Introduction

At most times and in most places, surface water is abundant in the basin: in 1990, about 19,500 million gallons per day (mgd), equivalent to about 30,000 cubic feet per second (cfs), flowed daily, on average, from the mouth of the Willamette River, while daily withdrawals for out-of-stream uses were 870 mgd, or 1,350 cfs.[47,135] Scarcity does occur in some places during the summer, though, as natural streamflows fall and demands for water rise. Water typically remains abundant, however, below the basin's federal reservoirs, as releases from them can double or triple the summertime flows that would occur otherwise at the mouth of the Willamette.

Water in the basin has many uses: to support fish and wildlife habitat, navigation, and recreation; to dilute wastes, generate hydropower, and irrigate crops; and to meet the diverse demands of municipal, industrial, commercial, and other users. Demands for surface water, however, are not expressed freely, as with most goods in a market economy. Rather, they are controlled by water rights, which specify the location and type of each allowed use, the amount to be used, and the priority date when the right was established (see pp. 34-35). Although some water rights are intended to protect in-stream flows for fish and wildlife, most are for out-of-stream uses, such as irrigation, or for in-stream commercial uses, such as generation of hydropower. Roughly one-quarter of withdrawals in 1990 were intended for irrigating crops, 30% for public supplies, and the remainder for self-supplied domestic, commercial, and industrial uses.[135]

Oregon's system of water rights laws and regulations links each water right to others upstream and downstream. In effect, this system creates a queue of claims on water, with those water rights having earlier priority dates placed in the queue ahead of those with later ones, and the system allocates water along the queue, beginning at the front with the earliest water right and continuing until the available supply of water is exhausted. Transfers of water rights from the initial use to another, though allowed, have occurred infrequently and water rights established in the past for one type of use generally continue to be limited to that use. Thus, new demands might not receive a water right, if all the available water has already been allocated previously, and some existing water rights might represent demands that are not the same as they once were.[43]

For the basin as a whole, a substantial portion of the water rights for agricultural, hydropower, and some other uses were established prior to 1950 (Table 40). The bulk of the water rights for municipal and industrial uses were established in the 1950s, and three-quarters of the water rights to protect in-stream flows were established in the 1960s. Of all the water allocated to water rights by 1998, 14% was for rights and uses established prior to 1950, 40% for those prior to 1960, and 79% for those prior to 1970. Only 4% of the total allocated water covered by water rights is for uses established in the 1990s. Comparable percentages vary from place to place within the basin.

	Type of Water Use					
Decade	Agriculture	Municipal& Industrial	Hydro-power	In-Stream	Other	Total
1990s	7	1	0	7	2	4
1980s	8	4	3	10	11	7
1970s	14	21	0	7	22	10
1960s	24	4	25	76	13	39
1950s	17	64	31	0	20	26
Prior to 1950	30	6	41	0	32	14

Table 40. *Percent of total volume of water allocated to water rights in the WRB prior to 1998, by decade of priority date and type of use.*

Of the total volume of all water rights in 1998, the shares, by type of use, were: protect in-stream flows, 41%; municipal and industrial, 27%; hydropower, 23%; agriculture, 7%; and other, 2%. Although in-stream rights have the greatest share, their priority dates often are junior to those for other uses, as two-thirds of the water rights established by 1998 for out-of-stream uses were established before the first in-stream right, in 1963.

Method of analysis

Our method consists of four steps, which we complete for 1990 and each future scenario:

1. For each water right, we develop a plausible estimate of the demand for water, that is, the amount of water that each water-right-holder would want to use. For some, such as agricultural and municipal water rights, we estimate the demand using a predictive or behavioral model. For others, we assume demand equals the water right's maximum limit.

2. We develop a plausible water availability scenario for the total supply of surface water (natural streamflows and net releases from the federal reservoirs) available in each of 178 water availability basins (WABs).

3. We use a computer program, called "The WATERMASTER,"[136] to calculate the extent to which the supply of water in each of the 178 WABs can satisfy the queue of demands under each alternative.

4. We calculate the resulting streamflows and describe the degree of scarcity by examining the unsatisfied water rights at the end of the queue. To standardize estimates of scarcity, we calculate them as the total unsatisfied demand as a percent of natural streamflow, for each WAB.

Assumptions

Each water availability scenario focuses on the month of August, which, with September, typically has the year's highest demand and lowest supply. Existing water rights are governed by current state laws and policies, with new rights awarded only for small, self-supplied users and along the mainstems of the Lower McKenzie and Willamette Rivers (Fig. 50, p. 35).

We assume municipal demand changes in proportion to the human population, and varies by alternative future according to the population's distribution across the basin. In Plan Trend 2050 per capita municipal use of water is projected to decline somewhat in the Portland area relative to 1990, but remains constant elsewhere. Relative to Plan Trend 2050, per capita use is 12.5% higher in Development 2050 and 8.2% lower in Conservation 2050. Although the basin's population increases dramatically by 2050, much of the related increase in demand for water does not affect the basin, because the Portland metropolitan area draws much of its water from the Bull Run watershed, which lies outside the Willamette Basin, and, hence, outside this analysis.

For agricultural water demands, we use estimates derived from the agricultural crop-allocation model (pp. 102-3) These estimates vary by alternative future, depending upon the agricultural landscape and its corresponding demand for irrigation. Demand for all other rights equals the maximum amount to which each right is legally entitled.

In Conservation 2050, we assume there would be transfers of water from municipal and agricultural uses to in-stream use. Some of these transfers would occur through the conversion of land from agriculture to management primarily for conservation of native habitats. Other transfers would occur through a 10% reduction in consumption of water by municipalities and irrigators. We assume the conserved water would remain in-stream as if it were protected by an in-stream water right with the same priority date as the right from which it derives.

Each water availability scenario uses the same level of natural streamflow (i.e., flow that would occur in a stream if there were no upstream water withdrawals) set at a level representing a moderately "dry" year, which results in a level of flow exceeded in 80% of the time in recent decades. We estimate natural streamflow using a predictive model developed by the Oregon Water Resources Department.[137] Water withdrawn from streams but not consumed—90% for industrial, and 55% for municipal—is assumed to return immediately to the stream in the same WAB.

The LULC ca. 1990, Plan Trend 2050, and Development 2050 scenarios use releases from the federal reservoirs based on the current operational pattern: reservoirs store as much water as possible in the winter and spring; release it in the summer to meet existing stream-flow targets along the mainstem of the Willamette; and are emptied before the start of the next flood-control season. In the Conservation 2050 scenario, we assume natural flows are passed through the dams in March through April to accommodate anadromous fish. Thus, the reservoirs contain less water in summer months, and, to the extent possible given the amount in storage, water is released in the summer to meet existing flow targets along the mainstem Willamette River.

Results

For conditions as represented on LULC ca. 1990, simulations from The WATERMASTER indicate that, given the patterns of water use in 1990, if dry-year conditions had occurred, actual streamflows would have far exceeded natural streamflows below the 11 federal dams. Away from the federal dams, though, streamflows would have been less than natural streamflows, especially in the Pudding and Molalla subbasins (Fig. 140). Some WABs would have experienced scarcity, that is, the available supply would have fallen short of the demands, as represented by water rights (Fig. 141). In some WABs the unsatisfied demands would have exceeded the natural streamflow, indicating that total water rights were more than twice the natural supply in a moderately dry year. The highest scarcity would have fallen on a small number of rights for irrigation and hydropower generation (Fig. 142).

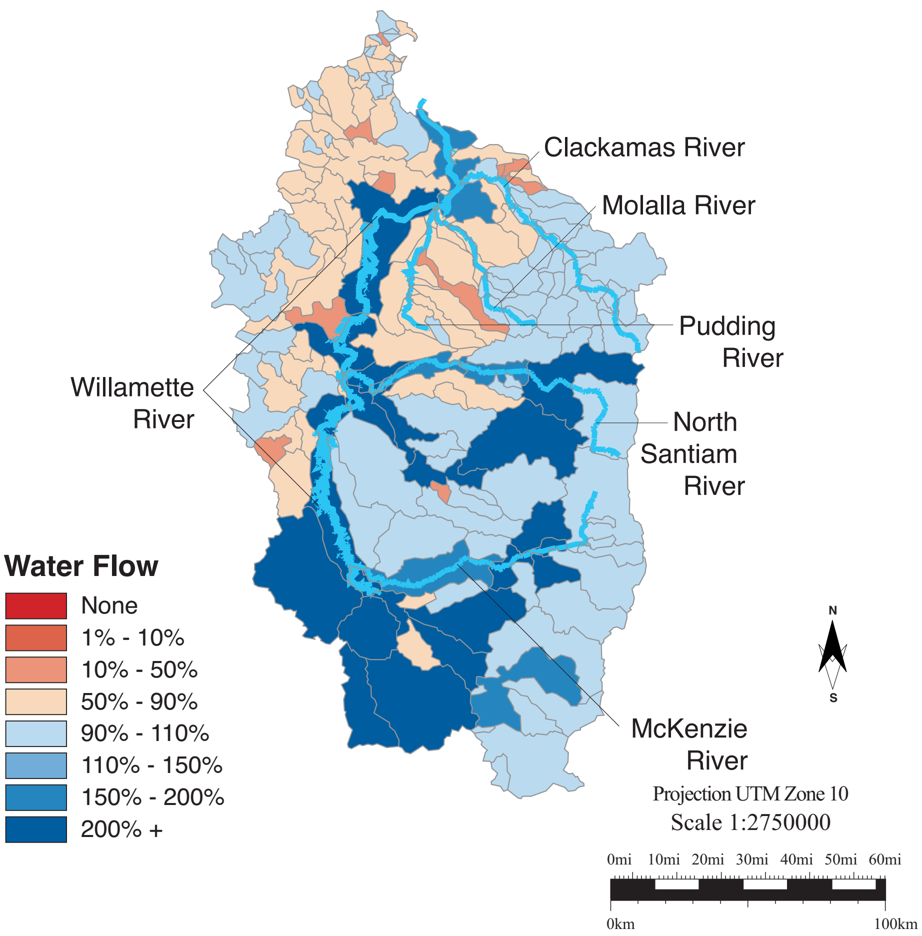


Figure 140. *Comparison of simulated flows under dry-year conditions in August, ca. 1990 to natural streamflow (100 x 1990 flow/nsf). Red indicates that natural flows would have been higher than 1990 flows, deep blue indicates they would have been lower. Municipal water supplies come primarily from the McKenzie (Eugene), North Santiam (Salem), and Clackamas (Portland Metro area) Rivers.*

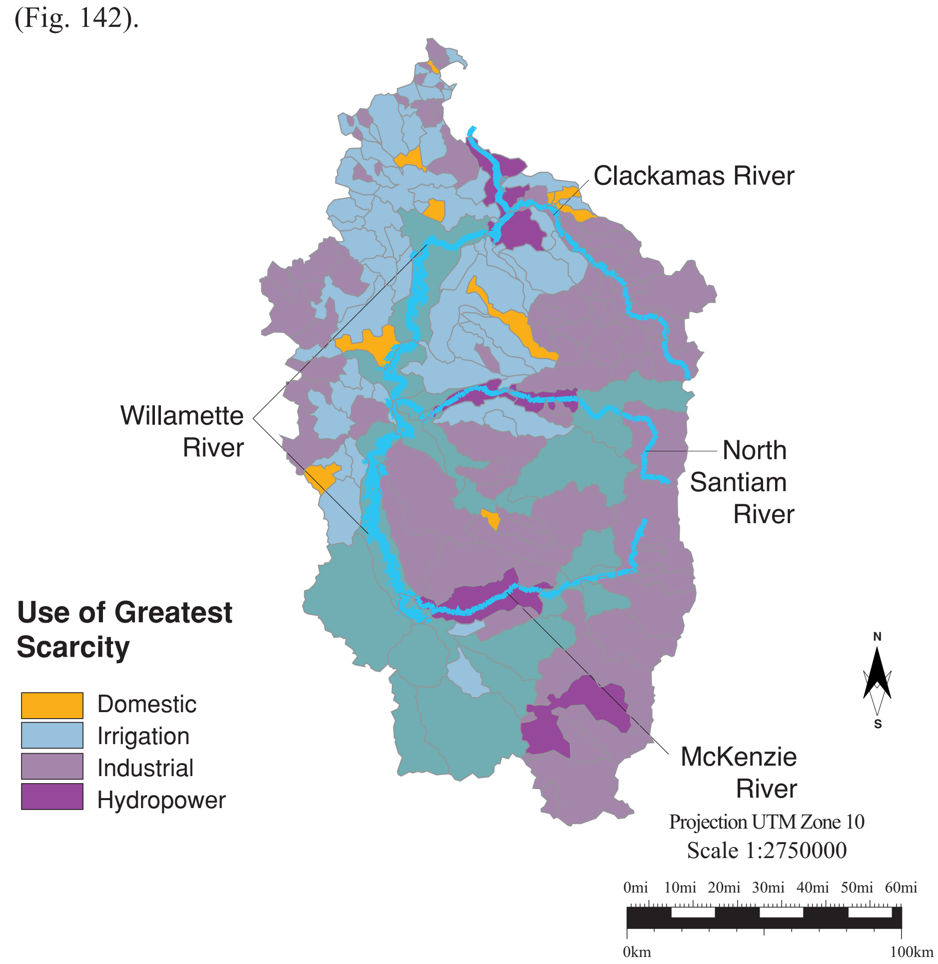


Figure 142. *Types of out-of-stream use that would have experienced the greatest estimated scarcity under dry-year conditions in August, ca. 1990.*

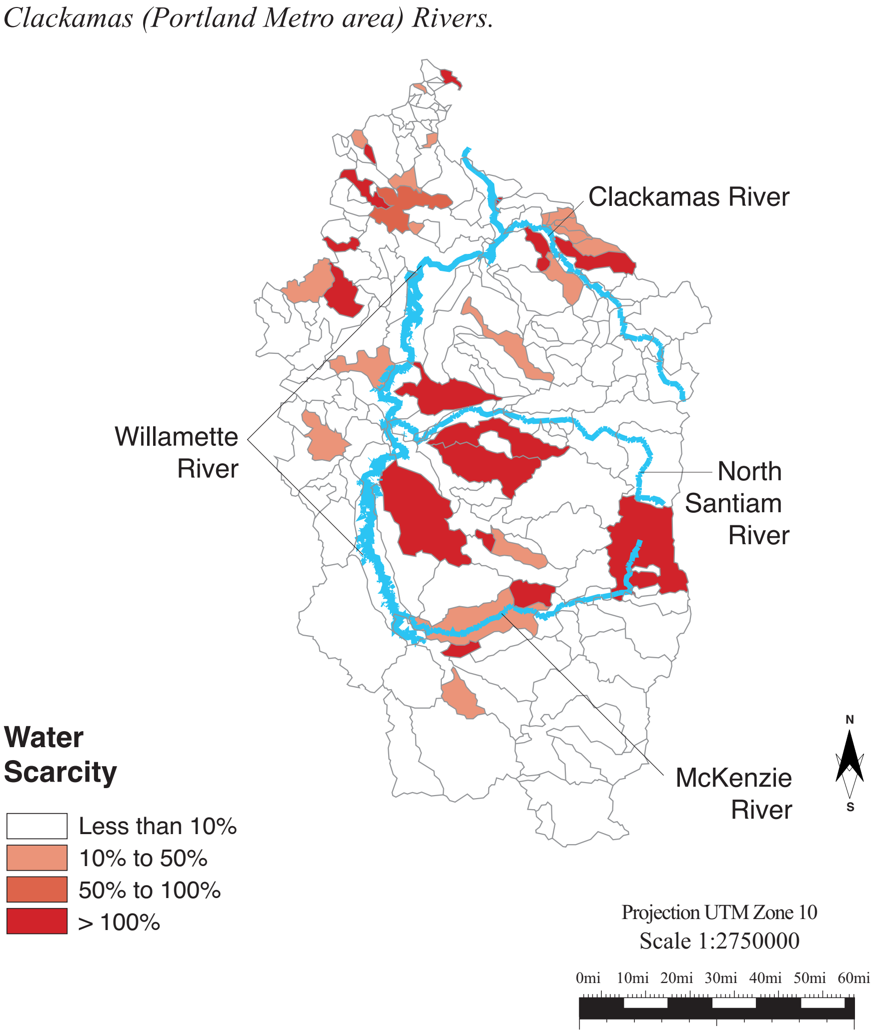


Figure 141. *Estimated scarcity of water for out-of-stream uses during dry-year conditions in August, ca. 1990. Scarcity equals unsatisfied demands as percent of natural streamflow.*

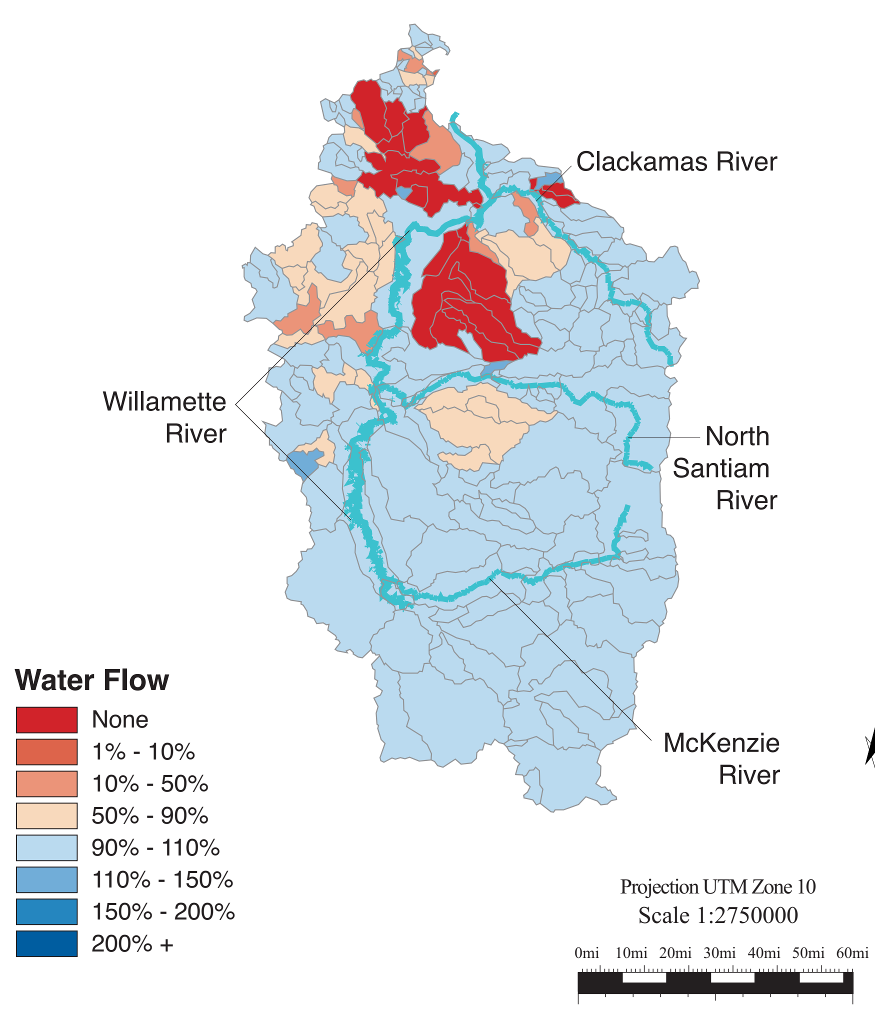


Figure 143. *Estimated streamflow under dry-year conditions in August: Plan Trend 2050, relative to 1990.*

Plan Trend 2050. By 2050, increases in demand for irrigation dramatically reduce simulated streamflows in some parts of the northern half of the Basin (Fig. 143). In some places—Deep Creek and the Tualatin, Pudding, and Molalla Rivers—the total supply of surface water is allocated to out-of-stream uses. Thus, these streams go completely dry in August, under dry-year conditions. No municipalities are adversely affected, but other out-of-stream demands (mainly irrigation) go unsatisfied in these subbasins.[138]

Development 2050. Increases in irrigation have effects similar to those in Plan Trend 2050 (Fig. 144). Many streams run dry, as in Plan Trend, but, in general, streamflows do not fall as much as in Plan Trend because this scenario entails greater conversion of land from agricultural to urban and rural residential uses, and these types of development usually use less water, per acre, than irrigation. The pattern of increased scarcity resembles that in Plan Trend 2050.

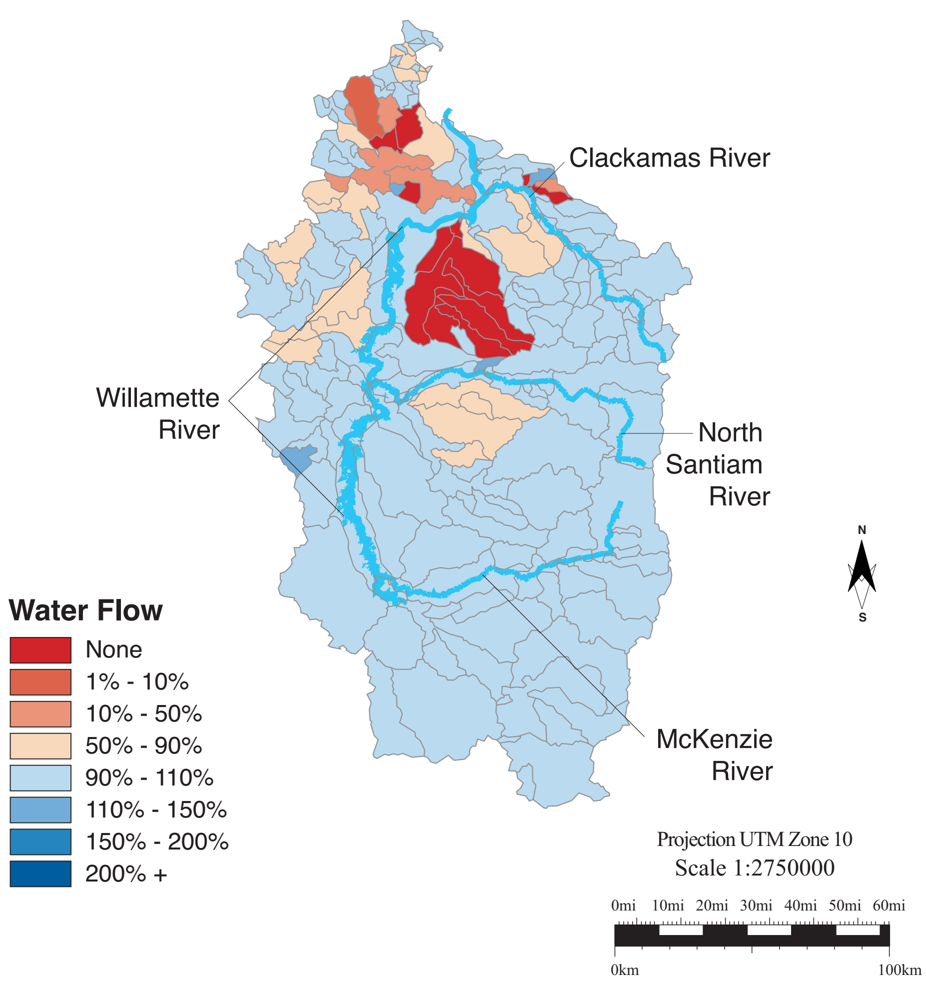


Figure 144. *Estimated streamflow under dry-year conditions in August: Development 2050, relative to 1990.*

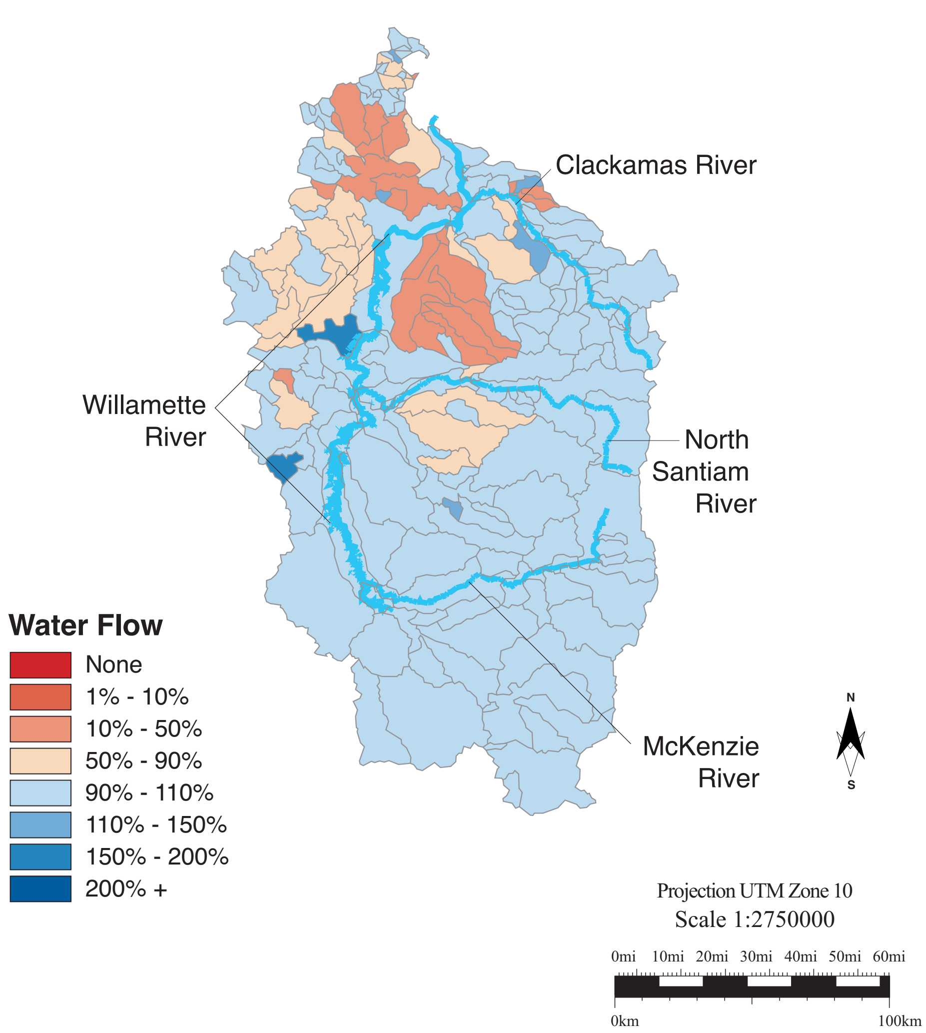


Figure 145. *Estimated streamflow under dry-year conditions in August: Conservation 2050, relative to 1990.*

Conservation 2050. As in the other two water availability scenarios, increases in irrigation relative to 1990 reduce streamflows in some northern water availability basins, although none run completely dry in this scenario (Fig. 145). The maintenance of streamflows in this scenario results partly from lower diversions per acre by irrigators and lower water use per capita in municipalities. Also important is the voluntary transfer of water from out-of-stream uses to in-stream flows. Some water availability basins, though, have lower streamflows in this scenario, compared to the other scenarios. The distribution of releases across the federal reservoirs changes, with some reservoirs releasing water earlier than they have done historically.

Comparison of Alternatives. Projected agricultural diversions of surface water—for irrigation, livestock, and other uses—is greatest under Plan Trend 2050, where diversions under dry-year conditions in 2050 are 165% of the levels in circa 1990 for August, and 220% for September (Table 41). The other two scenarios show smaller, and roughly equal increases, reflecting the underlying assumptions about farm acreage and water use per acre. Both Development 2050 and Conservation 2050 have sufficiently fewer irrigated acres that the total amount of water used for irrigation increases less, relative to 1990, than in Plan Trend 2050. Across the two months, diversions for municipal and industrial uses generally show smaller percentage increases than those for agriculture, with both Development 2050 and Conservation 2050 about 130% of the 1990 levels. The two scenarios have offsetting trends: Development 2050 has higher water use per capita but more rural residential users obtaining water from groundwater; Conservation 2050 has lower use per capita but more users using surface water from municipal systems.

Projected Changes in Major Diversions of Surface Water, Circa 1990 = 100%

Month	Use	Circa 1990	Plan Trend	Development	Conservation
Aug	Agriculture	100%	165%	133%	129%
	Municipal & Industrial	100%	121%	133%	128%
Sept	Agriculture	100%	220%	171%	172%
	Municipal & Industrial	100%	119%	131%	127%

Table 41. *Projected changes in major diversions of surface water under the alternative futures in the season of highest scarcity using 1990 as a baseline.*

Summary and Conclusions

The agricultural crop-allocation model (pp. 102-3) predicts increased irrigation in parts of the northern basin, and the analysis here shows that these increases severely reduce streamflows in 2050 in those areas. In two of the three scenarios for 2050, the natural supply of water is insufficient to satisfy all out-of-stream demands, and some streams go dry during dry conditions. In contrast, it appears the predicted increases in municipal demand for water would not have significant adverse effects on streamflows, under current water laws. Preventing streams from running dry requires a combination of conservation, shifting water from out-of-stream uses to in-stream flows, and protecting in-stream flows so that water left in a stream in one place is not withdrawn under other, out-of-stream water rights further downstream.

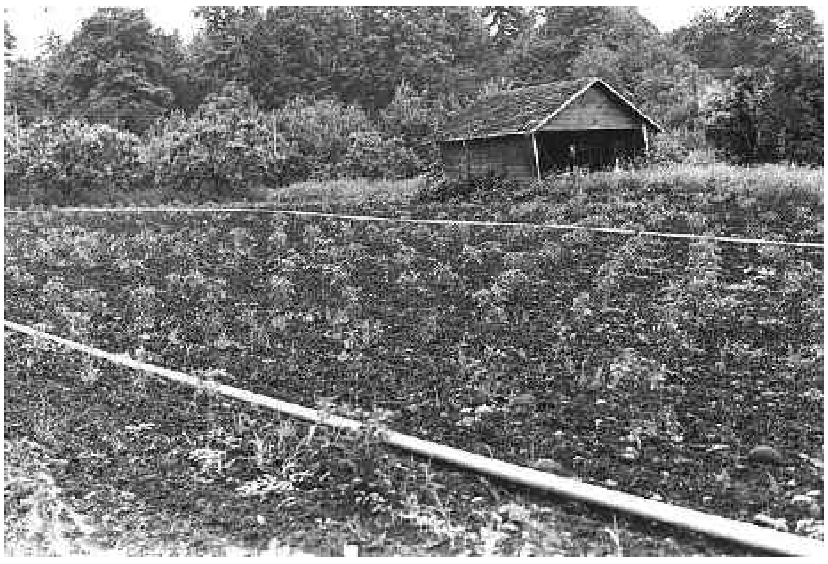
The analysis using water rights to represent demands indicates that, although water is abundant in the rivers below federal dams, scarcity—often extreme—already exists in many subbasins. Actual scarcity is greater to the extent that some types of demand, especially those associated with fish, wildlife, recreation, and other in-stream uses, are not fully incorporated in existing water rights, which generally reflect economic conditions of several decades ago. Surface water scarcity will increase under all alternative futures, but less under Conservation 2050.

Ira Keller (Forecourt) Fountain, Portland Oregon.
Photo: Stan Jones

The West Linn sewage treatment plant, showing its effluent discharge into the center of the Willamette River.
Photo: Citizens for Safe Water

Hills Creek Dam and Lake on the Middle Fork of the Willamette River.
Photo: US Army Corps of Engineers

The millrace at the Thomas Kay Woolen Mill in the Mission Mill Complex, Salem, OR. Water from Mill Creek was diverted by early pioneers to power local industries. Photo taken in 1950s.
Photo: Salem Public Library Historic Photograph Database, Salem Public Library, Salem, Oregon.



Crop irrigation as part of the Eugene-Springfield Hot Water Project in Lane County. 1969
Photo: Oregon State Archives, Oregon Department of Agriculture, OAG0111

The powerhouse at Big Cliff Dam on the Santiam River.
Photo: US Army Corps of Engineers

Boaters on Fern Ridge Reservoir near Eugene, Oregon.
Photo: US Army Corps of Engineers

Irrigation of Willamette Valley farmland.
Photo: USGS[139]