WATERSHED PLANNING, CLIMATE VARIABILITY, AND CLIMATE CHANGE: BRINGING A GLOBAL SCALE ISSUE TO THE LOCAL LEVEL

By

Lara C. Whitely Binder

A degree project submitted in partial fulfillment
of the requirements for the degree of

Master of Public Administration
University of Washington

2002

Approved by:

____

Table of Contents

List of Figures

List of Tables and Boxes

Acknowledgements

This publication would not have been possible without the support of staff and affiliated researchers at the Climate Impacts Group (CIG) at the University of Washington. It has been a privilege to work with CIG and to have the opportunity to participate in discussions on adapting the region's water resources to climate impacts.

Special thanks goes to Phillip Mote and Ed Miles of CIG and Geoff Tallent of the Department of Ecology, whose comments and guidance were particularly helpful throughout development of the project; the Watershed Planning Leads at Ecology who participated in the survey; and Adrienne Karpov at CIG, who kindly shared her cubicle space and supportive comments with me over the last year.

Last but certainly not least I would like to thank Malcolm for being the wonderful person he is and encouraging me to do my best. Thanks for all the support (as well as the meals and loads of laundry!) during this project and my two years of graduate school.

1.0 Executive Summary

Washington State faces many challenges in managing its water resources. Growing population, endangered species requirements, irrigation needs, water quality concerns, and demands for hydroelectric power production are continuing to place strains on a system already struggling to meet existing demands in many areas of the state.

Natural climate variability and human-induced climate change will exacerbate water resource conflicts by altering the type and timing of precipitation throughout Washington. The likelihood for increased precipitation and increased water shortages as a consequence of climate variability and climate change, although seemingly counterintuitive, could result in significant disruptions to natural environments, local economies, and community lifestyles. Early recognition and assessment of potential climate impacts at a local level gives communities time to consider options for action – rather than reaction – to climate variability and climate change, potentially reducing the effects of these disruptive changes. This is particularly important given that the watershed level is where the impacts will first be felt and where many of the difficult choices must be made.

Few programs represent as significant an opportunity to incorporate planning for climate variability and climate change into local water resource management decisions as Washington State's Watershed Planning Program. The Watershed Planning Program was established in 1998 with the adoption of the Watershed Management Act (Engrossed Substitute House Bill 2514) by the Washington State legislature. The purpose of the act is to encourage the development of comprehensive, long-range watershed planning through voluntary collaborative efforts at the watershed level. The watershed plan must, at a minimum, address short-term and long-term concerns related to water quantity in order to qualify for state funding. Watersheds are also encouraged, but not required, to address planning needs related to instream flows, water quality, and habitat. The program is administered by the Washington Department of Ecology (Ecology).

The purpose of this study is to determine the extent to which the Watershed Planning Program may serve as a vehicle for adapting to the hydrologic impacts of climate variability and climate change at the watershed level. A survey of Ecology watershed planning staff was instrumental in making this determination. The study also provides a preliminary assessment of natural, socioeconomic, regulatory, and other factors that may leave a watershed more or less vulnerable to climate impacts and/or inhibit adapting to climate impacts at the watershed level. The analysis is focused on the 42 watersheds, or Watershed Resources Inventory Areas (WRIAs), participating in Washington State's Watershed Planning Program.

1.1 Survey of Watershed Planning Leads

The first part of the study involved conducting a qualitative survey of Ecology watershed planning staff, known as Watershed Planning Leads. The primary purpose of the survey was to assess the extent to which climate variability and climate change are being addressed in watershed planning. Challenges to incorporating climate impacts into watershed planning, specific watershed vulnerabilities, the use of hydrologic models as an aid to watershed planning, and the willingness of watershed planning units to consider building climate scenario testing into models were also explored. Eleven of 15 Leads representing 33 of 42 WRIAs participated in the survey.

Responses to the survey provide a broad overview of issues faced in moving the climate adaptation focus to a watershed level in Washington State. While most planning units recognize climate impacts as an issue in watershed planning, the belief by some planning units that climate impacts will happen in the future removes the pressure to address impacts now, particularly in light of the existing challenges planning units must deal with (e.g, instream flows, water rights, water quality, general supply challenges). The limited funding provided by the state for watershed planning has also been a factor in restricting the scope of planning to only the most current of pressing issues.

Another challenge to moving the adaptation focus to the watershed level is the limited flexibility many watersheds have to adapt to climate impacts. According to surveyed Leads, there is a fairly uniform distribution between WRIAs considered to have some or good flexibility (13 WRIAs) and limited flexibility (12 WRIAs) in adapting water supplies to climate impacts. Leads were uncertain about the level of flexibility in eight WRIAs. Identified barriers to adapting to climate impacts include natural limitations in supply, the political culture of a watershed (e.g., reluctance to change the status quo and/or encroach on private property rights), and administrative/regulatory uncertainties related to the overallocation of water rights and status of instream flows for endangered species.

One area where a lack of flexibility is already evident is drought management. Opinions about the ability to better manage drought or other supply crises at the watershed level as a result of watershed planning varied but were generally optimistic. Several Leads noted that this type of contingency planning is outside the scope of the Watershed Planning Program, however. The lack of specific planning for drought management leaves many watersheds vulnerable to drought impacts despite watershed planning.

Aiding adaptation at the watershed level is the fact that many watershed planning units (in 22 of 33 WRIAs) have discussed the effects of climate variability and/or climate change on water resources and to a lesser extent are including recognition of those impacts, particularly climate variability, in planning documentation (15 of the 22 WRIAs). Only two planning units were identified as choosing not to address climate impacts because of a fundamental disbelief in climate change, a number that was lower than expected. Additionally, all Leads indicated that their planning units would be receptive to building "what if" climate scenarios into a watershed hydrologic model if doing so was cost-effective and not too difficult technically. Twenty-two (22) WRIAs are using, or considering using, hydrologic modeling as part of their watershed planning effort at this time. Tying climate impacts modeling to a larger effort (i.e., something being done by the federal government or some of the models developed by the state) may bring the additional funding needed to include climate impacts in watershed planning.

1.2 Vulnerability Indicators

The second part of the research involved identifying factors that may make a watershed more or less vulnerable to hydrologic changes associated with climate variability and climate change. Use of these indicators in a vulnerability assessment gives decision-makers the opportunity to consider climate impacts as a two-way street. In one direction, the vulnerability assessment facilitates considering how climate variability and climate change might affect specific characteristics of a watershed. In the other direction, the vulnerability assessment helps identify how specific watershed characteristics might influence vulnerability to climate impacts. Recognizing and understanding these relationships may contribute to the development of watershed management strategies that reduce overall watershed vulnerability by minimizing negative feedback loops and creating more opportunities for adaptation.

Forty-eight (48) primary vulnerability indicators were identified based on a review of multiple sources of information, including Watershed Planning Program Phase II Level 1 Technical Assessment Reports, Habitat Limiting Factors reports, interviews with Watershed Planning Leads, peer reviewed journal articles and publications, and other watershed level studies. The indicators are grouped into six general categories: Climate and Hydrology, Land Use/Land Features, Water Use Characteristics, Water Quality, Regulatory Characteristics, and Watershed Planning. Examples of vulnerability indicators include Average Annual Basin Precipitation, Average Temperature, Transboundary Issues, Population, Major Water Storage Systems, and Surface Water Quality Problems.

To differentiate the degree to which the indicators influence vulnerability to climate impacts, indicators are categorized as one of three types: Level 1, Level 2, Level 3, or descriptive.

- Level 1 vulnerability indicators directly affect vulnerability to hydrologic impacts independent of all other factors. Examples include the type of basin (snow dominant, transient, or rain dominant basins), population, and average annual precipitation.
- Level 2 vulnerability indicators do not have a direct effect on vulnerability but may still positively or negatively affect a watershed's ability to adapt to climate impacts, thereby affecting the watershed's overall vulnerability. Examples include trends in annual surface water flow, major water uses, and surface water quality problems
- Level 3 vulnerability indicators are identical to Level 2 indicators by definition but have less influence on vulnerability than a Level 2 indicator. Examples include watershed size, major land uses, and the number of exempt wells believed to be located in the watershed.
- Finally, some indicators are considered "Descriptive Only" indicators. These are indicators providing descriptive information relevant to assessing vulnerability but which

do not have any influence on vulnerability. Examples include major cities, major water sources, and total annual allocation of water through water rights.

Each indictor, indicator level ranking, assumptions regarding the influence of the indicator on vulnerability, and any vulnerability reduction bias in assessing the indicator are presented in the analysis. An attempt was made to apply the vulnerability indicators in a vulnerability assessment for 19 WRIAs participating in the Watershed Planning Program. The effort was deferred, however, after it became evident that additional research was needed to build more specificity into the assumptions made for certain indicators. For example, while it is clear that watersheds receiving less precipitation will be more vulnerable to climate impacts, ranges that will define "less precipitation" must be determined for a vulnerability assessment to be completed.

In lieu of this, nominal conditions that would leave a watershed most vulnerable to climate impacts are identified to serve as an example of how individual vulnerability indicators can combine to increase vulnerability in a watershed. The list of conditions represents a hypothetical case but is likely to apply at least in part to many watersheds in Washington State. The nominal conditions include the following (by vulnerability indicator category):

<u>Indicator Category: Climate and Hydrology</u>

- Transient basin or lower elevation snow dominant basin *(Type of Basin indicator)*
- Lower average annual precipitation or large disparities between the upper and lower basin precipitation values, which forces greater reliance on upper level precipitation *(Annual Precipitation indicator)*
- Higher basin-wide summer temperatures and/or winter temperatures nearing freezing in the primary watershed catchment area(s) *(Average Temperatures indicator)*

<u>Indicator Category: Water Use</u>

- High projected population growth rate relative to current population *(Population indicator)*
- Watershed population largely dependent on surface water *(Water Use by Source indicator)*

- Little carryover storage capacity for managing floods as well as droughts *(Major Water Storage Systems indicator)*

Indicator Category: Regulatory Characteristics Indicator

- Uncertainty over the use status of surface and/or groundwater rights *(combined overview of Surface Water Rights, Groundwater Rights sub-indicators)*
- Instream flow restrictions present *(Instream Flows indicator)*
- Total Maximum Daily Load restrictions *(TMDL indicator)*

Indicator Category: Watershed Planning

- Major watershed planning challenges sensitive to climate variation and change *(Major Planning Challenges Sensitive to Climate indicator)*
- Little or uncertain perceived adaptation flexibility *(Perceived Level of Adaptation Flexibility indicator)*

Five additional "next steps" are recommended to fully develop the applicability of the list of indicators. A first step is continued literature research on climate impacts, vulnerability indicators, and indicator assumptions to help verify (or correct) the choice of indicators and assumptions. Studies and other publications that may be of value to planning units and Leads should be made available in copy or by reference on the Climate Impacts Group web site for use by these entities.

A second recommended step is initiating discussions with climate impacts researchers and Leads to review the listed indicators, indicator assumptions, and methodology for assessing vulnerability. Approaches to assessing the specific effects of combinations of indicators on watershed vulnerability should also be discussed in these meetings. Developing specific ranges for indicator assumptions and continued review of watershed reports for Watershed Planning Program WRIAs (including completing unreported or inconsistently reported data) are also recommended.

Finally, and most importantly, the vulnerability analysis should be conducted for individual

WRIAs to identify which watersheds are potentially more vulnerable to climate impacts. It is recommended that CIG staff complete the vulnerability assessment for all Watershed Planning WRIAs as a comparative assessment and develop a list of watersheds grouped by high/medium/low vulnerability classifications. If staffing and/or funding limitations at CIG restrict work on this task, a vulnerability assessment could be done for individual WRIAs by planning units and/or watershed planning consultants.

1.3 Concluding Assessment on Watershed Planning as a Vehicle to Adaptation

As a final component to the research, an assessment of the extent to which the Watershed Planning Program may serve as a vehicle for adapting to the hydrologic impacts of climate variability and climate change at the watershed level was made. Based on information related in the survey of Watershed Planning Leads, the answer to this question is a qualified yes. The affirmation of the program is based on the optimism Leads have that the Watershed Planning Program will lead to better management of water resources at the watershed level, the number of watersheds that are discussing and integrating climate impacts, the potential for implementing an adaptive management approach in the watershed plans, and the legislative support to date for watershed planning at the state level. Funding for implementation of the watershed plans, continuation of the watershed planning units in some formal capacity, and the willingness of the State Legislature and state agencies to adjust policies that limit flexibility at the watershed level are critical to the success of watershed planning as a vehicle for adapting to climate impacts.

2.0 Purpose

The purpose of this study is to determine the extent to which Washington State's Watershed Planning Program may serve as a vehicle for adapting to the hydrologic impacts of climate variability and climate change at the watershed level. The study also provides a preliminary assessment of natural, socioeconomic, regulatory, and other factors that may leave a watershed more or less vulnerable to climate impacts and/or inhibit adapting to climate impacts at the watershed level. The analysis is focused on watersheds participating in Washington State's Watershed Planning Program.

Specific questions the analysis attempts to answer include the following:

- To what extent is information on climate variability and climate change being discussed and incorporated into planning at the watershed planning level?
- How much flexibility is there at the watershed level to adapt to climate impacts?
- What are the barriers to adapting to climate impacts at the watershed level?
- What type of resources (information or otherwise) would be most helpful in discussing and incorporating climate issues at the watershed level?
- To what extent is hydrologic modeling being used in watershed planning?
- Is the Watershed Planning Program a good vehicle for adapting to climate impacts?
- What factors affect vulnerability to climate impacts at the watershed level (and how)?
- At a preliminary level, what methodology should be used to evaluate impacts?

It is hoped that the analyses presented herein will benefit watershed planning units, Department of Ecology Planning Leads, members of the general public, and other federal, state, and local public agency staff involved with watershed planning in Washington State and elsewhere.

3.0 The Watershed Planning Program: Background

Washington State's Watershed Planning Program represents one of the state's most significant commitments to date to locally-based water resource management planning. The program, established in 1998, continues a national trend dating back to the 1960s in the devolution of water resource planning authority from a centralized state level to a more decentralized local level (Leach and Pelkey 2001, Kenney 1999). The Pacific Northwest currently has the highest concentration of watershed initiatives among western states (Kenney 1999).

3.1 Early Watershed Planning

An important precursor to the Watershed Planning Program is the Nisqually River Management Plan, which was initiated in 1985 by the State legislature with the passage of Substitute House Bill 323 (SHB 323). SHB 323 required that Ecology develop "an overall management plan" for long-term stewardship of the Nisqually River (Canning and Hashim 1987). The final plan adopted for the Basin in 1987 covered water quality, water quantity, flood control, and fish management, in addition to other issues.

The Nisqually Plan is considered pioneering in its successful break from a more traditional linear planning process to that of an iterative "circular" planning process (Hashim 1998). Prior to the Nisqually effort, planning processes took a very linear form: an agency identified goals, objectives, problem statements, and actions to solve the problems. The process often involved little input from stakeholders and did little to improve coordination with other planning efforts (ibid).

The approach taken in the Nisqually plan recognized the interactive nature of watershed management decisions, keeping representatives from federal and state agencies, local governments, agriculture, forestry, the Nisqually Indian Tribe, and environmentalists centrally involved in the planning process for regular dialogue on planning issues. A 24 member Steering Committee developed recommendations for the plan based on input from a larger Technical Advisory Committee. Ecology staff was charged with preparing the final plan. This is in marked contrast to the Watershed Planning Program, where Ecology staff (i.e., Watershed

Planning Leads, see Section 3.5) participate in an advisory capacity only and responsibility for plan writing rests with the planning units, not Ecology staff.

Additional groundwork for watershed planning was laid in the early 1990s with settlement of the Chelan Agreement. The Chelan Agreement was negotiated in 1991 by the executive branch, legislative branches, and tribal organizations to address instream flows and water allocation. The Agreement, among other tasks, established consensus-based pilot watershed planning programs in the Dungeness-Quilcene and Methow watersheds (WRIAs 17/18 and WRIA 48, respectively). Lessons learned from these efforts were instrumental in developing the legislation establishing the Watershed Planning Program (Rushton 2000).

3.2 Watershed Planning Program Legislation

Efforts to establish the Watershed Planning Program in its present form began in January 1997 with proposal of House Bill 1133, which set out to authorize and fund the development of locally-based watershed plans. As noted in the proposed legislation, problems with the state's "seriously threatened" watersheds were creating great economic and environmental uncertainty[1]. Successful development of locally-based watershed plans was necessary to reduce the uncertainty posed by problems, and to reduce the potential for federal or judicial intervention likely to result from noncompliance with state law and federal treaties and laws. Despite the promise of House Bill 1133, the legislation did not pass the State legislature[2].

Legislation was again proposed in 1998. Engrossed Substitute House Bill 2514 (ESHB 2514), also known as the Watershed Management Act, provided the legal authority and funding for developing comprehensive voluntary watershed-level water resource management plans. Watershed planning would, according to the state legislature, provide for: "adequate water quantity for the future, adequate water quality to protect and promote beneficial uses, and

[1] http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=10&X=606142434&p=1
[2] According to the House Bill Report for ESHB 2514, "interest groups expressed concerns about the [original] bill, and it was placed on hold." These concerns, which were not identified in the House Bill Report, were addressed in ESHB 2514 (http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=9&X=606142434&p=1)

sufficient protection and enhancement of habitat so that water-related wildlife and fish resources thrive to be used and enjoyed by citizens of the state"[3]. This would be accomplished by:

- Protecting existing water rights;
- Improving the ability of local governments and citizens to be involved in the design and implementation of solutions to water quantity, water quality, and habitat needs for water-related wildlife and fish species;
- Providing a flexible mechanism for conducting locally initiated watershed planning;
- Providing for thorough review and inclusion, as appropriate, of work done by existing planning groups and agencies related to the scope of activities to be addressed by the planning unit;
- Retaining prerogatives of state and local governments who are directly accountable to local citizens to identify problems and formulate acceptable solutions to state and local issues;
- Allowing local people to determine the scope of the watershed planning process while encouraging them to consider comprehensive watershed planning that includes addressing water quantity, water quality, and habitat for water-related wildlife and fish species in concert with one another; and
- Encouraging collaboration and cooperation between the wide range of interests "…to ensure that management of the state's economic destiny and environmental heritage remains in the hands of Washington's citizens as much as possible." [4]

As with the 1997 legislation, effective water resource management and locally based watershed planning were tied to the state's long-term economic and environmental interests. As noted in the revised code for ESHB 2514:

> "…local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests…The development of such plans serves the state's vital interests by ensuring that the state's water resources

---

[3] Section 2, http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=16&X=606145122&p=1
[4] ibid

are used wisely, by protecting existing water rights, by protecting instream flows for fish, and by providing for the economic well-being of the state's citizenry and communities." (RCW 90.82.010)

The voluntary nature of the Watershed Planning Program was a major selling point in supporting the legislation. In testimony before the House Agriculture and Ecology Committee, speakers noted appreciation for the ability to choose if and when to initiate watershed planning, and to control city and county obligations under it[5]. The program's acknowledgement of other planning efforts that may be on-going (such as Salmon Recovery planning), the provision of funding and technical support, and "not allowing a state review for approval at the end of the process" were also favorably noted [6].

Governor Gary Locke signed ESHB 2514 into law on April 1, 1998 with few modifications[7]. In approving the law, Governor Locke commended the legislature on its leadership towards resolving "the long-standing stalemate over instream flow level in Washington"[8] and other water resource conflicts related to water quality and habitat. The Governor was clear to note, however, that "if progress is not being made…[he would be] prepared to utilize existing authority to protect [Washington's] water and fish habitat"[9], indicating that the State is ready to decide these conflicts if watershed planning is not moving towards resolution of the region's water resource conflicts.

---

[5] http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=9&X=606142434&p=1
[6] ibid
[7] Governor Locke selectively vetoed Sections 10-14 when approving the law. Section 10 would have prohibited Ecology from establishing a moratorium on water right processing while planning is underway. In some instances, the Governor noted, Ecology "may need to impose a moratorium on water rights processing in order to preserve options for future water allocations by the watershed planning unit". Sections 11 through 14 would have required that plans developed under ESHB 2514 preempt water-related planning processes established under other statutes. Governor Locke vetoed these sections under the belief that the language "would remove any flexibility of the state to use other authorities to correct any deficiencies that emerge from plans adopted under the process provided in this bill. Quoted from Governor Locke's veto message to the State Legislature, Washington State Archives (http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=13&X=606151420&p=1)
[8] No instream flows have been set by rule as of this writing (July 2002) since flows were set for the Nooksack on December 4, 1985 (Rushton 2000). Quote excerpted from Governor Locke's veto message to the State Legislature (http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=13&X=606151420&p=1)
[9] ibid

3.3 Water Resource Inventory Areas (WRIAs)

Planning areas for the Watershed Planning Program are based on geographic sub-units known as Watershed Resource Inventory Areas, or WRIAs (pronounced "Y-rahs"). WRIAs were developed by Ecology under the Water Resources Act of 1971 (Ch. 90.54 RCW) for the purposes of making decisions on water allocation and use. WRIAs may include a single river basin, artificially-designed segments of a basin, or an assemblage of smaller individual streams and rivers within a geographic area that never join together. Forty-two (42) of the 62 delineated WRIAs in Washington State are currently participating in the Watershed Planning Program (Figure 1). The 42nd watershed, WRIA 35 (the Middle Snake), will begin watershed planning under ESHB 2514 in summer 2002.

3.4 Watershed Planning Units

Watershed planning is conducted at the WRIA level by watershed planning units. The watershed planning unit functions as the primary decision-making body for watershed planning, defining the scope of work, managing the planning process, developing plan options, and approving final plan recommendations. Only one planning unit is established for WRIA planning efforts regardless of whether the effort is for a single WRIA (e.g., WRIA 1) or multiple WRIAs working together (e.g., WRIAs 3/4, WRIAs 55/57).

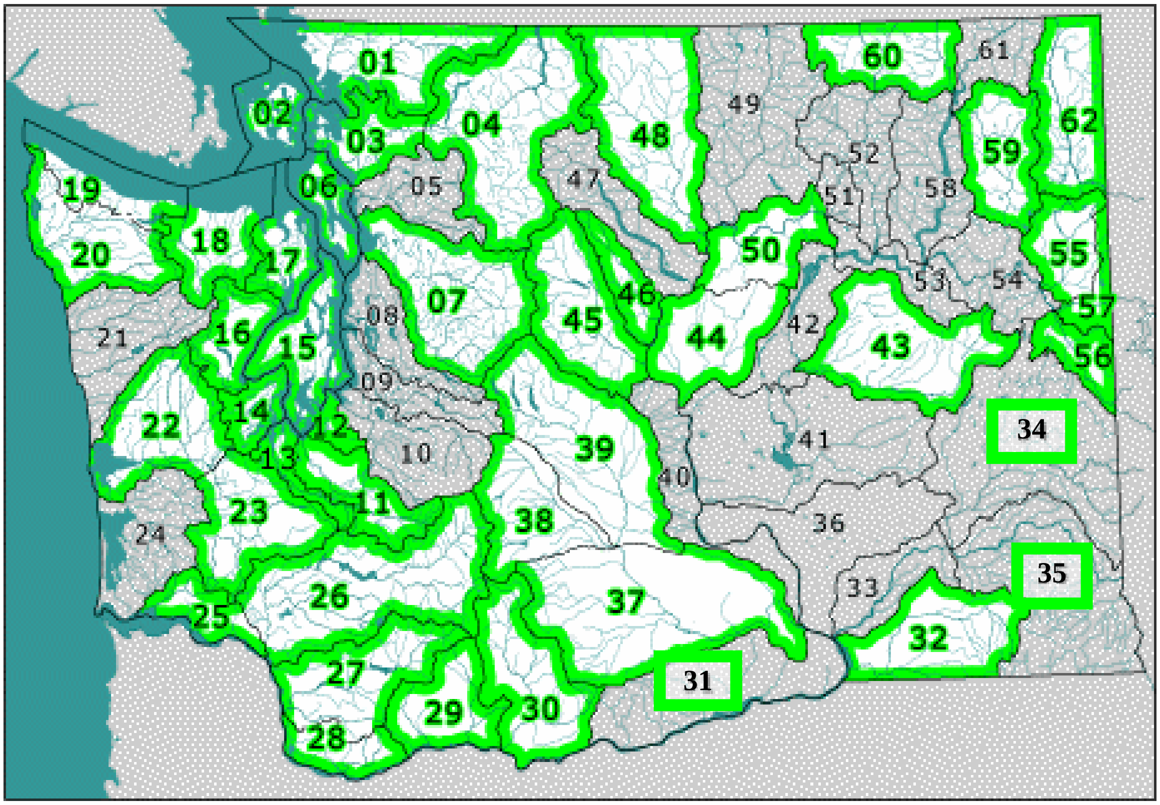
Planning units must be widely representative of local governments and water resource interests. The composition of the planning unit is determined by local governments for each WRIA, who are authorized to initiate the planning process under ESHB 2514. Initiating governments include all counties within the WRIA(s), the largest city or town in a WRIA (or in each WRIA where there is more than one), and the utility obtaining the largest quantity of water from a WRIA (or in each WRIA where there is more than one). Tribes with reservation land in the WRIA must be invited to join the initiating process but are not required to participate.

Recommended members of the planning unit may include, but are not limited to:

- other cities and local governments in the WRIA(s),

Figure 1 - Water Resource Inventory Areas (WRIAs)

WRIAs in white are participating in the Watershed Planning Program



Source: http://www.ecy.wa.gov/watershed/index.html

WRIA 1 - Nooksack
WRIA 2 - San Juan
WRIA 3/4 - Lower/Upper Skagit-Samish
WRI 6 - Island
(**WRIA 7** - Snohomish) **
WRIA 11 - Nisqually
WRIA 12 - Chambers-Clover
WRIA 13 - Deschutes
WRIA 14 - Kennedy-Goldsborough
WRIA 15 - Kitsap
WRIA 16 - Skokomish-Dosewallips
WRIA 17 - Quilcene-Snow
WRIA 18 - Elwha-Dungeness
WRIA 19/20 - Lyre-Hoh/Soleduck-Hoh
WRIA 22/23 - Lower/Upper Chehalis
WRIA 25/26 - Grays-Elochoman/Cowlitz
WRIA 27/28 - Lewis/ Salmon-Washougal
WRIA 29 - Wind-White Salmon
WRIA 30 - Klickitat
WRIA 31 - Rock-Glade
WRIA 32 - Walla Walla
WRIA 34 - Palouse
WRIA 35 - Middle Snake
WRIA 37/38/39 - Lower/Upper Yakima/Naches
WRIA 43 - Upper Crab/Wilson
WRIA 44/50 - Moses Coulee/Foster
WRIA 45 - Wenatchee
WRIA 46 - Entiat
WRIA 48 - Methow
WRIA 55/57 - Little/Middle Spokane
WRIA 56 - Hangman
WRIA 59 - Colville
WRIA 60 - Kettle
WRIA 62 - Pend Oreille

*** The Snohomish Basin (WRIA 7) had submitted an application for ESHB 2514 funding when this map was generated but, is not participating in the Watershed Planning Program at this time*

- state and federal agencies,
- special districts (e.g., sewer districts, conservation districts, flood control districts),
- tribes,
- citizens appointed to represent the public at large,
- private landowner representatives,
- business representatives,
- recreation interests,
- farming interests, and
- environmental organizations.

State and federal agencies may take part in the planning process through active participation on a planning unit and/or through the provision of technical assistance to planning units on an as-needed basis. Each planning unit is assigned a Watershed Planning Lead (Section 3.5) to provide guidance and to speak for participating state agencies. Issues related to terms of participation in the planning unit, committee structure, roles, ground rules, defining consensus, and cost-sharing obligations are also determined by individual planning units (Ecology 1999).

3.5 Watershed Planning Leads

The Department of Ecology provides administrative and technical support to watershed planning units in the form of Watershed Planning Leads (Leads). The Leads, who are full-time employees with Ecology, serve as liaisons between state agencies and the planning units and will actively participate on a planning unit at the request of the planning unit. Leads also serve as grant managers, signing off on state funded work products. There are currently 15 Leads assigned to the 42 WRIAs participating in the Watershed Planning Program. The Leads have a diverse range of backgrounds, including hazardous waste management, planning, and water resource management. Previous experience with collaborative planning groups and leadership ability were major factors in filling Leads positions (Geoff Tallent, personal communication, 6/10/02). The Leads operate out of any one of four regional offices or headquarters in Washington State.

3.6 Requirements of the Program and State Assistance

The Watershed Management Act requires that participating planning units collaboratively develop a watershed plan for their watershed(s). The plan must, at a minimum, address short-term and long-term concerns related to water quantity in order to qualify for state funding. This includes assessing current water supplies in the WRIA(s) and developing strategies for meeting current and future instream and out-of-stream needs. Communities are also encouraged, but not required, to address:

- Instream Flow (optional) – Planning units may recommend modifications to existing instream flows already set by rule, or recommend minimum instream flow levels for waters that do not currently have set instream flows. Thirty-two (32) of 37 WRIAs with established planning units are currently working on instream flows[10] (Table 1).

- Water Quality (optional) – Includes identifying to what extent existing standards are being met, causes of water quality problems, and monitoring recommendations. Planning units cannot set water quality standards but the information collected for this component may be beneficial to Ecology's efforts to establish discharge permits and Total Maximum Daily Load requirements. Thirty-three (33) of 37 WRIAs with established planning units are currently working on water quality (Table 1).

- Habitat (optional) – Involves developing watershed plans providing for the protection and enhancement of fish habitat in the management area. This includes coordination with other habitat restoration programs occurring state-wide and/or at the watershed level. . Thirty-three (33) of 37 WRIAs with established planning units are currently working on habitat (Table 1).

As indicated by the language included in ESHB 2514, collaboration is the cornerstone to the watershed planning process. Watershed planning units must be widely representative of local

[10] Five WRIAs (31, 34, 35, 43, 60) are in the start-up phase and have not determined which, if any, optional components they will address. WRIA 6, which is established, is considering addressing Habitat and Quality.

governments and water resource interests, including utilities, citizen groups, and agriculture. Tribes with reservation land in the WRIA must be invited to join the initiating process but are not required to participate. State and federal agencies may also take part in the planning process through active participation on a planning unit and/or through the provision of technical assistance to WRIA planning units on an as-needed basis. Each WRIA planning unit is assigned a Watershed Planning Lead at the DOE to provide guidance to the planning units and to speak for participating state agencies.

Table 1 - WRIA Participation in Optional Watershed Planning Program Components

Instream Flows		Habitat		Quality	
1	29	1	27/28	1	27/28
3/4	30	2	30	2	30
11	32	11	32	11	32
13	37/38/39	12	37/38/39	12	37/38/39
15	44/50	13	44/50	13	44/50
16	45	14	45	14	45
17	46	15	46	15	46
18	55/57	16	48	16	48
19/20	56	17	55/57	17	55/57
22/23	59	18	56	18	56
25/26	62	19/20	59	19/20	59
27/28		22/23	62	22/23	62
		25/26		25/26	

Source: Interviews with Watershed Planning Leads and Washington Department of Ecology, Office of Financial Management (2001)

Participating WRIAs are eligible for up to $500,000 in state grants per planning unit to fund planning activities. Funding is administered in three phases:

- Phase I: Organizing the Planning Unit ($50,000 for single WRIA planning units, $75,000 for multi-WRIA planning units).
- Phase II: Conducting a Technical Assessment for the Watershed ($200,000 for each WRIA in the management area). Phase II includes three recommended steps: compilation and review of existing data (Level 1); short-term collection of new data to fill critical data gaps (Level 2); and long-term monitoring, data collection, and data management (Level 3).

- Phase III: Watershed Plan Development ($250,000 for each WRIA in the management area).

Funding for Phase IV, Implementation, has not been decided at this time (see Section 3.7).

Multiple WRIA management areas, such as upstream/downstream WRIAs, are encouraged to participate jointly through preferential funding. Several planning units are taking a combined approach. Examples include the Lower/Upper Skagit-Samish (WRIAs 3/4), the Lewis/Salmon Washougal (WRIAs 27/28), the Little/Middle Spokane (WRIAs 55/57), and the Yakima planning units (WRIAs 37/38/39). An additional $300,000 per WRIA was made available through Engrossed Senate House Bill 1832, passed in 2001, for additional Phase II studies on setting instream flows, water quality, and/or assessing multi-purpose water storage opportunities or projects. Each activity is eligible for $100,000 in additional funding under ESHB 1832. Preferential funding is given, however, to WRIAs choosing to set or amend existing instream flows.

According to Ecology's Office of Financial Management (OFM) (Ecology 2001b), three WRIAs were in Phase 1, 26 WRIAs were in Phase II, and 13 WRIAs were in Phase III of watershed planning as of November 2001. Some overlap in stages is included in these totals. Leads participating in the survey conducted for this study (Section 5) were asked to provide more detail on the status of their WRIA planning efforts after noting discrepancies between what OFM was reporting and what Leads were reporting. Eight of 11 surveyed Leads (8 of 15 total Leads) representing 22 WRIAs responded to the request. According to these responses, most WRIAs are in the data collection phase for Level 1 or Level 2 Technical Assessments (15 of 22 WRIAs) and/or are considering the scope for Phase III watershed plans (18 of 22 WRIAs) (Table 2). These results are considered fairly representative of the overall program status.

Table 2 - Current Status of WRIA Planning (Partial Review)*

** The status information in this table is based on responses from 8 of 11 Planning Leads interviewed for the study's survey. The table is not a complete listing of WRIAs participating in Watershed Planning. The distribution is considered representative of the Watershed Planning Program effort, however.*
Source: Interviews with Watershed Planning Leads and Washington

Phase 1 - Organizing		Phase 2 - Technical Assessment Reports				Phase 3 - Watershed Plans		
Start-up	*Work Plan*	*Data collection for Level 1*	*Data Collection for Level 2 (optional)*	*Writing Report*	*Finalizing Report*	*Considering Scope*	*Writing*	*Finalizing*
31		6	25/26	12	2	2	3/4	
34		12	27/28	19/20	17	3/4		
35		14		32	32	6		
		15			48	12		
		16			44/50	15		
		22/23				17		
		19/20				19/20		
		29				22/23		
		32				25/26		
						27/28		
						44/50		
						48		

3.7 Plan Approval and Implementation Concerns

Planning units have four years from initial funding for Phase II activities to complete the watershed plan. Plans must be approved by planning units by consensus of all members of the planning unit. What defines consensus is to be determined by each planning unit, but in general Ecology considers consensus to mean that planning unit members either agree or "can live with and support" a decision (Ecology 1999). If approval of the entire program cannot be obtained, planning units may elect to:

- Approve individual components of the watershed plan, with commitment to continue discussion on the sections where consensus could not be reached; or
- Terminate the planning process.

Once approval is obtained from the planning unit, watershed plans must be submitted to and approved in a special joint session by each of the counties in the WRIA(s). County governments may recommend changes to the plan but cannot amend the plan themselves in the hearing process. Any changes made to the plan on the basis of comments from local governments must be reapproved using the standards listed above. If the county governments again fail to approve the proposed plan, Ecology program guidance dictates that the planning process terminates. Approval of the plan obligates the counties and state agencies to implement the plan as required.

Approval procedures for instream flows are more rigorous. Recommended changes to existing instream flow levels must be agreed to unanimously by local governments and tribes on the planning unit. Recommendations to establish new minimum instream flow levels where they previously did not exist must be approved unanimously by local governments and tribes on the planning unit, and have majority approval of non-governmental parties present at the time of vote. The flow recommendations can then be forwarded to Ecology for adoption into state law.

While there appears to be no direct repercussions for failing to adopt the watershed plan, a potential repercussion communicated by some Watershed Planning Leads during a survey conducted for this study (Section 5) is the likelihood that Ecology will proceed to set instream flows in WRIAs where planning units have failed to set flows. According to Ecology's Guide to Watershed Planning and Management (Ecology 1999), Ecology has authority under the Watershed Planning Act to unilaterally adopt rules setting minimum instream flows on streams where approval is not obtained through the watershed planning process. This commitment is consistent with written statements from Governor Gary Locke to the State Legislature when approving ESHB 2514 (see Section 3.2).

Although procedures for adopting the plans are clearly laid out in program guidance, there is still considerable uncertainty over how implementation will proceed. A primary concern is funding. At this time, there is no dedicated state funding for implementation. Possible sources of funding include utility rate changes, user fees, permit fees, special district taxes, state and federal grant programs, and grants from private foundations (Ecology 1999). Ecology established an Implementation Committee in late 2001 to begin looking at the implementation issue in more detail. A preliminary scope of work for the Committee includes surveying watershed planning units and lead agencies to determine implementation needs and reviewing long-term funding options at the local, state, and federal level for implementation of watershed plans. A report to the State Legislature is expected to be ready by late 2002 for consideration in the 2003 legislative session (Ecology 2001a).

Many Leads interviewed for this study believe the state legislature will provide funding for implementation. Leads view funding as a critical component to capacity building for development and maintenance of the watershed plans. Without state funding, capacity building is less likely to occur given that few local governments have the ability to fund implementation on their own. The question is how much funding and for how long, particularly in light of the state's current budget crisis and aggressive cuts in spending. Relying on local governments to fully fund implementation "would be a mistake" according to one western Washington Lead.

The state must also, in the opinion of another Lead, assure that funding is provided at the WRIA-level only and not made available to sub-parts of the WRIA (i.e., counties). Open funding to all levels would leave poorer counties at a disadvantage against wealthier counties within the same WRIA who may be more aggressive in pursuing specific components of the plan. Doing so could jeopardize efforts made to develop collaborative watershed plans.

4.0 Climate Variability and Climate Change in Washington

Extensive research over the last five years by the Climate Impacts Group (CIG) at the University of Washington and other climate research institutions has furthered the region's understanding of the effects of natural climate variability and human-induced climate change on the Pacific Northwest. While the effects cross-cut many natural systems, including coastal and forest environments, the most significant change in terms of socioeconomic impact is the effect on water resources. The following provides a brief overview of known and projected impacts associated with climate variability and climate change. For more detail on climate impacts on the Pacific Northwest, please refer to the Impacts of Climate Variability and Change: Pacific Northwest (Mote et al. 1999)[11].

4.1 Climate Variability and Climate Change in the Pacific Northwest

Climate in the Pacific Northwest is dominated by variations in the El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) cycles. El Niño, the warm phase of ENSO, is the warming of ocean temperatures for three or more seasons in the equatorial belt of the Pacific Ocean. La Niña, the cool phase of ENSO, is a cooling of the same equatorial waters for three or more seasons. Although concentrated in the tropics, ENSO-related changes in ocean and air temperatures, winds, and precipitation patterns can affect climate conditions around the world (Zebiak 1999).

Less well known but possibly more influential on Pacific Northwest climate is the PDO[12]. Unlike ENSO events, which typically last 6 to 18 months, the PDO produces variations in ocean temperature in the North Pacific in 20 to 30 year cycles. A warm phase PDO brings warmer coastal ocean water to the Pacific Northwest while a cool phase PDO brings cooler ocean water. These changes have been linked to boom/bust cycles in certain marine and anadromous fish populations, including salmon, as well as variations in precipitation in the Pacific Northwest.

---

[11] This and other publications on climate and the Pacific Northwest are available on the Climate Impact Group's web site at http://jisao.washington.edu/PNWimpacts/.

[12] Section 1.3.1, http://jisao.washington.edu/PNWimpacts/CDTheme.htm#Sec3

Little is known at this time about the causes or the predictive ability of the PDO. Evidence suggests a possible shift from a warm phase to a cool phase PDO sometime during 1998.

Global warming is also likely to play a significant role in shaping Pacific Northwest climate. While climate variability is strongly influenced by natural ENSO and PDO cycles, global warming (and resulting climate change) is driven by increases in atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases[13]. Since the beginning of the 20th century, global average surface temperatures have increased by 0.7-1.5° Fahrenheit (0.4 - 0.8° Celsius). Although seemingly small, this change is likely to have been the largest of any century in the last 1,000 years (IPCC 2001). Average temperatures in the Pacific Northwest have shown a slightly stronger increase over the past century (+1.5°F, or 0.8° C) (Mote et al. 2001). Climate models projecting future climate change for the Pacific Northwest suggest an increase in the annual average temperature of 3.1°F for the region by the 2020s and 5.3°F by the 2050s (Mote et al. 1999)[14].

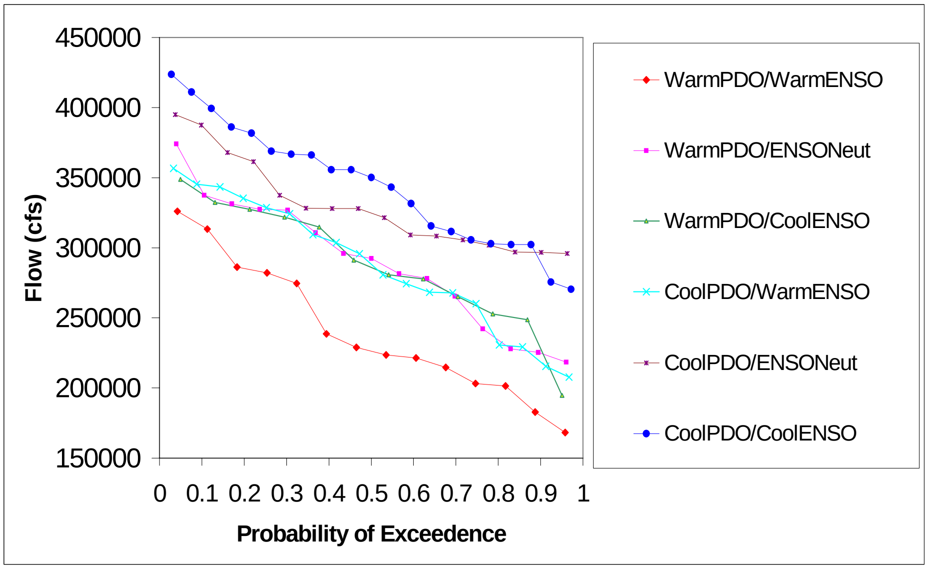
4.2 The Effects of Climate Variability and Climate Change on Water Resources

Natural climate variability and human-induced climate change can significantly affect precipitation patterns in the Pacific Northwest. Examination of past climate records indicate that El Niño events and warm PDO phases increase the potential for below normal precipitation and above normal temperatures, although not necessarily at the same time. Conversely, La Niña events and cool phase PDOs increase the potential for above normal precipitation and cooler temperatures. When the warm/cool variations of these cycles occur together (El Niño in a warm phase PDO/La Niña in a cool phase PDO), the probabilities for precipitation and streamflow extremes are increased even higher (Figure 2).

[13] Atmospheric concentrations of CO_2 have increased 31% since 1750, a rate of increase unprecedented in at least 20,000 years (IPCC 2001).

[14] The current average annual temperature for the PNW is 47 F. The projected temperature changes cited are based on a continued 1% per year increase in CO_2 emissions. Changes in economic growth, energy use, and public policies regarding climate change and CO_2 emissions can effect temperature projections (CIG). Nonetheless, researchers are "very confident that future temperatures will be significantly higher [in the 21st century] than the 20th century" (Miles et al. 2001).

Figure 2 - Naturalized Summer Streamflows at the Dalles



Source: Hamlet et al. (in review)

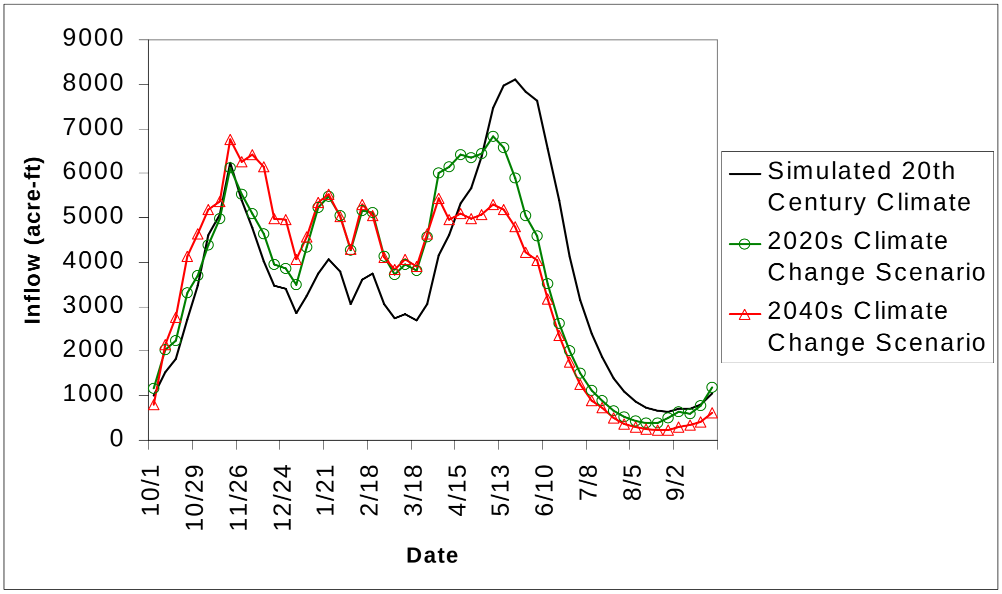
Climate change will exacerbate certain aspects of natural climate variability. Although climate models project a 5% increase in average annual rainfall by the 2020s, the availability of water – especially during drier summer months - may actually decrease (Mote et al. 1999). Increasing temperatures will lead to more precipitation falling as rain rather than snow, reducing total snowpack and subsequent spring and summer stream flows. Warming temperatures will also shift the timing of flows, moving peak flows up by two weeks to one month (Figure 3). Timing shifts of this magnitude can affect the availability of water for all users but could be particularly detrimental to migrating juvenile salmon, which depend on cool and ample flows in the late spring for migration. Increased flooding is also expected as more winter precipitation falls as rain. Although the Columbia River system is highly developed with more than 250 dams, most Columbia River dams are run-of-the river dams capable of storing water only for a few days at a time. Increased runoff rates from rain can quickly overwhelm the system and result in flooding, particularly in unmanaged rivers to the west of the Cascades.

The degree to which climate variability and climate change affect water resources depends on the elevation of the basin and type of precipitation contributing to flows in the watershed (Figure 4). Higher elevation snowmelt-dominated basins, located mostly east of the Cascade Mountain Range, are significantly affected by decreases in snow pack and earlier peak flows. Under normal conditions, winter precipitation falls primarily as snow in the mountains with runoff of accumulated snows in late spring and early summer (May/June). These late flows are critical to meeting water demands through the drier summer months – 75% of precipitation in Washington falls during the October-March "rainy season". Reduced snow pack and earlier peak flows from climate variability and climate change limit the ability to meet summertime water demands in snowmelt-dominant basins. The Yakima River Basin (WRIAs 37/38/39) is an example of a snowmelt-dominated basin.

Transient or snow/rain dominated (intermediate elevation) basins such as the Snohomish River Basin are similarly affected by changes in the timing of flows. Transient basins have two seasonal runoff peaks under normal conditions. The first peak occurs in mid-winter with the peak in winter rainfall (November-January). The second seasonal runoff peak occurs with the late spring/early summer snowmelt. As with snowmelt-dominated basins, late season flows are critical to meeting summertime water demands. Therefore, changes in the type and timing of seasonal flows will affect the ability to meet water demands during the driest time of the year. Transient basins are primarily located west of the Cascades.

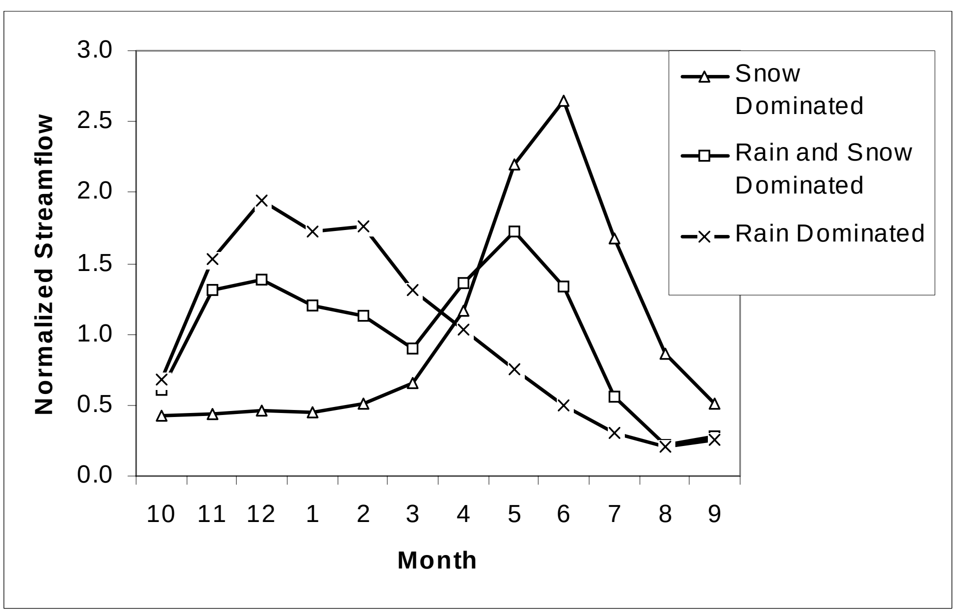
The third basin type, lower elevation rain-dominated basins, is located mostly west of the Cascades. An example of a rain-dominated basin is the Kitsap Basin (WRIA 15). Temperatures in rain-dominated basins tend to stay above freezing so most precipitation falls as rain. Peak flows in rain-dominated basins occur in winter. Increases in winter rainfall as a result of climate variability and climate change will increase the likelihood for flooding in these basins. The ability to meet summer water demands may also be affected, but not as significantly as snowmelt and snow/rain-dominant basins.

Figure 3 - Simulated average seasonal streamflow into Chester Morse reservoir from the Cedar River for 20th century climate and future climate scenarios



(Source: Hahn et al., 2001, excerpted from Hamlet 2001)

Figure 4- Seasonal distribution of streamflow for Snowmelt Dominant, Transient Snow, and Rain Dominant river basins in the PNW



(Source: Hamlet 2001 (excerpted from Hahn et al., 2001))

5.0 Survey Analysis

Research for this study followed two distinct but related tracks. The first track involved conducting interviews with Ecology Watershed Planning Leads to examine the place of climate variability and climate change in watershed planning and to obtain additional insight on vulnerabilities specific to individual watersheds. The second track, presented in Section 6, involved identifying potential watershed-level indicators for vulnerability to climate-induced hydrologic changes. A summary of the survey approach and results is presented in the following sections.

5.1 Purpose

A qualitative survey of Watershed Planning Leads (Leads) was conducted over three weeks in May 2002 to learn more about watershed vulnerabilities to climate impacts, and how and if climate variability and climate change were being included in the scope of ESHB 2514-funded watershed planning. Specific objectives of the survey included:

- Gauging how much is known about climate variability and climate change among Leads,
- Identifying if and how climate variability and climate change are being included in the scope of watershed planning,
- Identifying challenges to planning for climate impacts at the watershed level,
- Identifying additional resources that may be helpful in facilitating consideration of climate impacts at the watershed level,
- Identifying vulnerabilities specific to the watershed level, and
- Assessing if, in the opinion of the Leads, watershed planning will improve water resource management at the watershed level.

The use of hydrologic models as an aid to watershed planning, and the willingness of planning units to consider building climate scenario testing into models, was also explored through the survey.

5.2 Methodology

A qualitative survey was chosen given the varied nature of individual watershed planning efforts. General survey topics included:

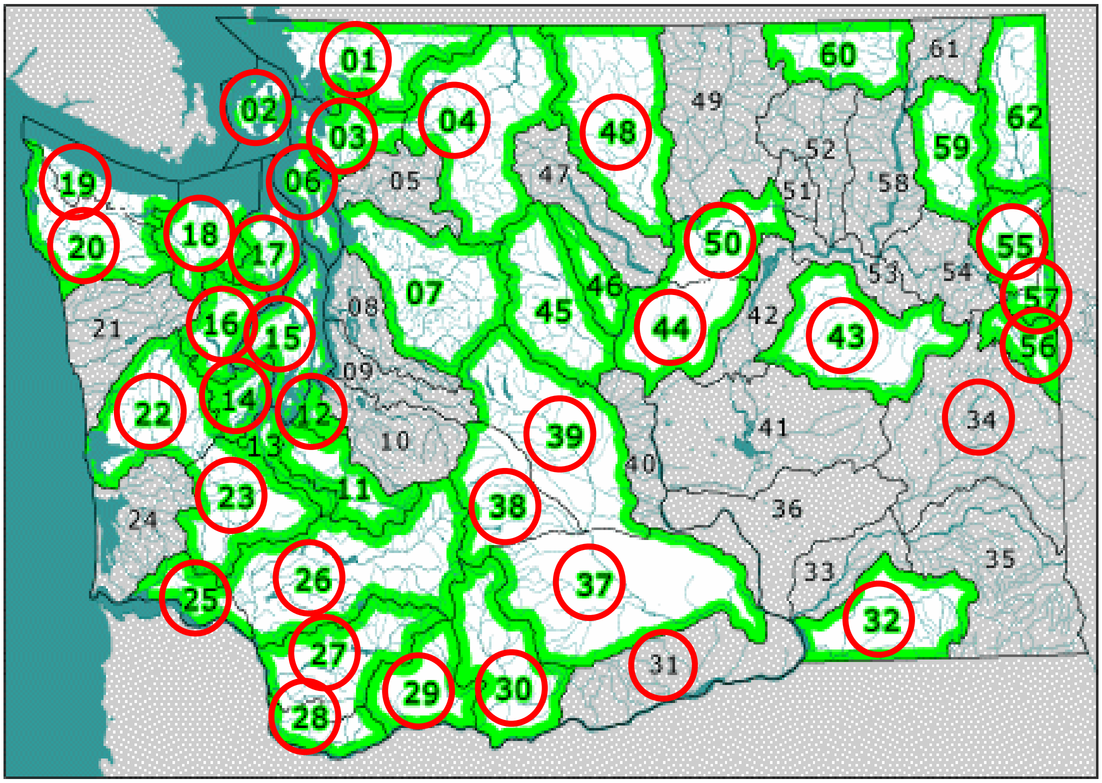
- General climate, watershed planning questions
- Adapting to climate impacts
- Incorporating climate concerns into the watershed planning program process
- Hydrologic modeling as aids in watershed planning

A copy of the survey is included in Appendix 1. All but one of the questions (#13) were open-ended. This was done intentionally so as not to bound the responses within any pre-determined set of choices. However, as a consequence of the format, responses varied widely. This can also be attributed to the individual natures of the WRIAs.

All Leads were contacted about the survey via e-mail. Phone interviews were scheduled at a day and time convenient to the Lead. Phone interviews were chosen over submission of written responses based on: 1) the author's preference to have direct contact with the Leads (facilitating relationship building and enabling follow-up questions), and 2) prior conversations with Leads noting a general "survey fatigue" as a result of other research and state reporting efforts. Removing any requirement that a response form be completed was expected to increase likelihood that Leads would participate in the survey.

Eleven of 15 Leads (33 of 42 WRIAs) participated in the survey (Figure 5). Prior contact with the Leads at various meetings, including presentations on climate impacts at a monthly Lead staff meeting in September 2001 and two state-wide Peer-to-Peer meetings for watershed planning in October/November 2001, is likely to have contributed to the good response rate. No effort was made to follow-up with the four Leads who did not respond to the initial e-mail due to time constraints.

Figure 5- WRIAs Covered in the Watershed Planning Lead Survey
(noted by red circles)



Map Source: http://www.ecy.wa.gov/watershed/index.html

Interviews generally took thirty minutes to two hours depending on how many WRIAs the Lead had responsibility for and the level of detail provided in the responses. Survey questions were sent prior to the interview to allow time for review. Responses were manually entered into a computer during the interviews and later analyzed for content. No statistical or computer-based survey analysis programs were used for analyzing the responses. In almost all cases, responses are reported in general terms ("a Lead noted…", "four Leads reported…."). This was done for two reasons. First, the general references simplified results reporting. Secondly, it allowed Leads to speak more freely about their WRIA planning efforts. Specific examples are provided when applicable, however.

The survey was initially expected to play a more supportive role to the vulnerability indicators portion of the research project. However, the survey evolved into a more integral part of the analysis given the number of participants and quality of information obtained from the survey. A detailed review of the survey questions and results follows.

5.3 Analysis of Part 1: General Climate and Watershed Planning Questions

Part 1 of the survey included general questions related to climate impacts and the Watershed Planning Program.

5.3.1 *__Question #1__: Are you familiar with regional studies on the impacts of natural climate variability and climate change on the Pacific Northwest? If so, what impacts are you familiar with and where have you heard of these impacts?*

<u>Purpose of the Question:</u> Question 1 was asked to determine how familiar watershed planning leads are with climate variability, climate change, and related impacts.

<u>Results:</u> Information about climate impacts is being picked up at a very general level but it seems only recently (in the last year or so). Most Leads (7 of 11) described themselves as being somewhat familiar with climate impacts. Four Leads felt that they were not that familiar with the impacts but had a sense of what the impacts were. Identified impacts included changes in winter precipitation and snowpack, increased potential for flooding, shifts in runoff patterns, and lower summer baseflows.

Sources of information on climate and climate impacts vary but presentations and coverage in general circulation newspapers or other print media appear to provide the most exposure. For many Leads (6 of 11), CIG presentations at a monthly staff meeting (September 2001) and annual Peer-to-Peer meetings (October/November 2001) provided their first real exposure to the issue. A CIG presentation by Philip Mote at a Tri-County Water Resources Agency meeting in Yakima was also mentioned as being influential (date not specified).

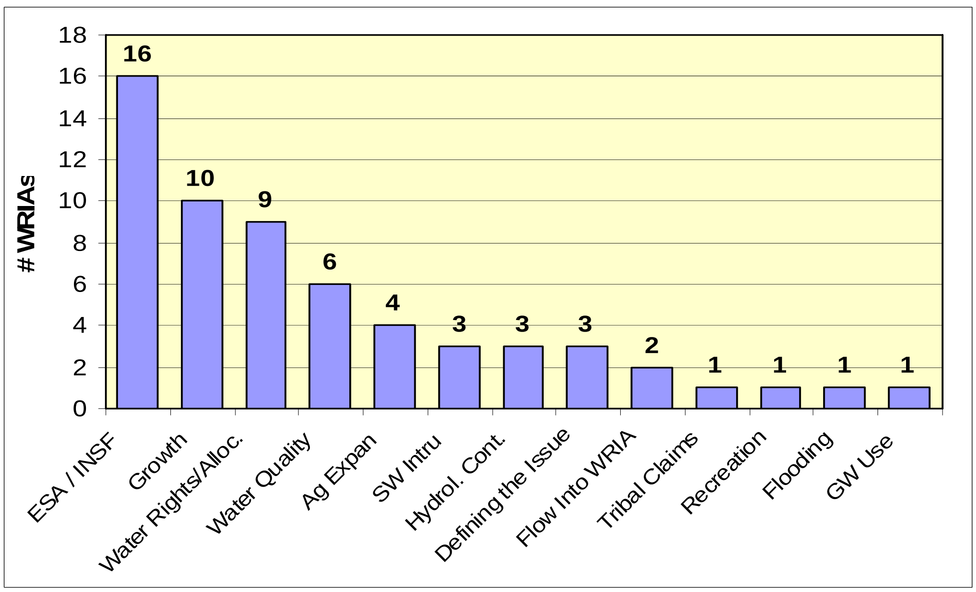
5.3.2 *__Question #2__: What is(are) the most significant water resource management challenge(s) your WRIAs face in their current watershed planning effort(s)?*

<u>Purpose of the Question:</u> Question #2 is asked for the purpose of having a better understanding of the issues driving participation in the Watershed Planning Program. Identifying these issues for individual watersheds helps define what the perceived vulnerabilities are at the watershed

level. Identifying these issues will also assist outreach efforts by specifying where additional information on climate impacts and adaptation is needed.

Results: Planning Leads identified many different challenges. As seen in Figure 6, major water resource management challenges include ESA and related instream flow requirements for salmonids (16 WRIAs), meeting future growth (10 WRIAs), water rights (9 WRIAs), and water quality (6 WRIAs).

Figure 6 – Question #2: Major Planning Challenges for Watershed Planning



Other challenges include meeting water demands for expanding agriculture (4 WRIAs), salt water intrusion (3 WRIAs), questions over hydrologic continuity between surface water and groundwater systems (3 WRIAs), concerns over flows originating outside the WRIA (2 WRIAs), tribal claims on water resources (1 WRIA), flooding (1 WRIA), recreation (1 WRIA), and groundwater use (1 WRIA). Simply defining the major challenge is, in itself, the major challenge of the planning effort for three WRIAs. Funding and lack of data appear to be universal challenges in all of the WRIA-based planning efforts even though not specifically identified in the response to this question.

In addition to the technical and policy challenges listed above, many Leads noted the difficulty in dealing with the human dimension in managing water resources. One challenge in particular is "genetic knowledge", or knowledge espoused by long-time residents in a consensus building process such as the Watershed Planning Program. As noted by the several Leads, long-time residents can at times be more resistant to incorporating new information (particularly if it challenges the status quo) and new management approaches. Comments similar to "It's always been like this so why should we expect it to change?" and "We've seen weather come and go, and the river go dry and come back" are common. Related to this is the challenge of politics and public attitude. Some of the decisions that must be made in the planning process require addressing potentially controversial issues such as water rights enforcement. Many planning units, however, are reluctant to try controlling illegal uses.

5.3.3 Question #3: Were there existing watershed-level stakeholder groups working on water or related issues in the WRIAs prior to the Watershed Planning Program effort? If yes, what type of management/planning activities were they involved with?

Purpose of the Question: Previous efforts at watershed-based multi-stakeholder planning in a WRIA may increase the likelihood that the Watershed Planning Program approach will be effective in the WRIA. Previous efforts provide the opportunity to evaluate how past decisions have been approached and how consensus-based decision making works (or hasn't worked). Previous success is not a guarantee for future success, however. In some cases, previous efforts have failed to address the challenging questions (WRIA 1). In other cases, the tough issues were addressed but did not garner the political support necessary to implement the decisions (WRIA 48). In such cases, the lesson to future planning participants is to avoid the potentially controversial decisions.

Results: Most WRIAs (28 of 33 WRIAs) saw some form of watershed-level stakeholder planning before the Watershed Planning Program (Figure 7). These efforts ranged from limited, small scale studies to full-scale watershed-based planning efforts. Stakeholder planning most frequently addressed water quality concerns (14 WRIAs) and habitat/fish concerns (12 WRIAs) (Figure 8). Plans for water supply and water rights have been the focus of previous stakeholder

Figure 7 - Question #3: Previous Multi-Stakeholder Planning Efforts? (n=33)

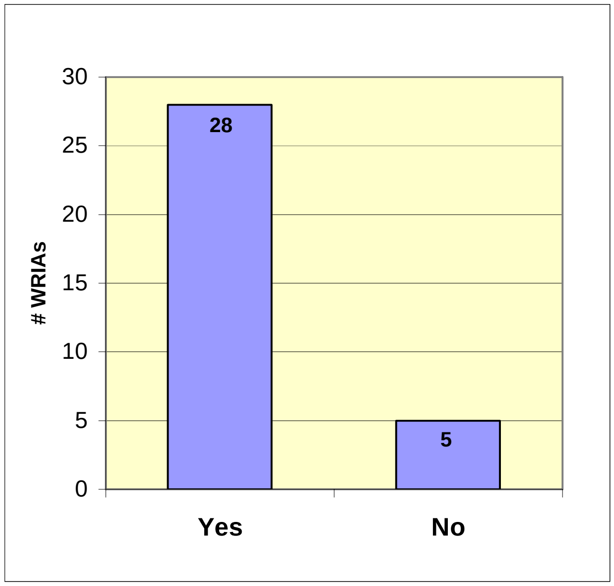
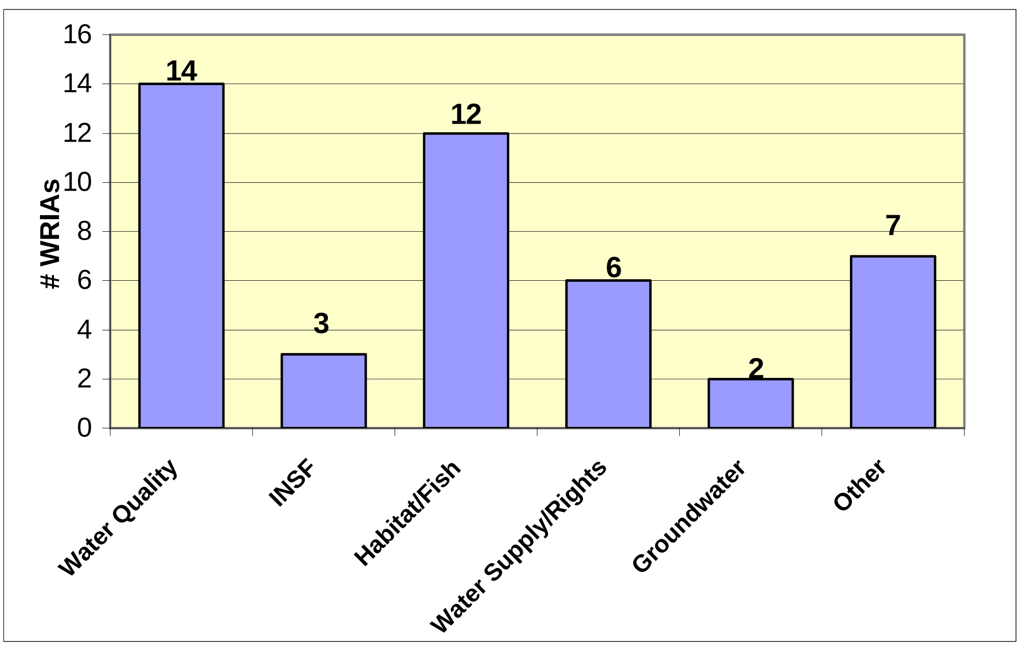


Figure 8 - Question #3 (cont.): Planning Issues for Previous Multi-Stakeholder Efforts



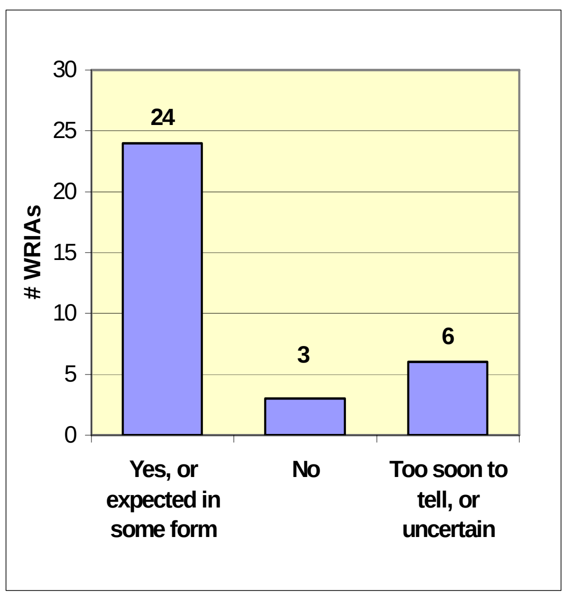
efforts in 6 WRIAs. Instream flow planning was identified for three WRIAs. Other watershed level stakeholder planning efforts include flood management (2 WRIAs), coordinated system use planning (2 WRIAs), groundwater use (2 WRIAs), and general issue identification (2 WRIAs). Five WRIAs were identified as not having any previous watershed level multi stakeholder planning efforts.

5.3.4 ***<u>Question #3(a)</u>: Do you expect the current planning unit to continue in some type of formal, more permanent capacity as a result of the Watershed Planning Program?***

<u>Purpose of the Question:</u> The continuation of planning units in some formal capacity is assumed to increase the probability that the watershed plan will be implemented and new issues addressed as they arise. Responses to Question 3(a) for individual WRIAs may help in assessing the overall vulnerability of WRIAs to climate impacts. Responses on the whole also factor into determining how effective the Watershed Planning Program may be in managing water resource challenges and serving as a vehicle for adapting to climate impacts.

<u>Results</u>: Planning units in 24 of 33 WRIAs are expected by their respective Leads to continue in some type of more formal or permanent capacity as a result of the Watershed Planning Program (Figure 9). It was too early in the development stage to tell or otherwise uncertain in six WRIAs. Only one Lead expected his planning units (2 units in 3 WRIAs) to stop after the watershed planning effort is completed.

Figure 9 - Question #3(a): Planning Unit to Continue? (n=33)



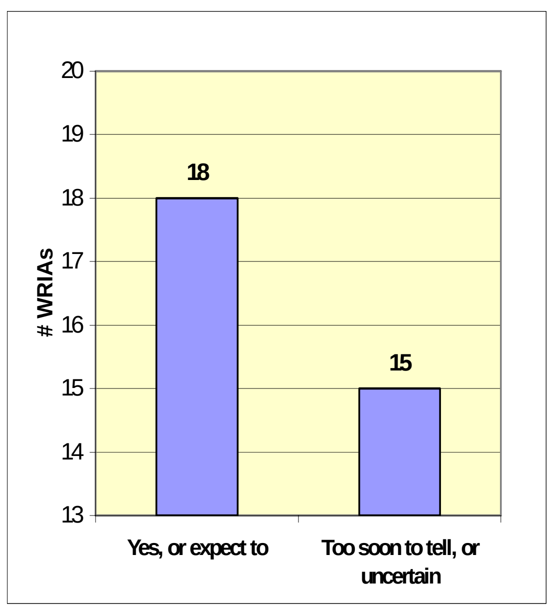
Primary challenges for continuing the planning units are the time commitment and future funding. The 4 year planning time frame under the Watershed Planning Program requires a long commitment for participating members and institutions, many of whom are voluntary. Once the plan is developed it may be difficult to keep current participants involved. Funding is also a factor. According to one Lead, a more permanent planning unit is more likely to continue if funds are made available by the State for implementation. If funding is not provided, the continuation of any permanent watershed planning group may in the end depend on the interest and financial willingness of local governments or stakeholders to continue in a much less formal capacity. Questions over political balance and the role of a continuing planning unit in implementing the watershed plan was also cited as a possible challenge in one WRIA to continuing the planning unit structure. Similar questions are likely to be raised in other WRIAs as planning units begin formulating the watershed plans.

5.3.5 Question #3(b): Are there any plans in your WRIAs to periodically revisit and update the watershed plans?

Purpose of the Question: It is assumed that planning units planning to revisit and update their watershed plans will keep the plan more relevant to concerns of the time and will be better able to incorporate new information. Frequent updating provides more opportunities for reassessing impacts from climate variability and climate change, as well as assessing other factors which may complicate adapting to these impacts.

Results: Leads expect slightly over half of the planning units (18 WRIAs) to periodically revisit and update their watershed plans (Figure 10). Few planning units have had specific discussions about the topic, however, nor have any planning units set specific time frames at this point. Leads reported that it was too soon too tell or uncertain in 15 WRIAs. No planning units are expected to not update their plans at this point.

Figure 10 - Question #3(b): Planning to Update Plans? (n=33)



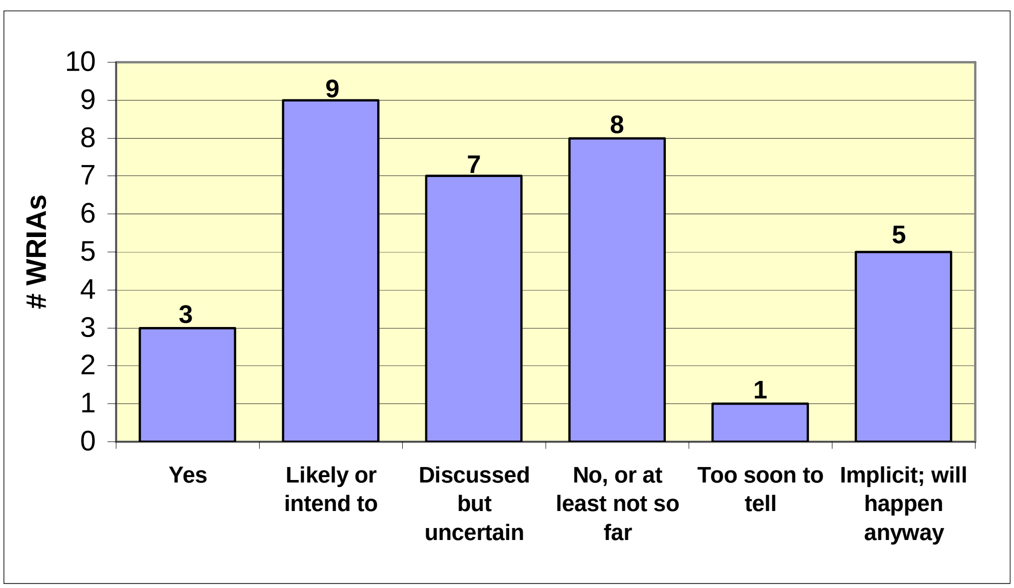
The likelihood that most WRIAs will build some type of reassessment requirement into their WRIAs stems in part, according to several Leads, from the recognition by many planning units that they will not have all the data needed to make specific recommendations on planning issues. More data collection and evaluation will be needed. Whether the funding necessary for further work is provided by the State or local governments in the WRIA is an issue that could greatly influence how soon and how often the plans are revisited.

5.3.6 <u>Question #4</u>: Is the concept of adaptive management being included in your WRIAs' watershed planning efforts? (yes/no) If so, how?

<u>Purpose of the Question</u>: Ecology's Guide to Watershed Planning and Management describes adaptive management as "the use of well designed monitoring programs to inform management actions and permit adjustments over time" (Ecology 1999). The approach is emphasized throughout the guidance, and considerable attention is paid to developing long-term monitoring and data management programs to support an adaptive management approach. The iterative nature of adaptive management may also facilitate adapting to climate impacts by creating a management framework based on regular data collection, analysis, and adjustment. Question 4 is asked to determine if and how adaptive management is being built into watershed planning.

<u>Results</u>: Answers to Question 4 varied widely (Figure 11). Only one Lead affirmatively

Figure 11- Question #4: Including Adaptive Management in Plans? (n=33)



answered that adaptive management was being included in at least one of their WRIA's watershed plans (WRIAs 37/38/39). Several Leads noted that their planning units either intend to include, or are likely to include, adaptive management in their watershed plans (9 WRIAs). In seven WRIAs, discussions on adaptive management have occurred but no resolution has been reached to date on whether the concept will be included in plans. Adaptive management is not expected to be part of watershed plans in eight WRIAs. Only one WRIA is considered to be too early in the process to know. Two Leads (5 WRIAs) felt that adaptive management was implicit to the planning process regardless of whether it is intentionally addressed since all the information needed to make specific recommendations in the plans won't be available.

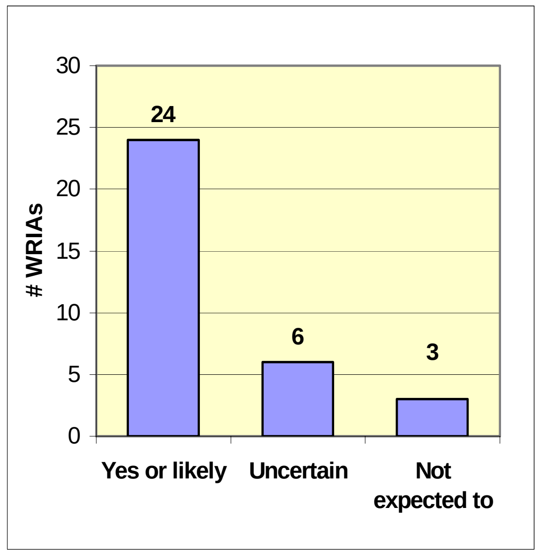
Several Leads questioned what the term "adaptive management" really means for watershed planning. While application of an adaptive management process to habitat restoration is clear, application to water supply management is not as evident due to the rigidities set by the Prior Appropriation Doctrine and other planning challenges, such as instream flow requirements and water quality standards. WRIA 1 has discussed in general how an adaptive management approach might be built into conditioning water rights but administrative and legal barriers will likely prevent formal inclusion of the idea in the watershed plan. No other specific examples showing how adaptive management is being built into watershed plans are available at this time.

5.3.7 Question #5: In your opinion, will watershed planning efforts such as this lead to better management of water resources within the watersheds? (yes/no) *How integrated do you expect the plans to be in future management of water resources in the WRIAs? Will the watershed plans being developed help water managers better manage supply shortages and other water management crises?*

Purpose of the Question: The ability of the Watershed Planning Program to serve as a potential avenue for adapting to climate impacts will largely depend on whether the Watershed Planning Program has the potential to lead to real improvements in managing water resources at the watershed level. Question 5 is asked to gauge Lead opinions to date on the potential success of the Watershed Planning Program.

Results: Ecology Leads appear optimistic that the watershed planning process will lead to better management of water resources at the watershed level. Leads expect watershed planning to improve water resource management in 24 of 33 WRIAs (Figure 12). Leads for six WRIAs felt it was too soon to tell. Watershed planning is not expected to improve management in three WRIAs.

Figure 12 - Question #5: Will the Watershed Planning Program Lead to Better Management? (n=33)



It is important to note that many Leads feel that the watershed planning process itself, and not just development of a watershed plan, is likely to produce benefits. The planning process has inherent value in bringing key players together to discuss different viewpoints, develop a shared understanding of what the water resource challenges are, and to collect up-to-date information on water resource issues in the WRIA. In the opinion of one Lead, the short-term focus on the watershed plan was not as important as the long-term foundation being developed. Real results, the Lead noted, will be seen as far as 20 years from now when the region really starts seeing water shortages.

Other acknowledged benefits of the planning process include:

- The effort to identify data gaps and information needs through the planning process will provide a road map for future work in the watershed;
- The effort will help locals better recognize how land use decisions have an impact on water use and water quality; and
- The effort will give locals a better appreciation of what Ecology does and how complex managing water issues is.

Despite the general optimism, there is some concern that planning units will not make the tough decisions needed to successfully address resource concerns. One Lead noted that while consensus is a great goal, it often results in people agreeing only on the less important issues. Another Lead with extensive experience in collaborative planning cautioned that the effectiveness of the plans will depend largely on: 1) state provision of financial or technical support for enforcing implementation (i.e., having someone "bird-dogging" implementation activities to make sure plans are truly implemented), and 2) the continuation of some kind of watershed council at the watershed level.

Regarding integration of watershed plans into future management: The extent to which planning units integrate watershed plans into active management of water resources will vary from one watershed to the next on the basis of how each plan is written and what it addresses. It is not possible to project how integrated the plans will be given how few watersheds have drafted their plans at this time. In general, however, many Leads feel that the plans will serve as an important guidance document for future watershed planning. Ecology will also be required to reference the plans once they have been adopted and implemented.

Regarding use of the plans in managing crises: Opinions about the ability of watershed plans to serve as an effective tool for managing drought or other water crises varied but were generally optimistic. Leads for 14 of 33 WRIAs felt the watershed plans would likely lead to better drought or crisis management; one Lead suggested that this would occur within his watersheds by clearly defining the thresholds (such as legally established instream flows) at which WRIAs are actually in a crisis. Three Leads (for 6 WRIAs) were uncertain about the plan's use in managing crises. Two Leads (for 8 WRIAs) did not comment on this part of the question.

Two Leads (for 5 WRIAs) did not expect drought/crises management to be improved by watershed plans. This expectation is based on the opinion that drought planning/crisis management is not the focus of the watershed planning effort and therefore will not likely be addressed. Another reason why plans may not improve drought/crises management is the defensive positioning that occurs during droughts. One Lead noted that during the 2001 drought there was very little cohesion associated with watershed planning and the drought. Stakeholder groups tended to retreat (or be pushed) away from cooperation back towards traditional roles of protecting interests. Agencies such as Ecology, for example, had to shift back into a regulatory "by-the-book" mode. A watershed plan will likely do little to prevent this, the Lead noted, when a water crisis such as drought unfolds. The concern that planning units will not address the tough decisions needed to manage water in drought was also cited as a limitation to any plan's ability to effectively assist in managing crises.

Note: Questions 6 and 7 were not analyzed. Responses to these questions varied significantly with each WRIA and are therefore more applicable to WRIA-specific vulnerability analysis. Additionally, few Leads could specify storage capacities in Question 7. Therefore, additional independent research is required to answer the question.

5.4 Analysis of Part 2: Adapting to Climate Impacts

Part 2 of the survey asked Leads to consider the impacts of climate variability and climate change on their WRIAs and responses to these impacts, particularly multi-year droughts.

5.4.1 Question #8(a): How much flexibility do you feel your WRIAs have to adapt to future changes in water supply availability?

Purpose of the Question: Responses to Question 8(a) provide a general overview of how well Leads see their WRIAs being able to weather climate-induced changes in water supplies. The responses will be used to gauge general watershed vulnerability to climate impacts. Information on specific WRIAs can also be used to supplement conclusions made through application of the vulnerability assessment indicators.

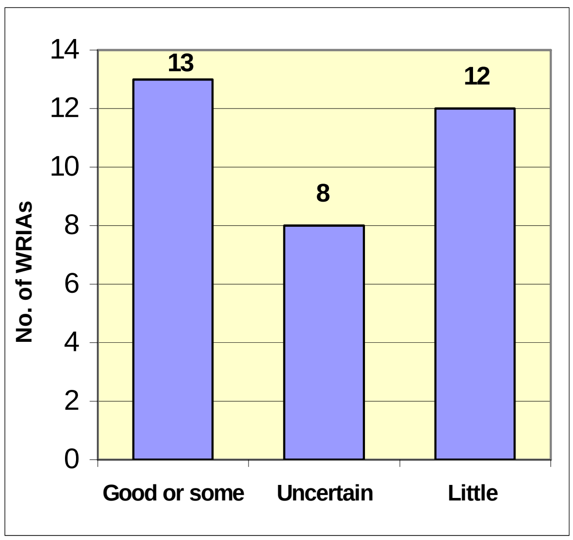
Results: There is a fairly uniform distribution between WRIAs considered to have good or some flexibility (13 WRIAs), limited flexibility (12 WRIAs), or uncertain flexibility (8 WRIAs) in adapting water supplies to climate-induced changes in supply (Figure 13). Leads see flexibility coming from any one or a combination of the following:

- an ability to increase groundwater use,
- availability of water rights (outright or through clarification of paper versus perfected rights),
- current or potential reservoir capacity,

- having an adequate volume of streamflow overall (although seasonality of flows may still be an issue),
- low population pressures, and
- good stakeholder cooperation

Several Leads feel that populous areas "will get water one way or another". One Clark County PUD official (WRIA 27/28) was noted as saying that there is plenty of water available but it will be expensive.

Figure 13 – Question #8(a): What Level of Adaptation Flexibility? (n=33)



Lack of flexibility is generally due to a lack of options. Leads associate a lack of flexibility with any one or a combination of the following:

- physical limitations of the supply (shallow groundwater table, low natural flows),
- dependence on one source (groundwater or surface water),
- physical isolation (islands),
- water quality (i.e., temperature, sea water intrusion)
- lack of available water rights, even for groundwater (i.e., closed basins),
- uncertainty over groundwater supplies,

- politics and water culture (particularly in agricultural areas where there are concerns over relinquishment of water rights from conservation),
- limited storage sites, and
- ESA and instream flow obligations.

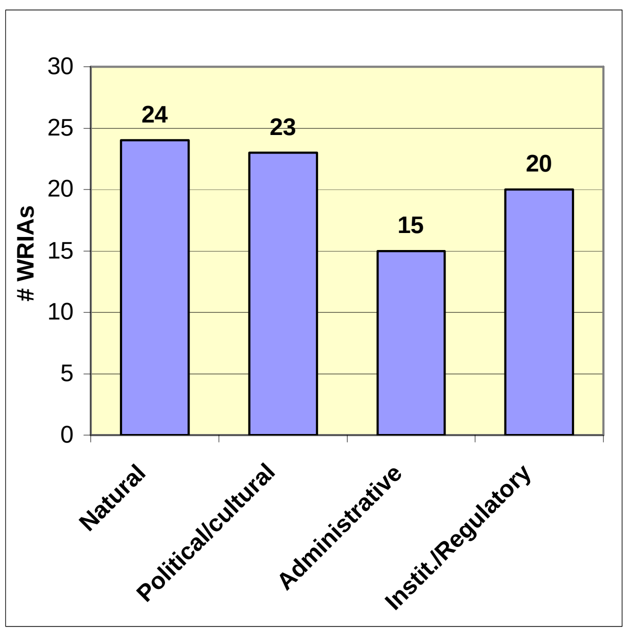
Sub-areas, particularly cities, were sometimes identified specifically as having more or less flexibility than the WRIA overall. Examples include Friday Harbor in WRIA 2, which has two surface water reservoirs, and Port Townsend in WRIA 17, which has an informal agreement with the local paper mill to cut production water delivery to the mill when reservoirs and stream flows drop below a certain point.

5.4.2 Question #8(b): In your opinion, where do the barriers to adapting exist?

Purpose of the Question: Question 8(b) is asked for the purpose of identifying the types of barriers that may inhibit adapting to climate impacts. Understanding what the barriers are and where they lie may be useful for providing technical assistance on adaptation to watershed planning units and Ecology Leads.

Results: As expected, Leads identified any combination of natural, political/cultural, administrative, and/or institutional/regulatory barriers to adapting to climate impacts (Figure 14).

Figure 14 - Question #8(b): General Barriers to Adaptation at the WRIA Level



- *Natural Barriers*: Natural challenges include losing glaciers to climate change, the seasonality of flows, limited surface water and groundwater resources, uncertain or declining groundwater levels, the arid climate of eastern Washington, and reliance on flows from outside the WRIA.

- *Political or Cultural Barriers*: Political or cultural barriers include a general reluctance to change the status quo and a reliance on genetic knowledge (see Question #2, Section 5.3.2). Several Leads noted the challenge in convincing people of the need to consider climate impacts. For some planning unit members, climate change will be a hard sell until they see it happening. Distrust towards government, particularly Ecology making decisions on instream flows and water rights, serves as a barrier to adapting. There is less tolerance for decisions and regulations that encroach on private property rights in eastern and western Washington. Finally, tribal interests in protecting or re-establishing treaty rights and salmon cultures and the economic interests of the irrigators were cited as barriers.

- *Administrative Barriers*: Administrative barriers most commonly related to water rights allocation and administration. Over-allocation is common in most basins, as is the inconsistency between paper rights records and actual water use. Administering water rights in pace with changes in irrigation technologies may be a barrier for Ecology and WRIAs with substantial irrigation use. This challenge was specifically noted as contributing to the politics of water rights administration in WRIA 31[15], but is likely to be an issue for most WRIAs where irrigated agriculture is a large water use. Large numbers of domestic well users and small water systems also provides an administrative challenge to adapting to climate impacts.

- *Institutional/Regulatory Barriers*: Water rights and ESA-related instream flow requirements were the primary institutional and regulatory barriers identified by Leads. The dedication of rights to hydropower and flood control (through the rule curve) was seen as a regulatory barrier to using stored water. Competing, or at least non-compatible, state laws and federal demands were considered a significant barrier to adaptation in WRIA 31. Technical

[15] This has been an issue in eastern Washington (WRIA 31) with what is now known as "the Shell Game." Initial rights for corporate farming were allocated in square sections. As farms converted to central pivot (circle) irrigation, the edges and corners of the original square sections were not irrigated. Technically, this meant that farmers were not beneficially using the rights for edges and corners. The Shell Game involved farmers effectively moving the land area for the corners and edges around to a new field, building infrastructure for irrigation, and transferring their own or other parties water rights to those areas for use in a new field. Ecology was required to step in and put a stop to the practice. This has added to the politics of water rights administration in WRIA 31.

documentation indicates that this is also a problem for the Spokane watershed planning effort (WRIAs 55/57).

5.4.3 Question #8(c): What kind of impact would a multi-year drought have in your WRIAs? What types of responses could be expected to manage a multi-year drought?

Purpose of the Question: In terms of natural, political, and socioeconomic impacts, Washington's watersheds appear to be more sensitive to drought than flooding. Question 8(c) is asked in order to learn more about particular sensitivities to multi-year droughts and how WRIAs might respond. This information has relevance to vulnerability assessments as well as potential applicability to future research on climate impacts and adaptation strategies given the potential for more single year and multi-year droughts in climate change scenarios for the Pacific Northwest.

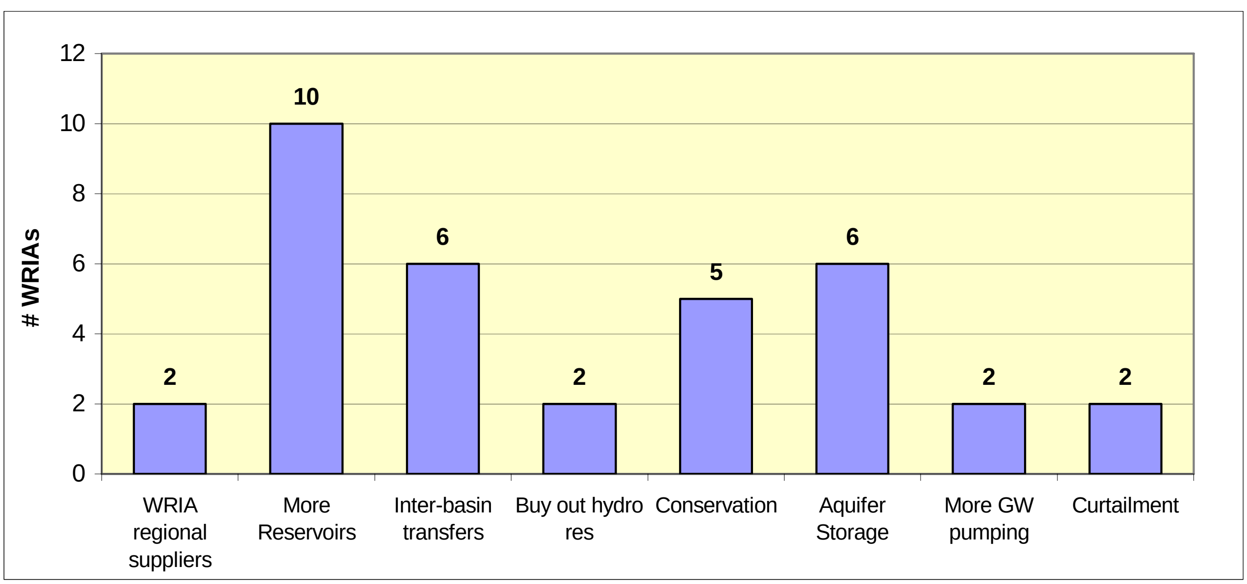
Results: Leads identified many impacts from multi-year droughts, all of which were predictable given the known history of the region with drought. Impacts included reductions in water supplies for municipal users, industrial users, irrigation, fish, and hydroelectric generation. Groundwater levels are expected to decline in some areas. An increase in chloride levels (associated with salt water intrusion) is also expected. One Lead noted that Washington State does not have the infrastructure for a long-term drought.

Potential responses to drought at the WRIA level vary (Figure 15). The most frequently cited potential drought response was construction of new reservoirs (10 WRIAs). Some planning units are currently investigating new reservoir construction under watershed planning (e.g., WRIAs 37/38/39). In other cases, previous studies have shown that more reservoirs are not cost-effective (e.g., WRIA 1). Several Leads felt, however, that consideration of climate impacts could change previous cost effectiveness decisions. Noted limitations to new dam construction include the lack of good sites, water rights basin closures, instream flow requirements, concerns over property rights acquisition for construction of new reservoirs, and political opposition from fish groups.

Other potential responses to multi-year droughts are inter-basin transfers and/or transfers between water uses (e.g., from agriculture to municipal users). Inter-basin transfers face many challenges however. First, most Leads noted that any multi-year drought affecting one WRIA would very likely affect surrounding WRIAs as well, making inter-basin transfers difficult. The politics involved with inter-basin transfer decisions also can be divisive. Finally, general questions about economic feasibility, legal feasibility, and infrastructure availability are important limitations to inter-basin transfers.

Transfers between water uses may face fewer challenges but still have significant political barriers. The Lead for the Yakima region noted that the agriculture industry is very concerned with transfers to population growth areas. Municipalities are seen as having deeper pockets if the state went to a water market-based system. Agriculture also perceives water transfers as a permanent loss. The City of Yakima, for example, is considering aquifer storage for meeting future water needs and instream flows. To do this, the city must find additional supply for storage. Farmers are very concerned the additional supply will come from water rights transfers. Once the water rights transfer is made, they believe, the water is pulled from agriculture in perpetuity. The same concern exists for transferring water from agriculture to instream flows; once the transfer is made, the water may be gone from agriculture forever.

Figure 15 – Question #8(c): Potential WRIA-Level Responses to Multi-Year Drought



Leasing water rights is more feasible but there are concerns in many parts of the state about putting water rights into a state-run trust system. Local agricultural interests want a locally based privatized trust. The Lead raising this issue noted that agricultural water rights holders do not want to put leased rights back into a stream; the rights holders want to be able "to pat the back" of the person the right has been leased to. An additional concern with leasing rights is the attention it draws to the fact that the water is not being used. There is concern that it will fall to the courts to decide which water rights are in the trust because the rights are not perfected (i.e., put to beneficial use) and therefore subject to relinquishment[16], versus those that are perfected but in the trust. The distinction is important given recent rulings from state courts that unperfected rights cannot be transferred,

More water system inter-ties and/or the development of new (or growth of existing) regional water suppliers were also cited as potential drought responses. Considerable political buy-in is required for this type of response, which may be a limitation. Desalination may be an option for coastal WRIAs. Desalination is currently being done on a small scale in WRIA 2 (40-60 hook-up systems using reverse osmosis). Deer Harbor (on Orcas Island, WRIA 2) is also moving towards desalination. Other potential responses to multi-year droughts include buying out hydropower flows from reservoirs, water conservation and curtailments, enforcement of senior rights (which, as noted by 2 Leads, are not necessarily the best uses of the water and politically unsavory to enforce), water re-use, aquifer storage, and denial (as a first response).

One Lead noted several interesting barriers related to Washington water law and limitations on crop flexibility to implementing more efficient irrigation technologies as a form of water conservation. If a farmer with rights to 2 acre-feet (af) of water chooses to switch to a low water crop such as grapes using a more efficient irrigation system delivering only the 1.2 af of water required to grow grapes, the farmer may loose his right to the surplus water (0.8 af) if the surplus

[16] Relinquishment occurs when any person with a water right abandons or voluntarily fails to beneficially use all or part of a water right without sufficient cause for a period of five successive years. In such cases, the rights holder relinquishes the total right or the unused portion of the right to the State of Washington. Municipal water rights are protected from relinquishment due to non-use due to the obligation of public agencies to provide water. Effort has been made to bring more flexibility into the relinquishment rules. Washington State Senate Bill 5910, which became effective May 11, 2001, expanded the definition of the "sufficient cause" exception to the relinquishment rule to include five new circumstances, including reduced irrigation needs due to weather conditions, crop rotation, and reduced water use due to electric buy-back obligations (Ecology 2001a).

is not put to beneficial use at any time for five or more consecutive years. Additionally, if the farmer is a junior water rights holder and his/her rights are prorated in a drought, the impact of the drought on that farmer may be more significant since the farmer is already using a minimum amount of water[17]. Finally, if the market for grapes collapses or there is a blight, the farmer cannot go back to higher water crops such as alfalfa because he/she has lost the water rights required to farm alfalfa. These concerns will have to be addressed if more water is to be made available from implementation of new irrigation technologies.

5.5 Analysis of Part 3: Incorporating Climate Concerns into the Watershed Planning Program Process

Part 3 of the survey specifically focused on issues related to recognizing climate impacts in the watershed planning process.

5.5.1 <u>Question #9</u>: Have climate variability and climate change been discussed by any of the planning units you work with?

<u>Purpose of the Question:</u> Question 9 is asked to determine if and how much climate variability and climate change are being considered by planning units.

<u>Results:</u> A majority of WRIAs (22 of 33) have discussed climate variability and climate change to varying degrees (Figure 16). Most discussions were described as being very general. Nine WRIAs have not discussed climate variability and/or climate change. Two WRIAs covered in the survey (WRIAs 31 and 34) are too early in the planning process to have discussed the issue.

Most Leads reported that response to the information on climate impacts was typically mixed. While most planning units recognize it as an issue, the degree to which planning units are willing to actively address climate impacts varies. In WRIA 1, for example, some planning unit

[17] In some cases, farmers expecting curtailment may be able to adjust irrigation practices before curtailment in order to improve soil moisture deeper in the soil column. If, however, the farmer has water rights limited to the volume of water that can be delivered by the newer irrigation technologies, the farmer may not have rights to enough water to adjust irrigation practices in anticipation of the curtailments. Consequently, the efficient farmer's crops may be damaged more quickly by the drought than neighboring senior rights holders.

members felt the issue only complicates the planning effort and suggested addressing climate impacts another time. Others in WRIA 1 are very interested, but overall no one has taken the initiative to really push for inclusion yet. In WRIA 12, a discussion about including climate change in the scope of work for the watershed plan generated similar responses – brief statements of skepticism from some members but strong support from others (climate change will be kept in the scope of work).

A few Leads reported having planning unit members that have taken a “convince me” stance; if the member(s) can be convinced that climate impacts are a real concern, they will be willing to address the issue. In other cases, general uncertainty about how to manage climate impacts is hindering further discussion.

Interestingly enough (but perhaps not surprising), information on climate impacts has been embraced by some planning unit members as a cause for lobbying for additional reservoir construction. In another planning unit, climate impacts are seen by some as a way to justify not meeting instream flow requirements. Therefore, while support for acknowledging climate impacts at the watershed level appears good, reasons for the support may in some cases be driven by other objectives.

Several Leads drew attention to an important link between trust and discussing climate impacts. According to Bob Duffy, Lead for planning efforts in WRIAs 12 and 19/20, group dynamics and trust play an important role in the willingness of a planning unit to address new concepts such as climate change and climate impacts. Units often have low levels of trust in the early stages as representatives of different vested interests sit down to discuss water management issues in the watershed. As participants get to know one another and build up trust, participants tend to become more accepting of a process that allows knowledge to be sought. There will always be some skeptics in any group, Duffy noted, but to the extent that the groups have a level of trust, they will be more willing to look at the issue now and/or in the future.

Only two planning units were identified as choosing not to address climate change because of a fundamental disbelief in the issue. This number was much lower than expected and is taken as a positive sign that more members of the general public (insofar as it is represented by the planning units) are moving past questioning if climate change is real. In WRIAs 22/23, climate change was brought up but will not be addressed in planning due to uncertainties over the science of climate change and the opinion of some Planning unit members who felt that climate change was "left wing scientist paranoia". (It is worth noting, however, that the impacts of climate variability on streamflows in WRIA 22/23 have been included in that planning unit's Level 1 Technical Assessment. See Section 5.5.3 for more detail.) Similar disbelief was noted for WRIA 48 where, according to the Lead, some planning unit members feel climate change is part of a greater governmental conspiracy to have more control.

Figure 16 - Question #9: Have WRIAs Discussed Climate Varaibility/Change? (n=33)

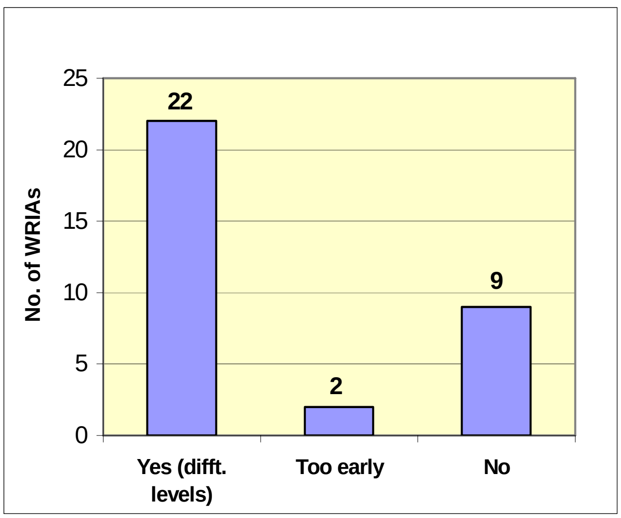
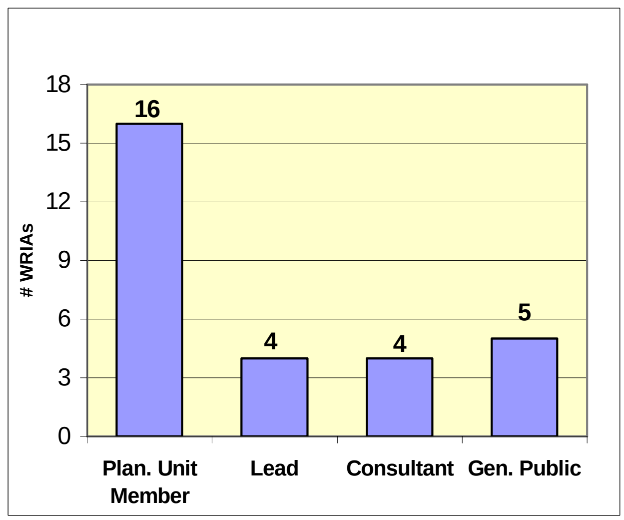


Figure 17 - Question #9(a): Who Raised the Climate Discussion(s)?



5.5.2 <u>Question #9(a)</u>: Who raised the topic for discussion (you, a planning unit member, a contractor, other?)?

<u>Purpose of the Question:</u> Question 9(a) is asked to determine where the impetus for discussion on climate impacts is coming from most frequently.

<u>Results</u>: The topic of climate variability and climate change was raised by planning unit members in 16 of 33 WRIAs, by the general public in five WRIAs (including the local media in WRIA 48), consultants in four WRIAs, and the watershed planning lead in four WRIAs (Figure 17). These totals include some duplication given that in some WRIAs (e.g., WRIA 1, 2, 3/4, 12,

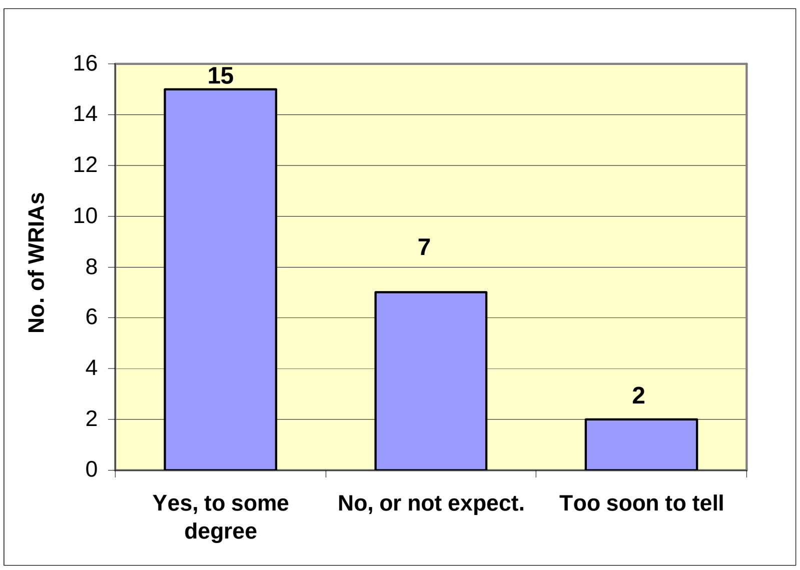
19/20), multiple parties raised the issue of climate impacts for discussion in some WRIAs (e.g., WRIA 1, 2, 3/4, 12, 19/20).

5.5.3 ***Question #9(b): Have the issues been included in the WRIA's Technical Assessment (or scope of work for the Technical Assessment)? Have they been included in the Watershed Plan (or scope of work for the Plan)?***

Purpose of the Question: To determine if and how planning units might be including climate variability and climate change in their Phase II Level 1 Technical Assessments and/or Phase III Watershed Plans (see Section 6.2 for more information on the Level 1 Technical Assessments).

Results: Fifteen (15) WRIAs are including climate variability and/or climate change in their Level 1 Technical Assessments to some degree (Figure 18). Planning units in 12 of the 15 WRIAs have discussed climate impacts in their planning meetings; the planning unit in two additional WRIAs (WRIAs 27/28) was reported as not having discussed climate impacts but is including PDO effects in the Technical Assessment despite the apparent lack of discussion.

Figure 18 - Question #9(b): Planning Units Integrating Climate Impacts into Technical Assessments? (n=23)



The WRIA 22/23 planning unit also has included climate variability (PDO and ENSO) in its Technical Assessment even though further discussion of climate impacts was reportedly dismissed by the planning unit (see Question 9). The discrepancy in the responses for WRIAs 22/23 and 27/28 (i.e., including climate variability and/or climate change in the Technical Assessments while not discussing the issues as a group) is likely the result of those respondents focusing on the climate change component of the question when responding to Questions 9 and 9(b), and/or possibly interpreting the question to mean that the planning units are taking formal action on the issues.

Seven of the 22 WRIAs identified in Question 9 as having discussed climate variability and/or climate change in planning meetings will not include, or at least do not expect to include, climate variability or climate change in their Level 1 Technical Assessment. In one case (WRIA 48), climate change was dismissed due to a fundamental objection to the notion of climate change by some planning unit members (see Question 9). In WRIAs 44/50, climate change is considered outside the current scope of the plan. The Lead noted that the planning unit has chosen to focus on approaches to extending water supplies (i.e., working on on-farm practices, slowing runoff to maximize groundwater recharge) and not on how the water is used. They have set "reasonable expectations" according to the Lead. It is too early to tell if climate issues will be addressed in the Technical Assessments for two WRIAs where climate variability and climate change have been discussed (WRIAs 30 and 43).

Climate Variability v. Climate Change: What Is Being Included? Responses were analyzed to determine if planning units were choosing to address climate variability over climate change (or vice versa), or if both issues were being addressed equally. To date, six WRIAs are addressing climate variability only; only WRIAs 55/57 have included climate change in the Level 1 Technical Assessment report (to date).

The extent to which planning units are addressing climate impacts varies from a few sentences noting the general effects of climate variability and climate change on water supplies to detailed reporting on scientific understanding of climate variability and climate change (WRIAs 37/38/39, 55/57). Several planning units have analyzed streamflow sensitivity to PDO cycles in their Technical Assessments (WRIA 2, 3/4, 22/23, 27/28, 55/57). Examples of this type of analysis are included in Appendix 2.

In some cases, climate variability and/or climate change has been addressed only generally in reports but included in model runs. In WRIA 1 for example, Utah State University will be running hydrologic models with a wider range of precipitation events, including lower low water years, and shifts in timing for evaluating management scenarios. These modifications are consistent with the types of changes expected with climate change.

In an unusual reversal of trends, the planning unit for WRIAs 55/57 intends to back-off some of the statements made about climate change by its consultant in the Level 1 Technical Assessment. According to the Lead, the planning unit will likely say that annual climate variations, decadal variations, global warming, and cumulative water use all affect water supply. The November 2001 draft of the Technical Assessment emphasized too much, in the opinion of the planning unit, the influence of climate variability and climate change on water supply. The revised statements from the planning unit will make climate variability and climate change equal to other concerns.

Included in Phase III Watershed Plans? Question 9(b) also asked Leads to identify if and how climate variability and climate change are being included in Phase III Watershed Plans. In all cases, Leads noted it is too soon to know for sure. As noted previously, most watersheds are presently determining what will be included in the scope of the Phase III watershed plans. It is worth noting that the WRIA 12 planning unit recently voted to include climate change on the list of issues to be addressed in their Phase III watershed plan (May 28, 2002 planning unit meeting).

Closing Comment on Question 9(b): Analyzing Question 9(b) consistently was somewhat challenging due to the tendency of some respondents to focus specifically on climate change in responding to the question. Therefore, climate variability was sometimes not addressed in the response. If the survey was given again, Question 9(b) would be separated into two questions, one asking about climate variability and the next about climate change.

Note on Question #9(c): Question 9(c) was repeated twice in the survey, once for those respondents answering "yes" to Question 9 and once for those answering "no". The question was repeated to test for differences in information needs based on whether climate variability and climate change were being discussed in WRIAs or not. No distinction was evident. Consequently, the results were merged into one response for analysis (see Question 9(f)).

5.5.4 ***<u>Question #9(d)</u>: Do you anticipate discussing climate trends and hydrologic impacts with your planning unit(s)? (Yes/No) If no, why not?*** *[Asked for those planning units that have <u>not</u> discussed climate variability and climate impacts…]*

<u>Purpose of the question</u>: This question was asked specifically to those Leads with WRIAs that have not discussed climate variability and/or climate change. The question is asked to determine how many other WRIAs may address climate variability or climate change in their planning efforts.

<u>Results</u>: As noted in the response to Question 9, seven planning units in nine WRIAs have not discussed climate variability or climate change. Therefore, Question 9(d) applied to only a small subset of Planning Leads (three Leads) with oversight over the nine WRIAs that have not addressed climate variability or climate change.

Leads for four of the nine WRIAs expect to discuss climate variability and climate change with those planning units. The Lead for the five remaining WRIAs does not expect to address the issue at this time given the difficulties the planning units are currently having balancing existing program requirements within the context of watershed planning. According to the Lead, it is a question of timing; it would be overload to address climate change now. There is also an element of disbelief in the concept of climate change. This does not totally preclude addressing the issue in the future, however. The Lead notes that climate impacts could be addressed further along but only in the sense of drought (i.e., plans for managing drought or worst-case conditions).

5.5.5 ***<u>Question #9(e)</u>: How do you think the information on hydrologic impacts (such as that presented at the Peer-to-Peer workshops) would be received within your planning unit(s)? How likely is it that the planning unit(s) would or could incorporate the information?*** *[Asked for those planning units that have <u>not</u> discussed climate variability and climate impacts…]*

<u>Purpose of the question</u>: Question 9(e) is asked to gauge the anticipated response to a climate impacts discussion. The possibility of addressing climate impacts, and therefore potentially

reducing vulnerability to impacts, in the planning process is assumed to be greater is the planning unit reaction is expected to be favorable.

Results: Question 9(e) applied to the same small subset of Leads as Question 9(d). Leads universally acknowledged the variety of interests in planning units and the likelihood that some members will want to take action while others will not (at least right away). One Lead noted that his planning units would need to be convinced of the need to address climate impacts at this time. There is already disagreement on current watershed conditions. Given that climate change is perceived as happening in the future and not affecting anyone immediately, the planning units likely will not see it as a pressing issue to address in the watershed plan.

Another Lead expected that some planning unit members will want to use climate impacts as a justification to secure additional water. Other members might see acknowledging climate variability and climate change as important explanations of why we have water shortages but beyond that the information would not be particularly helpful in planning. The third Lead was optimistic about how the information will be received. Whether climate variability and climate change are included in the plan will depend on whether membership is composed of "legitimate and real interests". According to the Lead, the watershed plans must look at the short-term and long-term; to that extent climate impacts is the kind of issue that needs to be addressed, it would be included.

5.5.6 *Question #9(f): What type of resources (information or otherwise) would be most helpful in discussing climate issues with your planning units? What resources would increase the likelihood of incorporating climate concerns into the watershed plans?*

Purpose of the question: Question 9(f) is asked to better understand what types of information are needed by Leads and planning units to more effectively integrate climate variability and climate change into the planning process.

Result: Leads provided a wide range of suggested resources that would be most helpful in addressing climate issues with their planning units. In general, Leads would like additional information on the range of scenarios and climate trends, multiple presentations addressing varying levels of complexity, and more technical assistance (particularly with modeling and planning). The need for "good science" was also mentioned several times. Specific suggestions include the following:

- *Regarding the need for more information on climate trends, scenarios, and impacts:*
  - More detailed projections of potential scenarios. One Lead suggested a generic model accessible via the web showing projected impacts on snowpack collected at 3,500 feet or other incremental elevations (to get an idea of what percentage of your snow would fall as rain as a result of climate change). Another Lead suggested giving planning units or consultants ranges for the likelihood of change (e.g., a 50% chance for 10% drop in streamflow and a shift in flows by 1 month).
  - Credible, technical reports from peer review journals, research groups, or other non-governmental sources. Two Leads specifically mentioned National Academy of Science studies. One Lead noted that climate information should not come from Ecology since it won't be considered credible.
  - Good data (mentioned in general terms).
  - Data or other documentation that is specific to eastern Washington would be good, particularly information that helps frame the issue.
  - An analysis showing changes in rainfall trends related to climate trends (something showing monthly rainfall changes over 100 years and its relation to natural cycles).
  - Information on how changes will affect groundwater recharge (over long-term changes).

- *Regarding presentations, outreach, and other forms of technical assistance:*
  - Information needs to be developed for different audiences. Good, technical information is needed for consultants and more technical members of the planning effort. At the same time, information that is non-technical, clear, and to the point is needed since planning is taking place at the grass-roots level. Once you have the attention of the planning units, web site and fact sheets are helpful.

- A series of presentations talking about climate change in a number of different levels of complexity is needed to make sure enough people are exposed to the issue. The information has to be explained over a series of presentations at different levels of detail and to different committees in the planning units (mentioned by 2 Leads). One Lead specifically mentioned the information provided in Phil Mote's (of the CIG) presentations as being very helpful. Dr. Mote's presentation on trends over the last 100 years, explaining how quality assurance has been built in, on-going monitoring, and forecast scenarios was very useful.
- The planning units need scientific expertise available to help with modeling and climate projections; need people who can work with the experts, providing them information in terms of modeling tools and predictive information (mentioned by 2 Leads). In the opinion of one Lead, the more specific, one-on-one consultation available to the planning units, the greater the likelihood that climate will be addressed.
- Planning tools identifying specific ways information can be integrated into a plan (sample policies, actions).
- Reports on other groups looking at long-term planning for climate would be helpful.
- One Lead suggested working with consultants involved in the planning process since that is who planning units are already used to hearing from.

5.5.7 <u>Question #10</u>: Do your WRIAs have a strong leader? (yes/no)

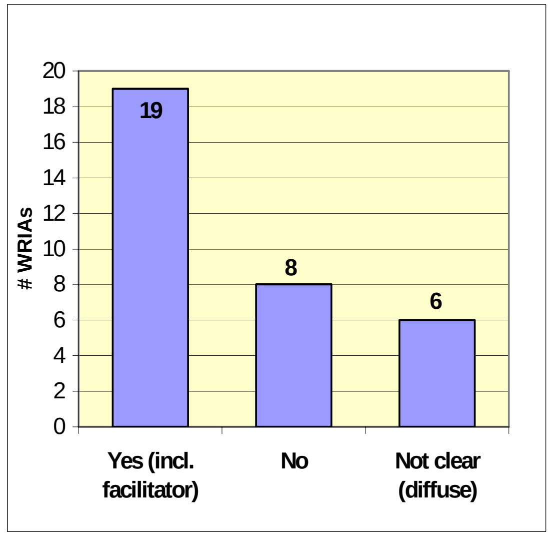
<u>Purpose of the question:</u> Question 10 is asked on the assumption that leadership is a factor in successful watershed planning. This assumption is supported by research conducted by Leach and Pelkey (2001) on factors affecting the success of watershed planning efforts, in which the authors identified use of a skilled facilitator as "one of the most important steps a partnership can take".

<u>Result</u>: Leads report 19 WRIAs having a strong leader or, as differentiated by Leads, a strong facilitator (Figure 19). Many Leads emphasized the value of a good facilitator over a strong leader for watershed planning given the consensus-based nature of the program and planning process. Eight WRIAs do not have a strong leader according to Leads. The presence of a strong

leader or facilitator was uncertain for six WRIAs. One Lead noted the presence of multiple strong personalities, which does not necessarily equate to strong leadership.

Several Leads offered observations on how leadership is affected in a planning process such as the Watershed Planning Program. One Lead noted that leadership is a function of the commitment of elected officials; are representatives in the planning process empowered to be good leaders? If a representative does not have good support from superiors (e.g., County Commissioners), the representative may be reluctant to take the lead in planning. In other cases, efforts by local governments to take on a leadership role has been perceived as trying to dictate the planning process.

Figure 19 - Question #10: Do WRIAs Have a Strong Leader? (n=33)



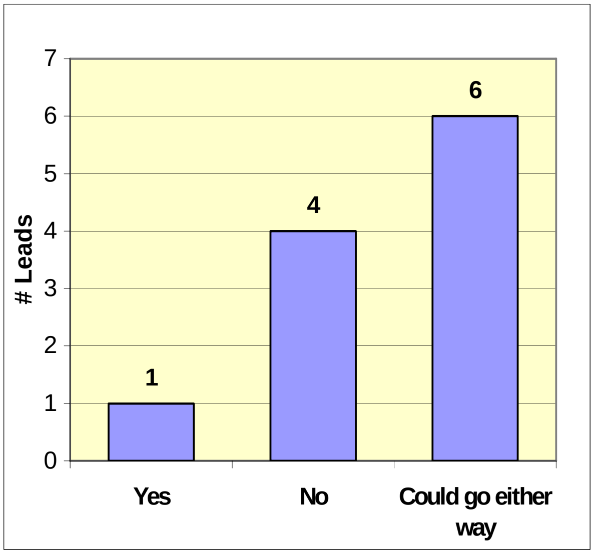
5.5.8 Question #10(a): Does having (or not having) a strong leader affect the likelihood that climate impacts could be included in the scope of the watershed planning effort? If climate variability and/or climate change impacts have been included, was strong leadership a factor?

Purpose of the Question: Question 10(a) is asked on the assumption that leadership may affect (or has affected) if and how climate variability or climate change are (or were) addressed by planning units.

Results: Most Leads (6 of 11) felt that strong leadership could help or hinder the likelihood that climate impacts are addressed in the planning process depending on the position the leader took on the issue (Figure 20). Four Leads thought strong leadership had no bearing on the likelihood of discussion. One Lead thought a strong leader would have an impact.

Leads with the opinion that strong leadership could go either way frequently noted that a strong leader could serve as a driver or a barrier to addressing climate impacts depending on whether the leader supported or opposed discussing the issue. One Lead saw strong leadership as a risk; without it, there is greater opportunity to win over each person individually and build a groundswell of support for an issue.

Figure 20 – Question #10(a): Does Strong Leadership Affect Discussing Climate Impacts? (n=11)



Leads that thought a strong leader did not matter emphasized the consensus-based nature of the Watershed Planning Program and the role of the group. In a true consensus-based process, one Lead noted, planning unit members will only transfer those functions and authorities to a leader that they want the leader to have. Therefore, the leader is not necessarily making decisions on their own. The leader's responsibility is to move the process along towards consensus. Therefore, you have to make the argument to the group that climate change is important, not to the leader.

This notion was reiterated by other "no" Leads. One Lead indicated that group dynamics really affect how issues such as climate impacts are addressed; if members feel comfortable raising new issues, there is a greater chance that those issues will be considered (particularly with a good facilitator. Another Lead commented having the discussion on climate impacts is really a matter of getting on the agenda and working with the planning unit as a whole. A third Lead noted that discussing climate impacts does not require a strong leader if supporting information is available, at the right level, makes sense, and can be recognized as an important issues. Finally, on a separate note, one Lead felt that strong leadership has more a bearing on short-term recommendations than recognizing long term issues and therefore would not increase the likelihood that climate impacts are discussed.

5.6 Analysis of Part 4: Hydrologic Modeling as Aids in Watershed Planning

Hydrologic modeling can provide watershed planning groups the opportunity to analyze the potential impact of planning decisions and other changes, including climate variability and climate change, on water resources before those changes occur. A model's ability to provide these projections will depend on the construction of the model and availability of quality data. Part 4 of the survey provides a general overview of the use of hydrologic modeling in watershed planning efforts.

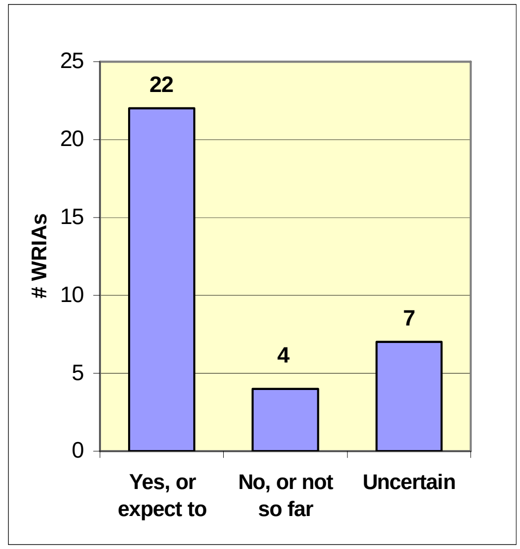
5.6.1 Question #11: Are any of your planning units using, or considering using, hydrologic modeling as an aid for developing watershed plans? (yes/no)

Purpose of the Question: Question 11 is asked to determine how many watersheds are or possibly will be using hydrologic models as part of the planning process.

Results: Twenty-two (22) WRIAs are using, or considering using, hydrologic modeling as part of their watershed planning effort (Figure 21). Planning units in seven WRIAs are uncertain. Four WRIAs are not planning on using hydrologic modeling at this time. Several Leads with WRIAs that are not modeling noted that the lack of modeling has more to do with resource constraints than a lack of desire.

The types of models being developed vary between watersheds. Most models include combined surface water/groundwater components for investigating hydrologic continuity. In some instances planning units have elected to split the surface and groundwater components. In other cases, planning units are looking at surface water or groundwater only. Consulting firms, universities (primarily Utah State University), and government agencies (primarily USGS) are working with planning units to do develop the models.

Figure 21 - Question #11: WRIAs Using Hydrologic Models? (n=33)



WRIA 1, the Nooksack, is developing a Decision Support System (DSS) with Utah State University to assist with decision making during development and implementation of the watershed plan. The DSS serves as a "technical filter", bringing quality controlled databases together from the other models to evaluate management options (Hardy and Stevens 2001). The DSS is expected to become an integral part of WRIA 1's watershed planning effort during and after plan development.

With the exception of WRIA 1, whose DSS approach was mentioned by multiple Leads throughout the State, no effort was made during the survey to identify specific software modeling packages or other technical aspects of the modeling approach. This information was considered beyond the scope of the question at this point. Many Leads mentioned not knowing the specifics off-hand as well.

Regardless of status or type of model used, Leads noted that the lack of good data (or sometimes any data) is a major concern in developing a good model. Additionally, it is important to note that developing a model does not guarantee that a planning unit will be able to use the model to test climate-related "what if" scenarios. This type of assessment must be considered for each model individually.

5.6.2 ***<u>Question #11(a)</u>*: What questions are the planning units trying to address with the model(s)? What model(s) are being (will be) used?** *[Asked of Leads who answered "Yes" for Question 11]*

<u>Purpose of the Question:</u> Question 11(a) was asked specifically to Leads with planning units that are currently developing hydrologic models for their WRIAs. Question 11(a) asks Leads to identify what types of questions the models are being designed to answer.

Results: Models are being developed to answer a variety of questions, reflecting the individual nature of the participating WRIAs. Identified modeling objectives include:

- General streamflow modeling
- Developing a water budget and water balance, assessing water quantity (4 WRIAs)
- Instream flow setting (3 WRIAs)
- Water quality
- Groundwater supplies, including net groundwater recharge (2 WRIAs)
- Surface/groundwater interaction (hydrologic conductivity) (2 WRIAs)
- Streamflow impacts from water storage and changing water use/water storage
- Return flows from irrigation

Many models are being designed to meet one or more of the above listed objectives.

The modeling objective in one eastern Washington WRIA has taken a unique twist. Some planning unit members are advocating developing a model to prove that efficiency improvements in irrigation are a detriment to water supplies and instream flows. The members believe that leakage from unlined ditches benefits groundwater recharge and improves instream flows for endangered species. State and federal agencies expect a model to show otherwise. The question the model needs to answer is whether return flow from the irrigation ditches makes up for increased surface water diversion.

5.6.3 Question #11(b): Does the planning unit expect to continue using the model for managing the watershed? In other words, is development of the model a one-time project specifically related to writing the Watershed Plan or will the model become an integral part of water resource decision-making in the WRIA?

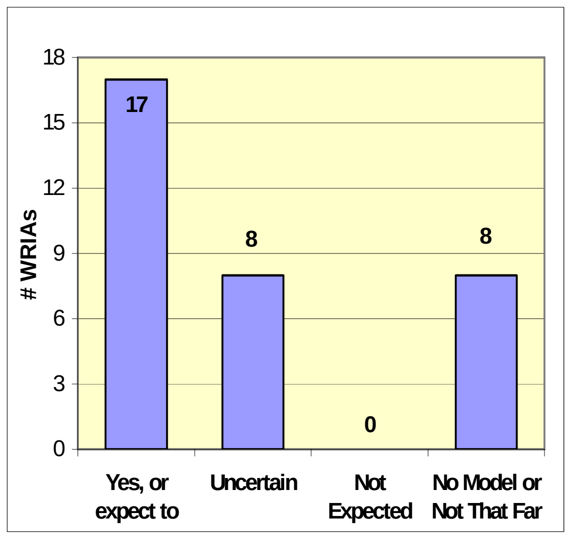
Purpose of the Question: A potential hazard of any planning process is the chance that the final plan and other end products do not get integrated into the management of the resource. Continued use of a hydrologic model after the watershed planning process is complete may help a watershed planning unit better manage its water resources and may provide continued opportunities to test management approaches against climate-related "what if" scenarios (e.g., "what if flows are reduced or increased by XX?"). Question 11(b) is asked for the purpose of assessing how likely models being developed, or expected to be developed, for the Watershed Planning Program will be used for long-term management of the watershed.

Results: Of the 22 WRIAs currently developing or expected to develop a hydrologic model, Leads expect the models to be integrated into long-term management of the watershed in 17 WRIAs (Figure 22). Leads for eight WRIAs were uncertain if the models would continue to be used after the Watershed Planning Program. No (0) Leads reported with certainty that their WRIAs would not use the models being developed to manage the watersheds after completing the watershed plan. Factors affecting continued use of the model include:

- how sophisticated the model is, how good the model it is at meeting the needs of the management area,
- how easy the model is to use, and
- if there is someone to use the model.

Continued use also depends in part on the planning unit's commitment to implementation.

Figure 22 - Question #11(b): Lead Expectations About Continued Use of WRIA Models (n=33)



5.6.4 *Question #11(c): Was use of a model considered and if so, why was the idea rejected? Are there other decision-aids similar to a hydrologic model being used? [Asked to Leads who answered "No" for Question 11]*

Purpose of the Question: Question 11(c) is asked to better understand what factors affect whether a hydrologic model is developed for watershed planning efforts.

Results: As noted in Question 11, only four of 33 WRIAs covered in the survey have considered and rejected the idea of developing a hydrologic model. Leads identified several factors affecting the decision to develop a model. For one planning unit, the number of small systems (over 1,000) makes modeling particularly difficult. Distrust in modeling and a lack of resources were also identified. Models may indicate a future problem but genetic knowledge reminds planning unit members of past variations and recovery. Conservative assumptions built into models can lead to conservative outcomes that planning unit members do not consider realistic, adding to distrust in the results. In other cases, distrust may stem from previous experience with models. In WRIA 23, reliance on strict model results for determining Total Maximum Daily Load (TMDL) limits unnecessarily restricted - in the view of the parties negotiating the TMDL - the use of innovative treatment methods for meeting TMDL limits, resulting in significant compliance burdens for major dischargers in the watershed (see Section 6.4.5.7 footnote).

5.6.5 Question #12: If your WRIA was given information indicating that it was relatively easy and cost-effective to build climate-related hydrologic impact testing into a model, do you think that they would take the additional step to include it? If no, why not?

Purpose of the Question: Question 12 is asked to gauge how willing planning units might be to add climate scenarios into hydrologic models, and to determine if there are fundamental (i.e., political or other) barriers to including climate scenarios in modeling. Question 12 was asked to all participating Leads regardless of whether their planning units are developing a model or not.

Results: All Leads felt that their planning units would be receptive to building climate scenarios into a hydrologic model if doing so was cost-effective and not too difficult technically. The extent to which planning units actually choose to do this will depend on the planning unit, cost, and the availability of funding now and for implementing watershed plans (if the ability to test scenarios is to be added to existing models in the future). In some cases, interest in building in climate scenarios might be conditional. One Lead thought the planning unit would be receptive only if results could unequivocally demonstrate the need for storage. Similarly, another Lead thought his planning units would be interested only if the Units consider new storage. In other cases, as one Lead acknowledged, groups like CIG will still have to get past the perception that climate change is considered “new science”.

5.6.6 Question #13: *How much additional cost do you think your WRIA(s) would be willing to incur to include testing for climate impacts on water resources in a hydrologic model?*

Purpose of the Question: Question 13 is asked to determine what the theoretical price sensitivity is among planning units to building climate scenarios into models for assessing climate impacts.

Results: Question 13 was the only question in the survey with a structured response. Leads were given the following choices: 0%, 1-10%, 11-20%, 21-30%, 31-40%, 40-50%, and 50% or higher.

Five of 11 Leads estimated the price sensitivity of planning units for building climate scenarios into models is 1-10% (Figure 23). Four Leads chose 0% (planning units either would not include, or would not spend any additional money to include). One Lead selected the 11-20% price sensitivity for their planning unit but only if the work would support the need for additional reservoirs.

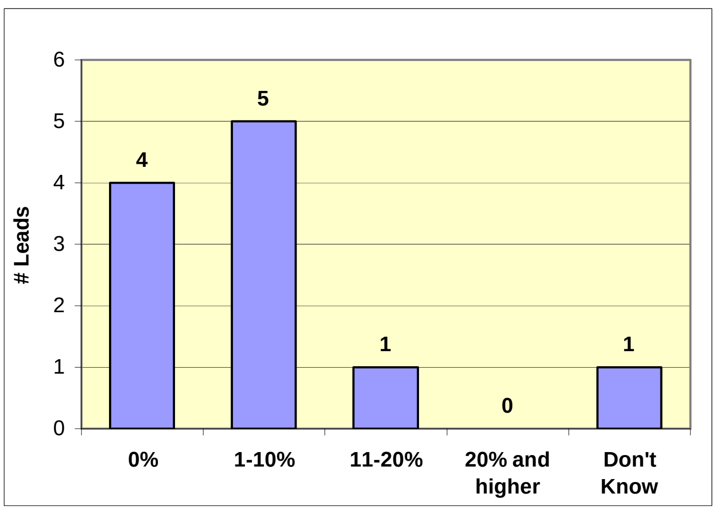
Funding limitations are a major factor in selecting a range. As many Leads noted, $500,000 does not provide a lot of room for options in watershed planning. WRIA 17, for example, has $200,000 to fill data gaps estimated by a consultant to cost over $1 million to fill. Some WRIAs have received supplemental funding from the state legislature (e.g., WRIAs 48, 37/38/39) but opportunities for additional funding are unlikely in the near future given the 2001-2002 state budget crisis. If additional funds are provided by the state, planning units might be very willing to add climate testing to models. One Lead noted, however, that if additional money was made available, his planning units would likely buy more water rights rather than invest in more technology.

Cost and price sensitivity are not the only challenges to adding climate scenarios to watershed planning models. As noted by several Leads, climate change is a low priority compared to other planning requirements under the Watershed Planning Program. Planning units will have to be convinced that the additional work is valid and worth it. One Lead offered that following hierarchy of possibilities:

- Give the planning unit money only → there is some probability that a planning unit will add climate scenarios into a model.
- Give the planning unit cash + technical assistance → the probability is higher.
- Give the planning unit cash + technical assistance + you convince them that the effort is worthwhile → climate scenarios will likely be added.

Tying climate impacts modeling to a larger effort (i.e., something being done by the federal government or some of the models developed by the state) may bring the additional funding needed to include climate impacts, according to one Lead.

Figure 23 – Question #13: Estimated Price Sensitivity to Adding Scenarios to Models (n=11)



5.7 Summary of the Survey: General Findings and Conclusions

The survey of Watershed Planning Leads provides a broad overview of the issues faced in moving the climate adaptation focus to a watershed level in Washington State. As evidenced by the variety in responses, adapting to climate impacts at the watershed level is not likely to occur through a "one size fits all" approach. Effort should be made to develop a suite of adaptation options at the watershed level that will allow watersheds to adapt to climate impacts while meeting unique local planning objectives.

Responses to the survey questions can be summarized along four major themes: the Watershed Planning Program in general, integrating climate impacts into the planning process, adapting to climate impacts, and modeling as a tool for adapting to climate impacts. Each is presented in the following sections.

5.7.1 The Watershed Planning Program in General

Comprehensive watershed planning such as that being done under the Watershed Planning Program is a major undertaking for local planning groups. The willingness to undertake this effort is driven in many watersheds by the necessity to develop approaches to managing major water supply planning challenges, including endangered species and related instream flow requirements for salmonids (16 WRIAs), future growth (10 WRIAs), water rights (9 WRIAs), and water quality (6 WRIAs) *(Question #2, Section 5.3.2)*. Funding provided by Ecology for watershed planning was also a major incentive.

Most Leads (for 24 of 33 WRIAS) are optimistic about the ability of the Watershed Planning Program to lead to better water management at the watershed level *(Question #5, Section 5.3.7)*. Several Leads noted that the planning process itself, and not just development of a final watershed plan, is likely to produce benefits. The planning process has inherent value in bringing key players together to discuss different viewpoints, develop a shared understanding of what the water resource challenges are, and collect up-to-date information on water resource issues in the WRIA. Some concern remains, however, that planning units will be reluctant to make the tough decisions needed to effect change, particularly on issues related to water rights and allocation. Limited funding and data are also limiting the types of decisions that can be made at this time. Consequently, many Leads (for 18 of 33 WRIAs) expect their planning units to periodically revisit and update their watershed plans as data gaps are filled and new information and/or funding becomes available *(Question #3b, Section 5.3.5).*

5.7.2 Integrating Climate Impacts into the Planning Process

Integrating climate impacts into the watershed planning process will depend largely on Lead familiarity with climate impacts, the willingness of planning units to discuss climate impacts, and the degree to which climate impacts are being included in planning documentation. Each of these factors was considered in the survey.

5.7.2.1 Lead Familiarity with Climate Impacts

An important first step in bringing climate impact concerns into the watershed planning process is assessing how familiar Watershed Planning Leads are with climate impacts *(Question #1, Section 5.3.1)*. Although Leads do not have responsibility for drafting watershed plans, Leads serve in an advisory capacity to multiple planning units and as such may have the opportunity to help planning units determine what can and should be addressed in the planning effort.

Familiarity with climate impacts among Leads is good but at a very general level. Most Leads (7 of 11) describe themselves as being somewhat familiar with climate impacts. The remaining four Leads felt they were not that familiar with climate impacts, but had a sense of what the impacts are. Impacts identified by Leads included changes in winter precipitation and snowpack, increased potential for flooding, shifts in runoff patterns, and lower summer baseflows. The most common sources of information on climate impacts for Leads are presentations and general circulation newspapers.

5.7.2.2 Planning Unit Discussion of Climate Impacts

Planning unit interest in discussing climate impacts is vital to including climate impacts in the watershed planning process. Leads reported that 22 of 33 WRIAs have discussed climate variability and/or climate change as part of the watershed planning process. This number was higher than expected but does not capture the depth to which the topics were discussed; most Leads described the discussions as "general level". Despite this general treatment, the high number of planning units discussing climate impacts is seen as an indication of the willingness of planning units to consider the issue further during this and future planning efforts.

This does not mean, however, that there is uniformity in opinion about climate variability, climate change, and climate impacts among planning unit members. Many Leads reported that responses to information on climate impacts and opinions on taking steps to address impacts have been mixed *(Question #9, Section 5.5.1)*. While most planning units recognize climate impacts as an issue in watershed planning, the belief that climate impacts will happen in the future removes the pressure to address impacts now, particularly in light of the existing challenges planning units must deal with (e.g, instream flows, water rights, water quality, general supply challenges).

A few Leads reported having planning unit members take a "convince me" stance; if the member(s) can be convinced that climate impacts are a real concern, they will be more willing to address the issue. In other cases, support for acknowledging climate impacts may be driven by other objectives. In one watershed, for example, some planning unit members have embraced information on climate impacts as a cause for lobbying for additional reservoir construction. In another planning unit, climate impacts are seen by some as a way to justify not meeting instream flow requirements.

Only two planning units have chosen not to address climate impacts because of a fundamental disbelief in climate change. This number was much lower than expected and is taken as a positive sign that more members of the general public (insofar as it is represented by the planning units) are moving past questioning if climate change is real to questioning how to deal with climate change impacts.

Trust among planning unit members was emphasized by several Leads as being a key determinant in whether new issues like climate impacts are discussed by a planning unit. Strong leadership, on the other hand, was not considered a major factor given the consensus-based nature of the watershed planning effort *(Question #10(a), Section 5.5.8)*. Six Leads felt that strong leadership could help *or* hinder the likelihood that climate impacts are addressed in the planning process depending on the position the leader took on climate impacts. Only one Lead thought a strong leader would have an impact. Several Leads emphasized the value of a good facilitator over a strong leader for watershed planning.

Leads also suggested a wide range of additional resources that would be helpful in addressing climate issues with their planning units *(Question #9(f), Section 5.5.6)*. In general, Leads would like additional information on the range of climate scenarios and trends, multiple presentations addressing varying levels of complexity, and more technical assistance (particularly with modeling and planning). The need for "good science" was also mentioned several times.

5.7.2.3 Phase II Level 1 Technical Assessments

Including climate impacts in planning documentation is an important step towards integrating climate impacts into the watershed planning process. The first major planning document prepared under the Watershed Planning Program is the Phase II Level 1 Technical Assessment Report. Technical Assessment reports provide a comprehensive overview of water supply availability and use within a watershed (see Section 6.2). Information collected for the reports serve as the starting point for developing watershed plan recommendations under Phase III of the Watershed Planning Program.

Planning units for 15 WRIAs are including climate variability and/or climate change in their Phase II Level 1 Technical Assessments *(Question #9(b), Section 5.5.3).* The extent to which planning units are addressing climate impacts varies from a few sentences noting the general effects of climate variability and/or climate change on water supplies to detailed reporting on scientific understanding of climate variability and/or climate change. Several planning units (7 WRIAs) have analyzed streamflow sensitivity to PDO cycles in their Technical Assessments. In an unusual case (WRIA 55/57), the planning unit intends to ease back on statements made about climate change by its consultant in the Level 1 Technical Assessment. According to the Lead, the planning unit felt the draft Assessment over-emphasized the influence of climate variability and climate change on water supply in relation to other concerns such as population growth. Revised statements will likely make climate variability and climate change equal to other concerns.

5.7.3 Adapting to Climate Impacts

Adapting to climate impacts will be necessary if water resource managers are to meet future water supply needs. Flexibility to adapt to changes is key given the uncertainties over specific impacts of climate variability and climate change at the watershed level, as well as standard uncertainties over future population growth, regulations, and other planning variables. As noted by Stakhiv (1998):

> "…Essentially, adaptation to future climate change uncertainty relies on the same elements and components of a sound water management strategy geared *to contemporary variability and uncertainty in supply and demand* matters" (emphasis added). (p.167)

Question #8(a) *(Section 5.4.1)* asked Leads to assess how much flexibility their WRIAs have for adapting water resources to climate impacts. According to the responses, there is a fairly uniform distribution between WRIAs considered to have some or good flexibility (13 WRIAs) and limited flexibility (12 WRIAs) in adapting water supplies to climate impacts.

One area where a lack of flexibility is already evident is drought management. Significant droughts such as those experienced in the 1930s, 1977, and 2000-2001 show that Washington's watersheds are most sensitive naturally, politically, and socioeconomically to severe drought. Given this and the increased potential for more drought as a result of climate change, Leads were asked how a multi-year drought would affect their watersheds and what types of responses could be expected *(Question #8(c), Section 5.4.3)*. Identified drought impacts included reductions in water supplies for municipal, industrial, irrigation, fish, and hydroelectric generation purposes. Groundwater levels are expected to decline in some areas due to the combined effects of reduced precipitation and increased groundwater pumping. Increased groundwater production may also induce new, or worsen existing, salt water intrusion along coastal watersheds, potentially limiting groundwater use.

Potential responses to severe drought vary. The most frequently cited potential drought response was construction of new reservoirs. Another potential response is inter-basin transfers and/or transfers between water uses (e.g., from agriculture to municipal users). Both types of transfers could face significant political and logistical challenges, however. Other potential drought responses include desalination, water conservation and curtailments, enforcement of senior water rights, water re-use, aquifer storage, and denial (as a first response). In all cases, no single response is expected to address all drought impacts.

Opinions about the ability to better manage drought or other supply crises at the watershed level as a result of watershed planning varied but were generally optimistic *(Question #5, Section 5.3.7)*. Leads for 14 of 33 WRIAs felt the watershed plans would likely lead to better drought/crisis management; one Lead suggested that this would occur by clearly defining the thresholds (such as legally established instream flows) at which WRIAs are actually in a crisis. Other Leads were uncertain about the plan's use in managing crises (6 WRIAs) or did not expect drought/crisis management to be improved by watershed plans (5 WRIAs). Several Leads noted that this type of contingency planning is outside the scope of the Watershed Planning Program. The lack of specific planning for drought management leaves many watersheds vulnerable to drought impacts despite watershed planning.

5.7.3.1 Barriers to Adaptation

Building in the flexibility for adapting water resources to climate impacts will require addressing any combination of natural, political/cultural, administrative, and/or institutional/regulatory barriers *(Question #8(b), Section 5.4.2*). Natural barriers may be some of the most challenging to resolve. Natural barriers to adaptation include losing glaciers to climate change, the seasonality of flows, limited surface water and groundwater resources, and uncertain or declining groundwater levels. Political or cultural barriers can be just as difficult to manage. Political or cultural barriers include a general reluctance to change the status quo, distrust towards government, and a reliance on "genetic knowledge" (see *Question #2, Section 5.3.2).*

Administrative barriers, most of which are related to water rights administration, might be addressed through changes in administrative policies. This assumes, however, that there is willingness to do so. As noted by many Leads, interest at the planning unit level in changing existing water rights allocations and/or enforcing water rights is limited. Additionally, these types of changes often must be made at the state or even federal level. Developing the momentum to change controversial or sensitive barriers at these levels can be difficult for individual watersheds. A similar predicament holds true for many of the identified institutional/regulatory barriers, which include water rights and endangered species-related instream flow requirements, the dedication of water rights to hydropower and flood control through the rule curve (limiting use of stored water), and competing, or at least non-compatible, state laws and federal demands.

5.7.3.2 Adaptive Management

One potential approach to adapting to climate impacts is using adaptive management in watershed plans. Adaptive management builds flexibility into resource management decisions by establishing a process through which new information can be integrated on a regular basis into decision-making processes. Stakhiv (1998) notes:

> "…sound adaptive water management relies on functioning institutions that are designed to accommodate changes and new information, not only in meteorology and hydrology, but the more rapidly shifting changes in the socioeconomic structure, demographics, technology, and public preferences regarding strategies for sustainable development…" (p.167)

New information gathered through monitoring and other feedback loops can be evaluated to determine if management approaches are achieving intended objectives. If the objectives are not being met, management approaches can be modified as needed. The approach, originally advocated for salmon restoration and management, is being embraced in other resource management arenas, including forestry and water resources (Smith et al. 1998, Ecology 1999).

The adaptive management approach has been advocated by some researchers (Stakhiv 1998, Neuman 2001) as an effective approach to adapting to climate impacts. The flexibility allowed under adaptive management gives water resource managers the ability to adjust management decisions in order to cope with the changes and uncertainties of climate variability and climate change. Many Leads are uncertain, however, of how an adaptive management approach fits into a water resource management context, particularly under current water law *(Question #4, Section 5.3.6)*. As noted by Leads and Neuman (2001), the Prior Appropriation Doctrine creates a very rigid system for water allocation. It is very difficult to build an adaptive management framework around Prior Appropriation. Despite this uncertainty, many planning units will include (3 WRIAs) or are likely to include (9 WRIAs) adaptive management in some form in their watershed plans. Two Leads felt that adaptive management was implicit to the planning process even if not intentionally addressed since all the information needed to make specific recommendations in the plans won't be available during the initial planning effort (and will therefore require updating).

5.7.4 Modeling as a Tool for Adapting to Climate Impacts

In addition to using adaptive management as a framework for decision-making, specific tools such as hydrologic modeling may also be effective in facilitating adaptation to climate impacts. Hydrologic modeling can provide watershed planning groups the opportunity to analyze the potential impact of planning decisions and other changes, including climate variability and climate change, on water resources before those changes occur. A model's ability to provide these projections will depend on the construction of the model and availability of quality data.

Twenty-two (22) WRIAs are using, or considering using, hydrologic modeling as part of their watershed planning effort *(Question #11, Section 5.6.1)*. Most of the models currently being used or under development include combined surface water/groundwater components for investigation hydrologic continuity *(Question #11(a), Section 5.6.2)*. In some instances planning units have elected to split the surface and groundwater components. In other cases, planning units are looking at surface water or groundwater only. Regardless of status or type of model used, Leads note that the lack of good data (or sometimes any data) is a major concern in developing a good model for their watersheds.

Additional steps may be required to enable use of hydrologic models in analyzing climate-related "what if" scenarios. Given this, Leads were asked how receptive their planning units might be to taking the additional step(s) *(Question #12, Section 5.6.5)*. All Leads indicated that their planning units would be receptive to building climate scenarios into a hydrologic model if doing so was cost-effective and not too difficult technically. The extent to which planning units actually choose to do this will depend on the planning unit, cost, and the availability of funding now and for implementing watershed plans (if the ability to test scenarios is to be added to existing models in the future). In some cases, interest in adding climate scenarios might be conditional. One Lead, for example, thought their planning unit would be receptive only if results could unequivocally demonstrate the need for storage.

Price sensitivity for building climate testing scenarios into hydrologic models is high. Five of 11 Leads estimated that their planning units might be willing to incur additional costs in the range of 1-10% *(Question #13, Section 5.6.6)*. Four Leads chose 0%, meaning that the planning units either would not include the ability or would not be willing to spend any additional money for it. Funding limitations are a major factor. As many Leads noted, $500,000 does not provide a lot of room for options in watershed planning. If additional funds are provided by the State, planning units might be willing to add climate testing to models. One Lead noted, however, that if additional money was made available, his planning units would likely buy more water rights rather than invest in more technology.

Cost and price sensitivity are not the only challenges to adding climate scenarios to watershed planning models. As noted by several Leads, climate change is a low priority compared to other planning requirements under the Watershed Planning Program. Planning units will have to be convinced that the additional work is valid and worth it. One Lead offered that following hierarchy of possibilities:

- Give the planning unit money only → there is some probability that a planning unit will add climate scenarios into a model.
- Give the planning unit cash + technical assistance → the probability is higher.
- Give the planning unit cash + technical assistance + you convince them that the effort is worthwhile → climate scenarios will likely be added.

Tying climate impacts modeling to a larger effort (i.e., something being done by the federal government or some of the models developed by the state) may bring the additional funding needed to include climate impacts, according to one Lead.

5.7.5 Concluding Thoughts on the Survey Process

The survey of Watershed Planning Leads provides insightful and instructive information regarding the challenges of integrating climate impacts into watershed planning efforts under ESHB 2514. The one-on-one phone contact required for the survey provides a good starting point for further interaction between Ecology Planning Leads and the Climate Impacts Group. Several Leads have expressed interest in presentations and other opportunities to continue discussing climate impacts and adaptation at the watershed level. It is hoped that by making this initial effort to familiarize Ecology Leads with climate impacts and the Climate Impacts Group, watershed planning units and Leads will feel more empowered to begin addressing climate impacts.

6.0 Vulnerability Indicators

Washington State's watersheds are highly variable with respect to temperature, precipitation, land use, population levels, water supplies, and other features. Climate variability and climate change are expected to affect watersheds to varying degrees based on these differences. Early identification and evaluation of factors influencing watershed vulnerability to climate impacts can prove valuable for minimizing vulnerabilities.

The purpose of this section is to identify those factors that may make a watershed more or less vulnerable to the hydrologic impacts associated with climate variability and climate change. This vulnerability may stem directly from impacts associated with changes in streamflow and temperature, or indirectly from factors that positively or negatively affect a watershed's ability to adapt to climate impacts. Assumptions relating how the indicators influence watershed vulnerability are also stated.

Once identified, the vulnerability indicators can be assessed to determine overall watershed vulnerability. A vulnerability assessment gives decision-makers the opportunity to consider climate impacts as a two-way street. In one direction, the vulnerability assessment facilitates considering how climate variability and climate change might affect specific characteristics of a watershed. In the other direction, the vulnerability assessment helps identify how specific watershed characteristics might influence vulnerability to climate impacts. Recognizing and understanding these relationships may contribute to the development of watershed management strategies that reduce overall watershed vulnerability by minimizing negative feedback loops and creating more opportunities for adaptation.

6.1 Defining Vulnerability

Assessing vulnerability to climate impacts provides important opportunities for avoiding, mitigating, or at a minimum recognizing how climate variability and climate change may affect local watershed processes and water use. Defining what vulnerability is, however, can be challenging. A review of vulnerability definitions by Kelley and Adger (2000) found common themes as well as important differences. In general, vulnerability definitions include some acknowledgement of an ability or inability to adapt to changing conditions. Vulnerability may provide a starting point for impact analysis, or may define an end point by identifying where impacts remain after adaptation. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as:

> "…the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." (IPCC 2001 p.6)

Other definitions may focus primarily on the human dimension. Kelley and Adger (2000) define vulnerability in terms of "the ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from, or adapt to, any external stress placed on their livelihoods and well-being." For the purposes of this study, the IPCC definition of vulnerability is assumed in identifying vulnerability indicators.

6.2 Information Sources for Identifying Vulnerability Indicators

Multiple sources of information were reviewed to identify vulnerability indicators and assumptions important to a watershed level vulnerability analysis. The preferred source of information, when available, was the Phase II Level 1 Technical Assessment Reports being developed by watershed planning units for the Watershed Planning Program. The Technical Assessment provides a comprehensive overview of the current status of water supply availability and demand in the watershed based largely on existing data collected from various federal, state, and local agencies. Data collection for identified data gaps can be deferred in most cases to Phase IV (implementation). Information collected for the Technical Assessments serves as the starting point for developing watershed plan recommendations under Phase III of the Watershed Planning Program. General requirements for the Technical Assessment report are listed in Table 3. Seven draft Technical Assessments were reviewed to identify the type of information collected for Technical Assessments. A majority of vulnerability indicators were derived from these reports.

Additional sources of information were used to supplement the Technical Assessment Reports, or used in lieu of the reports when not available. Information sources included the following, where available:

- Habitat Limiting Factors Reports
  Habitat Limiting Factors (HLF) Reports are required under Engrossed Substitute House Bill 2496 (the Salmon Recovery Act), passed in 1998 by the Washington State legislature. HLF reports are developed for watersheds by locally-based technical advisory groups convened by and including the Washington State Conservation Commission, local governments, treaty tribes, and other stakeholders. The purpose of each report is to identify those conditions limiting "the ability of habitat to fully sustain populations of salmon"[18] at the watershed level. Limiting factors include fish passage barriers and degraded estuaries, stream channels, riparian corridors, and wetlands. Information collected for the HLF Report can be used to prioritize salmon recovery activities.

- Department of Ecology Initial Watershed Assessments
  Draft Initial Watershed Assessments were issued by Ecology between 1995 and 1997 for 17 WRIAs. Nine of these WRIAs are participating in the Watershed Planning Program. The assessments were undertaken for the purpose of making decisions on pending water rights applications. The assessments provide an overview of water resource availability, use, and rights status in each WRIA as of 1995.

- Interviews with Watershed Planning Leads
  Eleven of 15 Department of Ecology Watershed Planning Leads were surveyed for this study. Many of topics addressed through the survey related to factors affecting vulnerability to climate impacts and adaptation. A summary of survey results with Watershed Planning Leads is described in detail in Section 5.

---

[18] http://salmon.scc.wa.gov/more/faq.html#four

Table 3 **Technical Assessment Requirements of the Watershed Management Act**	
Element	Technical Assessment Requirements
Water Quantity (Required as a condition of grant funding)	❑ Estimate of surface and groundwater present in the management area. ❑ Estimate of the water in the management area represented by claims in the water rights claims registry, water use permits, certified rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water. ❑ Estimate of the surface and groundwater actually being used in the management area. ❑ Estimate of the water needed in the future for use in the management area. ❑ Identification of the location of areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface. ❑ Estimate of the surface and groundwater available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.
Water Quality (if addressed)	❑ An examination based on existing studies conducted by federal, State, and local agencies to the degree to which legally established water quality standards are being met in the management area. ❑ An examination based on existing studies conducted by federal, State, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and nonpoint sources of pollution, and pollution-carrying capacity of water bodies in the management area.
Habitat (if addressed)	❑ The analysis shall take into account seasonal streamflow or level variations, natural events, and pollution from natural sources that occur independent of human activities. ❑ An examination of the legally established characteristic uses of each of the nonmarine bodies of water in the management area. ❑ An examination of the impacts to beneficial or characteristic uses, caused by changes in watershed hydrology. ❑ An examination of any total maximum daily load established for nonmarine bodies of water in the management area, unless a total maximum daily load processes has begun in the management area as of the date the watershed planning process is initiated under section 2 of [the Watershed Management Act]. ❑ An examination of existing data related to the impact of fresh water on marine water quality. ❑ The Watershed Planning Act contains no specific requirements for technical assessment. However, where habitat restoration activities are being developed under the Salmon Recovery Act, such activities must be relied on as the "primary nonregulatory habitat component" under the Watershed Management Act. ❑ The Salmon Recovery Act requires analysis of "limiting factors" in developing a habitat project list. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon…primarily fish passage barriers and degraded estuarine areas,

Table 3 **Technical Assessment Requirements of the Watershed Management Act**	
	riparian corridors, stream channels and wetlands" (see Appendix A of this manual). The discussion of the Salmon Recovery Act in the law appears to indicate that planning units should rely on studies conducted under the SRA wherever, rather than undertaking separate studies.
Instream Flows (if addressed)	❑ The Watershed Planning Act contains no specific requirements for technical assessment.

Source: Ecology 1999 (pp. 4-2 and 4-3)

- Peer reviewed journal articles and publications

  Researched topics included climate impacts on water supplies, wetlands, and water quality; assessing vulnerability; and adapting to climate impacts. Articles included research specific to the Pacific Northwest when possible.

- Other watershed level studies

  Includes watershed-level studies prepared salmon restoration and other projects. The availability and applicability of these additional studies to the research was limited at best.

- WRIA 27/28 Sub-Watershed Ranking

  The WRIA 27/28 Technical Assessment Report includes a ranking of sub-basins within WRIAs 27/28 to determine which sub-basins have water resource conflicts and therefore have priority status for evaluating data limitations. The sub-basin ranking was based on the following criteria:

  - ❑ Surface water rights availability (potentially available, near closure, low-flow restriction, or closed)
  - ❑ Current/future water use (low, medium, high)
  - ❑ Available streamflow data to evaluate "natural flows" (low, moderate, high or combinations thereof)
  - ❑ Hydraulic continuity (i.e., the degree to which groundwater has the potential to influence streamflow) (low, moderate, high)

- Instream flow requirements (i.e., ability to meet) – often unknown but in some watersheds it was known that "habitat requirements may exceed stream flow"
- Potential for altered stream flow from land use (low, moderate, high); and
- Water Quality (low, moderate, high or some combination thereof)

Although these ranking criteria were developed specifically for WRIAs 27/28, the criteria served as a good starting point for considering broader-scale watershed level vulnerability indicators.

Comments from water resource managers at regional meetings on climate and water resources[19] and the author's personal experience with multi-stakeholder watershed planning efforts were also instrumental in identifying vulnerability indicators.

6.3 Vulnerability Indicators and Indicator Levels

Reports and other sources of information for 19 watersheds were reviewed as part of the vulnerability identification process to determine what types of information was being reported and how consistently information was reported. Through this process, a total of 48 primary indicators were identified for potential use in a watershed-based vulnerability assessment. The indicators are grouped into six general categories:

- Climate and Hydrology – Provides an overview of the watershed's climate and hydrology. Vulnerability indicators listed in this section include major water sources, average annual flows, average precipitation, air temperature, average water temperatures, and the type of basin (snow dominant, transient, or rain dominant).

- Land Use/Land Features – Provides a basic overview of land use and land features in the WRIA. Vulnerability indicators listed in this section include the size of the WRIA, high/low elevation points, land use, land ownership, and transboundary issues

[19] Climate and Water Policy Workshop, held July 16-17, 2001 at Skamania Lodge in Stevenson, Washington, and the Senior Stakeholders Meeting on Climate and Water Policy, held March 20, 2002 in Portland, Oregon. Both meetings were sponsored by the Climate Impacts Group.

in the watershed.

- Water Use Characteristics – Provides an overview of major water uses within the watershed. Vulnerability indicators listed in this section include population, water use by source, major water uses, agricultural water use, and major storage systems.

- Water Quality – Provides an overview of water quality conditions within the WRIA. Vulnerability indicators listed in this section include noted problems with surface water and groundwater quality, and the presence of Section 303(d) listed impaired water bodies within the watershed.

- Regulatory Characteristics – Provides an overview of regulatory programs affecting water use within the watershed. Vulnerability indicators listed in this section include water rights allocations, use by exempt wells, the presence of endangered salmonids and other at-risk species, and instream flow requirements.

- Watershed Planning – Includes factors specific to the Watershed Planning Program. Vulnerability indicators listed in this section include recognition of climate impacts in watershed reports, the use of hydrologic models in watershed planning efforts, and the whether planning units will continue in some capacity after developing the watershed plan.

To differentiate the degree to which the indicators influence vulnerability to climate impacts, indicators are categorized as one of three types:

- Level 1 Indicator – Factors directly affecting vulnerability to hydrologic impacts, independent of all other factors (high level of influence).
    - *Ex: type of basin, population, and average annual precipitation.*

- Level 2 Indicator – Factors which do not have a direct effect on vulnerability but which still may positively or negatively affect a watershed's ability to adapt to climate impacts, thereby affecting the watershed's overall vulnerability (medium level of influence).

- *Ex: trends in annual surface water flow, the presence of transboundary water issues, and surface water quality problems.*

- Level 3 Indicator – Identical to Level 2 indicators by definition but having less influence on vulnerability than a Level 2 indicator (low level of influence).
  - *Ex: major land uses, the number of exempt wells believed to be located in the watershed, and whether previous watershed-based multi-stakeholder planning has been done in the watershed prior to the Watershed Planning Program.*

- Descriptor Only – Factors providing descriptive information relevant to assessing vulnerability. Descriptive Only indicators do not have any influence on vulnerability.
  - *Ex: Major cities, major water sources, and total annual allocation of water through water rights*

A complete list of indicators, associated indicator levels, and vulnerability assumptions are provided in Tables 4 and 5.

6.4 Detailed Indicator Descriptions and Assumptions By Category

A description of each indicator, its indicator level, and the assumptions used to guide evaluation of the indicator follows. Each indicator is presented using the following format:

(Section #) Indicator Name

Sub-indicator(s)	Identifies one or more sub-components to the indicator, and/or the units by which the indicator is evaluated. For example, the Major Water Uses indicator has 6 sub-indicators: 1st major water use (% of overall water use), 2nd major water use (% of overall water use), and 3rd major water use (% of overall water use). Sub-indicators are described collectively by default

	unless the indicator levels differ for sub-indicators or other information is unique enough to warrant addressing all or some sub-indicators separately.
Description	Describes what type of information is being addressed by the indicator.
Indicator Level	Level 1 (high), Level 2 (medium), Level 3 (low), or Descriptive Only in accordance with the criteria established in Section 6.3.
Vulnerability Reduction Bias in Favor of	Identifies what, if any, bias is placed on an indicator with respect to the indicator's ability to reduce vulnerability. For example, low population growth is expected to leave a watershed less vulnerable to climate impacts than high growth. Therefore, the bias for evaluating the Population indicator is towards low population growth.
Assumptions	Identifies what assumptions are made in evaluating the indicator. Additional background information on the indicator is also provided in this section as needed.

In all cases, indicator assumptions and assessments are made on an indicator-by-indicator basis using a base assumption that all other factors in the watershed other than the indicator being considered are held the same. No attempt has been made to assess the specific effects of combinations of indicators on watershed vulnerability at this time. Please see Section 6.5.5 for more information on recommended next steps.

Table 4 - Vulnerability Indicators by Level

LEVEL 1 Indicators		
Category	***Indicator***	***Sub-Indicator***
Climate and Hydrology	Type of Basin	Rain/Transient/Snow
	Average Annual Surface Water Flow	Trends in Flow Volume (incr./decr./no change), Shifts in the Timing of Peak Flows
	Average Annual Precipitation (in.)	Total Basin, Lower Basin, Upper Basin
	Average Temperature (°F)	Summer – Total Basin Average, Summer – Lower Basin Average, Summer - Lower Basin Maximum Average Temp., Winter - Total Basin Avg., Winter - Upper Basin Avg., Winter - Upper Basin Minimum Avg. Temperature
Land Use/Land Features	Elevations Ranges (ft.)	Low, High
Water Use	Population	Current, Projected, Annual Growth Rate, % Change
	Water Use by Source (%)	Surface Water, Groundwater
	Major Water Storage Systems	Dams/Aquifer Storage and Recovery Sites, AF Storage, Ration of Total Storage to Annual Streamflow
Water Quality	*(No Level 1 Indicators)*	
Regulatory Characteristics	Endangered Species	Endangered, Threatened, Other At-Risk Species
	Instream Flows (INSF)	INSF set?, Avg. #days/% below INSF, Stream Closures, Comments
Watershed Planning	Major Planning Challenges Sensitive to Climate?	(y/n), description
	Perceived Level of Adaptation Flexibility (from Leads)	Description

LEVEL 2 Indicators		
Category	***Indicator***	***Sub-Indicator***
Climate and Hydrology	*(No Level 2 Indicators)*	
Land Use/Land Features	Major Land Uses	1st, acres or %, 2nd, acres or %, 3rd, acres or %, Other, acres or %, Trends
	Transboundary Issues	Transboundary Issues
	Coastal/Estuary Zone	(y/n)

Water Use	Major Water Uses (Consumptive)	1st, %, 2nd, %, 3rd, %, Trends
	Major Surface Water Uses	1st, %, 2nd, %, 3rd, %
	Major Groundwater Uses	1st, %, 2nd, %, 3rd, %
Water Quality	Surface Water Quality Problems	Flow, Temp, DO, pH, Fecal Coliform, TSS/Turbidity, Metals, Phosphorus, Nitrogen, Other, Most common concern
	Groundwater Quality Problems	Comments on Overall Quality, Fecal Coliform, Nitrates, Phosphorus, Iron, Manganese, Chlorides, Salt Water Intrusion, Other
	303(d) Water Bodies	(y/n), Description
Regulatory Characteristics	Surface Water Rights (af or cfs)	Claims, Applications
	Groundwater Rights (af or cfs)	Claims, Applications
	TMDLs	(y/n), description
Watershed Planning	Natural Variability Addressed	(y/n), ENSO/PDO
	Climate Change Addressed	(y/n)
	Using (or Possibly Using) Hydrologic Model?	(y/n)
	Planning Unit to Continue?	Yes/No/Not Certain
	Will Update Plans	(y/n)
	Drought Plan Developed and Up to Date?	(y/n), comments

LEVEL 3 Indicators		
Category	***Indicator***	***Sub-Indicator***
Climate and Hydrology	Annual Surface Water Flow	Avg. Annual Flow Rates (cfs or af)
Land Use/Land Features	WRIA Size	Acres, Sq. mi.
	Major Land Owners (%)	Private, Federal, Tribes, State
Water Use	Dominant Water Supplier(s)	(y/n), Description
Water Quality	*(No Level 3 indicators)*	
Regulatory Characteristics	Surface Water Rights (af or cfs)	Estimated Actual Usage
	Groundwater Rights (af or cfs)	Estimated Actual Usage
	Exempt Wells	Estimated Use / # Exempt Wells

Watershed Planning	Previous Multi-stakeholder Planning	(y/n), Description

DESCRIPTIVE ONLY Indicators		
Category	***Indicator***	***Sub-Indicator***
Climate and Hydrology	Major Water Sources	Surface, Groundwater
	Major Precipitation Season	Months, % of Total
	Low Flow Periods	Time Frame
Land Use/Land Features	Major City(ies)	Description
	Counties	Description
	Major Mountain Systems	Major Peak(s)
Water Use	Agricultural Water Use	Major Irrigated Crops, Irrigated Acres (% or acres), Trends
Regulatory Characteristics	Total Annual Water Rights Allocation	Acre-feet or cu.ft./sec
	Surface Water Rights (af or cfs)	Annual Surface Water Allocation
	Groundwater Rights (af or cfs)	Annual Groundwater Allocation
Watershed Planning	*(No Descriptive Only indicators)*	

CONDITIONAL INDICATORS (Level ranking is contingent on entry)		
Category	***Indicator***	***Sub-Indicator***
Climate and Hydrology	Other Factors of Note	Description
Land Use/Land Features	Other Factors of Note	Description
Water Use	Other Factors of Note	Description
Water Quality	Other Factors of Note	Description
Regulatory Characteristics	Other Programs Affecting Water Use/Management	Description
Watershed Planning	Other Factors of Note	Description

Table 5 - Summary of Indicator Assumptions (By Category)

Category (Section No.)	Primary Indicator	Sub-indicator	Indicator Level	General Assumptions *(all other factors held the same)*	Vulnerability Reduction Bias (in favor of…)
Climate and Hydrology (Sec. 6.4.1)	Major Water Sources	Surface Water Groundwater	Descriptive only	No assumptions made	No bias
	Type of Basin	Rain/Transient/Snow	**LEVEL 1**	Rain-dominant basins are assumed to be least vulnerable to climate impacts (lower vulnerability). Snow-dominant basins are assumed to be more vulnerable to climate impacts than rain dominant basins but less vulnerable than transient basins (intermediate vulnerability). Transient basins are assumed to be most vulnerable to climate impacts (higher vulnerability).	Rain-dominant basins, then snow-dominant; transient are most vulnerable
	Annual Surface Water Flow	Avg. Annual Flow Rates (cfs or af)	**Level 3**	Watersheds with higher average annual flow rates are assumed to be less vulnerable to climate impacts. Seasonality of flows and current water allocation are major considerations in assessing this indicator.	Higher average annual flows
		Trends in Flow Volume (incr/decr/no change)	**LEVEL 1**	Watersheds with declining trends in flow are assumed to be more vulnerable to climate impacts While it may be difficult to definitively prove that declining flow trends are related to long-term climate trends, the net effects for the decline are the same regardless of the cause.	No decrease in flows over time
		Shifts in Timing of Peak Flows	**LEVEL 1**	Watersheds where there is evidence of a shift in the timing of flows are assumed to be more vulnerable to the impacts of climate variability and climate change.	No shifts in the timing of flows
	Average Annual Basin Precipitation (in.)	Total Basin Lower Basin Upper Basin	**LEVEL 1**	Watersheds receiving more precipitation overall may be less vulnerable to the hydrologic impacts of climate variability and climate change. The seasonality of precipitation increases, where the precipitation falls (with respect to elevation), and the form of precipitation (rain, snow, or rain/snow mix) are important factors to consider when assessing this indicator.	Higher average precipitation levels
		Summer - Basin Avg. Summer-Lower Basin Avg. Summer - Lower Basin Maximum Average Temp.		High average summer temperatures are assumed to increase vulnerability to climate variability and climate change in all types of basins (rain, transient, or snow dominant) by increasing the demand for water resources while concurrently increasing evaporative losses.	

Category (Section No.)	Primary Indicator	Sub-indicator	Indicator Level	General Assumptions *(all other factors held the same)*	Vulnerability Reduction Bias (in favor of…)
	Avg. Temp (°F)	Winter - Basin Avg. Winter - Upper Basin Avg. Winter - Upper Basin Minimum Avg. Temperature	**LEVEL 1**	-- Watersheds where average upper basin winter temperatures are at or near freezing *(transient basins)* are assumed to be more vulnerable to changes in snowpack due to changes in the type of winter precipitation (more rain, less snow). The potential for more winter flooding from rain-on-snow events is also increased, particularly in watersheds west of the Cascades. -- Watersheds where average upper basin winter temperatures are well below freezing *(snow-dominant basins)* are less vulnerable than transient basins, but may still lose snowpack near snowline due to changed precipitation and/or warming temperatures. -- Watersheds where average upper basin winter temperatures are already well above freezing *(rain-dominant basins)* are least vulnerable to changes in snowpack but may be more vulnerable to winter flooding given the projections for increased winter precipitation in climate change scenarios.	Moderate summer temperatures and/or winter temperatures well below or well above freezing.
	Major Precipitation Season	Months % of total	Descriptive only	No assumptions are made given that the dominant precipitation season is consistent for all watersheds in Washington State (generally October through March).	No bias
	Low Flow Periods	Time Frame	Descriptive only	No assumptions are made given that low flow periods are consistent for all watersheds in Washington State (generally July through September).	No bias
	Other Factors of Note	Description	Contingent on entry	No assumptions made	No bias
Land Use/Land Features (Sec. 6.4.2)	WRIA Size	Acres Sq.mi.	**Level 3**	Larger watersheds are assumed to have an adaptation advantage and therefore are assumed to be less vulnerable to climate impacts, although this advantage is expected to be minimal and heavily influenced by other factors in the watershed.	Larger WRIAs

Category (Section No.)	**Primary Indicator**	**Sub-indicator**	**Indicator Level**	**General Assumptions *(all other factors held the same)***	**Vulnerability Reduction Bias (in favor of…)**
	Elevation Ranges (ft.)	Low High	**LEVEL 1**	Watersheds with elevations ranging from sea level to approximately 3,000 feet *(rain-dominant basins)* are assumed to be least vulnerable to climate impacts. Watersheds with elevations ranging from approximately 3,000 to 6,000 feet *(transient basins)* are assumed to be most vulnerable to climate impacts. Watersheds with elevations approximately 6,000 feet and higher *(snow-dominant basins)* are assumed to be more vulnerable to climate impacts than rain-dominant basins but less vulnerable than transient basins. Many basins have elevation ranges that fall within more than one basin type (ie., sea level to 10,000 feet). Therefore, a hydrograph and average winter temperatures should be used in all cases to confirm the basin type.	Rain-dominant basins, then snow-dominant basins; transient basins are most vulnerable.
	Major Land Uses	1st acres or % 2nd acres or % 3rd acres or % Other acres or % Trends	**Level 2**	General advantages and disadvantages of major land uses in relation to climate impacts and adaptation are identified but no assumptions made. Any vulnerability associated with specific land uses should be determined on a case-by-case basis. Major Washington land uses include forestry, agriculture, and urban developement.	No bias
	Major City(ies)	--	Descriptive only	No assumptions made	No bias
	Counties	--	Descriptive only	No assumptions made	No bias
	Transboundary Issues	County State Tribal Canada	**Level 2**	Coordination with multiple counties within Washington is assumed to be the easiest type of transboundary coordination to manage (least challenging). Coordination across state borders with Oregon, Idaho, and tribes with reservation land requires a greater level of transboundary coordination (more challenging). Coordination across national borders is the most difficult level of transboundary coordination (most challenging). In all cases these assumptions are subject to change based on the working history of the transboundary parties.	No transboundary issues or limited county transboundary issues only.
	Major Land Owners (%)	Private Federal Tribes State	**Level 3**	Watersheds with large public land holdings are assumed to be less vulnerable to climate impacts. This assumption is based on a presumed ability to implement adaptation strategies over large areas of land. Within the realm of public ownership, state ownership is assumed to be more flexible than federal ownership given the ability to work more closely with state decision-makers and agency directors.	Large public land holdings, preferably state land holdings.

Category (Section No.)	**Primary Indicator**	**Sub-indicator**	**Indicator Level**	**General Assumptions *(all other factors held the same)***	**Vulnerability Reduction Bias (in favor of…)**
	Major Mountain Systems	Major Peak(s)	Descriptive only	No assumptions made	No bias
	Coastal/Estuary Zone	(y/n)	**Level 2**	Watersheds with coastal zones and estuarine areas are assumed to be more vulnerable to climate impacts than inland watersheds. With the exception of island watersheds, however, the additional vulnerabilities associated with coastal zones and estuaries may be relatively small in comparison with other vulnerabilities.	No bias. While coastal areas and estuaries incur some increased vulnerability, the increase is not sufficient to warrant a bias towards inland watersheds over coastal watersheds in Washington State.
	Other Factors of Note	Description	Contingent on entry	No assumptions made	No bias
Water Use (Sec. 6.4.3)	Population	Current	**LEVEL 1**	Watersheds with large population centers and/or rapid population growth projections are assumed to be more vulnerable to climate impacts given the total volume of customer demand that must be met, particularly in the drier summer months.	Stable population or low population growth rate projections
		Projected			
		Annual Growth Rate			
		% Change			
	Water Use by Source	Surface water (%)	**LEVEL 1**	Watersheds relying predominantly on surface water as a water source are assumed to be more vulnerable to climate impacts that those watersheds relying predominantly on groundwater.	Groundwater dominant systems
		Groundwater (%)			
	Dominant Water Supplier(s)?	(y/n), Description	**Level 3**	Watersheds where the majority of population is served by a few dominant water suppliers are assumed to be more able to adapt to climate impacts and therefore less vulnerable.	Fewer suppliers serving a larger proportion of the population
	Major Water Uses (Consumptive)	1st	**Level 2**	The vulnerability of specific water use categories to climate variability and climate change, and the role of water use categories in adapting to climate variability and climate change, will vary with each watershed based on development patterns, water use patterns, resource availability, and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.	Slight bias towards water uses considered to have more flexibility in adjusting use.
		%			
		2nd			
		%			
		3rd			
		%			
		Trends			

Category (Section No.)	Primary Indicator	Sub-indicator	Indicator Level	General Assumptions *(all other factors held the same)*	Vulnerability Reduction Bias (in favor of…)
	Major Surface Water Uses	1st % 2nd % 3rd %	**Level 2**	The vulnerability of major surface water uses to climate variability and climate change, and the role of different surface water uses in adapting to climate variability and climate change, will vary with each watershed based on development patterns and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.	Slight bias towards surface water uses considered to have more flexibility in adjusting use.
	Major Groundwater Uses	1st % 2nd % 3rd %	**Level 2**	The vulnerability of major groundwater uses to climate variability and climate change, and the role of different groundwater uses in adapting to climate variability and climate change, will vary with each watershed based on development patterns and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.	Slight bias towards groundwater uses considered to have more flexibility in adjusting use.
	Agricultural Water Use	Major Irrigated Crops Irrigated Acres (% or acres) Trends	Descriptive only	Watersheds with large amounts of irrigated agriculture are assumed to be more vulnerable to the hydrologic impacts associated with climate variability and climate change.	Slight bias in favor of fewer irrigated crops
	Major Water Storage Systems	Dams/Aquifer Storage and Recovery sites AF Storage Ratio of total storage to annual flow	**LEVEL 1**	Watersheds with storage reservoirs capable of storing a large percentage of total annual streamflow and carrying that capacity to the next year are less vulnerable to climate impacts (lower vulnerability). Watersheds with storage reservoirs storing a smaller percentage of total annual streamflow and/or lacking carryover capacity are more vulnerable to climate impacts (intermediate vulnerability). Watersheds with no major storage reservoirs are most vulnerable to climate impacts (higher vulnerability).	Reservoirs (above or below) with carryover storage capacity
	Other Factors of Note	Description	Contingent on entry	No assumptions made	No bias
Water Quality (Sec. 6.4.4)	Surface Water Quality Problems	Flow Temp DO pH Fecal Coliform TSS/Turbidity Metals Phosphorus Nitrogen Other Most common concern	**Level 2**	Watersheds with existing surface water quality problems are assumed to be more vulnerable to the impacts of climate variability and climate change. The more quality problems in the watershed, the more vulnerable the watershed is expected to be.	None or few surface water quality problems.

Category (Section No.)	**Primary Indicator**	**Sub-indicator**	**Indicator Level**	**General Assumptions *(all other factors held the same)***	**Vulnerability Reduction Bias (in favor of…)**
	Groundwater Quality Problems	Comments on Overall Quality Fecal Coliform Nitrates Phosphorus Iron Manganese Chlorides Salt Water Intrusion Other	**Level 2**	Watersheds with existing groundwater quality problems are assumed to be more vulnerable to the impacts of climate variability and climate change. The more quality problems in the watershed, the more vulnerable the watershed is expected to be. However, the extent to which groundwater quality is a source of vulnerability will depend on the size, location, and geologic properties of aquifers; land use patterns over the aquifer(s); and groundwater production and use within individual watersheds.	None or few groundwater quality problems.
	303(d) Water Bodies	(y/n), description	**Level 2**	The presence of Section 303(d) listed water bodies in a watershed is assumed to increase vulnerability to climate impacts.	No or few listed water bodies
	Other Factors of Note	Description	Contingent on entry	No assumptions made	No bias
Regulatory Characteris-tics (Sec. 6.4.5)	Total Annual Water Rights Allocation	Acre-feet or cu.ft./sec	Descriptive only	No assumptions made	No bias
	Surface Water Rights (acre-feet of cfs)	Annual SW Allocation	Descriptive only	No assumptions made	No bias
		Claims Applications	**Level 2**	Watersheds with large (by volume) and/or more (by number) outstanding water rights claims and applications are assumed to be more vulnerable to climate impacts given the constraints associated with granting new rights and/or modifying existing rights in high demand watersheds.	Less (by vol.) and/or fewer (by no.) outstanding water rights claims and applications.
		Estim. Actual Usage	**Level 3**	Watersheds where estimated actual surface water usage is less than 50% of allocated surface water rights may be less vulnerable to climate impacts given the buffering capacity in the system and the potential ability to allocate unused rights to instream flows, a major limiting factor in many watersheds. This assumption relies, however, on the presumption that: 1) the unused flows are real (i.e., the estimate is correct), and 2) the unused flows will be dedicated to meeting instream flow requirements before meeting any requests for new water rights.	Lower estimated usage

Category (Section No.)	**Primary Indicator**	**Sub-indicator**	**Indicator Level**	**General Assumptions *(all other factors held the same)***	**Vulnerability Reduction Bias (in favor of…)**
	Groundwater Rights (acre-feet or cfs)	Annual GW Allocation	Descriptive only	No assumptions made	No bias
		Claims	**Level 2**	Watersheds with large (by volume) and/or more (by number) outstanding water rights claims and applications are assumed to be more vulnerable to climate impacts given the constraints associated with granting new rights and/or modifying existing rights in high demand watersheds.	Less (by vol.) and/or fewer (by no.) outstanding water rights claims and applications.
		Applications			
		Estimated Actual Usage	**Level 3**	Watersheds where estimated actual usage for groundwater is less than 50% of allocated groundwater rights may be less vulnerable to climate impacts given the buffering capacity in the system and the potential ability to allocate unused rights to new uses.	Lower estimated usage
	Exempt Wells	Estim.Use/# Exempt Wells	**Level 3**	Watersheds where use of exempt wells is known or believed to be widespread are assumed to be more vulnerable to climate impacts due to: 1) the uncertainties in the number of wells and volume of water used, and 2) the sensitivity of these wells to small changes in groundwater levels.	Fewer exempt wells, when known
	Endangered Species	Endangered	**LEVEL 1**	Watersheds with endangered, threatened, or other at-risk species are considered more vulnerable to the hydrologic impacts of climate variability and climate change due to the potential restrictions placed on water use and other activities as a result of the listings.	No endangered species, or no to few threatened species or at-risk species
		Threatened			
		Other At-Risk Species			
	Instream Flows (INSF)	INSF Set?	**LEVEL 1**	Instream flow requirements and stream closures are assumed to increase a watershed's vulnerability to climate impacts by restricting adaptation options involving changes in flow, use, and/or storage.	No instream flow limitations and/or no closures
		Avg. # days (or %) below INSF			
		Stream Closures?			
		Comments	Descriptive only	No assumptions made	
	Total Maximum Daily Load (TMDL)	(y/n), description	**Level 2**	TMDL requirements in a watershed are assumed to increase the watershed's vulnerability to climate impacts. This assumption is largely based on the use limitations that may result from the TMDL standard, but may vary with the impaired water quality parameter.	No TMDL requirements
	Other Programs Affecting Water Use/Management	Description	Contingent on entry	No assumptions are made. The degree to which other programs affecting water use and management in a watershed increase or decrease vulnerability to climate impacts will depend on the specific nature of the program.	Will depend on the program

Category (Section No.)	**Primary Indicator**	**Sub-indicator**	**Indicator Level**	**General Assumptions *(all other factors held the same)***	**Vulnerability Reduction Bias (in favor of…)**
Watershed Planning (Sec. 6.4.6)	Natural Variability Addressed	(y/n), ENSO/PDO	**Level 2**	Watersheds examining the climate variability/hydrology relationship are assumed to be less vulnerable to climate impacts insofar as the relationship is understood and integrated into future decision making processes as appropriate.	Including variability
	Climate Change Addressed	(y/n), Description	**Level 2**	Watersheds acknowledging climate change impacts on water resources in watershed planning documents are assumed to be less vulnerable to climate impacts than those watersheds that have not recognized climate impacts. The more proactive the watershed is in addressing climate impacts, the less vulnerable the watershed may be.	Including climate change
	Using (or Possibly Using) Hydrologic Model?	(y/n)	**Level 2**	Watersheds with hydrologic models that are 1) based on quality data, 2) capable of reasonably evaluating the impact of "what if" scenarios on water resources, and 3) easily used by watershed resource managers, are assumed to be less vulnerable to climate impacts than watersheds without models or using models not meeting these criteria.	Using model meeting criteria
	Previous Multi-Stakeholder Planning	(y/n)	**Level 3**	Previous (successful) experience with watershed-based multi-stakeholder planning is assumed to reduce watershed vulnerability to climate impacts. However, because each planning effort is driven by different objectives and is likely to involve different people over time, previous success should not be considered predictive of future success.	Previous multi-stakeholder planning efforts completed successfully
	Planning Unit to Continue?	Yes/No/Not Certain	**Level 2**	Watersheds with planning units expecting to continue in some type of formal capacity are assumed to be less vulnerable to climate impacts than watersheds with no continuing planning unit, or where continuation is uncertain at the time of the vulnerability assessment	Continuing in some type of formal capacity
	Will Update Plans	Yes/No/Not Certain	**Level 2**	Watersheds where planning units have set a schedule (or intend) to update their watershed plans are assumed to be less vulnerable to climate impacts than watersheds not expecting to update their watershed plans. The more frequent the updating, the more likely the watershed will be able to fine-tune management strategies to manage climate impacts (further reducing potential vulnerability).	Updating plans
	Major Planning Challenges Sensitive to Climate?	(y/n), Description	**LEVEL 1**	Watersheds where major planning challenges are sensitive to climate impacts are assumed to be more vulnerable to climate variability and climate change.	Planning challenges not sensitive to climate impacts

Category (Section No.)	Primary Indicator	Sub-indicator	Indicator Level	General Assumptions *(all other factors held the same)*	Vulnerability Reduction Bias (in favor of…)
	Perceived Level of Adaptation Flexibility (from Leads)	Description	**LEVEL 1**	Watersheds where the level of flexibility for adapting to climate imapcts is thought to be good by the Watershed Planning Leads are assumed to be less vulnerable to climate impacts. This is a subjective assessment from the Leads, however, and may be subject to change.	Good flexibility
	Drought Plan Developed and Up to Date?	(y/n), Comments	**Level 2**	Watersheds where comprehensive drought management plans have been developed and are kept up to date are assumed to be less vulnerable to droughts resulting from climate variability and climate change. The more inclusive the range of drought scenarios included in the drought plan, the more effective the plan may be in managing droughts brought on by climate variability and climate change.	Drought plans ideveloped and current
	Other Factors	Description	Contingent on entry	No assumptions made	No bias

<u>Nominal Conditions for Increased Vulnerability</u> (see Section 6.5.4)

The following combination of **nominal vulnerability** characteristics is provided to serve as an example of how individual vulnerability indicators can combine to increase vulnerability in a watershed. This combination of characteristics represents a hypothetical case but is likely to apply at least in part to many watersheds in Washington State. Additional characteristics not included in this list may also leave a watershed vulnerable. Conditions are listed by vulnerability indicator category.

Indicator Category: Climate and Hydrology
- Transient basin or lower elevation snow dominant basin *(Type of Basin indicator)*
- Lower average annual precipitation or large disparities between the upper and lower basin precipitation values, which forces greater reliance on upper level precipitation *(Annual Precipitation indicator)*
- Higher basin-wide summer temperatures and/or winter temperatures nearing freezing in the primary watershed catchment area(s) *(Average Temperatures indicator)*

Indicator Category: Water Use
- High projected population growth rate relative to current population *(Population indicator)*
- Watershed population largely dependent on surface water *(Water Use by Source indicator)*
- Little carryover storage capacity for managing floods as well as droughts *(Major Water Storage Systems indicator)*

Indicator Category: Regulatory Characteristics Indicator
- Uncertainty over the use status of surface and/or groundwater rights *(combined overview of all Surface Water Rights, Groundwater Rights sub-indicators)*
- Instream flow restrictions present *(Instream Flows indicator)*
- Total Maximum Daily Load restrictions *(TMDL indicator)*

Indicator Category: Watershed Planning
- Major watershed planning challenges sensitive to climate variation and change *(Major Planning Challenges Sensitive to Climate indicator)*
- Little adaptation flexibility *(Perceived Level of Adaptation Flexibility indicator)*

6.4.1 Climate and Hydrology Indicators

The following explains how indicators related to climate and hydrology can be considered in a vulnerability analysis.

6.4.1.1 Indicator: Major Water Sources

Sub-indicator(s): Surface water, Groundwater

Description: Helps define the overall watershed. Identifies dominant surface water and groundwater systems by name (for surface water) or by description (for groundwater).

Indicator Level: Descriptive only

Bias in favor of: None

Assumptions: No assumptions made.

6.4.1.2 Indicator: Type of Basin

Sub-indicator(s): Rain/Transient/Snow

Description: The Type of Basin indicator identifies watersheds as rain dominant, transient, or snow dominant basins. A description of each type follows. A hydrograph should be used in all cases to confirm the type of basin.

Rain dominant basins: The dominant form of winter precipitation is rain. Rain dominant basins may be more vulnerable to flooding as a result of projected increases in winter precipitation. In the absence of storage, rain dominant basins are also more vulnerable to summer low flows given the absence of any snowpack to supplement river flows in the early and mid-summer. Rain dominant basins are more difficult to model given the influence of individual rain events on flows.

Transient basins: Winter precipitation falls as rain and snow. Transient basins may be more vulnerable to decreases in winter snowpack (and hence lower summer flows) given that average winter temperatures in these basins sit at or near the freezing threshold (32° F), and are therefore sensitive to a few degrees of warming. Transient basins may also be more vulnerable to increased flooding as a result of more winter rain and rain-on-snow events.

Snow dominant basins: The dominant form of winter precipitation is snow. Snow dominant basins may be more vulnerable to decreasing snowpack (and hence lower summer flows), particularly near the snowline where average winter temperatures are near 32° F. Snowpack at upper elevations may be unaffected if average winter temperatures at upper elevations are sufficiently below freezing even with several degrees warming. Modeling and forecasting flows in snow dominant basins is technically easier due to the general predictability of snowpack measurements and runoff patterns.

Indicator Level: Level 1 (high)

Bias in favor of: Rain dominant, then snow dominant, and finally transient basins

Assumptions: For the purpose of this analysis, the following is generally assumed when considering basin type:

- Rain dominant basins are assumed to be least vulnerable to climate impacts, all other factors held the same (lower vulnerability).
- Snow dominant basins are assumed to be more vulnerable to climate impacts than rain dominant basins but less vulnerable than transient basins, all other factors held the same (intermediate vulnerability); and
- Transient basins are assumed to be most vulnerable to climate impacts, all other factors held the same (higher vulnerability).

6.4.1.3 Indicator: Annual Surface Water Flow

Sub-indicator: Average Annual Flow Rates (cubic feet per second or acre-feet)

Description:	The Average Annual Flow Rates sub-indicator provides perspective on the size of the major surface water system.
Indicator Level:	Level 3 (low)
Bias in favor of:	Higher average annual flows
Assumptions:	At a very basic level, higher flows could reduce vulnerability to climate impacts given that more water is available (theoretically) for use and storage. It is assumed, therefore, that WRIAs with higher average annual flow rates are less vulnerable to climate impacts, all other factors the same. However, because flow measurement does not address the seasonality of flows or current levels of water allocation, the indicator is ranked only as a Level 3 indicator.

Sub-indicator:	*Trends in Flow Volume*
Description:	Trends in Flow indicates whether the total volume of stream flow in major rivers is increasing or decreasing over time. Seasonal trends (changes in summer versus winter streamflow levels) should also be considered.
Indicator Level:	Level 1 (high)
Bias in favor of:	No decrease in flows over time
Assumptions:	Changing trends in flow may result from changes in land use, changes in stream channel morphology, increasing temperatures, and other factors. If flows are decreasing over time, particularly during the dry summer months, meeting current and future water demands may become more difficult. It is assumed, therefore, that WRIAs with declining trends in flow are more vulnerable to climate impacts. Although it may be difficult to definitively prove that declining flow trends are related to long-term climate trends, the net effect of reductions in flow, regardless of the cause, is essentially the same. Making the link to long-term climate trends will depend on the length of the data record for various parameters (e.g., precipitation, temperatures, snowpack, streamflow), data quality, and the ability to control for other potential causes in the analysis (e.g., changes in land use).

Sub-indicator(s): *Shifts in the Timing of Peak Flows*

Description: A projected impact of climate change is an earlier shift in peak runoff for snow-dominant and transient (mix rain/snow) basins. The Shifts in the Timing of Flows sub-indicator identifies watersheds where there has been a change in the timing of traditional peak runoff period(s).

Indicator Level: Level 1 (high)

Bias in favor of: No shifts in the timing of flows

Assumptions: Timing shifts to earlier peak flows increase the span of time between the spring freshet and fall rains, lengthening the summer dry season and potentially affecting water availability for irrigation, salmon migration, and other water uses during the spring and summer. Watersheds where there is evidence of a shift in the timing of flows are therefore assumed to be more vulnerable to the impacts of climate variability and climate change.

6.4.1.4 Indicator: Average Annual Basin Precipitation

Sub-indicator(s): *Total Basin, Lower Basin, Upper Basin Averages (inches)*

Description: The Average Annual Basin Precipitation indicator describes how much precipitation a watershed receives on average in a year. The Annual Average sub-indicator gives the annual average precipitation value for the entire watershed. The Lower Basin and Upper Basin Average sub-indicators describe how much precipitation falls annually on average in the lower and upper portions of the watershed.

Indicator Level: Level 1 (high)

Bias in favor of: Higher average precipitation levels

Assumptions: Watersheds receiving more precipitation overall may be less vulnerable to the hydrologic impacts of climate variability and climate change due to the increase in overall supply. The seasonality of precipitation increases, where the precipitation falls (with respect to elevation), and the form of precipitation (rain, snow, or rain/snow mix) are important factors to consider when assessing this indicator; some basins may still be sensitive to climate impacts even with high precipitation values (see Section 6.4.1.2). It is worth noting that watersheds with high annual precipitation values may be more vulnerable to wet season flooding as well.

6.4.1.5 Indicator: Average Temperature

Sub-indicator(s): *Summer – Total Basin Average, Summer - Lower Basin Average, Summer – Lower Basin Maximum Average Temperature; Winter – Total Basin Average, Winter – Upper Basin Average, Winter – Upper Basin Minimum Average Temperature.*

Description: The Average Temperature indicator describes average summer and winter temperatures for the total watershed, the lower portion of the watershed, and the upper portion of the watershed.

Indicator Level: Level 1 (high)

Bias in favor of: Moderate summer temperatures and/or winter temperatures well below or well above freezing.

Assumptions: Vulnerability to increases in temperature will vary depending on the type of basin the watershed sits in (rain dominant, transient, or snow dominant) and the seasonality of temperature increases (summer versus winter). In general, increasing average temperatures may:

- Push average winter temperatures close to or above the freezing point (32°F), resulting in a change in the dominant type of winter precipitation from less snow to more rain. This change will decrease winter snow pack (and resulting summer flows) while increasing winter flows and the potential for flooding from more rain and rain-on-snow events; and/or
- Decrease summer water availability as a result of changes in winter snowpack (see above) and higher demands for irrigation (due in part to reduced soil moisture and higher evapotranspiration), urban water use, and instream flows (to provide flows for fish and manage water temperatures).

The following, therefore, is generally assumed when considering average temperatures:

For summer temperatures:

- High average summer temperatures for the lower basin may increase vulnerability in all types of basins (rain, transient, or snow dominant) by increasing the demand for water resources while concurrently increasing evaporative losses from surface water systems. If long-term temperature data for the lower basin cannot be found, average summer temperature for the entire basin may serve as a guide.

For winter temperatures:

- Watersheds where average upper basin winter temperatures are at or near freezing (transient basins) are assumed to be more vulnerable to the hydrologic impacts of climate variability and climate change due to changes in the type of winter precipitation (more rain, less snow). The potential for more winter flooding is also increased given projections for an overall increase in winter precipitation and the potential for more rain-on-snow events.
- Watersheds where average upper basin winter temperatures are well below freezing (snow-dominant basins) are less vulnerable than transient basins to overall changes in snowpack, but may still lose snowpack near snowline due to changed precipitation and/or warming temperatures.
- Watersheds where average upper basin winter temperatures are already well above freezing (rain-dominant basins) are least vulnerable to changes in snowpack but may be may be more vulnerable to winter flooding given the projections for increased winter precipitation in climate change scenarios.

- If long-term temperature data for the upper basin cannot be found or used, the average winter temperature for the entire basin may serve as a guide. Also, if a watershed receives a large proportion of its water supply from mid or low elevation tributaries, the average winter temperature for the lower basin may be beneficial. The above assumptions for average upper basin winter temperatures apply to total basin and lower basin average temperatures as well.

These assumptions apply to both surface water and groundwater supplies given the hydrologic continuity of most groundwater systems to surface water bodies. The use of deeper, regional aquifer systems not closely connected to surface water may be less vulnerable in the short-run to changes in snowpack but be may more vulnerable to overproduction as a result of increased summer water demands. Groundwater recharge may also be reduced due to reductions in soil moisture, which affects the amount of precipitation and/or irrigation water that percolates through the soil column to the groundwater table.

6.4.1.6 Indicator: Major Precipitation Season

Sub-indicator(s): *Months, Percent of Total*

Description: The Major Precipitation Season indicator identifies when the majority of precipitation falls in the watershed and the percent of total precipitation that falls during that time.

Indicator Level: Descriptive only

Bias in favor of: None

Assumptions: No assumptions are made regarding the Major Precipitation Season indicator given that the dominant precipitation season is consistent for all watersheds in Washington State (generally October through March).

6.4.1.7 Indicator: Low Flow Periods

Sub-indicator(s): *Time Frame*

Description: The Low Flow Periods indicator identifies what months are typically low flow periods for Washington State rivers and streams.

Indicator Level: Descriptive only

Bias in favor of: None

Assumptions: No assumptions are made regarding the Low Flow Periods indicator given that low flow periods are consistent for all watersheds in Washington State (generally July through September).

6.4.1.8 Indicator: Other Factors of Note

Sub-indicator(s): *Description*

Description: The Other Factors of Note indicator provides an opportunity to note other factors not reflected in the Climate and Hydrology indicators list that may affect watershed vulnerability.

Indicator Level: Contingent on entry

Bias in favor of: None

Assumptions: No assumptions are made.

6.4.2 Land Use and Land Features

The following explains how indicators related to land use and land features can be considered in a vulnerability analysis.

6.4.2.1 Indicator: Watershed Size

Sub-indicator(s): *Acres, Square Miles*

Description: The Watershed Size indicator describes the overall size of the watershed.

Indicator Level: Level 3 (low)

Bias in favor of: Larger watersheds

Assumptions: Larger watersheds are assumed to have an adaptation advantage and therefore are assumed to be less vulnerable the climate impacts, although this advantage is expected to be minimal and heavily influenced by other factors in the watershed. Potential advantages of a larger watershed (i.e., factors that may reduce vulnerability) include:

- (+) A greater variety of surface water sources (more streams and rivers located at various elevations).
- (+) Greater access to groundwater resources (through access to new groundwater sources or greater access to an existing groundwater source).
- (+) More opportunities for off-stream storage (possibly more varied topography and water sources).
- (+) More opportunities for water use transfers (either due to land uses within the WRIA or through sub-basin water transfers from one water system to another).
- (+) More opportunities for funding. Larger WRIAs may be more competitive in applying for additional funding opportunities.

Potential disadvantages of a larger watershed (i.e., factors that may increase vulnerability) include:

- (-) A greater number of stakeholders and governing authorities may be involved in the planning effort and implementation of subsequent planning measures. More coordination is required.
- (-) Population centers and other water users may be more scattered, making system inter-ties and water transfers cost prohibitive.

Individual watersheds that undertake watershed planning as a single planning unit (e.g., WRIAs 37/38/39) are viewed as a large watershed under this indicator. In these cases, the joint planning effort is likely to improve coordination of water management across watershed boundaries and provide more options for incorporating adaptation strategies (in addition to the advantages and disadvantages listed above).

6.4.2.2 Indicator: Elevation Range

Sub-indicator(s): *Low (feet), High (feet)*

Description: The Elevation Range indicator describes the highest and lowest elevation ranges in the watershed.

Indicator Level: Level 1 (high)

Bias in favor of: Rain-dominant basins, then snow-dominant basins; transient basins are most vulnerable.

Assumptions: Elevation ranges affect how winter precipitation collects within the WRIA. In accordance with climate impacts research, vulnerability to climate change impacts may vary with elevation. For the purpose of this analysis, the following is generally assumed when considering elevation ranges:

- Sea level to ~3,000 feet: The estimated range for rain-dominant basins (see 6.4.1.2). WRIAs with elevations ranging from sea level to ~3,000 feet are assumed to be least vulnerable to climate impacts, all other factors held the same.
- ~3,000 to ~6,000 feet: The estimated range for transient basins (see 6.4.1.2). WRIAs with elevations ranging from ~3,000 to ~6,000 feet are assumed to be most vulnerable to climate impacts, all other factors held the same.
- ~6,000 feet and higher: The estimated elevation range for snow-dominant basins (see 6.4.1.2). WRIAs with elevations of ~6,000 feet and higher are assumed to be more vulnerable to climate impacts than rain-dominant basins but less vulnerable than transient basins, all other factors held the same.

The given elevation ranges are meant to serve as a guide only for initial assessment of basin type. A hydrograph and average winter temperatures should be used in all cases to confirm the basin type.

6.4.2.3 Indicator: Major Land Uses

Sub-indicator(s): *1st (acres or %), 2nd (acres or %), 3rd (acres or %), Other (acres or %), Trends*

Description: The Major Land Uses indicator describes the first, second, and third most predominant land uses in the watershed. Trends in land uses are also identified.

Indicator Level: Level 2 (medium)

Bias in favor of: No bias.

Assumptions: Land uses may directly and/or indirectly affect a watershed's vulnerability to climate variability and climate change. Land uses may also shape options for adaptation. Preliminary reviews of Level 1 Technical Assessments for the Watershed Planning Program indicate that forestry, agriculture, and urban development are the three most common land uses in Washington State. Advantages (+) and disadvantages (-) of different land uses with respect to vulnerability and adaptation to climate impacts include the following:

Urban dominated watersheds:

- (+) Urban areas may have more options for adapting to climate impacts depending on the size of the customer base, the political weight of the urban area, and financial resources. For example, watersheds where urban development is a major land use may find that conservation and water re-use are options for expanding future water supplies. Urban areas may also be able to secure more water by purchasing water rights through a market-based approach (if available) or land purchases. This option may be limited, however, by the availability (or lack thereof) of infrastructure for water transfers.

- (+) Urban areas are typically served by one or a few dominant water suppliers, facilitating implementation of conservation programs, retrofitting programs, changes in policies, and other adaptation options among water users.
- (-) Urbanization increases the “flashiness” of stormwater runoff due to the expansion of paved areas. This may leave urban areas more vulnerable to flooding associated with natural climate variability and climate change. Increased development within and along flood plains increases this risk. Increased stormwater runoff can also have adverse impacts on salmonid habitat.
- (-) Costs to minimize the impacts of flooding, such as installation of dikes, rip-rap, and/or dams, may be higher in urban areas.
- (-) Urbanization often leads to habitat loss and reduced water quality. These effects may be worsened by climate variability and climate change and/or trigger additional regulatory requirements that potentially limit water use and adaptation options.

Agricultural dominated watersheds:

- (+) Approximately 80% of water use in Washington State is associated with agriculture. Given this, agricultural areas may have better access to water via transfer of water rights between water uses.
- (-) Agricultural areas are generally more vulnerable to drought impacts associated with climate variability and change; agricultural land owners have few options economically when drought limits farming.
- (-) Agricultural land uses can lead to the degradation of water quality and habitat. As in urban areas, these impacts may be worsened by climate variability and climate change, and/or may

trigger additional regulatory requirements that potentially restrict water use. Increased stormwater runoff in agricultural areas can increase sediment loads in surface water bodies, potentially affecting salmonid habitat, degrading water quality, and increasing the risk of flooding if sediments are not dredged.

Forest dominated watersheds:

- (+) Forests can have a moderating effect on surface and groundwater flow (Keeton et al., in review). Therefore, forested watersheds may be able to better moderate increases in winter precipitation and release from groundwater into surface water systems.
- (+) If forest productivity increases as a result of climate change (due to higher precipitation levels in the spring/fall "shoulder" season or summer, and/or improved vegetation water use efficiency), forests may expand into shrub-steppe communities and alpine areas. Logging economies may benefit. Habitat diversity may benefit as well, depending on if and to what extent species composition shifts in response to climate change (and what habitats forests expand in to). Note: any increases in productivity may be transient at best (~100 years) if summer temperatures outpace increases in precipitation (ibid).
- (-) If forests decline as a result of climate change (due to higher summer temperatures, soil moisture deficits, and disturbance events) long-term reductions in timber yields may have a detrimental effect local economies dependent on logging. Reduced forest cover also has implications for water quality and water quantity. Declines may be more pronounced on the east side of the Cascades and interior Washington at low elevation interfaces between forested and non-forested plant communities (ibid).
- (-) Shifts in species composition over time may trigger additional

regulatory requirements for protection of threatened and endangered plant and animal species (ibid).

- (-) Logging, development, drought, fire, and insect disturbances in forested areas may affect water quantity (e.g., increased frequency and intensity of stormwater runoff), water quality (e.g., increased sedimentation and temperatures), and habitat diversity. These effects may become more problematic as the potential for drought, fire, and pests increases under climate change.

6.4.2.4 Indicator: Major City(ies)

Sub-indicator(s): *None*
Description: The Major City(ies) indicator identifies one or more major cities in the watershed.
Indicator Level: Descriptive only
Bias in favor of: None
Assumptions: No assumptions made.

6.4.2.5 Indicator: Counties

Sub-indicator(s): *None*
Description: The Counties indicator identifies the counties the watershed is located in.
Indicator Level: Descriptive only
Bias in favor of: None
Assumptions: No assumptions made.

6.4.2.6 Indicator: Transboundary Issues

Sub-indicator(s): *County, State, Tribal, Canada*
Description: Most watersheds extend into two or more counties. However, some watersheds also cross state, tribal, and national borders. The Transboundary Issues indicator identifies whether the watershed crosses county, state, tribal (i.e., reservation), and/or national boundaries. In these

cases, management may require recognizing factors outside the watershed that affect water quantity and quality, and may require more coordination with cross-boundary watershed parties.

Indicator Level: Level 2 (medium)

Bias in favor of: No transboundary issues or limited county transboundary issues only.

Assumptions: Watersheds with transboundary issues are expected to face more challenges implementing coordinated adaptation efforts. Potential transboundary challenges include:

- General lack of administrative control over all parts of the water supply;
- Different standards for water quality and water allocation across boundaries;
- Different enforcement policies for water quality and water use violations;
- Different natural resource, land use, and development philosophies, priorities, and objectives;
- Different monitoring capacities; and
- Different preferences for information sharing.

The extent to which these challenges apply will depend largely on the nature of the transboundary setting. Given this, the following hierarchy is generally assumed in assessing transboundary issues:

- <u>Least Challenging</u>: Coordination with multiple counties within Washington is assumed to be the easiest type of transboundary coordination to manage due to consistencies in regulations and increased likelihood that the counties have worked with each other in the past on other issues.
- <u>More Challenging</u>: Coordination across state borders with Oregon and Idaho requires a more challenging level of transboundary

coordination largely due to differences in regulatory standards, management objectives, monitoring, and enforcement. Coordination across tribal borders is also considered more challenging due to different natural resource, land use, and development philosophies, particularly when the tribes has reservation land within the watershed. Information sharing between tribal and non-tribal parties has also been a challenge in some watershed planning efforts.

- Most challenging: Coordination across national borders is the most difficult level of transboundary coordination due to many of the reasons listed above.

In all cases these assumptions are subject to change based on the working history of the transboundary parties.

6.4.2.7 Indicator: Major Land Owners

Sub-indicator(s): *Private (%), Federal (%), Tribal (%), State (%)*

Description: The Major Land Owners indicator identifies the percentage of land owned by private, federal, tribal, and state interests.

Indicator Level: Level 3 (low)

Bias in favor of: Large public land holdings, preferably state land holdings.

Assumptions: The dominance of one type of land ownership over another may affect adaptation options. Advantages (+) and disadvantages (-) to private land ownership with respect to adapting to climate impacts include the following:

- (+) Private land owners may be able to respond more quickly to a changing environment.
- (-) Private land owners may be reluctant to incur the costs of adaptation if they do not see the benefits of such action directly benefiting them.

- (-) A large percentage of private land holdings held by a large number of individual property owners may make it more difficult to implement coordinated adaptation strategies.

Advantages (+) and disadvantages (-) to public land ownership with respect to adapting to climate impacts include the following:

- (+) Implementing adaptation strategies may be easier and more effective when large portions of a watershed are publicly owned (there are fewer parties to work with and implementation occurs uniformly, more or less, over a larger areas of the watershed).
- (-) If there are multiple public landowners, implementation may become more difficult due to different agency mandates. This problem may be exacerbated when the public landowners are based in different levels of government (e.g., federal agencies, state agencies, local agencies)
- (-) The issue of adapting to climate impacts through public agencies may get mixed into the larger political debate on climate mitigation (i.e., emissions reductions), making it difficult to move forward on adaptation strategies involving public lands. Some individuals who are unwilling or reluctant to become involved in mitigation debates may perceive discussing climate adaptation options as an acknowledgement that climate change is occurring. This may be particularly true if the adaptation strategy(ies) require legislative action.

Given these considerations, it is assumed that watersheds with large public land holdings are less vulnerable to climate impacts. This assumption is based on a presumed ability to implement adaptation strategies over large areas of land. Within the realm of public ownership, state ownership is assumed to be more flexible than federal ownership given the ability to work more closely with state decision-makers and agency directors.

6.4.2.8 Indicator: Major Mountain Systems

Sub-indicator(s):	*None*
Description:	The Major Mountain Systems indicator identifies one or more major mountain systems in a watershed.
Indicator Level:	Descriptive only
Bias in favor of:	None
Assumptions:	No assumptions made.

6.4.2.9 Indicator: Coastal/Estuary Zone

Sub-indicator(s):	*Yes/No*
Description:	The Coastal/Estuary Zone indicator identifies watersheds with coastal zones and estuaries.
Indicator Level:	Level 2 (medium)
Bias in favor of:	No bias. While the presence of coastal areas and estuaries incur some increased vulnerability, the increase is not sufficient to warrant a bias towards inland watersheds over coastal watersheds in Washington State[20].
Assumptions:	Watersheds with coastal zones and estuaries face additional challenges from climate impacts specific to these areas. Global seal level rise may lead to increased erosion and habitat loss along coastal areas and estuaries. Coastal wetlands are particularly vulnerable. Inward migration of coastal and estuarine wetland habitats in response to sea level rise is limited in many areas due to dikes, levees, fill, and other developments designed to

[20] Precipitation and temperatures differences between eastern and western Washington have created very distinct water supply and use characteristics in the state. Climate west of the Cascades is a maritime climate with cool wet winters and mild dry summers. Average precipitation west of the Cascades ranges from approximately 30 inches to greater than 200 inches (water equivalent) annually (Mote et al. 1999). Climate east of the Cascades is more continental with hotter summer days and colder winters. Average annual precipitation east of the Cascades is generally less than 20 inches but falls to as little as 7 inches in a large portion of eastern Washington (ibid). A bias may be evident in areas outside the Pacific Northwest where coastal and inland climates are more uniform.

protect near-shore properties (Burkett and Kusler 2000). The loss of coastal and estuarine habitat can have critical secondary impacts on salmonids and other sensitive species dependent on these areas.

Saltwater intrusion into freshwater sources is another potential vulnerability for coastal and estuarine watersheds. Groundwater sources may be contaminated by saltwater as a result of sea level rise and/or increased groundwater production in areas adjoining coastal/estuary zones. Rivers draining into coastal or estuarine areas are also vulnerable to saltwater intrusion from sea level rise and/or drought, which can lead to decreased discharges from rivers and/or increased surface water withdrawals at points close to the tidal reach of rivers[21]. In most cases, the severity of the saltwater intrusion will depend largely on shoreline hydrologic gradients, groundwater pumping rates, and the location of surface withdrawal points and/or groundwater wells (Winter 2000).

Saltwater may also prove to be a benefit for coastal areas. Advancements in desalination technologies continue to bring the costs of desalination down, potentially making desalination an option for water supply in the future. As noted in Section 5.4.3, desalination is currently being done on a small scale in WRIA 2. Deer Harbor (on Orcas Island, WRIA 2) is also moving towards desalination.

For the purpose of assessing vulnerability, watersheds with coastal zones and estuarine areas are assumed to be more vulnerable to climate impacts than inland watersheds. With the exception of island watersheds, however, the additional vulnerabilities associated with coastal zones and estuaries may be relatively small in comparison with other vulnerabilities.

---

[21] As noted by Winter (2000), the City of Poughkeepsie, New York temporarily lost use of the Hudson River as a source of drinking water in the mid-1990s when low flow conditions in the Hudson induced salt water intrusion to

6.4.2.10 Indicator: Other Factors of Note

Sub-indicator(s):	*Description*
Description:	The Other Factors of Note indicator provides an opportunity to note other factors not reflected in the Land Use/Land Features indicators list that may affect watershed vulnerability.
Indicator Level:	Contingent on entry
Bias in favor of:	None
Assumptions:	No assumptions are made.

6.4.3 Water Use Indicators

The following explains how indicators related to water use can be considered in a vulnerability analysis.

6.4.3.1 Indicator: Population

Sub-indicator(s):	*Current, Projected, Annual Growth Rate, % Change*
Description:	The Population indicator provides information on how populous a watershed is and whether population growth is expected to be a major factor in future water resource development.
Indicator Level:	Level 1 (high)
Bias in favor of:	Stable population or low population growth rate projections
Assumptions:	Watersheds with large population centers and/or rapid population growth projections are assumed to be more vulnerable to climate impacts given the total volume of customer demand that must be met, particularly in the drier summer months. Pressure for continued development in large population centers with high growth and the need to secure water rights to accompany that growth may also leave urban areas vulnerable to climate impacts. This assumption will depend largely on the overall amount of

points beyond the water supply intake pipe for the city.

water available in the watershed and the availability of new or transferable water rights.

6.4.3.2 Indicator: Water Use by Source

Sub-indicator(s): *Surface water (%), Groundwater (%)*

Description: The Water Use by Source indicator identifies what portion of water use in the watershed is derived from surface water sources versus groundwater sources.

Indicator Level: Level 1 (high)

Bias in favor of: Groundwater dominant systems

Assumptions: Both surface water and groundwater are used extensively throughout Washington State for water supply. Each source has its own capacity to increase and/or decrease vulnerability to climate impacts. More specifically:

Surface Water

- (+) Surface water is visible to water managers and users; management boundaries are clear, as is water availability and how changes in use affect flows. The impacts of drought are clearly visible, providing additional incentive to users to conserve.
- (-) Surface water flows are more sensitive to short term and annual droughts. In transient and snow dominant basins, spring and summer flows may be reduced by climate impacts on snowpack.
- (-) Surface water use is subject to many regulatory limitations, including water rights, water quality standards, and instream flow obligations.
- (-) Surface water quality is affected by changes in temperature. Water quality problems may affect large stretches of streams or river systems.
- (-) Constructing additional surface water storage may be difficult due to the limited availability of good sites, significant

infrastructure costs, the cost of purchasing property rights, limited availability of additional water rights to fill new reservoirs, and concerns over impacts on salmon and other endangered species. Evaporative losses can be significant during the dry summer months.

Groundwater

- (+) Groundwater resources generally act as a buffer against seasonal and annual droughts. Drought impacts on groundwater levels may take a year or more to show up, particularly if the aquifer is deep.
- (+) Projected increases in winter precipitation may provide more recharge to aquifer systems, potentially enhancing the buffering effect.
- (+) Groundwater quality is not directly affected by increases in temperature. Additionally, groundwater quality problems tend to be localized.
- (+) New wells for groundwater can be drilled without a state water right provided the volume of water produced is less than 5,000 gallons per day and meets other conditions specified for exempt well status (See Exempt Wells indicator, Section 6.4.5.4).
- (+) Although still somewhat experimental, aquifer storage may be easier to implement. Aquifer storage generally does not require purchasing property rights or extensive infrastructure, and evaporative losses are not a factor. The availability of water rights for storage and suitable aquifer conditions for storage may still be a challenge.
- (-) Groundwater recharge can be very slow; once an aquifer is impacted by a drought, recovery may be slow.
- (-) There are often many unknowns about the size and volume of aquifers. Uncertainties may include how extensive the aquifer

system is with respect to area and depth, how much water is available, and what the impact of groundwater production is on surface water systems (hydrologic continuity).

- (-) Remediating groundwater contamination can be lengthy and costly. In coastal areas, heavy groundwater production may result in saltwater intrusion, affecting water quality.

For the purpose of a vulnerability analysis, watersheds that rely predominantly on surface water as a water source are assumed to be more vulnerable to climate impacts that those watersheds relying predominantly on groundwater.

6.4.3.3 Indicator: Dominant Water Supplier(s)?

Sub-indicator(s): *Yes/No, Description*

Description: The Dominant Water Supplier(s) indicator identifies which watersheds are served by one or more dominant public, private, and/or community water suppliers.

Indicator Level: Level 3 (low)

Bias in favor of: Fewer water suppliers serving a larger proportion of the watershed's population

Assumptions: Watersheds with populations served by a large number of water suppliers[22], or where the majority of the population is served by private residential wells, may face additional logistical, financial, and political challenges in responding to climate impacts. Large and/or watershed-scale responses may be too costly for small and medium sized water systems. At the same time, building consensus among the numerous parties may prove tactically difficult if all parties do not see value to the response.

[22] No specific number of suppliers has been identified or suggested. While the answer may be clear in some cases, the decision on what is too many will depend largely on the nature of the watershed and the working relationship different utilities and water suppliers have established over time.

Watersheds with populations predominantly served by residential wells pose a similar challenge. It is theoretically more difficult to work with 10,000 individual users to implement an adaptation strategy than 10 suppliers, for example, serving the same population. Consequently, watersheds where the majority of population is served by a few dominant water suppliers are assumed to be more able to adapt to climate impacts and therefore less vulnerable.

6.4.3.4 Indicator: Major Water Uses (Consumptive)

Sub-indicator(s): *1st (%), 2nd (%), 3rd (%), Trends*

Description: The Major Water Uses indicator identifies the first, second, and third most predominant consumptive[23] water uses in the watershed by type and percentage of total water use. Trends in water uses are also identified in this indicator.

Indicator Level: Level 2 (medium)

Bias in favor of: Slight bias towards water uses considered to have more flexibility in adjusting use.

Assumptions: Dominant consumptive water uses in Washington State include irrigated agriculture, municipal and domestic water supply, and commercial/industrial water supply. The degree to which individual water uses are affected by climate impacts will vary with use patterns and resource availability. In general, however, demand for the dominant consumptive water uses increases in the summer when water supplies are lowest.

The vulnerability of specific water use categories to climate variability and

[23] The term "consumptive use" refers to "that part of water withdrawn that is evaporated, transpired, incorporated into products and crops, consumed by humans or livestock, or otherwise removed from the immediate water supply" (USGS, http://water.usgs.gov/watuse/wuintro.html).

climate change, and the role of individual water use categories in adapting to climate variability and climate change, will vary with each watershed based on development patterns, water use patterns, resource availability, and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.

6.4.3.5 Indicator: Major Surface Water Uses

Sub-indicator(s): *1st (%), 2nd (%), 3rd (%)*

Description: The Major Surface Water Uses indicator identifies the first, second, and third most predominant surface water uses in the watershed by type and percentage of total surface water use.

Indicator Level: Level 2 (medium)

Bias in favor of: Slight bias towards surface water uses considered to have more flexibility in adjusting use.

Assumptions: The vulnerability of major surface water uses to climate variability and climate change, and the role of different surface water uses in adapting to climate variability and climate change, will vary with each watershed based on development patterns and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.

6.4.3.6 Indicator: Major Groundwater Uses

Sub-indicator(s): *1st (%), 2nd (%), 3rd (%)*

Description: The Major Groundwater Uses indicator identifies the first, second, and third most predominant groundwater uses in the watershed by type and percentage of total groundwater use.

Indicator Level: Level 2 (medium)

Bias in favor of: Slight bias towards groundwater uses considered to have more flexibility in adjusting use.

Assumptions: The vulnerability of major groundwater uses to climate variability and climate change, and the role of different groundwater uses in adapting to climate variability and climate change, will vary with each watershed based on development patterns and community preference. Therefore, no assumptions are made at this level of analysis about the role of specific water uses in determining watershed vulnerability or adaptive capacity.

6.4.3.7 Indicator: Agricultural Water Use

Sub-indicator(s): *Major Irrigated Crops, Irrigated Acres (% or acres), Trends*

Description: The Agricultural Water Use indicator identifies the major irrigated crops in a watershed and the total number of irrigated acres (either by number or as a % of total farmland).

Indicator Level: Descriptive only

Bias in favor of: Slight bias in favor of fewer irrigated crops.

Assumptions: Approximately 80% of total water use in Washington State occurs in agriculture. In general, it is assumed that watersheds with large amounts of irrigated agriculture are more vulnerable to the hydrologic changes associated with climate variability and climate change. Absent substantial changes in reservoir management policies, irrigation technologies, or other variables (including commodity prices and community preferences), more variable water supplies and/or reductions in total water supply during critical summer growing months may result in significant economic losses to farmers and rural economies dependent on farming.

Irrigated agricultural might also serve as a source of water for non-agricultural water demands. Farmers may be willing to sell or lease water rights for other water uses, particularly if the dollar value per unit of water exceeds the dollar value per unit of irrigated crops. Therefore, irrigated agriculture in a watershed might also reduce overall vulnerability to climate impacts. The extent to which the increased vulnerability to agriculture is off-set by the reduced vulnerability to non-agricultural water uses will depend largely on community preferences for making tradeoffs (see Section 5.4.3 for more information on agriculture and water use transfers in response to drought).

6.4.3.8 Indicator: Major Water Storage Systems

Sub-indicator(s): *Dams/Aquifer Storage and Recovery (ASR) Sites*[24]*, Acre-feet of storage, Ration of Storage to Annual Flow*

Description: The Major Water Storage Systems indicator identifies and quantifies major surface water and groundwater storage systems in the watershed.

Indicator Level: Level 1 (high)

Bias in favor of: Reservoirs (above or below) with carryover storage capacity

Assumptions: The availability of water storage reservoirs may help reduce - but not totally mitigate - vulnerability to the hydrologic impacts of climate variability and climate change. Size, number, and carryover capacity are important factors in determining the extent to which major storage systems can reduce vulnerability. For the purpose of this analysis, the following is generally assumed with respect to major water storage systems:

- Watersheds with storage reservoirs capable of storing a large percentage of total annual streamflow and carrying that capacity to the next year are less vulnerable to climate impacts (lower vulnerability);
- Watersheds with storage reservoirs storing a smaller percentage of total annual streamflow and/or lacking carryover capacity are more

[24] Aquifer Storage and Recovery (ASR) involves injecting water into an aquifer through wells or by surface spreading and infiltration for use later as needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water falls short of demand. Changes in state water law in 2000 (RCW 90.03.370) now allow the Department of Ecology to issue reservoir permits for ASR projects. These permits were previously limited to surface storage projects only. Ecology is also drafting rules that will establish standards for review of ASR proposals and mitigation of any adverse impacts in areas such as existing water rights, hydraulic continuity, and chemical compatibility of surface and groundwater (http://www.ecy.wa.gov/programs/wr/asr/asr-home.html).

vulnerable to climate impacts (intermediate vulnerability); and

- Watersheds with no major storage reservoirs are most vulnerable to climate impacts (higher vulnerability).

These assumptions may be modified with further consideration of specific reservoir systems and/or current availability of surface water and groundwater supplies. *In all cases it must be noted that construction of more reservoirs is not a fail-safe approach to reducing vulnerability to climate impacts.*

6.4.3.9 Indicator: Other Factors of Note

Sub-indicator(s): *Description*

Description: The Other Factors of Note indicator provides an opportunity to note other factors not reflected in the Water Use indicators list that may affect watershed vulnerability.

Indicator Level: Contingent on entry

Bias in favor of: None

Assumptions: No assumptions are made.

6.4.4 Water Quality Indicators

The following explains how indicators related to water quality may be considered in a vulnerability analysis.

6.4.4.1 Indicator: Surface Water Quality Problems

Sub-indicator(s): *Flow, Temperature (Temp), Dissolved Oxygen (DO), pH, Fecal Coliform, TSS/Turbidity, Metals, Phosphorus, Nitrogen, Other, Most Common Concern*

Description: The Surface Water Quality indicator identifies known surface water quality problems within the watershed.

Indicator Level: Level 2 (medium)

Bias in favor of: Fewer quality problems

Assumptions: Surface water quality may be degraded and/or improved as a result of changes in water temperature and flows associated with climate variability and climate change. Declining surface water quality may increase a watershed's vulnerability to climate impacts by:

- Limiting water availability due to new or worsening water quality problems (e.g., temperature, DO), or making availability dependent on potentially expensive water treatment processes; and/or
- Triggering regulatory restrictions which limit water use on the basis of water quality conditions (e.g., Section 303(d) listings, Total Maximum Daily Load requirements).

For the purpose of this analysis, watersheds with existing surface water quality problems are assumed to be more vulnerable to the impacts of climate variability and climate change. The more quality problems in the watershed, the more vulnerable the watershed is expected to be.

6.4.4.2 Indicator: Groundwater Quality Problems

Sub-indicator(s): Comments on Overall Quality, Chlorides, Salt Water Intrusion, Nitrates, Phosphorus, Iron, Manganese, Fecal Coliform, Other.

Description: The Groundwater Quality indicator identifies known groundwater quality problems within the watershed.

Indicator Level: Level 2 (medium)

Bias in favor of: Fewer groundwater quality problems

Assumptions: Groundwater quality impacts associated with climate variability and climate change are most likely to stem from increased groundwater production, which can pull more contaminants into and/or accelerate travel times through groundwater systems to wellheads and surface water bodies. This effect, known as induced infiltration, has been a problem in some coastal watersheds where increased groundwater production has drawn saltwater into coastal aquifers. Induced infiltration may also pull contaminants from large potential pollution sources such as contaminated waste sites and abandoned underground storage tanks.

Groundwater quality is expected to be less sensitive to climate impacts than surface water but is still an important limiting factor, particularly for watersheds where groundwater is currently or expected to be a major source of water. Declining groundwater quality may increase a watershed's vulnerability to climate impacts by:

- Limiting water availability due to quality problems (e.g., nitrates in groundwater), or making availability dependent on potentially expensive water treatment processes; and/or
- Triggering regulatory restrictions that limit water use.

For the purpose of this analysis, watersheds with existing groundwater quality problems are assumed to be more vulnerable to the impacts of climate variability and climate change. The more quality problems in the watershed, the more vulnerable the watershed is expected to be.

The extent to which groundwater quality is a source of vulnerability will depend on the size, location, and geologic properties of aquifers; land use patterns over the aquifer(s); and groundwater production and use within individual watersheds. It is also important to note that groundwater contamination problems are often isolated to specific areas. Therefore, the presence of groundwater quality problems does not necessarily mean the entire aquifer system is contaminated and therefore unusable.

6.4.4.3 Indicator: 303(d) Listed Water Bodies

Sub-indicator(s): *Yes/No, Description*

Description: The 303(d) Listed Water Bodies indicator identifies if the watershed has streams regulated under Section 303(d) of the Clean Water Act. A water body is listed as a Section 303(d) water body when at least one beneficial or designated use is impaired by failure to meet one or more water quality standards (Ecology 2002a)[25]. Total Maximum Daily Load limits (TMDLs, see next indicator) must be set for Section 303(d) listed water bodies. Additional water quality improvement strategies may also be implemented.

Indicator Level: Level 2 (medium)

Bias in favor of: No or few listed water bodies

Assumptions: Changes in surface water quality as a result of climate variability and climate change may lead to more surface water quality violations in river and stream segments and, consequently, additional Section 303(d) listings. Climate impacts may also keep currently listed segments on the Section 303(d) list for longer periods of time if impacts reduce the effectiveness of actions taken to remedy Section 303(d) impairments. Therefore, for the purpose of this analysis, the presence of Section 303(d) listed water bodies in a watershed is assumed to increase vulnerability to climate impacts.

6.4.4.4 Indicator: Other Factors of Note

Sub-indicator(s): *Description*

Description: The Other Factors of Note indicator provides an opportunity to note other factors not reflected in the Water Quality indicators list that may affect watershed vulnerability.

Indicator Level: Contingent on entry

Bias in favor of: None

Assumptions: No assumptions are made.

[25] A water body is also listed (or re-listed) when it is not expected to meet relevant water quality standards before the next 303(d) assessment and the water body does not have a TMDL or other acceptable pollution control plan in place to address the impairment (Ecology 2002). Water bodies impaired by natural conditions and with documentation of no significant human contribution will not be proposed for the 303(d) listing. The 303(d) list for Washington State was last prepared in 1998. No states were required to prepare a list in 2000 due to USEPA's preparation of new rules during that time. The 2002 Section 303(d) list will be released in October 2002.

6.4.5 Regulatory Characteristics Indicators

The following explains how specific regulations may be considered in a vulnerability analysis. It is important to note that while regulatory programs are frequently identified here as limiting future options for adaptation, this assumption should not be interpreted as creating a justification for removal of specific regulatory program(s). Each regulation serves its distinct purpose in managing water quantity and quality. It is important to simply recognize these programs as possible constraints that must be worked with and around when assessing adaptation strategies. It is also possible that some restrictions put in place under a regulatory program may actually improve resiliency to climate impacts even while placing a constraint on use. Consequently, the effects of regulatory programs are not necessarily all negative.

Many of the following indicators are related to Washington State water rights requirements. For more detailed information on Washington State water law, water rights, and water rights processing, please refer to Ecology's Water Resources Program web page (http://www.ecy.wa.gov/programs/wr/rights/water-right-home.html).

6.4.5.1 Indicator: Total Annual Water Rights Allocation

Sub-indicator(s): *Acre-feet or cu.ft./sec*

Description: The Total Annual Water Rights Allocation indicator indicates in total how much surface water and groundwater water is allocated annually as water rights (according to state records).

Indicator Level: Descriptive only

Bias in favor of: No bias

Assumptions: No assumptions made.

6.4.5.2 Indicator: Surface Water Rights

Sub-indicator(s): *Annual Surface Water Allocation*

Description: The Annual Surface Water Allocation sub-indicator identifies how much surface water is allocated annually by right.

Indicator Level: Descriptive only

Bias in favor of: No bias

Assumptions: No assumptions made.

Sub-indicator(s): *Claims, Applications*

Description: The Claims and Applications sub-indicators identify how much surface water is being claimed as existing water rights in the watershed, and how much additional surface water is subject to new water rights applications or change in use applications.

Indicator Level: Level 2 (medium)

Bias in favor of: Less (by volume) and/or fewer (by number) outstanding water rights claims and applications; lower estimates of actual water used.

Assumptions: The number and quantity of surface water rights applications and claims in a watershed is an important indication of outstanding demands on a watershed. In each case, the Department of Ecology must determine if the claim is valid and if applications for new water rights or changes in use can be granted. The time required to complete this process can be lengthy[26]. Watersheds with large (by volume) and/or more (by number) outstanding water rights claims and applications are therefore assumed to be more vulnerable to climate impacts given the constraints associated with granting new rights and/or modifying existing rights in high demand watersheds.

Sub-indicator(s): *Estimated Actual Usage*

Description: The Estimated Actual Usage sub-indicator estimates how much surface water is actually used versus how much water is used on paper as a water

---

[26] The time required to process applications to change existing water rights has created a significant backlog and political controversy for the Department of Ecology. As of June 30, 2001, more than 5,400 new water rights applications were awaiting processing; an additional 2,000 application requests to change existing rights. To facilitate faster processing of applications, the Washington State Legislature authorized establishment of a two line processing approach separating new water rights applications, which take longer to process, from changes in use applications (established under ESHB 1832). The Legislature also provided Ecology with more funding and staffing for water rights processing. Since July 2001, water rights processing has occurred "at a brisk pace". (Ecology 2002b)

right.

Indicator Level: Level 3 (low)

Bias in favor of: Lower estimate

Assumptions: Actual water use is probably lower than paper use in many Washington watersheds (Pacific Groundwater Group et al. 1995, GeoEngineers 2001). In the Methow, for example, there is four times as much water claimed in the paper registry that is available in the basin[27]. This discrepancy is often attributed to undocumented changes in water use from allocated quantities and outdated water rights records (GeoEngineers 2001). Watersheds where estimated actual usage for surface water is less than 50% of allocated surface water rights may be less vulnerable to climate impacts given the buffering capacity in the system and the potential ability to allocate unused rights to instream flows, a major limiting factor in many watersheds. This assumption relies, however, on the presumption that: 1) the unused flows are real (i.e., the estimate is correct), and 2) the unused flows will be dedicated to meeting instream flow requirements before meeting any requests for new water rights. Although this indicator is potentially very important in determining water supply availability, uncertainties in the State's water rights records and the difficulty in accurately estimating actual usage necessitate ranking this indicator as a Level 3 indicator at this time.

6.4.5.3 Indicator: Groundwater Rights

Sub-indicator(s): *Annual Groundwater Allocation*

Description: The Annual Groundwater Allocation sub-indicator identifies how much groundwater is allocated annually by right.

Indicator Level: Descriptive only

Bias in favor of: No bias

Assumptions: No assumptions made.

[27] Noted by John Stormon, Watershed Planning Lead for WRIA 48, during interview for Section 5 of this paper.

Sub-indicator(s):	*Claims, Applications*
Description:	The Claims and Applications sub-indicators identify how much groundwater is being claimed as existing water rights in the watershed, and how much additional groundwater is subject to new water rights applications or change in use applications.
Indicator Level:	Level 2 (medium)
Bias in favor of:	Less (by volume) and/or fewer (by number) outstanding water rights claims and applications.
Assumptions:	The number and quantity of groundwater rights applications and claims in a watershed is an important indication of outstanding demands on a watershed. In each case, the Department of Ecology must determine if the claim is valid and if applications for new water rights or changes in use can be granted. The time required to complete this process can be lengthy (see previous footnote). Consequently, watersheds with large (by volume) and/or more (by number) outstanding water rights claims and applications are assumed to be more vulnerable to climate impacts given the constraints associated with granting new rights and/or modifying existing rights in high demand watersheds.

Sub-indicator(s):	*Estimated Actual Usage*
Description:	The Estimated Actual Usage indicator estimates how much groundwater is actually used versus how much groundwater is used on paper as a water right.
Indicator Level:	Level 3 (low)
Bias in favor of:	Lower estimate
Assumptions:	As with surface water rights, actual groundwater use is believed to be lower than recorded paper use. Watersheds where estimated actual usage for groundwater is less than 50% of allocated groundwater rights may be less vulnerable to climate impacts given the buffering capacity in the system and the potential ability to allocate unused rights to new uses. Although this indicator is potentially very important in determining water

supply availability, uncertainties in the State's water rights records and the difficulty in accurately estimating actual usage necessitate ranking this indicator as a Level 3 indicator at this time.

6.4.5.4 Indicator: Exempt Wells

Sub-indicator(s): *Estimated Number and/or Estimated Use of Exempt Wells*

Description: The Exempt Wells indicator identifies how many exempt wells are located in a watershed and/or water what volume of groundwater use is believed to be associated with exempt wells. Wells are exempt from the Department of Ecology's requirement to obtain a water right when:

- Total use of the well is less than 5,000 gallons per day (up to a maximum of 5.6 acre-feet per year), and
- The well is used for domestic purposes, irrigation or livestock watering, and watering a lawn or non-commercial garden that is one-half acre or less in size.

An estimated 8,000 new exempt wells are drilled each year in Washington State (Rushton 2000).

Indicator Level: Level 3 (low)

Bias in favor of: Fewer exempt wells, when known

Assumptions: Exempt wells present two types of increased vulnerability to climate impacts. First, the exemption leaves many uncertainties regarding the total number of exempt wells in a watershed and the total amount of water used by these wells[28]. Consequently, it is difficult to know how much of an impact exempt wells may have on groundwater supplies (and stream

[28] Although permitted for multiple purposes up to 5,000 gpd, most exempt wells are used for domestic purposes, which use considerably less water. National or local per capita water use statistics are often used to estimate actual water use from domestic exempt wells. The national estimate for average domestic water use is 175 gallons per capita per day (GeoEngineers 2001). The estimate for the Spokane, Washington area is 184 gallons per capita per day (Golder Associates 2001). High volume exempt wells include those used for irrigating large lawns and watering livestock.

flow if the well is located near a stream). The lack of any registration requirement also makes it difficult to verify if a well actually meets the exemption criteria.

Vulnerability may also be increased by the depth profile of exempt wells. While well depth will vary with individual wells based on location and groundwater source, most domestic wells are often drilled only to the upper boundaries of the water table. This leaves domestic wells more sensitive to decreases in groundwater levels associated with extended drought and/or increases in groundwater production. The impact is compounded by the fact that domestic well users, particularly rural well users, often have few options for alternate water sources when groundwater levels drop below well screens. Drilling deeper is costly and does not guarantee access to a potable water supply, and municipal service may not be available.

Given this, it is assumed for the purpose of this analysis that watersheds where use of exempt wells is known or believed to be widespread are more vulnerable to climate impacts. The degree to which vulnerability is increased will depend on:

- The number of known or estimated exempt wells;
- The purpose of the exempt wells;
- Known or estimated water use by exempt wells in proportion to total water use (when that can be determined);
- The distribution of exempt wells. A more scattered distribution may make providing alternate supplies more costly. At the same time, the more concentrated the well use, the more likely changes in use (i.e., increased production in response to drought) will have a cumulative impact on groundwater levels and other well users; and

- The availability of alternate water supplies, such as nearby municipal or public utility services.

6.4.5.5 Indicator: Endangered Species

Sub-indicator(s): *Endangered, Threatened, Other At-Risk Species*

Description: The Endangered Species indicator identifies watersheds where federally and/or state designated endangered species, threatened species, and other at-risk species are located.

Indicator Level: Level 1 (high)

Bias in favor of: No endangered species, or no to few threatened species or at-risk species.

Assumptions: The listing of specific salmonid species under the federal Endangered Species Act (ESA) and comparable state laws[29] has had a significant impact on water management in Washington State. As noted by Watershed Planning Leads in Section 5.3.2, the most cited major water resource management challenge for watersheds participating in the Watershed Planning Program is the ESA and related instream flow requirements for salmonids. The presence of ESA and state listed species in a watershed's rivers and/or streams affects current and future water use largely through requirements for:

- Minimum instream flows to protect listed species (see next indicator);
- Habitat restoration; and
- Restrictions on activities that may result in a regulatory "take" under the Act.

[29] Federally listed endangered and threatened species are protected by the Endangered Species Act of 1973, which is administered by the U.S. Fish and Wildlife Service and National Marine Fisheries Service. Classification of endangered, threatened, and sensitive wildlife species native to Washington State is managed by the Washington Department of Fish and Wildlife (WADFW) in accordance with Washington Administrative Code 232-12-297. Another listing relevant to Washington watersheds is the WADFW's Salmonid Stock Inventory (SaSI). The SaSI classifies native wild salmonid stocks as healthy, depressed, critical, unknown, or extinct. These classifications, which are used for prioritizing recovery efforts, also serve as indicators of species that could become threatened or endangered under state and federal endangered species programs. For more information on the SaSI listings, visit

The presence of other at-risk species, which includes salmonid stocks identified by the State as "critical stocks", "depressed stocks", or general species of federal or state concern, may also affect current and future water use as efforts are undertaken to prevent further decline and subsequent listing of these species. For the purpose of this analysis, therefore, watersheds with endangered, threatened, or other at-risk species are considered more vulnerable to the hydrologic impacts of climate variability and climate change.

6.4.5.6 Indicator: Instream Flow Requirements

Sub-indicator(s): *Instream Flows Set?, Average Number of Days (or %) Below Instream Flows*

Description: The Instream Flows Set and Average Number of Days (or %) Below Instream Flows sub-indicators identify those watersheds where instream flow requirements have been set by law as well as how often those instream flows are met. The Comments sub-indicator simply provides opportunity for including additional explanatory information related to instream flows in the analysis.

Indicator Level: Level 1 (high)

Bias in favor of: No instream flows set or required; no or few stream closures

Assumptions: Instream flow requirements establish a minimum flow level considered adequate to meet identified needs or management objectives for a river or stream, such as water quality and/or habitat needs (Rushton 2000). Maintaining instream flows can be difficult due to the seasonality of flows and the legal entitlement of senior water rights, which substantially dewater streams in many areas of Washington State.

The ability (or inability) to meet instream flow requirements is a major limiting factor in the allocation of new water rights. If flows are set by

http://www.wa.gov/wdfw/fish/sassi/intro.htm.

law, the instream flows receive a priority date much like a water right. All subsequent water rights applications become junior to the instream flow levels. If instream flows cannot be met, new surface water rights will not be issued for that stream. Groundwater rights may also be affected if the groundwater is hydrologically connected to the restricted surface water body. These closures typically apply when water demand is highest – during the summer low flow season. It is important to note that new water rights can be conditioned to instream flows even where not set by rule.

Instream flow requirements have also been a factor in considering off-stream storage projects such as surface water reservoirs (WRIAs 37/38/39) and aquifer storage (WRIAs 43 and 56)[30]. In both cases, the ability to develop these projects while still meeting instream flows is a major planning issue.

For the purpose of this assessment, instream flow requirements are assumed to increase a watershed's vulnerability to climate impacts by restricting adaptation options that involve changes in flow, use, and/or storage. The extent to which instream flow requirements increase vulnerability depends on how important the river or stream is to meeting water demands in the watershed, and how close the water body is to meeting required instream flow levels (i.e., will significant steps be required to meet flows or can flows be met with minor modifications?).

Sub-indicator(s): *Stream Closures*

Description: The Stream Closures sub-indicator identifies those watersheds where no additional water rights can be issued seasonally or permanently due to

---

[30] According to the Watershed Planning Lead for WRIAs 43 and 56, both watersheds are considering aquifer storage projects. Implementing this option, however, depends largely on the availability of aquifers disconnected from any surface water bodies with instream flows that might be affected by groundwater pumping. In WRIAs 37/38/39 (the Yakima Basin), no instream storage sites are being considered due to instream flow requirements and potential impacts on salmon.

instream flow limitations. The term "stream" includes streams and rivers of any size.

Indicator Level: Level 1 (high)

Bias in favor of: No stream closures, or closures on small tributaries only

Assumptions: Stream closures occur when the Department of Ecology has determined that a water body is over-allocated and not able to meet instream flow demands. Stream closures may occur seasonally (most often during the dry summer months) or permanently, and can be issued for streams with or without instream flows set by rule. Once a stream is closed, no new water rights for that water source can be issued during the closure period. Closures may also apply to groundwater sources known to be hydrologically connected to closed surface water sources.

For the purpose of this assessment, stream closures are assumed to increase a watershed's vulnerability to climate impacts by restricting adaptation options that involve changes in flow, use, and/or storage. The extent to which stream closures increase vulnerability depends on how many streams are closed, the volume of flows affected by the closure, and the location of the streams in relation to demand. The more significant the stream to meeting water demands in the watershed, the greater the vulnerability imposed by the closure.

Sub-indicator(s): *Comments*

Description: The Comments sub-indicator provides additional information on instream flow requirements and stream closures that may be beneficial to the vulnerability assessment.

Indicator Level: Descriptive only

Bias in favor of: No bias

Assumptions: No assumptions made.

6.4.5.7 <u>Indicator: Total Maximum Daily Load (TMDL)</u>

Sub-indicator(s): *Yes/No, Description*

Description: The Total Maximum Daily Load (TMDL) indicator identifies if and how many TMDLs are present in the watershed.

Indicator Level: Level 2 (medium)

Bias in favor of: No TMDL requirements

Assumptions: Total Maximum Daily Load (TMDL) standards identify the maximum amount of specified pollutant(s) that an impaired water body can receive from point and nonpoint sources, and then allocates the limit among pollution sources (Ecology 2002a). Climate variability and climate change may reduce the effectiveness of pollution control activities undertaken for TMDL restricted water bodies, potentially requiring additional steps and/or requiring that control activities be conducted over a longer period of time. TMDL standards may also restrict water uses that can further degrade listed water bodies, or restrict alternative approaches to reducing pollution[31].

For the purpose of this assessment, the presence of TMDL requirements on river segments in a watershed is assumed to increase vulnerability to climate impacts. This assumption is largely based on the use limitations that may result from the TMDL standard, but may vary with the impaired water quality parameter.

---

[31] In the lengthy process of negotiating TMDL limits in the City of Chehalis (WRIA 23) for Biological Oxygen Demand (BOD), modeling results led the U.S. Environmental Protection Agency (USEPA) to recommend a zero waste load allocation for BOD in a critical reach of the river. The zero load limit had significant implications for two large dischargers (including the City of Chehalis), requiring cessation of approximately 1,000,000 gallons per day of discharge to the river. One option considered by local decision makers to minimize this impact was routing the discharges through a constructed wetland. The wetland would serve as a final treatment stage for the diminimis levels of pollutants found in the discharges while also creating habitat and promoting biodiversity. The recommended TMDL limit eliminated the wetland as an option, however, because the wetland itself would contribute to BOD levels naturally even as it provided treatment for point source discharges. According to the Lead, the USEPA was not willing to accept any loading to the system, even at diminimis levels, due to the zero load limit required by the model. Using the constructed wetland would have required constructing another treatment process at the end of the wetland to treat the natural discharges from the wetland in order to meet the BOD TMDL. The net effect of the zero load is the removal of 1,000,000 gallons of water from a river struggling to meet current demands for land application.

6.4.5.8 Indicator: Other Programs Affecting Water Use/Management

Sub-indicator(s): *Description*

Description: The Other Programs Affecting Water Use/Management indicator identifies and describes other regulatory and non-regulatory programs that may affect water use and management within the watershed. Examples include the Wild and Scenic Rivers Act of 1968 (16 USC 1271), the Columbia River Gorge National Scenic Act (Public Law 99-663), and designated national wildlife areas/refuges.

Indicator Level: Contingent on entry

Bias in favor of: Will depend on the program

Assumptions: No assumptions are made. The degree to which other programs affecting water use and management in a WRIA increase or decrease vulnerability to climate impacts will depend on the specific nature of the program.

6.4.6 Watershed Planning Characteristics

The following explains how indicators classified as "other" may be considered in a vulnerability analysis. This includes indicators that do not fit within the existing classifications.

6.4.6.1 Indicator: Natural Variability Addressed

Sub-indicator(s): *Yes/No*

Description: The Natural Variability Addressed indicator identifies those watersheds where natural climate variability has been included in a Phase 2 Level 1 Technical Assessment Report for watershed planning or other water resources planning documentation.

Indicator Level: Level 2 (medium)

Bias in favor of: Including natural variability

Assumptions: Recognizing the hydrologic impacts of climate variability in planning documentation is an important step in adapting to climate impacts at the watershed level. One approach to identifying the climate/hydrology relationship is examining long-term streamflow records for trends corresponding to PDO and El Niño/La Niña cycles. Consequently, watersheds that have examined or are planning to examine the climate variability/hydrology relationship are assumed to be less vulnerable to climate impacts insofar as the relationship is understood and integrated into future decision making processes as appropriate.

6.4.6.2 Indicator: Climate Change Addressed

Sub-indicator(s): *Yes/No, Description*

Description: The Climate Change Addressed Included indicator identifies those watersheds where climate change has been included in a Phase 2 Level 1 Technical Assessment Report for watershed planning or other water resources planning documentation.

Indicator Level: Level 2 (medium)

Bias in favor of: Including climate change

Assumptions: As with climate variability, acknowledging the hydrologic impacts of climate change in planning documentation is an important step towards adaptation at the watershed level. Even if a watershed is not ready to take action on possible adaptation strategies, including climate change impacts in planning documentation keeps the issue on the agenda for future planning and decision-making purposes. Consequently, watersheds acknowledging climate change impacts on water resources in watershed planning documents are assumed to be less vulnerable to climate impacts than those watersheds that have not recognized climate impacts. The more proactive the watershed is in addressing climate impacts, the less vulnerable the watershed may be.

6.4.6.3 Indicator: Using (or Possibly Using) Hydrologic Model?

Sub-indicator(s): *Yes/No*

Description: The Using (or Possibly Using) Hydrologic Model indicator identifies which watersheds are using or plan to use a hydrologic model to aid in watershed planning.

Indicator Level: Level 2 (medium)

Bias in favor of: Watersheds using a hydrologic model meeting the listed criteria

Assumptions: Hydrologic models may serve as a valuable planning tool by allowing analysis of "what if" scenarios for different hydrologic conditions and water use allocations. Analyzing these decisions in advance may reduce vulnerability to climate impacts by helping decision-makers conceptualize climate impacts and the effects of long-term management decisions. The ability of a model to serve in this capacity will depend on how the model is constructed, the quality of the data going into the model, and how readily water resource managers and decision-makers can use the model.

For the purpose of a vulnerability assessment, watersheds with hydrologic models that are:

- based on quality data,
- capable of reasonably evaluating the impact of "what if" scenarios on water resources, and
- easily used by watershed resource managers

are assumed to be less vulnerable to climate impacts (all other factors the same) than watersheds with no models or models not meeting these criteria.

6.4.6.4 Indicator: Previous Multi-stakeholder Planning

Sub-indicator(s): *Yes/No*

Description: The Previous Multi-stakeholder Planning indicator identifies those watersheds where multi-stakeholder watershed-based planning efforts have been undertaken in the past.

Indicator Level: Level 3 (low)

Bias in favor of: Previous multi-stakeholder planning efforts completed successfully

Assumptions: As noted in Section 5.3.3, previous experience with watershed-based multi-stakeholder planning efforts may increase the likelihood that watersheds will be successful in developing effective watershed management plans. Previous efforts give participants the opportunity to evaluate how past planning decisions were made and how consensus-based decision processes worked (or don't work).

It is assumed that adapting to climate impacts will require consensus-based, multi-stakeholder decision making to some degree. Given that, previous (successful) experience with watershed-based multi-stakeholder planning may reduce watershed vulnerability to climate impacts more so than where previous experience has been unsuccessful (and therefore a negative experience for participants), or where participants have no experience working together in consensus-based decision-making processes. However, because each planning effort is driven by different objectives and is likely to involve different people over time, previous success should not be considered predictive of future success. The indicator, therefore, is ranked Level 3 (low).

6.4.6.5 Indicator: Planning Unit to Continue?

Sub-indicator(s): *Yes/No/Not certain*

Description: The Planning Unit to Continue indicator identifies watersheds where Planning Leads expect watershed planning units to continue in some type of formal or more permanent capacity after the watershed plan has been developed.

Indicator Level: Level 2 (medium)

Bias in favor of: Planning units will continue in some capacity

Assumptions: The continuation of planning units in some type of formal capacity is assumed to increase the probability that watershed plans will be implemented and new issues – such as climate impacts - addressed as they arise. Continuing the planning unit maintains the momentum developed in the planning process, facilitates continued dialogue between stakeholders, and potentially keeps participants who have developed extensive background knowledge on planning issues and process involved (although this may be challenging over time). For the purposes of a vulnerability assessment, therefore, it is assumed that watersheds with planning units expecting to continue in some type of formal capacity will be less vulnerable to climate impacts than watersheds with no continuing planning unit, or where continuation is uncertain at the time of the assessment.

6.4.6.6 Indicator: Will Update Plans

Sub-indicator(s): *Yes/No/Not certain*

Description: The Will Update Plans indicator identifies those watersheds where planning units have set a schedule (or intend) to regularly update watershed plans.

Indicator Level: Level 2 (medium)

Bias in favor of: Updating plans

Assumptions: The Watershed Planning Program requires that planning units make challenging decisions about water use and allocation within their watersheds. Many Planning Leads indicated in the survey that the scope of current planning efforts and the time frame permitted for completing the plans often pushes "extra" issues like climate variability and climate change off the agenda (see Sections 5.5.4, 5.6.5). Updating plans provides an opportunity to begin actively discussing climate impacts and adaptation. Frequent updating also facilitates the use of adaptive management, an approach advocated by many researchers for complex planning issues like climate impacts (see Sections 5.2.3.2, 5.3.6). Therefore, watersheds where planning units have set a schedule (or intend) to update their watershed plans are assumed to be less vulnerable to climate impacts than watersheds not expecting to update their watershed plans. The more frequent the updating, the more likely the watershed will be able to fine-tune management strategies to manage climate impacts (further reducing potential vulnerability).

6.4.6.7 Indicator: Major Planning Challenges Sensitive to Climate?

Sub-indicator(s): *Yes/No, Description*

Description: The Major Planning Challenges Sensitive to Climate indicator identifies watersheds where the major watershed planning challenges (as identified by Planning Leads in the survey) are sensitive to climate impacts. Planning challenges sensitive to climate impacts may include general supply limitations, instream flow requirements, water rights limitations, and water quality.

Indicator Level: Level 1 (high)

Bias in favor of: Planning challenges not sensitive to climate impacts.

Assumptions: Planning challenges sensitive to climate-induced changes in hydrology are expected to remain challenging or become more challenging as a result of climate variability and climate change. Therefore, watersheds where major planning challenges are sensitive to climate impacts are assumed to be more vulnerable to climate variability and climate change.

6.4.6.8 Indicator: Perceived Level of Adaptation Flexibility (from Leads)

Sub-indicator(s): *Description*

Description: The Perceived Level of Adaptation Flexibility indicator describes the level of flexibility Watershed Planning Leads feel their watersheds have to adapt to climate impacts.

Indicator Level: Level 1 (high)

Bias in favor of: Good amount of flexibility

Assumptions: Those who think they have more flexibility may also be more willing to address climate impacts. Those who think they don't may not feel that there is much they can do, even though they have more incentive. However, this is a subjective assessment.

6.4.6.9 Indicator: Drought Plan Developed and Up to Date?

Sub-indicator(s): Yes/No, Comments

Description: The Drought Plan Developed and Up to Date indicator identifies watersheds where comprehensive drought plans have been or are being developed and kept up to date.

Indicator Level: Level 2 (medium)

Bias in favor of: Drought plan developed and updated regularly

Assumptions: Droughts place significant strain on Washington water supplies. Comprehensive drought planning may buffer water users and natural systems from system failure by determining in advance how varying levels of drought should be managed within a watershed. Therefore, it is assumed that watersheds where a comprehensive drought plan has been developed (or is under development) and is kept up to date will be less vulnerable to droughts associated with climate variability and climate change. The more inclusive the range of drought scenarios included in the plan, the more effective the plan may be in managing droughts brought on by climate variability and climate change.

6.4.6.10 Indicator: Other Factors of Note

Sub-indicator(s): *Description*

Description: The Other Factors of Note indicator provides an opportunity to note other factors not reflected in the Watershed Planning indicators list that may affect watershed vulnerability.

Indicator Level: Contingent on entry

Bias in favor of: None

Assumptions: No assumptions are made.

6.4.7 Concluding Statements on the Vulnerability Indicators

The comprehensive list of vulnerability indicators described in the preceding section has been developed for the purpose of encouraging dialogue on ways to identify watershed-level vulnerability to climate impacts. The list is considered preliminary and subject to change. In fact, it is hoped that opportunities to continue discussion about these indicators will identify additional indicators that may need to be added, current indicators which may need to be removed, and/or assumptions that need to be modified, added, or corrected.

It is also important to note that the vulnerability indicator list is specific to Washington State. Therefore, while many of the indicators could be applied universally to any watershed, some indicators may not have value to watersheds outside Washington State. Other indicators specific to another region also may need to be added.

6.5 A Methodological Approach to Applying the Indicators

A preliminary vulnerability assessment using only the Level 1 vulnerability indicators was initiated as part of this study but halted before completion due to a number of challenges related to data limitations and classification ranges. Although not completed, the exercise of applying the indicators provided an early opportunity to develop a methodology for assessing the indicators. The following is an overview of the approach taken (and expected to be taken) for the preliminary vulnerability assessment.

6.5.1 Populating the Data Fields

As noted in Section 6.2, multiple information sources for 19 WRIAs were reviewed to develop a preliminary list of vulnerability indicators. Specific details for each WRIA were tracked in spreadsheets as sources were reviewed first to determine how consistently indicators were reported, and then for later use in the vulnerability assessment. As expected, there was great variation in what information was reported across watersheds.

6.5.2 Scoring Indicator Data Fields

The preliminary vulnerability assessment, which served as a trial application of the approach, focused only on Level 1 indicators (Table 3). Each WRIA's indicator entry[32] was scored as follows based on how the entry met assumptions made in the previous section:

- If it was believed that the indicator entry would strongly increase vulnerability, the indicator entry was ranked high and scored 5 points.
- If it was believed that the indicator entry would moderately increase vulnerability, the indicator entry was ranked medium and scored 3 points.
- If it was believed that the indicator entry would not increase vulnerability, or had a very low impact on vulnerability, the indicator entry was ranked low and scored 1 point.
- If the indicator did not apply to a watershed, the indicator was scored 0 points.

The same process will be applied to the Level 2 and Level 3 indicators in a full assessment.

Each indicator score will also be weighted based on the indicator level. All Level 1 indicator entry scores will be multiplied by 5, Level 2 indicator scores will be multiplied by 3, and Level 3 indicator scores will be multiplied by 1. The weighting is important given the different levels of influence each indicator category represents (see Section 6.3). A score of 5 for a Level 3 indicator, for example, does not carry the same vulnerability implication as a 5 assigned to a Level 1 indicator. Weighting the indicator entry scores differentiates the vulnerabilities represented by the Level 1 and Level 3 scores in the final assessment process by making the Level 1 score worth 25 (5x5) and the Level 3 score worth 5 (5x1).

6.5.3 Determining Overall Vulnerability

The final steps for the assessment require totaling the indicator vulnerability scores for each WRIA and determining the overall vulnerability on the basis of the cumulative score. The higher

[32] An indicator entry is the data entered into the indicator spreadsheet for a specific indicator and WRIA. For example, the indicator entry for the Average Annual Basin Precipitation (Total Basin) indicator for WRIA 13 is 51 inches.

the score, the greater the assumed vulnerability. The final assessment of a watershed's vulnerability will be reported as "high", "medium", or "low", however, and not as a number. A generic high/medium/low approach was chosen to avoid giving the impression that a watershed with a cumulative score of 55 is less vulnerable than a watershed with a score of 60 even though both scores qualify for the high vulnerability category (hypothetically; no range of high/medium/low scores has been selected at this time).

It is important to note that the indicators and assumptions presented herein are meant to serve only as a preliminary guide for assessing watershed vulnerability. No assessment made on the basis of the listed indicators and assumptions should be considered final. Factors that may affect how indicators are evaluated now or in the future include:

- The potential for interactions between different vulnerability indicators (e.g., land use and water quality),
- The availability of new information on the watershed, the vulnerability indicators, and/or climate impacts, and/or
- Changes in watershed characteristics that may change how the indicators were initially evaluated.

All vulnerability assessments, therefore, should be re-evaluated periodically and updated these conditions are met.

6.5.4 Challenges in Conducting the Preliminary Assessment and Nominal Indicators

As expected, there were several challenges in conducting the preliminary assessment. A major challenge is the inconsistency in which information is reported and, in some cases, the lack of any reporting for a particular indicator. The variability in reporting is attributed to several factors, including:

- the different planning stages watersheds are in, making availability of Phase II Level 1 Technical Assessments (the preferred information source) inconsistent;

- the general nature of the study requirements for Phase II Level 1 Technical Assessments, which gives watersheds great flexibility with data collection and assessment but also makes comparison across watersheds more difficult; and
- the different sources consulted to populate data fields.

Inconsistency in reporting was a problem with nearly all indicators and sub-indicators, including Total Average Basin Precipitation (reported in 7 of 16 cases), Average Summer Basin Temperature (reported in 2 of 16 cases), and Shifts in the Timing of Flow (reported in 0 of 16 cases).

Data inconsistency relates not only to how often an indicator is reported but also how well the information is reported. For example, some Technical Assessments provided specific information on storage systems in the watershed (WRIAs 55/57) while others addressed the presence of storage reservoirs only generally. Similar disparities are found with the inclusion of hydrographs in describing flow patterns; some watershed studies include hydrographs while others do not. Given the importance of the hydrograph in assessing vulnerability, the absence of hydrographs in many of the available reports requires that additional work be done to fill this information need before conducting a comparative assessment.

Another challenge is the need to establish ranges for scoring individual indicator entries. Several indicator assumptions lack the specificity needed to differentiate vulnerability. For example, it is known that lower precipitation totals can leave a watershed more vulnerable to climate impacts than higher precipitation. But how low is low in this case? Conversely, when are precipitation levels high enough to minimize vulnerability? Similar issues arise with interpreting summer and winter temperature ranges, population growth rates, ratios of total water storage, and other indicators. Preliminary ranges were developed for many of these indicators but could not be applied with confidence.

Given these challenges, an intermediate step was taken to qualitatively identify a nominal combination of vulnerability indicators likely to leave watersheds most vulnerable to climate impacts (Box 1, repeated in Table 5). The list is representative of a hypothetical watershed and

Box 1 - Nominal Conditions for a "Most Vulnerable" Watershed

The following combination of nominal characteristics is provided to serve as an example of how individual vulnerability indicators can combine to increase vulnerability in a watershed. The following combination of conditions is expected to leave watersheds most vulnerable to climate impacts. The scenario represents a hypothetical case but is likely to apply at least in part to many watersheds in Washington State. Additional characteristics not included in this list may also leave a watershed vulnerable. Conditions are listed by vulnerability indicator category.

<u>Indicator Category: Climate and Hydrology</u>

- Transient basin or lower elevation snow dominant basin *(Type of Basin indicator)*
- Lower average annual precipitation or large disparities between the upper and lower basin precipitation values, which forces greater reliance on upper level precipitation *(Annual Precipitation indicator)*
- Higher basin-wide summer temperatures and/or winter temperatures nearing freezing in the primary watershed catchment area(s) *(Average Temperatures indicator)*

<u>Indicator Category: Water Use</u>

- High projected population growth rate relative to current population *(Population indicator)*
- Watershed population largely dependent on surface water *(Water Use by Source indicator)*
- Little carryover storage capacity for managing floods as well as droughts *(Major Water Storage Systems indicator)*

<u>Indicator Category: Regulatory Characteristics Indicator</u>

- Uncertainty over the use status of surface and/or groundwater rights *(combined overview of all Surface Water Rights, Groundwater Rights sub-indicators)*
- Instream flow restrictions present *(Instream Flows indicator)*
- Total Maximum Daily Load restrictions *(TMDL indicator)*

<u>Indicator Category: Watershed Planning</u>

- Major watershed planning challenges sensitive to climate variation and *change (Major Planning Challenges Sensitive to Climate indicator)*
- Little or uncertain perceived adaptation flexibility *(Perceived Level of Adaptation Flexibility indicator)*

should not be considered final. Other combinations of indicators not included in this nominal list, including many Level 2 and Level 3 indicators, also may increase vulnerability depending on the specific characteristics of a watershed. Nonetheless, it is likely that many of these nominal conditions are common across Washington watersheds.

6.5.5 Next Steps

The development of the vulnerability indicators list and guiding assumptions represents a starting point for more comprehensive discussions on assessing watershed vulnerability to climate impacts in Washington State and, ultimately, determining specific vulnerability classifications for Washington watersheds. Several additional steps will be required to meet this objective. Many of these steps can be undertaken simultaneously.

Step #1: Conduct an additional literature review for more information on indicators and indicator assumptions

Additional literature research on climate impacts, indicators, and indicator assumptions is recommended to help verify the choice of indicators and assumptions. Studies and other publications that may be of value to planning units and Leads should be added as an Appendix to this report or added to the Climate Impacts Group web site for reference by these entities.

Step #2: Meet with others to review and discuss vulnerability indicators and assumptions

Discussions should be initiated with climate impacts researchers and Ecology Watershed Planning Leads to review the listed indicators and indicator assumptions. The discussions may identify indicators that need to be added or removed, and/or assumptions that require modification or change altogether. The assessment approach outlined in preceding sections (6.5.2, 6.5.3), as well as possible approaches to assessing the specific effects of combinations of indicators on watershed vulnerability, should also be discussed in these meetings.

Step #3: Develop ranges for indicator assumptions for vulnerability classification

More specificity is required for some indicator assumptions if vulnerability is to be assessed for individual watersheds (see Section 6.5.4). Ranges for assigning overall watershed scores to high/medium/low vulnerability categories must also be determined. The literature review conducted under Step #1 and discussions with researchers and Leads as described in Step #2 will aid in developing these ranges.

Step #4: Continue collecting and reviewing watershed reports for current WRIAs and remaining WRIAs

Various reports for 19 WRIAs were consulted to develop the vulnerability indicators list and assumptions. Reports for the remaining 23 WRIAs must be collected (where available) and reviewed if the vulnerability assessment is to be completed for all Watershed Planning Program WRIAs. Additionally, several of the initial 19 WRIAs included in the preliminary assessment will be finalizing previously unavailable Technical Assessments in the second half of 2002. Evaluating these reports will provide additional details about specific WRIAs that may not have been available for the preliminary assessment.

In some cases, effort should be made to replace unreported or inconsistently reported data. Although the intention of the assessment approach is to rely on existing data, some indicator fields should be completed for the vulnerability assessment to be most accurate. Two examples from the attempted preliminary assessment include Basin Type and Average Temperature. Basin Type is most accurately determined by examining a hydrograph for the basin. Because hydrographs are provided inconsistently in technical watershed reports, hydrographs should be developed for any watershed where basin type has not been verified with a hydrograph. Average Temperature is another indicator where values were reported inconsistently but are needed to help ensure an accurate assessment. Differences in how average temperatures are calculated across watersheds may also affect the comparative value of the temperature data. Given the widespread availability of this information on the Web, it is recommended that new average temperatures be calculated for all watersheds so as to ensure accurate reporting of this indicator. This step is expected to be the most time consuming of all the recommended “next steps”.

Step #5: Conduct the vulnerability analysis for all WRIAs participating in the Watershed Planning Program

As a final step, the vulnerability assessment should be completed for WRIAs participating in the Watershed Planning Program. It is recommended that CIG staff complete the vulnerability assessment for all Watershed Planning WRIAs as a comparative assessment and develop a list of watersheds grouped by high/medium/low vulnerability classifications. If staffing and/or funding limitations at CIG restrict work on this task, a vulnerability assessment could be done for individual WRIAs by planning units and/or watershed planning consultants.

7.0 Concluding Thoughts on Watershed Planning as a Vehicle for Adaptation and Vulnerability Indicators

The Watershed Planning Program presents a potentially significant opportunity to begin addressing the hydrologic impacts of climate variability and climate change at the watershed level. Watershed-level assessment and adaptation to climate impacts is critical given that it is the local level where hydrologic changes are felt first and where the difficult choices must often be made and executed.

One purpose of this study was to determine the extent to which the Watershed Planning Program may serve as a vehicle for adapting to the hydrologic impacts of climate variability and climate change at the watershed level. Based on information related in the survey of Watershed Planning Leads and other information collected in researching the project, the answer to this question is a qualified yes. The affirmation of the program is based on the following observations:

- *Leads expect watershed plans will lead to better management at the watershed level.*. Most Watershed Planning Leads (for 24 of 33 WRIAs) feel optimistic that the Watershed Planning Program will lead to better management of water resources at the watershed level. The collaborative nature of the planning process brings various stakeholders together to discuss different viewpoints, develop a shared understanding of water resource problems in the watershed, and craft management plans sensitive to the needs of local communities. Even in cases where a plan might not be implemented, the planning process lays the groundwork for continued collaboration. Additionally, the Technical Assessment Phase of the program provides an opportunity for watersheds to collect up-to-date information on water supplies and identify data gaps that may be important to future decision-making. Many Leads feel that the plans will serve as an important guidance document for future planning.

- *Watersheds are discussing and integrating climate impacts.* A majority of watershed planning units (for 22 of 33 WRIAs covered under the survey) have discussed climate impacts to varying degrees during their planning efforts. Fifteen of these 22 WRIAs are including climate impacts in watershed planning documentation. These numbers were higher than expected and are considered an indication that watersheds see the significance of climate impacts, even if they are not willing to address those impacts at this time.

- *The potential adaptive nature of the plans*. Most Leads expect watershed plans developed under the Watershed Planning Program to be adaptive in nature (but not necessarily using a formal adaptive management approach). This is due to the fact that planning units will not have all the data necessary to make all the decisions needed for planning and will therefore have to revisit the plans as new data becomes available. Periodic updating of the plans, something which at least 18 of 33 WRIAs intend to do at this point, provides opportunities for evaluating climate impacts and addressing these concerns in watershed planning and decision-making processes.

- *Legislative Support.* The Washington State legislature is supportive of watershed planning (at least for now) and may be willing to provide the additional financial and technical support needed by watersheds to implement watershed plans. The assumption about state support is based on the legislative history of the Watershed Planning Act, including the Legislature's objectives in passing the legislation, and the Legislature's continued financial support for the program after its passage (see Section 7.2, ESHB 1832).

The determination that Watershed Planning can serve as a good vehicle for adaptation is qualified on a number of assumptions, however. First, the determination is dependent on the continued provision of technical and financial support from the State to fund implementation. Many Leads felt that without the funding their WRIAs will not be able to implement the plans. This not only jeopardizes the success of the current planning effort but also potentially jeopardizes the willingness of stakeholders to invest time and resources in future planning efforts.

Related to this is the need for watershed planning units to continue in some formal capacity after watershed plans are developed. Funding will be a major determinant to this. Continuation of the planning unit helps ensure implementation of the plan and provides a structure for presenting and integrating new information into watershed management. Finally, the ability of watershed planning to serve as a vehicle for adapting to climate impacts will depend on the willingness of the State Legislature and state agencies to adjust policies that limit flexibility at the watershed level.

The second purpose of this study was to provide a preliminary assessment of factors that may affect watershed vulnerability to climate impacts and to apply the indicators to Washington's Watershed Planning WRIAs. Early identification and assessment of these factors may allow watersheds to minimize potential negative impacts from climate variability and climate change while also helping watersheds capture any of the positive gains to be had from these events. Although additional work is required to apply the indicators for a comparative assessment of watersheds, identifying the vulnerability indicators and how they may affect watershed vulnerability provides a starting point for assessing climate impacts on water supplies and use at the watershed level. It is hoped that providing this starting point will help watersheds bring the seemingly overwhelming challenge of adapting to climate impacts down to a familiar and potentially more manageable watershed level.

Bibliography

Beckett, A. (2000). *2000 Washington State Water Quality Assessment: Section 305(b) Report*, Publication #00-10-058, Washington Department of Ecology, Olympia, Washington.

British Columbia Ministry of Energy and Mines (2002). Salmon Life Histories and Habitat Requirements, Appendix 2. In *Aggregate Operators Best Management Practices Handbook for British Columbia*, prepared by the British Columbia Ministry of Energy and Mines, Minerals, Oil and Gas Branch, Victoria, British Columbia. (http://www.em.gov.bc.ca/Mining/MiningStats/55AOBMPHand_pdf.htm)

Burkett, V. and J. Kusler. (2000) Climate change: potential impacts and interactions in wetlands of the United States. *Journal of the American Water Resources Association* Vol. 36, No.2: 313-320.

Canning, D.J. and Hashim, W.A. (1987). Nisqually River Management Plan. In *Coastal Zone '87: The Fifth Symposium on Coastal and Ocean Management*. American Society of Civil Engineers, New York. pp: 3293-3305.

GeoEngineers, Inc. (2001). *Level 1 Technical Assessment Water Resource Inventory Areas 27 and 28*. Prepared for the Lower Columbia Fish Recovery Board, Longview, Washington. (http://www.lcfrb.gen.wa.us/W27%20Final%20Report.htm)

Golder Associates. (2001). *Draft Report on Little Spokane (WRIA 55) and Middle Spokane (WRIA 57) Watersheds, Phase II - Level 1 Technical Assessment Data Compilation and Preliminary Analysis*. Prepared for Spokane County and the WRIA 55 and 57 Planning Unit, Spokane, Washington. (http://spokanewatershed.golder.com)

Hamlet, A.F. (2001). Effects of climate change on water resources in the Pacific Northwest: Impacts and Policy Implications. Preparatory White Paper for Climate and Water Policy Meeting, Skamania, Washington, July 16-17, 2001. Climate Impacts Group, University of Washington, Seattle, Washington.

Hamlet, A.F., P.W. Mote, A.K. Snover, and E.L. Miles (in review). Climate, Water Cycles, and Water Resources Management in the Pacific Northwest. Chapter 4 in *E.L. Miles, A. K. Snover and The Climate Impacts Group, Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*. Boston, Massachusetts: MIT Press.

Hardy, T. and D. Stevens (2001), "Draft Phase III SOW and Decision Support System Information Meeting Summary" (for WRIA 1), Utah State University. (http://www.wria1project.wsu.edu/documents/111401_Meeting_Summary.PDF)

Hashim, W.A. (1998). *Planning As Process: A Community Guide to Watershed Planning*. Publication #99-01-WQ, Washington State Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/biblio/9901.html)

(IPCC) Intergovernmental Panel on Climate Change (2001). *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

James, G. and C. Sheeler (2001). *Draft Walla Walla Subbasin Summary*. Prepared for the Northwest Power Planning Council, Portland, Oregon. http://www.cbfwa.org/files/province/plateau/PlateauAWP/010803WallaWallaDraft.pdf

Keeton, W.S., J.F. Franklin, and P.W. Mote (in review). Climate Variability, Climate Change, and Forest Ecosystems in the Pacific Northwest, Chapter 6. In Miles, E. L., A.K. Snover, and the JISAO/SMA Climate Impacts Group, *Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*. Boston, Massachusetts: MIT Press.

Kelly,P.M. and W.N. Adger. (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change,* Vol. 47, pp. 325-352.

Kenney, D.S. (1999). Historical and sociopolitical context of the western watersheds movement. *Journal of the American Water Resources Association*, Vol. 35, No. 3, pp. 493-503

Leach, W.D. and Pelkey, N.W. (2001). Making watershed partnerships work: A review of the empirical literature. *Journal of Water Resources Planning and Management*, Vol. 127, No.6, pp. 378-385.

Mantua, N.J., R.C. Francis, D. Fluharty, and P.W. Mote (in review). Climate and the Pacific Northwest Salmon Crisis: A case of discordant harmony, Chapter 5. In Miles, E. L., A.K. Snover, and the JISAO/SMA Climate Impacts Group, *Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*. Boston, Massachusetts: MIT Press.

Meyer, J.L., M.S. Sale, P.J. Mulholland, and N.L. Poff. (1999). Impacts of climate change on aquatic ecosystem functioning and health. *Journal of the American Water Resources Association*, Vol.35, No.6, pp.1373-1386.

Mote, P.W. et al. (1999). *Impacts of Climate Variability and Change: Pacific Northwest, A Report of the Pacific Northwest Regional Assessment Group for the U.S. Global Change Research Program.* JISAO/Climate Impacts Group, University of Washington, Seattle, Washington.

Mote, P.W. et al. (2001). Scientific Assessment of Climate Change: Global and Regional Scales. Preparatory White Paper for Climate and Water Policy Meeting, Skamania, Washington, July 16-17, 2001. Climate Impacts Group, University of Washington, Seattle, Washington.

Murdoch, P.S., J.S. Baron, and T.L. Miller (2000). Potential effects of climate change on surface-water quality in North America. *Journal of the American Water Resources Association* Vol.36, No.2, pp.347-366.

Pacific Groundwater Group Inc. and Associated Firms (1995). *Snohomish River Watershed Initial Assessment - Draft*, Publication #WR-95-154. Prepared in cooperation with the Water Resources Program, Washington Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/pubs/95154.pdf)

Rushton, C. D. (2000). *Instream Flows in Washington State of Washington: Past, Present, and Future (Draft)*. Water Resources Program, Washington Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/programs/wr/sw/if-ver12.pdf)

Smith, C.L., J.G. Gilden, and B.S. Steel (1998). Sailing the Shoals of Adaptive Management: The Case of Salmon in the Pacific Northwest. *Environmental Management*, Vol. 22, No.5, pp.671-681.

Stakhiv, E.Z. (1998). Policy implications of climate change impacts on water resources management. *Water Policy*, Vol. 1, pp.159-175.

Washington Department of Ecology (1999). *Guide to Watershed Planning and Management: A Manual to Assist Washington's Local Governments and Tribes with Watershed Planning and Management Under the Watershed Management Act (RCW 90.82/ESHB 2514) (Draft).* Publication #99-106. Prepared by Economic and Engineering Services, Inc. (http://www.ecy.wa.gov/biblio/99106.html)

Washington Department of Ecology (2001a). *Guide to Watershed Planning and Management, Addendum No. 1 (Draft)*. Prepared by Economic and Engineering Services, Inc. for the Washington Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/biblio/0206005.html)

Washington Department of Ecology (2001b). *Watershed Report*, Office of Financial Management, Washington Department of Ecology, Olympia, Washington. (http://www.ofm.wa.gov/watershed/watershed.htm)

Washington Department of Ecology (2002a). Assessment of Water Quality for the Section 303(d) List (Draft 7), Chapter 1. In *Water Quality Program Policy,* Policy WQP #1-11. Water Quality Program, Washington Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/programs/wq/303d/2002-revised/listpolicydraftfinal7.pdf)

Washington Department of Ecology (2002b). *Processing Applications for Changes to Water Rights: 2001 Report to the Legislature*, Publication #02-11-001, Water Resources Program, Washington Department of Ecology, Olympia, Washington. (http://www.ecy.wa.gov/pubs/0211001.pdf)

Winter, Thomas C. (2000). The vulnerability of wetlands to climate change: a hydrologic landscape perspective. *Journal of the American Water Resources Association,* Vol.36, No.2, pp. 305-311.

Zebiak, S. (1999). El Niño and the science of climate prediction. *Consequences*, Vol. 5, No. 2, pp. 3-15.

APPENDIX 1

WATERSHED PLANNING LEAD SURVEY

<u>Informational Survey Regarding Climate and the Watershed Planning Program:</u>
<u>Interviews with Department of Ecology Watershed Planning Program Leads</u>

The purpose of this interview is to provide additional information on watershed planning and the challenge of including climate information in watershed plans. This interview is being conducted as part of an effort to assess which watersheds participating in the Watershed Planning Program may be more or less vulnerable to the hydrologic impacts associated with climate variability and climate change.

The survey is organized into four parts:

- Part 1 – General Climate, Watershed Planning Questions
- Part 2 – Adapting to Climate Impacts
- Part 3 – Incorporating Climate Concerns into the Watershed Planning Program Process
- Part 4 – Hydrologic Modeling as Aids in Watershed Planning

I will contact you to schedule a time at your convenience to discuss the survey questions. **I expect the survey will take approximately 45 minutes.**

Planning Lead:______________________________ **Date:** ____________________

*WRIA(s):*____

General Comments/Notes:

Part 1 – General Climate, Watershed Planning Questions

1. **Are you familiar with regional studies on the impacts of natural climate variability and climate change on the Pacific Northwest? If so, what impacts are you familiar with and where have you heard of these impacts?**

2. **What is(are) the most significant water resource management challenge(s) your WRIAs face in their current watershed planning effort(s)?**

3. **Were there existing watershed-level stakeholder groups working on water or related issues in the WRIAs prior to the Watershed Planning Program effort?** If yes, what type of management/planning activities were they involved with?

   a) **Do you expect the current Planning Unit to continue is some type of formal, more permanent capacity as a result of the Watershed Planning Program?**

   b) **Are there any plans in your WRIAs to periodically revisit and update the watershed plans?**

4. **Is the concept of adaptive management being included in your WRIAs' watershed planning efforts?** (yes/no) If so, how?

____
____
____
____
____
____
____
____

5. **In your opinion, will watershed planning efforts such as this lead to better management of water resources within the watersheds?** (yes/no) How integrated do you expect the plans to be in future management of water resources in the WRIAs? Will the watershed plans being developed help water managers better manage supply shortages and other water management crises?

____
____
____
____
____
____
____
____

6. **Are there one or more dominant water suppliers in your WRIAs?** If so, please identify.

____
____
____

7. **Do your WRIAs have carry-over capacity for water storage that can be relied on during drought years?** If so, do you have an estimate of how much?

____
____
____

Part 2 - Adapting to Climate Impacts

The following questions are aimed at determining how much WRIAs will be able to adapt to more variable water supplies.

8. Climate change research for the Pacific Northwest projects warmer and wetter winters, reduced winter snowpack, earlier spring snowmelt, reduced summer streamflows, and an increased potential for multi-year droughts. For more information on these impacts, please refer to the following White Paper: http://jisao.washington.edu/PNWimpacts/Publications/Pub145a.htm.

a) How much flexibility do you feel your WRIAs have to adapt to future changes in water supply availability?

____

____

____

____

b) In your opinion, where do the barriers to adapting exist? Are the barriers:

- **Natural challenges (related specifically to the physical supply)?**
- **Political/cultural challenges? (e.g., opposition to changing the status quo)**
- **Administrative challenges? (e.g., the number of water suppliers in the WRIA), and/or**
- **Institutional or regulatory challenges?**

Please identify what type(s) of barrier exist in your WRIAs and provide examples where possible.

____

____

____

____

____

____

____

____

____

____

____

c) What kind of impact would a multi-year drought have in your WRIAs? What types of responses could be expected to manage a multi-year drought?

____

Part 3 – Incorporating Climate Concerns into the Watershed Planning Program Process

9. Have climate variability and climate change been discussed by any of the Planning Units you work with?

IF the answer to question #9 is YES…

a.) Who raised the topic for discussion (you, a Planning Unit member, a contractor, other?)?

b) Have the issues been included in the WRIA's Technical Assessment (or scope of work for the Technical Assessment)? Have they been included in the Watershed Plan (or scope of work for the Plan)?

- ❑ If yes, how are they being included?

- ❑ If no, why have they not been included?

c) What type of resources (information or otherwise) would be most helpful in discussing climate issues with your Planning Units? What resources would increase the likelihood of incorporating climate concerns into the watershed plans (if not already included)?

IF the answer to question #9 is NO…

d) Do you anticipate discussing climate trends and hydrologic impacts with your Planning Unit(s)? (Yes/No) If no, why not?

____

____

____

e) How do you think the information on hydrologic impacts (such as that presented at the Peer-to-Peer workshops) would be received within your Planning Unit(s)? How likely is it that the Planning Unit(s) would or could incorporate the information? (Note: Copies of the climate impacts presentations from the Peer-to-Peer meetings are available on request)

____

____

____

____

f) What type of resources (information or otherwise) would be most helpful in discussing climate issues with your Planning Units? What resources would increase the likelihood of incorporating climate concerns into the watershed plans?

____

____

____

____

10. Do your WRIAs have a strong leader? (yes/no) ________________________________

a) Does having (or not having) a strong leader affect the likelihood that climate impacts could be included in the scope of the watershed planning effort? If climate variability and/or climate change impacts have been included, was strong leadership a factor?

____

____

____

____

Part 4 - Hydrologic Modeling as Aids in Watershed Planning

Hydrologic modeling is becoming a more common tool for understanding surface and groundwater interactions within a watershed. Models allow watershed management groups to evaluate how changes within the watershed can affect current and future water flow and use within the watershed. Hydrologic models also can be used to estimate how sensitive a WRIA's water resources are to natural climate variability and human-induced climate change. Although the models are <u>not predictive</u> in nature, the *results may contribute to the development of more robust watershed management plans capable of meeting a wider range of water supply conditions.*

Questions 11 - 13 are aimed at determining how widespread hydrologic modeling is in the Watershed Planning Program, and how receptive Watershed Planning Units might be to using models to assess watershed sensitivity to climate-related hydrologic impacts.

11. **Are any of your Planning Units using, or considering using, hydrologic modeling as an aid for developing watershed plans?** (yes/no)

____

IF the answer to question #11 is YES…

a) What questions are the Planning Units trying to address with the model(s)? What model(s) are being (will be) used?

____

____

____

____

____

b) Does the Planning Unit expect to continue using the model for managing the watershed? In other words, is development of the model a one-time project specifically related to writing the Watershed Plan or will the model become an integral part of water resource decision-making in the WRIA?

____

____

____

____

____

IF the answer to question #11 is NO…

c) Was use of a model considered and if so, why was the idea rejected? Are there other decision-aids similar to a hydrologic model being used?

____

____

____

____

12. **If your WRIA was given information indicating that it was relatively easy and cost-effective to build climate-related hydrologic impact testing into a model, do you think that they would take the additional step to include it?** If no, why not?

____
____
____
____
____

13. **How much additional cost do you think your WRIA(s) would be willing to incur to include testing for climate impacts on water resources in a hydrologic model?** Recognizing that this answer is dependent on many factors (including the type of the model, the cost of the model and the financial resources available to your WRIAs), please estimate the maximum increase in price over current or expected modeling costs that you think your Planning Units would be willing to spend to include testing for climate sensitivities (note: this information will be kept confidential)**.**

0% (would not do it) ____________ 1-10% ______________ 11-20% ____________

21-30% _____________________ 31-40% _____________ 40-50% ____________

50% or higher ________________

Any Closing Comments? ____
____
____
____

APPENDIX 2

EXAMPLES OF CLIMATE IMPACTS DISCUSSIONS IN TECHNICAL ASSESSMENT REPORTS

Excerpted from reports for:

WRIA 22/23 (LOWER/UPPER CHEHALIS)
WRIA 27/28 (LEWIS/SALMON-WASHOUGAL)

WRIA 22/23 (Upper/Lower Chehalis)

WRIA 27/28 (LEWIS/SALMON WASHOUGAL