In cooperation with the U.S. Department of Defense Task Force for Business and Stability Operations

Estimated Monthly Streamflows for Selected Locations on the Kabul and Logar Rivers, Aynak Copper, Cobalt, and Chromium Area of Interest, Afghanistan, 1951–2010

Scientific Investigations Report 2014–5157

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

Cover photographs. Upper: Chakari River in Aynak area. Photograph by Thomas Mack, U.S. Geological Survey (USGS).
Lower left: Mountain in Aynak area. Photograph by Thomas Mack, USGS.
Lower right: Kabul River. Photograph by Michael Chornack, USGS.

Estimated Monthly Streamflows for Selected Locations on the Kabul and Logar Rivers, Aynak Copper, Cobalt, and Chromium Area of Interest, Afghanistan, 1951–2010

By Kevin C. Vining and Aldo V. Vecchia

In cooperation with the U.S. Department of Defense Task Force for Business and Stability Operations

Scientific Investigations Report 2014–5157

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

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2014

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Vining, K.C., and Vecchia, A.V., 2014, Estimated monthly streamflows for selected locations on the Kabul and Logar Rivers, Aynak copper, cobalt, and chromium area of interest, Afghanistan, 1951–2010: U.S. Geological Survey Scientific Investigations Report 2014–5157, 12 p., *http://dx.doi.org/10.3133/sir20145157*.

ISSN 2328-0328 (online)

Contents

Figures

Table

Conversion Factors and Datum

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	0.0008107	acre-foot (acre-ft)
	Flow rate	
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
cubic meter per month (m^3/month)	35.31	cubic foot per month (ft^3/month)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)

Horizontal coordinate information is referenced to the World Geodetic System of 1984 (WGS 84).

Water-Year Definition

Water year is defined as the 12-month period from October 1 through September 30 of the following calendar year. The water year is designated by the calendar year in which it ends. For example, water year 2010 is the period from October 1, 2009, thorugh September 30, 2010.

Abbreviations

AGS	Afghanistan Geological Survey
MEW	Ministry of Energy and Water
TFBSO	Task Force for Business and Stability Operations
USGS	U.S. Geological Survey

Estimated Monthly Streamflows for Selected Locations on the Kabul and Logar Rivers, Aynak Copper, Cobalt, and Chromium Area of Interest, Afghanistan, 1951–2010

By Kevin C. Vining and Aldo V.Vecchia

Abstract

The U.S. Geological Survey, in cooperation with the U.S. Department of Defense Task Force for Business and Stability Operations, used the stochastic monthly water-balance model and existing climate data to estimate monthly streamflows for 1951–2010 for selected streamgaging stations located within the Aynak copper, cobalt, and chromium area of interest in Afghanistan. The model used physically based, nondeterministic methods to estimate the monthly volumetric water-balance components of a watershed. A comparison of estimated and recorded monthly streamflows for the streamgaging stations Kabul River at Maidan and Kabul River at Tangi-Saidan indicated that the stochastic water-balance model was able to provide satisfactory estimates of monthly streamflows for high-flow months and low-flow months even though withdrawals for irrigation likely occurred. A comparison of estimated and recorded monthly streamflows for the streamgaging stations Logar River at Shekhabad and Logar River at Sangi-Naweshta also indicated that the stochastic water-balance model was able to provide reasonable estimates of monthly streamflows for the high-flow months; however, for the upstream streamgaging station, the model overestimated monthly streamflows during periods when summer irrigation withdrawals likely occurred. Results from the stochastic water-balance model indicate that the model should be able to produce satisfactory estimates of monthly streamflows for locations along the Kabul and Logar Rivers. This information could be used by Afghanistan authorities to make decisions about surface-water resources for the Aynak copper, cobalt, and chromium area of interest.

Introduction

Reliable sources of water are important for continued infrastructure and economic development in Afghanistan. Water is needed to develop agricultural, manufacturing, and mining industries, and also to supply populations that benefit from economic development; however, conflicts in Afghanistan that began about 1980 have hindered the development of water supplies, collection of water-resource data, and assessments of other natural resources in the country (Mack and Chornack, 2011). Beginning in 2004, the U.S. Geological Survey (USGS), in cooperation with the Afghanistan Geological Survey (AGS) and the Afghanistan Ministry of Energy and Water (MEW), completed assessments of Afghanistan mineral and water resources. Since 2009, the USGS, in cooperation with AGS and the U.S. Department of Defense Task Force for Business and Stability Operations (TFBSO), identified areas of interest in Afghanistan that have the potential to produce minerals in economically viable quantities for industrial development, calculated streamflow statistics and investigated water-resource potentials for mineral areas of interest, and reestablished streamgaging stations across the country (Peters and others, 2011; Olson and Mack, 2011).

Historical streamflow data that could be used by Afghanistan authorities to investigate surface-water resources for economic development generally are available from about 1951–1980. Some historical streamflow data have been collected as a result of streamgaging-station reestablishment, but no data exist from about 1980–2008. Techniques have been developed to estimate streamflow statistics for many streams in Afghanistan by using basin characteristics (Olson and Mack, 2011). Monthly streamflows for periods with no data can be estimated by using a stochastic monthly water-balance model similar to a model that was used to estimate monthly streamflows for the upper Helmand River in Afghanistan (Vining and Vecchia, 2007). The USGS, in cooperation with the TFBSO, used the stochastic monthly water-balance model to estimate monthly streamflows for selected streamgaging stations located along the Kabul and Logar Rivers within the Aynak copper, cobalt, and chromium area of interest in Afghanistan. Existing climate data were used in the stochastic model to estimate monthly streamflows and fill data gaps in monthly streamflows for 1951–2010. The purpose of this report is to present results from the modeling effort.

Aynak Copper, Cobalt, and Chromium Area of Interest

The Aynak copper, cobalt, and chromium area of interest has an area of about 3,440 square kilometers and is located south of Kabul in eastern Afghanistan (fig. 1). The area of interest derives its name from the Aynak copper-cobalt deposit and several chromium deposits, but the area also contains other minerals of interest (Taylor and others, 2011). The area has a semiarid climate with average annual precipitation about 315 millimeters that falls mostly November through May (Favre and Kamal, 2004). Grazing, farming, and deforestation have eliminated much of the original natural vegetation, which has resulted in the degradation and erosion of the land surface (Mack and Chornack, 2011).

The Kabul and Logar Rivers may become important surface-water resources for potential mining activities in the Aynak copper, cobalt, and chromium area of interest, but they currently (2014) are important surface-water supplies for agricultural and domestic needs in the Kabul area ((Favre and Kamal, 2004). Mean monthly streamflows for water years 1962–1980 for the streamgaging stations Kabul River at Maidan, Kabul River at Tangi-Saidan, Logar River at Shekhabad, and Logar River at Sangi-Naweshta indicate that streamflows were high during winter precipitation and spring snowmelt, with the highest streamflow at all stations occurring in April (table 1). No data were recorded at the stations from 1980 until 2008 when the streamgaging stations Kabul River at Tangi-Saidan and Logar River at Sangi-Naweshta were reestablished.

Monthly mean streamflows for the Kabul River decreased from the upstream streamgaging station Kabul River at Maidan to the downstream streamgaging station Kabul River at Tangi-Saidan during most months indicating that inflows from overland runoff, tributaries, and groundwater were smaller than losses from withdrawals, evapotranspiration, and seepage (fig. 2). For the Logar River, monthly mean streamflows decreased from the upstream streamgaging station Logar River at Shekhabad to the downstream streamgaging stations Logar River at Sangi-Naweshta during the late spring to early autumn months when losses were greater than inflows, but mean streamflows increased from the upstream to downstream streamgaging stations during winter and early spring months when inflows were greater than losses (fig. 3). The average increase in streamflow from the upstream to downstream Logar River streamgaging stations for November through March was about 7 cubic meters per second.

Irrigation is important for crop production in Afghanistan; approximately 32 square kilometers of the Kabul River Basin between the streamgaging stations at Maidan and Tangi-Saidan, and approximately 340 square kilometers of the Logar River Basin between the streamgaging stations at Shekhabad and Sangi-Naweshta may be irrigated (Favre and Kamal, 2004). From table 1, the decreases in historical mean monthly streamflows during April through October for the Kabul River between the streamgaging stations at Maidan and Tangi-Saidan and for the Logar River between the streamgaging stations at Shekhabad and Sangi-Naweshta were about 28 million cubic meters and 40 million cubic meters, respectively. For the Logar River, if the average increase in streamflow during November through March between the upstream and downstream streamgaging stations (7 cubic meters per second) continued during the remainder of the year (April through October), then an additional inflow of about 129 million cubic meters during April through October was also withdrawn or lost from the Logar River between the two streamgaging stations (fig. 3). If the downstream decreases in mean monthly streamflows for the Kabul and Logar Rivers during April through October were caused by irrigation only, then about 0.9 meter of water depth and about 0.5 meter of water depth could have been applied to the irrigated areas of the Kabul River Basin and Logar River Basin, respectively.

Stochastic Monthly Water-Balance Model

The stochastic monthly water-balance model used physically based, nondeterministic methods to estimate the monthly volumetric water-balance components of a watershed (Vining and Vecchia, 2007). Each watershed model used monthly values of total precipitation and mean temperature to estimate volumes of rain and snow, snowmelt, and evapotranspiration for each watershed. These estimated water volumes were then partitioned into infiltration, storage volumes, and watershed runoff by using equations with parameters estimated during a multiyear initialization period. Information on volumes of water for industrial and municipal use, diversions for irrigation, and possible irrigation returns to streams were unavailable for use in the model.

Input climate data for the water-balance model consisted of gridded (0.5 degree latitude by 0.5 degree longitude) monthly climate data for 1951–2002 (Climate Research Unit, 2012) and Afghanistan agrometeorological station data for April 2008 through September 2010 (U.S. Geological Survey Projects in Afghanistan, 2013). Missing climate data for January 2003 through March 2008 were re-created by using gridded monthly climate data for January 1951 through March 1956, which was assumed to be similar to the missing period. Model monthly precipitation and temperature input for each watershed was averaged from the associated gridded and agrometeorological data. Model monthly precipitation input incorporated total rainfall along with snow accumulation and snowmelt, which were derived from equations dependent on the monthly temperature input.

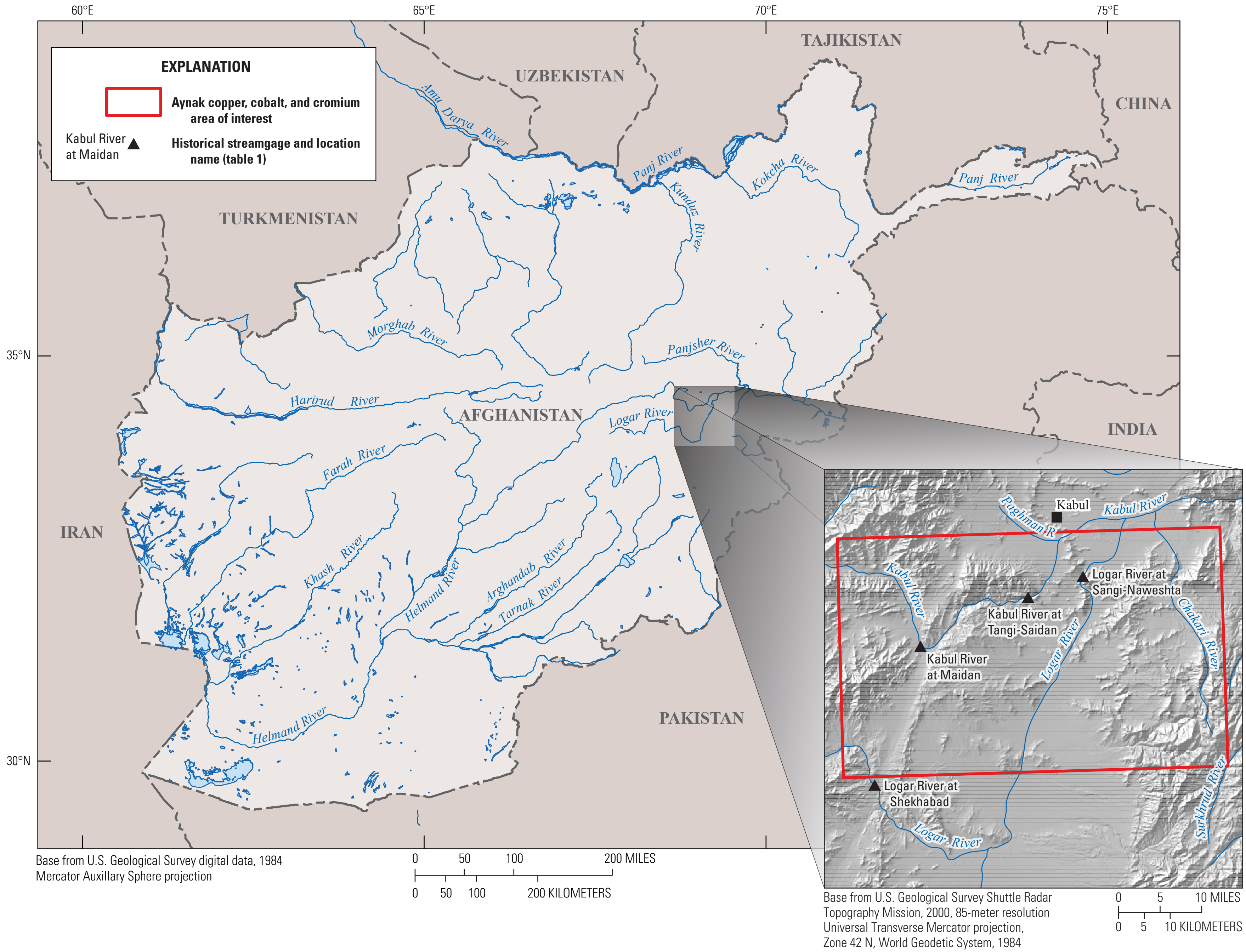

Figure 1. Locations of the Aynak copper, cobalt, and chromium area of interest and selected streamgages along the Kabul River and Logar River, Afghanistan.

Table 1. Mean monthly streamflows for water years 1962–1980 for the streamgaging stations Kabul River at Maidan, Kabul River at Tangi-Saidan, Logar River at Shekhabad, and Logar River at Sangi-Naweshta, Afghanistan.

Month	Kabul River at Maidan	Kabul River at Tangi-Saidan	Logar River at Shekhabad	Logar River at Sangi-Naweshta
	Mean monthly streamflow, in cubic meters per second			
October	1.08	0.44	5.48	3.82
November	1.63	1.05	7.17	10.9
December	2.12	1.61	7.67	14.4
January	2.50	2.48	7.39	15.8
February	2.65	2.67	7.70	15.8
March	6.65	6.15	10.4	17.4
April	20.7	17.2	23.3	22.9
May	14.4	11.1	14.2	10.3
June	5.71	4.38	4.10	1.58
July	1.72	1.00	3.17	1.55
August	1.09	0.40	2.93	0.80
September	0.92	0.31	3.65	0.75

The analysis procedure for a monthly water-balance occurred in a series of steps to determine monthly watershed inflows and outflows (Vining and Vecchia, 2007). The first step was to compute the available watershed water volume during each month that was analyzed (current month) as the storage in the watershed from the previous month plus the total precipitation and snowmelt input to the watershed during the current month. Next, current monthly evapotranspiration was calculated from available watershed water volume during the current month as a fraction of potential evapotranspiration (Hamon, 1961), where the fraction depends on the ratio of available watershed water volume to watershed storage capacity. Then, monthly infiltration was calculated from the monthly precipitation and snowmelt input and monthly evapotranspiration by using parameters (values greater than zero) estimated during the initialization period; monthly watershed direct runoff was calculated from monthly precipitation, infiltration, and evaporation. For the fourth step, total runoff for the current month (monthly streamflow) was computed as the sum of monthly watershed direct runoff and monthly watershed-storage runoff, which was controlled by a parameter (value from zero to one) determined during the initialization period. Last, the volume of watershed storage at the end of the current month consisted of the remaining storage.

The stochastic monthly water-balance model was used to estimate monthly streamflows, in million cubic meters, for 1951–2010 at the upstream streamgaging stations Kabul River at Maidan and Logar River at Shekhabad (fig. 1). The years 1951–1961 were used as the initialization period. Monthly streamflows for 1951–2010 at the downstream streamgaging stations Kabul River at Tangi-Saidan and Logar River at Sangi-Naweshta were estimated by adding the historical (water years 1962–1980) difference in mean monthly streamflows between the downstream and upstream streamgaging stations for each corresponding month (table 1) to the estimated monthly streamflows for the stations Kabul River at Maidan and Logar River at Shekhabad, respectively. Model results were compared to data recorded during water years 1962–1980, and to data recorded during intermittent months in water years 2008–2010 from the streamgaging stations Kabul River at Tangi-Saidan and Logar River at Sangi-Naweshta.

Estimated Monthly Streamflows

A comparison of estimated and recorded monthly streamflows for the streamgaging stations Kabul River at Maidan and Kabul River at Tangi-Saidan indicated that the stochastic water-balance model was able to provide satisfactory estimates of monthly streamflow for high-flow months and low-flow months even though withdrawals for irrigation likely occurred (figs. 4 and 5). Coefficients of determination (R^2) (Helsel and Hirsch, 2002) relating estimated to recorded monthly streamflows for October 1961 through September 1980 were 0.74 and 0.62 for the streamgaging stations Kabul River at Maidan and Kabul River at Tangi-Saidan, respectively. The model also was able to produce reasonable estimates of the monthly streamflow for the streamgaging station Kabul River at Tangi-Saidan during April 2008 through February 2010 after the reinstallation of the streamgaging station in 2008; data were missing during July through November 2008. These results indicate that the model should be able to produce satisfactory estimates of missing monthly streamflow for many locations along the Kabul River.

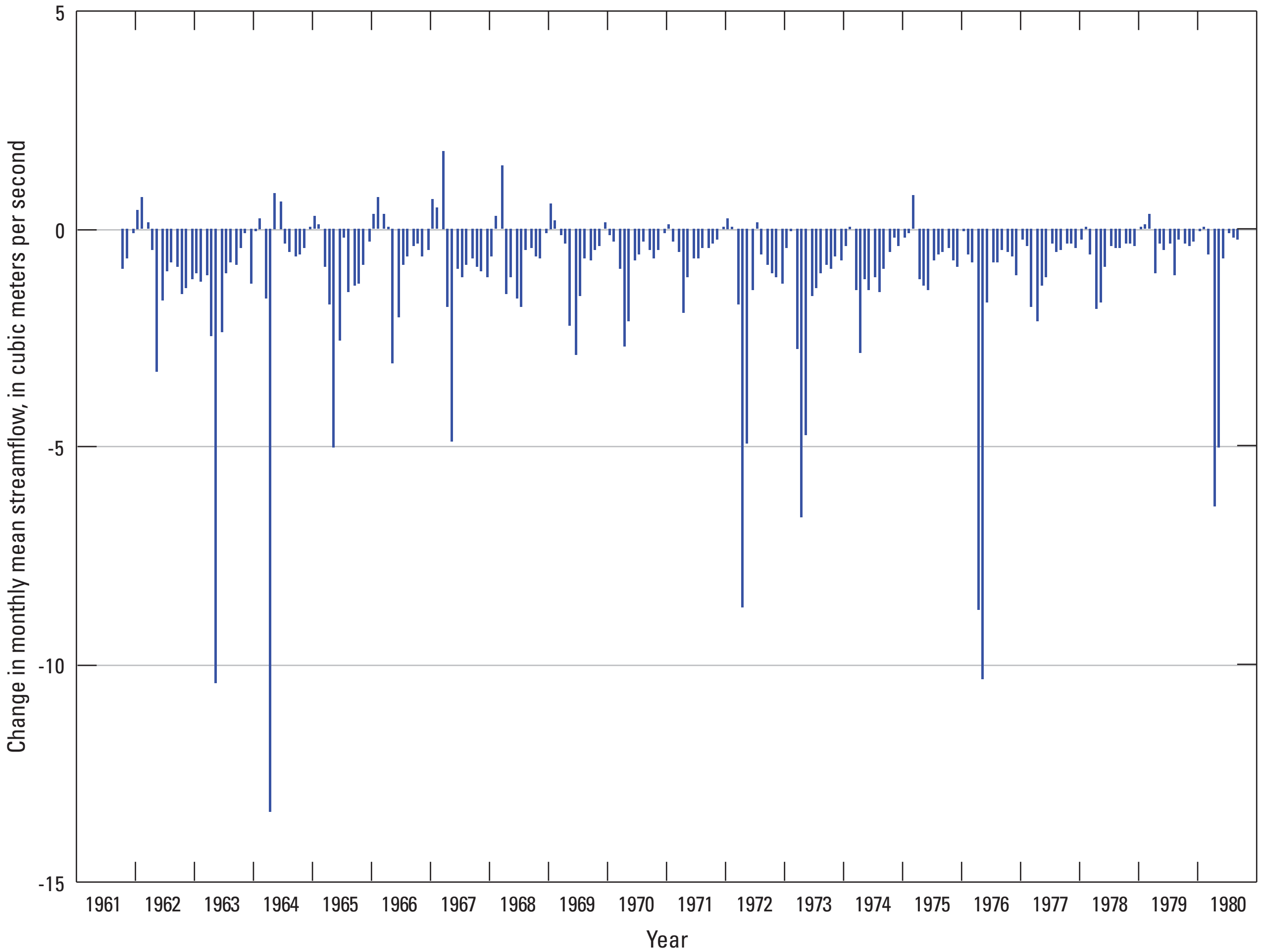

Figure 2. Changes in monthly mean streamflows from the upstream streamgaging station Kabul River at Maidan to the downstream streamgaging station Kabul River at Tangi-Saidan, Afghanistan.

A comparison of estimated and recorded monthly streamflows for the streamgaging stations Logar River at Shekhabad and Logar River at Sangi-Naweshta also indicated that the stochastic water-balance model was able to provide reasonable estimates of monthly streamflows for the high-flow months; however, for the upstream streamgaging station Logar River at Shekhabad, the model overestimated monthly streamflows during periods when summer irrigation withdrawals likely occurred (figs. 6 and 7). The R^2 values relating estimated to recorded monthly streamflows for October 1961 through September 1980 were 0.45 and 0.51 for the streamgaging stations Logar River at Shekhabad and Logar River at Sangi-Naweshta, respectively. The possibility also exists that greater infiltration from the riverbed occurred during low-flow months than were accounted for by the model. The reach along the Logar River between the streamgaging stations Logar River at Shekhabad and Logar River at Sangi-Naweshta may have complex stream and aquifer interactions than cannot be accounted for with this model. If the information was available, data on water use, diversions, and infiltration losses could be beneficial for model performance. The model was able to estimate monthly streamflows for the streamgaging station Logar River at Sangi-Naweshta during April 2008 through January 2010 after reinstallation of the streamgaging station in 2008 (fig. 7). Monthly streamflow data from the streamgaging station Logar River at Sangi-Naweshta were missing during June through October 2008 and July through October 2009.

Results from the stochastic water-balance model indicate that the model should be able to produce satisfactory estimates of monthly streamflows for locations along the Kabul and Logar Rivers. This information could be used by Afghanistan authorities to make decisions about surface-water resources for the Aynak copper, cobalt, and chromium area of interest.

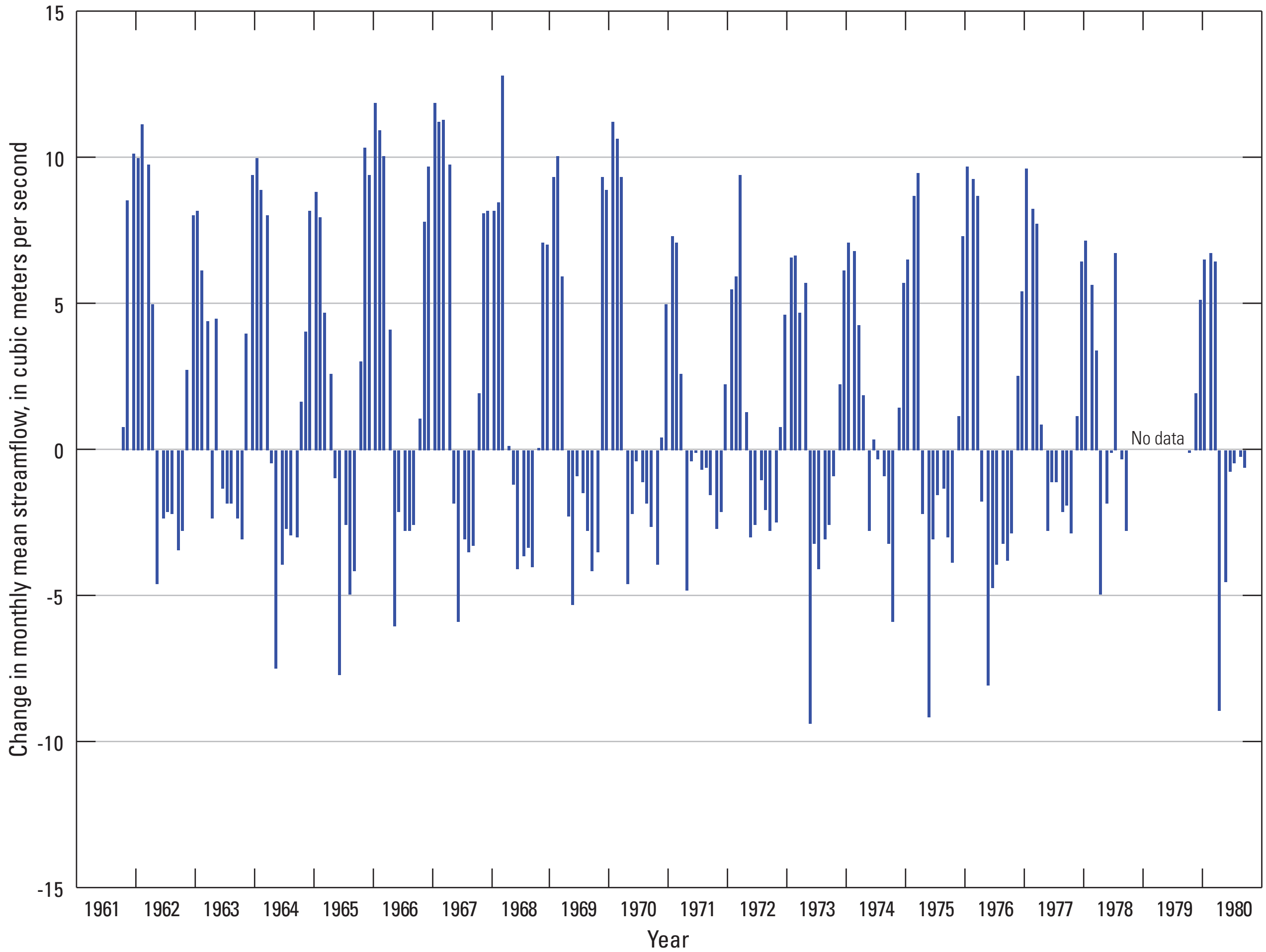

Figure 3. Changes in monthly mean streamflows from the upstream streamgaging station Logar River at Shekhabad to the downstream streamgaging station Logar River at Sangi-Naweshta, Afghanistan.

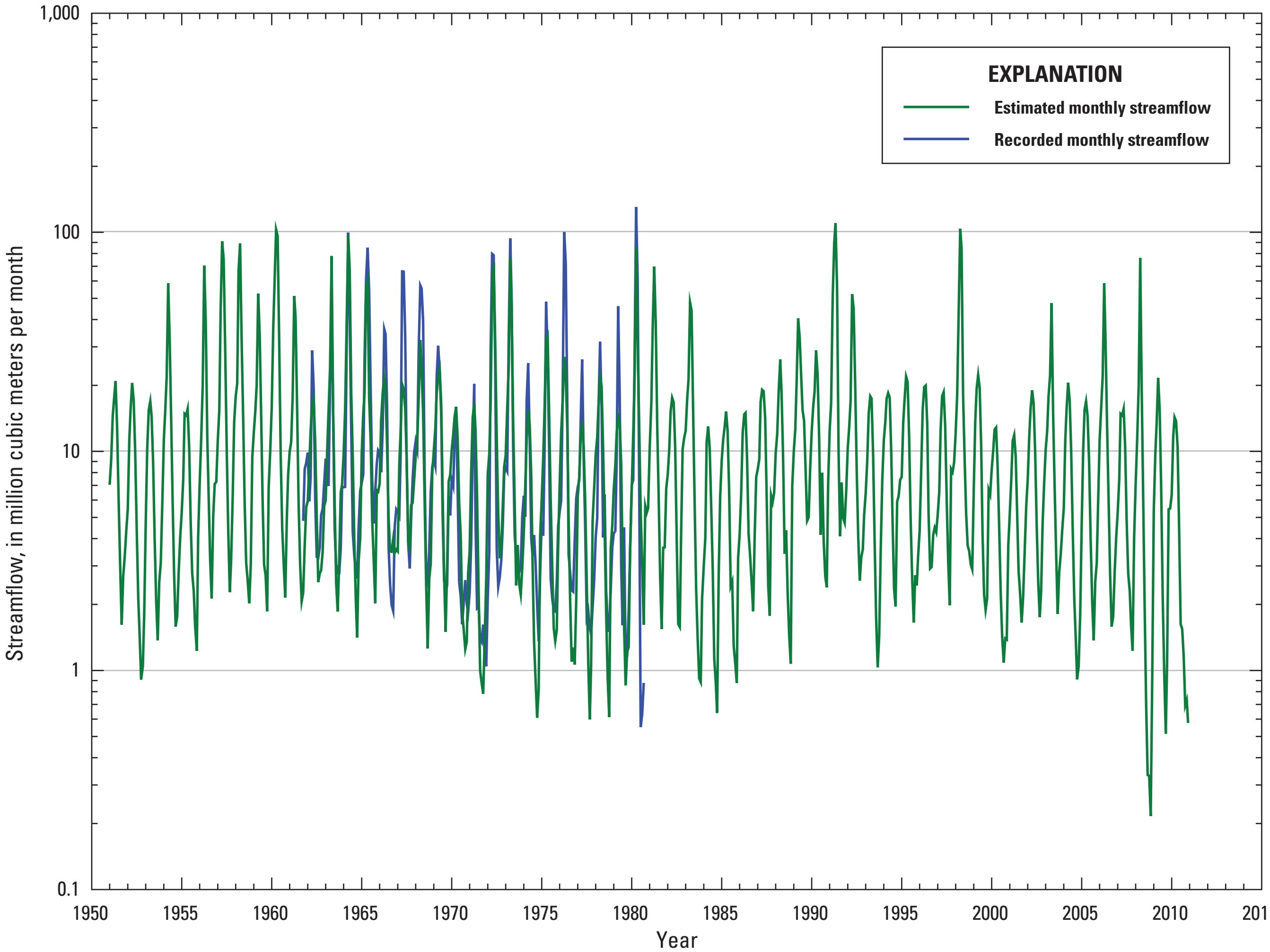

Figure 4. Estimated and recorded monthly streamflows for the streamgaging station Kabul River at Maidan, Afghanistan.

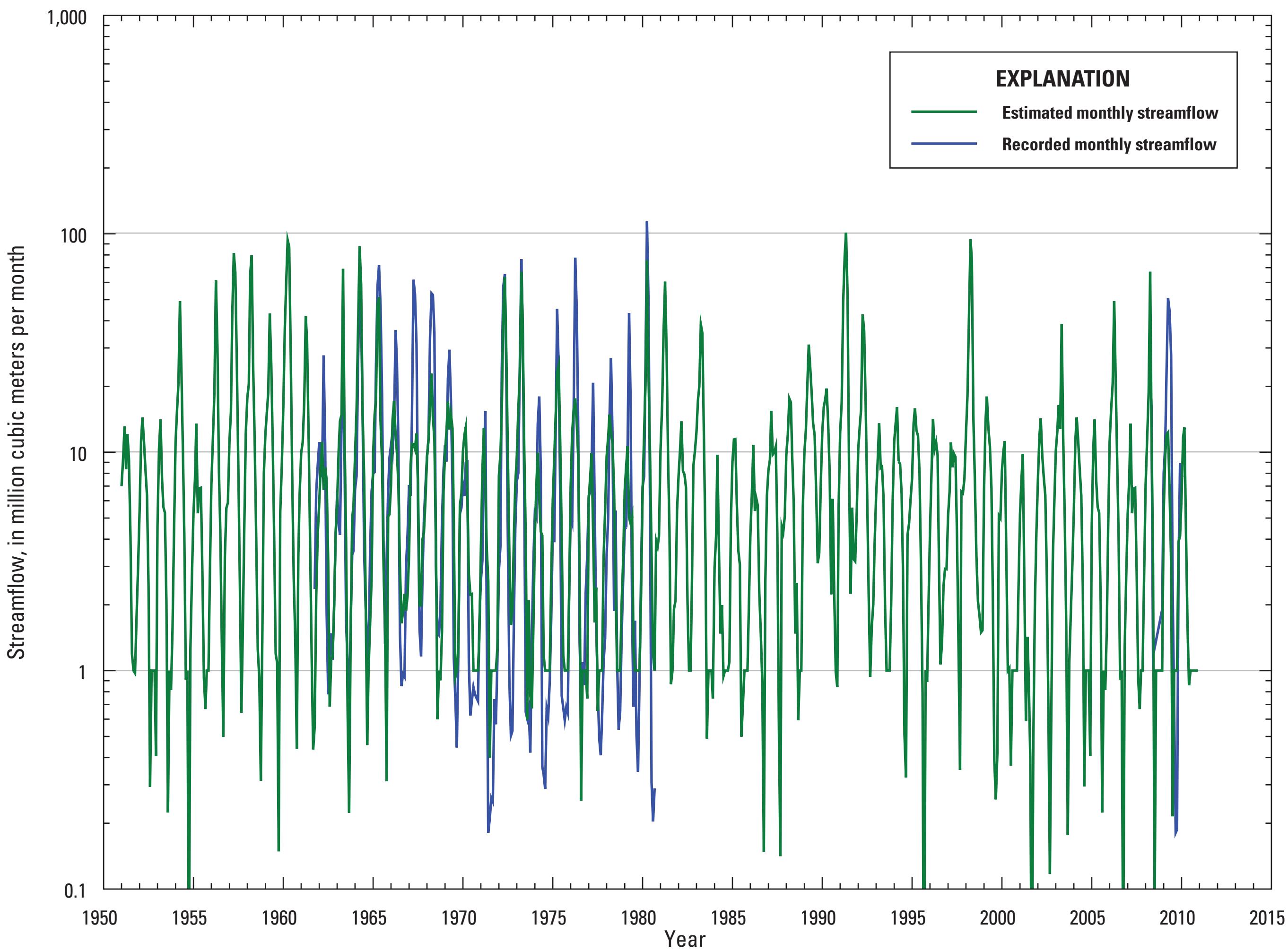

Figure 5. Estimated and recorded monthly streamflows for the streamgaging station Kabul River at Tangi-Saidan, Afghanistan.

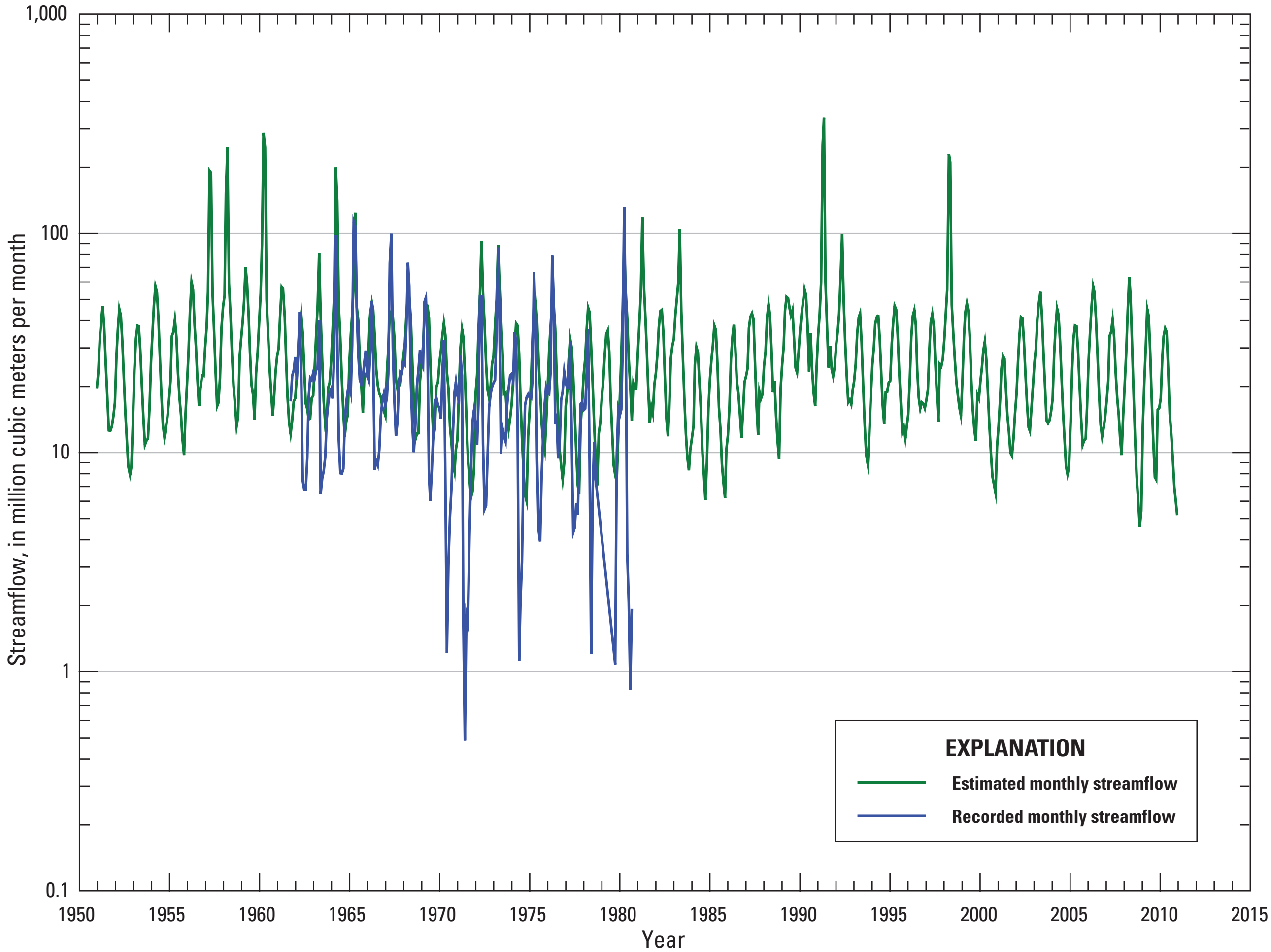

Figure 6. Estimated and recorded monthly streamflows for the streamgaging station Logar River at Shekhabad, Afghanistan.

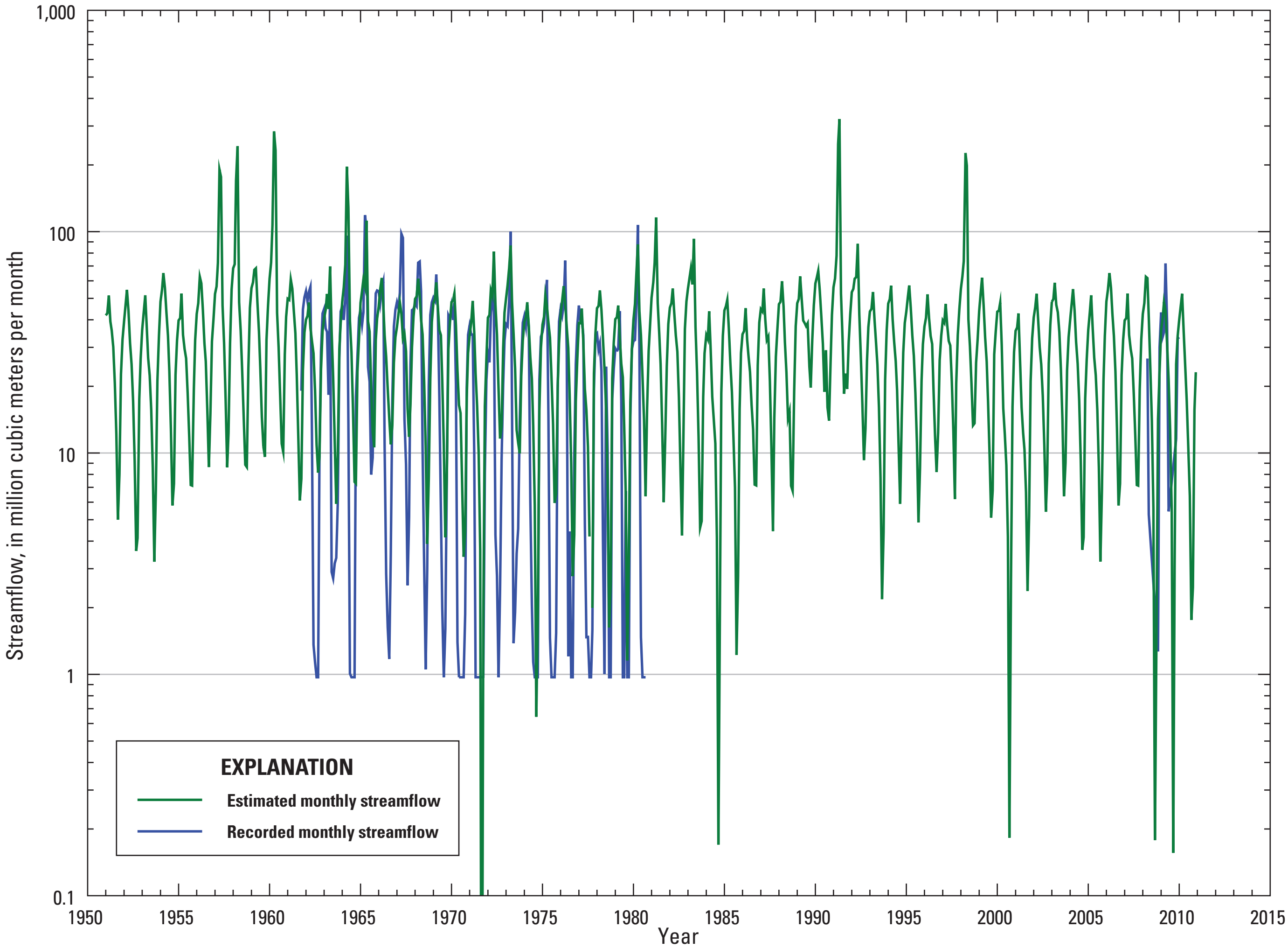

Figure 7. Estimated and recorded monthly streamflows for the streamgaging station Logar River at Sangi-Naweshta, Afghanistan.

Summary

Since 2009, the U.S. Geological Survey, in cooperation with Afghanistan Geological Survey and the U.S. Department of Defense Task Force for Business and Stability Operations (TFBSO), identified areas of interest in Afghanistan that have the potential to produce minerals in economically viable quantities for industrial development, calculated streamflow statistics and investigated water-resource potentials for mineral areas of interest, and reestablished streamgaging stations across the country. The USGS, in cooperation with the TFBSO, used the stochastic monthly water-balance model to estimate monthly streamflows for selected streamgaging stations located within the Aynak copper, cobalt, and chromium area of interest in Afghanistan. Existing climate data were used in the stochastic model to estimate monthly streamflows and fill data gaps in monthly streamflows for 1951–2010. The purpose of this report is to present results from the modeling effort.

The Kabul and Logar Rivers may become important surface-water resources for potential mining activities, but they currently (2014) are important surface-water supplies for agricultural and domestic needs in the Kabul area. Mean monthly streamflows for water years 1962–1980 for the streamgaging stations Kabul River at Maidan, Kabul River at Tangi-Saidan, Logar River at Shekhabad, and Logar River at Sangi-Naweshta indicate that streamflows were high during winter precipitation and spring snowmelt, with the highest streamflow at all stations occurring in April. No data were recorded at the stations from 1980 until 2008 when the streamgaging stations Kabul River at Tangi-Saidan and Logar River at Sangi-Naweshta were reestablished.

The stochastic monthly water-balance model used physically based, nondeterministic methods to estimate the monthly volumetric water-balance components of a watershed. Each watershed model used monthly values of total precipitation and mean temperature to estimate volumes of rain and snow, snowmelt, and evapotranspiration for each watershed. These estimated water volumes were then partitioned into watershed runoff, infiltration, and storage volumes. The stochastic monthly water-balance model was used to estimate monthly streamflows for 1951–2010 at the upstream streamgaging stations Kabul River at Maidan and Logar River at Shekhabad. Monthly streamflows for 1951–2010 at the downstream streamgaging stations Kabul River at Tangi-Saidan and Logar River at Sangi-Naweshta were estimated by adding the historical (water years 1962–1980) difference in mean monthly streamflows between the downstream and upstream streamgaging stations for each corresponding month to the estimated monthly streamflows for the stations Kabul River at Maidan and Logar River at Shekhabad, respectively.

A comparison of estimated and recorded monthly streamflow for the streamgaging stations Kabul River at Maidan and Kabul River at Tangi-Saidan indicated that the stochastic water-balance model was able to provide satisfactory estimates of monthly streamflow for high-flow months and low-flow months even though withdrawals for irrigation likely occurred. The model also was able to produce reasonable estimates of the monthly streamflow for the streamgaging station Kabul River at Tangi-Saidan during April 2008 through February 2010 after the reinstallation of the streamgaging station in 2008.

A comparison of estimated and recorded monthly streamflow for the streamgaging stations Logar River at Shekhabad and Logar River at Sangi-Naweshta also indicated that the stochastic water-balance model was able to provide reasonable estimates of monthly streamflow for the high-flow months; however, for the upstream streamgaging station Logar River at Shekhabad, the model overestimated monthly streamflows during periods when summer irrigation withdrawals likely occurred. The model was able to estimate monthly streamflow for the streamgaging station Logar River at Sangi-Naweshta during April 2008 through January 2010 after reinstallation of the streamgaging station in 2008.

Results from the stochastic water-balance model indicate that the model should be able to produce satisfactory estimates of monthly streamflows for locations along the Kabul and Logar Rivers. This information could be used by Afghanistan authorities to make decisions about surface-water resources for the Aynak copper, cobalt, and chromium area of interest.

References Cited

Climate Research Unit, 2012, High-resolution gridded datasets: Climate Research Unit, accessed April 2012 at *http://www.cru.uea.ac.uk/cru/data/hrg/*.

Favre, Raphy, and Kamal, G.M., 2004, Watershed atlas of Afghanistan: Kabul, Afghanistan, Afghanistan Information Management Service, 183 p.

Hamon, W.R., 1961, Estimating potential evapotranspiration: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 87, p. 107–120.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 522 p.

Mack, T.J., and Chornack, M.P., 2011, Geohydrologic summary of the Aynak Copper, Cobalt, and Chromium Area of Interest, chap. 2C, *in* Peters, S.G., King, T.V.V., Mack, T.J., and Chormack, M.P., eds, and the U.S. Geological Survey Afghanistan Mineral Assessment Team, Summaries of important areas for mineral investment and production opportunities of nonfuel minerals in Afghanistan: U.S. Geological Survey Open-File Report 2011–1204, p. 135–160.

Olson, S.A., and Mack, T.J., 2011, Technique for estimation of streamflow statistics in mineral areas of interest in Afghanistan: U.S. Geological Survey Open-File Report 2011–1176, 17 p.

Peters, S.G., Kalaly, S.S., Chirico, P.G., and Hubbard, B.E., 2011, Introduction to summaries of important areas for mineral investment and production opportunities of nonfuel minerals in Afghanistan, chap. 1, *in* Peters, S.G., King, T.V.V., Mack, T.J., Chornack, M.P., eds., and the U.S. Geological Survey Afghanistan Mineral Assessment Team, Summaries of important areas for mineral investment and production opportunities of nonfuel minerals in Afghanistan: U.S. Geological Survey Open-File Report 2011–1204, p. 1–35.

Taylor, C.D., Peters, S.G., and Sutphin, D.M., 2011, Summary of the Aynak copper, cobalt, and chromium area of interest, chap. 2A, *in* Peters, S.G., King, T.V.V., Mack, T.J., Chornack, M.P., eds., and the U.S. Geological Survey Afghanistan Mineral Assessment Team, Summaries of important areas for mineral investment and production opportunities of nonfuel minerals in Afghanistan: U.S. Geological Survey Open-File Report 2011–1204, p. 36–94.

U.S. Geological Survey Projects in Afghanistan, 2013, Publications and Maps, Agro-Meteorology, accessed July 2013 at *http://afghanistan.cr.usgs.gov/agrometeorology-publications-maps.*

Vining, K.C., 2010, Streamflow characteristics of streams in southeastern Afghanistan: U.S. Geological Survey Data Series 508, 104 p.

Vining, K.C., and Vecchia, A.V., 2007, Water-balance simulations of runoff and reservoir storage for the Upper Helmand watershed and Kajakai Reservoir, central Afghanistan: U.S. Geological Survey Scientific Investigations Report 2007–5148, 16 p.

Publishing support provided by:
Rolla Publishing Service Center

For more information concerning this publication, contact:
Director, USGS North Dakota Water Science Center
821 East Interstate Avenue
Bismarck, North Dakota 58503
(701) 250–7400

Or visit the North Dakota Water Science Center Web site at:
http://nd.water.usgs.gov/

Vining and Vecchia—**Estimated Monthly Streamflows for the Kabul and Logar Rivers, Aynak area, Afghanistan**—SIR 2014–5157

ISSN 2328-0328 (online)

http://dx.doi.org/110.3133/sir20145157