1 INTRODUCTION

The objective of the NSW DCP vulnerability assessment is to provide the necessary information to inform future mitigation and response actions that will improve resiliency to drought. To assess vulnerability, watershed assets and resources[1] that are at risk in the event of water shortage, and the impacts that may occur, were inventoried. Then the extent to which the assets are vulnerable to drought now and into the future was evaluated. Finally, the underlying causes of the vulnerability were assessed. These causes then become the starting point for Elements #3 and #4 of the DCP process, and will be used to develop mitigation and response actions to minimize drought impacts. This process is described in more detail in this chapter.

This DCP is intended to initiate ongoing, collaborative drought planning in the NSW study area. Over time (i.e., during a recurring period to update the DCP), the vulnerability assessment should be reviewed and adjusted based on new information, and how well it serves the needs of decision makers and their constituents. Some of this new information is discussed in Section 3 of this chapter.

2 VULNERABILITY ASSESSMENT

2.1 BACKGROUND

2.1.1 National Drought Mitigation Center definition

National Drought Mitigation Center preparedness planning materials recommend completing several tasks prior to identifying mitigation and response actions. These tasks include: conducting an impact assessment, ranking the impacts, and conducting the vulnerability assessment (Wilhite et al. 1991). An impact assessment examines the environmental, economic and social consequences of a given event or change. Ranking involves prioritizing impacts according to what work group members consider to be the most important, recognizing that quantifying the impacts can be very difficult. The vulnerability assessment then "bridges the gap between impact assessment and policy formulation by directing policy attention to the underlying causes of vulnerability, rather than to the result, the negative impacts…." (Wilhite et al. 1991).

2.1.2 Other DCPs

While ranking impacts and conducting a vulnerability assessment are recommended, these tasks are not often conducted, most likely due to the effort involved. The National Drought Mitigation Center website has a compilation of state, local and watershed level drought plans, though almost none undertake these tasks (http://drought.unl.edu/Planning/DroughtPlans/StateDroughtPlans/CurrentStatePlans.aspx). Of notable exception, the state of Colorado prepared a vulnerability assessment as part of their Drought Mitigation and Response Plan in 2013. The state used Federal Emergency Management Act risk assessment guidance to evaluate impacts to public and private sector assets for each county. Colorado's Plan is 736 pages; the technical "backup" information for its vulnerability assessment is over 400 pages, indicating the very lengthy, detailed process that is involved in completing these tasks. (http://cwcbweblink.state.co.us/WebLink/ElectronicFile.aspx?docid=173111&searchid=45a1d11c-9ccf-474b-bed4-2bccb2988870&&&dbid=0).

[1] Hereinafter referred to as "assets".

2.1.3 Concepts in the Literature

The literature includes quite a bit of academic information on drought vulnerability assessments worldwide, from India, to the McKenzie River watershed in Oregon. Most of this information is investigating the vulnerability of systems to climate change, or as part of the risk assessment process. B.L. Turner et al. (2003) provides a framework for vulnerability analysis in sustainability science that explains exposure, sensitivity and resilience are at the core of "multifaceted coupled system with connections operating a different spatiotemporal scales and commonly involving stochastic and nonlinear processes" (Turner et al. 2003, page 8076). Farley et al. (2011) makes Turner's complex system more manageable by evaluating vulnerability in terms of how sensitivity and response capacity affect adaptability. These concepts were adapted into the NSW DCP vulnerability assessment.

2.2 NSW DCP 5-STEP PROCESS

A Working Group of resource management professionals was convened to review and provide feedback on the NSW DCP vulnerability assessment process. Meetings were held on April 28 and May 26, 2016 to discuss draft materials and provide feedback. Additional input and participants were solicited via phone and email to ensure adequate sector representation. The final list of Working Group participants is provided in Appendix A of this DCP.

Due to the amount of time and resources that it would have taken to develop a quantitative assessment (ie., consistent metrics and scores to quantify and rank impacts for each asset within the watershed), a qualitative five-step vulnerability assessment process was developed and implemented. An overview of this process and the results of each step are presented in this section.

2.2.1 Step 1 - Assess assets/resources and potential impacts of drought

Sectors were identified to organize and inventory the watershed assets that would be affected by drought, as well as the potential direct and indirect impacts that could occur. Documents identified in the Work Plan were reviewed, and feedback obtained from the Working Group to develop the list of assets within the NSW, and the environmental, economic and social impacts that could occur. The complete list of assets and impacts are provided in Appendix B. As a result of the variety of assets within each sector, general groupings were identified to manage the amount of information to carry forward in this assessment (Table 1).

Table 1. Asset Sectors and General Asset Groups

Sector	General Asset/Resource Groups
Agriculture	Commercial crop irrigation[2] Non-commercial irrigation[2] Other irrigation/watering Non-municipal fire suppression[3]
Municipal supplied water	Municipal water use (drinking water / sanitation / fire suppression, water needed for public health, safety, and welfare)[2] Commercial/industrial use

[2] These general assets were re-defined during the May 26 meeting.
[3] Non-municipal fire suppression was added to this sector during the May 26 meeting.

Sector	General Asset/Resource Groups
Self-supplied domestic water	Individual domestic water supply
Energy	Hydropower
Forestry	Upland natural resources
Environmental	Instream natural resources
Recreation	Water dependent recreation
Socio-economic	Jobs/aesthetics

2.2.2 Step 2 - Prioritize assets/resources according to environmental, economic and social consequences of drought

Based on discussion and feedback provided in Step 1, the Working Group was asked to prioritize the assets, to see if there were any easily-identifiable breaks in priority based on the environmental, economic and social consequences of the impacts. Results also provided focus for follow-up steps in this assessment. Voting members of the Working Group included representatives from all sectors, with the exception of the self-supplied domestic. Results are provided in Table 2.

Table 2. Initial Priority of General Assets in the Watershed

General Asset/Resources	Priority
Municipal water uses	16
Instream natural resources	13
Commercial crop irrigation	10
Commercial/industrial uses	6
Fire suppression[4]	6
Individual domestic water	6
Water dependent recreation	5
Non-commercial irrigation	4
Hydropower	3
Upland natural resources	1
Other irrigation/watering	0

2.2.3 Step 3 - Evaluate vulnerability now and in the future

Step 3 in the assessment process involved evaluating vulnerability of the assets to drought under current conditions and future scenarios. This evaluation is summarized in the following sections.

2.2.3.1 Vulnerability - Current conditions

Baseline water conditions

To establish current baseline water conditions, GSI conducted preliminary water rights research using information from the Oregon Water Resources Department (OWRD) for the North Santiam River (surface water/natural flow/priority dates). This information was used to identify possible regulatory measures that could be implemented and create vulnerability for a water user. Findings indicated that under current conditions (e.g. current regulatory frame work and typical or low streamflows), it is unlikely that North Santiam surface water rights holders would be regulated (i.e., use curtailed or shut off by the OWRD Watermaster) due to insufficient flow. There are no instream water rights on the mainstem

[4] During voting, this asset represented municipal fire suppression. After the May 26 meeting, non-municipal fire suppression was added as an asset to specify that agricultural ponds are also used for this purpose.

North Santiam River below Detroit Reservoir, which typically account for a large share of the available water supply and the amount of water in the river (even during very low flows) has been sufficient to meet the demands of all out-of-stream users.

Current Conditions - Vulnerability Assessment

Based on the experience and professional judgement of the Working Group, the vulnerability of watershed assets was evaluated using two factors: consequences of impacts and sensitivity. Consequences of drought and reduced water supply were evaluated using the following criteria. The criteria were not weighted and are not in any priority order:

- Public health, safety and welfare impacts
- Economic impacts
- Watershed health (environmental) impacts

Information gathered in Step 2 was initially used to define the consequences of these impacts, and position the assets on the y-axis of a matrix[5]. On the x-axis of the matrix, sensitivity was evaluated using the following criteria:

- Is there a backup water source?
- Is there adaptability?
- Is there (assumed) importance to the public?

Baseline water conditions (i.e., current water rights and regulatory structure) and communication with working group members were used to define the sensitivity of the assets, and initially position the assets on the current conditions matrix. Assets were positioned relative to one another, and results should be viewed within the context of neighboring assets on the matrix. The results of the exercise indicate that most assets are either higher in consequences or higher in sensitivity, with a few in the moderate ranges of vulnerability. No assets are considered low consequences and low priority (ie., low vulnerability). Discussion at the May 26, 2016 Working Group meeting moved some positions of the assets on the matrix. Results from that meeting are shown in Figure 1, which indicates that the most vulnerable assets under current conditions are:

- Municipal water users: Detroit, Idanha, Lyons-Mehama, Gates, Stayton, and Salem
- In-stream natural resources (e.g, endangered species, water quality and wetlands)
- Commercial irrigation
- Municipal-supplied commercial/industrial use
- Water dependent recreation

2.2.3.2 Vulnerability - Future conditions

Future conditions were evaluated for each of the assets by considering the following likely impacts on water availability:

[5] Matrix format was utilized for evaluation based upon communication with E. Flick, Marion County Emergency Manager.

- Willamette Project Biological Opinion (Bi-Op) implementation
- Willamette Project stored water reallocation
- Population growth
- Climate change

It should be noted that for each of the above-listed factors, uncertainties exist that could produce a range of future conditions, such as how regulatory decisions will be implemented, or how multiple factors interact within the North Santiam basin to produce a specific change. It has even been suggested that USACE may alter its rule curve for filling Detroit Reservoir to adjust to future conditions (ie., to capture water earlier). Long-term and short-term (ie., multiple year droughts) adaptive responses may differ, and experience different consequences. Therefore, this future conditions evaluation was qualitative and based upon the most probable changes, as determined by best professional judgement of the resource users and managers within the watershed (ie., the working group). Background information for each of these future conditions is discussed in the following sections.

Future Condition #1: Willamette Project Biological Opinion implementation and stored water reallocation

Under the Willamette Bi-Op implementation and stored water reallocation scenario, stored water releases from Detroit Dam could be protected instream under an instream water right in order to meet Bi-Op objectives and requirements[6]. (Under the 2008 Bi-Op, USACE currently releases between 1000 and 1500 cfs of stored water from Detroit Reservoir depending on the time of year.) In addition, it is anticipated that OWRD will convert existing natural flow Minimum Perennial Streamflows (MPSF) established for the North Santiam to instream water rights. Once converted, these MPSFs would likely have a water right priority date of June 22, 1964 for the protection of "natural streamflow". [7] In this scenario, stored water releases are "protected" instream (i.e. not available to natural flow water right holders) and the natural flow is protected instream under a 1964 priority date instream water right. Consequently, under low-flow conditions, surface water/natural flow water rights holders with priority dates junior to 1964 could be regulated when the natural streamflow drops below the flows in the instream water right (converted MPSF).

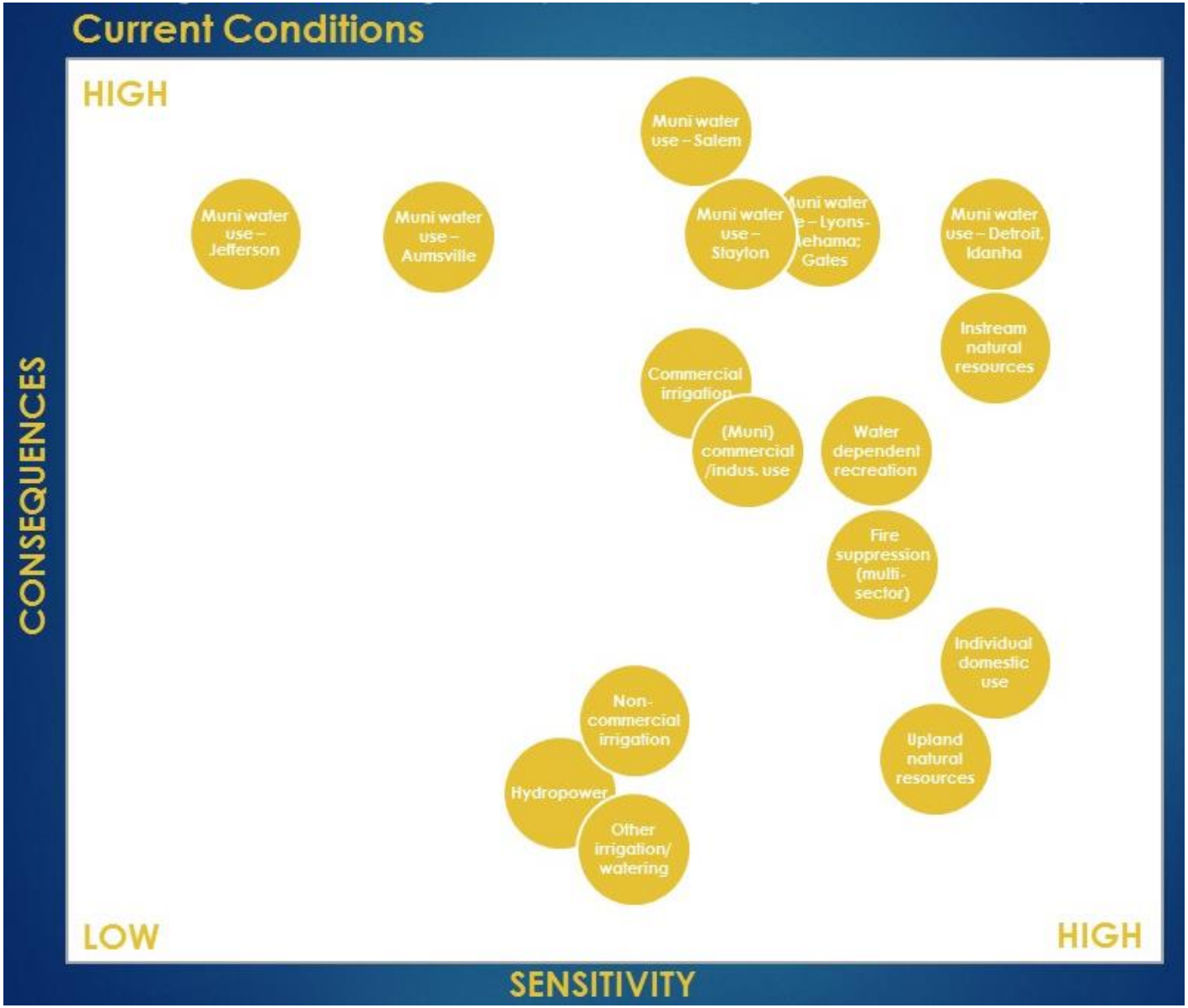
GSI estimated future water conditions using OWRD's Water Availability Reporting System, which estimates natural flows[8] for each month at multiple locations within a watershed. A comparison of this estimate of natural flow to the MPSF that will be converted to an instream water right shows that under this future scenario, surface water/natural flow water rights holders with priority dates junior to June 22, 1964 are vulnerable to regulation, especially from July to September in dry years.

[6] These instream water rights would be for stored water and would be regulated as a separate and district source of water from surface water/natural flow. Currently, once stored water is released from Detroit Reservoir, it is considered surface water/natural flow. This would change.

[7] Beginning in the 1960s, the Oregon Water Resources Board adopted MPSFs in the Willamette Basin to protect stream flows for aquatic life and reduce pollution. The MPSFs were established by administrative rule and are not water rights. As part of the 1987 legislation establishing instream water rights, the Oregon Legislature created a process to "convert" the MPSFs to instream water rights.

[8] This estimate of flow does not take into account the release of stored water and is a good surrogate for assuming all the released stored water is "protected" instream. It should also be noted that the OWRD natural flow estimate is based on an 80% exceedance flow, which would be an over-estimate of flow in a very dry year.

Figure 1. Vulnerability Assessment - Current Conditions



Future Condition #2: Population growth

Most of the cities in the North Santiam basin are located within Marion County, though Lyons (population 1,160) is in Linn County. Current populations range from approximately 140 people in Idanha, to approximately 189,000 in and served by Salem. The State Office of Economic Analysis estimates that the annualized growth rate in Marion County will reach 1.15% by 2030 and then drop to 0.93% by 2050 (State, 2013). The current total population of the County is approximately 332,000, and the total population of the cities within the watershed is approximately 187,000, or 56% of the county population. The County is expected to grow by approximately 167,000 people, which indicates an estimated 94,000 new watershed residents by 2050.

Most of this growth would be expected to occur within urban Salem and surrounding areas. However, Marion County and the Mid-Willamette Valley Council of Governments are working to stimulate development in the region, specifically in the Santiam Canyon. This group is exploring federal and state grant and loan opportunities to support identified economic development projects in the communities of Detroit, Gates, Idanha, and Mill City. Therefore, the population growth scenario is anticipated to affect communities from Salem through the Canyon.

Future Condition #3: Climate change

Climate models vary with the amount of carbon dioxide projected to occur in the atmosphere; however, most models project warmer, drier summers for Oregon. The Oregon Natural Hazards Mitigation Plan (2015) utilizes mean projected seasonal increases in summer temperatures of 2.6 to 3.6 ˚C, and in winter temperatures of 2.5 to 3.2 ˚C, by mid-century. The Oregon Climate Change Research Institute[9] summarizes: as winter temperatures warm up, more precipitation falls as rain than as snow. Less snow accumulates in the winter snow pack, and stream flow increases in the winter. Peak flow in rivers occurs earlier in the spring, and the magnitude of peak flow changes. In summer, without storage, there is generally less water in the rivers due to the earlier runoff. However, the North Santiam basin originates in the High Cascades. Runoff in these areas may be sustained through the summer for some time. In addition, it is uncertain how groundwater affects seasonal water flows in these areas, so water flows in high-elevation regions are difficult to forecast (Chang and Jung in OCCRI, 2015).

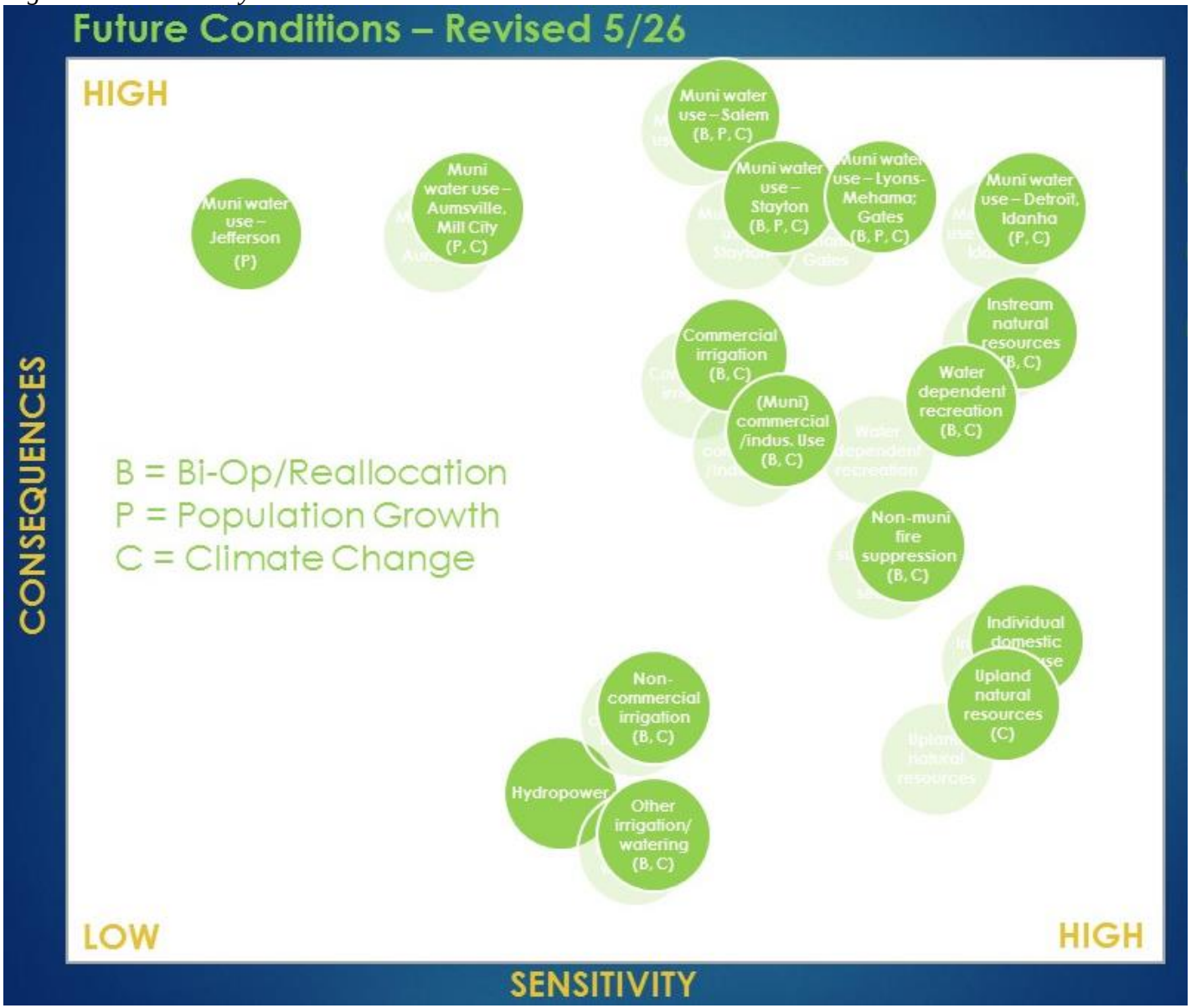
One assumption made in this scenario is that due to many factors (e.g., the large footprint of the Willamette Project, adaptive management efforts to meet competing demands for water, need for Congressional approval to change the rule curve), Detroit Dam and Reservoir operations are unlikely to change. However, as demonstrated by impacts experienced during the 2015 drought, this scenario may result in water levels within the reservoir occurring more frequently below rule curve thresholds.

Future Conditions: Vulnerability Assessment

The Working Group re-evaluated the vulnerability of watershed assets to account for the changes (based on the above discussed trends and assumptions) in the future. The “current condition” locations of the assets on the matrix were shifted to show the change in consequence and sensitivity as future conditions

[9] http://occri.net/climate-science/potential-impacts-of-climate-change/water-resources

Figure 2. Vulnerability Assessment - Future Conditions



arise. For example, under the Bi-Op implementation and stored water reallocation scenario, municipal water rights with priority dates junior to 1964 may be subject to regulation, and therefore, the asset becomes more sensitive. As a consequence, a "less certain" water supply is very likely to have public health, welfare, and economic impacts on a community, therefore the consequences also become higher. Conversely, both the released stored water protected under a water right for instream use, and the natural flow instream water right from the conversion of the MPSF, will provide a previously uncertain "backup" for in-stream natural resources (e.g, endangered species, water quality, and wetlands) that are downstream of the dam. However, climate change may have higher watershed health consequences on upstream flow and other in-stream assets due to warmer water, changes in timing of flow, etc., so this asset also shifts under future conditions.

The future condition scenarios that may potentially affect the assets are noted within the circles on Figure 2. Results indicate that almost all assets become more sensitive and vulnerable, though some shifts have a slightly greater magnitude than others (predominantly due to interactions of multiple variables). The Working Group also placed more emphasis on those assets that are directly reliant on water in the North Santiam River and where the implementation of actions can reduce drought vulnerability. Overall, the most vulnerable assets under future conditions are the same as under current conditions:

- Municipal water users: Detroit, Idanha, Lyons-Mehama, Gates, Stayton, and Salem
- In-stream natural resources (e.g, endangered species, water quality and wetlands)
- Commercial irrigation
- Municipal-supplied commercial/industrial use
- Water oriented recreation

2.2.4 Step 4 - Evaluate underlying causes (to identify actions)

To develop effective mitigation and response actions that build water resiliency, we need to understand the underlying causes of the vulnerability limiting water. Every asset/resource showed some level of current and/or future vulnerability, therefore, each was evaluated. The most vulnerable assets are highlighted in blue (Table 3). For the municipal water users (including municipal fire suppression), underlying causes were generally related to having a single source of water that may be inadequate under future conditions. Municipal water intakes at Salem, Detroit, and Idanha could experience difficulties receiving sufficient water at low flow.

Table 3. Vulnerability Assessment – Underlying Causes

Asset/resource	Underlying causes
Municipal water – Salem	Intake limitations, insufficient backup, reliant on single source to large degree
Municipal water – Lyons-Mehama	Below reservoir, single source, no backup, no interconnection, all water rights junior* to large downstream water users
Municipal water – Gates	Below reservoir, all but .10 cfs junior to potential future instream water right, all water rights junior to large downstream water users, no interconnection
Municipal water – Detroit, Idanha	Above reservoir, supply from small tributaries, single source, no backup, no interconnections
Instream natural resources	Below reservoir**, subject to prior out of stream

Asset/resource	Underlying causes
	appropriation, no backup, “single source”
Food crop production	Below reservoir, insufficient backup
Muni commercial/industrial use	Below reservoir**, insufficient backup, potentially subject to municipal curtailment
Water oriented recreation - *River* boating/fishing	Below reservoir**, subject to prior out of stream appropriation, no backup, “single source”
Water oriented recreation - *Reservoir* recreation	USACE operations (ie., rule curve/Bi-Op implementation), infrastructure limitations (eg., parks, ramps, docks)
Municipal water – Aumsville	No backup, no interconnections, single source (groundwater)
Municipal water – Jefferson	Single source, no interconnections
Upland natural resources	Insufficient precipitation/”single source”
Individual domestic use	Likely no backup, no interconnections, likely single source
Muni fire suppression	(See individual municipal water supplier causes)
Other commercial irrigation; Other irrigation/watering	Below reservoir, insufficient backup
Hydropower	USACE operations (ie., rule curve/Bi-Op implementation), SWCD dams below reservoir

*Junior water rights are prior to 1964 MPSF, and junior to Salem and SWCD water rights.
** These assets may occur above the reservoir, but actions to address water resiliency in these areas are limited.

3 RECOMMENDATIONS AND DATAGAPS

As noted in the discussion above, uncertainties exist that could interact to produce a range of future conditions, such as how regulatory decisions will be implemented to affect each asset (ie., will the stored water reallocation affect individual domestic water users – it is not anticipated to do so), or how multiple future scenarios interact within this watershed to produce a specific change. The following recommendations are made to document and account for these uncertainties and address them within future iterations of this vulnerability assessment.

- Track the Willamette Project Bi-Op implementation and stored water reallocation efforts to understand changes in regulatory structure, water rights and future availability of water to existing water right holders.
- Track USACE decision making regarding altering the rule curve to adjust to future conditions (i.e., to capture water earlier).
- Begin to gather quantitative data to assess the consequences of drought on watershed assets as they specifically relate to the underlying causes, such as gathering information on economic losses, community responses to manage water supply, and impacts on watershed resources such as water quality or salmonid redd survival.
- Examine and agree upon how groundwater interacts with surface water in this watershed, and the effects the interaction may have on low summer flow and individual domestic well users.
- Track the natural resource assessment in GIS being conducted by Partners of the North Santiam Resiliency Action Planning Process to see how it may be used to evaluate future potential drought effects on watershed health (e.g., current cold water refugia, predicted change in mean August temperature).
- Track future population growth forecasts, specifically with respect to future economic development within the Santiam canyon.

- Track adaptive responses and their success.

4 [NOTE TO READER REGARDING NEXT STEPS]

The results of this vulnerability assessment chapter will be incorporated into the DCP chapter for Mitigation Actions (Element #3), and the chapter for Response Actions (Element #4). Working Group meetings for Mitigation and Response Action planning (and future DCP chapter development) will be convened after the June 22 Task Force meeting.