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MONITORING DISCHARGE AND SUSPENDED SEDIMENT, REYNOLDS CREEK EXPERIMENTAL WATERSHED, IDAHO, USA

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ABSTRACT

The Northwest Watershed Research Center initiated a streamflow and suspended sediment research program at Reynolds Creek Experimental Watershed (RCEW) in the early 1960's. Continuous streamflow measurement began at two sites in 1963, at three additional sites in 1964, and at eight additional sites in subsequent years. Measurements were later discontinued at five sites. Data were or are currently acquired for basins ranging in contributing area from 1.03 ha to 23,866 ha, selected to represent the broad range of environmental settings found in northwestern rangelands and in RCEW. Quality-controlled, validated hourly streamflow data sets are available for these 13 sites for the period 1963 through 1996 (or for a subset of that time for some sites). Suspended sediment data were acquired from a restricted set of streamflow stations. Suspended sediment data are available for three streamflow measurement sites (high elevation, mid-elevation, and low elevation). All data are available on the Northwest Watershed Research Center anonymous FTP site (*ftp.nwrc.ars.usda.gov*).

1. INTRODUCTION

The Reynolds Creek Experimental Watershed (RCEW) streamflow and sedimentation program provides fundamental information for research into hydrologic processes, precipitation-runoff relationships, hydrograph characteristics, water yield, and the interactive effects of climate, vegetation, soils and land use on rangeland hydrologic response. The RCEW basic data set provides a basis for evaluating temporal variability in hydrologic regime and water yield, and for evaluating spatial variability within a “typical” upland rangeland landscape. Rangeland watersheds, with high-elevation seasonal snowpack that provides a major source of streamflow for spring and early summer, supply water for on-site biological production, in-stream and near-stream habitat, and downstream uses including irrigation, recreation and hydropower generation. Streamflow and sediment data from RCEW are particularly valuable for understanding complex upland runoff and sediment generation processes of rain and snowmelt on snow and frozen soils [*Deng et al*., 1994; *Flerchinger et al.*, 1994], which can produce flooding and property damage throughout the Northwestern United States [*Seyfried and Wilcox*, 1992; *Slaughter et al.*, 1997].

Early research in RCEW focused on relationships between runoff source areas and water yield [*Johnson and Hanson*, 1976; *Johnson and Smith*, 1978]. Selected source areas of varying size, elevation, aspect, climate, geology, soils and vegetation characteristics were instrumented, monitored and analyzed. The RCEW data provide a basis for investigating scale relationships in rangeland watersheds [*Seyfried and Wilcox*, 1995; *Tarboton et al.*, 1998] and for comparison with other hydrologic systems [*Slaughter et al.*, 1996]. Recent work has emphasized runoff and erosion processes at varying scales, through use of small-scale intensively instrumented study basins within RCEW [*Pierson et al.*, 1994; *Flerchinger et al.*, 1998], and use of RCEW data as a framework for hydrologic and hydraulic process research [*Goodwin et al.*, 1998]

The primary objectives of early sediment measurements in RCEW were to accurately sample sediment transport at key stations and to determine sediment yields from instrumented watersheds, especially during storm runoff events. Selected locations for monitoring sediment were instrumented in the mid-1960's. Bedload transport was measured at selected locations during runoff events using both Helley-Smith bedload samplers and sediment detention ponds. Bedload contributions to total sediment yields were estimated at about 20% of total sediment yield [*Johnson and Hanson*, 1976], and routine bedload measurements were discontinued.

Innovations in streamflow measurement and sediment sampling have been tested and applied in RCEW. Cooperative studies with the Albrook Hydraulics Laboratory of Washington State University were successful in developing the “drop-box” weir design that can pass high sediment loads and does not require regular channel cleaning (Johnson et al., 1966). Drop-box weirs have performed well over a wide range of discharges and sediment loads. A variety of early sediment samplers such as the U.S. PS-69 pumping sampler [*Brakensiek et al.*, 1979] and Helley-Smith bed load samplers [*Johnson et al.*, 1977] were tested in RCEW through cooperative efforts with other ARS locations, federal and state agencies, and universities.

2. WATERSHED CHARACTERISTICS

Locations of all stream gauging stations within RCEW are shown in Figure 1. The drainage area, elevation range, weir locations and flow characteristics for each gauged watershed are given in Table 1. A detailed description of the spatial data on soils, geology, topography and vegetation for each watershed is provided by *Seyfried et al.*, [2000]. Brief physical descriptions of each gauged watershed, based on *Stephenson* [1977] and subsequent research, are provided in the following sub-sections.

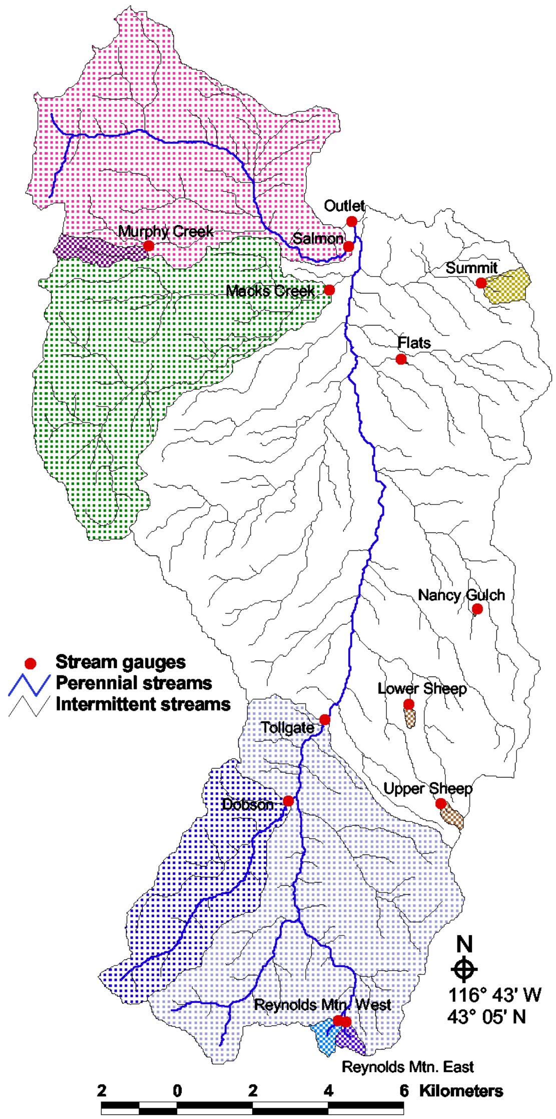

Figure 1. Stream network, watershed boundaries and weir locations on Reynolds Creek Experimental Watershed, Idaho.

Table 1. Watershed name, identification number, drainage area determined from original maps and surveys, drainage area determined from digital elevation map, range in elevation from digital elevation map, UTM coordinates of weir locations, and streamflow regime characteristics for each gauged watershed in the Reynolds Creek Experimental Watershed, Idaho.

Watershed Name	Watershed ID Number	Original Survey Drainage Area (ha)	DEM Drainage Area (ha)	DEM Elevation Range (m)	Weir UTM (E/N)	Streamflow Regime
Reynolds Crk. Outlet	036x68	23,372	23,866	1101-2241	520111E 4789673N	Perennial
Reynolds Crk. Tollgate	116x83	5,444	5,457	1410-2241	519393E 4776495N	Perennial
Reynolds Mtn. East	166x76	40.5	36.3	2026-2137	519954E 4768494N	Perennial
Reynolds Mtn. West	166x74	51.0	49.6	2016-2131	519746E 4768519N	Spring-fed Perennial
Salmon Creek	046x17	3,638	3,619	1121-1918	520015E 4788996N	Perennial
Macks Creek	046x84	3,175	3,298	1145-1891	519506E 4787853N	Intermittent
Dobson Creek	135x17	1,409	1,429	1478-2241	518432E 4774338N	Perennial
Murphy Creek	043x04	123.8	132.7	1383-1822	514728E 4789016N	Spring-fed Intermittent
Upper Sheep Creek	138x12	26.1	25.9	1839-2017	522462E 4774262N	Intermittent
Summit Wash	048x77	83.0	87.3	1260-1457	523520E 4788031N	Ephemeral
Flats	057x96	0.9	1.0*	1190-1198	521407E 4786030N	Ephemeral
Nancy Gulch	098x97	1.3	1.2*	1409-1426	523420E47 79426N	Ephemeral
Lower Sheep Creek	117x66	13.4	13.0	1583-1653	521616E 4776893N	Ephemeral

* - estimated using GPS readings.

2.1 Reynolds Creek: Outlet (036x68)

Reynolds Creek flows almost directly north from the northern flank of the Owyhee Mountains, and is a direct tributary of the Snake River. The Outlet weir, which defines the 239 km^2 Reynolds Creek Experimental Watershed, is located in a narrow canyon ca. 11 km south of the confluence of Reynolds Creek and the Snake River. The southwestern sector of RCEW is the coolest and wettest portion of the basin, while the northeastern sector, which includes Summit Wash and Flats watersheds, is the warmest and receives the least precipitation.

The vegetation of RCEW is almost entirely sagebrush rangeland (95%). Plant communities are representative of desert, foothill, and high mountain rangelands found throughout northwestern United States. The major grass species are cheatgrass (*Bromus tectorum*.), bluebunch wheatgrass (*Pseudoroegneria spicata*), bottlebrush squirreltail (*Elymus elymoides*), sandberg bluegrass (*Poa sandbergii*) and Idaho fescue (*Festuca idahoensis*). The dominant shrubs are big sagebrush (*Artemisia tridentata)*, low sagebrush (*Artemisia arbuscula*), bitterbrush (*Purshia tridentata*) and rabbitbrush (*Chrysothamnus* spp.). Significant stands of coniferous forest are found only in the extreme southern (highest) sectors of RCEW. Approximately two percent of the area is covered by small stands of Douglas fir (*Pseudotsuga menziesii*), aspen (*Populus* spp.), and alpine fir (*Abies lasiocarpa*), and three percent of the area is flood- irrigated pastureland.

RCEW is developed in an eroded structural basin in which late Tertiary volcanic and sedimentary rocks overlie Cretaceous granitic basement rocks. The primary geologic formations are granitics of the Idaho Batholith, Salmon Creek volcanics, the Reynolds Basin group complex of basaltic flows, silicic tuff, diatomite, arkosic sand and gravel, and latite, and rhyolitic welded ash flow tuffs [*Stephenson*, 1977].

The soils of RCEW include eight soil associations and 32 soil series. Major soil associations in RCEW include Bakeoven-Reywat-Babbington (35% by area), Harmehl-Gabica-Demast (25% of the watershed), and Nannyton-Larimer-Ackmen, Dark-Gray Variant (12% by area). Soils mapping and detailed descriptions of each association and individual series are provided in *Stephenson* [1977] and the availability of those data by *Seyfried et al.* [2000].

2.2 Reynolds Creek: Tollgate (116x83)

The Tollgate sector of RCEW, defined by the Tollgate weir, comprises the uppermost 23% of RCEW and thus encompasses the sectors receiving the greatest annual precipitation. The watershed is primarily sagebrush rangeland, with scattered high-elevation stands of Douglas fir and aspen, and a few mountain meadows. Vegetation consists predominantly of big sagebrush, low sagebrush, rabbitbrush, snowberry (*Symphoricarpos* spp.), bluebunch wheatgrass, Idaho fescue, and bottlebrush squirreltail. Estimates of total vegetative cover, by cover classes, are 25% of the watershed in the 0-25% cover class, 15 % in the 26-

50% cover class, 15% in the 51-75% cover class, and 45% of the watershed with 76-100% percent vegetative cover.

The topography is steep with numerous rock outcrops on ridges. The underlying geology of the watershed is primarily Reynolds Basin basalt and latite (73%) and granitics (25%), with very minor occurrences of both alluvium and rhyolitic welded tuff. The soils of the Tollgate watershed are dominated by two consolidated series groupings: Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series together comprise 68% of the watershed (3728 ha), and Takeuchi, Kanlee and Ola series comprise 20.4% (1114 ha) of the watershed. Minor soils in the Tollgate watershed include the grouped Reywat, Rucklick, Larimer-Reywat complex, Squal, Newell and Gemson series (6.2%, 339 ha), the grouped Searla, Bullrey and Dranyon series (4%, 217 ha) and grouped Larimer, Ackmen, Nannyton and Baldock series (0.2%, 13 ha).

2.3 Reynolds Mountain East Basin: (166x76)

The Reynolds Mountain East Basin is at the extreme headwaters of RCEW. The vegetation consists of scrub aspen, willow (*Salix* spp.), scattered Douglas fir, and big sagebrush with natural mountain meadows. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 15.7, 18.6, 5.7, and 60.0, respectively. The watershed is underlain by Reynolds Basin basalt and latite. Soils of the Reynolds Mountain East watershed include the grouped Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (81%, 29.3 ha) and the grouped Searla, Bullrey and Dranyon series (19%, 36.3 ha).

2.4 Reynolds Mountain West Basin: (166x74)

The Reynolds Mountain West Basin is also at the extreme headwaters of RCEW. In contrast to Reynolds Mountain East, streamflow is augmented upstream of the weir by a high-elevation perennial spring which is recharged by massive late-lying drifts. The vegetation consists of scrub aspen, willow, scattered Douglas fir, and big sagebrush with natural mountain meadows. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 15.7, 18.6, 5.7, and 60.0, respectively. The watershed is underlain by Reynolds Basin basalt and latite. Soils of the Reynolds Mountain West Basin include the grouped Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (68%, 33.7 ha) and the grouped Searla, Bullrey and Dranyon series (17%, 13.3 ha); 5% of the watershed is unclassified.

2.5 Salmon Creek: (046x17)

The Salmon Creek watershed drains steep, high-elevation lands in the northwestern sector of RCEW; the dominant aspect is east - southeast. Vegetation is almost entirely sagebrush rangeland except for approximately 1% of the area in irrigated pasture. Vegetation consists of big sagebrush, cheatgrass, bluebunch wheatgrass and Idaho fescue with scattered clumps of willow along the main watercourses. The watershed is characterized by steep topography, numerous basalt outcrops, and extensive areas of shallow rocky soil. The watershed is primarily underlain by Salmon Creek volcanics (57%), Reynolds Basin basalt and latite (23%), and the Reynolds Basin complex of basaltic flows, silicic tuff, datomite, arkosic sands and gravels, and latite (12.5 %), with a minor component of granitics (5%). Soils are dominated by three series groupings: Bakeoven, Reywat, Rucklick, Larimer-Reywat complex, Squaw, Nell and Gemson series (61%, 2215 ha), Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (20%, 718 ha), and Glasgow, Lassen and Babbington series (11%, 408 ha). Minor series groupings include the Farrot, Castlevale, Haw and Lolalita series (4%, 151 ha), Larimer, Ackmen, Nannyton, and Baldock series (0.2%, 7 ha), rocky and stony land (2%, 78 ha), and unclassified (1%, 43 ha).

2.6 Macks Creek: (046x84)

The Macks Creek watershed drains high-elevation rangelands on the western side of Reynolds Creek watershed. The Macks Creek weir was decommissioned in 1990. The watershed is sagebrush rangeland, except for about 70 ha of pasture that receives irrigation water. Sagebrush, bitterbrush, mountain mahogany (*Cercocarpus ledifolius*) and willow are the major shrubs with an understory of cheatgrass, bluebunch wheatgrass, and Idaho fescue. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 35.5, 32.9, 18.0, and 13.6, respectively. The watershed topography is steep except in the lower valley, with numerous basalt outcrops at the higher elevations. The watershed is developed in a mixed geology of Reynolds Basin basalt and latite (39%), Salmon Creek volcanics (30%), Reynolds Basin complex of basaltic flows, silicic tuff, datomite, arkosic sands and gravels, and latite (12%), granitics (11%), and alluvium (7%). Soils are dominated by three series groupings: Bakeoven, Reywat, Rucklick, Larimer-Reywat complex, Squaw, Newell and Gemson series (41%, 1340 ha), Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (32%, 1059 ha), and Glasgow, Lassen and Babbington series (14%, 478 ha). Minor series groupings include Farrot, Castlevale, Haw and Lolalita series (4%, 131 ha), Takeuchi, Kanlee and Ola series (3.6%, 120 ha), Larimer, Ackmen, Nannyton and Baldock series (2%, 65 ha), rocky and stony land (2%, 65 ha), and unclassified (1.2%, 40.5 ha).

2.7 Dobson Creek: (135x17)

The Dobson Creek watershed, in the southwestern sector of RCEW, drains to the north - northeast from the high-precipitation headwaters of RCEW. Vegetation is mixed sagebrush rangeland and coniferous and deciduous forest, with occasional upland meadows. Non-forest vegetation consists predominantly of big sagebrush, low sagebrush, rabbitbrush, snowberry, bluebunch wheatgrass, Idaho fescue, and bottlebrush squirreltail. Forested sites include aspen clones and stands, and Douglas fir and subalpine fir in moist high-elevation (high snow accumulation) settings. The watershed is underlain by Reynolds Basin basalt and latite (57%) and granitics (41%) with a minor inclusion of rhyolitic welded tuff. Soils are primarily two series groupings: Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (65%, 9312 ha), and Takeuchi, Kanlee and Ola series (28%, 406 ha). Minor series groupings include Searla, Bullrey and Dranyon series (4.6%, 65 ha), Larimer, Ackmen, Nannyton and Baldock series (1%, 13 ha), and unclassified (1%, 13 ha).

2.8 Murphy Creek: (043x04)

Murphy Creek is an east-flowing tributary to Salmon Creek, in northwestern RCEW. The watershed is sagebrush rangeland with willows common along watercourses and in seep areas. Vegetation consists largely of big sagebrush, bitterbrush, Idaho fescue, Sandberg bluegrass, bluebunch wheatgrass, squirreltail grass, and snowberry. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 10, 35, 20, and 35, respectively. The basin is underlain by Salmon Creek volcanics (56%) and Reynolds Basin basalt and latite (44%). Soils are primarily two series groupings: Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series (51%, 68 ha), and Bakeoven, Reywat, Rucklick, Larimer-Reywat complex, Squaw, Newell and Gemson series (47%, 63 ha). Under 2% (2.3 ha) is unclassified.

2.9 Upper Sheep Creek: (138x12)

The Upper Sheep Creek is a small, intensively studied, semi-arid watershed near the southeastern headwaters of RCEW. The watershed is entirely sagebrush rangeland, dominated by big sagebrush, snowberry, and sandberg bluegrass, with a small (<10%) component of quaking aspen. The basin is entirely underlain by Reynolds Basin basalt and latite. Soils are mapped as the grouped Harmehl, Gabica, Demast, Nettleton, Pit and Gemid series.

2.10 Summit Wash: (048x77)

The Summit Wash is a small arid ephemeral tributary in the northeastern, driest sector of RCEW. Summit Wash is subject to occasional (rare) convective storms. Streamflow and sediment observations were discontinued in 1975. The watershed is sagebrush rangeland with numerous barren ridges. Vegetation consists largely of big sagebrush, cheatgrass, Sandberg bluegrass, bluebunch wheatgrass, and bottlebrush squirreltail. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 25, 75, 0, and 0, respectively. The underlying materials are primarily Reynolds Basin basalt and latite (82%), with a minor (15%) component of granitics. Soils are primarily three series groupings: Bakeoven, Reywat, Rucklick, Larimer-Reywat complex, Squaw, Newell and Gemson series (66%, 57 ha), Farrot, Castelvale, Haw and Lolalita series (23%, 20 ha), and Larimer, Ackmen, Nannyton, Baldock series (9%, 8 ha); 2.2 ha are unclassified.

2.11 Flats: (057x96)

The Flats is a small, low relief, subwatershed in the lower northeast sector of RCEW. Streamflow is ephemeral. Vegetation is sagebrush rangeland with spiny hopsage (*Atriplex spinosa*) and shadscale components (*Atriplex confertifolia*). The Flats study basin lies in unconsolidated sediments; soils are the Larimer, Ackmen, Nannyton, Baldock series grouping.

2.12 Nancy Gulch: (098x97)

Nancy Gulch is located on the eastern slopes of RCEW. Vegetation is dominated by big sagebrush and bluebunch wheatgrass, with minor inclusions of rabbitbrush and spiny hopsage. The basin is underlain by Reynolds Basin basalt and latite. Soils are the grouped Bakeoven, Reywat, Rucklick, Larimer-Reywat complex, Squaw, Newell and Gemson series (92%, 1 ha), and the Glasgow, Lassen and Babbingtgon series (8%, 0.1 ha).

2.13 Lower Sheep Creek: (117x66)

Lower Sheep Creek is located on the eastern slopes of RCEW. The vegetation is entirely sagebrush rangeland with vegetation consisting of bluebunch wheatgrass, Sandberg bluegrass, cheatgrass, yarrow (*Achillea* spp.), and low sagebrush. Estimates of the percents of watershed area represented by the 0-25, 26-50, 51-75, 76-100 percent vegetative cover classes are 90, 10, 0, and 0, respectively. The basin is underlain by rhyolitic welded tuff. Soils are the grouped Searla, Bullrey and Dranyon series.

3. METHODS

3.1 Streamflow

Five types of stream-flow gauging devices are used on RCEW: (1) Self-Cleaning Overflow V-notch (SCOV) weir, (2) drop-box V-notch weir, (3) 30^o V-notch weir, (4) 90^o V-notch weir, and (5) Parshall flume [*Brakensiek et al.*, 1979; *Johnson et al.*, 1966]. All stations are equipped with stilling-wells and floats for obtaining instantaneous measures of stage height. Instrument shelters are heated to permit collection of streamflow and sediment data during cold winter periods. Gauging stations are visited on a weekly or biweekly basis to record staff gauge readings and service all instrumentation [*Pierson and Cram*, 1998]. The length of runoff record and type of installation for each watershed are given in Table 2.

Stage height measurements were originally recorded using Leopold-Stevens A-35 and FW-1 strip chart recorders [*Brakensiek et al.*, 1979], later supplanted by electronic data loggers. Pressure sensors are now used for redundant back-up measurements of stage height to guard against the occasional plugging of stilling well inlet pipes. Strip charts were processed by digitizing selected break-points along a recorded continuous trace to create a digital record of instantaneous stage height. Stage height was then used to create a digital record of streamflow using appropriate weir calibration equations. Later use of electronic recording equipment allowed collection of more comprehensive digital data. Stage height is now monitored every ten seconds to determine if the stage is rising or falling. If the stage has significantly changed, the new instantaneous stage height value is recorded at the nearest minute. If the stage has not significantly changed, then instantaneous stage height is recorded every fifteen minutes. Accuracy of stage height measurements is periodically checked against manual staff gauge measurements; if necessary, corrections to the recorded data are made in a linear step-wise fashion between staff gauge readings. Errors in gauge height measurements due to ice build-up in the weirs in winter are ocularly identified and manually corrected. Hourly runoff records are created from break-point runoff data using linear interpolation between break-point estimates.

Table 2. Duration of streamflow record, type of weir/flume used, and mean annual streamflow for each gauged watershed in the Reynolds Creek Experimental Watershed, Idaho.

Watershed Name	Watershed ID Number	Duration of Record	Type of Weir/Flume	Mean Annual Streamflow (m^3s^{-1})	Mean Annual Streamflow (mm)
Reynolds Crk. Outlet	036x68	1963-1996	Self-Cleaning Overflow V-Notch (SCOV)	0.560	75.7
Reynolds Crk. Tollgate	116x83	1966-1996	Drop-Box V-Notch	0.424	245.9
Reynolds Mtn. East	166x76	1963-1996	90° V-Notch	0.00671	523.1
Reynolds Mtn. West	166x74	1964-1984	Drop-Box V-Notch	0.00686	424.9
Salmon Creek	046x17	1964-1996	Drop-Box V-Notch	0.0823	71.4
Macks Creek	046x84	1964-1990	Drop-Box V-Notch	0.0724	72.0
Dobson Creek	135x17	1973-1980	Parshall Flume	0.132	295.9
Murphy Creek	043x04	1967-1977	Drop-Box V-Notch	0.00752	191.7
Upper Sheep Creek Basin	138x12	1970-1975; 1983-1996	90° V-Notch	0.000756	91.6
Summit Wash Basin	048x77	1967-1975	Drop-Box V-Notch	0.0000181	0.7
Flats Basin	057x96	1972-1996	30° V-Notch	0.000000566	2.0
Nancy Gulch Basin	098x97	1971-1996	30° V-Notch	0.00000280	7.0
Lower Sheep Creek Basin	117x66	1967-1984; 1989-1996	Drop-Box V-Notch	0.0000362	8.6

3.2 Suspended Sediment

Suspended sediment samples were collected at Reynolds Creek: Outlet, Reynolds Creek: Tollgate and Reynolds Creek: Reynolds Mountain East Basin gauging stations during the period covered by this report. Suspended sediment samples were collected manually in early years using a DH-48 integrated sampler at the large weirs or simple grab samples at the smaller weirs. Automated sediment samplers were subsequently used at all stream gauging sites to collect suspended sediment samples. Chickasha, PS-67, PS-69, ISCO, Manning and Sigma pump samplers have been used to collect suspended sediment samples at different gauging stations during different time periods [*Brakensiek et al.*, 1979]. All stations are currently equipped with Sigma pump samplers. Collected sediment samples are filtered and weighed to determine sediment concentration of each sample [*Pierson and Cram*, 1998]. The types of sediment samplers used and the length of sediment record for each gauging station are given in Table 3.

Table 3. Duration of record for measured and estimated suspended sediment concentrations using different types of sediment samplers for each gauged watershed in Reynolds Creek Experimental Watershed, Idaho.

Watershed Name	Watershed ID Number	Sediment Sampler Used	Duration of Measured Concentrations	Duration of Estimated Break-Point Concentrations
Reynolds Creek Outlet	036x68	Hand	1965-1975	1967-1975
		PS-67	1975-1979	1975-1979
		PS-69	1980-1988	1980-1986
		Sigma	1989-1996	
Reynolds Creek Tollgate	116x83	Hand	1967-1969	1967-1969
		PS-67	1969-1979	1969-1979
		PS-69	1980-1986	1980-1986
		ISCO	1987-1994	
		Sigma	1994-1996	
Reynolds Mountain East	166x76	Chickasha	1969-1984	1969-1984
		Manning	1984-1986	1984-1986
		ISCO	1987-1996	

Early sediment data include only manually-sampled sediment concentrations for large events. Later, automated sediment samplers made it possible to collect more samples during all events, but samplers were often unreliable resulting in intermittently missing data during early years of automated sampling. Pump samplers have become more reliable in recent years, and when coupled with data loggers can collect sediment samples at critical points during runoff events (e.g., Figure 5 portrays a typical runoff event with corresponding sediment concentrations and sample times).

A continuous break-point record of sediment concentrations was created based upon measured sediment concentrations and runoff patterns. This record was combined with the runoff record to estimate monthly and annual sediment losses. Both the record of measured sediment concentrations and the record of estimated break-point sediment concentrations are provided as part of this data report.

4. STREAMFLOW REGIME

Three streamflow gauging stations along the main stem of Reynolds Creek (Outlet, Tollgate and Reynolds Mountain East) constitute the backbone of the streamflow gauging network within RCEW. Streamflow has been measured from Outlet and Reynolds Mountain East weirs starting with the 1963 water year and continuing uninterrupted to the present time (Table 2). Tollgate weir was installed in 1966 to represent the mid-elevations on RCEW. Ten additional streamflow gauging stations were subsequently installed; five of those were still active in 1996 (Table 2).

Streamflow throughout RCEW is dominated by runoff from spring snowmelt, particularly at higher elevations (Figure 2). Average monthly discharge is greatest during May at all elevations. However, lower elevations also show the impact of rain-on-snow events during the winter months, resulting in a more even distribution of discharge from December through June. Mean annual discharge is quite variable between locations, varying with basin size, basin elevation, and specific setting within RCEW (Table 2).

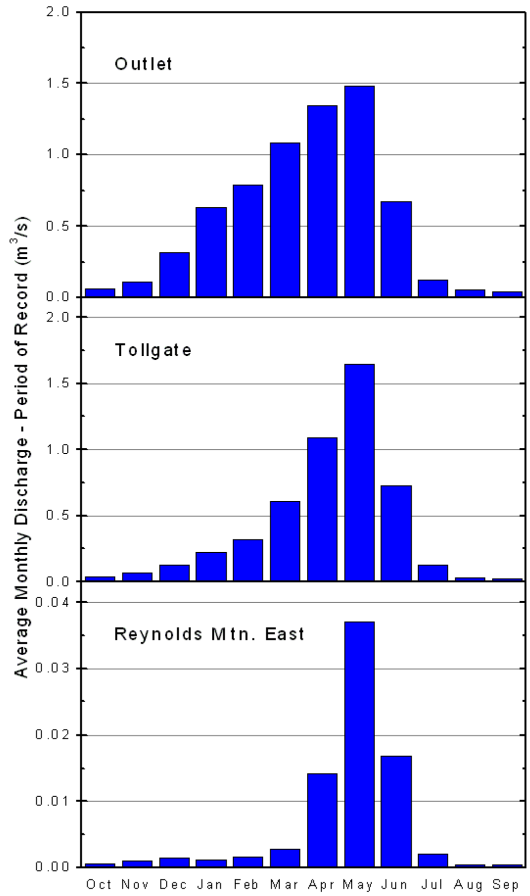

Figure 2. Average monthly discharge rate for Outlet, Tollgate and Reynolds Mountain East watersheds in Reynolds Creek Experimental Watershed, Idaho

Discharge is quite variable between years at all locations. Figure 3 shows the average daily discharge rate for Outlet, Tollgate and Reynolds Mountain East basins during years with high and low precipitation and streamflow. During high-flow years, discharge follows the expected pattern of increasing with discharge area: Outlet has the greatest discharge, followed by Tollgate, then by Reynolds Mountain East. During low-flow years, discharge rates are generally an order of magnitude lower, with highest flows being measured at Tollgate rather than Outlet due to water being diverted from Reynolds Creek below Tollgate for local irrigation. When discharge rates are normalized for watershed size (Figure 4), unit-area discharge rates are higher for areas with greater proportions of high elevation (Table 2). The high annual variability in discharge between high- and low-precipitation years is again demonstrated in Figure 4.

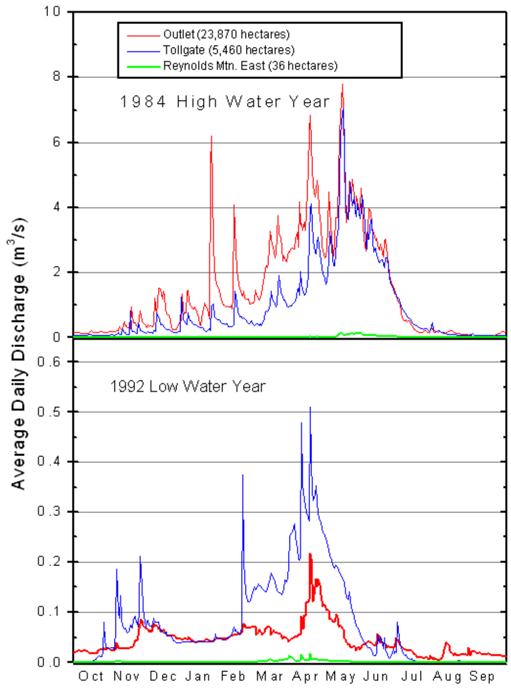

Figure 3. Average daily discharge rate for Outlet, Tollgate and Reynolds Mountain East watersheds during low (1992) and high (1984) water years in Reynolds Creek Experimental Watershed, Idaho.

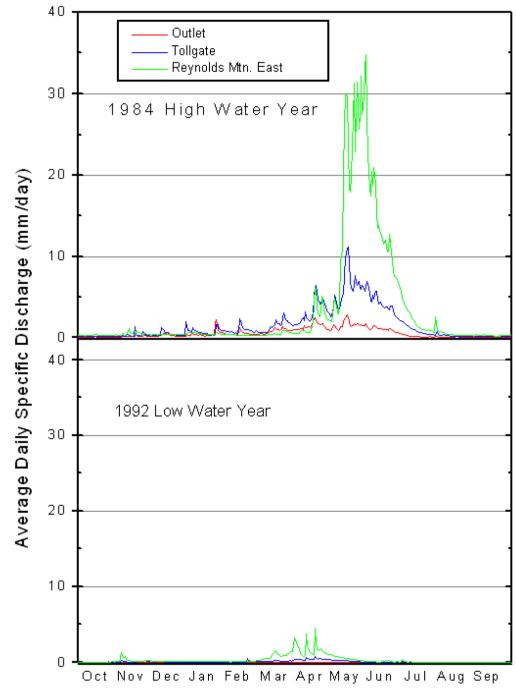

Figure 4. Average daily discharge for Outlet, Tollgate and Reynolds Mountain East watersheds during low (1992) and high (1984) water years normalized by watershed area in Reynolds Creek Experimental Watershed, Idaho.

Peak discharge rates for the ten greatest events recorded at Outlet, Tollgate and Reynolds Mountain East weirs are given in Table 4. The highest flows at Outlet have been driven primarily by rain-on-snow winter events, while Reynolds Mountain high flows have been dominated by rapid spring snowmelt. The winter flood in December 1964 was the highest flow recorded for both stations. Mid-elevations represented by the Tollgate weir experience both winter rain-on-snow and spring snowmelt events. Occasional intense thunderstorms can impact all elevations, but are particularly important for lower elevations and the eastern side of RCEW. The fifth-largest peak flow recorded at Outlet (Table 4) was the result of a short-duration high-intensity convective storm centered over Summit Wash, in the dry northeastern sector of RCEW.

Table 4. Top ten highest peak streamflow events for Outlet, Tollgate and Reynolds Mountain East watersheds in the Reynolds Creek Experimental Watershed, Idaho.

Watershed Name	Watershed ID Number	Date	Peak Flow Rate (m^3s^{-1})
Reynolds Creek Outlet	036x68	12/23/64	109.03
		01/31/63	66.02
		02/15/82	58.97
		01/11/79	47.09
		06/11/77	31.70
		01/28/65	31.53
		01/21/69	25.48
		04/11/82	24.40
		01/27/70	20.64
		03/02/72	19.19
Reynolds Creek Tollgate	116x83	12/19/81	12.10
		01/21/69	11.47
		04/11/82	11.26
		05/13/84	8.96
		03/18/93	8.43
		06/07/67	8.16
		02/23/86	7.88
		06/06/93	7.71
		03/02/72	7.67
		05/28/83	7.51
Reynolds Mountain East	166x76	12/23/64	0.303
		05/29/83	0.282
		06/02/75	0.263
		05/29/84	0.245
		05/12/93	0.182
		06/06/72	0.177
		05/17/70	0.167
		05/04/71	0.163
		04/28/90	0.155
		05/22/67	0.154

5. SUSPENDED SEDIMENT REGIME

A record of suspended sediment concentrations is available for Outlet, Tollgate and Reynolds Mountain East watersheds. The record began at Outlet weir in 1965 when major streamflow events were sampled using periodic grab samples throughout the duration of the event. The first pump samplers were used in 1969 increasing the number of events sampled and the number of samples taken during each event (Table 3). In current practice, sediment concentrations are intensely sampled during all events and periodically sampled during low flows. Figure 5 illustrates the frequency at which suspended sediment concentration is currently sampled at Outlet, Tollgate and Reynolds Mountain East weirs during runoff events.

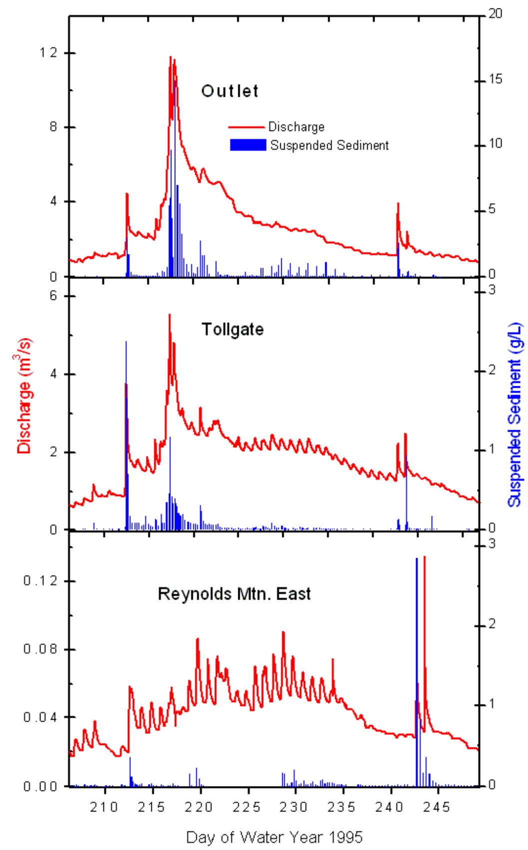

Figure 5. Discharge rate and associated measured sediment concentrations for Outlet, Tollgate and Reynolds Mountain East watersheds during spring flow 1995 in Reynolds Creek Experimental Watershed, Idaho.

Large runoff events account for most of the sediment yielded from RCEW [*Johnson et. al.*, 1974]. Sediment concentrations are highest during the rising stages of an event and then sharply decrease until discharge rate again rapidly increases during the next runoff event (Figure 5). Sediment concentrations during low flows are generally two orders of magnitude lower than during runoff events and contribute little to the overall RCEW sediment budget. *Johnson and Hanson* [1976] reported that average sediment yields from RCEW and individual watersheds (3200 to 23,000 ha) ranged from 1.14 to 1.9 tonnes/ha/year. Sediment concentrations and annual sediment yield increase with drainage area, as illustrated in Figure 5. During spring runoff, sediment concentrations for the entire RCEW can be an order of magnitude higher than for high elevations above Tollgate weir and two orders of magnitude higher than for Reynolds Mountain East Basin (Figure 5).

6. DATA AVAILABILITY

Discharge data from thirteen weirs, including nine currently in operation and four that were discontinued prior to Oct. 1, 1996 (see Tables 1 and 2) are available from the anonymous ftp site *ftp.nwrc.ars.usda.gov* maintained by the USDA Agricultural Research Service, Northwest Watershed Research Center in Boise, Idaho, USA. Data are located in the directory *publicdatabase/streamflow*, in ASCII files that have been compressed using a "zip" utility. Each file has a 26-line ASCII header providing brief information on file contents, location (Easting and Northing, UTM zone 11), both the GPS elevation and the DEM elevation (see Seyfried et al. 2000), time format, and period of record, column contents and units, missing data key, contact, citation and disclaimer information. An ASCII README file in the same directory gives a detailed description of the file formats and contents. Both the hourly and breakpoint discharge data are stored in 13 separate files (one for each weir) identified by the data type and station ID (e.g., "breakpoint036x68streamflow.txt" or "hourly036x68streamflow.txt"). Each record in the file consists of a line containing month, day, year, hour, minute, and stream discharge (m^3/s).

Sediment data from three weirs (036x68, 116x83, and 166x76) are also available at the same ftp site and located in the same directory as the discharge data. Each file has the same 26-line header, and is also described in the ASCII README file. Sediment data are stored in three separate files (one for each weir) identified by the data type and station ID (e.g., "breakpoint036x68sedimentconcentration.txt"). Each record in the file consists of a line containing month, day, year, hour, minute, discharge (m^3/s), sampler type, measured sediment concentration (mg/l), and estimated sediment concentration (mg/l).

Any publications generated from these data should cite this publication, and acknowledge the USDA-ARS Northwest Watershed Research Center as the source. In addition, we request that you notify NWRC of all publications, including theses and dissertations, which use or refer to these data. Citations may be sent by email to: *publicdatabase@nwrc.ars.usda.gov* or by mail to: USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Suite 105, Boise, ID 83712-7716. Your cooperation in this matter will promote further research and cooperation, help to validate the usefulness of the ARS experimental watersheds and data collection activities, and influence agency policy regarding future data collection.

7. DISCLAIMER

The mention of trade names or commercial products does not constitute endorsement or recommendation for use. The Agricultural Research Service (ARS) is a research organization. There are no legal mandates for the agency to collect or to distribute data collected for specific research projects. These data are being made available to the research community to promote the general knowledge of the processes relating to our country's natural resources.

8. DEDICATION

The quality and extent of the RCEW streamflow and sediment data are primarily due to the efforts of one man, Clifton W. Johnson. Cliff spent 27 years designing and constructing weirs, sampling streamflow and sediment during extreme conditions, processing and error checking countless data records, and publishing numerous journal articles describing and summarizing RCEW hydrology. This data report is dedicated to the memory of Clifton W. Johnson.

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