**Section B**

# SURFACE AND POINT SOURCE EROSION (ROADS/SKID TRAILS)

## Introduction

The surface and point source erosion module examines the past and present soil erosion from roads and skid trails of the Mendocino Redwood Company (MRC) ownership in the Willow/Freezeout Creeks watersheds, the watershed analysis unit (WAU). This module also provides a hazard assessment of the potential for future surface and point source erosion from roads in the Willow/Freezeout Creeks WAU. The potential erosion assessment is to assist in development of mitigation measures and actions to minimize future soil erosion from the road network. The road data that is the basis for most of this analysis was collected by MRC during a 100% road inventory of the Willow/Freezeout Creeks WAU. The erosion estimates utilize a combination of field observations and the use of the surface erosion model presented in the Standard Methodology for Conducting Watershed Analysis (Version 3.0, Washington Forest Practices).

Surface erosion is defined as the removal of soil particles from the surface of the soil. Processes such as rill erosion, sheetwash, biogenic transport (animal burrows, treefall, etc.) and ravel are considered surface erosion. Gullies, road crossing wash-outs, and large erosion features created by erosion from overland flow of water are considered point source erosion. In contrast, the largest discrete erosion event, landslides, are considered mass wasting.

This module examines road and skid trail associated surface and point source erosion delivering sediment into watercourses. The module also presents results from analysis done on hillslope point source erosion (grassland and forested gullies) by Trihey and Associates (1995) in the Willow Creek watershed. Excessive levels of fine sediments from surface and point source erosion can get trapped in porous streambed gravels; and can increase water turbidity and suspended sediment concentrations. Excessive coarse sediments from point source erosion can adversely affect stream channel morphology. These can reduce the survival of salmonids in their redds or affect habitat needs and physiological characteristics of rearing salmonids. Excessive surface and point source erosion when delivered to a watercourse can also affect other downstream uses such as water supplies, agricultural diversions and recreation users. It is important that best management practices be utilized in forest management operations to minimize the impacts of surface and point source erosion.

## Surface and Point Source Erosion from Roads

### *Methods*

Past, current and potential surface and point source erosion from roads was determined from field observations and a road surface erosion model. All of the roads in the Willow/Freezeout Creeks WAU were visited in the field during a road inventory of the Willow/Freezeout Creeks WAU (2000).

The road inventory consisted of traveling the road with a Global Positioning System (GPS) unit, identifying, mapping and inventorying all major features of the road network. Some of the features that are inventoried include watercourse-crossings and crossing structures (culverts, bridges, etc.), landings, erosion features and controllable erosion amounts (as defined below). Information relating to erosion and sediment delivery from the road inventory is analyzed in this report. Also dimensions of the road network such as length, width and sediment contributing road lengths are summarized. The road inventory collects information on the entire road infrastructure. This road infrastructure information allows for better management and tracking of the MRC road network, but is not presented in this report.

All road features (watercourse crossings, landings, road fill, etc.), during the road inventory, have the past deliverable point source erosion volume estimated for that feature. Deliverable point source erosion from a road is defined as rill or gully erosion which is observed in close proximity to a watercourse or which showed evidence of eroding directly into a watercourse. These measurements were used to calculate the volume of point source erosion delivered from the road. The volume of erosion was converted to a weight (in tons) assuming a soil bulk density of 100 lbs./cubic foot.

Future or potential point source erosion (gully or road fill wash-outs, not sheetwash) observations were collected during the road inventory. This potential future erosion is called controllable erosion, a term developed by the North Coast Regional Water Quality Control Board for Total Maximum Daily Load (TMDL) purposes. Controllable erosion is defined as soil that could potentially deliver to a watercourse in the next 40 years (the duration of a TMDL), is human created, and can be reasonably controlled by human actions. Typically controllable erosion is a measure of the fill material from a road that could erode if a road feature is left un-maintained or fails in the next 40 years. The controllable erosion amount is the volume of soil that can be controlled with high design standards for a road feature (i.e. watercourse crossing, side-cast fill, etc.).

The controllable erosion sites are further designated by the potential for sediment delivery and the immediacy of treatment for the site. Both the sediment delivery potential and the treatment immediacy are ranked low, moderate or high. The ranking of each controllable erosion site by these variables provides a hazard or risk assessment of the controllable erosion. This allows prioritization of road improvements and erosion control work.

Another important variable of potential future point source erosion from a road is the likelihood of diversion of water down the road prism. This diversion potential, as it is called, was evaluated for every watercourse crossing of every road in the

Willow/Freezeout Creeks WAU. A site has a diversion potential if when the watercourse crossing plugged, dammed or failed water could be diverted out of the "natural" watercourse channel and down the road prism. Water diverted out of its "natural" channel would erode the road prism creating potentially high sediment delivery. Sites with a diversion potential can be engineered such that the diversion of water down a road prism does not occur if the watercourse crossing plugged, dammed or failed.

Proper culvert sizing is another important characteristics for consideration of road erosion potential. Culverts that do not have the capacity to pass debris, water and sediment in high flow events can plug creating road prism failures with high sediment inputs. MRC currently designs all new culvert installations to pass the 100 year flood to ensure enough capacity in the pipe to pass water, debris and sediment in high flows. To determine if culvert sizing is appropriate for existing culverts the area behind each culvert inventoried is determined from topography data in the MRC Geographic Information System (GIS). The regression equation for the North Coast region (Waananen and Crippen, 1977) is used to predict the 50 and 100 year peak flow. A culvert sizing nomograph is used to determine the appropriate size for 50 and 100 year peak flow magnitudes and that predicted size is compared to the existing culvert sizing to determine if the culvert is large enough.

Surface erosion (sheetwash from the road tread and prism) from roads was not directly estimated in the field, the contributing length or extent of road that delivers erosion to a watercourse is measured in the field then used for surface erosion calculations. The contributing length of a road is the length of road prism that drains water and associated eroded soil into a watercourse. Thus it defines the length of surface erosion of any particular site on the road. The model used to calculate surface erosion from roads is from the Standard Methodology for Conducting Watershed Analysis (Version 3.0, Washington Forest Practices Board) and is described below.

Surface erosion from the road surface is influenced by the amount of road traffic (high use mainline, moderate use active secondary, etc.), the type of road surface material, precipitation, width and size of road (the more surface area to erode the more erosion), and vegetative cover (Reid, 1981). The Standard Methodology for Conducting Watershed Analysis (Version 3.0, Washington Forest Practices Board) provides relationships based on these factors to estimate the amount of surface erosion from different road types and conditions. For a complete description of all of the parameters used in calculating surface erosion from roads see the Standard Methodology for Conducting Watershed Analysis (Version 3.0, Washington Forest Practices Board).

Field observations from the road inventory determined the length of the road delivering sediment to a watercourse (contributing length), the road width, the road surface material and the type of road (seasonal or temporary) to aid in the surface erosion calculations. In some cases the road inventory lacked contributing road length. In these cases the contributing road length was assumed to be 200 feet. Typically culverts that drain an inside ditch of a road (cross-drain culverts) put the water and eroded soil on a hillslope and do not deliver to a watercourse. The exception to this is when the cross drain culvert is in close proximity to a watercourse. To account for this all cross-drain culverts within 200 feet of a watercourse were assumed to deliver sediment and surface

erosion. If a contributing road length was not collected for these features a 200 foot contributing length is assumed for the surface erosion modeling.

The following parameters were used to calculate surface erosion from roads in the Willow/Freezeout Creeks WAU. All of the observed roads were assumed to be older than 2 years, a base erosion rate of 60 tons/acre/year was used. This initial value was altered (multiplied) by the factors of traffic on the road, cut- and fill-slope vegetation cover, road surface type, annual precipitation and road type in an attempt to model the actual sediment volume contributed by a given road segment. The road tread width was determined in the field during the road inventory and is assumed to be 40% of the road prism. The cut- and fill-slopes are assumed to 60% of the road prism; their dimensions for the surface erosion model were determined by multiplying the tread width by 1.5.

Road cut- and fill-slopes usually had approximately 50% vegetative cover, giving a cover factor of 0.37. The majority of hauling on roads occurs during drier times of the year (i.e. late spring, summer and early fall). Therefore the lowest annual precipitation category is used (<47 in. precipitation annually). In this annual precipitation category a road with at least a 6 inch rock surface is given a factor of 0.2, while a native surface road has a factor of 1.

There were 4 traffic factors used in surface erosion modeling:

1) *Mainline roads with heavy traffic* have a factor of 20; these roads are actively used and maintained for log haul traffic.
2) *Mainline roads with moderate traffic* have a factor of 2; these roads are used for log haul traffic 2-3 times each decade.
3) *Seasonal roads* have a traffic factor of 1.2; these are tributary roads which receive moderate log haul traffic 1-2 years each decade and light traffic the remainder of the time.
4) *Temporary roads* receive a traffic factor of 0.61; these roads receive moderate log haul traffic 1-2 times per every 1-2 decades with little to no use in between.

The result of the surface erosion modeling is added to the total past point source erosion observed during the road inventory from a given road and presented as tons/year of sediment delivery (see Appendix B for erosion estimates of each road in the Willow/Freezeout Creeks WAU). For relative sediment contributions from each planning watershed for roads for sediment input evaluation the tons/year calculations for all roads was totaled by planning watershed and normalized by dividing by the MRC ownership, in square miles, for the planning watershed. The result is a tons/square mile of MRC ownership/year estimate of road surface and point source erosion.

Finally, with this information each road in the Willow/Freezeout Creeks WAU is assigned an erosion hazard class. The erosion hazard class is used to classify the roads in the Willow/Freezeout Creeks WAU by their current and potential erosion hazard. The erosion hazard class was determined by the amount of erosion a road produced and the likelihood for that erosion to be delivered to a watercourse. High levels of traffic, road surface, proximity to the stream, high past point source erosion, and high modeled surface erosion all were considered when ranking roads for their erosion hazard. The roads with the highest risk of sediment delivery and soil erosion were given a high erosion hazard

classification. The roads with medium risk of sediment delivery and soil erosion were given a moderate erosion hazard classification. The roads with the lowest risk of sediment delivery and soil erosion were given a low erosion hazard classification. A description of what each erosion hazard classification means can be found in the Road results and discussion sub-section of this Surface and Point source Erosion report.

### *Road Surface and Point Source Erosion Results and Discussion*

The surface and point source erosion estimates by planning watershed are presented in Table B-1. The breakdown of estimated erosion, road areas, road lengths and hazard rating by individual roads is in Appendix B of this report.

Roads in the MRC ownership in the Willow Creek planning watershed are estimated to generate, on average, 119 tons/mi$^2$/yr of sediment from road associated surface and point source erosion. Roads in the MRC ownership in the Freezeout Creek planning watershed are estimated to generate, on average, 138 tons/mi$^2$/yr of sediment from road associated surface and point source erosion. (Table B-1). Roads in the Dutch Bill Creek watershed are estimated to generate 68 tons/mi$^2$/yr of sediment. It must be noted that observations of road erosion at one point in time do not accurately reflect the characteristics of the road over time. For example, a culvert or road erosion site may have failed several times over its life, but it is not possible to determine that from current observations. Therefore the estimates of sediment yield are likely a minimum estimate.

Table B-1. Road Associated Surface and Point Source Erosion Estimates by Planning Watershed for the Willow/Freezeout Creeks WAU.

| **Planning Watershed** | **Total Road Assoc. Erosion (tons/yr)** | **Total Acres PLWS** | **MRC Owned Acres** | **Road Assoc. Erosion Rate (tons/sq mi/yr)** |
|---|---|---|---|---|
| Willow Creek | 546 | 11558 | 2928 | 119 |
| Freezeout Creek | 355 | 8954 | 1647 | 138 |
| ***Willow/Freezeout Creeks WAU*** | ***901*** | ***-*** | ***4575*** | ***105*** |

The erosion rate, though only an estimate, provides a good indicator of where road associated surface and point source erosion issues are currently occurring. However, the timing and amount of road use affects the amount of erosion estimated from a road. If the assumptions on the timing or amount of road used change, the erosion rate estimates may lose their reliability as an indicator of problem areas. Another indicator that can help in interpreting a potential road associated surface of point source erosion risk is the amount and density of road, and the amount of road that contributes erosion to a watercourse (contributing area). The road density and road area totals are presented for each planning watershed in the Willow/Freezeout Creeks WAU (Table B-2).

Road length and surface area is highest in the Willow Creek planning watershed (Table B-2). The amount of contributing road area (sediment delivery area) is similar

between Willow Creek and Freezeout Creek, however proportionately Freezeout Creek has much less road so the contributing road area is of greater concern for the Freezeout Creek roads. It should be a goal to lower the contributing road area in the Willow/Freezeout Creeks WAU particularly in the Freezeout Creek watershed.

Table B-2. Road Surface Areas, Contributing Road Surface Areas, Road Lengths and Road Densities for the Willow/Freezeout Creeks WAU.

| **Planning Watershed** | **Road Surface Area (ac)** | **Road Contributing Area (ac)** | **Road Length (miles)** | **Road Density (mi/sq mi)** |
|---|---|---|---|---|
| Willow Creek | 63 | 9 | 33.0 | 7.2 |
| Freezeout Creek | 36 | 7 | 18.5 | 7.2 |
| ***Willow/Freezeout Creeks WAU Total*** | ***99*** | ***16*** | ***51.5*** | ***7.2*** |

The road erosion hazard classification for each road in the Willow/Freezeout Creeks WAU is presented on Map B-1 and for each individual road in the appendix of this module. The categorizing of roads into hazard classes is intended to identify current problem areas, consider reconstruction and prioritize maintenance. The following are the definitions for each road erosion hazard class.

High Road Erosion Hazard Class - These roads have the highest amount of recent deliverable surface erosion to watercourses and a high potential for future deliverable erosion. These roads can be active, abandoned or closed. Often roads in this class are close to watercourses creating a high sediment delivery potential. Erosion is typically due to long contributing road lengths or native surfaces near watercourses: a result of too few waterbars and/or rolling dips or lack of rock surface. Erosion may also be a product of problem areas such as watercrossing wash-outs, poor road drainage, plugged road watercrossings, water diverted down the road surface, culverts not fitted with downspouts, etc. Active roads in this class should get the highest priority for maintenance or improvements. Closed roads in this class will need improvements before opening again. Opening abandoned roads in this class should be avoided.

Moderate Road Erosion Hazard Class - These roads have moderate amounts of recent deliverable surface erosion to watercourses and potential for future deliverable erosion. These roads can be active, abandoned or closed. Erosion problems on roads in this class can usually be handled with good road maintenance. Erosion is typically from problem areas such as poor road drainage, water diverted down the road surface, culverts not fitted with downspouts, and an occasional plugged culvert or watercourse crossing wash-out. Active roads in this class should be a priority for maintenance. Closed or abandoned roads in this class will need some improvements before opening again.

Low Road Erosion Hazard Class - These roads have low amounts of recent deliverable surface erosion to watercourses and low potential for future deliverable erosion. These roads can be active, abandoned or closed. Active roads in this class do not need to be a priority for maintenance. Closed or abandoned roads in this class will need only some improvements before opening again.

Potential controllable (point source) erosion sites were identified and prioritized in the Willow/Freezeout Creeks WAU. In the Willow/Freezeout Creeks WAU 6 controllable erosion sites have a high treatment immediacy and 20 controllable erosion sites have a moderate treatment immediacy. In addition to these controllable erosion sites 54 culverts in the Willow/Freezeout Creeks WAU have a diversion potential. These diversion potential sites need to be considered a high priority for road improvement as they can represent a significant potential point source erosion hazard. The treatment immediacies, road site numbers and road numbers are found on Map B-2. The road number and site number of each controllable erosion and diversion potential site is in Appendix B of this report.

The culvert size analysis has determined that 26 culverts are likely too small to pass the 50 year flood and an additional 3 culverts will not pass the 100 year flood. These culverts need to be a high priority for upgrade should they indeed be under-sized. The analysis of culvert sizing is only an estimate based on culvert location from the MRC road inventory and area behind the culvert based on MRC GIS topographic data. A field review will be required at each site to determine if the culvert is indeed under-sized, as our confidence in the analysis is low. However, the identification of these culverts as under-sized is a good hypothesis to work from and provides information to address potential road problems in Willow/Freezeout Creeks WAU.

## Surface and Point Source Erosion from Skid Trails

### *Methods*

Sediment delivery from surface and point source erosion from skid trails was determined from aerial photograph interpretation and sediment delivery estimates developed in previous MRC watershed analysis's (MRC, 1998 and MRC, 2000). Aerial photographs from 1961, 1971, 1978, 1980, 1996 and 2000 were used to identify skid trail activity.

The aerial photograph interpretation for skid trail activity consisted of determining the area harvested by ground based yarding by skid trail density (high, moderate, low) for each photo year. High-density skid trail activity is defined as having greater than 100 watercourse crossings per square mile. Moderate-density skid trail activity is defined as having between 50-100 watercourse crossings per square mile. Light skid trail density has less than 50 watercourse crossings per square mile or were trails with significant re-vegetation observed in the aerial photograph.

The amount of sediment delivery from the various densities of skid trail activity was estimated from sediment delivery rates estimated during previous watershed analysis by MRC (MRC, 1998 and MRC, 2000). A combination of surface erosion modeling and field observations of point source erosion from skid trails were used develop the skid trail

estimates. High skid trail density is estimated to contribute 300 tons/square mile/year of sediment. Moderate skid trail density is estimated to contribute 200 tons/square mile/year of sediment, while low skid trail density contributes 50 tons/square mile/year.

For each photo year the area in each skid trail density category was multiplied by the sediment delivery rate for that density. The estimated rate was then assumed to represent the decade previous to the photo year observed (i.e. 1961 photo represent activity in the 1950s). The exception being photo years that were in mid-decade or near the end of a decade, these were considered as part of that decade (i.e. 1978 is considered an observation for the 1970s).

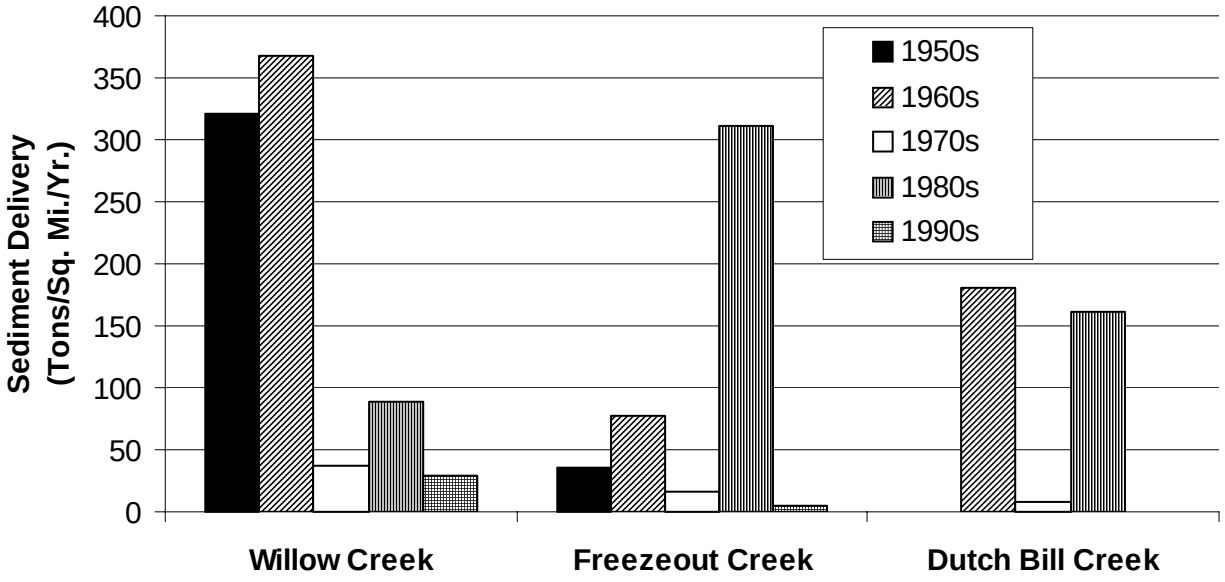
***Skid Trail Erosion Results and Discussion***

The results by time period for the skid trail sediment delivery estimates are summarized in Table B-3 and Chart B-1. The estimates should be considered only as a minimum sediment delivery for skid trails constructed and used in the decade. Undoubtedly, some if not many, sediment delivering skid trails were vegetated enough to be overlooked during the inventory. In particular are those trails constructed or used greater than five years prior to aerial photograph reconnaissance may be re-vegetated and not observed.

Table B-2. Skid Trail Use and Sediment Delivery Estimates for Willow/Freezeout Creek WAU by Decade.

| | **Willow Creek** | | **Freezeout Creek** | | **Dutch Bill Creek** | |
|---|---|---|---|---|---|---|
| | Skid Trail Use Area (acres) | Sediment Delivery (tons/mi$^2$/yr) | Skid Trail Use Area (acres) | Sediment Delivery (tons/mi$^2$/yr) | Skid Trail Use Area (acres) | Sediment Delivery (tons/mi$^2$/yr) |
| **1950s** | 1225 | 320 | 370 | 35 | 0 | 0 |
| **1960s** | 1200 | 370 | 260 | 80 | 774 | 180 |
| **1970s** | 500 | 40 | 200 | 15 | 97 | 10 |
| **1980s** | 275 | 90 | 1120 | 300 | 380 | 160 |
| **1990s** | 375 | 30 | 55 | 5 | 0 | 0 |

Figure B-1. Estimated Skid Trail Sediment Delivery Rate by Watershed and Decade for the Willow/Freezeout Creek WAU.




In Willow Creek the entire forested portion of what is now the MRC ownership was harvested using tractor based yarding during the 1950s and 1960s. This high level of skid trail construction and use is estimated to contribute a high level of sediment delivery. The sediment delivery estimated from skid trails in Willow Creek is by far the highest in the 1950s and 1960s (Figure B-1). Freezeout Creek was almost completely harvested using tractor based yarding during the 1980s and thus the highest sediment delivery for that watershed occurred during that decade. Dutch Bill Creek lands had high skid trail use and sediment delivery in both the 1960s and the 1980s.

Skid trail sediment delivery diminishes in the 1990s in all watersheds. This is produced from a combination of less harvest activity and stricter regulations on tractor based yarding use. Future skid trail sediment delivery rates will be lower than past rates because California Forest Practice Rules and MRC policy mandate better managed tractor yarding activities. Better erosion control measures are used on skid trails such as increased water bar spacing and a practice by MRC of packing the trails with logging debris (slash), when available, after operations to prevent surface erosion. Furthermore, skid trail operation is limited next to watercourses and prohibited directly in watercourses.

**Surface and Point Source Erosion from Gullies**

Active gully erosion is prevalent in the Willow Creek watershed. Analysis by Trihey and Associates (1997) suggest both forested and grassland gullies have had accelerated erosion since the tractor logging in the 1950s and 1960s. The Trihey and Associates definition of forested gullies could be interpreted to be created from channel degradation and bank erosion processes and therefore be discussed in the Stream Channel

Condition module. However, it is being discussed in this section to keep the discussion together with the grassland gully evaluation.

Trihey and Associates conclude that creation of the forested gullies in Willow Creek are the result of clearing of stream-side trees in the 1950s and 1960s that would have been recruited to the stream channel. This lack of a large wood source has destabilized the bed of the channels creating down cutting and bank failures. Trihey and Associates assume that 80 percent the channel downcutting has occurred since the early 1950s. Measurements of cross section areas of the downcut channels has yielded an estimated 160 tons/mi$^2$/year in sediment production. This estimate is averaged over time, it is likely that the forest gully creation was episodic with a large amount of the erosion created in early years of this time frame following large storm events. It is not likely that the current erosion from forested gullies persist at as high a level, though continued erosion is prevalent.

The grassland gullies in Willow Creek are active erosion features. This type of gully erosion is common in the Franciscan complex found in the Willow Creek area. Highly sheared and weathered siltstones and sandstones often produce a plastic or clay texture to the soils. This high clay texture creates lower water infiltration capacity, increased surface water flow and thus a greater tendency for point source erosion. This higher clay texture is particularly prevalent in the grassland areas of the Franciscan complex as the lack of woody vegetation suggests poor growing conditions from the soil properties. This greater tendency for point source erosion in the grassland areas is exacerbated by concentrated drainage from road outfalls, re-routing of natural drainage by roads, grazing, or forest clearing for increased grassland. Trihey and Associates estimate the rate of grassland gully erosion at about 100 tons/mi$^2$/year.

**Conclusions**

The overall road surface and point source erosion rate for the Willow/Freezeout Creeks WAU is 105 tons/sq. mi./yr. Proportionately Freezeout Creek watershed has the highest level of sediment contributing road areas. The amount of sediment contributing road area needs to be considered for road improvements and erosion reduction throughout the Willow/Freezeout Creeks WAU. By reducing contributing road area the amount of road that contributes sediment during forest management operations is reduced.

Road density is currently averaging 7.2 miles of road to every square mile of land MRC owns. This density is high and needs to be a source of improvement.

The road network is classified as High, Moderate and Low surface erosion hazard (Map B-1). The roads with the high hazard are the highest priorities for improvements, monitoring or maintenance. The moderate hazard roads are a medium priority for improvements, monitoring or maintenance. The low hazard roads are not much of a concern for sediment delivery.

High and moderate treatment immediacy controllable erosion and diversion potential sites were identified along the roads in the Willow/Freezeout Creeks WAU and needs to be a focal point of ongoing forest operations. The Willow/Freezeout Creeks WAU currently has 6 high treatment immediacy sites, 20 moderate immediacy sites and 54 sites with a diversion potential. Potentially 26 culverts are too small to pass the 50

year flood and 3 additional culverts likely will not pass the 100 year flood. These sites will be a priority for improvement of the road network in the Willow/Freezeout Creeks WAU. The road number, site number for each individual site is shown on Map B-2 and in Appendix B of this report.

Sediment delivery from skid trails was found to be highest in the Willow Creek in the 1950s and 1960s. Freezeout Creek had high sediment delivery in the 1980s, while Dutch Bill Creek had sediment delivery peaks in the 1960s and 1980s. This is mainly due to a high amount construction and use of skid trails during these time periods. Future skid trail sediment delivery rates will be lower than current or past rates because California Forest Practice Rules and MRC policy requires cable yarding on steep ground. Much of the skid trail erosion in the WAU came from skid trail use on steep terrain before the current Forest Practice Rule restrictions. Furthermore, skid trail operation next to or directly in watercourses is now restricted.

Forested and grassland gullies have been observed to be large sediment production areas in Willow Creek. Trihey and Associates (1997) estimate forested gully sediment production over the last 40 years at 160 tons/mi$^2$/year and grassland gully erosion at 100 tons/mi$^2$/year.

**Literature Cited**

Trihey and Associates. 1995. Sediment supply and sediment transport conditions Willow Creek, Sonoma County, California. Report prepared for State Department of Parks and Recreation Russian River – Mendocino District.

Louisiana-Pacific Corporation. 1998. Garcia River watershed analysis. Internal report, Fort Bragg, CA.

Mendocino Redwood Company. 2000. Noyo River watershed analysis. Internal report, Fort Bragg, CA.

Trihey and Associates. 1997. Sediment production estimates and restoration concepts for the Willow Creek watershed Sonoma County, California. Prepared for: San Francisco State University and State Department of Parks and Recreation. Sacramento, CA.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and flood frequency of floods in California. U.S. Geological Survey. Water Resources Investigation 77-21. Menlo Park, CA 96 p.

Washington Forest Practice Board. 1995. Standard methodology for conducting watershed analysis. Version 3.0. WA-DNR Seattle, WA.

# Willow Creek / Freezeout Creek Watershed Analysis Unit

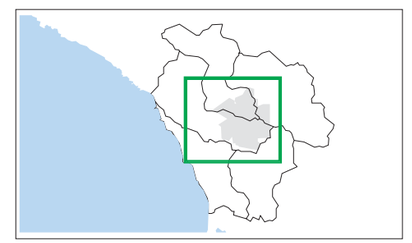
## Map B-1
## Road Surface Erosion Hazard Ratings

Erosion Hazard Rating
- Low
- Moderate
- High
- MRC Ownership
- Planning Watershed Boundary

Transportation
- Paved Road
- Rocked Road
- Native Road
- Jeep Trail
- Railroad
- WLPZ Roads

Flow Class
- Class I
- Class II
- Class III

Topography
- Index Contour (200′ interval)
- Regular Contour (40′ interval)



0 1/2 1 Mile



February 12, 2001

# Willow Creek / Freezeout Creek Watershed Analysis Unit

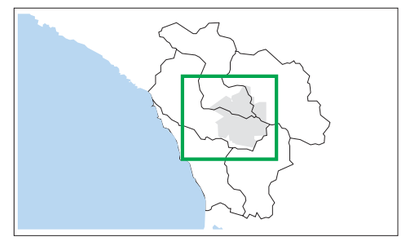
## Map B-2
## Road Feature
## Treatment Immediacy

| Culverts | Crossings | Landings |
|---|---|---|
| High | High | High |
| Moderate | Moderate | Moderate |
| Low | Low | Low |
| None | None | None |
| Undetermined | Undetermined | Undetermined |

MRC Ownership

Planning Watershed Boundary

| Transportation | Flow Class |
|---|---|
| Paved Road | Class I |
| Rocked Road | Class II |
| Native Road | Class III |
| Jeep Trail | |
| Railroad | |



N W E S

0 1/2 1 Mile



February 12, 2001

# Appendix B

## Surface Erosion Module

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-TG-006-03 | 3 | humboldt | high | 380 | high | REALLY BAD-STORED SED. ABOVE HUMBOLDT |
| 98-FO-011 | 1 | Landing | high | 230 | high | STREAM RUNING IN LANDING |
| 98-TG-006-03 | 2 | major rilling | high | 200 | high | |
| 98-RT-028 | 4 | watercourse | high | 80 | high | |
| 98-RT | 5 | watercourse | moderate | 370 | high | |
| 98-TG | 2 | watercourse | moderate | 30 | high | CULVERT EXPOSED IN ROAD |
| 98-FS004 | 1 | ditch relief | high | 200 | moderate | CONTROL WITH SLIDE FAILING MORE |
| 98-RT028 | 8 | watercourse | high | 75 | moderate | |
| 98-RT-024 | 5 | watercourse | high | 10 | moderate | |
| 98-BS-009-04 | 2 | Landing | high | 0 | moderate | |
| 98-BS | 3 | watercourse | moderate | 300 | moderate | CULVERT ON OLD HUMBOLDT |
| 98-FO-022 | 1 | Landing | moderate | 180 | moderate | |
| 98-WC-011 | 6 | watercourse | moderate | 140 | moderate | |
| 98-RT | 4 | watercourse | moderate | 130 | moderate | |
| 98-WC-011 | 5 | watercourse | moderate | 110 | moderate | |
| 98-WC-011 | 15 | bridge | moderate | 80 | moderate | |
| 98-WC-011 | 15 | bridge | moderate | 80 | moderate | |
| 98-WC-011 | 1 | watercourse | moderate | 60 | moderate | washout filled w/rock |
| 98-WC-011-04 | 1 | other | moderate | 50 | moderate | |
| 98-FS-002-02 | 2 | dipped | moderate | 45 | moderate | |
| 98-FS-002-02 | 1 | dipped | moderate | 35 | moderate | |
| 98-TG | 3 | watercourse | moderate | 30 | moderate | 0 |
| 98-BS | 6 | gully | moderate | 30 | moderate | WATERCOURSE |
| 98-RT-024-04 | 5 | Landing | moderate | 0 | moderate | |
| 98-WC | 14 | ditch relief | low | 15 | moderate | |
| 98-WC | 4 | ditch relief | low | 10 | moderate | |
| 98-BS-012 | 1 | watercourse | high | 925 | low | OLD CULVERT BELOW NEW |
| 98-BS-012 | 2 | watercourse | high | 200 | low | |
| 98-RT028 | 13 | bridge | high | 150 | low | RAILS NEED REPAIR |
| 98-TG-006 | 1 | dipped | high | 130 | low | |
| 98-WC--022 | 2 | dipped | high | 72 | low | |
| 98-BS | 1 | bridge | high | 70 | low | |
| 98-RT-024 | 4 | watercourse | high | 60 | low | |
| 98-RT028 | 9 | Landing | high | 50 | low | |
| 98-RT028 | 7 | watercourse | high | 50 | low | 50 ft FROM INTERSECTION |
| 98-RT028 | 10 | ditch relief | high | 15 | low | |
| 98-RT-028 | 6 | ditch relief | high | 10 | low | 300 ft FROM LAST CULVERT |
| 98-FO | 30 | watercourse | high | 7 | low | |
| 98-FO | 29 | watercourse | high | 7 | low | |
| 98-BS | 2 | ditch relief | high | 2 | low | CULVERT UNDER BRIDGE LOG RAIL |
| 98-RT | 6 | watercourse | moderate | 500 | low | |
| 98-FO | 7 | watercourse | moderate | 230 | low | |
| 98-WC-021 | 3 | watercourse | moderate | 120 | low | FRIST MAJOR DRAW FROM LAST GPS POINT |
| 98-RT-024-02 | 2 | Landing | moderate | 90 | low | |
| 98-BS-009 | 1 | watercourse | moderate | 90 | low | |
| 98-HC-022 | 1 | other | moderate | 70 | low | |
| 98-FO | 25 | watercourse | moderate | 60 | low | |
| 98-HC-022 | 3 | other | moderate | 60 | low | |
| 98-RT028 | 12 | Landing | moderate | 55 | low | |
| 98-RT-024 | 2 | watercourse | moderate | 50 | low | |
| 98-FO | 24 | watercourse | moderate | 50 | low | |
| 98-WC | 22 | gully | moderate | 46 | low | |
| 98-FO | 9 | watercourse | moderate | 45 | low | ON ROAD UP FROM LANDING |
| 98-FS-002-03 | 1 | Landing | moderate | 35 | low | class 3 through landing |
| 98-BS | 4 | Landing | moderate | 30 | low | SLASH OVER SIDE |
| 98-RT-028 | 5 | watercourse | moderate | 25 | low | NEXT WATERCOURSE ON MAP |
| 98-TG | 1 | watercourse | moderate | 20 | low | |
| 98-RT-024 | 1 | watercourse | moderate | 20 | low | |
| 98-FS-26-02 | 1 | watercourse | moderate | 20 | low | |
| 98-RT028 | 11 | watercourse | moderate | 15 | low | TWO CULVERTS |
| 98-FO | 8 | watercourse | moderate | 15 | low | 100 FT FROM CROSSING ON MAP |
| 98-RT-024-04 | 3 | watercourse | moderate | 10 | low | DRAINS WATERCOURSES UP ROAD |
| 98-FO | 26 | ditch relief | moderate | 10 | low | |
| 98-FO | 27 | ditch relief | moderate | 10 | low | |

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-RT-024 | 3 | watercourse | moderate | 9 | low | 300 ft DOWN ROAD FROM CULVERT |
| 98-BS | 5 | watercourse | moderate | 3 | low | |
| 98-WC-011 | 7 | gully | moderate | 0 | low | |
| 98-WC | 28 | watercourse | low | 890 | low | |
| 98-WC | 29 | watercourse | low | 660 | low | CULV. SPLIT ROAD SLIP OUT |
| 98-RT | 9 | watercourse | low | 555 | low | COW DESTROIED ROAD |
| 98-FS-28-02 | 1 | watercourse | low | 520 | low | |
| 98-RT | 3 | watercourse | low | 500 | low | ROOT WAD IN FRONT OF INLET |
| 98-RT | 2 | watercourse | low | 460 | low | |
| 98-RT | 1 | watercourse | low | 370 | low | |
| 98-WC | 32 | watercourse | low | 350 | low | |
| 98-WC-011-02 | 5 | Landing | low | 160 | low | |
| 98-FO | 20 | watercourse | low | 160 | low | |
| 98-WC | 8 | watercourse | low | 160 | low | |
| 98-WC-011 | 2 | watercourse | low | 150 | low | |
| 98-WC | 7 | watercourse | low | 150 | low | |
| 98-WC-011-02 | 2 | humboldt | low | 150 | low | |
| 98-WC | 30 | watercourse | low | 140 | low | |
| 98-WC | 18 | watercourse | low | 140 | low | |
| 98-WC | 16 | watercourse | low | 140 | low | |
| 98-WC | 15 | watercourse | low | 140 | low | |
| 98-WC | 10 | watercourse | low | 140 | low | |
| 98-WC | 19 | watercourse | low | 125 | low | |
| 98-FO | 16 | watercourse | low | 120 | low | |
| 98-WC | 6 | watercourse | low | 120 | low | |
| 98-WC-011 | 4 | watercourse | low | 100 | low | |
| 98-FS-002 | 12 | other | low | 100 | low | old logs covered w/fill |
| 98-FS-002 | 12 | other | low | 100 | low | old logs covered w/fill |
| 98-RT | 7 | Landing | low | 90 | low | |
| 98-BS-009 | 2 | Landing | low | 90 | low | |
| 98-HC | 20 | watercourse | low | 90 | low | |
| 98-WC | 38 | watercourse | low | 90 | low | |
| 98-WC | 35 | watercourse | low | 90 | low | |
| 98-FO | 19 | watercourse | low | 80 | low | |
| 98-WC | 25 | watercourse | low | 80 | low | |
| 98-WC | 11 | watercourse | low | 75 | low | |
| 98-WC | 24 | watercourse | low | 70 | low | |
| 98-WC | 23 | watercourse | low | 70 | low | |
| 98-WC-021-02 | 8 | watercourse | low | 70 | low | |
| 98-HC | 3 | watercourse | low | 62 | low | |
| 98-FO | 14 | watercourse | low | 60 | low | |
| 98-HC | 18 | watercourse | low | 60 | low | |
| 98-WC-021 | 2 | watercourse | low | 60 | low | |
| 98-BS-009 | 4 | Landing | low | 55 | low | |
| 98-FS-28-02 | 2 | watercourse | low | 55 | low | |
| 98-TG-006 | 3 | Landing | low | 50 | low | |
| 98-WC-011-02-01 | 1 | Landing | low | 50 | low | |
| 98-FO | 13 | ditch relief | low | 50 | low | |
| 98-WC-011 | 10 | watercourse | low | 50 | low | |
| 98-WC | 37 | watercourse | low | 50 | low | |
| 98-WC | 34 | watercourse | low | 50 | low | |
| 98-WC | 20 | watercourse | low | 50 | low | |
| 98-HC | 23 | bridge | low | 50 | low | |
| 98-HC | 21 | watercourse | low | 45 | low | |
| 98-WC | 51 | watercourse | low | 45 | low | CEMENT |
| 98-HC | 1 | watercourse | low | 40 | low | |
| 98-HC | 2 | ditch relief | low | 40 | low | |
| 98-HC | 10 | watercourse | low | 40 | low | |
| 98-HC | 12 | watercourse | low | 40 | low | |
| 98-HC | 13 | watercourse | low | 40 | low | |
| 98-WC | 53 | watercourse | low | 40 | low | CEMENT |
| 98-WC | 50 | watercourse | low | 40 | low | CEMENT |
| 98-WC | 43 | watercourse | low | 40 | low | |
| 98-WC | 41 | watercourse | low | 40 | low | |

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-WC-021-02 | 9 | watercourse | low | 40 | low | |
| 98-HC | 29 | bridge | low | 40 | low | |
| 98-WC-011-02 | 3 | gully | low | 40 | low | |
| 98-WC | 39 | watercourse | low | 35 | low | |
| 98-WC | 42 | watercourse | low | 35 | low | |
| 98-HC-023 | 2 | low water (temp) | low | 35 | low | |
| 98-FO | 12 | watercourse | low | 30 | low | |
| 98-FO | 21 | watercourse | low | 30 | low | |
| 98-FS-002 | 1 | watercourse | low | 30 | low | |
| 98-WC-011 | 11 | watercourse | low | 30 | low | |
| 98-WC | 54 | watercourse | low | 30 | low | CEMENT |
| 98-WC | 46 | watercourse | low | 30 | low | CEMENT |
| 98-WC | 21 | watercourse | low | 30 | low | |
| 98-WC-021-02 | 2 | watercourse | low | 30 | low | |
| 98-WC-021-02 | 6 | watercourse | low | 30 | low | |
| 98-WC-021-02 | 7 | watercourse | low | 30 | low | |
| 98-HC | 6 | watercourse | low | 25 | low | |
| 98-HC | 9 | watercourse | low | 25 | low | |
| 98-HC | 14 | watercourse | low | 25 | low | |
| 98-HC | 16 | watercourse | low | 25 | low | |
| 98-WC | 45 | watercourse | low | 25 | low | |
| 98-WC | 17 | ditch relief | low | 25 | low | |
| 98-FS | 1 | watercourse | low | 25 | low | |
| 98-WC-033 | 6 | watercourse | low | 25 | low | |
| 98-WC-033 | 5 | watercourse | low | 25 | low | |
| 98-WC-021-02 | 1 | watercourse | low | 25 | low | |
| 98-HC | 28 | bridge | low | 25 | low | |
| 98-WC-021-01 | 1 | Landing | low | 20 | low | |
| 98-FO | 28 | ditch relief | low | 20 | low | |
| 98-FO | 6 | ditch relief | low | 20 | low | |
| 98-FS-26 | 1 | watercourse | low | 20 | low | |
| 98-HC-018 | 2 | watercourse | low | 20 | low | |
| 98-HC | 25 | ditch relief | low | 20 | low | |
| 98-WC | 9 | ditch relief | low | 20 | low | |
| 98-WC | 5 | ditch relief | low | 20 | low | |
| 98-FS | 2 | watercourse | low | 20 | low | |
| 98-WC-021-02 | 4 | watercourse | low | 20 | low | |
| 98-WC-011 | 13 | dipped | low | 20 | low | |
| 98-WC-011 | 13 | dipped | low | 20 | low | |
| 98-WC-011-02-02 | 2 | dipped | low | 20 | low | |
| 98-WC-011-02-02 | 6 | dipped | low | 20 | low | |
| 98-WC | 36 | ditch relief | low | 18 | low | |
| 98-FS-26-02 | 2 | gully | low | 17 | low | |
| 98-HC | 26 | ditch relief | low | 15 | low | |
| 98-HC | 27 | ditch relief | low | 15 | low | |
| 98-WC | 52 | ditch relief | low | 15 | low | |
| 98-WC | 49 | ditch relief | low | 15 | low | |
| 98-WC | 48 | ditch relief | low | 15 | low | |
| 98-WC | 47 | ditch relief | low | 15 | low | |
| 98-WC | 44 | ditch relief | low | 15 | low | |
| 98-WC | 40 | ditch relief | low | 15 | low | |
| 98-WC | 33 | ditch relief | low | 15 | low | |
| 98-WC | 31 | ditch relief | low | 15 | low | |
| 98-WC | 13 | ditch relief | low | 15 | low | |
| 98-WC | 12 | ditch relief | low | 15 | low | |
| 98-WC | 3 | ditch relief | low | 15 | low | |
| 98-WC | 1 | ditch relief | low | 15 | low | |
| 98-FS-12 | 5 | ditch relief | low | 15 | low | |
| 98-FS-12 | 4 | ditch relief | low | 15 | low | |
| 98-FS-12 | 2 | ditch relief | low | 15 | low | |
| 98-FS-12 | 1 | ditch relief | low | 15 | low | |
| 98-WC-033 | 9 | ditch relief | low | 15 | low | |
| 98-WC-033 | 8 | ditch relief | low | 15 | low | |
| 98-WC-033 | 7 | ditch relief | low | 15 | low | |

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-WC-021-02 | 3 | ditch relief | low | 15 | low | |
| 98-WC-021-02 | 10 | ditch relief | low | 15 | low | |
| 98-FS-002 | 5 | dipped | low | 15 | low | |
| 98-FS-002 | 4 | dipped | low | 15 | low | |
| 98-FS-002 | 2 | dipped | low | 15 | low | |
| 98-FS-002 | 5 | dipped | low | 15 | low | |
| 98-FS-002 | 3 | dipped | low | 15 | low | |
| 98-HC-003 | 1 | dipped | low | 15 | low | |
| 98-WC | 27 | ditch relief | low | 14 | low | |
| 98-WC | 26 | ditch relief | low | 14 | low | |
| 98-FO | 5 | watercourse | low | 12 | low | |
| 98-HC | 17 | ditch relief | low | 12 | low | |
| 98-WC-033 | 10 | ditch relief | low | 12 | low | |
| 98-WC-033 | 4 | ditch relief | low | 12 | low | |
| 98-WC-033 | 3 | ditch relief | low | 12 | low | |
| 98-WC-033 | 2 | ditch relief | low | 12 | low | |
| 98-WC-021-02 | 5 | ditch relief | low | 12 | low | |
| 98-RT-002-02 | 1 | Landing | low | 10 | low | |
| 98-WC-021-02 | 1 | Landing | low | 10 | low | |
| 98-RT | 8 | ditch relief | low | 10 | low | COW DESTROIED ROAD |
| 98-FO | 17 | ditch relief | low | 10 | low | |
| 98-FS | 5 | ditch relief | low | 10 | low | |
| 98-WC-021 | 2 | watercourse | low | 10 | low | 40 FEET DOWN FROM LAST CULVERT |
| 98-FS-002-04 | 1 | dipped | low | 10 | low | dipped w/downspout |
| 98-FS-002 | 7 | dipped | low | 10 | low | |
| 98-FS-002 | 8 | dipped | low | 10 | low | |
| 98-FS-002 | 7 | dipped | low | 10 | low | |
| 98-FS-002 | 8 | dipped | low | 10 | low | |
| 98-HC-003 | 3 | dipped | low | 10 | low | |
| 98-HC-003 | 4 | dipped | low | 10 | low | |
| 98-HC-003 | 5 | dipped | low | 10 | low | |
| 98-HC-018 | 1 | dipped | low | 10 | low | |
| 98-WC-011-02-02 | 4 | dipped | low | 10 | low | |
| 98-FS-002 | 11 | dipped | low | 10 | low | |
| 98-HC-023 | 5 | dipped | low | 10 | low | |
| 98-FO | 10 | ditch relief | low | 8 | low | |
| 98-FO | 18 | ditch relief | low | 7 | low | |
| 98-FO | 11 | ditch relief | low | 5 | low | |
| 98-FO | 15 | ditch relief | low | 5 | low | |
| 98-FS-002-04 | 2 | dipped | low | 5 | low | |
| 98-BS | 7 | watercourse | low | 4 | low | |
| 98-BS-009-04 | 1 | ditch relief | low | 3 | low | |
| 98-FO | 2 | ditch relief | low | 3 | low | SLASH COVERING OUTLET |
| 98-FS-26 | 2 | ditch relief | low | 3 | low | |
| 98-FS-26 | 3 | ditch relief | low | 3 | low | |
| 98-RT-028 | 3 | Landing | low | 0 | low | |
| 98-RT | 10 | Landing | low | 0 | low | |
| 98-BS-013 | 1 | Landing | low | 0 | low | |
| 98-BS-007 | 1 | Landing | low | 0 | low | SLASH OVER SIDE |
| 98-BS-005 | 1 | Landing | low | 0 | low | |
| 98-BS-004 | 1 | Landing | low | 0 | low | |
| 98-RT-024-04 | 1 | Landing | low | 0 | low | |
| 98-FO | 4 | Landing | low | 0 | low | |
| 98-FS-002 | 10 | Landing | low | 0 | low | |
| 98-FS-002 | 14 | Landing | low | 0 | low | |
| 98-WC-011-04 | 2 | Landing | low | 0 | low | class 3 through landing |
| 98-WC-011 | 3 | Landing | low | 0 | low | |
| 98-WC-011 | 9 | Landing | low | 0 | low | |
| 98-FS-002 | 13 | Landing | low | 0 | low | |
| 98-FS-002-02 | 3 | Landing | low | 0 | low | |
| 98-HC-002-02 | 2 | Landing | low | 0 | low | |
| 98-HC | 4 | Landing | low | 0 | low | |
| 98-HC | 5 | Landing | low | 0 | low | |
| 98-HC | 7 | Landing | low | 0 | low | |

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-HC | 8 | Landing | low | 0 | low | |
| 98-HC-004 | 2 | Landing | low | 0 | low | |
| 98-HC-003-01 | 1 | Landing | low | 0 | low | |
| 98-HC-003 | 6 | Landing | low | 0 | low | |
| 98-HC-012 | 3 | Landing | low | 0 | low | |
| 98-WC-011-02-02 | 3 | Landing | low | 0 | low | |
| 98-WC-011-02-02 | 5 | Landing | low | 0 | low | |
| 98-WC-011-02-02 | 7 | Landing | low | 0 | low | |
| 98-WC-011-02-04 | 3 | Landing | low | 0 | low | |
| 98-WC-011-02-04 | 2 | Landing | low | 0 | low | |
| 98-WC-011-02 | 1 | Landing | low | 0 | low | |
| 98-FS | 6 | Landing | low | 0 | low | |
| 98-HC-012 | 1 | Landing | low | 0 | low | |
| 98-HC-023 | 3 | Landing | low | 0 | low | |
| 98-HC-023 | 4 | Landing | low | 0 | low | |
| 98-HC-002-04-01 | 1 | Landing | low | 0 | low | |
| 98-HC-002-04 | 3 | Landing | low | 0 | low | |
| 98-WC--022 | 1 | Landing | low | 0 | low | |
| 98-FS-12 | 7 | watercourse | low | 0 | low | |
| 98-FS-12 | 6 | watercourse | low | 0 | low | |
| 98-HC-023 | 1 | low water (temp) | low | 0 | low | |
| 98-WC-034 | 1 | dipped | low | 0 | low | |
| 98-FS004 | 1 | Landing | moderate | 0 | none | |
| 98-WC-021 | 4 | Landing | low | 50 | none | |
| 98-TG-005-02 | 1 | Landing | low | 40 | none | SLASH OVER SIDE |
| 98-TG-012 | 1 | Landing | low | 40 | none | 0 |
| 98-TG-012 | 2 | Landing | low | 40 | none | 0 |
| 98-RT-002 | 1 | Landing | low | 10 | none | |
| 98-FO | 23 | ditch relief | low | 4 | none | |
| 98-FO-022 | 2 | ditch relief | low | 3 | none | |
| 98-TG-005 | 1 | Landing | low | 0 | none | |
| 98-TG-006-03 | 5 | Landing | low | 0 | none | |
| 98-TG-006-03 | 1 | Landing | low | 0 | none | |
| 98-TG-006 | 2 | Landing | low | 0 | none | |
| 98-TG-006-02 | 1 | Landing | low | 0 | none | |
| 98-TG-004-02 | 1 | Landing | low | 0 | none | |
| 98-TG-004 | 1 | Landing | low | 0 | none | |
| 98-RT-002-02 | 2 | Landing | low | 0 | none | |
| 98-RT-003 | 1 | Landing | low | 0 | none | |
| 98-RT-026-01 | 1 | Landing | low | 0 | none | |
| 98-RT | 2 | Landing | low | 0 | none | |
| 98-RT | 1 | Landing | low | 0 | none | |
| 98-BS-009 | 3 | Landing | low | 0 | none | |
| 98-BS-009-02 | 1 | Landing | low | 0 | none | |
| 98-BS-012 | 3 | Landing | low | 0 | none | |
| 98-BS | 8 | Landing | low | 0 | none | |
| 98-BS | 9 | Landing | low | 0 | none | |
| 98-FS-004 | 2 | Landing | low | 0 | none | |
| 98-FO-013 | 1 | Landing | low | 0 | none | |
| 98-FS-26-02-03 | 1 | Landing | low | 0 | none | |
| 98-FS-023 | 2 | Landing | low | 0 | none | |
| 98-FS-023 | 1 | Landing | low | 0 | none | |
| 98-FS-21 | 1 | Landing | low | 0 | none | |
| 98-FS-21 | 2 | Landing | low | 0 | none | |
| 98-FO-011 | 1 | Landing | low | 0 | none | |
| 98-FS-004 | 1 | Landing | low | 0 | none | |
| 98-FS-26-02 | 3 | Landing | low | 0 | none | |
| 98-RT-022 | 1 | Landing | low | 0 | none | |
| 98-WC-011 | 12 | Landing | low | 0 | none | |
| 98-FS-002 | 6 | Landing | low | 0 | none | |
| 98-FS-002-04 | 3 | Landing | low | 0 | none | |
| 98-WC-011-02-01 | 2 | Landing | low | 0 | none | |
| 98-WC-011 | 14 | Landing | low | 0 | none | |
| 98-WC-011 | 16 | Landing | low | 0 | none | |

Treatment Immediacies and Controllable Erosion for Road Points in Willow/Freezeout Creeks WAU.

| Road_num | Site_num | Feature | Del_ers_pt | Contrl_vo | Treat_imm | Comments |
|---|---|---|---|---|---|---|
| 98-FS-002-04-02 | 1 | Landing | low | 0 | none | |
| 98-FS-002 | 9 | Landing | low | 0 | none | |
| 98-WC-011-02-01 | 3 | Landing | low | 0 | none | |
| 98-HC-002 | 1 | Landing | low | 0 | none | |
| 98-HC-002 | 2 | Landing | low | 0 | none | |
| 98-HC-002-02 | 1 | Landing | low | 0 | none | |
| 98-HC-004 | 1 | Landing | low | 0 | none | |
| 98-HC-004 | 3 | Landing | low | 0 | none | |
| 98-HC-003 | 2 | Landing | low | 0 | none | |
| 98-HC-003-02 | 1 | Landing | low | 0 | none | |
| 98-HC | 11 | Landing | low | 0 | none | |
| 98-HC | 15 | Landing | low | 0 | none | |
| 98-HC-014 | 1 | Landing | low | 0 | none | |
| 98-HC | 19 | Landing | low | 0 | none | |
| 98-HC | 22 | Landing | low | 0 | none | |
| 98-HC | 24 | Landing | low | 0 | none | |
| 98-HC-022 | 2 | Landing | low | 0 | none | |
| 98-WC-011-02-02 | 6 | Landing | low | 0 | none | |
| 98-WC-011-02-04-02 | 1 | Landing | low | 0 | none | |
| 98-FS | 3 | Landing | low | 0 | none | |
| 98-FS-14 | 1 | Landing | low | 0 | none | |
| 98-FS-14-02 | 1 | Landing | low | 0 | none | |
| 98-FS-14 | 4 | Landing | low | 0 | none | |
| 98-FS-003 | 1 | Landing | low | 0 | none | |
| 98-FS-003 | 2 | Landing | low | 0 | none | |
| 98-WC-011-02-01 | 4 | Landing | low | 0 | none | |
| 98-HC-022 | 4 | Landing | low | 0 | none | |
| 98-FS-12 | 3 | Landing | low | 0 | none | |
| 98-WC-033 | 1 | Landing | low | 0 | none | |
| 98-WC-034 | 2 | Landing | low | 0 | none | |
| 98-HC-012 | 2 | Landing | low | 0 | none | |
| 98-HC-023-01 | 1 | Landing | low | 0 | none | |
| 98-HC-012-04 | 1 | Landing | low | 0 | none | |
| 98-HC-012-02 | 1 | Landing | low | 0 | none | |
| 98-HC-004-02 | 1 | Landing | low | 0 | none | |
| 98-HC-023 | 6 | Landing | low | 0 | none | |
| 98-TG-004-04 | 1 | Landing | low | 0 | none | |
| 98-WC-032-02 | 1 | Landing | low | 0 | none | |
| 98-WC-032 | 1 | Landing | low | 0 | none | |
| 98-WC-031 | 1 | Landing | low | 0 | none | |
| 98-HC-016-04 | 1 | Landing | low | 0 | none | |
| 98-HC-016 | 1 | Landing | low | 0 | none | |
| 98-HC-016-02 | 1 | Landing | low | 0 | none | |
| 98-HC-024 | 1 | Landing | low | 0 | none | |
| 98-HC | 4 | Landing | low | 0 | none | |
| 98-WC-021 | 3 | Landing | low | 0 | none | |
| 98-WC-033 | 3 | Landing | low | 0 | none | |
| 98-WC-021 | 1 | Landing | low | 0 | none | |
| 98-HC-003 | 7 | low water (temp) | low | 0 | none | |

Culverts with a Diversion Potential for Willow/Freezeout Creeks WAU

| Road Number | Site Number | Culvert Type | Diversion Potential | Diversion Potenial Prevention |
|---|---|---|---|---|
| 98-FS004 | 1 | ditch relief | yes, ditch | n/a |
| 98-TG | 1 | watercourse | yes, road | ditch |
| 98-RT | 1 | watercourse | yes, road | none |
| 98-RT | 2 | watercourse | yes, ditch | none |
| 98-RT | 6 | watercourse | yes, road | water bar |
| 98-RT | 8 | ditch relief | yes, road | none |
| 98-RT | 9 | watercourse | yes, road | none |
| 98-BS | 5 | watercourse | yes, road | rolling dip |
| 98-BS | 7 | watercourse | yes, ditch | none |
| 98-BS-009-04 | 1 | ditch relief | yes, road | water bar |
| 98-RT-024 | 1 | watercourse | yes, road | none |
| 98-RT-024-04 | 3 | watercourse | yes, road | none |
| 98-RT-024 | 4 | watercourse | yes, road | water bar |
| 98-RT-024 | 5 | watercourse | yes, road | rolling dip |
| 98-RT-028 | 4 | watercourse | yes, road | rolling dip |
| 98-FO | 2 | ditch relief | yes, road | none |
| 98-FO | 12 | watercourse | yes, road | none |
| 98-FO | 19 | watercourse | yes, ditch | none |
| 98-FO | 28 | ditch relief | yes, ditch | none |
| 98-FO | 30 | watercourse | yes, road | none |
| 98-FS-26 | 2 | ditch relief | yes, ditch | none |
| 98-FS-26 | 3 | ditch relief | yes, ditch | none |
| 98-FO | 5 | watercourse | yes, road | none |
| 98-FO | 6 | ditch relief | yes, road | none |
| 98-FO | 7 | watercourse | yes, road | none |
| 98-FO | 8 | watercourse | yes, road | none |
| 98-FO | 9 | watercourse | yes, road | none |
| 98-FO | 14 | watercourse | yes, road | none |
| 98-FO | 21 | watercourse | yes, ditch | none |
| 98-FO | 23 | ditch relief | yes, road | none |
| 98-FO | 24 | watercourse | yes, ditch | none |
| 98-FO | 25 | watercourse | yes, ditch | none |
| 98-FO | 26 | ditch relief | yes, road | ditch |
| 98-FO | 27 | ditch relief | yes, road | none |
| 98-FS-26 | 1 | watercourse | yes, road | none |
| 98-RT | 5 | watercourse | yes, road | water bar |
| 98-RT-024 | 3 | watercourse | yes, road | water bar |
| 98-RT-028 | 5 | watercourse | yes, road | rolling dip |
| 98-RT-028 | 6 | ditch relief | yes, road | rolling dip |
| 98-RT028 | 8 | watercourse | yes, road | water bar |
| 98-HC | 1 | watercourse | yes, road | water bar |
| 98-HC | 2 | ditch relief | yes, road | water bar |
| 98-HC | 16 | watercourse | yes, road | water bar |
| 98-HC | 25 | ditch relief | yes, road | none |
| 98-WC | 32 | watercourse | yes, road | none |
| 98-WC | 31 | ditch relief | yes, ditch | ditch |
| 98-WC | 17 | ditch relief | yes, ditch | ditch |
| 98-WC | 14 | ditch relief | yes, ditch | ditch |
| 98-WC | 9 | ditch relief | yes, ditch | ditch |
| 98-WC | 4 | ditch relief | yes, ditch | ditch |
| 98-WC-033 | 2 | ditch relief | yes, ditch | ditch |
| 98-WC-021-02 | 10 | ditch relief | yes, ditch | ditch |
| 98-WC-021 | 2 | watercourse | yes, road | rolling dip |

**Culvert Size Analysis for Willow/Freezeout Creeks WAU** annual precip (in): 55

| Road Number | Site # | Culvert Type | Culvert Diameter (in) currently | Area (ac) | 50 year flood (cfs) | 100 year flood (cfs) | 50 yr Culvert Size (in) needed | 100 yr Culvert Size (in) needed | 50 yr pass | 100 yr pass |
|---|---|---|---|---|---|---|---|---|---|---|
| 98-TG | 1 | watercourse | 18 | 35 | 32 | 35 | 30 | 36 | NO | NO |
| 98-BS | 3 | watercourse | 18 | 12 | 13 | 14 | 24 | 24 | NO | NO |
| 98-BS | 5 | watercourse | 30 | 92 | 74 | 80 | 42 | 42 | NO | NO |
| 98-BS | 7 | watercourse | 12 | 6 | 7 | 7 | 18 | 18 | NO | NO |
| 98-BS-009 | 1 | watercourse | 24 | 43 | 38 | 41 | 36 | 36 | NO | NO |
| 98-FO | 12 | watercourse | 18 | 8 | 9 | 10 | 24 | 24 | NO | NO |
| 98-FO | 19 | watercourse | 24 | 26 | 25 | 27 | 30 | 30 | NO | NO |
| 98-FO | 5 | watercourse | 18 | 19 | 19 | 20 | 30 | 30 | NO | NO |
| 98-FO | 7 | watercourse | 24 | 23 | 22 | 24 | 30 | 30 | NO | NO |
| 98-FO | 9 | watercourse | 18 | 8 | 9 | 10 | 24 | 24 | NO | NO |
| 98-FO | 29 | watercourse | 24 | 21 | 21 | 22 | 30 | 30 | NO | NO |
| 98-FS-26 | 1 | watercourse | 18 | 23 | 22 | 24 | 30 | 30 | NO | NO |
| 98-FS-26-02 | 1 | watercourse | 18 | 16 | 16 | 17 | 24 | 24 | NO | NO |
| 98-HC | 6 | watercourse | 18 | 9 | 10 | 11 | 24 | 24 | NO | NO |
| 98-HC | 9 | watercourse | 18 | 15 | 15 | 17 | 24 | 24 | NO | NO |
| 98-HC | 14 | watercourse | 18 | 16 | 16 | 17 | 24 | 24 | NO | NO |
| 98-HC-018 | 2 | watercourse | 18 | 94 | 76 | 82 | 42 | 48 | NO | NO |
| 98-WC | 41 | watercourse | 18 | 29 | 27 | 29 | 30 | 30 | NO | NO |
| 98-WC | 39 | watercourse | 24 | 23 | 22 | 24 | 30 | 30 | NO | NO |
| 98-WC | 24 | watercourse | 24 | 28 | 26 | 28 | 30 | 30 | NO | NO |
| 98-FS-28-02 | 1 | watercourse | 24 | 29 | 27 | 29 | 30 | 30 | NO | NO |
| 98-FS | 2 | watercourse | 18 | 17 | 17 | 18 | 24 | 24 | NO | NO |
| 98-WC | 42 | watercourse | 24 | 56 | 48 | 52 | 36 | 42 | NO | NO |
| 98-FS-12 | 7 | watercourse | 12 | 2 | 3 | 3 | 18 | 18 | NO | NO |
| 98-WC-021-02 | 4 | watercourse | 18 | 25 | 24 | 26 | 30 | 30 | NO | NO |
| 98-WC-021-02 | 8 | watercourse | 18 | 10 | 11 | 12 | 24 | 24 | NO | NO |
| 98-HC | 13 | watercourse | 24 | 18 | 18 | 19 | 24 | 30 | YES | NO |
| 98-FS | 1 | watercourse | 18 | 7 | 8 | 9 | 18 | 24 | YES | NO |
| 98-WC-021-02 | 6 | watercourse | 18 | 7 | 8 | 9 | 18 | 24 | YES | NO |
| 98-TG | 2 | watercourse | 30 | 5 | 6 | 6 | 18 | 18 | YES | YES |
| 98-RT | 1 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-RT | 2 | watercourse | 24 | 1 | 1 | 2 | 18 | 18 | YES | YES |
| 98-RT | 3 | watercourse | 36 | 21 | 21 | 22 | 30 | 30 | YES | YES |
| 98-RT | 4 | watercourse | 24 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-RT | 6 | watercourse | 36 | 17 | 17 | 18 | 24 | 24 | YES | YES |
| 98-RT | 9 | watercourse | 24 | 7 | 8 | 9 | 18 | 24 | YES | YES |
| 98-BS-012 | 1 | watercourse | 36 | 20 | 20 | 21 | 30 | 30 | YES | YES |
| 98-BS-012 | 2 | watercourse | 48 | 107 | 85 | 91 | 48 | 48 | YES | YES |
| 98-RT-024 | 1 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-RT-024 | 2 | watercourse | 48 | 18 | 18 | 19 | 24 | 30 | YES | YES |
| 98-RT-024-04 | 3 | watercourse | 18 | 3 | 4 | 4 | 18 | 18 | YES | YES |
| 98-RT-024 | 4 | watercourse | 48 | 11 | 12 | 13 | 24 | 24 | YES | YES |
| 98-RT-024 | 5 | watercourse | 24 | 3 | 4 | 4 | 18 | 18 | YES | YES |
| 98-RT-028 | 4 | watercourse | 36 | 20 | 20 | 21 | 30 | 30 | YES | YES |
| 98-RT028 | 11 | watercourse | 18 | 6 | 7 | 7 | 18 | 18 | YES | YES |
| 98-FO | 16 | watercourse | 48 | 37 | 34 | 36 | 30 | 36 | YES | YES |
| 98-FO | 20 | watercourse | 48 | 41 | 37 | 40 | 36 | 36 | YES | YES |
| 98-FO | 30 | watercourse | 36 | 30 | 28 | 30 | 30 | 30 | YES | YES |
| 98-FO | 8 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-FO | 14 | watercourse | 24 | 14 | 14 | 16 | 24 | 24 | YES | YES |
| 98-FO | 21 | watercourse | 18 | 5 | 6 | 6 | 18 | 18 | YES | YES |
| 98-FO | 24 | watercourse | 36 | 44 | 39 | 42 | 36 | 36 | YES | YES |
| 98-FO | 25 | watercourse | 36 | 41 | 37 | 40 | 36 | 36 | YES | YES |
| 98-TG | 3 | watercourse | 36 | 13 | 14 | 15 | 24 | 24 | YES | YES |
| 98-RT | 5 | watercourse | 24 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-RT-024 | 3 | watercourse | 36 | 31 | 29 | 31 | 30 | 30 | YES | YES |
| 98-RT-028 | 5 | watercourse | 24 | 14 | 14 | 16 | 24 | 24 | YES | YES |
| 98-RT028 | 7 | watercourse | 48 | 115 | 90 | 97 | 48 | 48 | YES | YES |
| 98-RT028 | 8 | watercourse | 30 | 18 | 18 | 19 | 24 | 30 | YES | YES |
| 98-WC-011 | 4 | watercourse | 36 | 42 | 38 | 40 | 36 | 36 | YES | YES |
| 98-WC-011 | 5 | watercourse | 18 | 6 | 7 | 7 | 18 | 18 | YES | YES |
| 98-FS-002 | 1 | watercourse | 24 | 17 | 17 | 18 | 24 | 24 | YES | YES |

| Road Number | Site # | Culvert Type | Culvert Diameter (in) | Area (ac) | 50 year flood (cfs) | 100 year flood (cfs) | 50 yr Culvert Size (in) | 100 yr Culvert Size (in) | 50 yr pass | 100 yr pass |
|---|---|---|---|---|---|---|---|---|---|---|
| 98-WC-011 | 6 | watercourse | 36 | 29 | 27 | 29 | 30 | 30 | YES | YES |
| 98-WC-011 | 1 | watercourse | 18 | 1 | 1 | 2 | 18 | 18 | YES | YES |
| 98-WC-011 | 2 | watercourse | 36 | 33 | 30 | 33 | 30 | 30 | YES | YES |
| 98-WC-011 | 10 | watercourse | 36 | 52 | 45 | 49 | 36 | 36 | YES | YES |
| 98-WC-011 | 11 | watercourse | 36 | 41 | 37 | 40 | 36 | 36 | YES | YES |
| 98-HC | 1 | watercourse | 18 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-HC | 3 | watercourse | 48 | 30 | 28 | 30 | 30 | 30 | YES | YES |
| 98-HC | 10 | watercourse | 36 | 18 | 18 | 19 | 24 | 30 | YES | YES |
| 98-HC | 12 | watercourse | 36 | 19 | 19 | 20 | 30 | 30 | YES | YES |
| 98-HC | 16 | watercourse | 18 | 5 | 6 | 6 | 18 | 18 | YES | YES |
| 98-HC | 18 | watercourse | 60 | 47 | 41 | 45 | 36 | 36 | YES | YES |
| 98-HC | 20 | watercourse | 36 | 50 | 44 | 47 | 36 | 36 | YES | YES |
| 98-HC | 21 | watercourse | 36 | 52 | 45 | 49 | 36 | 36 | YES | YES |
| 98-WC | 54 | watercourse | 60 | 112 | 88 | 95 | 48 | 48 | YES | YES |
| 98-WC | 53 | watercourse | 60 | 216 | 156 | 168 | 60 | 60 | YES | YES |
| 98-WC | 51 | watercourse | 60 | 59 | 50 | 54 | 36 | 42 | YES | YES |
| 98-WC | 50 | watercourse | 60 | 64 | 54 | 58 | 42 | 42 | YES | YES |
| 98-WC | 46 | watercourse | 60 | 251 | 178 | 192 | 60 | 60 | YES | YES |
| 98-WC | 45 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 43 | watercourse | 24 | 11 | 12 | 13 | 24 | 24 | YES | YES |
| 98-WC | 38 | watercourse | 48 | 25 | 24 | 26 | 30 | 30 | YES | YES |
| 98-WC | 37 | watercourse | 48 | 14 | 14 | 16 | 24 | 24 | YES | YES |
| 98-WC | 35 | watercourse | 48 | 41 | 37 | 40 | 36 | 36 | YES | YES |
| 98-WC | 34 | watercourse | 24 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 32 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 30 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 29 | watercourse | 48 | 30 | 28 | 30 | 30 | 30 | YES | YES |
| 98-WC | 28 | watercourse | 24 | 12 | 13 | 14 | 24 | 24 | YES | YES |
| 98-WC | 25 | watercourse | 36 | 11 | 12 | 13 | 24 | 24 | YES | YES |
| 98-WC | 23 | watercourse | 24 | 15 | 15 | 17 | 24 | 24 | YES | YES |
| 98-WC | 21 | watercourse | 18 | 1 | 1 | 2 | 18 | 18 | YES | YES |
| 98-WC | 20 | watercourse | 48 | 29 | 27 | 29 | 30 | 30 | YES | YES |
| 98-WC | 19 | watercourse | 18 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-WC | 18 | watercourse | 36 | 32 | 30 | 32 | 30 | 30 | YES | YES |
| 98-WC | 16 | watercourse | 36 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 15 | watercourse | 48 | 22 | 21 | 23 | 30 | 30 | YES | YES |
| 98-WC | 11 | watercourse | 18 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC | 10 | watercourse | 36 | 15 | 15 | 17 | 24 | 24 | YES | YES |
| 98-WC | 8 | watercourse | 18 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-WC | 7 | watercourse | 36 | 12 | 13 | 14 | 24 | 24 | YES | YES |
| 98-WC | 6 | watercourse | 24 | 9 | 10 | 11 | 24 | 24 | YES | YES |
| 98-FS-28-02 | 2 | watercourse | 24 | 14 | 14 | 16 | 24 | 24 | YES | YES |
| 98-FS-12 | 6 | watercourse | 18 | 3 | 4 | 4 | 18 | 18 | YES | YES |
| 98-WC-033 | 6 | watercourse | 240 | 8 | 9 | 10 | 24 | 24 | YES | YES |
| 98-WC-033 | 5 | watercourse | 18 | 3 | 4 | 4 | 18 | 18 | YES | YES |
| 98-WC-021-02 | 1 | watercourse | 18 | 2 | 3 | 3 | 18 | 18 | YES | YES |
| 98-WC-021-02 | 2 | watercourse | 18 | 1 | 1 | 2 | 18 | 18 | YES | YES |
| 98-WC-021-02 | 7 | watercourse | 18 | 3 | 4 | 4 | 18 | 18 | YES | YES |
| 98-WC-021-02 | 9 | watercourse | 36 | 14 | 14 | 16 | 24 | 24 | YES | YES |
| 98-WC-021 | 2 | watercourse | 36 | 31 | 29 | 31 | 30 | 30 | YES | YES |
| 98-WC-021 | 3 | watercourse | 30 | 4 | 5 | 5 | 18 | 18 | YES | YES |
| 98-WC-021 | 2 | watercourse | 18 | 3 | 4 | 4 | 18 | 18 | YES | YES |