Glacier National Park

Final Report

Pesticide Monitoring Project

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Introduction

In early 2001, Glacier National Park (GNP) contacted the Montana Department of Agriculture (MDA) requesting assistance in designing and implementing a water resource monitoring program. The monitoring program will be used as an evaluative tool of the noxious weed control program the park established some ten years previous to determine if herbicides used for noxious weed control within Park boundaries are present in water resources and if so, to what degree and extent. Positive detections of pesticide residues in GNP, depending upon the concentration, may warrant review of and changes in the weed program to achieve the desired level of water resource protection.

Phase I refers to the environmental risk assessment component of the project. The assessment determines if monitoring is needed and if so, helps determine the scope of the monitoring program. It combines an environmental vulnerability and sensitivity evaluation and herbicide characterization. Phase II focused on design and implementation of a monitoring program. Phase III involved review of data resulting from monitoring activities and recommendations.

Phase I. Pesticide Risk Assessment for Water Resources

The purpose of the assessment was to determine the risk to water resources from herbicide applications used for noxious weed control. The assessment was based on three components – soils, distance to a water resource (i.e. depth to ground water and distance to surface water) and pesticide characterization.

<u>Soils</u>

Soils can be evaluated to determine relative risk to pesticide movement (leaching and runoff). Criteria used to evaluate soil risk are primarily based on amount of organic matter and soil texture. Additional risk weighting was given to soils having a high percentage of gravels, rocks, cobbles and stones. Soils having high organic matter content and clay dominated textures were classified as low risk since they promote sorption, enhance microbial attenuation and limit rapid water as well as pesticide movement through the profile. On the other end of the spectrum are soils with low or absent organic layers that have a sandy/gravelly dominated soil matrix. These soils are dominated by large, well-connected pore spaces enhancing water/pesticide movement but lacking the organic matter and clay content necessary for good pesticide sorption. These soils were classified as very high risk. Soils were placed in one of six soil risk classifications: low, low to moderate, moderate, moderate to high, high and very high. The soil coded A6 was not assigned a risk classification. Soil code A6 appears on the soils layer provided by the GNP but does not have an associated description upon which a classification can be derived. Soil descriptions, as described in Land and Water Consulting, Inc. (Dutton, 1990; Land and Water Consulting, 1995; Dutton and Marrett,

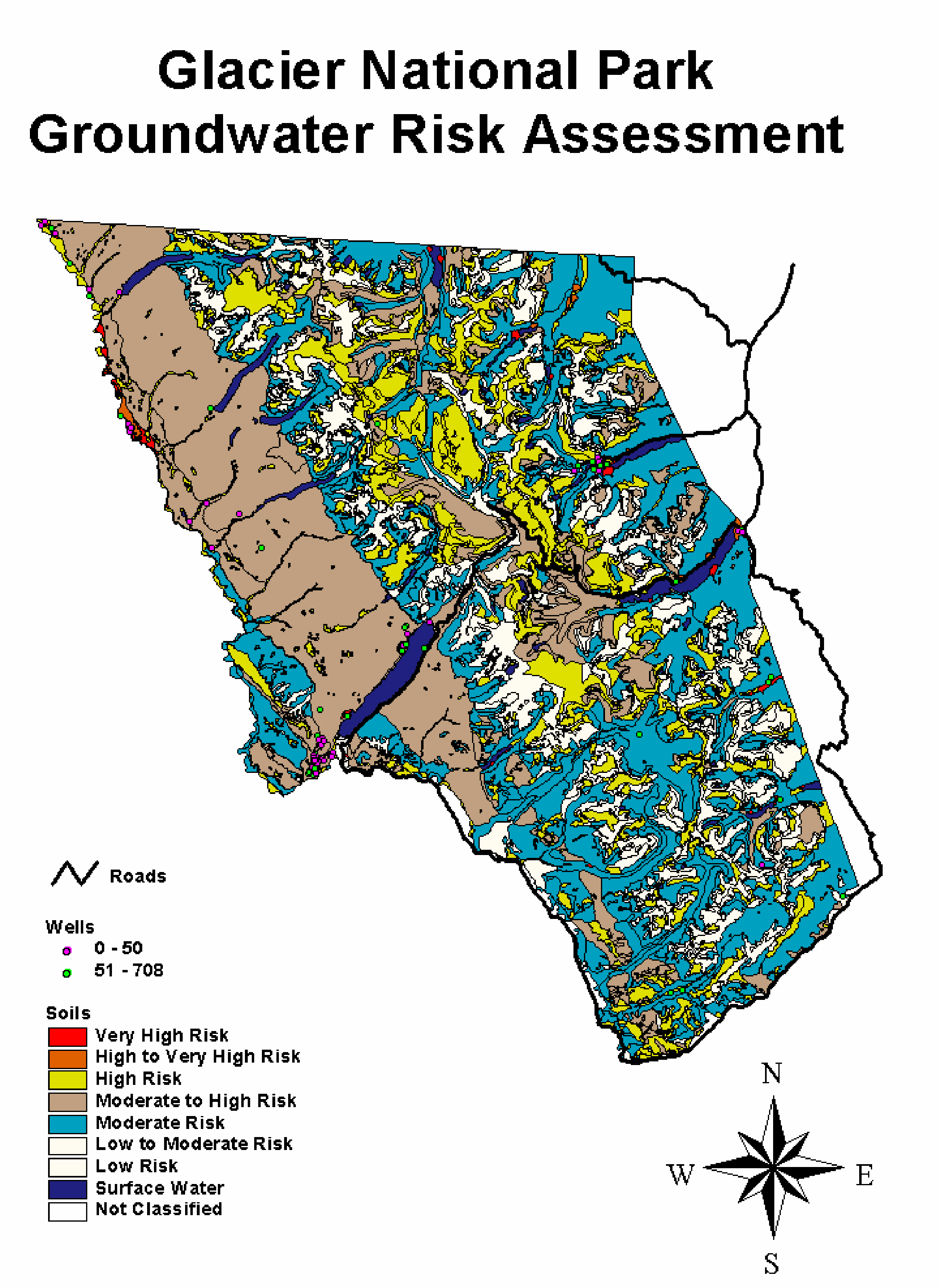

Figure 1. Glacier National Park ground water risk assessment map.

1997; and Dutton, Pettit and Hadlock) reports, were used for classification purposes. A map of soil risk classifications for ground water is shown in Figure 1. Surface water risk was based on soil characteristics and landscape slope. Soils dominated by clays have poorer infiltration capacity than more permeable soil textures. Precipitation, which exceeds soil infiltration capacity, may be moved off site via overland flow. Extreme storm events may exceed the infiltration capacity of any soil, even those with high rates of infiltration. Pesticides or pesticides attached to soil particles may move offsite with water movement or through wind movement of soil material. Slope enhances movement of water offsite. Impairment of surface water resources occurs when overland flow or wind blown materials are introduced to surface water and through ground water impaired-surface water connections. Soils with low infiltration capacity on steep slopes create the greatest risk for surface water quality. Using infiltration and water holding capacity evaluations described by Land & Water Consulting, surface water risk was determined for most soils within the park. Specific information on infiltration and water holding capacity information does not appear in the Land & Water Consulting reports for the following soil types: G2, G3, G4, G5, G6, G7, C9, LC6 and LC9. However, an inference can be drawn from the Land and Water Report soil descriptions. Soils with low infiltration rate (0.25 – 2.00") and high water holding capacity were designated as high risk, soils with 2 – 4" rate of infiltration and moderate water holding capacity were designated as moderate risk, and soils having a high infiltration rate (4 – 8") and low water holding capacity were designated as low risk. Appendix A lists the criteria used in the delineation. Figure 2 shows the surface water risk assessment based on soils and related information.

Ground Water

Depth to ground water is another factor that can be used to assess vulnerability and sensitivity of ground water resources to pesticide impairment. The greater the depth to ground water the less associated risk there is of resource impairment or contamination. This is because there is more opportunity for attenuation of the pesticide to occur. High-risk soils with shallow ground water, where weed control measures include herbicide application, represent the highest priority areas for monitoring. For this project, wells with ground water shallower than 50' will be used as a general indication of associated risk from pesticide impairment.

Information from area wells provides a good indication of depth to ground water resources. The Ground Water Information Center (GWIC) was searched via the internet to determine the number, location and characteristics of wells within GNP boundaries. GWIC well information is also available through NRIS website. The NRIS site was used to geographically display the wells on the soil risk classification map (Figure 1). Well are depicted as a dot symbol in either magenta or green. Magenta wells have a total depth ranging from 0' to 50' below ground surface while green wells have a total depth ranging from 51' to 708'. Wells are predominately located along park boundary edges and in public use areas. An attempt was made to match wells mapped through NRIS with well location information from the GWIC site. Some success was achieved on the eastern portion of the Park but considerable discrepancies were encountered on the west side. Since the discrepancies could not be reconciled satisfactorily, well identification

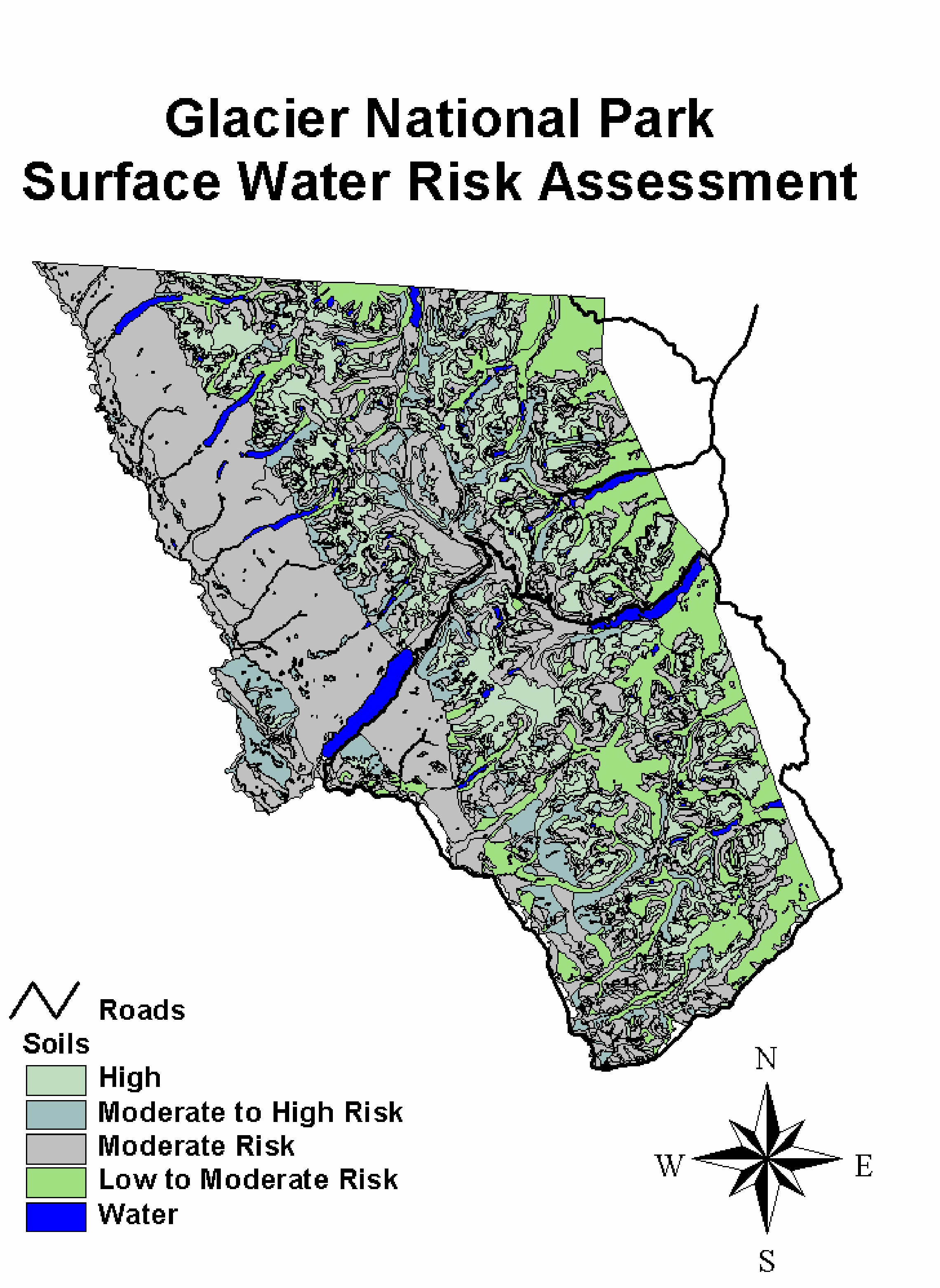

Figure 2. Glacier National Park surface water risk assessment map.

could not be completed. There is a lack of well information in other areas of the Park, which is a major limiting factor in this risk assessment.

Surface Water

The closer an application of herbicide is made to surface water, the greater the risk that pesticide could move with water or wind into surface water. Because of the importance of protecting surface water resources, many pesticide labels either require or recommend pesticides not be applied below a high water mark and that a buffer area between the application site and the surface water boundaries be established. Establishment of buffers should ideally be pesticide specific since individual pesticides behave differently and what might be appropriate for one pesticide may be overly protective or inadequate when using another pesticide. Slope also plays a key role in the establishment of an appropriate buffer. The steeper the slope, the greater the buffer width should be. In addition, strict attention to expected climatic conditions 24 to 48 hours after a proposed application should be given to areas where pesticide applications are expected to occur within close proximity and on slopes directly up-gradient of water surfaces. For this project, applications occurring within 10 feet of surface water features or occurring on slopes within 20 feet of surface water features were considered high risk regardless of soil risk classification. Applications occurring within 25 feet or occurring on slopes within 35 feet of surface water features represent a moderate risk unless associated with a high to very high- risk soils. Low risk included applications occurring on soils with no slope and 50 feet or more from surface water or on soils with slopes and distances greater than 75 feet from surface water features.

Pesticide Characterization

Environmental assessment should be paired with an understanding of pesticide characteristics. Pesticide characteristics provide insight into the anticipated behavior, movement and attenuation of the pesticide(s) in the environment. The scope of characterization for this project will focus on the following factors: sorption, solubility and half-life. Solubility refers to the pesticide's dissolution into a liquid (in this case water) and is measured in milligrams per liter or parts per million (ppm). Solubility should never be used as the sole factor in characterization because it can lead to erroneous environmental behavior assumptions. Sorption and half-life, when combined can provide a better picture of anticipated behavior. Sorption potential is an estimate of the soil's ability to absorb and adsorb pesticide to soil particles – particularly organic matter and clays. Soils with high organic matter and high clay contents will have a higher sorption capacity than coarse soils that are dominated by sands and have low or lack organic matter. The higher the sorption coefficient, the more strongly pesticides are sorbed and, hence, the less mobile it will be. The half-life is the amount of time that it takes for a pesticide to be reduced to half its original amount. Taken in combination, these factors can provide a general estimate of a pesticide's leaching potential. Table I summarizes the characteristics of all pesticides used in the program.

Picloram, trade name Tordon, is the pesticide used most often in herbicide control measures for noxious weeds within GNP. Picloram, as stated on the label, is known to leach through the soil profile and into ground water. Runoff potential for Picloram is also high, particularly in areas where the landscape slopes toward surface water resources. Under most labeled applications, Picloram does not represent a risk to water resources unless applied in vulnerable to very vulnerable areas.

Pesticide Characteristics				
Pesticide Name	Half-life (days)	Sorption Coefficient (Koc in ml/g)	Solubility (mg/L or ppm)	Leaching Potential
Picloram (trade name Tordon)	90	16	200,000	Very High
Clopyralid (trade name Curtail & Transline)	40	6	300,000	Very High
2,4-D	10	20	100	Moderate
Glyphosate (trade name Roundup)	47	24,000	900,000	Extremely Low
Triclopyr (trade name Garlon)	46	20	2,100,000	Very High

Table 1. Characteristics of pesticides used in GNP's Noxious Weed Program, 1996-2000 (GNP, 2000)

The soil half-life, or persistence of Picloram is 90 days. Picloram has relatively poor sorption and is very soluble. This combination of characteristics warrants careful evaluation of environmental conditions. In most areas Picloram, when used according to the label, provides effective weed control and poses little risk to water resources. Careful assessment of environmental conditions should always be considered when use is proposed in high to very-high risk areas. In these areas, application of Picloram may require additional mitigative measures to assure adequate protection of water resources. Alternative weed control measures should be used when the risk exceeds the benefits of weed control efforts, particularly in very high-risk areas.

Clopyralid and Triclopyr also exhibit very high leaching potentials based on the characteristics in Table 1. Careful consideration should be taken when considering application in vulnerable areas. Other pesticides should also be characterized and their use carefully considered when being proposed as a potential weed control measure due to environmental concerns.

Phase II. Ground Water and Surface Water Monitoring

The risk assessments for surface water and ground water based on soil risk classifications indicate that areas of GNP have high and very high potential for pesticide movement to water resources making monitoring an essential step in this project.

Ground Water

Ten ground water sites were chosen based on the risk assessment in Phase I along with some other considerations (Figure 3). Considerations included proximity to weed/pesticide use areas (no more than 1/4 to 1/3 mile), location with respect to ground water flow direction, depth of well, aquifer type (i.e. confined, semi-confined, or unconfined), ease of access, well condition, and landowner cooperation. The ten ground water sites consisted of the Many Glacier pumphouse well (GNP2; Figure 4), Many Glacier Sewer Treatment Plant pumphouse well (GNP3), the St. Mary USGS monitoring well (GNP4; Figure 5), the St. Mary pumphouse (GNP5), the Rising Sun pumphouse well (GNP6), the Cutbank Ranger Station well (GNP7), the Two Medicine pumphouse well (GNP8), the Fish Creek pumphouse well (GNP10), the Lake McDonald pumphouse well (GNP11), and the Sewage Effluent/Horse Pasture

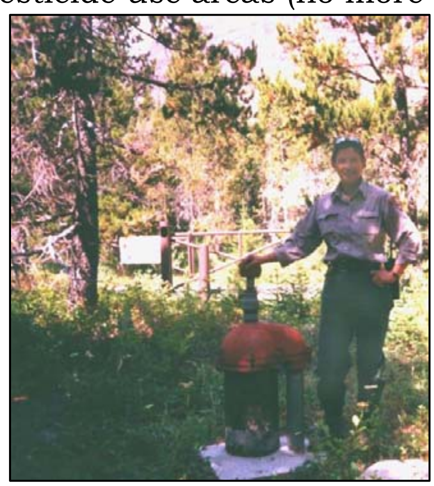

Figure 4. Tracey Vaile, campground maintenance for GNP standing beside Many Glacier well (GNP2).

Manager for MDA, bailing St. Mary USGS monitoring well (GNP4).

well (GNP12). Water samples and water quality parameter measurements were taken at all of the wells using MDA's standard operating procedures for sampling ground water, while static water level measurements were only taken at the wells where access was available. GNP3 was sampled on August 19, 2002; GNP4, GNP5, GNP6, GNP7, and GNP8 were sampled on August 20, 2002; and GNP10, GNP11, and GNP12 were sampled on August 21, 2002. All of the ground water samples were analyzed using a Phenoxy Multi-Residue method, which includes the most commonly used pesticides in GNP of 2,4-D, Clopyralid, Picloram, and Triclopyr. For the complete list of analytes included in the Phenoxy Multi-Residue method see Appendix C.

Surface Water

Three surface water sites were chosen based on the risk assessment in Phase I (Figure 6). Considerations included location, vulnerability, and location with regard to pesticide use areas. The three sites were located on Rose Creek (GNP1), near the Headquarters on the Middle Fork of the Flathead River (GNP9), and Bowman Creek at Polebridge (GNP13). Water quality parameter measurements (pH, Specific Conductance, and Temperature), discharge measurements, and water samples were taken at Rose Creek on August 19, 2002 (Figure 7). Stream discharge measurements were taken using the Velocity-Area method and a Marsh McBirney flow meter. Water quality parameter measurements and water samples were taken from directly below the headquarters on the

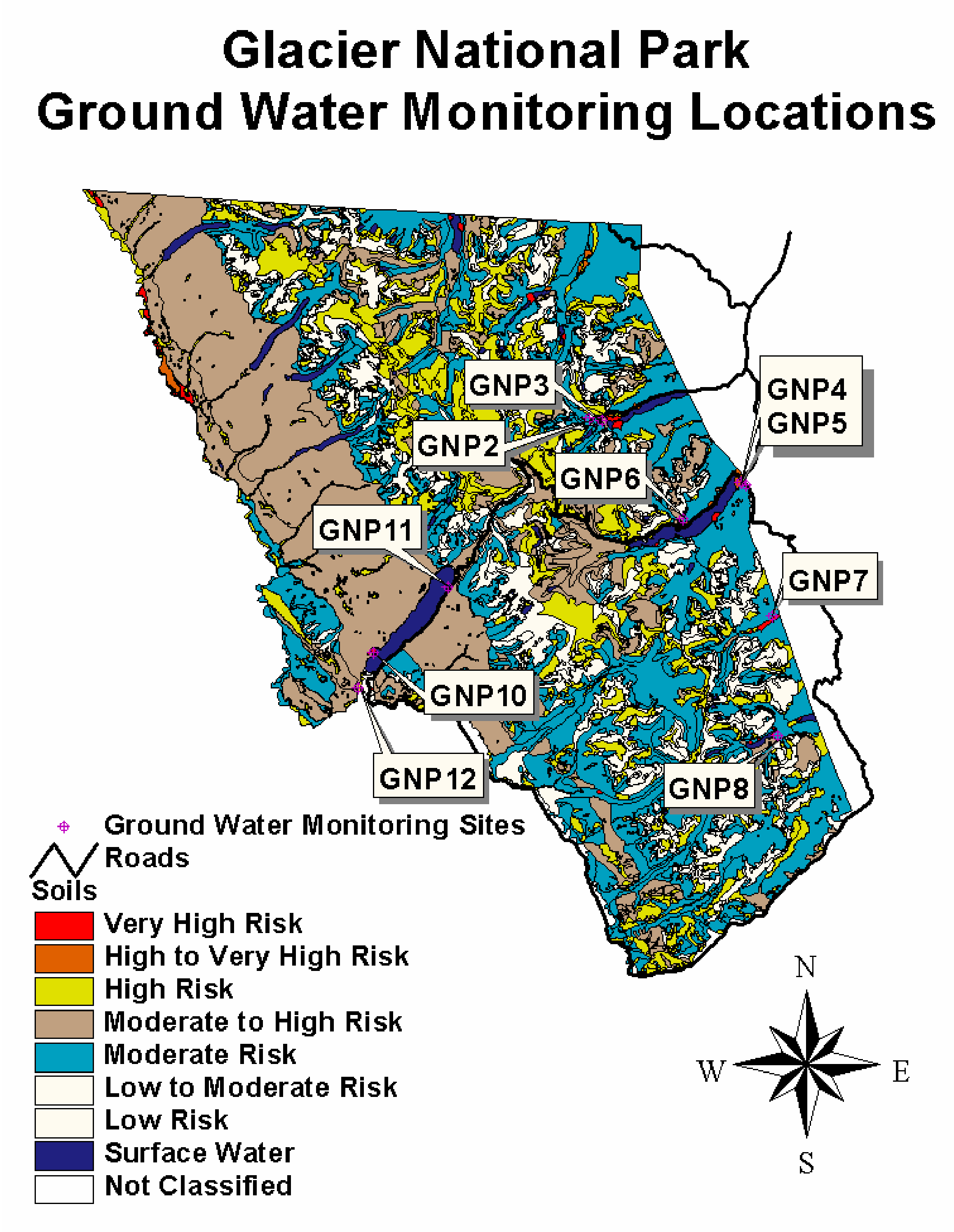

Figure 3. Ground water monitoring locations in Glacier National Park.

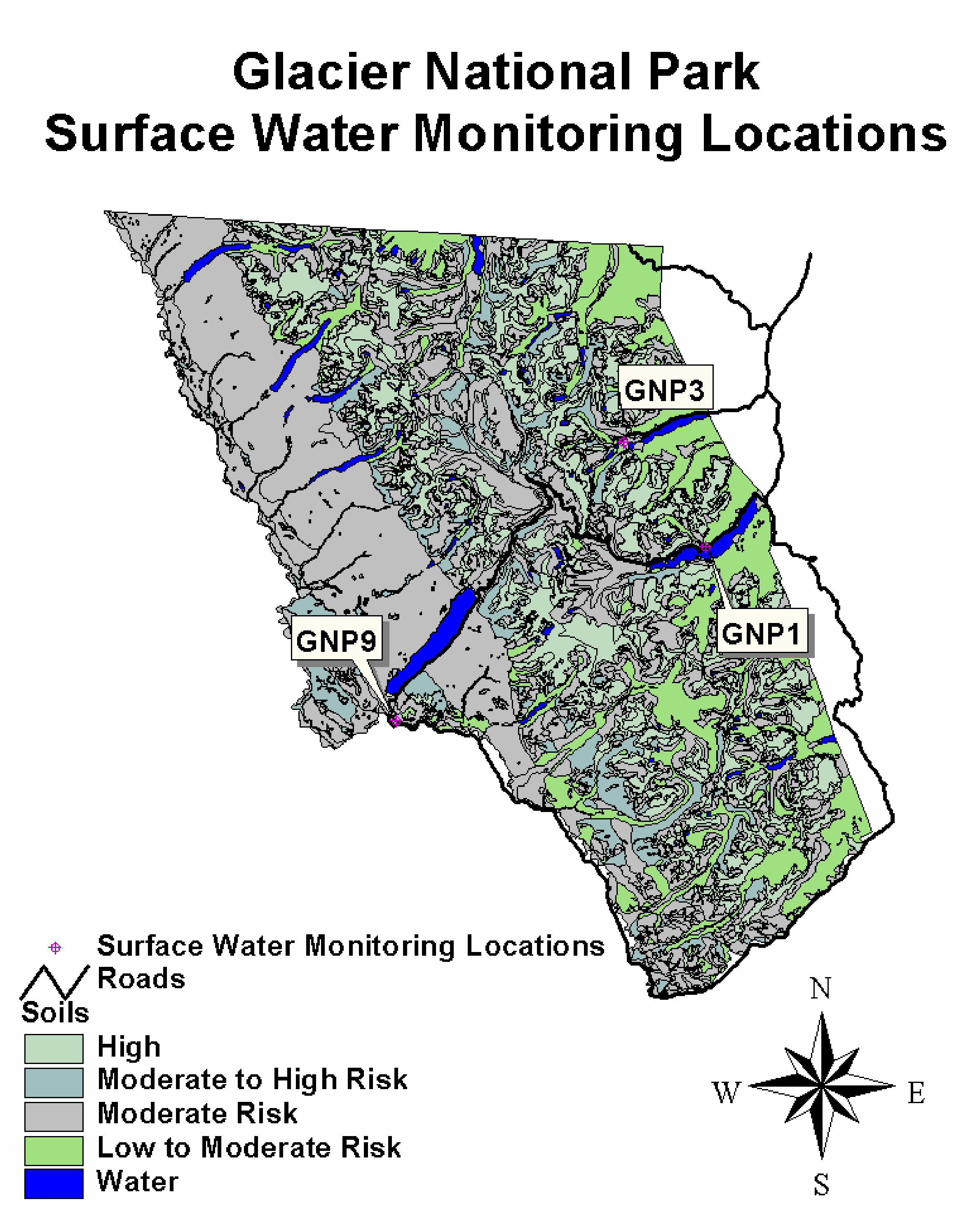

Figure 6. Surface water monitoring locations in Glacier National Park.

Figure 7. Stephanie Running Wolf of the EPA with a Blackfeet Tribe intern measuring the stream discharge in Rose Creek (GNP1).

Middle Fork of the Flathead River on August 21, 2002. Water quality parameter measurements and water samples were also taken on August 21, 2002 from the north exterior spigot of the Fire Cache Building, which is piped approximately 100 feet from a water infiltration gallery from under Bowman Creek. All water samples were taken in accordance with MDA's standard operating procedures. All of the surface water samples were analyzed using a Phenoxy Multi-Residue method, which includes the most commonly used pesticides in GNP of 2,4-D, Clopyralid, Picloram, and Triclopyr. For the complete list of analytes included in the Phenoxy Multi-Residue method see Appendix C.

Phase III. Results and Recommendations

Results

No Phenoxy herbicides listed in the Phenoxy Multi-Residue method used by the MDA analytical lab were found above the limit of quantitation in the surface water and ground water samples collected during the period of August 19-21, 2002 in Glacier National Park (Appendix C). Water quality parameter measurements for all of the sites except GNP1 are listed in Table 2. Water quality parameter and discharge measurements for GNP1 are listed on the surface water measurement sheet in Appendix B. The total stream discharge for GNP1 on August 19, 2002 was 6.94 cubic feet per second (cfs). Water level measurements were taken at GNP4 and GNP12 and were 73.87 feet and 6.72 feet below ground surface, respectively.

Site Name	Site Type	pH	SC (µS)	T (^oC)
GNP 2	GW	7.40	231.9	6.8
GNP 3	GW	7.27	252.8	11.8
GNP 4	GW	7.38	297.9	7.9
GNP 5	GW	7.57	226.1	6.1
GNP 6	GW	7.68	169.7	7.4
GNP 7	GW	8.34	107.8	7.8
GNP 8	GW	7.70	114.2	6.8
GNP 9	SW	7.35	140.1	12.8
GNP 10	GW	8.14	151.5	6.5
GNP 11	GW	7.40	92.7	6.8
GNP 12	GW	7.26	380.1	12.0
GNP 13	SW	7.29	208.6	13.5

Table 2. Water quality parameter measurements for the surface water and ground water sites, GNP2 to GNP13.

Recommendations

Based on the lack of detections in the surface water and ground water of the most commonly used herbicides during the period of measurement and based on limited funding resources, no further sampling was conducted for this project. For the period of measurement, it does not appear that the current weed control practices are having a detrimental affect on the water resources that were monitored for this project. Future monitoring, however, may be considered for other areas in the park that were not sampled for this project, as pesticide application locations change, or if new chemistries of herbicides are used. It should be mentioned that the lack of detections of herbicides in ground water and surface water, might be a result of the analytes chosen for laboratory analysis, the locations of the sites, or the timing of the sampling event.

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Appendix A

Surface Water Criteria Classification						
Soil Code	Surface Infiltration (surface to depth of 1')	Subsurface Infiltration (to 5' depth)	Description	Water Holding Capacity	Erosion Potential	Risk
A1	.25 - .50"	.25 – 2.5"	Well to poorly drained	Low	Moderate	Moderate
A2	.20 - .40"	1.00 – 2.00"	Well drained	Very Low	Low	Moderate
A3	.75 – 1.00"	2.50 – 3.50"	Well drained	Very Low	Moderate	Moderate
A4	1.0 – 1.5"	4.0 – 6.0"	Well drained	Moderate - High	Moderate	Moderate
A3/A4			40% A3, 60% A4 Well drained	*Low – Moderate**		Moderate
A5	1.50 – 2.00"	7.0 – 9.0"		Very High	Moderate	Moderate-High
W1	1.5 – 2.0"	7.0 – 10.00"	Poorly to very poorly drained	Very High	Low	Moderate-High
T1	.50"	2.0 – 3.0"		Low	Low	Moderate
T2	2.0"	6.0 – 8.0"		Very High	Moderate	Moderate-High
T3	2.0"	6.0 – 7.0"		Very High	Moderate	Moderate-High
LT1	1.5 – 2.0"	6.0 – 8.0"		Very High	Moderate	High
C1/C4			Rock & shallow soil	*Low*	*Low*	High
C1			Rock	***Low***	***Low***	**High**
C2			Rock & limited soil material	***Low***	***Low***	**High**
C3	1.5"	4.0 – 5.0"	Well drained	**Moderate**	**Moderate**	**Moderate-High**
C3/C5			Well drained	***Low***	Moderate	Moderate
C4	0.75 – 1.0"	1.5 – 2.0"		Low	Moderate	Moderate
C4/C6			Well drained	***Low***	Moderate	Moderate-High
C5	0.75 – 1.0"	2.0 – 3.0"		Low	Moderate	Moderate
C5/C4			Well drained	Low		Moderate

C6	1.5”	2.0 – 3.0”	Well drained	High – surface Low in subsurface	Moderate	High
C7/C1			Rock	***Low***		
C9/C5			Well drained	*Low*		Moderate
C8			Well drained	*Low*		Moderate
G1			Well drained	*Low*		Moderate
G2			Well drained	*Low*		Moderate
G2/G3			Well drained	*Low*	High	Moderate
G3			Well drained	*Low*		Moderate
G3/C3			Well drained and moderately drained	*Low - moderate*		Low-Moderate
G3/A3/G2			Well drained	*Low*		Moderate
G4/G5			Well drained – moderately drained	*Low - moderate*		Low-Moderate
G6			Well drained	*Low*		Moderate
G7			Well drained	*Low*		Moderate
G8			Well drained	*Low*		Moderate
LC1			Rock outcrop	***Low***	Moderate	High
LC1/LC4			Well drained	***Low***	Moderate	Moderate
LC2			Rock	***Low***	Moderate	High
LC3	1.5”	4.0 – 5.0”	Well drained	Moderate	Moderate	Moderate
LC3/LC5			Well drained	***Low***	*Low*	Moderate
LC4	0.75 – 1.0”	1.5 – 2.0”	Moderate – well drained	Low	Moderate	Low - Moderate
LC4/LC5			Well drained	***Low***	***Low***	**Moderate**
LC4/LC6			Well drained	*Low*		Moderate
LC5	0.75 – 1.0”	2.0 – 3.0”	Moderate – well drained	Low	Moderate	Low - Moderate
LC6			Well drained	*Low*		Low – Moderate

LC9/LC 5			Well drained	*Low*		Low – Moderate
* Values that appear in italics are inferred values Risk Based on drainage/ infiltration rate in the surface 1' and water holding capacity: those with low infiltration (0.25 – 2.00") and high water holding capacity are rated as having a high risk; those with 2 – 4" of infiltration and moderate water holding capacity as having a moderate risk and soils having a high infiltration rate (4 – 8") and low water holding capacity as having a low risk						

Appendix B

Rose Creek Discharge & Water Quality Mesurements

Date: 8/19/02

DISCHARGE MEASUREMENTS

Measurement Method: **0.6** 0.2 0.8
No. of Sections 45
9:59 **am**/pm to 11:15 **am**/pm

Pt #	Distance from initial point (ft)	Width (in feet)	Depth (in feet)	**0.6** Vel. (ft/s)*	Area (ft2)	Discharge (cfs)
1	0.50	1.0	0.90	0.00	0.900	0.000
2	1.50	1.0	0.33	0.09	0.330	0.030
3	2.50	1.0	0.20	0.00	0.200	0.000
4	3.50	1.0	0.27	0.10	0.270	0.027
5	4.50	1.0	0.41	0.27	0.410	0.111
6	5.50	1.0	0.45	0.29	0.450	0.131
7	6.50	1.0	0.43	0.64	0.430	0.275
8	7.50	1.0	0.46	0.56	0.460	0.258
9	8.50	1.0	0.59	0.58	0.590	0.342
10	9.50	1.0	0.72	0.80	0.720	0.576
11	11.15	0.3	0.51	1.15	0.153	0.176
12	11.45	0.3	0.63	0.35	0.189	0.066
13	11.75	0.3	0.60	0.05	0.180	0.009
14	12.05	0.3	0.65	0.72	0.195	0.140
15	12.35	0.3	0.69	0.10	0.207	0.021
16	12.65	0.3	0.59	0.83	0.177	0.147
17	12.95	0.3	0.60	0.87	0.180	0.157
18	13.25	0.3	0.71	1.10	0.213	0.234
19	13.55	0.3	0.68	1.20	0.204	0.245
20	13.85	0.3	0.63	1.28	0.189	0.242
21	14.15	0.3	0.50	1.22	0.150	0.183
22	14.45	0.3	0.55	1.30	0.165	0.215
23	14.75	0.3	0.81	0.66	0.243	0.160
24	15.05	0.3	0.79	1.07	0.237	0.254
25	15.35	0.3	0.71	1.65	0.213	0.351
26	15.65	0.3	0.70	1.50	0.210	0.315
27	15.95	0.2	0.71	1.65	0.142	0.234
28	16.05	0.2	0.67	1.80	0.134	0.241
29	16.35	0.3	0.60	1.80	0.180	0.324
30	16.65	0.3	0.60	1.40	0.180	0.252
31	16.95	0.2	0.60	1.30	0.120	0.156
32	17.05	0.2	0.59	1.15	0.118	0.136
33	17.35	0.3	0.59	0.39	0.177	0.069
34	17.65	0.3	0.45	1.05	0.135	0.142
35	17.95	0.2	0.40	1.11	0.080	0.089
36	18.05	0.2	0.37	0.99	0.074	0.073
37	18.35	0.3	0.31	0.80	0.093	0.074
38	18.65	0.3	0.35	0.75	0.105	0.079
39	18.95	0.2	0.30	1.07	0.060	0.064
40	19.05	0.2	0.30	0.98	0.060	0.059
41	19.35	0.3	0.30	0.90	0.090	0.081
42	19.65	0.3	0.35	0.97	0.105	0.102
43	19.95	0.2	0.30	0.82	0.060	0.049
44	20.05	0.2	0.21	0.46	0.042	0.019
45	20.35	0.3	0.20	0.50	0.060	0.030
				Total	**9.88**	**6.94**

* NM stands for "not measured" at that depth

WATER QUALITY MEASUREMENTS

Measurement Interval 2 '
11:15 **am**/pm
to
11:25 **am**/pm

Temp (° C)	SC (mS)	pH
9.6	46.6	7.40
9.6	46.2	7.40
9.5	46.2	7.43
9.5	46.1	7.49
9.5	46.1	7.50
9.5	46.1	7.54
9.5	46.1	7.58
9.5	46.1	7.62
9.6	46.1	7.67
9.6	46.1	7.69

Appendix C

Site Name	Site Type	Date Sampled	2,4-D (ppb)	2,4-DB (ppb)	2,4-DP (ppb)	Bentazon (ppb)	Clopyralid (ppb)	Dicamba (ppb)	5-OH-Dicamba (ppb)	Diclofop Methyl (ppb)	MCPA (ppb)	MCPP (ppb)	PCP (ppb)	Picloram (ppb)	Triclopyr (ppb)
GNP 1	SW	8/19/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 2	GW	8/19/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 3	GW	8/19/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 4	GW	8/20/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 5	GW	8/20/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 6	GW	8/20/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 7	GW	8/20/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 8	GW	8/20/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 9	SW	8/21/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 10	GW	8/21/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 11	GW	8/21/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 12	GW	8/21/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GNP 13	SW	8/21/02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* ND = no detection of the analyte above the Limit of Quantitation
GW = Ground Water
SW = Surface Water