U.S. Department of the Interior
U.S. Geological Survey

Determination of Upstream Boundary Points on Northeastern Washington Streams and Rivers Under The Requirements of The Shoreline Management Act of 1971

Water-Resources Investigations Report 98-4160

Prepared in cooperation with
Washington State Department of Ecology

science for a changing world

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Thomas J. Casadevall
Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
1201 Pacific Avenue - Suite 600
Tacoma, Washington 98402

Copies of this report may be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286, MS 517
Denver, Colorado 80225-0286

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Tacoma, Washington
1998

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CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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By David L. Kresch

ABSTRACT

Certain regulations affecting the shorelines of the State of Washington, as mandated by the Shoreline Management Act of 1971, are applicable to streams and rivers downstream from the points where the mean annual discharge or the size of the drainage basin equals specified amounts. The U.S. Geological Survey originally conducted a study in 1971 to determine these upstream boundary points for many of the State's streams. In this current study, boundary points were determined for 168 streams and rivers in northeastern Washington that come under the jurisdiction of the Shoreline Management Act of 1971. This includes 146 streams where the mean annual discharge exceeds 20 cubic feet per second and 22 rivers of statewide significance where either the mean annual discharge exceeds 200 cubic feet per second or the drainage area exceeds 300 square miles.

Boundary point locations were determined using a log-linear regression equation that relates mean annual discharge to drainage area and mean annual precipitation. The regression equation is based on data from 33 gaging stations with at least 10 years of record. The coefficient of determination, R^2, of the regression equation is 0.984, and the standard error of estimate of the equation is ± 0.0916 log units. The latter corresponds to an error of -3.8 to +4.7 cubic feet per second for a mean annual discharge of 20 cubic feet per second and an error of -38 to +47 cubic feet per second for a mean annual discharge of 200 cubic feet per second.

INTRODUCTION

The Washington State legislature, in 1971, identified the shorelines of the State as "among the most valuable and fragile of its natural resources" and expressed great concern regarding their utilization, protection, restoration, and preservation. Therefore, the legislature enacted the Shoreline Management Act of 1971 (hereafter referred to either as the Shoreline Management Act or as the Act) and designated the Washington State Department of Ecology (Ecology) as the agency responsible for regulating the State's shorelines (State of Washington, 1971). The stream and river reaches under the jurisdiction of the Shoreline Management Act are those where specified regulatory discharges or drainage basin sizes are exceeded. Thus, Ecology needs to know the locations on streams and rivers where the regulatory criteria are reached (upstream boundary points) to properly carry out the provisions of the Act.

The Act designates separate regulatory criteria for streams and rivers. For northeastern Washington, the study area of this report (fig. 1), the Act defines "shorelines" as stream reaches where the mean annual discharge exceeds 20 cubic feet per second (ft^3/s) and "shorelines of statewide significance" as river reaches where either the mean annual discharge exceeds 200 ft^3/s or the drainage area exceeds 300 square miles. The location of the upstream boundary for a stream or river is defined as the point where one of these criteria is met.

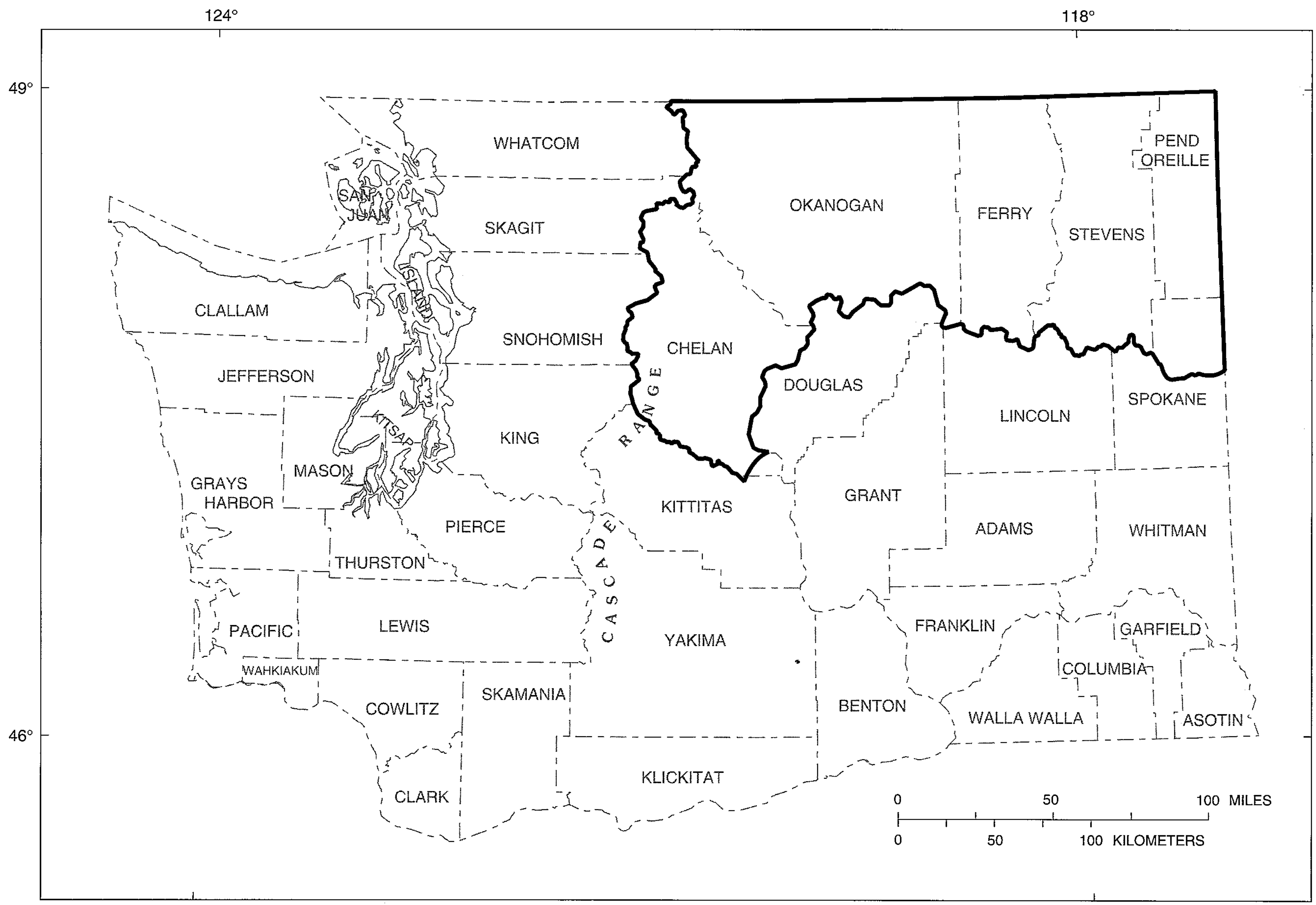

Figure 1. Study area location in northeastern Washington State.

Previous Investigations

The U.S. Geological Survey (USGS), in cooperation with Ecology, conducted a study in 1971 to determine the upstream boundary points on many streams throughout the State for which Ecology had regulatory responsibility (David H. Appel, U.S. Geological Survey, written commun., 1971). However, in 1990, Ecology decided that the boundary points determined in the 1971 study needed to be updated for the following reasons.

1. The 1971 study did not include all streams that met the regulatory criteria.
2. The 1971 study did not determine upstream boundary points for shorelines of statewide significance.
3. In the 1971 study, if the regulatory discharge occurred upstream of certain political or jurisdictional boundaries, such as those for national forests, Indian reservations, and national parks, the Shoreline Management Act upstream boundary point was placed at the political or jurisdictional boundary.
4. The 1971 study determined upstream boundary points for the regulatory discharge of 20 ft^3/s plus the standard error of the determining regression equations rather than for just the regulatory discharge itself.
5. Over two additional decades of streamflow data collected since 1971 could provide improved estimates of long-term mean annual discharges.

From 1990 through 1995, the USGS, in cooperation with Ecology, determined updated upstream boundary points for all western Washington streams and rivers for which Ecology has regulatory responsibility. Those updated boundary point locations were published in USGS Water-Resources Investigations Report 96-4208 (Kresch, 1998).

Purpose and Scope

This report presents the results of a study to determine the upstream boundary points for the streams and rivers in northeastern Washington that come under the jurisdiction of the Shoreline Management Act. The study was conducted by the USGS in 1995, in cooperation with Ecology. The study area (figure 1) includes most of Chelan County, all of Okanogan, Pend Oreille, Ferry, and Stevens Counties, and the portion of Spokane County located north of the Spokane River. The study area boundary near the southeast corner of Chelan County follows the drainage divide between the Yakima and Wenatchee River Basins rather than the county boundary.

APPROACH

Most of the streams and rivers of interest in this study are not gaged. Thus, a direct-measurement approach for determining upstream boundary points could not feasibly be used because (1) the use of stream-gaging records to determine mean annual discharges would require continuous operation of a number of new gages on each stream over a period of years, (2) the locations at which to gage the streams would not be known beforehand, and (3) the cost of operating the large number of gages required would be economically impractical.

The most practical way to determine streamflow at ungaged sites is by transfer of information developed for gaged sites. A widely accepted approach uses multiple-log-linear-regression equations that relate streamflow to physical and climatic characteristics. The previous USGS study (David H. Appel, U.S. Geological Survey, written commun., 1971) concluded that only drainage area and mean annual precipitation were needed in order to determine mean annual discharge at ungaged sites. The form of the regression equations developed for that study was

$$Q = aA^{b}P^{c} \quad , \qquad (1)$$

where Q is mean annual discharge, A is basin drainage area, P is mean annual precipitation averaged over the basin, and a , b , and c are constants. The basin area (A) and precipitation (P) are those for the drainage basin upstream of the point on the stream or river at which mean annual discharge (Q) is desired. The use of only drainage area and mean annual precipitation as independent variables in the 1971 study was partially compensated for by splitting the State into 13 hydrologically distinct regions. Specifying different constants in equation 1 for each region implied different hydrologic responses for the same basin area and precipitation among the different regions.

The inclusion of additional independent variables into equation 1, namely percentage of forest cover, mean drainage basin elevation, and January minimum temperature, was considered in the 1971 study. However, that study found that these additional variables did not significantly improve the accuracy of the equation in determining the boundary points. Including additional independent variables in equation 1 also would make applying the equation more difficult and impractical because values for each additional variable, many of which are not readily available, would have to be known for the drainage basins upstream of the boundary points. Thus, only basin drainage area and mean annual precipitation were used as independent variables for both the 1971 study and this current study.

Basin areas for selected points along streams in eastern Washington have been published (Williams, 1964). Basin areas needed for other points in this study were determined using ARC/INFO, a geographic information system (GIS) software package. Drainage basin boundaries were manually delineated on 7.5-minute topographic quadrangle maps and digitized into ARC/INFO coverages. Automatic delineation of drainage basin boundaries by using an ARC/INFO procedure had been investigated previously when boundary point locations were determined for western Washington streams and rivers. When the automatic procedure was tested by applying it to 33 stream basins that had previously been manually delineated and then digitized, it was found not to be reliable enough to use for this study. Although 17 of the automatically delineated basins differed from the manually delineated basins by less than 10 percent, 7 of the remaining 16 differed by between 10 and 20 percent, 4 differed by between 20 and 50 percent, and 5 differed by more than 50 percent.

The mean annual precipitation for each basin area was approximated from an ARC/INFO coverage of mean annual precipitation for Washington that was developed and used previously in the determination of boundary points on western Washington streams and rivers (Kresch, 1998). That coverage was generated by digitizing all the lines of equal mean annual precipitation on a U.S. Weather Bureau precipitation map of Washington (1965) and then converting that arc coverage into a grid coverage of point values. The precipitation map was developed using data for the period 1930 to 1957. Data needed for a meaningful update of that map probably are not available, because most precipitation gages are at low elevations rather than in the mountainous areas where the positioning of the lines of equal precipitation is the least well defined. It should be noted, however, that the regression itself (equation 1) compensates for any linear adjustment one might make in the logarithms of precipitation values. The mean annual precipitation over a basin is calculated as the average of all the grid point values that lie within the basin.

DEVELOPMENT OF THE REGIONAL REGRESSION EQUATION

Thirty-three gaging station records with at least 10 years of record were used in the development of the regional regression equation for determining the mean annual discharge of northeastern Washington streams and rivers. The values of mean annual discharge, mean annual precipitation, and basin drainage area for each of these records are given in table 1 (at end of report).

In the 1971 study, the State was divided into 13 hydrologically distinct regions such that streamflow response was similar throughout each region. This allowed unique constants a, b, and c to be determined for and applied throughout each region. The current study area contains only 2 of those 13 regions—the Colville to Wenatchee and the Pend Oreille regions. The major drainage basins located within the Colville to Wenatchee region are the Colville, Columbia, Sanpoil, Okanogan, Methow, and the Wenatchee River Basins. The only major drainage basin in the Pend Oreille region is the Pend Oreille River Basin. Although separate regression equations were developed for the Colville to Wenatchee and the Pend Oreille regions in the 1971 study, the data for these two regions were combined into a single equation for use in the current study because there are only five gaging stations in the Pend Oreille region (station numbers 12396000, 12396900, 12397100, 12397500, and 12398000); because the mean annual discharges (69.8 to 222 ft^3/s) at those gages are all significantly greater than the 20 ft^3/s regulatory discharge; and because regression residuals for the five Pend Oreille region gages are within the same range of magnitudes as those for many of the gages in the Colville to Wenatchee region. The mean annual discharges for the 28 gages located within the Colville to Wenatchee region range from 7.37 to 3,059 ft^3/s.

Base-10 logarithmic transformations of the mean annual discharge (Q), basin drainage area (A), and mean annual precipitation (P) from each of the 33 gaging-station records in the study area were used in a linear regression analysis to determine the values of the constants a, b, and c in equation 1. The regression equation thus determined is

$$\log_{10} Q = -2.986 + 1.81\left(\log_{10} P\right) + 1.04\left(\log_{10} A\right) . \quad (2)$$

Expressed in the format of equation 1, this equation becomes

$$Q = 0.00103\,(P)^{1.81}\,(A)^{1.04} \qquad (3)$$

The coefficient of determination, R^2, of the regression equation is 0.984, which indicates that about 98.4 percent of the variation in the base-10 logarithm of Q is explained by the regression equation. The standard error of estimate of the equation is ± 0.0916 log units. The standard error expressed in terms of discharge ranges from -3.8 ft^3/s (- 19.0 percent) to +4.7 ft^3/s (+23.5 percent) for a mean annual discharge of 20 ft^3/s and from -38 to +47 ft^3/s for a mean annual discharge of 200 ft^3/s.

The approximate error in a boundary point location can be obtained from equation 3 and the estimated errors in discharge. All that is required is to replace the variable Q by Q_{error}, the standard error of estimate of regression equation 3 in cubic feet per second, and the variable A by $W*L_{error}$, where W is the average basin width in miles in the vicinity of the boundary point and L_{error} is the error in the boundary point location. When solved for L_{error}, the result (equation 4) will give only a rough estimate of the error because of the uncertainty in the distance to use for average basin width.

$$L_{error} = 745\frac{\left(Q_{error}\right)^{0.96}}{W(P)^{1.74}} \qquad (4)$$

For example, if the mean annual precipitation (P) in the vicinity of a boundary point is 60 inches and the average basin width (W) is 2 miles, then the estimated possible error in the location of the boundary point would range from 1.1 miles upstream, corresponding to an error in discharge of -3.8 ft^3/s, to 1.3 miles downstream, corresponding to an error in discharge of +4.7 ft^3/s.

Equation 4 is applicable only to those locations where inflow in the vicinity of the boundary point increases approximately linearly along the stream reach. Actual possible errors for boundary points that are located at the confluence of two or more streams will normally be less than those calculated by equation 4.

During the process of selecting gaging station records for use in the regional regression analysis, station records that predominantly span only especially wet or dry periods, such as the period of drought from the mid-1930's to the mid-1940's, were not used because the regressions are intended to represent average rather than extreme conditions. In order to provide good representation in the regression for the conditions in the entire region, streamflow records for all remaining stations, except those operated less than 10 years and those significantly affected by regulation or diversion, were used.

The use of a common base period, such as 1937–76, for determining the mean annual discharge of all gaging-station records used in the regression analysis would be desirable because it would place all mean annual discharges on a common footing. However, using a common base period would greatly complicate the analysis because few station records span 1937–76, or any other suitably long, representative period of hydrologic conditions, so synthetic records would have to be generated for most stations. Therefore, it was decided to use just the actual period of record available at each station.

DETERMINATION OF UPSTREAM BOUNDARY POINTS

For 146 northeastern Washington streams, upstream boundary points were determined where the mean annual discharge is 20 ft^3/s. Latitude-longitude and Universal Transverse Mercator (UTM) coordinates for these boundary points are given in tables 2–7 (at end of report). Those points located west of 120 degrees longitude are given in UTM zone 10 coordinates, whereas those points located east of 120 degrees longitude are given in UTM zone 11 coordinates.

For 22 northeastern Washington rivers upstream boundary points were determined where either the mean annual discharge is 200 ft^3/s or the drainage area is 300 square miles. Coordinates for these boundary points are given in table 8 (at end of report) in the same coordinate systems as those used for the stream boundary points.

The following steps were used to determine the location of each upstream boundary point:

1. A trial point was selected as an initial estimate of the location of the boundary point on the stream or river.
2. The drainage-basin boundary upstream of the trial point was manually delineated on a 7.5-minute topographic quadrangle map.
3. The basin boundary was digitized into an ARC/INFO coverage.
4. ARC/INFO programs were used to determine the basin area contributing streamflow to the trial point and the mean annual precipitation over the basin.

5. The basin area and mean annual precipitation were entered into the regional regression equation to determine the mean annual discharge at the trial point.
6. Steps 1–5 were repeated at upstream or downstream trial points until the calculated discharge was within 1 percent of either 20 ft^3/s (± 0.2 ft^3/s) for boundary points of shorelines or 200 ft^3/s (± 2 ft^3/s) for boundary points of shorelines of statewide significance.
7. The point on a river at which the mean annual discharge was determined to be 200 ft^3/s was designated as the upstream boundary of the shoreline of statewide significance for the river unless the corresponding drainage area at that point was greater than 300 square miles. In the latter case, steps 1–4 were repeated at upstream trial points until the location of the point having a drainage area of 300 square miles was determined. That point was then designated as the upstream boundary for the shoreline of statewide significance.

There are two conditions for which the discharge at an upstream boundary point may not be equal to a regulatory discharge. The first is the occurrence of an upstream boundary point at the confluence of two or more streams, and the second is the occurrence of an upstream boundary point at either the inlet or outlet of a lake.

If the discharge of each of two or more confluent streams at their mouths is less than the regulatory discharge but their combined discharge at the confluence is equal to or greater than the regulatory discharge, then the upstream boundary point would be placed at the confluence. For example, if two streams each have discharges of 19 ft^3/s at their mouths, then the upstream boundary point would be placed at their confluence, and the discharge at that point would be 38 ft^3/s, the sum of the two discharges. Likewise, if three streams having a common confluence have discharges of 13, 15, and 18 ft^3/s at their mouths, then the upstream boundary point would be placed at their confluence, and the discharge at that point would be 46 ft^3/s, the sum of all three discharges.

If the discharge from a lake's outlet exceeds the regulatory discharge and the discharge of the lake's largest inflow is less than that discharge, then the location of the boundary point depends on the nature of the inflow to the lake. If the inflow originates from two or more separate streams and each stream has a discharge of less than the regulatory discharge, then the upstream boundary point would be placed at the lake outlet, and the discharge there would exceed the regulatory discharge. However, if the inflow to the lake is primarily from a single stream with a discharge of less than the regulatory discharge, then the upstream boundary would be placed at the lake inlet, and the discharge at that point would be less than the regulatory discharge. For example, the upstream boundary point for a lake fed by three inflow streams that have discharges of 7, 13, and 19 ft^3/s would be placed at the outlet of the lake, and the stream discharge at that point would be at least 39 ft^3/s—the sum of the three inflow streams. However, if a lake is fed primarily by only a single stream with a discharge of 17 ft^3/s, then the upstream boundary point would be placed at the mouth of the inflow stream, and the stream discharge at that point would be 17 ft^3/s.

Although the most accurate way to determine a stream's boundary point would be to operate several gaging stations on the stream, this was not done because it would not be economically feasible. However, gaging-station discharge data already available for a given stream, which are inherently more site specific than discharges determined by the regional regression equation, can be used to refine the boundary point location on that stream. This can be accomplished by assuming that the ratio of the actual to the regression discharge at the boundary point is the same as the ratio of the actual to the regression discharge at the gaging station. Applying this technique to a stream reach consists of the iterative process of selecting trial boundary points until the discharge ratio at the boundary point is equal to the discharge ratio determined for the gage. This technique was applied to determine the boundary point location on any stream for which there was a gaging-station record with a mean annual discharge of less than 100 ft^3/s. For example, data for gaging station 12408500 were used in the determination of the upstream boundary point on Mill Creek in Stevens County. The ratio of the actual discharge at the gage (47.9 ft^3/s) to the regression discharge at the gage (37.1 ft^3/s) is 1.29. In order to obtain the same discharge ratio at the boundary point, where the desired discharge is 20 ft^3/s, the regression discharge at the boundary point would need to be 15.1 ft^3/s. The same technique was applied in determining boundary point locations on rivers of statewide significance for which there was a gaging-station record with a mean annual discharge of between 100 and 1,000 ft^3/s. For example, data for gaging station 12452800 were used in the determination of the upstream boundary point on the Entiat River in Chelan County. The ratio of the actual discharge (370 ft^3/s) to the regression discharge (422 ft^3/s) at the gage is 0.88. A regression discharge of 227 ft^3/s at the boundary point was needed to result in a ratio of 0.88 between the desired discharge (200 ft^3/s) at the boundary point and the regression discharge.

After all the boundary points were determined, the ARC/INFO coverages of their locations were given to the Department of Ecology. If the USGS, Ecology, local governments, or others had additional data that allowed a more accurate determination of streamflow at or near some of these locations, those boundary point locations were adjusted, if necessary, to reflect the additional information.

SUMMARY

The State of Washington, Department of Ecology (Ecology) is responsible for regulation of the shorelines of the State, as mandated by the Shoreline Management Act of 1971. Implementation of the portion of the Act that deals with stream and river shorelines requires a knowledge of the locations of upstream boundary points where specific regulatory criteria are satisfied.

The U.S. Geological Survey, in cooperation with Ecology, conducted this study to update upstream boundary points previously determined on northeastern Washington streams during a 1971 statewide study. The 1971 study needed to be updated because it had not determined boundary points for streams located within certain political boundaries and for rivers of statewide significance, because it had used the regulatory discharge of 20 cubic feet per second (ft^3/s) plus the standard error of the regression to determine boundary point locations, and because the additional streamflow data that have been collected since 1971 could provide improved estimates of long-term mean annual discharges.

For 146 northeastern Washington streams upstream boundary points were determined where the mean annual discharge is 20 ft^3/s. In addition, for 22 northeastern Washington rivers of statewide significance upstream boundary points were determined where either the mean annual discharge is 200 ft^3/s or the drainage area is 300 square miles. Boundary point locations were determined by application of a multiple-log-linear regression equation that relates mean annual discharge to basin drainage area and mean annual precipitation averaged over the basin. The regression equation is based on data from 33 gaging stations with at least 10 years of record. The coefficient of determination, R^2, of the regression equation is 0.984, and the standard error of estimate of the equation is ± 0.0916 log units. The latter corresponds to an error of -3.8 to +4.7 ft^3/s for a mean annual discharge of 20 ft^3/s and an error of -38 to +47 ft^3/s for a mean annual discharge of 200 ft^3/s.

Drainage area sizes were determined by digitizing drainage-area boundaries from 7.5-minute topographic quadrangle maps into geographic information system (GIS) coverages. A GIS coverage of mean annual precipitation, created by digitizing lines of mean annual precipitation from a 1965 U.S. Weather Bureau map, was used to determine the mean annual precipitation within each digitized drainage basin.

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State of Washington, 1971, Shoreline Management Act of 1971, Chapter 286, Laws of 1971, First Extraordinary Session, Chapter 90.58 RCW, adpoting a new chapter 173-16 WAC.

U.S. Weather Bureau, 1965, Mean Annual Precipitation, 1930-57, State of Washington: Portland, Oregon, U.S. Soil Conservation Service, map M-4430.

Williams, J.R., 1964, Drainage-area data for eastern Washington: U.S. Geological Survey Open-File Report, 197 p.

Table 1. Gaging-station records used in the development of the regression equation for determining mean annual discharge of northeastern Washington streams and rivers

Station number	Station name	Mean annual discharge (cubic feet per second)	Mean annual precipitation (inches)	Drainage area (square miles)	Period of record (water years)
12396000	Calispell Creek near Dalkena	69.8	38.44	68.5	1951-73
12396900	Sullivan Creek above Outlet Creek near Metaline Falls	119	45.04	70.0	1960-72
12397100	Outlet Creek near Metaline Falls	72.6	40.50	51.9	1960-93
12397500	Sullivan Creek near Metaline Falls	191	43.08	122	1913-25
12398000	Sullivan Creek at Metaline Falls	222	41.64	142	1954-68
12407500	Sheep Creek at Springdale	12.0	21.40	48.5	1954-72
12407700	Chewelah Creek at Chewelah	36.8	22.21	93.2	1958-74
12408300	Little Pend Oreille River near Colville	58.5	29.44	130	1959-75
12408420	Haller Creek near Arden	7.37	19.60	36.4	1960-70
12408500	Mill Creek near Colville	47.9	26.16	82.0	1940-72, 1978-86
12409000	Colville River at Kettle Falls	296	21.67	1022	1923-93
12409500	Hall Creek at Inchelium	77.2	23.90	160	1914-29, 1973
12424000	Hangman Creek at Spokane	230	21.32	688	1949-77, 1979-93
12427000	Little Spokane River at Elk	56.4	30.30	114	1949-71
12431000	Little Spokane River at Dartford	295	25.44	676	1930-32, 1948-93
12433200	Chamokane Cr below Falls near Long Lake	51.8	18.20	178	1972-78, 1988-93
12437500	Nespelem River at Nespelem	39.3	20.17	122	1912-29
12442000	Toats Coulee Creek near Loomis	45.8	27.62	131	1958-69
12446500	Salmon Creek near Conconully	31.2	20.77	120	1911-22
12449500	Methow River at Twisp	1312	34.57	1304	1920-62, 1992-93
12449600	Beaver Creek below South Fork near Twisp	20.5	25.16	62.6	1961-78
12449950	Methow River near Pateros	1531	31.77	1774	1960-93
12451000	Stehekin River at Stehekin	1405	96.36	320	1911-14, 1927-93
12452500	Chelan River at Chelan	2036	59.12	934	1905-93
12452800	Entiat River near Ardenvoir	370	59.63	202	1958-93
12453000	Entiat River at Entiat	507	46.10	418	1911-25, 1952-58
12454000	White River near Plain	807	105.98	149	1912, 1914, 1955-83
12455000	Wenatchee River below Wenatchee Lake	1317	97.96	273	1933-58
12456500	Chiwawa River near Plain	489	70.13	172	1912-14, 1937-49, 1955-57, 1992-93

Table 1. Gaging-station records used in the development of the regression equation for determining mean annual discharge of northeastern Washington streams and rivers--Continued

Station number	Station name	Mean annual discharge (cubic feet per second)	Mean annual precipitation (inches)	Drainage area (square miles)	Period of record (water years)
12457000	Wenatchee River at Plain	2244	79.83	596	1911-79, 1990-93
12458000	Icicle Creek above Snow Creek near Leavenworth	625	86.01	193	1937-71
12459000	Wenatchee River at Peshastin	3059	72.47	995	1929-93
12461400	Mission Creek above Sand Creek near Cashmere	13.2	23.58	39.3	1960-71
	Maximum	3,059	105.98	1774	
	Minimum	7.37	18.20	36.4	
	Mean	536	43.20	348	
	Median	191	31.77	149	

Table 2. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Chelan County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates

		Boundary point			
				Universal Transverse Mercator coordinates[1]	
Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Latitude (degrees in minutes and seconds)	Longitude (degrees in minutes and seconds)	Easting (meters)	Northing (meters)
Agnes Creek, West Fork	Dome Peak	48 19 50	121 02 02	645,719	5,354,712
Agnes Creek, South Fork	Suiattle Pass	48 13 38	120 55 59	653,501	5,343,418
Basin Creek	Cascade Pass	48 28 01	121 00 59	646,630	5,369,885
Big Meadow Creek	Plain	47 52 22	120 42 55	670,834	5,304,465
Boulder Creek	Clark Mountain	48 00 40	120 56 54	653,000	5,319,370
Boulder Creek	Stehekin	48 21 23	120 37 53	675,451	5,358,414
Bridge Creek, North Fork	Mt. Logan	48 30 24	120 55 22	653,413	5,374,482
Bridge Creek, South Fork	McGregor Mountain	48 25 58	120 45 31	665,789	5,366,611
Bridge Creek	McAlester Mountain	48 30 00	120 42 30	669,281	5,374,190
Buck Creek	Suiattle Pass	48 07 33	120 56 08	653,610	5,332,131
Cady Creek	Bench Mark Mountain	47 55 57	121 08 38	638,625	5,310,262
Chikamin Creek	Chikamin Creek	47 56 41	120 43 17	670,150	5,312,467
Chiwaukum Creek	Big Jim Mountain	47 42 51	120 51 27	660,706	5,286,553
Chiwaukum Creek, South Fork	Big Jim Mountain	47 40 44	120 52 04	660,035	5,282,611
Chiwawa River	Suiattle Pass	48 08 24	120 53 40	656,621	5,333,796
Chumstick Creek	Winton	47 39 41	120 38 25	677,166	5,281,169
Company Creek	Mt. Lyall	48 16 38	120 49 55	660,851	5,349,189
Cottonwood Creek	Goode Mountain	48 26 40	120 59 22	648,668	5,367,462
Eightmile Creek	Cashmere Mountain	47 31 37	120 50 27	662,514	5,265,767
Entiat River	Pinnacle Mountain	48 07 54	120 42 48	670,138	5,333,263
Entiat River, North Fork	Pyramid Mountain	48 03 52	120 36 39	677,988	5,326,035
Fish Creek	Bench Mark Mountain	47 54 01	121 08 57	638,324	5,306,665
Fish Creek	Sun Mountain	48 15 15	120 32 43	682,207	5,347,256
Flat Creek, South Fork	Goode Mountain	48 24 21	120 56 36	652,206	5,363,253
Flat Creek, West Fork	Cascade Pass	48 25 13	121 00 16	647,637	5,364,719
Flat Creek	Cascade Pass	48 23 14	121 02 35	644,872	5,360,989
French Creek	The Cradle	47 34 20	121 03 10	646,438	5,270,398
Grizzly Creek	Mt. Arriva	48 31 25	120 50 44	659,073	5,376,532

Table 2. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Chelan County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates—Continued

Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Boundary point: Latitude (degrees in minutes and seconds)	Boundary point: Longitude (degrees in minutes and seconds)	Universal Transverse Mercator coordinates[1]: Easting (meters)	Universal Transverse Mercator coordinates[1]: Northing (meters)
Ibex Creek	Mount David	47 56 20	120 58 15	651,527	5,311,279
Ice Creek	Saska Peak	48 06 27	120 44 30	668,094	5,330,493
Indian Creek	Poe Mountain	47 59 17	121 04 32	643,587	5,316,566
Ingalls Creek	Enchantment Lakes	47 26 58	120 52 08	660,639	5,257,098
Jack Creek	Jack Ridge	47 30 45	120 56 52	654,506	5,263,963
Lake Creek	Labyrinth Mountain	47 51 32	121 05 54	642,232	5,302,158
Lake Creek	Silver Falls	47 57 26	120 30 02	686,592	5,314,363
Leland Creek	The Cradle	47 36 50	121 05 02	643,988	5,274,964
Lightning Creek	Glacier Peak East	48 02 27	121 03 03	645,280	5,322,476
Little Wenatchee River	Poe Mountain	47 58 05	121 06 24	641,318	5,314,290
Mad River	Sugarloaf Peak	47 51 36	120 36 12	679,253	5,303,326
Maple Creek	McGregor Mountain	48 28 48	120 47 28	663,230	5,371,786
McAlester Creek	McAlester Mountain	48 26 46	120 41 33	670,629	5,368,257
Meadow Creek	Jack Ridge	47 32 39	120 58 51	651,930	5,267,413
Mill Creek	Labyrinth Mountain	47 46 00	121 01 50	647,575	5,292,034
Mission Creek	Tiptop	47 25 49	120 30 24	688,024	5,255,780
Mountaineer Creek	Cashmere Mountain	47 30 10	120 50 41	662,297	5,263,096
Napeequa River	Clark Mountain	48 05 03	120 58 27	650,871	5,327,430
Nason Creek	Labyrinth Mountain	47 46 57	121 03 09	645,868	5,293,753
Panther Creek	Poe Mountain	47 55 27	121 00 29	648,802	5,309,577
Park Creek	Goode Creek	48 28 44	120 57 23	651,017	5,371,348
Peshastin Creek	Blewett	47 25 32	120 39 29	676,629	5,254,903
Phelps Creek	Holden	48 08 37	120 51 06	659,808	5,334,291
Prince Creek	Prince Creek	48 12 15	120 26 25	690,186	5,341,963
Prospect Creek	Stevens Pass	47 38 55	121 05 23	643,454	5,278,809
Railroad Creek	Suiattle Pass	48 12 06	120 52 45	657,569	5,340,669
Rainbow Creek	McAlester Mountain	48 23 22	120 41 04	671,406	5,361,971
Rainy Creek	Labyrinth Mountain	47 49 24	121 01 51	647,382	5,298,328

Table 2. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Chelan County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates—Continued

Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Boundary point: Latitude (degrees in minutes and seconds)	Boundary point: Longitude (degrees in minutes and seconds)	Universal Transverse Mercator coordinates[1]: Easting (meters)	Universal Transverse Mercator coordinates[1]: Northing (meters)
Rimrock Creek	Agnes Mountain	48 20 58	120 59 11	649,191	5,356,893
Roaring Creek	Lake Wenatchee	47 46 07	120 48 24	664,339	5,292,715
Rock Creek	Trinity	48 01 57	120 45 48	666,734	5,322,140
Snowall Creek	The Cradle	47 34 49	121 00 56	649,221	5,271,347
Spruce Creek	Agnes Mountain	48 16 48	120 59 09	649,426	5,349,175
Stehekin River	Cascade Pass	48 27 51	121 02 00	645,382	5,369,561
Swamp Creek	Agnes Mountain	48 18 04	120 54 24	655,230	5,351,689
Thunder Creek	Glacier Peak East	48 03 12	121 01 06	647,653	5,323,930
Tommy Creek	Silver Falls	47 55 48	120 32 29	683,641	5,311,239
Trapper Creek	Stevens Pass	47 40 58	121 05 09	643,650	5,282,600
Trout Creek	Jack Ridge	47 35 01	120 53 53	658,034	5,271,970
Twentyfive Mile Creek, North Fork	Stormy Mountain	47 57 30	120 18 06	701,433	5,315,009
Unnamed trib. to Agnes Creek, West Fork	Dome Peak	48 19 31	121 00 54	647,126	5,354,168
Unnamed trib. to Lake Creek	Labyrinth Mountain	47 51 57	121 06 24	641,598	5,302,913
White River	Glacier Peak East	48 01 44	121 06 27	641,091	5,321,029
Whitepine Creek	Stevens Pass	47 43 32	121 00 10	649,767	5,287,515
Wildhorse Creek	Chiwaukum Mountains	47 42 40	120 58 02	652,471	5,285,995

[1]Universal Transverse Mercator zone 10 coordinates.

Table 3. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Ferry County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates.

		Boundary point			
				Universal Transverse Mercator coordinates[1]	
Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Latitude (degrees in minutes and seconds)	Longitude (degrees in minutes and seconds)	Easting (meters)	Northing (meters)
Boulder Creek, South Fork	Bulldog Mountain	48 45 20	118 20 04	401,916	5,400,944
Curlew Creek	Karamin	48 46 21	118 38 49	378,973	5,403,275
Deadman Creek	Boyds	48 41 30	118 12 49	410,671	5,393,689
Granite Creek	Storm King Mountain	48 38 55	118 45 32	370,428	5,389,683
Hall Creek	Sitdown Mountain	48 27 27	118 28 04	391,461	5,367,991
Ninemile Creek	Ninemile Flat	48 04 12	118 27 16	391,637	5,324,888
Sanpoil River	Republic	48 39 10	118 41 45	375,085	5,390,028
Sherman Creek	South Huckleberry Mountain	48 34 40	118 17 34	404,628	5,381,108
Stranger Creek	Moon Mountain	48 16 31	118 15 54	406,136	5,347,470

[1]Universal Transverse Mercator zone 11 coordinates.

Table 4. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Okanogan County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates

		Boundary point			
	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Latitude	Longitude	Universal Transverse Mercator coordinates[1]	
Stream name		(degrees in minutes and seconds)		Easting (meters)	Northing (meters)
Andrews Creek	Mt. Barney	48 51 29	120 09 37	708,288	5,415,352
Antoine Creek	Burge Mountain	48 45 40	119 19 53	328,656	5,403,325
Ashnola River	Ashnola Pass	48 57 09	120 18 46	696,723	5,425,443
Beaver Creek	Blue Buck Mountain	48 26 06	120 01 13	720,390	5,368,741
Bonaparte Creek	Mt Annie	48 41 12	119 07 08	344,050	5,394,573
Boulder Creek	Pearrygin Peak	48 36 34	120 04 14	715,924	5,387,991
Buttermilk Creek	Hoodoo Peak	48 20 23	120 18 07	699,930	5,357,368
Castle Creek	Castle Creek	48 58 41	120 48 59	659,769	5,427,120
Cedar Creek	Silver Star Mountain	48 31 35	120 33 05	680,778	5,377,485
Chewack River	Bauerman Ridge	48 55 27	120 04 55	713,730	5,422,913
Chuchuwanteen Creek	Frosty Creek	48 56 35	120 42 22	667,963	5,423,446
Early Winters Creek	Washington Pass	48 33 07	120 37 34	675,178	5,380,164
Eureka Creek	Mt Lago	48 46 21	120 33 15	679,699	5,404,858
Gold Creek	Hungry Mountain	48 12 16	120 11 18	708,889	5,342,638
Lake Creek	Mt Barney	48 48 14	120 10 21	707,602	5,409,291
Little Bridge Creek	Thompson Ridge	48 23 50	120 18 48	698,859	5,363,738
Little Nespelem River	Nespelem	48 08 05	118 56 33	355,460	5,332,899
Lost Creek	Moses Meadow	48 27 00	119 04 31	346,539	5,368,205
Lost River	Ashnola Mountain	48 53 30	120 28 48	684,704	5,418,267
Methow River	Mt Arriva	48 37 14	120 45 23	665,337	5,387,513
Nespelem River	Stepstone Creek	48 15 15	118 57 18	354,876	5,346,184
Omak Creek	Camp Seven	48 21 45	119 15 25	332,810	5,358,855
Pasayten River, East Fork	Tatoosh Buttes	48 56 36	120 31 30	681,231	5,423,924
Pasayten River, Middle Fork	Pasayten Peak	48 48 10	120 37 41	674,151	5,408,055
Pasayten River, West Fork	Pasayten Peak	48 49 00	120 42 25	668,319	5,409,407
Robinson Creek	Robinson Mountain	48 41 32	120 33 11	680,072	5,395,923
Rock Creek	Frosty Creek	48 53 49	120 42 27	668,017	5,418,323

Table 4. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Okanogan County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates—Continued

		Boundary point			
				Universal Transverse Mercator coordinates[1]	
Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Latitude (degrees in minutes and seconds)	Longitude (degrees in minutes and seconds)	Easting (meters)	Northing (meters)
Salmon Creek	Conconully East	48 32 15	119 44 48	297,252	5,379,473
Sanpoil River, West Fork	Bailey Creek	48 34 25	119 04 00	347,549	5,381,916
Sinlahekin Creek	Loomis	48 45 36	119 39 13	304,967	5,403,971
South Creek	Gilbert	48 25 20	120 35 27	678,220	5,365,827
Toats Coulee Creek, South Fork	Duncan Ridge	48 50 07	119 46 49	295,964	5,412,671
Toroda Creek	Bodie	48 51 15	118 52 46	362,122	5,412,751
Trout Creek	State Peak	48 40 44	120 39 00	672,983	5,394,210
Twentymile Creek	Spur Peak	48 41 53	120 05 26	714,074	5,397,788
Twisp River	Gilbert	48 27 48	120 36 03	677,351	5,370,385
War Creek	Oval Peak	48 21 16	120 26 44	689,233	5,358,641
Wolf Creek	Thompson Ridge	48 28 47	120 21 45	694,896	5,372,784

[1]Points west of 120 degrees longitude are given in Universal Transverse Mercator zone 10 coordinates, and points east of 120 degrees longitude are given in Universal Transverse Mercator zone 11 coordinates.

Table 5. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Pend Oreille County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates

Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Boundary point: Latitude (degrees in minutes and seconds)	Boundary point: Longitude (degrees in minutes and seconds)	Universal Transverse Mercator coordinates[1]: Easting (meters)	Universal Transverse Mercator coordinates[1]: Northing (meters)
Granite Creek, South Fork	Orwig Hump	48 40 27	117 04 28	494,500	5,391,039
Harvey Creek	Pass Creek	48 45 01	117 12 37	484,534	5,399,517
Le Clerc Creek, East Branch	Ruby	48 35 07	117 15 38	480,764	5,381,176
Le Clerc Creek, West Branch	Scotchman Lake	48 38 29	117 16 39	479,548	5,387,426
Little Spokane River	Newport	48 08 31	117 06 21	492,104	5,331,896
Middle Fork Calispell Creek	Boyer Mountain	48 14 43	117 25 57	467,889	5,343,437
Mill Creek	Jared	48 29 21	117 15 29	480,931	5,370,491
Moon Creek	Sacheen Lake	48 08 47	117 20 04	475,119	5,332,414
North Fork Calispell Creek	Winchester Peak	48 17 09	117 27 07	466,464	5,347,955
North Fork Granite Creek	Orwig Hump	48 43 29	117 04 12	494,842	5,396,663
Priest River, Upper West Branch	Gleason Mountain	48 30 29	117 03 16	495,966	5,372,566
Skookum Creek	Skookum Creek	48 19 03	117 14 16	482,363	5,351,413
Slate Creek	Boundary Dam	48 56 13	117 17 47	478,285	5,420,293
Small Creek	Cusick	48 19 15	117 18 28	477,168	5,351,789
Sullivan Creek	Salmo Mountain	48 54 14	117 04 55	493,993	5,416,557
Tacoma Creek	Tacoma Peak	48 27 13	117 23 18	471,276	5,366,581

[1]Universal Transverse Mercator zone 11 coordinates.

Table 6. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Spokane County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates

		Boundary point			
				Universal Transverse Mercator coordinates[1]	
Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Latitude (degrees in minutes and seconds)	Longitude (degrees in minutes and seconds)	Easting (meters)	Northing (meters)
Deadman Creek	Mead	47 47 11	117 15 00	481,271	5,292,371
Dragon Creek	Clayton	47 56 44	117 30 19	462,261	5,310,164

[1] Universal Transverse Mercator zone 11 coordinates.

Table 7. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on streams in Stevens County, Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates

		Boundary point			
		Latitude	Longitude	Universal Transverse Mercator coordinates[1]	
Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	(degrees in minutes and seconds)		Easting (meters)	Northing (meters)
Chamokane Creek	Forest Center	48 02 14	117 50 53	436,773	5,320,572
Chewelah Creek, North Fork	Chewelah	48 21 20	117 43 02	446,849	5,355,855
Colville River	Forest Center	48 07 11	117 45 45	443,241	5,329,691
Deep Creek, North Fork	Leadpoint	48 54 36	117 35 40	456,427	5,417,419
Little Pend Oreille River	Lake Gillette	48 32 51	117 34 20	457,764	5,377,106
Mill Creek	White Mud Lake	48 37 19	117 45 16	444,397	5,385,515
Onion Creek	Onion Creek	48 49 00	117 48 57	440,090	5,407,180
Rocky Creek	Aladdin	48 43 26	117 40 08	450,792	5,396,766

[1]Universal Transverse Mercator zone 11 coordinates.

Table 8. Upstream shoreline boundary points, as defined in The Shoreline Management Act of 1971, that are located on rivers of statewide significance in Northeastern Washington. Boundary point locations are given in both latitude-longitude coordinates and Universal Transverse Mercator grid coordinates.

County	Stream name	U.S. Geological Survey 7.5-minute topographic quadrangle map name	Boundary point: Latitude (degrees in minutes and seconds)	Boundary point: Longitude (degrees in minutes and seconds)	Universal Transverse Mercator coordinates[1]: Easting (meters)	Universal Transverse Mercator coordinates[1]: Northing (meters)
Chelan	Agnes Creek, South Fork	Agnes Mountain	48 18 38	120 55 14	654,178	5,352,709
Chelan	Agnes Creek, West Fork	Agnes Mountain	48 20 16	120 56 25	652,639	5,355,674
Chelan	Bridge Creek	McGregor Mountain	48 27 41	120 48 47	661,663	5,369,701
Chelan	Chiwawa River	Trinity	48 04 12	120 51 04	660,065	5,326,090
Chelan	Entiat River	Silver Falls	47 59 13	120 34 41	680,690	5,317,490
Chelan	Icicle Creek	Chiwaukum Mountains	47 38 10	120 57 46	653,027	5,277,666
Chelan	Little Wenatchee River	Poe Mountain	47 53 46	121 04 28	643,917	5,306,353
Chelan	Nason Creek	Mount Howard	47 47 07	120 52 32	659,131	5,294,427
Chelan	Railroad Creek	Lucerne	48 11 17	120 37 00	677,123	5,339,743
Chelan	Stehekin River	Goode Mountain	48 25 31	120 54 58	654,161	5,365,454
Chelan	White River	Clark Mountain	48 01 33	120 59 36	649,591	5,320,931
Ferry & Okanogan	Sanpoil River, West Fork	Bald Knob	48 27 21	118 47 57	366,975	5,368,318
Okanogan	Chewuch River	Doe Mountain	48 38 01	120 09 19	709,577	5,390,433
Okanogan	Methow River	Robinson Mountain	48 39 00	120 30 37	683,372	5,391,347
Okanogan	Pasayten River	Tatoosh Buttes	48 58 46	120 33 38	678,482	5,427,845
Okanogan	Twisp River	Hoodoo Peak	48 21 46	120 20 17	697,155	5,359,856
Pend Oreille	Pend Oreille River	Newport	48 11 46	117 02 16	497,178	5,337,898
Pend Oreille	Sullivan Creek	Metaline Falls	48 51 34	117 19 37	475,999	5,411,697
Spokane	Little Spokane River	Chattaroy	47 55 32	117 20 05	474,984	5,307,864
Stevens	Big Sheep Creek	Belshazzar Mountain	49 00 01	117 56 31	431,084	5,427,706
Stevens	Columbia River	Boundary	49 00 03	117 37 52	453,827	5,427,527
Stevens	Colville River	Chewelah	48 15 33	117 43 23	446,312	5,345,147

[1]Points west of 120 degrees longitude are given in the Universal Transverse Mercator zone 10 coordinates, and points east of 120 degrees longtitude are given in Universal Transverse Mercator zone 11 coordinates.

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