APPENDIX D

Hydrology and Fisheries

This page intentionally left blank.

Hydrology and Fisheries

The main stem of the Swan River flows from Graywolf Lake near the Clearwater-Swan Divide at the southwestern end of the Swan Valley north to Flathead Lake. Tributaries flow east from the Mission Mountains and west from the Swan Range. Within the Upper Swan Valley Landscape Assessment Area there are 15 “major” watersheds that will be discussed and compared. Their historic and existing water and sediment yield conditions and their ability in adjusting to changing conditions will be noted.

The watersheds on the east side of the valley differ from those on the west side in many ways. There is more surface water on the west side of the valley than the east, due to the greater abundance of lakes and ponds. The east side watersheds are smaller with a linear or trellis pattern to the stream network. The west side drainages are of a more complex dendritic pattern, similar to the veins of a maple leaf. About half to two thirds of the way down the west side drainages, the streams generally sweep north, a result of past glaciers.

Density of streams in a drainage (miles of stream divided by square miles of the drainage) is calculated to compare areas. The density of the stream network flowing through each drainage is similar overall, but varies from tributary to tributary. In some cases stream channels have widen out into narrow lakes such as Holland and Lindbergh Lakes. The tables on the following pages summarize the basic physical characteristics of the major tributaries.

Table D-1. ***Upper Swan Valley Drainage Area and Stream Densities***

Watershed Name	Area-Acres	Area Sq. Miles	Stream Miles	Stream Density
East Side - North to South				
Lion	20,770	32.45	72.7	2.24
Dog	5,549	8.67	16.5	1.90
Condon	13,301	20.78	40.8	1.96
Cooney	4,785	7.48	16.2	2.17
Rumble	3,522	5.5	13.4	2.44
Buck	6,146	9.6	22.9	2.38
Barber	3,969	6.2	13.1	2.11
Holland	14,510	22.67	53.5	2.36
Subtotal	72,552	113.35	249.1	2.20
West Side – North to South				
Piper	7,839	12.25	22.7	1.85
Jim	12,003	18.75	37.0	1.97
Cold	21,500	33.59	81.0	2.41
Elk	16,801	26.25	58.0	2.21
Glacier	35,800	55.94	130.5	2.33
Upper Swan	27,099	42.34	53.7	1.27
Beaver	15,824	24.73	22.7	0.92
Lower Swan*	39,708	62.04	148.3	2.39
Subtotal	176,574	275.89	553.9	2.01
Entire Area	**249,126**	**389.24**	**803.0**	**2.06**

* *Lower Swan area represents the valley bottom adjacent to the Swan River and small unnamed tributaries. This area is not analyzed as a separate catchment but must be included when looking at the entire Upper Swan Analysis Area.*

The size of individual watersheds varies considerably, but overall the drainage areas are larger on the west side of the valley than on the east. There appear to be slightly higher stream densities in the watersheds on the east side, but this factor alone does not represent the overall presence of water. To better view overall water presence, the following table **(Table D-2.)** compares distribution of lakes, wetlands and “Riparian Landtypes.”

Table D-2. ***Upper Swan Valley Surface Water and Wet Areas***

Watershed Name	Acres	Acres in Lakes	Riparian Landtype Acres	Percent "Wet"
East Side				
Lion	20,770	143	1,418	7.5%
Dog	5,549	15	394	7.4%
Condon	13,301	143	1,899	15.4%
Cooney	4,785	19	453	9.9%
Rumble	3,522	62	501	16.0%
Buck	6,146	24	515	8.8%
Barber	3,969	18	507	13.2%
Holland	14,510	596	2,153	19.0%
Subtotal	72,552	1,020	7,840	12.2%
West Side				
Piper	7,839	157	800	12.2%
Jim	12,003	234	1,187	11.8%
Cold	21,500	394	2,857	15.1%
Elk	16,801	295	2,073	14.1%
Glacier	35,800	1,173	5,323	18.2%
Upper Swan	27,099	2,019	3,346	19.8%
Beaver	15,824	385	2,213	16.4%
Lower Swan*	39,708	807	8,682	23.9%
Subtotal	176,574	5,464	26,481	18.1%
Entire Area	**249,126**	**6,484**	**34,321**	**16.4%**

** Lower Swan area represents the valley bottom adjacent to the Swan River and small unnamed tributaries. This area is not analyzed as a separate catchment but must be included when looking at the entire Upper Swan Analysis Area.*

Stream density and the abundance of lakes and ponds is a simple way to view runoff efficiency and fish habitat potential. Not all stream miles are truly available for fish due to stream slope and natural- and human-caused blockages. Waterfalls, beaver dams, and areas where streams go underground are examples of natural blockages; whereas undersized or misaligned culverts, human-built dams and irrigation diversions are examples of human-caused blockages. Streams can be classified for potential fish habitat by looking at the gradient and the landtypes that the stream flows through. Most of the streams providing the best fish habitat are located in the valley bottom. This is also the area that is host to and impacted by a myriad of human activities.

Artesian wells are located at the Swan/Clearwater Summit and at Salmon Prairie. Artesian springs can also be found in these areas as well as Buck Creek. Shallow to middle range wells (40' to 160') are found in the subdivision at the Summit, while deep wells and dry holes are in other areas – Buck Creek, Kraft Creek near the river bottom. Lindbergh Lake is an area where well drilling is difficult due to rock breaking drill bits. Some summer cabin owners still use water directly from lakes, creeks, or springs.

A very general way to view potential fish habitat is through the Rosgen Channel Classification System. The following is a general description of the "channel types" as separated using the Rosgen system and how these stream types can be related to fish habitat quality.

ROSGEN CHANNEL CLASSIFICATION SYSTEM

A-type Channel

These are relatively steep streams ranging in gradient from 4% to 10%, normally occupying narrow "V" shaped valleys, and characterized by straight cascading reaches with closely spaced pools. As they flow through bedrock and boulders (Sub-Types A1 and A2) they are very stable with low sensitivity to increases in water yields, peak flows or sediment. As they flow through smaller soil particles they are increasingly sensitive to changes in flows. Steeper segments usually do not provide habitat for fish, and can create blockage to fish migration. Streams over 10 percent (10%) are designated Type Aa+. While streams over 18% gradient are not usually occupied by fish, they may contain transients moving through where these segments are located below populated lakes.

B-type Channel

These moderately steep streams range in gradient from 2 percent (2%) to 4 percent (4%), usually occupying narrow valleys with gently sloping sides. Riffles are their dominant characteristics, with frequently spaced pools. They are usually very stable, although streams moving through fine soils can be moderately sensitive to channel erosion from increased peak flows. Most segments provide some form of fish habitat.

C-type Channel

These streams are low gradient systems with moderate to high sinuosity (meandering), occupying broad valleys with wide flood plains bordered by abandoned terraces of alluvial soils (rounded rocks and sand). They are characterized by well-defined meanders, point bars, and alternating riffles and pools. They are the most important fishery streams because they are found in key migratory pathways and spawning areas. These have moderately high to very high sensitivity to increases in stream flow or changes in sediment loads.

D-type Channel

These are wide-braided channels with gravel bars splitting the stream flow into many "streamlets." Stream banks are usually unstable. They are highly susceptible to increases in stream flow.

E-type Channel

These are slow moving streams with very low gradient. They are very efficient in transporting water and fine suspended sediment; forming in broad valley bottoms, often flowing through meadows. They are highly sinuous with stable banks when well vegetated. E-type streams are only moderately sensitive to increases in stream flow or sediment loads when their banks are fully vegetated because they are highly efficient at transporting water and sediment. They are excellent fish habitat, but can become unstable if grazing or bank trampling breaks down root structures of stream bank vegetation.

Because the Rosgen system is useful for identifying potentially sensitive areas and other important habitat characteristics, a computer model was developed to predict the area streams classification. The following is a summary of the information.

Table D-3. ***Predicted Rosgen Channel Types***

Watershed Name	A-Type Miles	B-Type Miles	C-Type Miles	E-Type Miles
East Side – North to South				
Lion	51.4	5.8	12.5	3.0
Dog	12.2	2.5	1.8	0
Condon	20.4	6.9	10.1	3.4
Cooney	11.1	3.6	1.5	0
Rumble	7.7	2.4	3.3	0
Buck	11.5	5.2	6.0	0.2
Barber	4.7	2.1	6.3	0
Holland	25.5	10.3	14.8	2.9
West Side – North to South				
Piper	12.1	5.7	4.9	0
Jim	19.2	6.0	11.2	0.6
Cold	39.6	11.0	26.5	3.9
Elk	37.2	5.8	11.5	3.5
Glacier	62.9	20.2	41.3	6.1
Upper Swan	39.2	6.4	7.5	0.5
Beaver	20.6	9.4	21.0	2.5

** The chart contains no D-type Channels because the model was not able to differentiate between E-type Channels and D-type Channels.*

Physical conditions of stream channels in watersheds of the 15 major tributaries can be monitored in several ways. Long-term monitoring depends on permanently established cross-sections. Several of these cross-sections have been established in the Upper Swan Valley. Three are established on Dog and Cat Creeks in conjunction with water quality sampling initiated to monitor changes related to management in the Meadow Smith Ponderosa Pine Restoration Project. Other locations include Kraft, Windfall, Beaver, Cold, and Elk Creeks. Ideally, a network of sites would track channel conditions above any human-caused disturbances, establishing a range of variability in undisturbed areas; and would further have additional sites lower in the valley, to determine if different levels of disturbance have measurable effects on channel morphology and particle size distribution.

Water quality monitoring has been conducted on streams in the Upper Swan Valley since the late 1970s in response to increased concern about the nation's waterways. Initial investigations documented the overall chemical profile of all streams on the forest. Data collected from Lion, Holland, Beaver, Elk, and Glacier Creeks, and on the river above Lindbergh Lake, revealed that natural water quality in Upper Swan Valley streams is very good. Temperatures, pH, dissolved oxygen, and other data taken indicate that these streams provide ideal situations for native fish. Since then, monitoring has focused on determining the effects that forest management activities, such as road construction and timber harvest, has on streams.

HISTORIC LAND USE AND EXISTING CONDITIONS

Human interaction with the environment has occurred in the Swan Valley for centuries, making it important to establish a "range of variability," comparing that to the current landscape.

Historically, the indigenous people often started ground fires in the fall to promote better wildlife forage; affecting shrubs and grasses with little change to the forest canopy. There are also indications of large wildfires significantly altering the forest. These large fires would have affected water quality and perhaps sediment levels in the individual tributaries. Water samples collected at various locations has shown a significant increase on nutrients during and directly after forest fires; however, these significant increases appear to be short-lived, with lower increases lasting about five years. Large-scale fires can also affect water quantity and the timing and intensity of runoff. While fire history for the Upper Swan Valley suggests that there may have been fires within some of the "major" watersheds large enough to have caused accelerated channel erosion, it is unlikely that they would have had a measurable effect upon the geomorphology (shape) of the main stem of the Swan River.

Within the past 100 years, extensive human development has occurred, especially in the valley bottom: logging, conversion of forest to pastureland, homesteads, and roads. Forest canopy coverage directly affects water yield (i.e., quantity), and in turn affect channel morphology and aquatic habitat. The following describes how each forest canopy component interacts with the hydrologic cycle.

Interception

In a mature forest, snow accumulates in the canopy. Some moisture is returned to the atmosphere through sublimation (vaporization of a solid) or evaporated as the snow melts. A percentage of the intercepted water runs down the branches and tree bole and enters the soil. Several factors influence the amount of moisture lost to interception: crown density, tree species, season, latitude, and storm characteristics (frequency, size, duration and intensity). Interception losses of winter precipitation can be significant, and forest cutting can reduce that loss significantly, resulting in more water in the snowpack. Interception is negligible until the stand of trees is approximately twice the height of the average snow depth.

Redistribution

Snow blown from tall trees to adjacent openings takes on a different structure than snow in the canopy. It becomes more concentrated, has a higher water content, and melts at a different rate than snow in the canopy. This can be observed both in the valley, where drifts stay long after fallen snow in undisturbed areas, and in the mountainside forests where the snow pack persists in openings. Redistribution effects are considered to be at pre-harvest conditions when the trees are at least three-quarters the height of the surrounding forest. Redistribution effects may persist until the continuity of the canopy is restored; that is, until the height of the new vegetation returns to the height of the surrounding area. In fully-managed forests with stands being harvested at differing times over some rotation period, pre-harvest redistribution conditions may never return.

Transpiration

A fully stocked stand transpires at the maximum rate as long as water and the energy to utilize that water is available. This rate depends on soil characteristics, stand or cover density, tree species, and available energy and water. Changes in the vegetative cover alter the plant/soil/water balance. An area returns to pre-activity transpiration levels when the soil is completely revegetated, including trees, brush, forbs, grasses, and similar vegetation.

ROADS AND WATER

Roads are another factor affecting aquatic environments. Roads with insufficient cross drainage can collect sufficient water during snowmelt and rain and may cause accelerated channel erosion. Stream crossings insufficient to accommodate high flows during snowmelt can also cause major damage to the stream channel. In extreme situations, culverts can plug and cause the road to wash out.

Examining road densities and timber harvest levels is one way to determine the risk of current land uses that might an impact on water quality and aquatic environments. There may be a high risk of watershed impact if road densities are greater than 1.7 miles per square mile of forest, and if harvest levels exceed 25 percent of the area. In 1997, the Inland West Watershed Reconnaissance concluded that most major tributaries of the Swan Valley would fall into the low category for geomorphic integrity based on total harvested area and road densities. It appears that there is the likelihood of some adverse affects due to current and past land management levels. While this may be true in some specific areas, there are several environmental factors which may ameliorate potentially harmful impacts at larger scales.

In 1982, because of concern about the cumulative effects of land management on stream morphology of the Swan River, Gordon Grant conducted a study of stream conditions using aerial photography. Grant concluded, "Increased delivery of water from harvested units is unlikely as a mechanism for generating cumulative effects because: 1) snowpack melting results in only negligible increases in runoff from harvested units versus unharvested areas; 2) the drainage network connecting valley floor units with the main channel is poorly developed; and, 3) there exists ample opportunity for storage and detention of runoff in the number of lakes, ponds, and marshes along the valley floor." It was Grant's "impression that the combination of readily erodible bank materials, relatively high sediment loads, seasonally high discharges, absence of bedrock, and the presence of large quantities of woody debris result in a naturally dynamic channel." The main river channel has many characteristics that would lead to naturally dramatic changes. This does not mean, however, that excessive road densities or inappropriate land management activities would not be responsible for channel degradation in specific locations or at a smaller scale.

The Flathead Lake Biological Station conducted an intensive study of nutrient and carbon loading in the Swan River in 1998. The study noted that they "observed no statistically significant relations between human landscape disturbance and water quality." Further, "... determination of actual transfer rates in large river systems can be very difficult," because of storage, chaotic timing of nutrient movement, and mixing. **Water quality monitoring of watersheds at a smaller scale suggests that there is a measurable difference in sediment and nutrients in managed watersheds versus non-managed watersheds.**

UNDERGROUND HYDROLOGY

To date, groundwater studies in the Swan Valley have been limited to well surveys. However, geologists believe that the groundwater structure of the valley is typical of most smaller mountain valleys in western Montana. The valley was formed by glaciers depositing well-sorted layers of sand and gravel. These layers of sand and gravel beneath the surface of the land store water and are generally recharged by spring runoff.

Each year, water from snowmelt and rain infiltrates the ground along high elevation scree slopes and then flows downward, accumulating in the layers of sand and gravel. These scree fields represent recharge sites and, so far, geologists are confident that groundwater in the Swan Valley is fairly abundant. Since underground systems basically display the same structure as surface topography, geologists believe that, in the Swan Valley, groundwater moves from the sides of the valleys toward the river.

Well water level surveys help hydrologists map direction and movement of water in existing aquifers. Unfortunately, the extent of specific aquifers in the Swan Valley is not known, and cannot be predicted, because of the glacial structure of the landforms; i.e., the haphazard way in which the layers of sand and gravel were deposited. In other words, there is no guarantee that the sand and gravel layers are continuous across the valley.

Residential well drillers sometimes come up with ‘dry holes’ in certain areas of the Swan Valley, providing evidence of the lack of uniformity in the groundwater system structure. Well water surveys indicate that the groundwater in the Swan Valley is high quality water, free from contaminants. There are artesian wells located at the Swan/Clearwater Summit and also at Salmon Prairie. Artesian springs can also be found in these areas as well as in Buck Creek. Shallow to middle range wells (40’ to 160’ deep) are found in the residential subdivision at the Summit, while deep wells and dry holes exist in other areas such as Buck Creek and Kraft Creek near the river bottom. Well drilling is difficult due to rock breaking drill bits in the Lindbergh Lake area. Some summer cabin owners still use water directly from lakes, creeks, or springs.

WATER QUALITY MONITORING

Physical conditions of stream channels in watersheds of the fifteen major tributaries can be monitored in several ways. Long term monitoring depends on permanently established cross-sections. Several of these cross-sections have been established in the Upper Swan Valley. Three are established on Dog and Cat Creeks in conjunction with water quality sampling initiated to monitor changes related to management in the Meadow Smith Ponderosa Pine Restoration Project. Other locations include Kraft, Windfall, Beaver, Cold, and Elk Creeks.

Water quality monitoring has been conducted on streams in the Upper Swan Valley since the late 1970s in response to increased concern about the nation’s waterways. Initial investigations documented the overall chemical profile of all streams on the forest. Data collected from Lion, Holland, Beaver, Elk, and Glacier Creeks, and on the river above Lindbergh Lake, reveal that natural water quality in Upper Swan streams is very good. Temperatures, pH, dissolved oxygen, and other data taken indicate that these streams provide ideal situations for native fish. Monitoring is now focused on determining the effects that forest management activities, such as road construction and timber harvest, have on streams.

FISHERIES AND AQUATIC SPECIES

The natural aquatic communities have been changed by widespread fish stocking and habitat alteration in the Swan River Basin. Numerous wetlands and small ponds continue to provide habitat for native amphibians, aquatic plants, and other organisms. Where aquatic habitat remains largely intact, native fishes display a remarkable resistance to the effects of introduced species. Certain reaches of the main stem of the Swan River retain floodplain forests, a high degree of channel complexity, and evidence of strong interaction between surface waters and the local alluvial aquifer (underground water flowing through mud and sand deposits).

Cat, Dog, Holland (above the falls), Beaver, Red Butte-Hemlock and Elk Creeks are important areas for westslope cutthroat trout. Lion, Upper Holland, Elk, and Piper Creeks are strongholds of bull trout in the Upper Swan. Upper Holland Creek has a resident bull trout population above the falls that is secure. The Swan Valley is recognized by Montana Fish, Wildlife & Parks as some of the most important bull trout habitat.

Brook trout are an introduced, invasive species, which can displace native fish and pose a significant threat to cutthroat trout if habitats are altered (e.g., by warming) to favor brook trout population expansion. Important habitat for amphibians and other non-fish biota include portions of Upper Holland and Elk Creek.

Source: Liz Hill, Hydrologist, and Beth Gardner, Fisheries Biologist, Swan Lake Ranger District, Flathead National Forest.