

## **APPENDIX B**

### **Forest Road Sediment Assessment Method (FROSAM)**

## **Introduction**

Section 303 of the Clean Water Act requires the identification of all impaired waterbodies in the United States. Once identified, the Clean Water Act further requires the establishment of a maximum pollutant load that can be assimilated by a given impaired waterbody and the implementation of an explicit plan to keep total pollutant loads below that maximum. The water quality improvement plans that are developed to meet these requirements are known as TMDLs (Total Maximum Daily Load).

The development of TMDLs for waterbodies impaired by siltation has become one of the major challenges for states that have substantial numbers of watersheds with agriculture and timber harvest as the dominant land uses. The challenge has two facets: first, an accurate assessment of the existing sources of siltation must be conducted and second, an accurate measure of any improvements must be made.

In most of the managed forested watersheds in the Western United States, forest roads are frequently one of the largest sources of non-point source pollution. The following discussion presents a practical approach for quantifying sediment load from forest roads as well as predicting and measuring improvements made during TMDL implementation.

The assessment method presented here is a refinement of the methods developed by the Washington Forest Practices Board, which is essentially an accounting procedure involving field observations of erosion and sediment delivery to streams. Streams are defined as any drainage depression containing a defined bed and banks extending continuously below the drainage site. Flow regime can be ephemeral, intermittent, or perennial. Therefore, erosion that is delivered to a drainage feature known to be discontinuous below (i.e. the flow goes subsurface and does not deliver to fish-bearing waters) should not be counted into the sediment load calculation.

## **Methods**

### **Step 1: Measure Source Area**

The source area for sediment load quantification encompasses all areas of road tread, ditches, cut slope, and fill slope from which water could flow to a stream. As an example in determining sediment load, suppose water flow over a road tread and cut slope is diverted by a drain-dip 100 feet from a stream crossing, and then passes into a heavily vegetated, flat area that precludes overland flow from reaching the stream. The area uphill of the drain-dip would not be counted into the sediment load to the stream, since the drain-dip serves to isolate it from the stream.

The length (longitudinally along the road) and width (across the road prism) of the tread, cut slope and fill slope are measured to derive the total areal extent (acres) of source area. If the cut and fill slopes vary significantly in width along a reach of road, the observer must estimate an average width of those features.

## Step 2: Apply Modifying Factors

Several modifying factors which are described below and summarized in **Table B-1** are applied to the measurement of actual eroding surface area. These are applied as average factors over each individual eroding area.

### Cover Factor

The cover factor is the percent of non-erodible cover on each of three road features: tread, cut slope, and fill slope. Cover percent translates into the modifying factors shown in **Table B-2**.

### Gravel Factor

The gravel factor accounts for reduced erosion from roads that have gravel applications. With a gravel lift of 2 to 6 inches in depth, the factor is 0.50. With a gravel lift of greater than 6 inches, the factor is 0.20.

### Traffic Factor

The traffic multiplier accounts for the fact that roads receiving heavy truck traffic have higher erosion rates. This factor ranges from 1 to 50, as shown in **Table B-3**. The value assigned depends on the use that the road experiences, with heavier traffic volume resulting in a greater multiplier.

### Percent Delivery

The determination of the percent of eroded fine sediment delivered to a stream is perhaps the most challenging part of this assessment methodology. This factor must take into account the observer's sense of sediment delivery over time and, without an accurate way to characterize historical or potential future sedimentation, it becomes a matter of professional judgment.

Another difficulty in establishing sediment delivery is the potential for "double mitigation". For example, the calculated amount of sediment generated at a given location would be overly reduced if the gravel factor was applied while the percent delivery was simultaneously reduced due to the lack of sediment generation. This would result in a double mitigation. The amount of fine sediment *generated* and the amount of fine sediment *delivered* are two different factors. To avoid this pitfall, "delivery" is considered as the *potential* for sediment to be carried to a stream once it is eroded. If there is no sediment being eroded, the lack of erosion is accounted for with the modifying factors of cover, gravel, etc.

**Table B-4** describes the categories of sediment delivery to streams. These can be adjusted based on the experience and judgment of the observer.

## Step 3: Calculate Road Sediment Load

To calculate the volume of sediment contribution from each road location, the following steps should be applied:

1. Assign a base (natural) erosion rate from roads in tons/acre/year. This can be derived from a combination of published values and professional knowledge of the soils in the watershed.
2. Calculate the area of erosion (length times width) for the tread, cut and fill slopes, and convert it to acres.
3. Apply each modifying factor: cover, gravel, traffic, and percent delivery.
4. Multiply all of these together to derive the sediment volume from each of these road features (road tread, cut slope and fill slope) individually.
5. Sum these three values for the total delivery for that location, which will yield a figure in tons of sediment per year.

Location totals thus derived can be summed for the entire watershed to arrive at a total fine sediment contribution from roads.

**Table B-1. Factors Applied in Forest Road Surface Sediment Assessment.**

<b>Factor</b>	<b>Definition</b>
Cover	Percent of non-soil cover.
Gravel	A categorical factor accounting for mitigating that results in gravel road surfacing.
Traffic	Factor accounting for higher erosion from higher traffic roads.
Delivery	Percent of displaced fine sediment which is delivered into a waterbody.

**Table B-2. Factor for Percent Cover Values.**

<b>Cover Percent</b>	<b>Factor</b>
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

**Table B-3. Traffic Factors.**

<b>Traffic Use/Road</b>	<b>Annual Precipitation</b>
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<b>Category</b>	<b>&lt;1200 mm</b>	<b>1200 mm-3000 mm</b>
Heavy Traffic--active mainline	20	50
Moderate Traffic--active secondary	2	4
Light Traffic--not active	1	1

**Table B-4. Categories of Sediment Delivery to Streams.**

<b>Percent Category</b>	<b>Description</b>
100%	Chronic direct delivery under most erosional scenarios.
75%	Direct delivery evident but not chronic; effective buffer (provided by distance, gentle topography, or vegetation) during low intensity erosional events.
50%	Direct sediment delivery, but minor amounts or older events.
25%	Direct delivery unlikely except in moderate to major erosional events.
5%	Effective buffer, but proximity of road to stream makes 5% necessary.







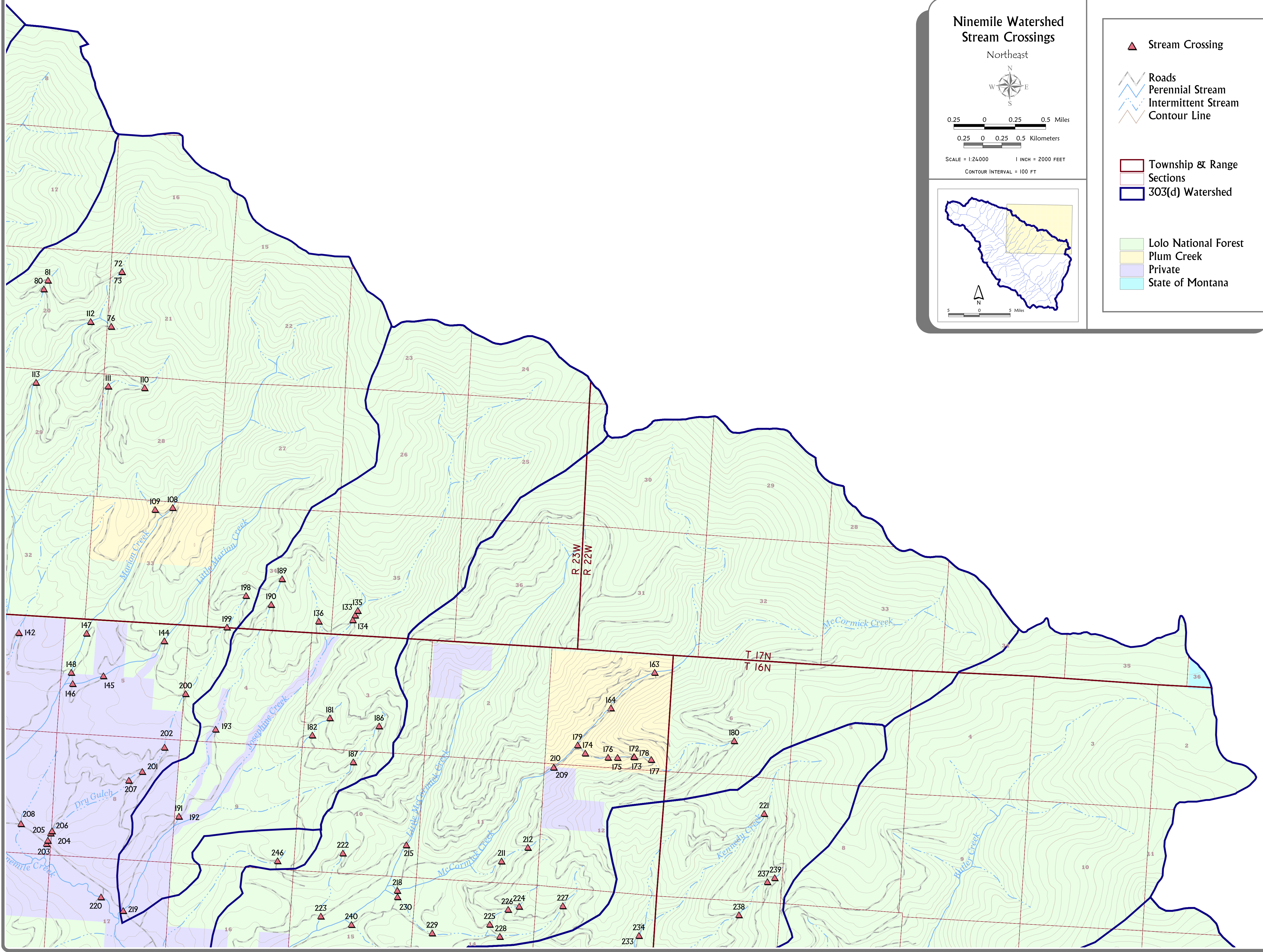






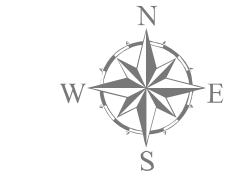
Ninemile TMDL - Existing Road Sediment Sources																																	
Location Number	Drainage	TREAD			Base Erosion Rate (tons/ac/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivery (tons/yr)	CUTSLOPE					FILLSLOPE					Base Erosion Rate (tons/ac/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivery (tons/yr)	Location Total Sediment (tons/yr)	Comments			
		Tread length (ft)	Tread Width (ft)	Acres of Tread									Cutslope Length (ft)	Avg. Cutslope Width (ft)	Acres of Cutslope	Base Erosion Rate (tons/ac/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivery (tons/yr)	Fillslope Length (ft)									Avg. Fillslope Width (ft)	Acres of Fillslope	Base Erosion Rate (tons/ac/yr)
373	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel.			
374	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	GIS error			
375	Ninemile	1300	28	0.835629	30	0.5	2	15	0.7	50	0.5	8.77410468	0	0	0	0	0	0	0	0	0	0	80	8	0.0146924	30	90	0.15	100	1	0.066115702	8.840	
376	Ninemile	0	0	0	30			0		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	paved.			
377	Ninemile	75	15	0.025826	30	2	2	5	0.9	10	0.1	0.27892562	60	6	0.0082645	30	60	0.3	10	0.1	0.00743802	50	4	0.0045914	30	100	0.1	5	0.05	0.000688705	0.287		
378	Ninemile	225	16	0.082645	30	0.5	1	25	0.58	50	0.5	0.35950413	0	0	0	0	0	0	0	0	0	70	5	0.0080349	30	90	0.15	95	0.95	0.034349174	0.394	private	
379	Ninemile	230	13	0.068641	30	1	1	5	0.9	20	0.2	0.37066116	410	5	0.0470615	30	75	0.21	20	0.2	0.05929752	120	6	0.0165289	30	100	0.1	20	0.2	0.009917355	0.440		
380	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing - GIS Error			
381	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	not contributing -- paved			
382	Ninemile	850	18	0.35124	30	1	2	10	0.77	50	0.5	8.11363636	640	10	0.1469238	30	25	0.58	45	0.45	1.15041322	200	4	0.0183655	30	90	0.15	75	0.75	0.061983471	9.326		
383	Ninemile	1300	28	0.835629	30	1	2	10	0.77	40	0.4	15.4424242	800	18	0.3305785	30	40	0.45	40	0.4	1.78512397	80	8	0.0146924	30	100	0.1	90	0.9	0.039669421	17.267		
384	Ninemile	990	16	0.363636	30	1	2	30	0.53	45	0.45	5.20363636	960	16	0.3526171	30	70	0.23	60	0.6	1.45983471	270	16	0.0991736	30	100	0.1	100	1	0.297520661	6.961		
385	Ninemile	770	18	0.318182	30	1	1	50	0.57	30	0.3	1.63227273	120	14	0.0385675	30	40	0.45	30	0.3	0.15619835	150	18	0.0619835	30	100	0.1	90	0.9	0.167355372	1.956		
386	Ninemile	510	30	0.35124	30	1	1	5	0.9	50	0.5	4.74173554	430	10	0.0987144	30	90	0.15	40	0.4	0.17768595	190	20	0.087236	30	100	0.1	95	0.95	0.24862259	5.168		
387	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel.			
388	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	GIS error			
389	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing--paved.			
390	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	GIS error			
391	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing due to dense vegetation and lack of evidence of flowing water			
392	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing due to dense vegetation and lack of evidence of flowing water			
393	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing; no channel.			
394	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel.			
395	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing due to dense vegetation and lack of evidence of flowing water			
396	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing due to dense vegetation and lack of evidence of flowing water			
397	Ninemile	270	10	0.061983	30	1	2	60	0.3	25	0.25	0.27892562	140	10	0.0321396	30	70	0.23	70	0.7	0.15523416	80	8	0.0146924	30	100	0.1	70	0.7	0.030853994	0.465		
398	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel			
399	Ninemile	270	16	0.099174	30	1	1	75	0.21	20	0.2	0.12495868	240	14	0.077135	30	60	0.3	20	0.2	0.13884298	95	8	0.0174472	30	100	0.1	90	0.9	0.047107438	0.311		
400	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing due to dense vegetation and lack of evidence of flowing water			
401	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Paved county road			
402	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Paved county road			





**Ninemile Watershed  
Stream Crossings**

Northeast

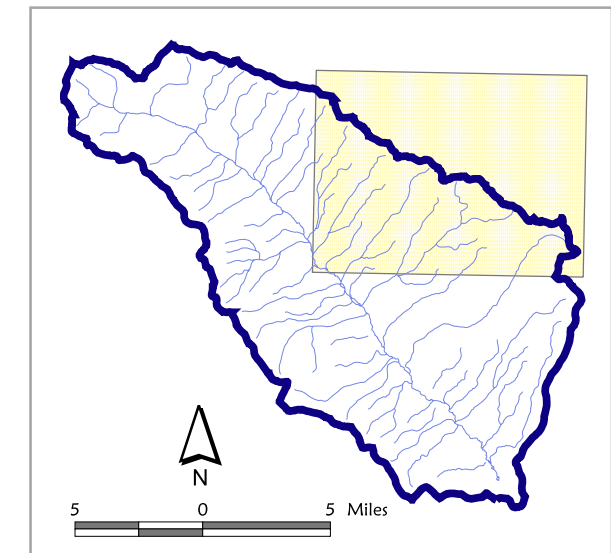


0.25 0 0.25 0.5 Miles

0.25 0 0.25 0.5 Kilometers

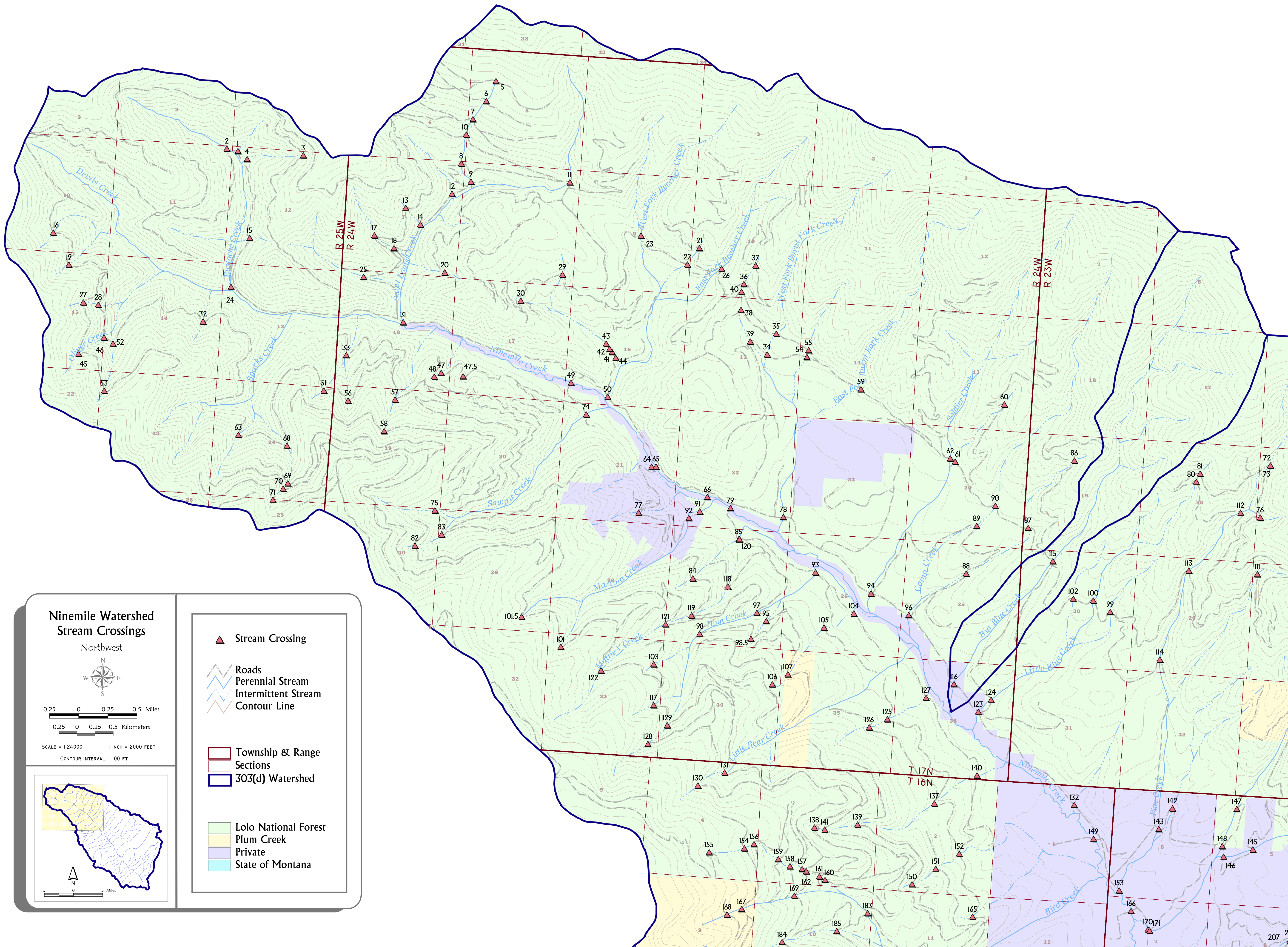
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CONTOUR INTERVAL = 100 FT



- Stream Crossing
- Roads
- Perennial Stream
- Intermittent Stream
- Contour Line
- Township & Range Sections
- 303(d) Watershed
- Lolo National Forest
- Plum Creek
- Private
- State of Montana





**Ninemile Watershed  
Stream Crossings**

Northwest

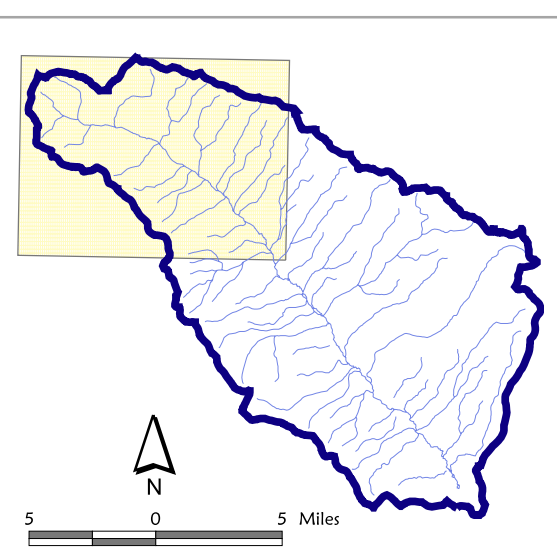


0.25 0 0.25 0.5 Miles

0.25 0 0.25 0.5 Kilometers

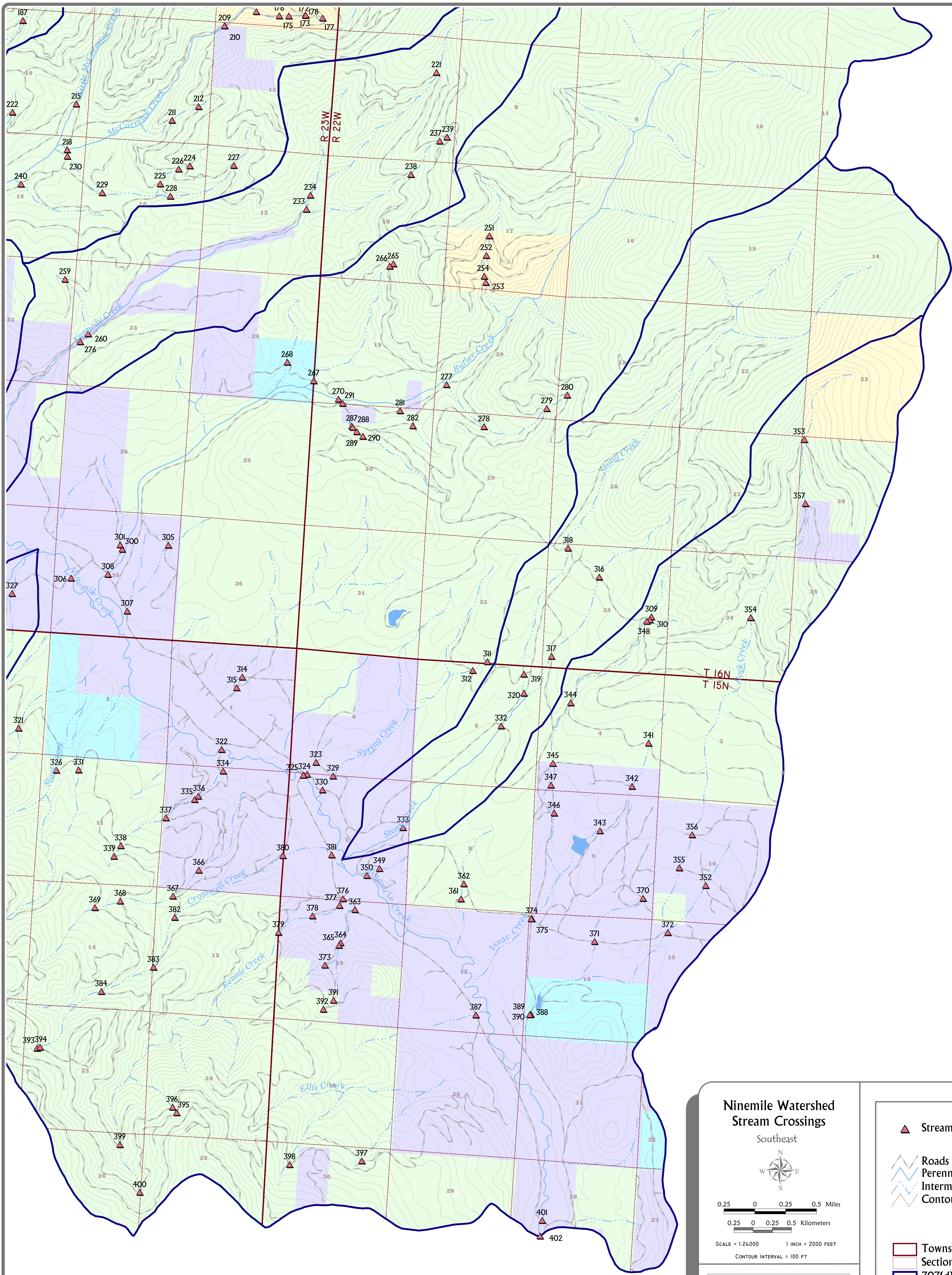
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CONTOUR INTERVAL = 100 FT



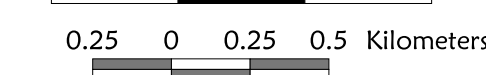
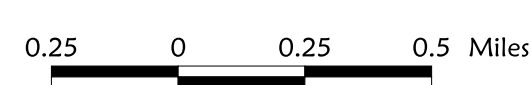
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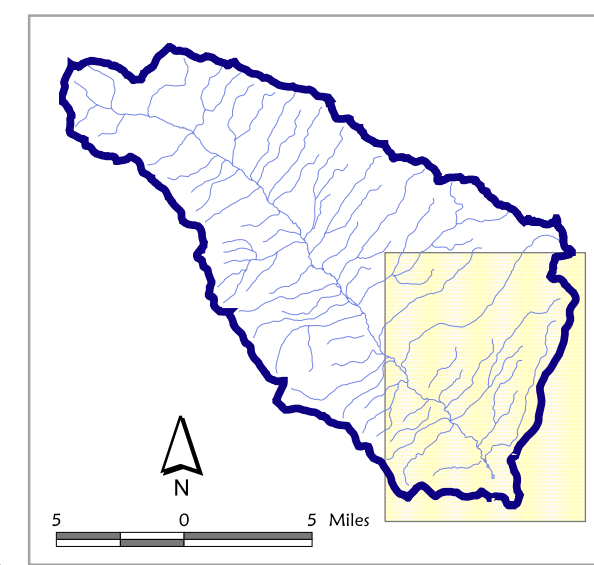
**Ninemile Watershed Stream Crossings**

Southeast



SCALE = 1:24,000 1 INCH = 2000 FEET

CONTOUR INTERVAL = 100 FT



- Stream Crossing
- Roads
- Perennial Stream
- Intermittent Stream
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- Township & Range
- Sections
- 303(d) Watershed

- Lolo National Forest
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