**APPENDIX D**

**Graphs of Streamflow Change for Major Puget Sound Watersheds**

This appendix contains graphs of the historical and projected changes in streamflow for the 12 major Puget Sound watersheds analyzed in this report (see Section 3). Results are shown for changes in monthly average streamflow as well as peak and low flow statistics. As in Appendices B and C, results are included for the following two datasets:

- **Integrated Scenarios for the Future Northwest Environment.** The current set of projections, developed by Mote et al. in 2015,\(^1\) which stem from the newer 2013 IPCC report,\(^2\) and

- **The Pacific Northwest Hydroclimate Scenarios Project.** A previous set of projections, developed by Hamlet et al. in 2010,\(^3\) which are based on the climate projections used in the IPCC’s 2007 report.\(^4\)

The global climate model projections that form the basis of these two datasets stem from the current and previous generations of the Coupled Model Intercomparison Project (“CMIP”, see Section 1). The previous projections originate from the CMIP3 archive, while the current projections come from the newer CMIP5 archive.\(^5\),\(^6\) Each CMIP experiment is associated with a different set of greenhouse gas scenarios.\(^A\) For simplicity, each figure is labeled with the CMIP experiment on which it is based (“CMIP3” or “CMIP5”), as well as the name(s) of the greenhouse gas scenarios that are the basis of the projections shown in each figure (e.g. “Moderate (A1B)”, or “Low (RCP 4.5)”).

Projections are included for the following climate and hydrologic variables:

- Figures D-1a, b: Nooksack
- Figures D-2a, b: Samish
- Figures D-3a, b: Skagit
- Figures D-4a, b: Stillaguamish
- Figures D-5a, b: Snohomish
- Figures D-6a, b: Cedar
- Figures D-7a, b: Green
- Figures D-8a, b: Nisqually
- Figures D-9a, b: Puyallup
- Figures D-10a, b: Skokomish
- Figures D-11a, b: Dungeness
- Figures D-12a, b: Elwha

\(^A\) Greenhouse gas scenarios were developed by climate modeling centers for use in modeling global and regional climate impacts. These are described in the text as follows: “very low” refers to the RCP 2.6 scenario; “low” refers to RCP 4.5 or SRES B1; “moderate” refers to RCP 6.0 or SRES A1B; and “high” refers to RCP 8.5, SRES A2, or SRES A1FI – descriptors are based on cumulative emissions by 2100 for each scenario. See Section 1 for more details.
Each of the following pages includes three plots:

1. The larger plots on the left side of each page show monthly average streamflow for the water year, comparing historical (black) to the range among future projections (colored shading). Results for mid-century are shown in the top plot (2040s for CMIP3, 2050s for CMIP5), and for the end of the century (2080s) on the bottom. Thick colored lines show the average among 10 climate models, and different colors are used to either distinguish among time periods (CMIP3) or between high and low greenhouse gas scenarios (CMIP5).

2. The top-right plots show the projected changes in the annual maximum of daily flows. Results for mid-century are on the left (2040s for CMIP3, 2050s for CMIP5), while the end of century (2080s) projections are on the right. Results are shown for the 10-, 50-, and 100-year return interval flows, with each dot representing one of the 10 model projections for each greenhouse gas scenario. Bars indicate the interquartile range (25th to 75th percentiles) of the projections. Note that for the CMIP5-based projections, there is a range among historical simulations, reflecting the fact that each model has a separate historical simulation.

3. The bottom-right plots show the projected changes in the annual minimum in 7-day streamflow. The format is identical to that used for the peak flows plots, except that results are shown for the 2- and 10-year return intervals.

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Nooksack River Watershed
CMIP3 projections

Figures D-1a. As described on Page D-2, for the Nooksack River watershed, based on the CMIP3-based hydrologic projections.\textsuperscript{3,4}
Nooksack River Watershed
CMIP5 projections

Figures D-1b. As described on Page D-2, for the Nooksack River watershed, based on the CMIP5-based hydrologic projections.\(^1,2\)
Samish River Watershed
CMIP3 projections

Figures D-2a. As described on Page D-2, for the Samish River watershed, based on the CMIP3-based hydrologic projections.³⁴
Samish River Watershed
CMIP5 projections

**Figures D-2b.** As described on Page D-2, for the Samish River watershed, based on the CMIP5-based hydrologic projections.\(^1\,\,^2\)
Figures D-3a. As described on Page D-2, for the Skagit River watershed, based on the CMIP3-based hydrologic projections.\textsuperscript{3,4}
Skagit River Watershed
CMIP5 projections

**Figures D-3b.** As described on Page D-2, for the Skagit River watershed, based on the CMIP5-based hydrologic projections.\(^1\)\(^2\)
Stillaguamish River Watershed

CMIP3 projections

**Figures D-4a.** As described on Page D-2, for the Stillaguamish River watershed, based on the CMIP3-based hydrologic projections.\(^3\)\(^4\)
Stillaguamish River Watershed
CMIP5 projections

**Figures D-4b.** As described on Page D-2, for the Stillaguamish River watershed, based on the CMIP5-based hydrologic projections.\textsuperscript{1,2}
Snohomish River Watershed
CMIP3 projections

Figures D-5a. As described on Page D-2, for the Snohomish River watershed, based on the CMIP3-based hydrologic projections.3,4
Snohomish River Watershed
CMIP5 projections

**Figures D-5b.** As described on Page D-2, for the Snohomish River watershed, based on the CMIP5-based hydrologic projections.\(^1\,2\)
Cedar River Watershed
CMIP3 projections

**Figures D-6a.** As described on Page D-2, for the Cedar River watershed, based on the CMIP3-based hydrologic projections.3,4
Cedar River Watershed
CMIP5 projections

**Figures D-6b.** As described on Page D-2, for the Cedar River watershed, based on the CMIP5-based hydrologic projections.¹²
Green River Watershed
CMIP3 projections

Figures D-7a. As described on Page D-2, for the Green River watershed, based on the CMIP3-based hydrologic projections. 3, 4
Green River Watershed
CMIP5 projections

**Monthly Streamflow**

- **Source**: CMIP5
- **Legend**:
  - Historical
  - Low Emissions median (RCP 4.5)
  - High Emissions median (RCP 8.5)
  - Low Emissions range (RCP 4.5)
  - High Emissions range (RCP 8.5)

**Figures D-7b.** As described on Page D-2, for the Green River watershed, based on the CMIP5-based hydrologic projections.\(^1\)\(^2\)
Nisqually River Watershed
CMIP3 projections

**Monthly Streamflow**

![Graph showing monthly streamflow from October to September for 2040s and 2080s.](image)

**Peak Flows**

![Graph showing peak flows for 2040s and 2080s.](image)

**Low Flows**

![Graph showing low flows for 2040s and 2080s.](image)

**Figures D-8a.** As described on Page D-2, for the Nisqually River watershed, based on the CMIP3-based hydrologic projections.³⁴
Nisqually River Watershed
CMIP5 projections

Figures D-8b. As described on Page D-2, for the Nisqually River watershed, based on the CMIP5-based hydrologic projections.\textsuperscript{1,2}
Puyallup River Watershed
CMIP3 projections

Figures D-9a. As described on Page D-2, for the Puyallup River watershed, based on the CMIP3-based hydrologic projections.\(^3\),\(^4\)
Puyallup River Watershed
CMIP5 projections

**Figures D-9b.** As described on Page D-2, for the Puyallup River watershed, based on the CMIP5-based hydrologic projections.¹²
Skokomish River Watershed
CMIP3 projections

Figures D-10a. As described on Page D-2, for the Skokomish River watershed, based on the CMIP3-based hydrologic projections.3,4
Skokomish River Watershed
CMIP5 projections

Figures D-10a. As described on Page D-2, for the Skokomish River watershed, based on the CMIP5-based hydrologic projections.1,2
Dungeness River Watershed
CMIP3 projections

**Figures D-11a.** As described on Page D-2, for the Dungeness River watershed, based on the CMIP3-based hydrologic projections.³⁴
Appendix D

Dungeness River Watershed
CMIP5 projections

Figure D-11b. As described on Page D-2, for the Dungeness River watershed, based on the CMIP5-based hydrologic projections.1,2
Elwha River Watershed
CMIP3 projections

**Monthly Streamflow**

*Source: CMIP3*
- Historical
- Moderate Emissions (A1B)
- Moderate Emissions range (A1B)

**Peak Flows**

*Source: CMIP3*
- Historical
- Moderate Emissions (A1B)
- Median

**Low Flows**

*Source: CMIP3*
- Historical
- Moderate (A1B)
- Median

**Figures D-12a.** As described on Page D-2, for the Elwha River watershed, based on the CMIP3-based hydrologic projections.3,4
Elwha River Watershed
CMIP5 projections

Figure D-12b. As described on Page D-2, for the Elwha River watershed, based on the CMIP5-based hydrologic projections.¹²