service Jurisdiction

Little Cottonwood Canyon falls within the Central Wasatch Management Area of the Wasatch-Cache National Forest (see Figure 2-1, Jurisdictional Boundaries). Management of the forest is primarily guided by the Wasatch-Cache National Forest Revised Forest Plan, which was last updated in February 2003. The Revised Forest Plan describes desired future conditions, management prescriptions, and standards and guidelines for decisions affecting the forest. Although SR-210 is not specifically mentioned in the plan, the plan specifies how construction and reconstruction of roads should occur to minimize impacts to the environment and forest resources. Furthermore, the plan states that preservation of the watershed is a primary factor in managing roads in the Central Wasatch Management Area, that the Forest Service will not

permit expansion of parking beyond current levels, and that the Forest Service will work with local parties to explore options for minimizing private vehicular use in the canyon.

Since much of the canyon is within Forest Service jurisdiction, requirements of the National Environmental Policy Act (NEPA) will be applicable for actions that would affect the environment. Generally, NEPA is prompted for any major federal action likely to have a significant impact on the environment. Changes in right-of-way for SR-210 or alternatives that require substantial property acquisition in the forest are likely to require NEPA review. Certain actions that do not have significant impacts can be processed through a categorical exclusion. Actions that would have significant impacts, unusual circumstances (such as substantial controversy), significant impacts on historic properties and parklands, or that are inconsistent with local, state or federal laws are likely to require more detailed study under an Environmental Impact Statement (EIS). If there is any question whether the impacts are significant, an Environmental Assessment (EA) can be conducted to determine the significance of the impacts. Actions within the wilderness boundary would require some level of NEPA analysis, commensurate with the scope of the action.

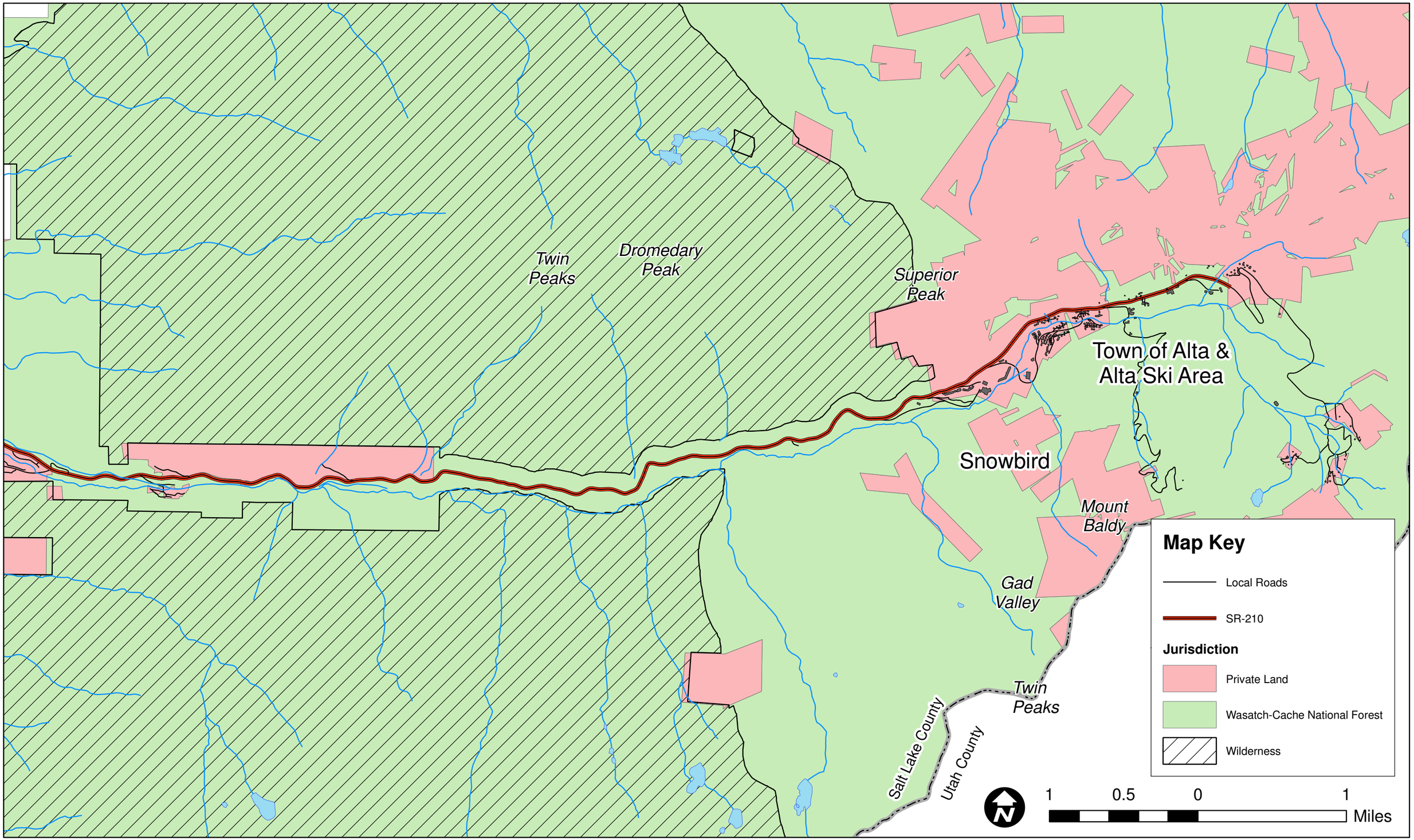


Figure 2-1: Jurisdictional Boundaries

Sources: Utah State Automated Geographic Resource Center (County Boundary Line, Wilderness, Lakes, Streams), Town of Alta (Roads, Structures), USFS Wasatch-Cache National Forest (Jurisdiction). Note: The data presented is subject to error.

Land Ownership

Land in Little Cottonwood Canyon is primarily public land, managed by the U.S. Forest Service. The Bureau of Land Management manages some smaller parcels of public land, but these parcels are fairly distant from SR-210 and the areas of avalanche activity. The remaining land in Little Cottonwood Canyon is privately owned. The distribution of private land is separated into two general areas: upper canyon and lower canyon. In the lower portion of the canyon near the canyon mouth, properties are used for archival storage and for clustered residential development. In the upper reaches of the canyon, private parcels are more abundant. Ownership in this area is divided between the ski resorts, individuals, and several holding companies and organizations.

Backcountry and Recreational Use

Recreation resources in Little Cottonwood Canyon are abundant (see Figure 2-2: Recreation Resources). The canyon is used year-round by myriad recreationalists and is home to two ski resorts. The Recreation Resources map depicts areas where current recreational activities occur, including major trails, campgrounds, streams and lakes, areas for rock climbing and bouldering (a branch of rock climbing in which no ropes or harnesses are used), and ski resorts. It is important to note that SR-210 itself is a recreational amenity for sightseers, recreational drivers, road-cyclists, and other users.

Although the nature of recreational use changes in the winter months, recreationalists are present on trails, climbing routes, and other backcountry areas year-round. White Pine Trailhead is a major backcountry access point for winter recreation. Backcountry access also occurs in areas where drainages are accessible to the roadway.

Little Cottonwood Canyon is considered a world-class rock climbing, ice climbing, and bouldering destination. The locations of climbing and bouldering areas are of particular concern with regard to potential roadway realignment alternatives. Since bouldering areas are scattered throughout the bottom of the canyon, realignment of the roadway would likely result in a reduction in routes. Access patterns for the bouldering areas would also be a concern. Climbing routes are typically located at higher elevations on the steep granite slopes that line the north and south sides of the canyon. In addition, ice climbing in Little Cottonwood Canyon attracts numerous visitors during the winter. Although roadway realignment alternatives would not likely have direct impacts on climbing routes, access patterns would likely be impacted.

Numerous recreation access points, including user-created trailheads, are accessed directly from SR-210. At these locations, limited parking on the shoulders of SR-210 is utilized by recreationalists. The supply of parking is often insufficient in meeting the demand, and recreationalists frequently park illegally. Enforcement is difficult because signage is often removed and there is a perception that it is legal to park in areas where it is actually prohibited. Particularly in the winter, on-street parking is cited as a safety hazard because parked cars slow snow removal and limit the area for snow storage. These issues slow traffic in the canyon and exacerbate existing hazards associated with winter travel in the canyon.

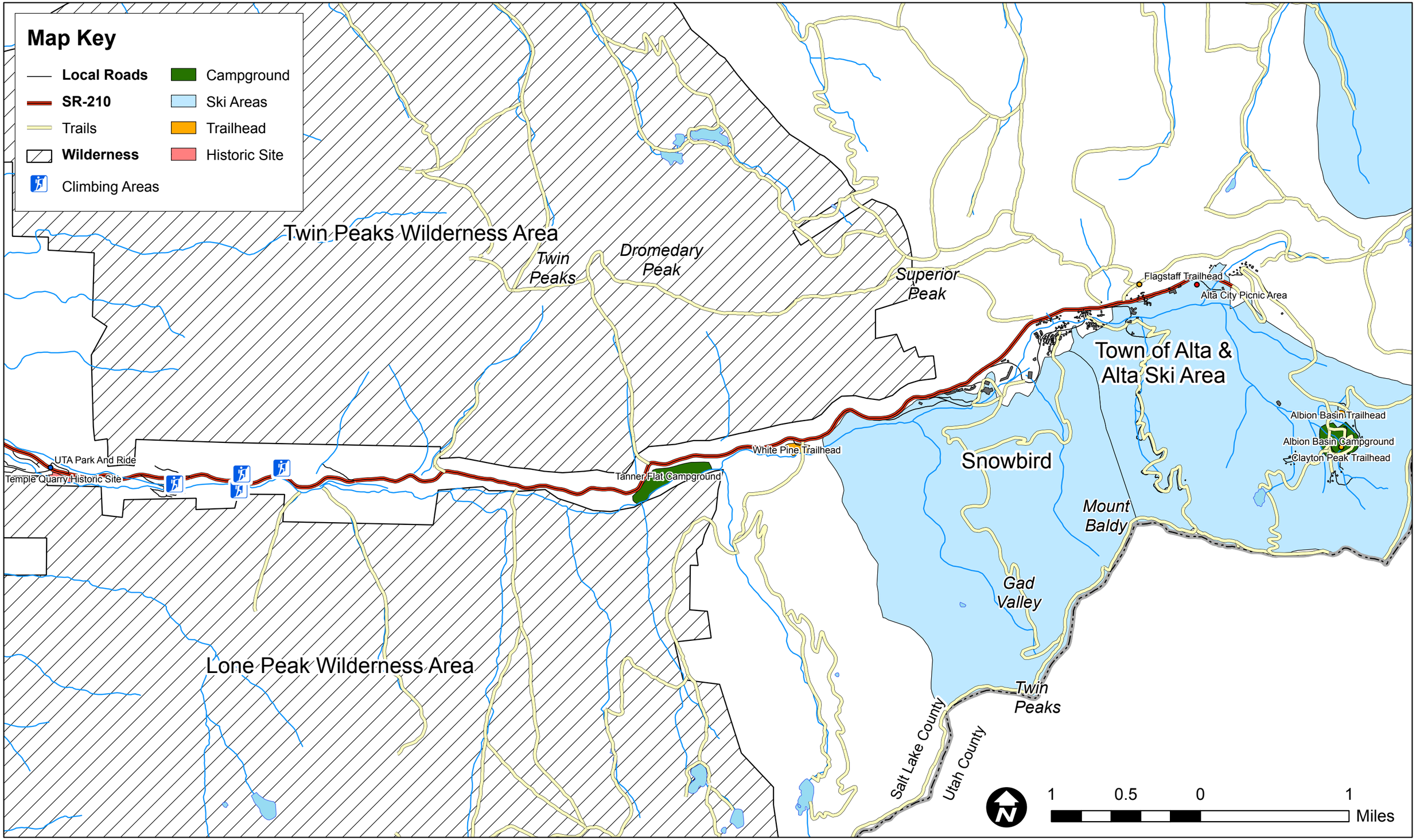


Figure 2-2: Recreation Resources

Sources: Utah State Automated Geographic Resource Center (County Boundary Line, Lakes, Streams), Town of Alta (Roads, Structures), Salt Lake City (Trails), Forest Service (Developed Use Areas, Recreation Points) Note: The data presented is subject to error. Climbing Areas are approximate and do not represent all climbing areas in Little Cottonwood Canyon.

Resort Master Plan Summary

Snowbird

The Final Environmental Impact Statement for Snowbird's Master Development Plan (dated November, 1999) provides a summary of proposed actions at Snowbird. These include:

- Regrading and paving Entry 1 and the Gad Valley parking lot
- Upgrade of skier service facilities on Hidden Peak
- Expand snowmaking system
- Development of the Gad 3 lift and associated ski trails
- Upgrade Little Cloud lift
- NASTAR course improvements
- Vegetation management plan
- Changes/additions to ski trail network
- Develop new hiking trails
- Special Use Permit boundary changes

Alta

The Final Environmental Impact Statement for Alta's Master Development Plan (dated April, 1997) provides a summary of proposed actions at Alta. These include:

- Upgrade Albion and Sunnyside lifts
- Modify selected runs to improve safety
- Expand snowmaking system
- New Special Use Permit
- Structure expansions at Albion Lodge and Albion Ticket Office
- Replace Watson Shelter
- Expand Upper Grizzly parking lot by 28 spaces
- Remodel/replace patrol buildings
- Implement forest management plan

Environmental Concerns

Watersheds

According to the Salt Lake City Watershed Management Plan, Little Cottonwood Creek is part of the larger Salt Lake City watershed that provides drinking water for nearly 400,000 Utahns. Currently, the quality of water in the watershed is good to excellent. According to the Water Quality and Treatment Administrator for the Salt Lake City Department of Public Utilities, water quality at the collection point is well within EPA guidelines. The only problem with current water quality is a concentration of zinc that enters the stream from a mining tunnel in the higher elevations of the canyon. Most metals leach out of the water as the pH increases in the lower parts of the stream.

The watershed is regulated by numerous agencies including Salt Lake City Department of Public Utilities, Salt Lake County, the Salt Lake Valley Health Department, the U. S. Forest Service, the Metropolitan Water District of Salt Lake City, the Town of Alta, Sandy City, and the Jordan Valley Water Conservancy District. Protecting water quality is a primary concern for

many of the agencies responsible for managing activities in Little Cottonwood Canyon. Reflecting this, Salt Lake City's Watershed Management Plan "prioritizes water quality first and multiple use of the watershed second," and states "to the extent that, in the reasonable judgment of the City, a proposed development or activity, either individually or collectively, poses an actual or potential impact to the watershed or water quality Salt Lake City will either oppose, or seek to modify, manage, control, regulate or otherwise influence such proposed development or activity so as to eliminate or mitigate potential impacts". In addition, the Salt Lake City-County Health Department (SLCCHD) maintains a strict 50-foot building setback from all streams. The SLCCHD health regulations for watersheds do not specifically regulate transportation facilities. Any alternatives will likely require consultation with the SLCCHD as well as the Salt Lake City Division of Public Utilities.

Within the context of these strict watershed controls, any soil disturbing activities would be subject to a great deal of scrutiny by the agencies with authority over the watershed. The fact that soils in the roadway may contain hazardous materials (see the hazardous materials section of this report) exacerbates the issue by increasing the severity of impacts associated with soil disturbance. Alternatives that disturb contaminated soils may be difficult to implement, or may require substantial mitigation.

Riparian Habitat Conservation Areas

The Forest Service has established Riparian Habitat Conservation Areas (RHCAs) that surround surface water bodies (see Figure 2-3: Water Resources). While the RHCA designation allows a full range of activities, it places a priority on riparian management objectives (USFS 2003). The RHCAs are classified into four categories based on water body type. The first classification is for fish bearing streams, and consists of a 300-foot buffer surrounding the active stream channel. The area surrounding the main-stem of Little Cottonwood Creek is a Category 1 RHCA (Cowley 2005 Pers. Comm.). The second RHCA classification is for permanently flowing, non-fish bearing streams. A Category 2 RHCA consists of a 150-foot buffer surrounding the active stream channel. The tributaries to Little Cottonwood Creek and the areas surrounding them would fall under this category (Cowley 2005 Pers. Comm.). The third type of RHCA applies to ponds, lakes, reservoirs and wetlands greater than one acre in surface area. A Category 3 RHCA consists of the body of water and a surrounding buffer of 150 feet. Category 3 RHCA's are present in Little Cottonwood Canyon and are depicted in the Water Resources map. Lastly, the fourth category includes seasonally flowing or intermittent streams, wetlands less than one acre, landslides, and landslide prone areas.

Due to the variability of the size of these elements, a Category 4 RHCA must contain at a minimum, the area of historic landslides and landslide prone areas, or the area of the stream or wetland plus a buffer of 100 feet slope distance in watersheds containing Bonneville or Colorado Cutthroat Trout, or a buffer of 50 feet slope distance otherwise. Known areas that are considered to be included in the Category 4 RHCA are two wetland areas near the base facilities of Snowbird (see discussion of wetlands, below), and an historic landslide area in Albion Basin. Development within any area that is classified as an RHCA will require coordination with the Forest Service, and may require coordination with other agencies such as the Utah Division of Wildlife Resources, or the watershed management agencies described above, depending on the anticipated impacts.

Wetlands

Review of National Wetland Inventory (NWI) maps indicates that wetlands exist throughout Little Cottonwood Canyon. Although NWI maps typically underestimate the quantity and size of

wetlands, the data provides a preliminary overview of the types of wetlands that may be encountered in the project area. This data was obtained from the Utah Automated Geographic Resource Center and is depicted in the Water Resources map (Figure 2-3).

Using the NWI maps, four areas of wetlands were identified along Little Cottonwood Creek. Two wetlands are located in the northern portion of Snowbird, adjacent to SR-210. Each of these wetland areas is less than one acre and is therefore considered to be part of a Category 4 RHCA. One wetland area is west of the Cliff Lodge, approximately 280 feet from SR-210 in the heart of Snowbird's base facilities. Another wetland is located east of the Cliff Lodge approximately 80 feet to the east side of the bypass road. Two additional wetland areas are located in the Town of Alta, along Little Cottonwood Creek. These wetland areas, at 2.6 and 7.6 acres respectively, are the largest wetlands identified along the creek, and are considered to be Category 3 RHCAs. The edges of the Category 3 RHCAs are 200-280 feet from SR-210.

In addition to these wetlands, other wetlands were identified in the higher elevations of the canyon. These wetlands are typically associated with streams and lakes in alpine sections of the canyon. Most of the higher elevation wetlands are on north-facing slopes, in areas such as Gad Valley. Due to the steep grade on the south-facing slopes, it is not likely that substantial wetlands would be present in these areas

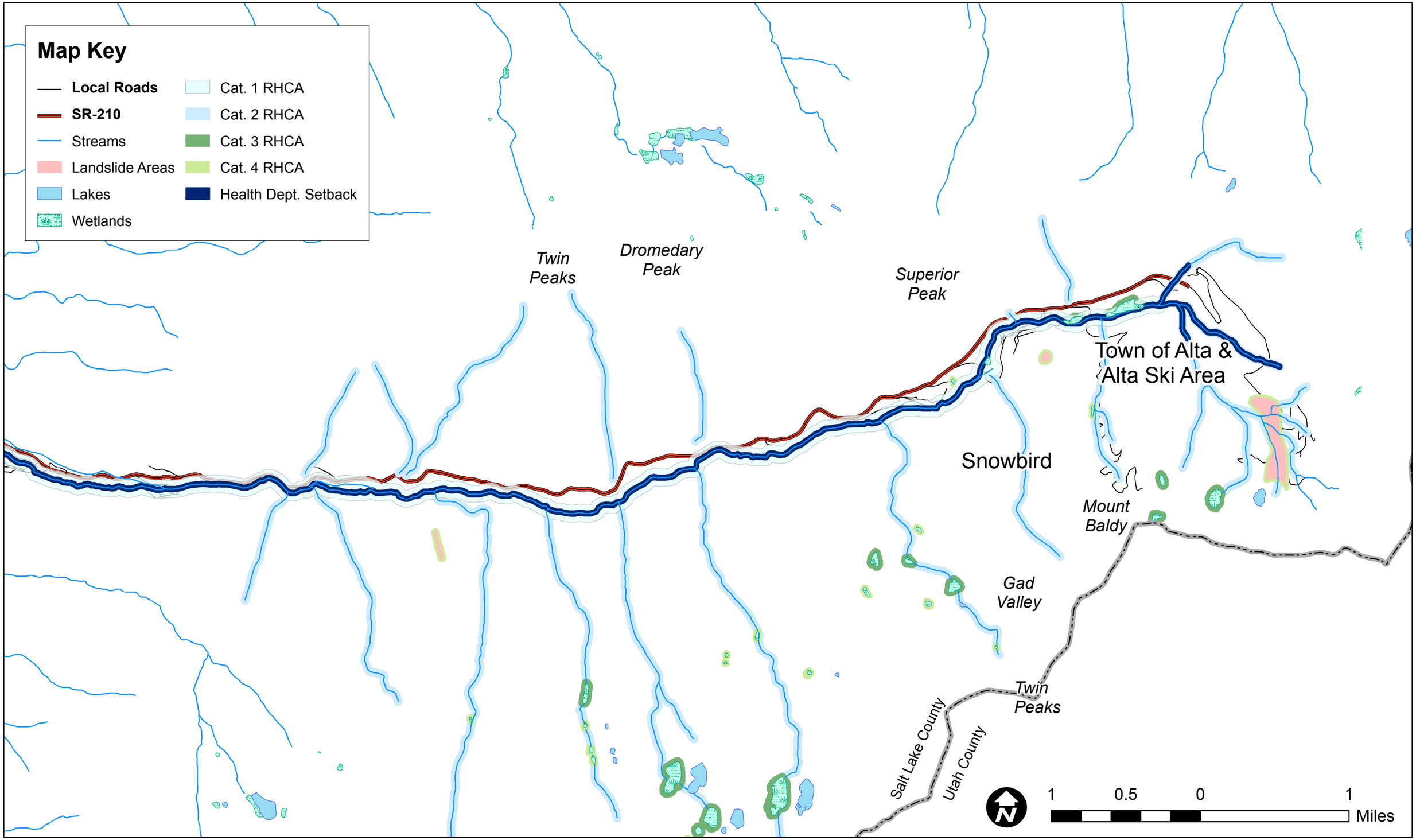


Figure 2-3: Water Resources

Sources: Utah State Automated Geographic Resource Center (County Boundary Line, Lakes, Streams, Wetlands, Landslide Areas), Town of Alta (Roads) Note: RHCA's are depicted for Little Cottonwood Canyon only. The data presented is subject to error.

Biological Resources

Animals

Little Cottonwood Canyon provides habitat for a variety of protected species. Protected species are of particular concern with regard to potential roadway improvements or alternatives, because the regulations that surround such species can limit or constrain the types of development that can occur. Based on conversations with Forest Service personnel and review of Forest Service documents, it is estimated that there are a total of 15 protected species that inhabit Little Cottonwood Canyon. These species are listed by their common names and status in Table 2-3.

Table 2-3: Protected Species in Little Cottonwood Canyon

Common Name	*Status*
Bonneville Cutthroat Trout	Conservation Agreement Species
Columbia Spotted Frog	Conservation Agreement Species
Yellow-billed Cuckoo	Federally Threatened Species
Bald Eagle	Federal Candidate Species
Northern Goshawk	Conservation Agreement Species, Forest Sensitive Species
Three-toed woodpecker	Wildlife Species of Concern, Forest Sensitive Species
Flammulated Owl	Forest Sensitive Species
Boreal Owl	Forest Sensitive Species
Peregrine Falcon	Forest Sensitive Species
Golden Eagle	Federally Protected
Canada Lynx	Federally Threatened Species
Townsend's Big-eared bat	Wildlife Species of Concern, Forest Sensitive Species
Spotted Bat	Wildlife Species of Concern, Forest Sensitive Species
Wolverine	Forest Sensitive Species
Pine Martin	Forest Sensitive Species

In addition to these species, up to 190 species of migratory birds may use Little Cottonwood Canyon. All migratory birds are protected by the Migratory Bird Treaty Act of July 3, 1918, (16 U.S.C. 703-712) and Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. Coordination with the Utah Division of Wildlife Resources, Forest Service, and the parties associated with the Conservation Agreements will generally be required in order to implement a project in sensitive habitat areas that are covered by these various protections.

Plants

According to the Forest Ecologist for the Wasatch-Cache National Forest, Little Cottonwood Canyon contains the highest concentration of rare plants in terms of species numbers and populations in the entire Salt Lake County portion of the Wasatch-Cache National Forest. Most of these species occur at alpine elevations and would not occur along the roadside, or in the canyon bottom. Any loss of or impact to these rare alpine species communities is strongly discouraged in the Forest Plan. Other protected plant species include a variety of species present in the riparian portions of the canyon. Although suitable habitat may not be present in the canyon, potential protected plant species include the federally threatened Ute-Ladies'-Tresses Orchid (*Spiranthes diluvialis*). *Spiranthes diluvialis* is believed to be the only federally listed plant species with a potential for being present in Little Cottonwood Canyon.

Hazardous Materials

Windshield level investigations in Little Cottonwood Canyon indicate that hazardous materials are a potential concern in the canyon. However, the extent of these hazards cannot fully be understood without further investigations.

Environmental hazards data was downloaded from the Utah Automated Geographic Resource Center (AGRC) to determine the distribution of hazardous material sites in Little Cottonwood Canyon. Two Comprehensive Environmental Response Compensation and Liability Act (CERCLA) sites were identified in the canyon; both are sites of historic smelters. In addition, three underground storage tank sites were identified; two at Alta and one at Snowbird. Underground storage tank facility information was available for a fourth site owned by Qwest, near Alta on the north side of SR-210. Each of the sites is depicted in the Hazardous Materials map. A number of historic mine sites (mineral location points from the AGRC) were also identified and are included on the Hazardous Materials map (Figure 2-4). It is important to note that not all of the mineral location points identified in the Hazardous Materials map are designated as hazardous material sites. The map simply illustrates areas where mine tailings may be present.

With the abundance of historic mines and few suitable soils for fill available in Little Cottonwood Canyon, it is possible that tailings material was used as road fill for SR-210. Disturbance of potentially contaminated soils potentially contained within the roadbed could result in the conveyance of hazardous materials into the water supply through storm water runoff or other means of conveyance. Coordination with various agencies will be required to determine the extent of contamination present in the roadway. Generally, disturbance of hazardous material sites will require coordination with the Utah Division of Environmental Response and Remediation, the Utah Division of Water Quality, and/or the Utah Division of Oil, Gas, and Mining. Other agencies such as the Salt Lake City Department of Public Utilities and the Salt Lake City-County Health Department will also be interested in issues affecting the quality of water in the watershed.

Cultural Resources

Little Cottonwood Canyon was used historically by Native Americans and early European settlers alike. Discussions with the Utah State Historic Preservation Office (SHPO) suggest that a number of small archeological studies have been conducted for a variety of projects in the canyon. According to SHPO records, no archeological overview of the entire canyon has been conducted to date, but some historic sites have been discovered (SHPO 2005) in individual studies. In order to provide more detail, additional investigations would be necessary. Consultation with a licensed archeologist and coordination with SHPO would be required to determine the extent of these resources.

Another cultural concern in Little Cottonwood Canyon is the China Wall, a retaining structure located at the base of the White Pine avalanche path area. China Wall consists of a linear stone wall, behind which is a dugout area that can contain slide debris and prevent it from reaching SR-210. Bio-West, the environmental consulting firm for this study, contacted representatives from both USFS and SHPO to investigate the historical context and use of the China Wall. This research was inconclusive: SHPO was unaware of the wall, and reference materials suggested by USFS indicated that stone walls had been used to support snow sheds in the canyon as early as the 1870's, but these materials made no specific references to the China Wall.

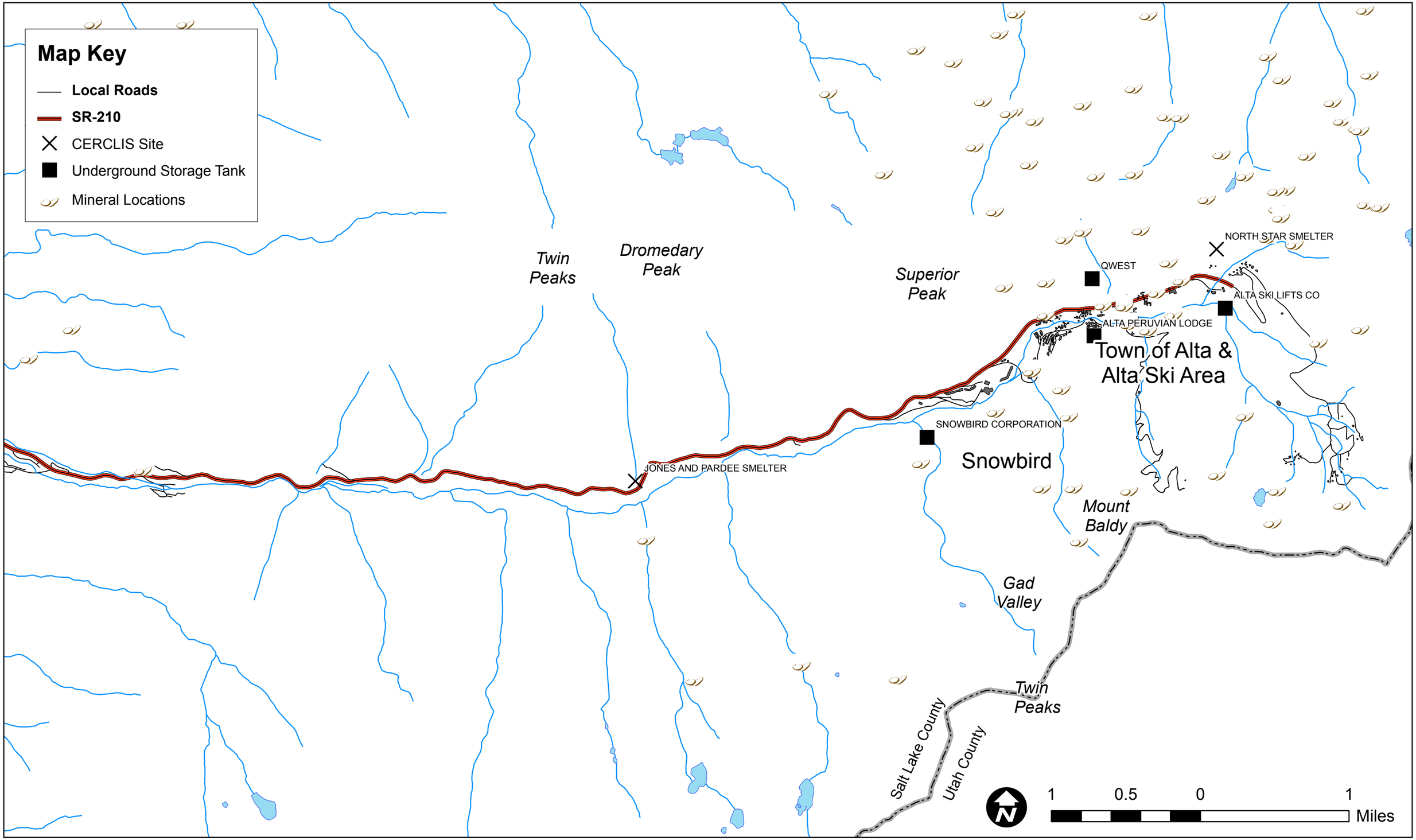


Figure 2-4: Hazardous Materials

Sources: Utah State Automated Geographic Resource Center (County Boundary Line, Lakes, Streams, CERCLIS Sites, Underground Storage Tanks, Mineral Locations), Town of Alta (Roads, Structures) Note: The data presented is subject to error.

Avalanche

Slide Areas

SR-210 is threatened by 35 major avalanche paths; all but three of these paths originate on the southerly facing slopes on the north side of the canyon. In most cases the road travels through run out zones of specific paths; in several cases, it travels through the transition between the track and the run out zone. The latter situation contributes significantly to the frequency of avalanche events reaching the road. Over the past 50 years, an average of 33 avalanches have hit the road annually. Traffic volume on the canyon road frequently exceeds capacity during the ski season, and the steep grade and winter driving conditions can exacerbate the situation leading to "bumper to bumper" traffic that requires several hours to clear in the canyon.

The combination of numerous and frequent avalanche events reaching the road annually, and the excessive number of vehicles traveling at slow speeds under numerous avalanche paths has contributed to the Highway Avalanche Hazard Index rating in Little Cottonwood Canyon being higher than on any other major road in North America.

Canyon Road Sections

For reasons related to terrain, local custom and logistics, the canyon road has been divided into six different sections (see Figure 2-5 for an illustration):

1. Lower Canyon extends from the mouth of the canyon to the Maybird avalanche path.

2. Mid-Canyon extends from the Maybird avalanche path to the Monte Cristo avalanche path near Entry I of the Snowbird Ski Area.

3. Snowbird Village, which extends from the Monte Cristo avalanche path through the Hilton avalanche path at Entry IV of the Snowbird Ski Area. Avalanche paths in this section affect not only the canyon road but also the parking areas and several buildings within the Snowbird Village.

4. Hellgate-Superior is the portion of the canyon road affected by the Hellgate and Superior avalanche paths.

5. Town of Alta, which extends from the East Hellgate avalanche path to the end of the state maintained road below the Grizzly Gulch avalanche path.

6. Bypass Road, which was constructed to allow traffic to and from the Town of Alta while avoiding the large avalanche paths of Hellgate and Superior.

Nearly the entire length of road in the Hellgate-Superior and Town of Alta sections of the canyon is threatened by avalanches, with very few safe areas. These sections also contain the greatest number of buildings exposed to avalanche hazard as well. The terrain above the different sections of the canyon road varies considerably, which in turn leads to differences in the development and nature of the avalanche hazard. An example of this variation would be the Mid-Canyon section compared to the Town of Alta section. Above Alta, the terrain consists of wide, open slopes with sparse tree cover. Avalanche starting zone slope angles in this section average around 30 degrees. In contrast, the terrain above the Mid-Canyon section contains numerous steep, confined gullies connecting the avalanche starting zones near the ridgeline

UDOT GOING THE EXTRA MILE

Sources: Utah State Automated Geographic Resource Center (Avalanche Paths, Aerial Photo), Town of Alta (Roads, Staging Areas, Avalanche Gates) Note: The data presented is subject to error.

Figure 2-5: Canyon Road Sections

with the creek along the bottom of the canyon. The starting zone angles in this section of the canyon average in the 40 degree range. Consequently, Mid-Canyon avalanche activity is often defined by smaller new snow avalanche events with a considerable volume of snow during the descent through the steep track, versus the larger and wider avalanches frequently involving several layers of the snowpack that can occur in the Town of Alta section.

Avalanche Hazard Development Above Separate Roadway Sections

The differences in physical characteristics determine the frequency, magnitude, and extent of avalanche activity in the particular sections of the canyon.

The Lower Canyon section has the least number (two) of avalanche paths affecting the road. Those paths that do affect the road do so very infrequently. The lower elevation of this part of the canyon is often reflected in lower amounts of snowfall, which in turn frequently leave the run out zones of the paths in this section lacking sufficient snow depth to cause avalanche debris on the road. During years with above normal snowfall at lower elevations, these paths are more threatening, especially in early and mid spring when seasonal snow depths usually reach their maximum. The avalanche hazard in this area usually develops in response to large, cold late season storms, during winters with above normal snowfall. The infrequent threat from the avalanche paths in this section seems to be adequately managed by occasional closure and helicopter control.

The Mid-Canyon section has the greatest number (16) of avalanche paths affecting the road. The steepness and confined nature of these paths allows even small to medium sized avalanches to reach the road. This problem is exacerbated because portions of the road in this section are located in the upper part of the run out zones of some of the avalanche paths. Traffic congestion along this section of the canyon road is often some of the worst, with large amounts of slow moving traffic occurring frequently during the avalanche season. These paths frequently respond first in a natural avalanche cycle brought about by heavy precipitation. In situations with a large number of slow moving vehicles and heavy snowfall initiating a natural avalanche cycle, once the first avalanche reaches the road and blocks traffic, the number of stationary vehicles are exposed to more than a dozen additional paths. This increases the likelihood of additional natural avalanche events, and creates an immediate and serious threat to public safety.

The frequency of avalanche activity in the Mid-Canyon section is usually dependent on the amount of snow at the lower elevations. Normal and above normal seasonal snowfall usually produces an active winter and spring. Below normal snow years often keeps the snow depth in the run out zones - and sometimes the starting zones – low enough to prevent these paths from posing a hazard to traffic. The avalanche hazard in this area is often the result of a sudden increase in the snowfall rate, which is frequently accompanied by an increase in wind speed. Snow pack structure plays a role in development of the avalanche hazard in this section, but perhaps not as much as in other parts of the canyon.

Currently, avalanche control is addressed by road closure and artillery control, occasionally supplemented by helicopter control. As there are no occupied structures in this section of the highway, avalanche control work can be implemented simply by closing and securing the road; consequently, it is frequently carried out more than once a day. In contrast, the upper sections of the canyon with developed ski resorts and numerous occupied structures make it much more difficult to carry out avalanche control work intermittently during the day. In spite of a very active artillery control program, more natural avalanche events have reached the road while it has been open in this section than in any other.

In the Snowbird Village section, five avalanche paths affect SR-210. East of the Monte Cristo avalanche path, the terrain is significantly influenced by the south ridge of Mt. Superior. This ridge and the associated buttress reduce the amount of terrain at low enough slope angles to allow a significantly deep snow pack to develop. Therefore, many of the avalanche paths in this section have a much smaller vertical drop than those in the Mid-Canyon area. In most cases, the starting zones are small to medium in size as well. The larger and more frequent running paths are located on the west and east ends of this section, where in some cases avalanche events have run to Little Cottonwood Creek.

A number of parking areas and occupied buildings are threatened by the paths in this section, and although large events in this section of the canyon are less frequent than elsewhere, a considerable hazard does develop occasionally. Most of the buildings are located relatively close to the road; while avalanche control work is primarily to protect SR-210, it is widely accepted that this work also improves safety at the buildings and parking lots as well. However, this also means that natural or controlled avalanches will not necessarily stop on the road, but will sometimes continue on to hit occupied buildings. Unfortunately, only a few of the buildings in this section have been designed to withstand avalanche impact forces. Inter-lodge Travel Restrictions, implemented under the authority of the Salt Lake County Sheriff, are put into effect during periods of high avalanche hazard or during explosives control work. These restrictions keep individuals inside buildings, rather than in the more exposed areas outside. Under more extreme conditions, portions of certain buildings that are considered to be exposed to a greater risk are evacuated, and the occupants relocated in other areas until the hazard has subsided.

As in the Mid-Canyon area, the avalanche hazard in the Snowbird Village section is often in response to a sudden increase in precipitation intensity, as well as during prolonged winter storms. Control work is implemented through road closure, Inter-lodge travel restrictions, and military artillery, with the occasional use of the helicopter for hand thrown explosives. The close proximity of the buildings to the avalanche starting zones makes the shrapnel associated with military ammunition an issue. Also of concern is the fact that in order to reach some of the target areas, it is necessary to fire over occupied buildings.

There are only five avalanche paths in the Hellgate-Superior section, but nearly the entire length of road in this area is threatened by avalanches on a frequent basis. The broad open slope of Mt. Superior (with a starting zone of nearly 200 acres, and a vertical drop to the road of up to 2500') and the hanging snowfields of Hellgate are notorious for producing large and destructive avalanches. The Bypass Road was constructed to avoid these paths, and to provide safer access to and from the Town of Alta during hazardous conditions. In spite of this notoriety, several single-family dwellings, one lodge, and a major parking area have been located in this section. Most of the single family dwellings have been constructed to withstand the maximum avalanche impact pressures, and frequent restrictions are placed on the parking area, which somewhat reduces the threat of harm. This section of the canyon road is closed more often and for longer periods than any other section, which causes access problems with the residents and guests located in this area.

The avalanche hazard in the Hellgate-Superior section develops in response to many conditions, including snow pack structure, prolonged storms, wind-transported snow in the absence of measurable precipitation, rapid warming after a major storm, and prolonged thaw. Avalanche control work is implemented in the form of closure and military artillery with additional control work carried out by helicopter and a trailer mounted Avalauncher. During prolonged

storms, even though the road is not intended to be opened, artillery control work is carried out to provide some protection to the inhabited buildings located in this area.

While UDOT is responsible for the safety of the road, not the buildings, many buildings are located in avalanche paths that also affect the road (it should be noted that there are no public agencies responsible for avalanche control to protect buildings in Little Cottonwood Canyon). When a large event (whether natural or controlled) takes place in certain paths that affect the road, buildings can be hit also. The intended result of avalanche control work is to initiate a large number of small-to-medium avalanches artificially, rather than to allow conditions to develop to the point where large and destructive avalanches might occur. UDOT's work increases the return interval of these larger avalanches, thereby lessening the odds of a destructive avalanche that would damage or destroy structures. Artificial release of avalanches generally works to minimize the number of large events, but sometimes those larger events do take place. Town of Alta property owners sign Hold Harmless Agreements, intended to protect UDOT from liability in the event of property damage or other negative effects. The general philosophy behind avalanche control in this section is that if UDOT were not doing control work, structures would be hit by avalanches anyway.

In the Town of Alta section, the terrains on the north side of the canyon changes considerably from steep cliffs and hanging snowfields, to broad, open slopes. The seven major avalanche paths above the Town of Alta represent a more or less continuous avalanche starting zone, with few prominent ridgelines or large stands of timber to break up the terrain. The history of Alta includes several avalanche disasters that destroyed much of the town and claimed numerous lives in the late 19th century. An active artillery control program, initiated in the 1940's, has allowed the Town of Alta to exist with only a few destructive avalanche events taking place since the transformation from a mostly deserted mining town to a major ski resort. More recently, the slopes that threaten the canyon road, as it passes through the Town of Alta, have become increasingly popular as backcountry ski terrain, and skier compaction has had a small but noticeable stabilizing affect on the snow pack in some of these areas.

In spite of the relative success in avoiding major avalanche damage, the numerous buildings that make up most of the Town of Alta and the road in this area are seriously threatened by avalanches much of the year. As in other sections of the canyon where the road and inhabited structures are threatened by the same avalanche paths, the control work done to protect the road also affords some protection to the buildings. However, due to the size of the avalanche paths in this section and the close proximity of several buildings to the road, avalanches that are initiated during highway avalanche control work have, on several occasions, hit and damaged occupied buildings. This precarious balance between protecting the road, contributing to the safety of buildings, and damage and destruction remains in place, but it may be on borrowed time.

In contrast to some of the other sections of the canyon, the avalanche hazard in this section often develops in response to the presence of structurally weak layers in the snowpack combined with multi-day storms. These conditions can, in some cases, produce avalanche events with particularly long fracture lines and involve a significant volume of snow. The lower slope angles of the avalanche starting zones in this area limits the number of smaller avalanche events that take place naturally during storms, and that may reduce the frequency of larger, more destructive avalanches in other, steeper areas of the canyon. Inter-lodge Travel and Maximum Security (evacuating certain sections of exposed buildings and relocating the occupants in areas considered to be safer) restrictions are put into effect in the Town of Alta by authority of the Town Marshall upon consultation with UDOT avalanche forecasters. Avalanche

control work is carried out through closure and military artillery, supplemented at times with helicopter control. Of concern to the military artillery program is the problem of firing over inhabited structures, and the possibility of firing into avalanche starting zones when backcountry skiers may be in the area. Of all the areas in the canyon, this section presents the greatest number of problems, and the greatest risk of disastrous consequences. This situation makes the Town of Alta a unique community.

As stated earlier in this report, the Alta Bypass Road was constructed to allow travel into and out of the Town of Alta while avoiding the Hellgate and Superior avalanche areas. Except for the largest avalanche events from these areas, there is little or no effect on this section of the road, and consequently, it serves as a "life-line" to the Town of Alta during the avalanche season. It is, however, not entirely free of avalanche concerns. The Blackjack Cliffs can pose a significant threat to safe travel on the Bypass Road, as do portions of the west facing slope that divides Collins and Peruvian Gulch. The northwesterly aspect of the starting zones of these two paths allow for snowpack structure to play an important role in the development of the avalanche hazard in this area, and a hazard may develop in this section when no threat is posed to other sections of the canyon road.

Although these avalanche starting zones lay within the permitted area of the Snowbird Ski Resort, little or no skier compaction takes place in this complex and rugged terrain, therefore the stabilization that occurs in other more accessible portions of the ski area does not occur here. Control work is carried out with closure and hand thrown explosives (much of the area can be reached from lift-served terrain in Alta and Snowbird), with some of the areas controlled with military artillery. In spite of the rather low frequency with which the Bypass Road is over-run by avalanches, an aggressive explosives control program is carried out in these areas. This is due to the accessibility by hand-charge teams, and to the fact that travel, including emergency services, between the Town of Alta and the Village of Snowbird is often limited to this corridor during the winter months.

Overview of the Avalanche Hazard Index

The Avalanche Hazard Index (AHI) assesses the avalanche risk to traffic. It is a numerical expression of the avalanche hazard on a road. The index is determined by calculating the probability of moving and waiting vehicles being hit by various types of avalanches and multiplying the probability with a weight according to the severity of damage. Calculation of the AHI considers several factors, including:

- Average daily traffic
- Traffic speeds
- Average length of avalanche debris on the roadway centerline
- Vehicle braking
- Avalanche frequency

Waiting vehicles are more likely to be hit by avalanches than moving vehicles. This occurs where an avalanche blocks the road ahead, vehicles line up waiting for the traffic to clear and a second avalanche hits the waiting traffic. Drivers wait in the vehicles due to poor weather and difficulty or inability to turn around (e.g. large vehicles). Usually they will wait until maintenance staff come along and clear the vehicles or at least the drivers from the hazard area.

This method has been applied on most highways in the United States, Canada and New Zealand to quantify the avalanche hazard for roads. The AHI has the following applications:

1. Comparison of the avalanche hazard between different roads and the level of control that is applied and acceptable;
2. Identification of the avalanche paths that contribute most strongly to the hazard of a road and consequently the paths that should be given priority for control measures;
3. Evaluation of the effect of alternative control measures, including cost benefit analysis;
4. Calculation of the hazard for future traffic volumes to allow orderly planning of control measures.

Highways are categorized with respect to the AHI as described in Table 2-4.

Table 2-4: Category of Hazard

Hazard Category	*Avalanche Hazard Index*
Very Low	<1
Low	1 to 10
Moderate	10 to 40
High	40 to 150
Very High	>150

North American practices in highway operations are summarized in Table 2-5 with respect to the Avalanche Hazard Index. Agencies utilizing these strategies include several state departments of transportation (Alaska, California, Colorado, Washington, and Wyoming), as well as the British Columbia Ministry of Transportation and Parks Canada.

Table 2-5: North American Practices in Highway Operations

Category	*Personnel*	*Explosives -*	*Structures*	*Data*	*Closures*
Very High	Full-and- part time personnel in forecasting and control operations	Active control with multiple fixed & mobile explosive systems	Snowsheds & earthworks (mounds, diversion berms, benches, dams)	Multiple remote alpine weather stations & alpine snow plot observers	Short control closures with occasional preventative closure
High	Full-or part time personnel in forecasting and control operations	Active control operations at all accessible sites	Earthworks & wide road ditching	Remote alpine weather stations	Short control closures with occasional preventative closures
Moderate	Part time personnel in forecasting and control operations	Mobile or fixed explosive control at key sites	Wide road ditching & occasional earthworks at key sites	Remote alpine weather stations	Preventative closures
Low	Maintenance staff, with periodic site visits by avalanche technicians	Occasional heli-bombing	Wide road ditching	Some remote weather stations or shared data	Preventative closures
Very Low	Maintenance staff				Preventative closures in exceptional circumstances

Source: Stetham et al, 1994

Methodology for Calculation of the AHI for SR-210

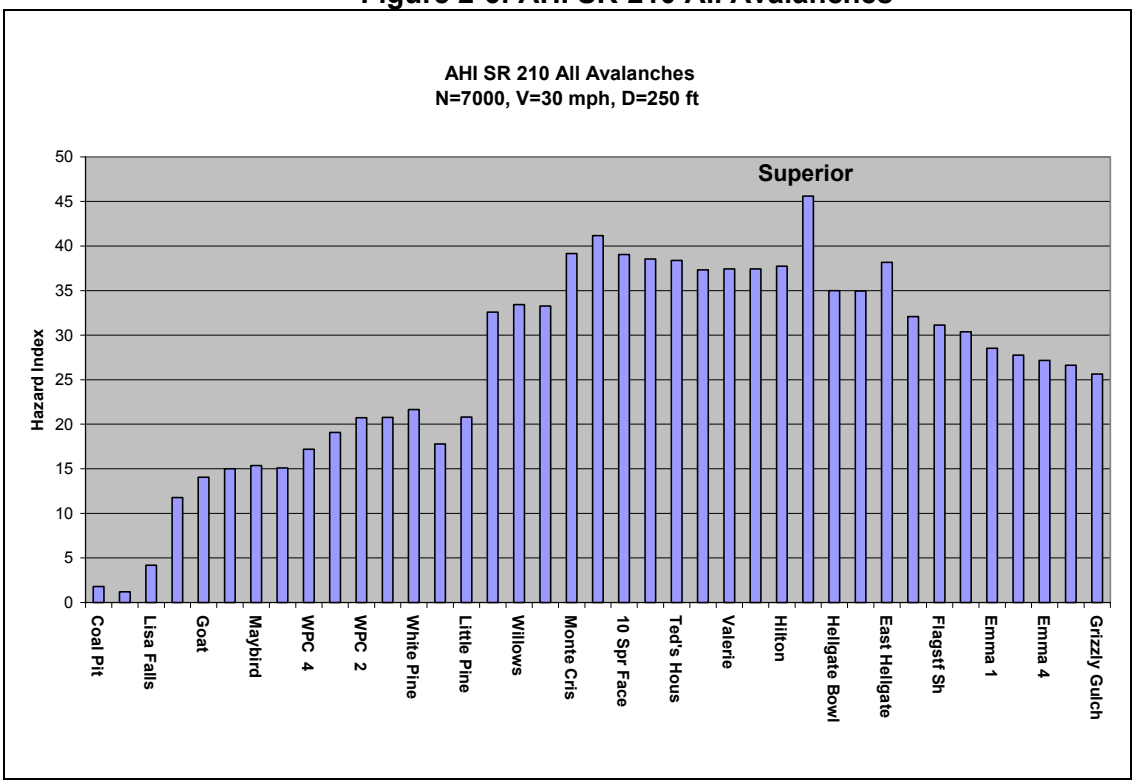
The inputs for the current analysis have been based on the historic record of avalanche occurrences accumulated for SR-210. Avalanche occurrence data have been compiled by UDOT for the period from 1972 to 2005. Additional historic data have been gleaned from the Highway Safety Plan (UDOT 2002) and interviews with key personnel.

We have separated the avalanche data into light snow avalanches (≤ 3 ft deposit on the road) and deep snow (>3 ft. deposit on the road) in accordance with the method of the AHI. Where more than one avalanche path runs out to the road in the same runout zone we have combined the data for these paths under one name (e.g. Superior or Little Pine East). The widths on the road are the actual averages from the light and deep snow deposits recorded in the database. The safe distance between paths is estimated from the minimum distance between paths plus 10% of the widths of the two adjacent paths. This is due to the fact that avalanches do not usually cover the full width of the path.

The Avalanche Hazard Index for SR-210

The baseline AHI for SR210 for an average winter daily traffic (WADT) of 7000 vehicles is 1045, in the Very High category. This includes all avalanches and assumes no control measures and free flowing traffic. The indices for the individual paths are illustrated in Figure 2-6.

Figure 2-6: AHI SR-210 All Avalanches

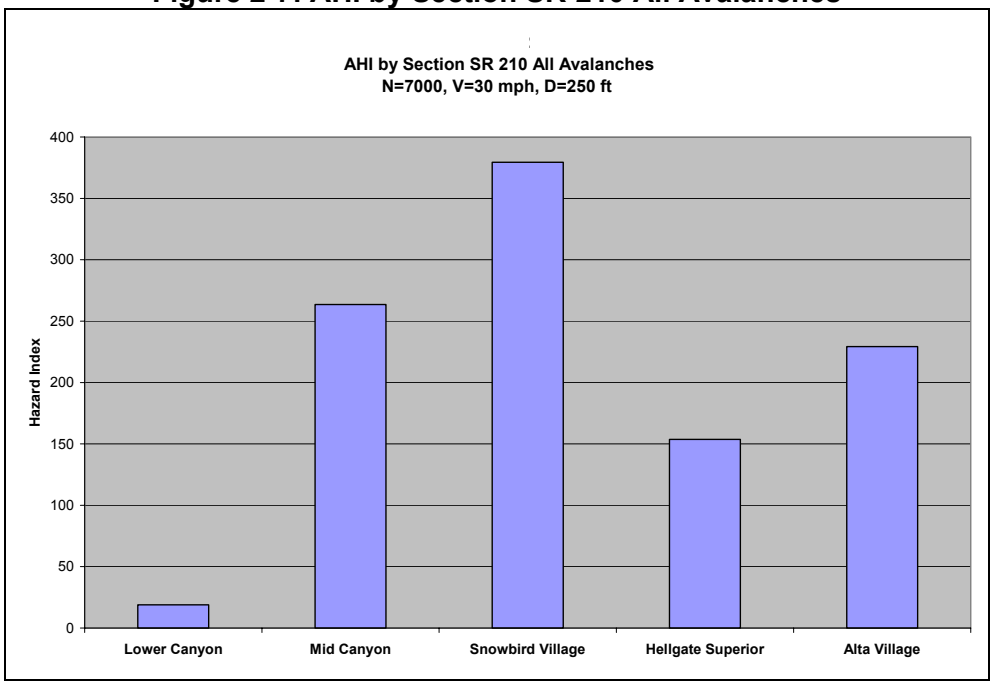


Note: The variables are winter average daily traffic N=7000, average traffic speed V=50 km/h (30 mph) and the stopping distance D=75 m (250 ft).

The index values for the road indicate a severe hazard spread through a large number of relatively high frequency and closely spaced avalanche paths. An important factor in this is the high traffic volume (7000 vehicles) and the resultant long queue of waiting traffic if an avalanche blocks the road (2188 m or 1.3 miles for a waiting period of 1 hour). The highest hazard is encountered at the Superior path.

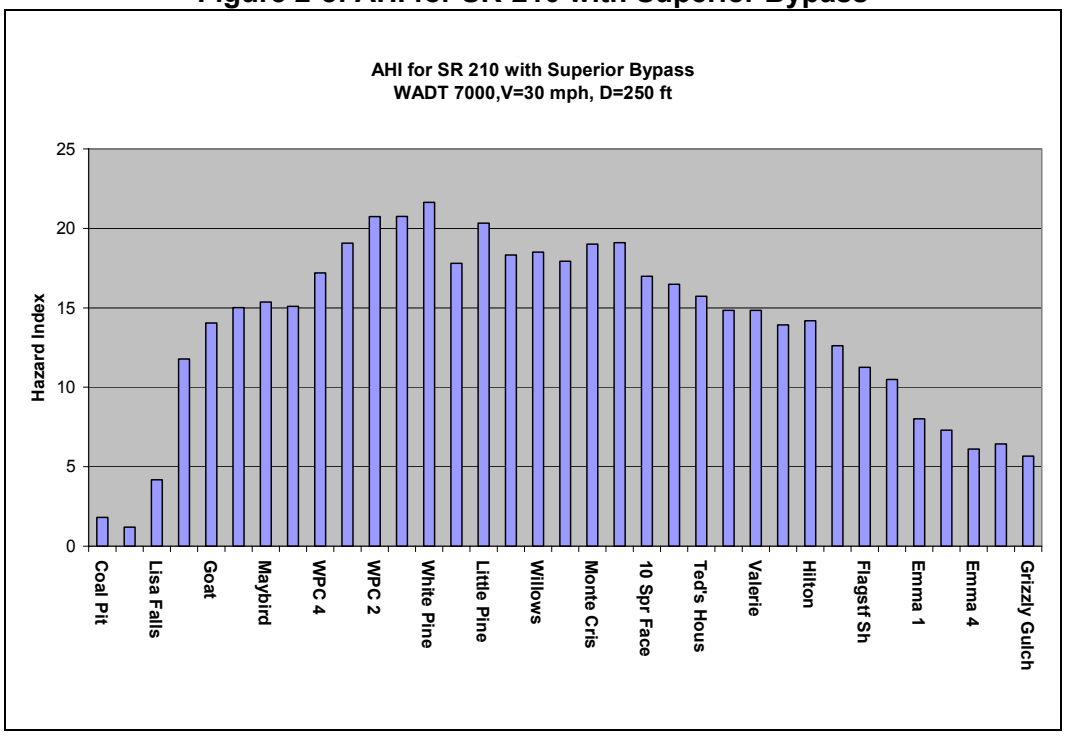
Figure 2-7 shows how the indices from Figure 2-6 combine to form AHI rankings for each of the six canyon sections. For each canyon section, the AHI for individual avalanche paths in that section are added together to determine a cumulative canyon section AHI.

Figure 2-7: AHI by Section SR-210 All Avalanches



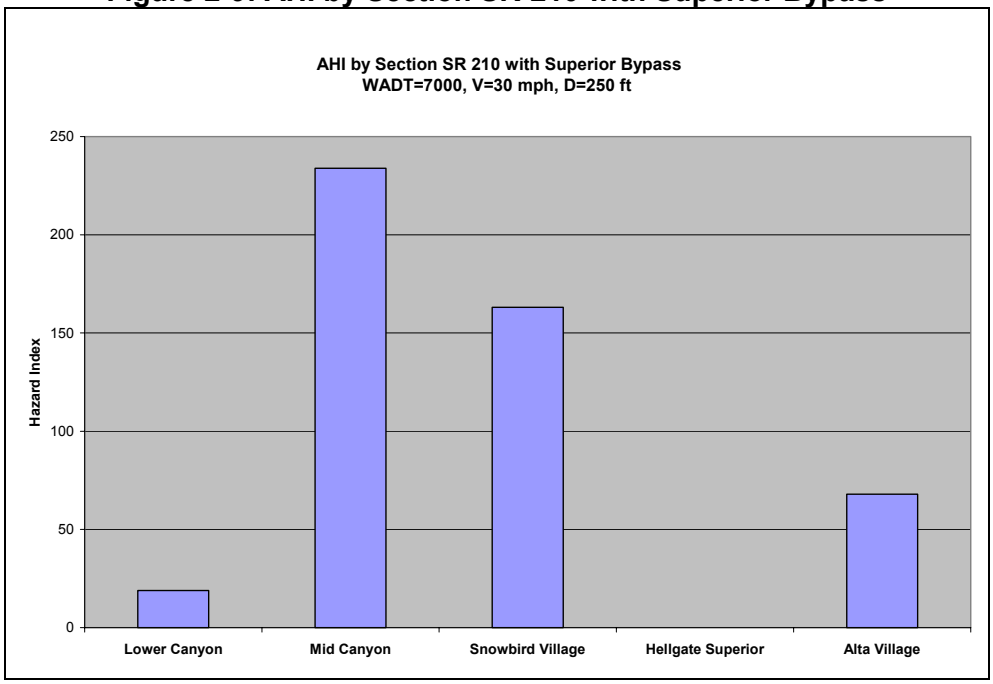
This result is no great surprise given the high frequency of avalanches at Hellgate and Superior and their impact on waiting traffic in the Snowbird, Superior and Alta groups. If the Superior Bypass is in effect and we take the hazard from Hellgate-Superior out of the equation, then the data are significantly different (Figure 2-8).

Figure 2-8: AHI for SR-210 with Superior Bypass



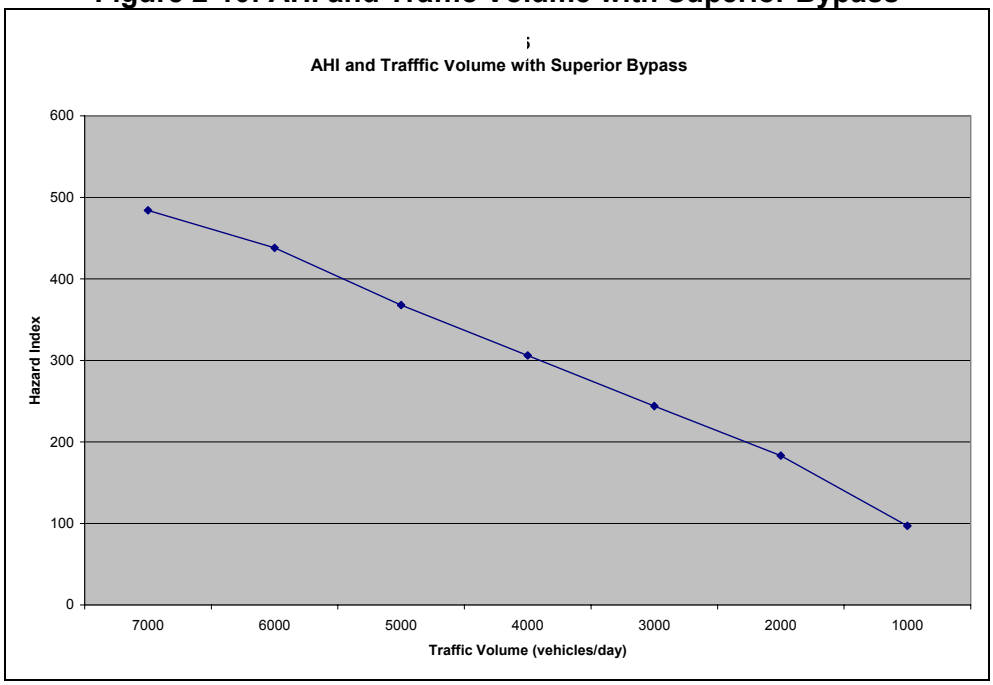
Given the Superior Bypass, it is the White Pine group of avalanche paths which stand out. Figure 2-9 depicts the AHI by section of the canyon with the Superior Bypass in effect.

Figure 2-9: AHI by Section SR-210 with Superior Bypass



With the Superior Bypass in effect, the Mid-Canyon becomes the priority followed by the Snowbird group of paths. It is not, however one or two paths which present the hazard but rather several avalanche paths.

Figure 2-10: AHI and Traffic Volume with Superior Bypass



The effect of traffic volume with the Superior Bypass in place is illustrated in Figure 2-10. The solutions for reducing the hazard on SR-210 must address multiple avalanche paths and could combine avalanche protection and traffic management.

The present system of artillery control is spread over the whole canyon with three gun positions allowing explosive control at most paths. Under the present system of avalanche control with artillery we can calculate the residual hazard by looking at those avalanches which have occurred with the road open (Figure 2-11). In this analysis we have used the actual frequency of road open occurrence of light and deep avalanches in the Mid Canyon and Snowbird sections, for which the best records exist. We have applied a uniform assumption of 1 in 100 year road open avalanches for the Alta section and the lower Canyon. It is reasonable to assume the frequency in the Alta section is lower but the data are incomplete so it is difficult to be more specific.