Opportunities and Costs for Agricultural Water Optimization

Document no.: 260318162200_5dbfd6b4
Version: Final

Prepared for: Utah Division of Water Resources
Prepared by: Utah State University, Jacobs Engineering Group Inc., and M.Cubed

April 21, 2026

Executive Summary

The Great Salt Lake (GSL) Basin (GSL Basin or the Basin) includes all of the watersheds that drain into the GSL. The Basin covers more than 21,000 square miles and includes much of northern Utah, a small part of eastern Nevada, the southeastern corner of Idaho, and the southwestern corner of Wyoming.

Agriculture is a cornerstone of the economy and environment within the Great Salt Lake Basin, serving as both a key economic driver and a major force in shaping land and water management. According to Utah State University Extension (Zesiger et al., 2023), irrigated agriculture in the basin generated roughly $881 million in cash receipts (2022 dollars), and when input costs from farm and ranch operations are included, its total economic contribution exceeds $1.6 billion, with potential estimates reaching up to $6.7 billion. The basin supports a diverse range of agricultural production, including livestock, dairy, and crops such as alfalfa, wheat, and corn silage. In 2017, farms in the basin produced about 118 million pounds of wheat flour, accounting for nearly 72% of Utah's total production, and 123 million gallons of milk, or 51% of the state's output, figures that highlight the basin's critical role in sustaining both local and statewide food supply chains.

Beyond its economic significance, agriculture has played a defining role in the hydrology and ecology of the Great Salt Lake Basin. The water used for agriculture supports livelihoods and food production, and it also affects inflows to the Great Salt Lake, contributing to fluctuations in lake levels and salinity that have widespread environmental consequences. As the region faces increasing water scarcity, the balance between maintaining agricultural productivity and sustaining lake health has become a central focus for the state. The future of agriculture in the Great Salt Lake Basin will depend on innovation in water management, improved irrigation efficiency, and collaboration across sectors. Continued investment in sustainable agricultural practices and water optimization could help preserve both the economic vitality of the basin's farming communities and the ecological stability of the Great Salt Lake itself - an ecosystem vital to Utah's biodiversity, recreation, and climate resilience.

This report, a component of the Utah Division of Water Resources GSL Basin Integrated Plan (BIP), included the estimation of recent (2019-2023) agricultural depletions and diversions within the GSL Basin and evaluation of the technical and economic feasibility of some options to reduce these depletions. These options included 11 irrigation system conversions, seven scenarios for leasing water, three crop substitution scenarios, and improving on-farm conveyance systems. Based on direction from the GSL Commissioner's Office, the potential of these options to reduce agricultural depletions by 10% was evaluated. There are many other options (for example, automated surge irrigation, soil health practices, pivot corner conversions) that could be evaluated in future planning efforts. Depletion reductions from completed Utah Agricultural Water Optimization Program projects were also evaluated to the extent possible within 2019-2023.

This report is a planning exercise, not an implementation plan. The results of this report should be used with caution and within the context, constraints, assumptions, and limitations of the data and methods that were used to develop the report. For example, the data and estimation methods have significant uncertainty (as do all other hydrologic estimates in the Basin). The results are not recommendations. The legal feasibility of the depletion reduction options (including water right change applications) or guaranteeing and tracking reduced depletion from the source to the GSL is outside the scope of this report. Further, a comprehensive examination of tradeoffs and practical feasibility is not included. It is important to note, however, that the data presented in this BIP is among the best data currently available for the GSL and provides one of the first and most comprehensive views of opportunities and costs for agricultural water optimization.

This report focuses on the entire GSL Basin and the Utah portion of the GSL Basin. It does not include an evaluation of the impacts of depletion reduction on all aspects of local communities and economies.

Some of the effects of reduced depletion could be devastating and long-lasting. The economic evaluations are based on input-output models and a key assumption of making farm income ‘whole’ when depletion is reduced. This is a conservative approach that tries to account for any loss in profit from depletion reduction. It cannot account directly for how other industries and organizations that interact with agriculture would be affected. It is also important to note that given the economic approach, the impacts of depletion reduction on farms and ranches could likely be reduced as water users innovate and optimize ways to achieve reductions.

Major findings are as follows:

- Agricultural depletion estimates
  - Estimated agricultural depletion in the Basin ranged from 1.0 million acre-feet (AF) to 1.7 million AF annually using three evapotranspiration (ET) datasets. There was an estimated average of 1.32 million AF for 2019 through 2023 for the entire GSL Basin and 830,000 AF for the Utah portion. About one-third of the total depletions (360 – 590 thousand AF) occurred in Idaho and Wyoming.
  - Two of the ET data products (the OpenET eeMETRIC and Ensemble) were highly correlated (R > 0.86) and generally resulted in lower depletion than the GridET model, likely because they are estimating actual ET compared to idealized ET with GridET. Despite high correlation of the two OpenET models, they varied by more than 150 thousand AF in 2021. This uncertainty highlights the challenge of accurate depletion estimation for the GSL Basin. This uncertainty needs to be considered when evaluating opportunities and strategies for depletion reduction.
  - As expected, depletion varied annually within each of the three ET datasets due to irrigation water availability, precipitation, climate, farmer behavior, and other related factors. For example, within the eeMETRIC dataset, depletion ranged from 1.04 to 1.55 million AF during 2019 to 2023. This variation of more than 500 thousand AF among years also highlights that annual variation will be key to evaluating depletion reduction opportunities.
- Agricultural diversion estimates
  - Agricultural diversions estimated from the depletion results ranged from 2.1 million AF in 2019 to 3.1 million AF in 2020 in the Basin, paralleling depletion trends.
  - Agricultural diversions varied by subbasin, irrigation method, and crop type.
- **Agricultural depletion reduction opportunities:** The following four options were assessed to evaluate what it would take to achieve a 10% reduction in agricultural water depletion across the entire GSL Basin (132,000 AF per year) or the Utah portion (83,000 AF per year):
  - Irrigation upgrades (for example, low-elevation sprinklers on center pivots and subsurface drip irrigation) could result in reduced depletion depending on acreage converted. Conversion to low-elevation sprinklers could reduce depletions by up to 2% and conversions to subsurface drip irrigation by nearly 10%.
  - Crop substitution from alfalfa to winter small grains could reduce depletions by up to 10%. Substitution from alfalfa to corn could reduce depletion by up to 2% across the entire Basin.
  - Water leasing (that is, temporary cessation of irrigation), especially three of the six split-season leasing scenarios, could achieve reductions up to 10% but would require participation across large areas.
  - Conveyance improvements, like piping ditches, could save about 4,500 AF annually across the entire Basin, representing a reduction of 0.3% in depletion.
- Economic evaluation of depletion reduction opportunities

- Two economic evaluation methods were used: (1) estimating farmers' minimum payment to adopt strategies and (2) modeling regional economic impacts using a multi-region input-output model.
- Five strategies were evaluated: (1) full- and split-season leasing, (2) crop substitution, (2) irrigation system changes, (4) balanced implementation combining a third of all three, and (5) least cost implementation.
- A custom spreadsheet tool supports ongoing analysis and stakeholder use.
- Cost-effectiveness and feasibility
    - Options with the lowest cost per AF included use of low-elevation on existing pivots ($148 per AF), wheel-line to pivot conversions ($176 - $209 per AF), ceasing alfalfa irrigation early or full-season leasing ($236 per AF), and substitution of alfalfa for winter wheat ($276 per AF).
    - Options with moderate costs were delayed irrigation start, replacing alfalfa with corn or spring wheat ($340 - $493 per AF).
    - The most expensive options were wheel-line to subsurface drip ($509 - $667 per AF), or conversions from surface irrigation to other systems ($1,014 - $22,094 per AF). Given the low depletion savings and high cost of irrigation system conversions away from surface irrigation, other efforts to improve surface irrigation such as automation and surge irrigation should be considered.
    - Some strategies require additional management (for example, acreage limits, deficit irrigation) for depletion reductions to occur.
    - The balanced implementation approach combining leasing, irrigation system conversions, and selective crop substitution offers the lowest-cost depletion reduction with an annual cost of $30 million compared to $31 million (leasing alone) to $75 million (irrigation system changes alone) for approaches that only include a single approach.

Table ES-1. Summary of Options with Potential to Reduce Agricultural Depletions in the Utah Portion of the Great Salt Lake Basin

Option	Estimated Depletion Reduction (AFY)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Cost ($/AF)	Advantages	Challenges
Ag to M&I conversion	29,000	3.5	80,000	N/A	Net reductions related to projected growth in Utah. There are several contrasting views of how much growth should occur, and this is beyond the scope of this report.	
Piping head ditches	2,900	0.3	2,400 miles	N/A	Provides more control of irrigation water for farmers. Reduces evaporation of open water and ET of plants around open ditches.	Can result in increased depletion if it's used to deliver more water for irrigation (that is, the water saved from the piping).
Wheel-line to pivot LESA and LEPA	10,000	0.8	38,000	$176-$209	Common option already occurring on many farms. It reduces labor and increase remote control and programming of irrigation.	Field geometry (from square or rectangle to circle) causes pivot corners that are difficult to manage. Pivot technology requires more skilled labor and maintenance costs increase.

Option	Estimated Depletion Reduction (AFY)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Cost ($/AF)	Advantages	Challenges
MESA to LESA	6,000	0.7	93,000	$148	Many existing pivots with MESA can easily be adapted to LESA. Irrigation uniformity and crop yield can increase.	Runoff can increase for LESA compared to MESA for fields with high slope. Increased maintenance due to additional sprinklers.
Wheel-line to SDI	21,000	2.5	50,000	$509	Field geometry works well for conversions to SDI. Increased control of irrigation management with SDI.	Labor, rodent issues, and installation and maintenance costs increase significantly with SDI.
Leasing Scenario 1 (cease irrigation after June)	83,000	10	77,000	$235	Allows for first 1-2 cuttings of alfalfa to be harvested before irrigation ceases.	Reduced forage production. May require purchasing of forage for high cost outside the Basin for operations with livestock to feed. Soil health concerns is non-irrigated land is not managed.
Leasing Scenario 2 (cease Alfalfa after July)	83,000	10	135,000	$237	Allows for first 2-3 cuttings of alfalfa to be harvested before irrigation ceases.	
Leasing Scenario 4 (start Alfalfa in July)	83,000	10	168,000	$340	First cutting of alfalfa could sometimes be harvested without irrigation.	
Substitution of Alfalfa with Winter wheat (lower valleys)	83,000	10	140,000	$276	Small grains can be used for forage or grain. New markets may be available in northern Utah.	Possible decline in soil health due to uncovered soil. May require shift in farm investments in harvest equipment. Insufficient market demand for small grains.
Substitution of Alfalfa with Corn	26,000	3.1	224,000	$424	Corn markets are relatively stable. Demand for corn increasing in dairy production.	Corn silage is expensive to transport long distances and does not grow well at high elevations with short growing seasons. May require shift in farm investments in harvest equipment. Insufficient market demand for small grains.

N/A = not applicable or available

- Agricultural Water Optimization Program
  - Launched in 2019 by Utah Department of Agriculture and Food, the Agricultural Water Optimization Program has supported 84 completed and 223 ongoing projects (including canal lining, piping, and conveyance projects) within the GSL basin.
  - The analysis was limited to projects that could be evaluated from 2019-2023. This included nearly half (161 projects) of all projects and represents over 11,000 acres of irrigation system conversions funded in the GSL Basin. The estimated potential depletion reduction was about 1,500 AF. Some projects had no estimated savings in depletion or could potentially increase depletion.
  - Diversion reductions have been estimated in other evaluations of the Agricultural Water Optimization Program and are available at: https://www.arcgis.com/apps/dashboards/5475010c6c41445b86463739226760c9.
- Agricultural depletion reduction through land Use conversion
  - Another BIP section estimated that converting agricultural land to municipal and industrial (M&I) use in Utah's portion of the GSL Basin could reduce agricultural depletion by 53,000 to 90,000 AF per year by 2050. After accounting for new municipal and industrial demands, the net reduction is about 29 KAF per year, which is approximately 3.5% of the total depletion (830 KAF) in the Utah portion of the GSL Basin. It is important to note that conversions from agriculture to M&I can result in increased depletion due to the spreading of reduced or eliminated return flows from agriculture beyond historical use areas. Thus, these estimates should be used with caution and actual/physical depletion changes (vs. those estimated on paper) warrant further and careful study. However, this conversion of agriculture to M&I reduction comes at the cost of losing agricultural land, creating a clear conflict with efforts to preserve farming and rural landscapes. For these reasons, relying on agricultural-to-M&I conversion as a depletion-reduction strategy may not be desirable.

The present report highlights some of the potential pathways to reduce agricultural water depletion in the GSL Basin while considering economic and operational feasibility. The report is intended to provide guidance for the BIP. The high uncertainty of depletion estimates and the annual variation in depletions across the GSL Basin need to be considered when evaluating depletion reduction opportunities. This uncertainty may be greater than the 10% reduction of 132 thousand AF evaluated in this study. Within this uncertainty, projected agricultural-to-M&I conversion is estimated to reduce agricultural depletions by nearly 3.5% in Utah's portion of the Basin, but many other options evaluated here offer reductions ranging from 0.1% to 10% without requiring a shift away from agricultural land use. Some of the irrigation system conversions (wheel-line to pivot and pivot mid-elevation sprinklers to pivot low-elevation sprinklers) are already happening within the Basin (especially with support of the Utah Agricultural Water Optimization Program) and may be among the most feasible options for farmers. The economic tool provided with this report will allow for various combinations of scenarios of all considered options to be explored. The tool also includes the potential to add more options for future analyses.

Contents

Appendices

Tables

Figures

Acronyms and Abbreviations

$	2025 United States dollars
AF	acre-foot or feet
AF/acre	acre-feet or -foot per acre
AFY	acre-feet or -foot per year
Basin	Great Salt Lake Basin
CSU	Colorado State University
DWRe	Utah Division of Water Resources
ET	evapotranspiration
GDP	gross domestic product
GSL	Great Salt Lake
GSL Basin	Great Salt Lake Basin
ICA	Industry Contribution Analysis
I-O	input-output
Jacobs	Jacobs Engineering Group Inc.
KAF	thousand acre-feet
KAFY	thousand acre-feet per year
LEPA	low-energy precision application
LESA	low-elevation spray application
MESA	mid-elevation spray application
MRIO	multi-region input-output
N/A	not applicable or available
NASS	National Agricultural Statistics Service
NWS	National Weather Service
SDI	subsurface drip irrigation
UCRC	Upper Colorado River Commission
UDAF	Utah Department of Agriculture and Food
USDA	United States Department of Agriculture
USU	Utah State University
WRLU	Water Related Land Use dataset
WTA	willing or willingness to accept

1. Introduction

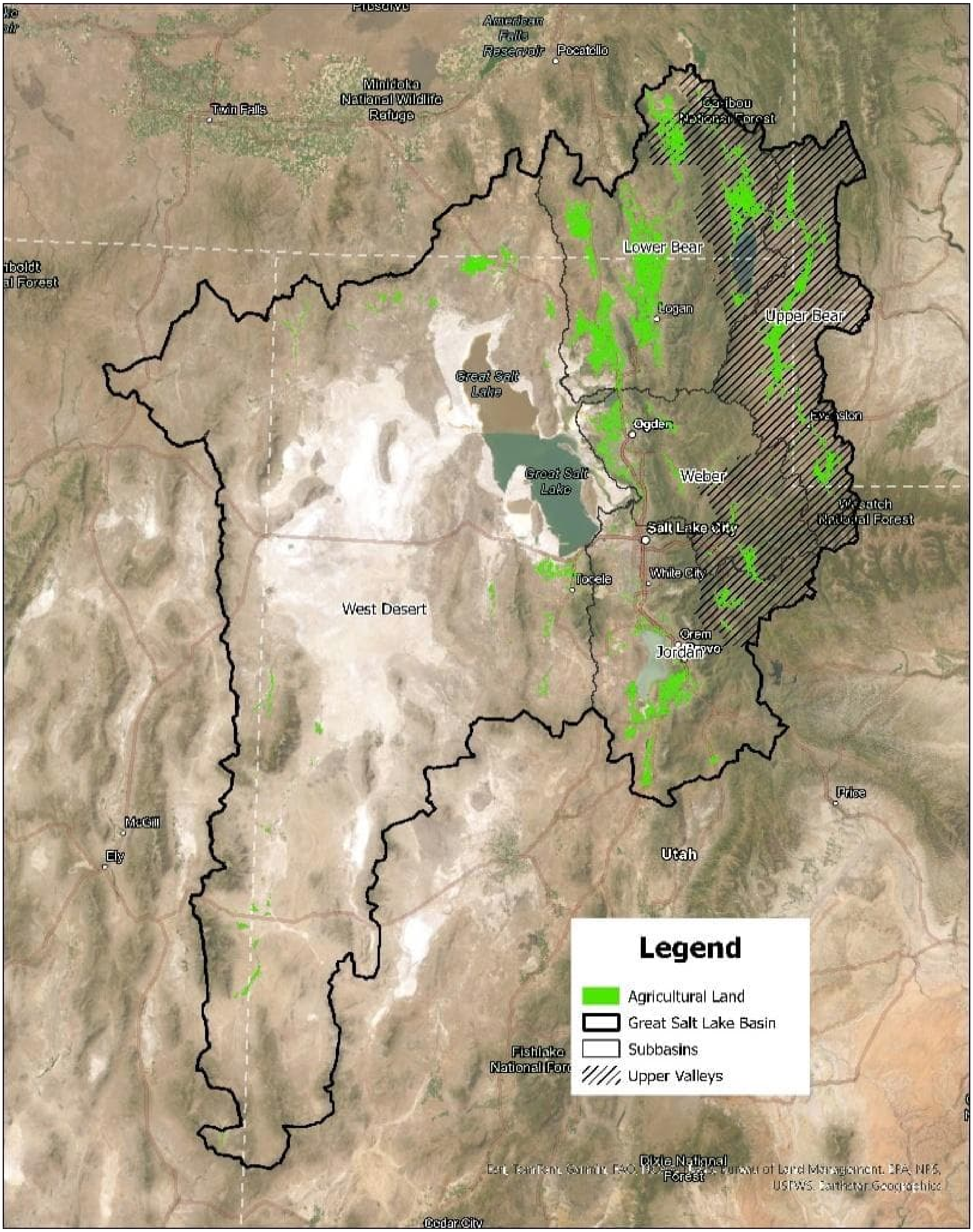
In April of 2024 DWRe completed the GSL Integrated Plan Work Plan. The Work Plan was created as a guidance document to develop the GSL BIP that is intended to be a process and a tool for ensuring a resilient water supply for the GSL and all water uses in the basin. The Gap Analysis in the Work Plan (Appendix G) identified several projects that are intended to inform water management decisions in the basin. This Opportunities and Cost for Agricultural Water Optimization was identified as a key study to better understand how changes in agricultural practices could impact depletions in the GSL Basin. In August 2024, Utah State University (USU) and subconsultants Jacobs Engineering Group Inc. (Jacobs) and M.Cubed (collectively the Team) were contracted to meet the Utah Division of Water Resources' (WRe's) and the Great Salt Lake (GSL) Commission's goal of quantifying water depletion and potential depletion savings and costs through agricultural water optimization in the GSL Basin.

To quantify depletion savings opportunities, the Team conducted an analysis across the GSL Basin (Figure 1-1). The analysis included four major tasks:

- **Task 1:** Understanding the current conditions in the GSL Basin by quantifying the current estimated amount of agricultural depletion and diversion.
- **Task 2:** Quantifying the opportunity for agricultural depletion reduction from agricultural optimization (such as irrigation system changes), split-season and seasonal leases, and crop substitution across the GSL Basin at the field scale. On-farm conveyance system improvements were also considered.
- **Task 3:** Conducting an economic assessment that estimates the cost of each optimization practice, developing and analyzing strategies to meet 10% depletion targets, evaluating regional economic impacts of select scenarios, and developing a decision-support tool to model and compare additional scenarios.
- **Task 4:** Evaluating depletion changes of completed Utah Department of Agriculture and Food Agriculture Water Optimization Program projects during the study period (2019 through 2023) and developing methodology for evaluating future completed projects.

This *Estimates of Technical and Economic Agricultural Depletion Reduction Opportunities in the Great Salt Lake Basin Report* summarizes these four tasks. A specific focus on a 10% depletion reduction goal was included in support of a request from the GSL Commissioner's Office.

Figure 1-1. Hydrologic Subbasins and Agricultural Lands in the Great Salt Lake Basin



Note: Upper Valleys were specifically delineated to support evaluation of crop substitution opportunities.

2. Agricultural Depletion for Irrigated Fields in the Great Salt Lake Basin

2.1 Study Period Weather Conditions

The study period used for this report was 2019 through 2023; this period includes both wet and dry years. Table 2-1 is a summary of annual precipitation departures from the 1994 – 2024 average for the study years from four weather stations (NOAA, 2025) randomly selected to represent different areas of the GSL Basin. In 2020 and 2022, all four stations recorded negative departures, indicating drought conditions, particularly severe in Provo and Tooele, with departures of -9.5 inches and -10.5 inches in annual precipitation, respectively. In contrast, 2023 was a relatively wet year, with all stations having positive departures, including 3.0 inches at Lifton and 4.2 inches at Richmond. The year 2021 presented a mixed pattern: Lifton and Provo experienced slightly positive departures (3.1 inches and 0.9 inches, respectively), while Richmond and Tooele faced drought conditions with departures of -4.7 inches and -2.1 inches, respectively. The year 2019 was also generally wet, especially in Richmond (5.8-inch departure) and Lifton (4.4-inch departures). Additional details about the precipitation patterns are included in Appendix A.

Table 2-1. Annual Precipitation Departures from Long-Term Average (1994 through 2024) for Four Great Salt Lake Basin Weather Stations, 2019 through 2023.

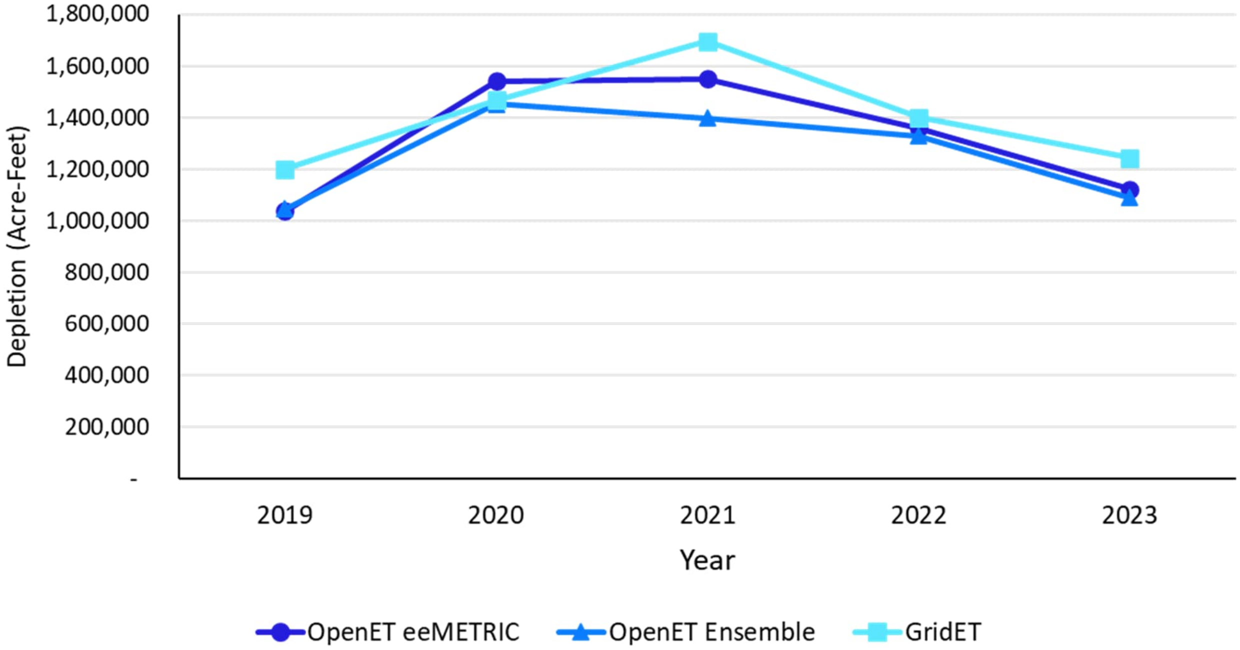
Weather Station	Annual Precipitation Departures from Average (inches)				
	2019	2020	2021	2022	2023
Lifton Pumping Station	4.45	-2.7	3.1	-1.7	3.0
Provo	0.2	-9.5	0.9	-4.1	2.2
Richmond	5.8	-5.7	-4.7	-3.6	4.2
Tooele	2.1	-10.5	-2.1	-5.5	0.1

Note: Positive value indicates wetter-than-average years, while negative value indicates drier-than-average years.

2.2 Depletion Accounting Method Comparison

Agricultural depletion in the GSL Basin was quantified using three ET models: Modeling Evapotranspiration with Internal Calibration version for Google Earth Engine (eeMETRIC; Allen and Trezza 2007) using data available from the OpenET platform (OpenET 2024a), the Open ET Ensemble ET dataset (OpenET 2024b), and GridET, a model originally developed for WRe by Lewis and Allen (2017). Methodology used in this study to calculate depletion is described in Depletion Calculation Methodology (Jacobs 2025); resulting depletion values for these three ET models for the study period (2019 through 2023 irrigation seasons) are compared in Figure 2-1. Depletion ranged from a minimum of 1.0 million acre-feet (AF) in 2019 to a maximum of 1.7 million AF in 2021 with the OpenET models generally producing lower estimates of depletion volumes compared to GridET. Depletions within a model are expected to vary year to year due to several factors including irrigation water availability, precipitation, climatic conditions, and irrigator behavior. Differences among models are also expected because GridET estimates ET for nonstressed, nonwater-limiting conditions, and OpenET products (eeMETRIC and Ensemble) estimate actual ET.

Figure 2-1. Comparison of Depletion Estimates Based on eeMETRIC, Ensemble, and GridET Models in the Great Salt Lake Basin



Depletion estimates were obtained for irrigated and sub-irrigated land in the GSL Basin. The WRe's Water-Related Land Use (WRLU) dataset layer was clipped to the GSL Basin boundary and filtered to include only agricultural lands. Any agricultural fields with an irrigation method equal to "Dry Crop" or "None" or a crop group equal to "Fallow/Idle" or "None" were excluded. Some WRLU farm fields had depletion values of zero during the study period. The number of fields with zero depletion values ranged from 94 fields (0.1% of fields by count) in 2020 to 1,731 fields (2.2% of fields by count) in 2019. The median field size of fields with zero depletion values was smallest using the GridET estimates and largest for the Ensemble ET estimates.

On average, the size of fields with zero depletion values was just over 5 acres. Some fields had no depletion due to the following: 1) sparse irrigation and the combination of carryover soil moisture and irrigation season precipitation outweighing depletion of applied water, and/or 2) sufficiently small field boundaries allowing ET values to be influenced by neighboring fields (Appendix A provides more details).

The relationships between the two OpenET models and GridET were compared to evaluate their depletion estimations using Pearson's correlation coefficients (R). The two OpenET models were always highly correlated to GridET with R values at or above 0.86 during 2019 through 2023. The average 2019 through 2023 correlation coefficient is 0.88 between the eeMETRIC and GridET models and 0.92 between the Ensemble and GridET models (Table 2-2).

Despite the high correlation between the two OpenET models (R > 0.86), there was still substantial variation in depletions within some years. For example, in 2021, the two OpenET models varied by more than 150 thousand AF in depletion estimates. This variation is greater than 10% of the total GSL Basin depletions that year and highlights the high uncertainty in depletion estimates.

Table 2-2. Pearson's Correlation Coefficients Comparing Depletion Values from the eeMetric and Ensemble Models Compared with the GridET Model for 2019 through 2023

Year	Pearson's Correlation Coefficient for eeMETRIC	Pearson's Correlation Coefficient for Ensemble
2019	0.90	0.94
2020	0.88	0.92
2021	0.86	0.89
2022	0.87	0.90
2023	0.90	0.93

Note: Correlations were compared using depletion values from all irrigated agricultural fields in the Basin.

In the following sections, the eeMETRIC was selected to characterize agricultural depletions by hydrologic basin, irrigation method, and crop type. eeMETRIC-based depletion results were chosen for these summary graphics over other ET model-based estimates for consistency with the Upper Colorado River Commission's identification of eeMETRIC as the most appropriate method for determining consumptive use for irrigated agriculture in the Upper Colorado River Basin (UCRC 2022). While the two basins are significantly different in climate, a sufficiently comprehensive, GSL-Basin-focused validation of the three ET models has not yet been conducted to suggest eeMETRIC is not as justifiable as the other two methods for use in this study. Attribute data for irrigation method and crop type for each field in the Basin were obtained from the WRe Water-Related Land Use (WRLU) dataset (WRe 2024).

2.3 Agricultural Depletion by Hydrological Basin

Agricultural depletions computed using ET estimates from the eeMETRIC model organized by hydrological basin are shown in Table 2-3. On average, across 2019 through 2023, 66% of the agricultural depletion in the GSL Basin occurred in the Bear River Subbasin, which is expected as the Bear River Subbasin constitutes approximately 66% of the agricultural lands in the GSL Basin by area. Annual variability in depletion is apparent and was likely driven by water-year precipitation totals with 2019 and 2023 having above average precipitation and 2020 through 2022 having below average precipitation (NWS 2024).

Table 2-3. eeMETRIC-Based Agricultural Depletion in Great Salt Lake Basin by Hydrologic Subbasin

Hydrologic Subbasin	Depletion[a] (AF)						10 Percent of Average (AF)
	2019	2020	2021	2022	2023	Average	
Bear River (Utah)	303,000	477,000	477,000	404,000	327,000	398,000	40,000
Bear River (Idaho and Wyoming)	364,000	528,000	568,000	520,000	398,000	476,000	48,000
Jordan River	6,000	9,000	8,000	6,000	6,000	7,000	1,000
Utah Lake	135,000	209,000	193,000	166,000	148,000	170,000	17,000
Weber River	105,000	160,000	156,000	129,000	123,000	135,000	14,000
West Desert (Utah)	109,000	136,000	127,000	115,000	103,000	118,000	12,000
West Desert (Nevada and Idaho)	19,000	21,000	22,000	19,000	18,000	20,000	2,000
Total	1,041,000	1,540,000	1,551,000	1,359,000	1,123,000	1,324,000	132,000

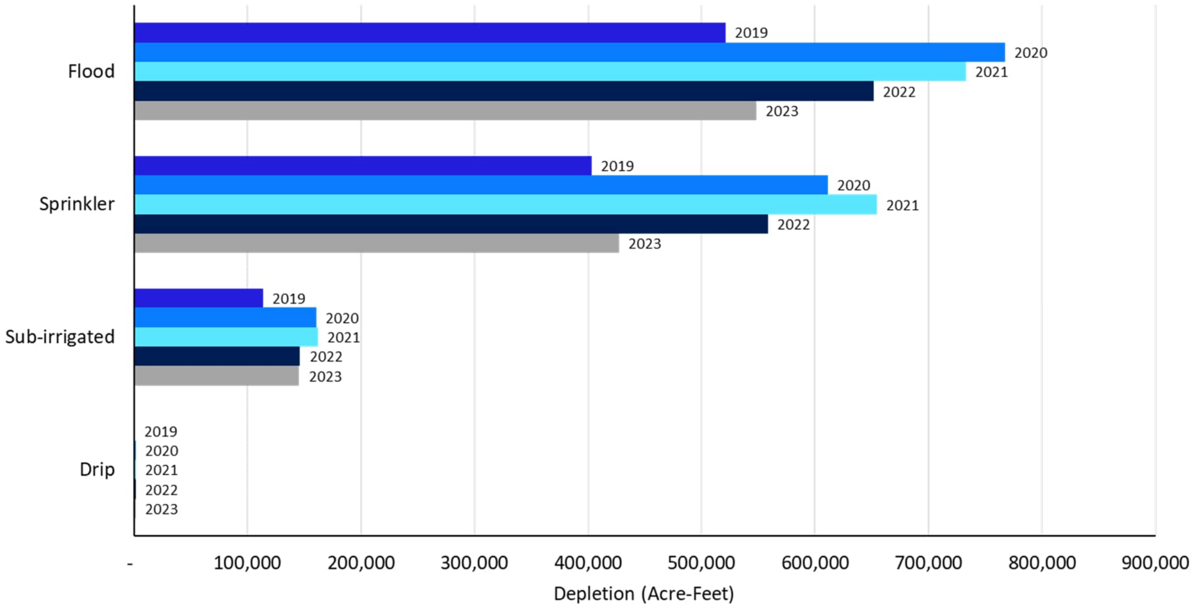
[a] Depletions are rounded to the nearest 1,000 AF.

2.4 Agricultural Depletion by Irrigation Method

The majority of agricultural lands (by both depletion volume and area) within the GSL Basin are surface (flood) or sprinkler irrigated as shown on Figures 2-2 and 2-3. According to the WRLU datasets, the total area which is surface (flood) irrigated within the GSL Basin has been steadily decreasing from 2019 through 2023 while sprinkler irrigated acreage has been increasing in this same time. Sub-irrigated and drip irrigated lands make up less than 15% of the total irrigated acreage within the GSL Basin and thus exhibit much lower depletion volumes compared to surface (flood) and sprinkler irrigated fields. Sub-irrigated land is agricultural land that "does not have irrigation water applied, but due to a high water table receives more water, and is generally closely associated with a riparian area" (WRe's Water-Related Land Use (WRLU) dataset layer). This land may be among the first that farmers are willing to lease or retire because it can be less productive than irrigated land. Further, improvements in drainage with tiles and other methods could improve crop productivity and alter depletions, likely at a lower cost than other types of water optimization strategies. These aspects of sub-irrigated land were not considered in this report but warrant further study.

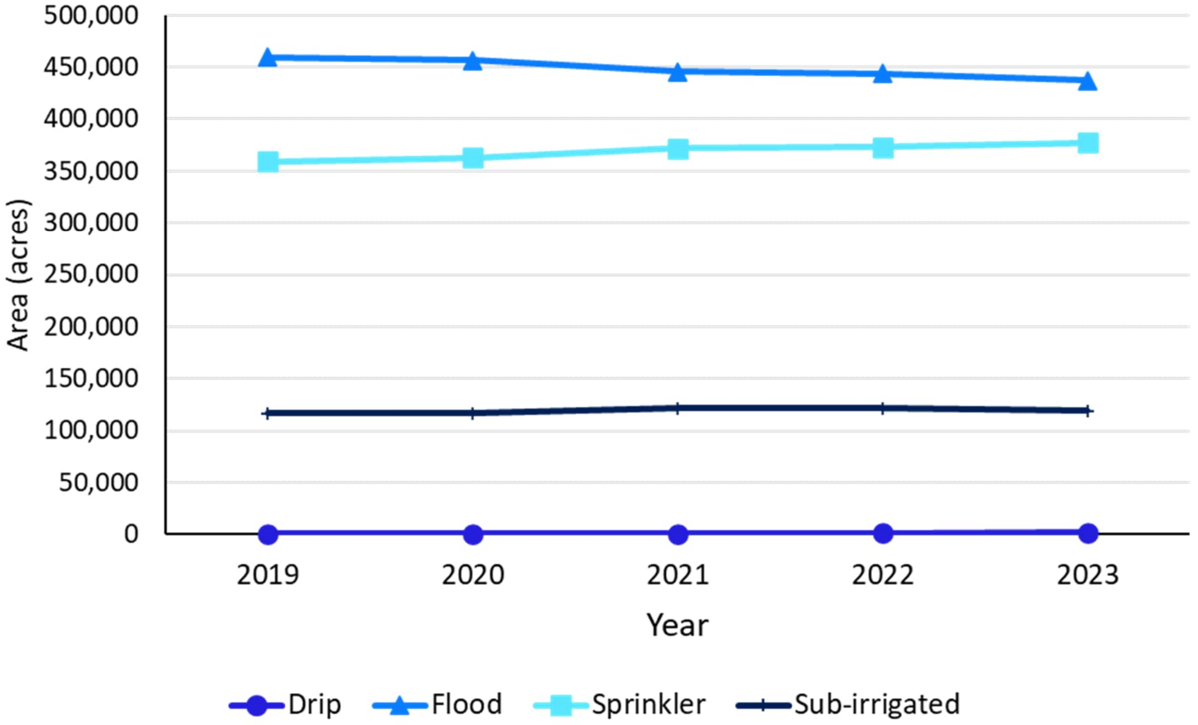
Figure 2-4 is a summary of the aggregated acreage of irrigated lands by state within the GSL Basin with Utah making up approximately 60% of the irrigated lands. Over this 5-year period, Utah consistently maintained a larger irrigated area, though it experienced a slight decline from 589,000 acres in 2019 to 576,000 acres in 2023. In contrast, the combined area of Idaho, Nevada, and Wyoming had a gradual increase, rising from 348,000 acres in 2019 to 360,000 acres by 2022 and maintaining that level through 2023.

Figure 2-2. Agricultural Depletion by Irrigation Method in the Great Salt Lake Basin



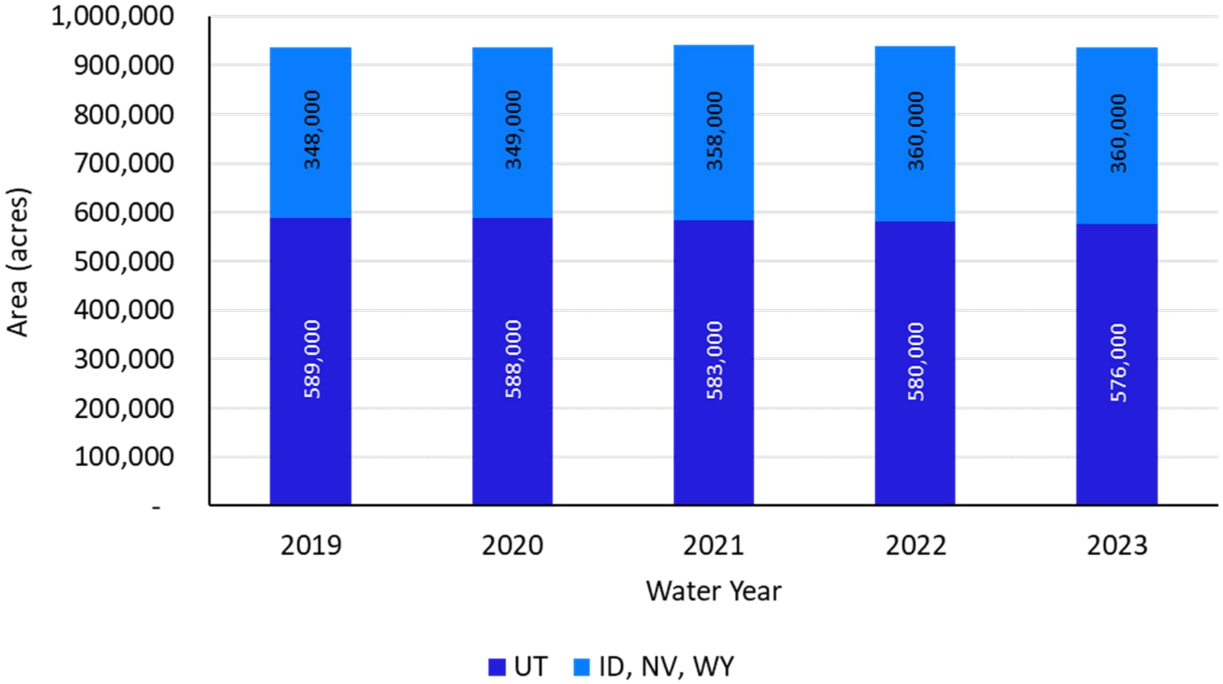
Notes:
The values represent the total depletion for each irrigation type.
Flood irrigation is the highest because there are more acres with flood than other irrigation systems in the basin.
Magnitude of depletion within drip irrigation was so little it does not appear on the figure.
Depletion in AF for drip irrigation was as follows when rounded to nearest 100 AF: 700 (2019), 1,400 (2020), 1,300 (2021), 1,900 (2022), and 1,800 (2023).

Figure 2-3. Irrigated Acreage by Irrigation Method in the Great Salt Lake Basin



Notes:
The magnitude of acreage within drip irrigation was so little it did not appear on the chart.
Area in acres for drip irrigation was as follows when rounded to the nearest 100 acres: 900 (2019), 1,000 (2020), 900 (2021), 1,600 (2022), and 1,700 (2023).

Figure 2-4. Irrigated Acreage within the Great Salt Lake Basin by State

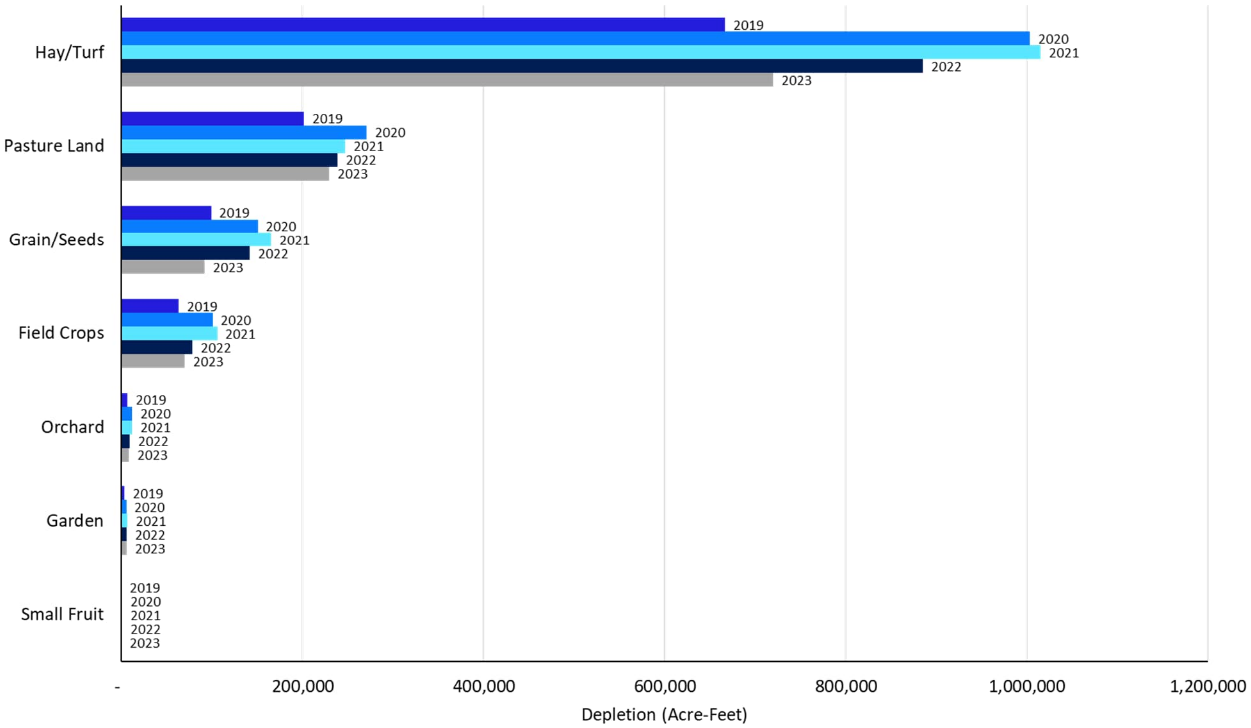


Note: Irrigated acres are rounded to the nearest 1,000 acres.

2.5 Agricultural Depletion by Crop Type

Most agricultural irrigated lands (by area and depletion volume) in GSL Basin are in Hay/Turf crop group, as shown on Figure 2-5. This crop group includes alfalfa, grass hay, and turfgrass (that is, sod farms). Sod farms represent relatively few acres in the Basin (less than a dozen farms) compared to alfalfa and grass hay but could not be separated in the available dataset. Thus, nearly all the depletions in this category are alfalfa and grass hay.

Figure 2-5. Agricultural Depletion Summarized by Crop Type in the Great Salt Lake Basin



Notes:

Magnitude of depletion within small fruit crop types was so little it does not appear on the figure.
Depletion in AF for small fruit crop type when rounded to nearest 100 AF were as follows: 100 (2019), 200 (2020), 200 (2021), 200 (2022), and 100 (2023).

2.6 Agricultural Depletion from On-Farm Conveyance Systems

Converting **on-farm** water conveyance systems from open head ditches to pipes is a common improvement that many farms in GSL Basin are already implementing. Farmers often pursue these conversions to improve their capacity to deliver water from the source to fields. Conversion projects that decrease amount of nonconsumptive ditch seepage loss so that more water can be applied to fields may increase depletion. Piping of head ditches that does not increase irrigation applications may reduce depletion through reduced evaporation losses and ET from vegetation on ditch banks.

Depletion from unlined head ditches for surface-irrigated fields in the Basin were estimated, assuming there are roughly 3,700 miles of ditches in the GSL Basin. The area’s estimated depletion is nearly 4,500 AF per year (AFY) for the total Basin and 2,900 AFY for the Utah portion (Table 2-4). The methods used to estimate ditch length, width, and bank size are very approximate, perhaps within the nearest order of magnitude at best. The results should be interpreted accordingly. Based on these rough estimates, if all of the ditches in the Utah portion and the entire GSL Basin were piped, the reduction may be 0.3% of the total depletion. Although this is a small number, it is low hanging fruit that is relatively inexpensive and would likely result in little to no resistance from the agriculture industry.

Table 2-4. Summary of Depletion Reduction Capacity from Piping All Unlined On-Farm, Field, Head Ditches in the Great Salt Lake Basin

Hydrologic Subbasin	Surface Irrigated Area (acres)	Total Head Ditches (miles)	Total Depletion[a] (AF)
Bear River (Utah)	100,000	1,000	1,000
Bear River (Idaho and Wyoming)	123,000	1,200	1,500
Jordan River	6,000	100	100
Utah Lake	59,000	600	800
Weber River	71,000	700	1,000
West Desert (Utah)	12,000	100	100
West Desert (Nevada and Idaho)	1,000	0	0
Total	372,000	3,700	4,500

[a] Depletions are rounded to nearest 1,000 AF.

3. Agricultural Diversion for Irrigated Fields in the Great Salt Lake Basin

In addition to depletion, water diversions and diversion reductions are important to consider in the context of the BIP for the GSL. Reduced diversions often allow for more control of where water is consumed and could improve water tracking to the GSL and could reduce interception of return flows. Diversions can also be measured more accurately and are more readily available to farmers and water managers than depletion. The Utah Division of Water Rights tracks most diversions that occur in the GSL Basin but this data is not spatial and cannot to connected to certain land use Therefore, in this report, diverted water is derived from depletion data and is assumed to be twice the depleted water per basin based on the eeMETRIC depletion data provided in Section 2.3. This is a simplified calculation due to limited data. However, a study performed by Follum et al. (2025) in the Duchesne River Basin substantiates the claim that 50% of all diverted water is used by crops. Similarly, as shown in a study performed for UDNR in 2020, the allowable irrigation duty value in Logan, Utah is approximately twice the estimated depletion (Jacobs et al. 2020).

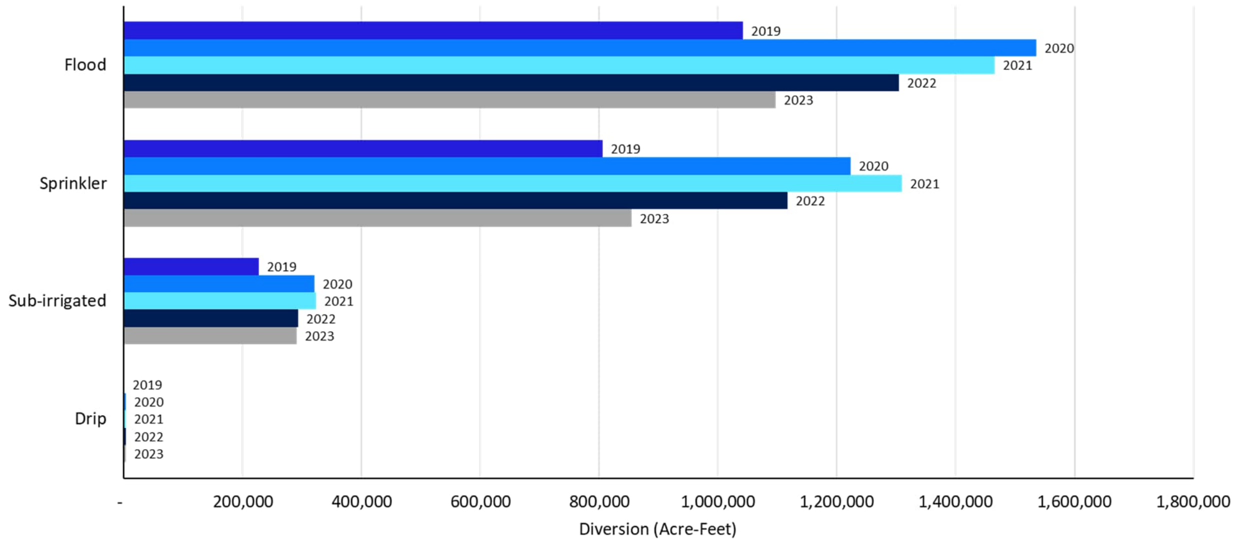
The estimated volume of diverted water in the GSL Basin due to agricultural use ranged from 2.1 million AF in 2019 to 3.1 million AF in 2020. Summaries of agricultural diversion in the GSL Basin are shown by hydrologic basin in Table 3-1, by irrigation method on Figure 3-1, and by crop type on Figure 3-2. It should be understood that because of return flows, some water may be diverted, returned, and diverted again. Further, diversions that are derived from depletion may be misleading in some cases. For example, the Bear River Canal company diverted and delivered much less water in 2021 than in 2019, 2020, and 2022 (personal communication, Trevor Nielson). Thus, caution should be used when evaluating diversion estimates.

Table 3-1. Agricultural Diversion by Hydrologic Subbasin in the Great Salt Lake Basin

Hydrologic Subbasin	Agricultural Diversion (AF)[a]						Ten Percent of Average (AF)
	2019	2020	2021	2022	2023	Average	
Bear River (Utah)	606,000	954,000	954,000	808,000	654,000	796,000	80,000
Bear River (Idaho and Wyoming)	728,000	1,056,000	1,136,000	1,040,000	796,000	952,000	96,000
Jordan River	12,000	18,000	16,000	12,000	12,000	14,000	2,000
Utah Lake	270,000	418,000	386,000	332,000	296,000	340,000	34,000
Weber River	210,000	320,000	312,000	258,000	246,000	270,000	28,000
West Desert (Utah)	218,000	272,000	254,000	230,000	206,000	236,000	24,000
West Desert (Nevada and Idaho)	38,000	42,000	44,000	38,000	36,000	40,000	4,000
Total	2,082,000	3,080,000	3,102,000	2,718,000	2,246,000	2,648,000	265,000

[a] Diversions are rounded to nearest 1,000 AF.

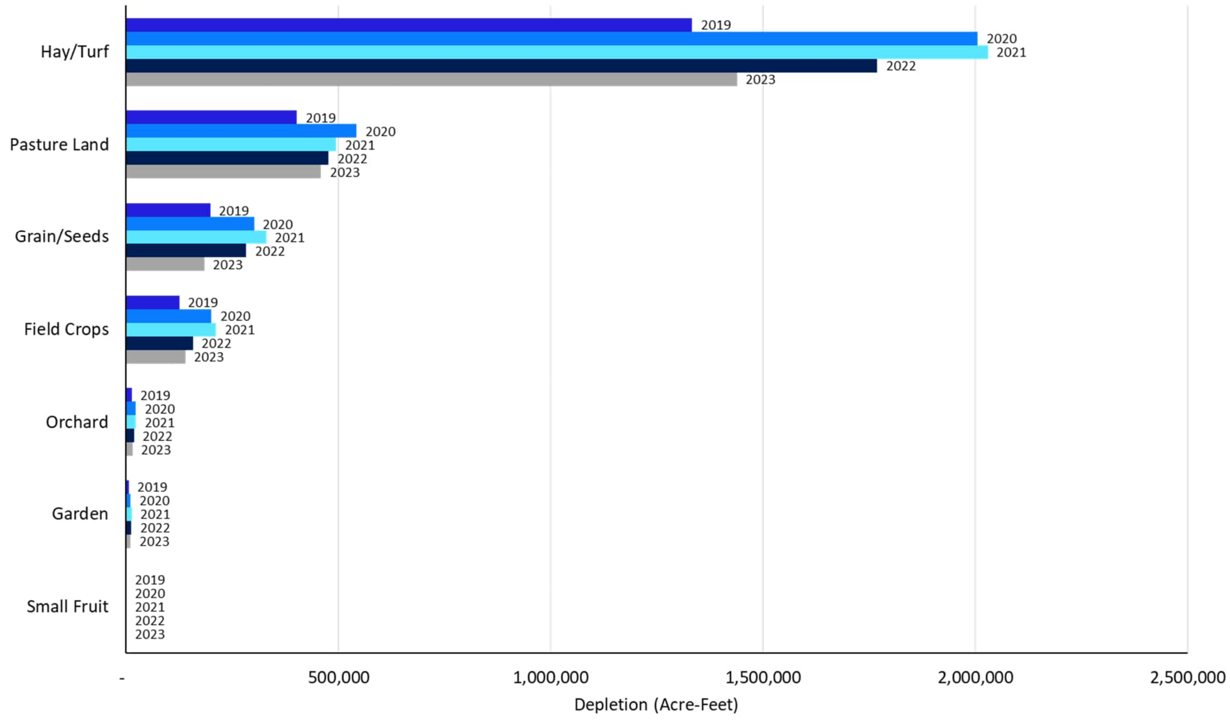
Figure 3-1. Agricultural Diversion by Irrigation Method in Great Salt Lake Basin



Notes:

Magnitude of diversion within drip irrigation was so little it does not appear on the figure.
Diversion in AF for drip irrigation was as follows when rounded to nearest 100 AF: 1,400 (2019), 2,700 (2020), 2,700 (2021), 3,700 (2022), and 3,500 (2023).

Figure 3-2. Agricultural Diversion by Crop Type in Great Salt Lake Basin



Notes:
Magnitude of diversion within small fruit crop types was so little it does not appear on the chart.
Depletion for small fruit crop type when rounded to nearest 100 AF were as follows: 200 (2019), 300 (2020), 300 (2021), 300 (2022), and 300 (2023).

4. Agricultural Depletion Reduction Opportunities

A set of potential volumetric agricultural depletion reduction opportunities in the GSL Basin are shown in Table 4-1 and Table 4-2. Table 4-2 contains similar results as 4-1 but is limited to agricultural lands located in the state of Utah, where Table 4-1 is for the full Basin. Results in both tables are based on the estimated average depletion for 2019 through 2023. Results for both OpenET models and the GridET model are presented for comparison. The methods used to calculate the results shown in Tables 4-1 and 4-2 are included in Appendix A.

The following five sections contain the key findings of the depletion reduction opportunities. At the request of the GSL Commissioner's Office, depletion reduction opportunities were evaluated based on their ability to meet a goal of a 10% reduction in total agricultural depletion. They are also presented in the context of the reductions presented in the 2025 GSL Strike Team (2025) summary.

A 10% reduction in depletion for the entire Basin is 132,000 AFY with 83,000 AFY in the Utah portion of the Basin. The GSL Strike Team assessment considered two levels (250 and 750 thousand AFY [KAFY]) of additional flow to the GSL to reverse long-term downward trends in lake levels and/or to reach healthier lake levels. The 10% reduction in agricultural depletion of 132 KAFY for the entire Basin would represent 53% of the 250 KAFY scenario. However, it is important to note that reductions in depletion throughout the Basin do not equate directly to additional flow to the GSL unless that water can be successfully shepherded to the lake.

In this report, we evaluate the impact of making isolated changes for each option on all eligible acres. Some of these options could be implemented simultaneously. The 11 irrigation system conversions, seven water leasing scenarios, and three crop substitution options were selected by the Team, WRe, GSL Commissioner's Office, and through consultation with other partners in this effort (for example, the Utah Department of Agriculture and Food, Utah Division of Water Rights, Agricultural Water Optimization Committee). The 21 options were evaluated individually based on their respective depletion reduction potential and associated costs (refer to Appendix A for more details about each category of options). Section 5 includes an evaluation of some combinations and the economic considerations for two example scenarios that combine irrigation system changes, crop substitution, and water leasing.

The intention of the 21 selected options was to represent commonly discussed pathways for reducing depletion. Some of the irrigation system conversions are already occurring on farms in the GSL Basin, and are common applications being submitted to the Utah Department of Agriculture and Food's (UDAF's) Agricultural Water Optimization Program. The list is intended in no way to be prescriptive or comprehensive of all potential options. The feasibility of implementing each of the 21 selected options varies widely. Each option presents a unique set of advantages and disadvantages that need to be considered by all those involved in implementing it to reduce depletion. The Team and all partners discussed other options but elected not to include others due to a lack of data or time. Some of the other options that were discussed included automated surge irrigation, soil health practices (for example, reduced tillage, cover crops), management of ponds or open water, deficit irrigation, irrigation scheduling, additional crop substitutions (including the use of double cropping), additional irrigation system conversions (for example, surface irrigation to wheel-line), and additional leasing scenarios (leasing involves ceasing irrigation for a time and leasing the water for other uses; one example not included is leasing water from pivot corners). These and many other options could be viable ways to reduce depletion and should be explored in future analysis.

Table 4-1. Estimated Depletion Savings and Affected Field Area by Depletion Reduction Opportunity Type for eeMETRIC-, Ensemble-, and GridET-Based Depletion Models in the Great Salt Lake Basin

			OpenET eeMETRIC			OpenET Ensemble			GridET		
Type	From	To	Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)
Irrigation system changes	Surface (border irrigation)	Pivot/lateral MESA	--	0.0%	437,000	--	0.0%	437,000	--	0.0%	437,000
		Pivot/lateral LEPA	9,000	0.7%	317,000	9,000	0.7%	317,000	9,000	0.6%	317,000
		Pivot/lateral LESA	23,000	1.7%	317,000	22,000	1.7%	317,000	23,000	1.6%	317,000
		SDI	113,000	8.5%	437,000	107,000	8.5%	437,000	115,000	8.2%	437,000
	Wheel line, hand line, solid set	Pivot/lateral MESA	19,000	1.4%	83,000	19,000	1.5%	83,000	21,000	1.5%	83,000
		Pivot/lateral LEPA	9,000	0.7%	38,000	9,000	0.7%	38,000	10,000	0.7%	38,000
		Pivot/lateral LESA	11,000	0.8%	38,000	11,000	0.9%	38,000	12,000	0.9%	38,000
		SDI	35,000	2.6%	83,000	35,000	2.8%	83,000	39,000	2.8%	83,000
	Pivot/lateral MESA	Pivot/lateral LEPA	2,000	0.2%	134,000	2,000	0.2%	134,000	2,000	0.1%	134,000
		Pivot/lateral LESA	8,000	0.6%	134,000	8,000	0.6%	134,000	9,000	0.6%	134,000
		SDI[c]	131,000	9.9%	295,000	126,000	10.0%	293,000	140,000	10.0%	278,000
Lease[a]	Full season irrigation	Full season lease[b]	132,000	10.0%	94,000	126,000	10.0%	94,000	140,000	10.0%	94,000
		Scenario 1 (cease alfalfa after June)[b]	132,000	10.0%	127,000	126,000	10.0%	134,000			
		Scenario 2 (cease alfalfa after July)[b]	132,000	10.0%	219,000	126,000	10.0%	246,000			
		Scenario 3 (start alfalfa in June)	32,000	2.4%	355,000	43,000	3.4%	355,000			
		Scenario 4 (start alfalfa in July)[b]	132,000	10.0%	305,000	126,000	10.0%	273,000			
		Scenario 5 (start corn in June)	4,000	0.3%	47,000	7,000	0.6%	47,000			
		Scenario 6 (start corn in July)	18,000	1.4%	47,000	24,000	1.9%	47,000			
Crop switching	Alfalfa	Spring grain forage (upper valleys)	1,000	0.1%	79,000	1,000	0.1%	79,000	1,000	0.1%	79,000
		Winter wheat (lower valleys)[b]	132,000	10.0%	236,000	126,000	10.0%	233,000	140,000	10.0%	211,000
		Corn[b]	24,000	1.8%	355,000	(14,000)	-1.1%	355,000	140,000	10.0%	336,000

Note: GSL Basin includes Utah, Idaho, Wyoming, and Nevada. Results in this table are based on 2019 through 2023 average depletions; all depletion and acreage values are rounded to the nearest 1,000

[a] Split-season GridET-based depletion estimates were not available when this report was prepared. These are indicated as N/A or not available.

[b] Scenario exceeded a 10% reduction of total depletion with full adoption at applicable fields.

-- = no savings in depletions

Table 4-2. Estimated Depletion Savings and Affected Field Area by Depletion Reduction Opportunity Type for eeMETRIC-, Ensemble-, and GridET-Based Depletion Models in Utah Portion of the Great Salt Lake Basin

Type	From	To	OpenET eeMETRIC			OpenET Ensemble			GridET		
			Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)	Estimated Depletion Savings (AF/yr)	Ratio of Total Depletion (%)	Affected Field Area (acre)
Irrigation system changes	Surface (border irrigation)	Pivot/lateral MESA	--	0.0%	274,000	--	0.0%	274,000	--	0.0%	274,000
		Pivot/lateral LEPA	6,000	0.7%	219,000	6,000	0.7%	219,000	7,000	0.8%	219,000
		Pivot/lateral LESA	16,000	1.9%	219,000	16,000	2.0%	219,000	17,000	1.8%	219,000
		SDI	72,000	8.7%	274,000	70,000	8.6%	274,000	76,000	8.2%	274,000
	Wheel line, hand line, solid set	Pivot/lateral MESA	12,000	1.5%	50,000	12,000	1.5%	50,000	13,000	1.4%	50,000
		Pivot/lateral LEPA	6,000	0.7%	26,000	6,000	0.7%	26,000	7,000	0.8%	26,000
		Pivot/lateral LESA	8,000	1.0%	26,000	8,000	1.0%	26,000	8,000	0.9%	26,000
		SDI	21,000	2.5%	50,000	21,000	2.6%	50,000	23,000	2.5%	50,000
	Pivot/lateral MESA	Pivot/lateral LEPA	1,000	0.1%	93,000	1,000	0.1%	93,000	2,000	0.2%	93,000
		Pivot/lateral LESA	6,000	0.7%	93,000	6,000	0.7%	93,000	6,000	0.6%	93,000
		SDI[c]	79,000	9.6%	178,000	77,000	9.5%	178,000	90,000	9.7%	178,000
Lease[a]	Full season irrigation	Full season lease[b]	83,000	10.0%	58,000	81,000	10.0%	58,000	93,000	10.0%	58,000
		Scenario 1 (cease alfalfa after June)[b]	83,000	10.0%	77,000	81,000	10.0%	83,000			
		Scenario 2 (cease alfalfa after July)[b]	83,000	10.0%	135,000	81,000	10.0%	152,000			
		Scenario 3 (start alfalfa in June)	29,000	3.5%	224,000	37,000	4.6%	224,000			
		Scenario 4 (start alfalfa in July)[b]	83,000	10.0%	168,000	81,000	10.0%	155,000			
		Scenario 5 (start corn in June)	3,000	0.4%	39,000	7,000	0.9%	39,000			
		Scenario 6 (start corn in July)	16,000	1.9%	39,000	21,000	2.6%	39,000			
Crop switching	Alfalfa	Spring grain forage (upper valleys)	--	0.0%	22,000	--	0.0%	22,000	--	0.0%	22,000
		Winter wheat (lower valleys)[b]	83,000	10.0%	140,000	81,000	10.0%	141,000	93,000	10.0%	132,000
		Corn[b]	26,000	3.1%	224,000	5,000	0.6%	224,000	93,000	10.0%	173,000

Notes: Utah portion of the GLS Basin excludes Idaho, Wyoming, and Nevada. Results are based on 2019 through 2023 average depletions; Utah's portion of total depletions in GSL was approximately 62%, or 827,000 AF. All depletion and acreage values are rounded to the nearest 1,000.

[a] Partial-season GridET-based depletion estimates were not available when this report was prepared. These are indicated as N/A or not available.

[b] Scenario exceeded a 10% reduction of total depletion with full adoption at applicable fields.

-- = no savings in depletions

Three crop substitution scenarios were evaluated: converting alfalfa acreage to winter wheat, spring wheat, or corn. These examples were chosen to represent substitutions that could be practical or appealing to farmers in certain areas of the GSL Basin. While many other crop substitutions are possible, the success of any alternative will depend heavily on market demand for crops other than alfalfa. Market demand was a factor that was beyond the scope of this report. However, it is important to note that the demand for forage crops is generally high in Utah. Thus, small grains grown as an alternative forage to alfalfa will likely have a steady market. Conversely, small grains produced for grain may have market restrictions if local or regional grain mills cannot handle the additional capacity. It is also important to note that the substitutions evaluated single crop changes in a single year and not crop rotations. Alfalfa, small grains, corn, and other crops are already grown in various crop rotations in Utah. Future research should evaluate depletion reduction opportunities of various crop rotations.

A large variety of water leasing scenarios could be evaluated. In this report, the Team evaluated seven options. These options included a full-season lease and six split-season lease options. In all split-season lease scenarios, we evaluated conditions where irrigation is either delayed or ceased early. Nonirrigated crop growth could happen outside the irrigation period. In scenarios with alfalfa, we sought to account for additional depletion of alfalfa shortly before or after the irrigation period. We did not include any additional depletion from other nonirrigated crops (for example, dryland crops) that might be planted in split-season leasing scenarios.

In this report, we did not account for all social implications of the 21 options, nor did we rate or rank the feasibility of the options. Some of the options will be more feasible or desirable by farmers, and some will include large barriers to adoption. One example is the use of subsurface drip irrigation. This option has high upfront costs that can be prohibitive for farmers, often increases irrigation system maintenance cost and labor, and can present new and difficult challenges related to crop germination and rodent control. Another is the geometry of agriculture fields, and how crop yield or irrigation management may change with certain irrigation system conversions. To achieve depletion reduction, irrigated area reductions or deficit irrigation are sometimes needed. The conditions that we set for each system are described in detail below.

It should be noted that depletion reduction is less difficult to monitor with some options (for example, irrigation system changes) compared to others (for example, split-season leasing or crop substitution scenarios). Changes to an irrigation system are semi-permanent and usually remain in place for many years. Administrative oversight and cost to monitor depletion reductions will need to be considered for the included 21 options and other practices to reduce depletion. Also, diversion reductions and water control (for example, ability to set irrigation rates, timing, deficit irrigation) are important considerations in addition to depletion that will affect what options will be feasible for farms and water managers to implement.

The opportunities for depletion reduction from each of the 21 options are highlighted below to provide examples. The conversion from agriculture to municipal and industrial is considered independently from other alternatives as this conversion may be credited in part to different sectors.

4.1 Reduction Opportunities from Irrigation System Changes

Following are depletion reduction opportunities resulting from irrigation system changes. The percentage reductions are based on the total average depletion during 2019-2023 in the entire GSL Basin (1,340,000 AFY) or the Utah portion of the Basin (830,000 AFY). They were capped at 10% reduction:

- **Entire GSL Basin**
  - Converting existing pivots with mid-elevation spray application sprinklers (MESA) to low-elevation spray application and low energy precision application sprinklers (LESA and LEPA) is an option that

might be the least disruptive and simplest irrigation system change to implement. It does not require new infrastructure in most cases as LESA and LEPA can be adapted to existing pivots, provided the soils are suitable for these sprinkler types. Conservative estimates of eligible, existing fields for implementation of LESA or LEPA resulted in a total 0.6% or 0.2% reductions in depletion, respectively, if applied to all 134,000 eligible acres (14% of all irrigated land in the Basin).

  - Converting sprinklers (wheel line, hand line, solid set) to pivots is a common option already occurring in the Basin, so it is feasible and may be desirable by many farmers. This option often reduces farm labor and increases control of irrigation management. Converting from sprinklers to MESA pivots on all 83,000 eligible acres would save 1.4% of total depletion across the Basin. Conversion to LESA or LEPA on all 38,000 eligible acres would save 0.8% or 0.7% of total depletion, respectively, across the Basin.
  - If sprinklers were converted to subsurface drip irrigation (SDI) on all 83,000 eligible acres, savings in depletion would be 2.6%. Converting wheel lines to SDI may be more desirable than surface to SDI because much less area would be impacted (83,000 vs. 437,000).
  - Surface irrigation (all types were included) conversions to SDI could save 8.5% in depletions but would require all 437,000 eligible acres (47% of all irrigated acres in the Basin). Surface irrigation types (for example, level basin, border, wild flood) are not distinguished in the WLRU dataset. It should be noted that depletion can differ widely among surface irrigation types, and that savings in depletion with SDI could be much less for laser-graded basin/border irrigation.

- **Utah Portion of the Basin**
  - Converting from MESA to LESA or LEPA on all existing eligible pivots in Utah could result in a 0.7% or 0.1% reduction, respectively, in Utah depletions when applied on 93,000 acres (26% of all irrigated acres in Utah portion).
  - Sprinklers to LEPA or LESA pivots could provide a 0.7% or 1.0% reduction, respectively, when applied on 26,000 acres.
  - Conversion from sprinklers to SDI could produce a 2.5% reduction if applied to 50,000 acres.
  - Surface irrigation to SDI could produce an 8.7% reduction if applied on all 274,000 eligible acres.

Some of irrigation system conversions would take time to implement, especially on tens to hundreds of thousands of acres. Thus, more rapid changes such as some types of crop substitution or water leasing could be used to offset this as conversions occur.

4.2 Reduction Opportunities from Crop Substitution

Following are depletion reduction opportunities resulting from crop substitution:

- **Entire GSL Basin**
  - Crop substitution of winter wheat for alfalfa in lower valleys could produce up to a 10% reduction if 236,000 available acres were replaced (Figure 1-1). Substitution of spring wheat for alfalfa in upper valleys (Figure 1-1) would only result in about 0.1% savings and require 79,000 acres. Note, small grains included here could be harvested for grain or forage.
  - Substitution of corn for alfalfa on 355,000 acres would result in a 1.8% reduction in depletions. This scenario did not account for other crops planted in between corn crops (for example, cover crops or winter small grain that is harvested in the spring before a delayed corn planting). If these practices are used, the savings in depletion would be reduced and might be negated.

- **Utah portion of the Basin**
  - Crop substitution of winter wheat for alfalfa in lower valleys may produce up to a 10% reduction if 140,000 available acres were replaced. Substitution of spring wheat for alfalfa in the upper valleys would result in no depletion savings.
  - Corn as a substitute for alfalfa may result in 3.1% savings in depletions on 224,000 available acres.

4.3 Reduction Opportunities from Water Leases

Seven water leasing scenarios were evaluated as part of this study including a full-season lease and six partial or split-season lease options where water is leased at the beginning or end of the typical irrigation season. It is important to note that the term "leasing" as used herein is not referring to the rental of water but rather to ceasing irrigation for a period of time. The results are summarized as follows.

- **Entire GSL Basin**
  - The two split-season leasing of late season water (ceasing irrigation after June or July) could result in depletion reductions. If the entire 10% depletion reduction goal was accomplished with these options, it would require participation of 127,000 and 219,000 acres if irrigation ceased in June or July, respectively.
  - Four options for split-season leasing of early water (starting irrigation in June or July) for both corn and alfalfa were investigated. Split season leasing of alfalfa fields with irrigation starting in June or July would contribute savings of 2.4% and 10% when applied on 355,000 and 305,000 acres, respectively. Split season leasing of corn fields with irrigation starting in June or July would contribute savings of 0.3% and 1.4%, respectively, both on 47,000 acres. The scenario where irrigation starts in July for alfalfa was the only one of the four early water leasing scenarios that could reach 10% savings.
  - Full-season leasing has the largest negative impact on crop production of all leasing scenarios evaluated. It would require an estimated total of 94,000 acres annually to reach the 10% depletion reduction goal.
- **Utah Portion of the Basin**
  - The two split-season leasing of late season water (ceasing irrigation after June or July) would require participation of 77,000 or 135,000 acres if irrigation ceased in June or July, respectively, to reach up to 10% savings.
  - The four options for split-season leasing early water for both corn or alfalfa for the Utah portion of the Basin showed that split-season leasing of alfalfa fields with irrigation starting in June or July would contribute savings of 3.5% and 10% when applied on 224,000 and 168,000 acres, respectively. Split season leasing of corn fields with irrigation starting in June or July could contribute savings of 0.4% and 1.9%, respectively, both on 39,000 acres. The scenario where irrigation starts in July for alfalfa was the only split-season leasing scenario that could reach 10% savings.
  - Full-season leasing would require an estimated total of 58,000 acres annually to reach the 10% depletion reduction goal.

The results of the water leasing scenarios in Utah indicate that 58,000 to 168,000 acres of land (depending on the leasing scenario) would need to participate in water leasing to reach a 10% reduction. This would require a herculean effort to enroll and manage leases, and shepherd leased water on this land. It is also an annual cost with no residual savings unlike irrigation improvements that have long-term implications for depletion reductions. These should be considered when weighing various options.

4.4 Reduction Opportunities from On-Farm Conveyance Systems

In total, the Team estimated about 4,500 AFY of depletion could be reduced by piping unlined head ditches on surface-irrigated land across the entire Basin. This would include piping 3,700 miles of ditches in Utah's portion, the Team estimated the reduction opportunity is about 2,900 AFY. In both cases – the entire Basin and Utah portion – piping all unlined head ditches would represent about 0.3% reduction in the total depletions. These estimates do not include off-farm conveyance systems (e.g., canals). Datasets were not available to estimate savings from canal conveyance improvements. Given that most water is conveyed through these systems and that nearly half of the Utah Water Optimization Program funding is supporting canal and similar conveyance improvements, this is a critical next step in evaluating opportunities to reduce depletion in the GSL Basin.

4.5 Reduction Opportunity Due to Conversion from Agriculture to Municipal and Industrial Uses

A separate analysis completed for the GSL BIP contemporarily to this report estimated approximately 80,000 acres of agricultural land may come out of production in Utah's portion of the GSL Basin due to population growth and development between 2020 and 2050 [refer to Jacobs et al. (2025)]. Utah's agricultural depletion reductions resulting from this change in land use are estimated to range from 53 KAF to 90 KAF per year by 2050, nearly 10% of Utah's agricultural depletion in the GSL Basin. The net depletion reduction, after accounting for additional municipal and industrial demands on these converted agricultural lands, is approximately 29 KAF per year. This reduction represents approximately 3.5% of the total 830 KAF depletion in the Utah portion of the GSL Basin. As noted above, caution is needed in interpreting these estimates as depletion may increase if water is spread or existing return flows from agriculture are used for M&I uses.

5. Evaluation and Tools for Economic Implications of Depletion Reduction Opportunities

The on-farm depletion reduction opportunities described above were evaluated using two complementary economic approaches:

- **Implementation cost of each strategy was assessed.** This cost was defined as the minimum payment a farmer would be willing to accept (WTA) to adopt the strategy, calibrated to ensure the farmer breaks even relative to current farm returns. To support comparison and ranking, WTA payment levels are expressed both on a per-acre and a per-AF of depletion savings basis, allowing assessment of each strategy's cost-effectiveness.
- **Regional economic impacts of implementing each strategy at scale were estimated.** Specifically, the analysis modeled the effects of achieving a 10**%** reduction in agricultural depletions across the GSL Basin. Impacts were expressed in terms of changes to regional employment, income, and value added (analogous to gross domestic product), and were estimated using a multiregional input-output (MRIO) economic model developed for the Basin.

Both implementation costs and regional economic impacts were assessed for the following five depletion reduction strategies:

- Full- and split-season leasing
- Crop substitution
- Irrigation system changes
- Balanced implementation
- Least cost implementation

Each strategy was optimized to achieve the depletion reduction target at the lowest possible cost. In the balanced implementation strategy, seasonal leasing, crop substitution, and irrigation system changes each account for one-third of the savings. The least-cost strategy reflects the specific mix of approaches that minimizes overall implementation cost.

A spreadsheet-based analytical tool developed for this project was used to conduct the economic assessments. This tool is provided as a supplemental resource to this report for use by the GSL Commissioner’s Office. In the future, the tool is intended to be web-enabled for broader stakeholder access and to facilitate centralized updates and maintenance by USU Extension.

5.1 Implementation Cost Assessment

Implementation costs were assessed separately for a range of seasonal leasing, crop substitution, and irrigation system change strategies for depletion reduction. In each case, implementation cost is defined as the minimum WTA payment a farmer would require to adopt the strategy, calculated to ensure the farmer breaks even relative to existing farm returns. Appendix B includes a detailed discussion of the calculations. Results are summarized in Table 5-1. Notably, crop production prices constantly fluctuate. When market prices are high and production costs are low, farmers are likely to require greater compensation for leasing their water, and the opposite holds true under less favorable conditions. As with crop production, there is inherent variability in these outcomes; farmers may earn more or less than anticipated. However, this uncertainty mirrors existing risks associated with agricultural production decisions made prior to knowing final market prices or input costs. Farmers have long developed strategies to manage such risks, and water leasing is expected to present a comparable risk profile. Indeed, the ability to lease water may provide an additional financial tool that can enhance flexibility and help mitigate economic uncertainty.

Table 5-1. Summary of Cost-Effectiveness of Depletion Reduction Strategies

Unit Cost Range	Depletion Reduction Strategy	From	To	Savings Rate (AF/acre)	Unit Cost (cost per AF)
Less than $300 per AF	Irrigation system changes	Pivot MESA	Pivot LESA	0.063	$148
	Irrigation system changes	Wheel line	Pivot LESA	0.270	$176
	Irrigation system changes	Wheel line	Pivot LEPA	0.236	$209
	Split-season leasing	Alfalfa	Scenario 1 (cease irrigation after June)	0.770	$235
	Full-season leasing	Alfalfa	Full Season Fallow	1.504	$236
	Split-season leasing	Alfalfa	Scenario 2 (cease irrigation after July)	0.525	$237
	Crop substitution	Alfalfa	Winter Wheat	0.614	$276
$300 to $500 per AF	Split-season leasing	Alfalfa	Scenario 4 (begin irrigation in July)	0.735	$340
	Split-season leasing	Corn	Scenario 6 (begin irrigation in July)	0.345	$345
	Split-season leasing	Alfalfa	Scenario 3 (begin irrigation in June)	0.527	$369
	Split-season leasing	Corn	Scenario 5 (begin irrigation in June)	0.173	$371
	Crop substitution	Alfalfa	Corn	0.533	$424
	Crop substitution	Alfalfa	Spring Wheat	0.502	$493
$500 to $1,000 per AF	Irrigation system changes	Wheel line	SDI	0.394	$509
	Irrigation system changes	Pivot MESA	Pivot LEPA	0.019	$599
	Irrigation system changes	Pivot MESA	SDI	0.422	$667
More than $1,000 per AF	Irrigation system changes	Flood	SDI	0.257	$1,014
	Irrigation system changes	Flood	Pivot LESA	0.067	$1,985
	Irrigation system changes	Flood	Pivot LEPA	0.024	$5,550
	Irrigation system changes	Flood	Pivot MESA	0.006	$22,094

The results indicate substantial variation in cost-effectiveness across strategies and scenarios:

- **Most cost-effective strategies (less than $300/AF):** The **lowest-cost options** were found in a select set of leasing, crop substitution, and irrigation system upgrade scenarios:
  - **Converting wheel line systems to LEPA/LESA or MESA pivots to LESA** yielded the most cost-effective savings, with costs of $148–$209 per AF.
  - Ceasing alfalfa irrigation early and full-season leasing were the top-performing leasing options, with an average cost of $236 per AF.
  - Substituting winter wheat for alfalfa was the most cost-effective crop substitution strategy, with an expected cost of $276 per AF.
- **Moderate-cost strategies ($300 to $500/AF):** Delaying the start of irrigation (split-season leasing scenarios 3-6) had moderate cost-effectiveness, with costs ranging from $340 to $371 per AF. Replacing alfalfa with corn or spring wheat are also moderate-cost strategies, with costs of $424 and $493 per AF, respectively.
- **Higher-cost strategies ($500 to $1,000/AF):** Wheel line to SDI conversion and converting pivot MESA to LEPA or SDI have costs ranging from $509 to $667 per AF. These strategies may still be feasible in specific contexts but are less favorable from a cost standpoint.

- **Least cost-effective** options **(more than $1,000/AF)**: All the flood irrigation conversions have costs exceeding $1,000 per AF and are the least cost-effective of the options evaluated.

Overall, the results indicate that a **balanced approach**—prioritizing high-performing leasing and irrigation upgrades while selectively using crop substitution or SDI in appropriate contexts—can achieve meaningful depletion reductions at relatively low cost per AF.

5.2 Implementation Cost of 10-Percent Reduction in On-Farm Basin Depletion

Table 5-2 summarizes the annualized cost of achieving a 10% reduction in on-farm agricultural depletion across the GSL Basin through each of the five depletion reduction strategies:

- Full- and split-season leasing
- Crop substitution
- Irrigation system changes
- Balanced implementation
- Least cost implementation

The comparison of alternative strategies shows clear differences in both cost and flexibility. Strategies that rely on a **single approach**—such as seasonal leasing, crop substitution, or irrigation system changes—are more expensive, with annual costs ranging from about $31 million for leasing to more than $74 million for irrigation upgrades.

By contrast, strategies that **combine multiple approaches** achieve the same reduction at lower cost. The balanced implementation strategy costs about $30 million annually, while the least-cost strategy is slightly less at $29.5 million. In addition to lower costs, these mixed strategies provide greater **implementation flexibility**, allowing program managers to adjust the blend of leasing, crop substitution, and irrigation upgrades in response to landowner interest, funding constraints, or evolving Basin conditions. Furthermore, there has been significant interest expressed by the agricultural community for a suite of options or even flexibility to develop additional options for depletion reduction. Thus, combining multiple approaches may be the most likely way to encourage a critical mass of participants to reach desired outcomes.

Overall, the results indicate that **mixed strategies offer the most cost-effective and adaptable pathway** for reducing agricultural depletion in the Great Salt Lake Basin.

5.3 Regional Economic Impacts Assessment

To gauge the broader economic consequences of reducing on-farm agricultural depletion in the GSL Basin by 10%, a multi-region input-output (MRIO) model was developed using IMPLAN software. This model estimates how the five alternative conservation strategies affect regional employment, wage income, and value added—an economic measure akin to gross domestic product (GDP). The model captures both the direct consequences of changes in agricultural production and the broader ripple effects that occur through supply chains and household spending. These results offer essential insights for policy development, stakeholder engagement, and informed public discourse—especially in communities where conservation programs are likely to be implemented.

Table 5-2. Costs of Alternative Strategies for 10-Percent Reduction of Great Salt Lake Basin On-Farm Depletion

Depletion Reduction Strategies	Treatable Acres	Treated Acres	Basin-Irrigated Acres (percent)	Depletion Savings (AF)	Basin Depletion (percent)	Unit Cost (cost per AF)	Annual Cost ($million)
Strategy 1: Seasonal Leasing							
Scenario 1 (cease irrigation after June)	353,955	172,334	18.3	132,620	10.0	$235	$31.1
Strategy 2: Crop Substitution							
Alfalfa to winter wheat	278,155	215,856	22.9	132,620	10.0	$276	$36.6
Strategy 3: Irrigation System Changes							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.7
Pivot MESA to LESA	272,748	24,471	2.6	1,537	0.1	$148	$0.2
Pivot MESA to SDI	272,748	248,277	26.4	104,694	7.9	$667	$69.8
Strategy 3 total		**370,543**	**39.4**	**132,620**	**10.0**	**$563**	**$74.7**
Strategy 4: Balanced Implementation							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.6
Pivot MESA to LESA	272,748	270,843	28.8	17,014	1.3	$148	$2.5
Pivot MESA to SDI	272,748	1,904	0.2	803	0.1	$667	$0.5
Alfalfa to winter wheat	278,155	71,952	7.6	44,207	3.3	$276	$12.2
Scenario 1 (cease irrigation after June)	353,995	57,445	6.1	44,207	3.3	$235	$10.4
Strategy 4 total		**499,940**	**53.2**	**132,620**	**10.0**	**$228**	**$30.3**
Strategy 5: Least Cost Implementation							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.4
Pivot MESA to LESA	272,748	14,018	1.5	881	0.1	$148	$0.1
Full Season Fallow	353,995	12,970	1.4	19,509	1.5	$236	$4.6
Scenario 1 (cease irrigation after June)	353,995	111,548	11.9	85,842	6.5	$235	$20.1
Strategy 5 total		**145,543**	**25.1**	**132,620**	**10.0**	**$223**	**$29.5**

5.3.1 Understanding Input-Output Modeling

Input-output modeling is a well-established economic framework that quantifies the interconnections among sectors in a regional economy. It traces how changes in one industry (for example, agriculture) affect other sectors—upstream suppliers, downstream service providers, and households—through three primary channels:

- **Direct effects** result from the immediate change in economic activity, such as reduced crop production or installation of irrigation systems.
- **Indirect effects** reflect how suppliers to the affected industry respond (for example, reduced demand for farm inputs like seed, fertilizer, or irrigation equipment).
- **Induced effects** capture shifts in household spending due to changes in income among workers and business owners affected by the direct and indirect effects.

The GSL Basin MRIO model incorporates these dynamics across seven GSL subbasins, capturing local impacts as well as cross-boundary economic spillovers—for instance, when a reduction in farm activity in one subbasin affects input suppliers in another.

5.3.2 Regional Impact Categories

The assessment separates regional economic impacts into two primary categories:

- **Changes in crop production**: All five depletion reduction strategies involve some form of production change—either through reduced acreage (full-season leasing), shorter growing periods (split-season leasing), or shifts to lower-input crops (crop substitution). These changes have ongoing economic consequences for labor, input purchases, and upstream businesses.
- **Irrigation system investment**: Strategies involving irrigation upgrades (Strategies 3-5) generate temporary increases in economic activity during the installation phase. These impacts are transitory, spanning the 10-year rollout period assumed for the analysis.

This distinction is important: while reductions in crop production may have persistent effects, irrigation investment provides a short-term economic stimulus that can help offset these losses during the transition period.

5.3.3 Key Modeling Assumptions

- **Voluntary participation with compensation**: All strategies are assumed to be implemented voluntarily, with landowners fully compensated for changes in net income. Therefore, reductions in farm income are not included in the impact estimates. Instead, the analysis focuses on broader economic effects stemming from changes in labor demand, input purchases, and supply chain activity.
- **10-year investment rollout**: Irrigation upgrades are assumed to occur evenly over 10 years. Economic impacts from these investments are reported as average annual values over the rollout period. This assumption enables a consistent comparison between temporary investment benefits and ongoing production-related impacts.

5.3.4 Regional Impact Estimates Summary

The regional economic assessment presented in Appendix B indicates that all five depletion reduction strategies would have very small overall effects on the GSL Basin economy. Standard regional economic impact modeling shows that any adverse employment or income impacts are on the order of tenths of a percent relative to baseline regional benchmarks. These modest effects reflect the limited scale of production changes, the compensation provided to participating farmers for any reductions in income, and, for strategies involving irrigation system improvements, the offsetting stimulus from increased regional capital investment.

Although all strategies have minimal regional economic impacts overall, they differ considerably in both implementation cost and distribution of effects. Strategies centered on a single approach—such as crop substitution, seasonal leasing, or irrigation system changes—tend to exhibit higher costs or more concentrated regional effects. In contrast, strategies combining multiple approaches generally achieve depletion reductions at lower implementation cost but can involve higher social or distributional costs.

In terms of employment, wage income, and value added, the largest relative impacts occur under crop substitution (Strategy 2) and the mixed strategies (Strategies 4 and 5). These approaches reduce irrigated acreage or shift production toward less labor-intensive crops, leading to modest declines in on-farm and related off-farm employment, hired labor income, and regional value added. Seasonal leasing (Strategy 1) produces smaller effects, given its limited influence on crop mix and production intensity, while lease income provides a partial offset to local employment and income changes. Irrigation system improvements (Strategy 3) generate the smallest long-term losses because they mostly preserve irrigated acreage and production levels, though they require the highest up-front investment. As detailed in Appendix B, the short-term stimulus from irrigation system investments during the rollout period more than offsets temporary reductions in farm employment, leaving net regional effects near zero. In the mixed strategies (4 and 5), these investment-related gains offset roughly one-fifth of the production-related employment and income effects.

Overall, the modeling highlights a clear trade-off between implementation cost and regional economic impact. Strategies 4 and 5 (balanced and least-cost implementation) achieve depletion reductions most efficiently but produce slightly larger reductions in regional employment and income. Conversely, Strategy 3 (irrigation system changes) is the most expensive to implement but yields the smallest long-term employment losses and the strongest temporary economic offsets.

These findings underscore the importance of evaluating both program cost-effectiveness and regional economic implications when selecting among depletion reduction strategies. They also reinforce the value of ongoing investments under Utah’s Agricultural Water Optimization Program, which promotes irrigation system improvements that minimize impacts on employment, income, and value added within the GSL Basin.

6. Evaluation of Depletion Changes in Utah Department of Agriculture and Food Agricultural Water Optimization Projects

The development of the dataset for this BIP report allows for the evaluation of ongoing depletion reduction investments by Utah farmers and state programs. UDAF launched the Agricultural Water Optimization Program in 2019 to "help agricultural producers optimize their water use to create water resiliency in Utah" (UDAF 2025). Since 2019, approximately 84 projects have been completed, and an additional 223 projects are underway as of May 2025 (Freeze 2025).

To evaluate the potential depletion reduction of irrigation system conversions completed under the Agricultural Water Optimization Program from 2019 through 2023 (to allow for years for which we performed the analysis), a subset of 161 projects totaling over 11,000 acres were considered. These 161 projects represent all on-farm irrigation system conversion projects enrolled in the Agricultural Water Optimization Program as of May 2025. Pre-project depletion was estimated using the methodology outlined in Appendix A, though the baseline period was limited to 2019 through the project completion date for each of the 161 projects considered. Thus, the potential depletion reduction of the 161 irrigation system conversion projects completed within the Agricultural Water Optimization Program from 2019 through 2023 is approximately 1,464 AFY as shown in Table 6-1.

Table 6-1. Depletion Reduction Estimates for 2019 through 2023 Irrigation System Conversion Projects in the Great Salt Lake Basin Enrolled in Agricultural Water Optimization Program

Type	From	To	Acres	Depletion Reduction	
				Percent[a]	AFY
Irrigation system changes	Surface (border irrigation)	Pivot/lateral MESA	1,886	0	0
		Pivot/lateral LEPA	35	2	1
		Pivot/lateral LESA	2,932	5	220
		SDI	846	18	220
		Improved surface irrigation[b]	322	0	0
		Wheel line, hand line, solid set	680	0	0
	Wheel line, hand line, solid set	Pivot/lateral MESA	1,058	16	220
		Pivot/lateral LEPA	30	17	6
		Pivot/lateral LESA	1,873	20	530
		SDI	652	29	260
	Pivot/lateral MESA	Pivot/lateral LEPA	0	1	0
		Pivot/lateral LESA	0	4	0
		SDI	0	29	0
		Wheel line, hand line, solid set	710	0	0
Total			11,024	-	1,460

[a] Section A.3 in Appendix A provides assumptions used to estimate irrigation system depletion reduction estimates.

[b] Four selected projects show irrigation system improvements, but the irrigation system type remained unchanged. There may be some depletion savings from these projects, but further data is required to determine the water savings associated with these projects.

It should be noted that there is potential for increased depletion from some projects. As discussed above in other sections, other benefits may be realized with these projects such as reduced water diversions, increased control of irrigation management that could enable participation in other programs (for example, leasing, demand management), reductions in labor and cost, and improvements in farm resiliency. Depletion, diversion, irrigation control, and other factors are all important considerations for advancing water optimization efforts.

In addition to irrigation system conversions, canal lining and piping and conveyance projects were also funded under the Agricultural Water Optimization Program. Although the hydrologic data available at the completion of this study were insufficient to estimate post-project depletion using the OpenET-based approach discussed in this report, location-specific depletion savings estimates could provide value in the future when multiple years of precipitation and remote-sensed ET data following project completion become available.

7. References

Allen, R.G., M. Tasumi, and R. Trezza. 2007. "Satellite-Based Energy Balance for Mapping Evapotranspiration with Internalized Calibration (METRIC)—Model." *Journal of Irrigation and Drainage Engineering*. 133(4): 380-394. https://doi.org/10.1061/(ASCE)0733-9437(2007)133:4(380).

Freeze, Hannah. 2024. Personal communication via email including spreadsheet and Shapefiles containing active UDAF Water Optimization projects from Hannah Freeze/Utah Department of Agriculture and Food to Drew Stock/Jacobs Engineering Group, Inc. September 11, 2024.

Follum, Michael, Betsy Morgan, Leland Dorchester, Adolph Coors, Anthony Powell, Bart Leeflang, Mark Wahl, and Joshua Rayes. 2025. "Development of Diversion Runoff Calculator to Estimate Agricultural Water Consumption and Irrigation Diversions at the Field- to Basin-Scale in Northeastern Utah." *J. Irrig. Drain Eng.* 151(2).

Jacobs Engineering Group Inc., Utah State University, and Evapotranspiration Plus. 2020. *Depletion Accounting for Irrigation Water Rights in Utah: A Review of Potential Agricultural Depletion Accounting Methods.* Final Technical Memorandum. Prepared for Utah Division of Water Resources Legislative Agricultural Water Optimization Task Force. June 26.

Jacobs Engineering Group Inc. (Jacobs). 2025. *Depletion Calculation Methodology.* Final Technical Memorandum. Prepared for Utah Division of Water Resources Opportunities and Costs for Agricultural Water Optimization and Leasing Task Order No. 2, Subtask 2.a. July 10.

Jacobs Engineering Group Inc. (Jacobs), Utah State University, M.Cubed, and Hansen Allen & Luce Inc. 2025. *Estimates of Depletion Reduction from Agricultural to Municipal and Industrial Land Conversion in the* Great *Salt Lake Basin.* Final Report. Prepared for Utah Division of Water Resources. September 10.

Lewis, Clayton S. and L.N. Allen. 2017. "Potential crop evapotranspiration and surface evaporation estimates via a gridded weather forcing dataset." *Journal of Hydrology*, Vol. 546: 450-463.

National Weather Service (NWS). 2024. Climate Charts. Salt Lake City, Utah. Accessed November 19, 2024. https://www.weather.gov/slc/CliPlot.

Neibling, Howard. 2019. *Analysis of Sprinkler Systems: Comparing Center Pivots, Linears, Wheel lines*. Forage Irrigation Workshop, Wester Alfalfa and Forage Symposium, Reno, Nevada. November 19-21, 2019. https://alfalfasymposium.ucdavis.edu/+symposium/2019/Presentations/1_IrrigationSession/PDFs/2019Irrig08ComparingSpringklersNeibling.pdf.

North Dakota State University Extension Service (NDSU). 2005. *Selecting a Sprinkler Irrigation System*. Service Bulletin AE-91. August. https://www.wcc.nrcs.usda.gov/ftpref/wntsc/waterMgt/irrigation/ae91.pdf.

OpenET. 2024a. Public Google Bucket containing eeMETRIC modeled evapotranspiration from 2018-2024 in the provided project region. Accessed September 2024. https://console.cloud.google.com/storage/browser/utah-temp;tab=objects?project=openet&prefix=&forceOnObjectsSortingFiltering=false.

OpenET. 2024b. Public Google Bucket containing Ensemble modeled evapotranspiration from 2018-2024 in the provided project region. Accessed September 2024. https://console.cloud.google.com/storage/browser/utah-temp;tab=objects?project=openet&prefix=&forceOnObjectsSortingFiltering=false.

Upper Colorado River Commission (UCRC). 2022. *Resolution of the Upper Colorado River Commission. Consumptive Use Measurement in the Upper Colorado River Basin*. June 14, 2022. Accessed November 15, 2024. http://www.ucrcommission.com/wp-content/uploads/2022/07/2022-06-14-Resolution-Consumptive-Use-Measurement.pdf.

Utah Department of Agriculture and Food (UDAF). 2025. *Agricultural Water Optimization Program*. Accessed May 2025. https://ag.utah.gov/agricultural-water-optimization/.

Utah Division of Water Resources (WRe). 2024. *Data Collected with CDL Methodology: Water-Related Land Use Data 2017 through 2023.* Accessed September 2024. https://WRe-utahdnr.opendata.arcgis.com/pages/wrlu-data.

Zesiger, Cody, Burdette Barker, Sarah Null, Earl Creech, Matt Yost, Ryan Larsen, and Josh Dallin. 2023. *Agriculture water use and economic value in the Great Salt Lake Basin [Fact sheet].* Utah State University. Retrieved from https://extension.usu.edu/irrigation/research/agricultural-water-use-salt-lake-basin.

Appendix A
Study and Depletion Estimation Details

Appendix A. Study and Depletion Estimation Details

A.1 Study Period Precipitation Anomalies (2019 through 2023)

Precipitation data from four stations, Lifton Pumping Station, Provo, Richmond, and Tooele, were extracted from the dataset of National Weather Service (Figure A-1). Figure A-1 illustrates precipitation anomalies for the four spots in Great Salt Lake (GSL) Basin over the period from 1994 to 2023. Precipitation anomalies were computed relative to each station's long–term average. All four locations show high interannual variability, with alternating wet and dry years.

Figure A-1. Location Map of the Four Precipitation Monitoring Stations: Lifton Pumping Station, Provo, Tooele, and Richmond

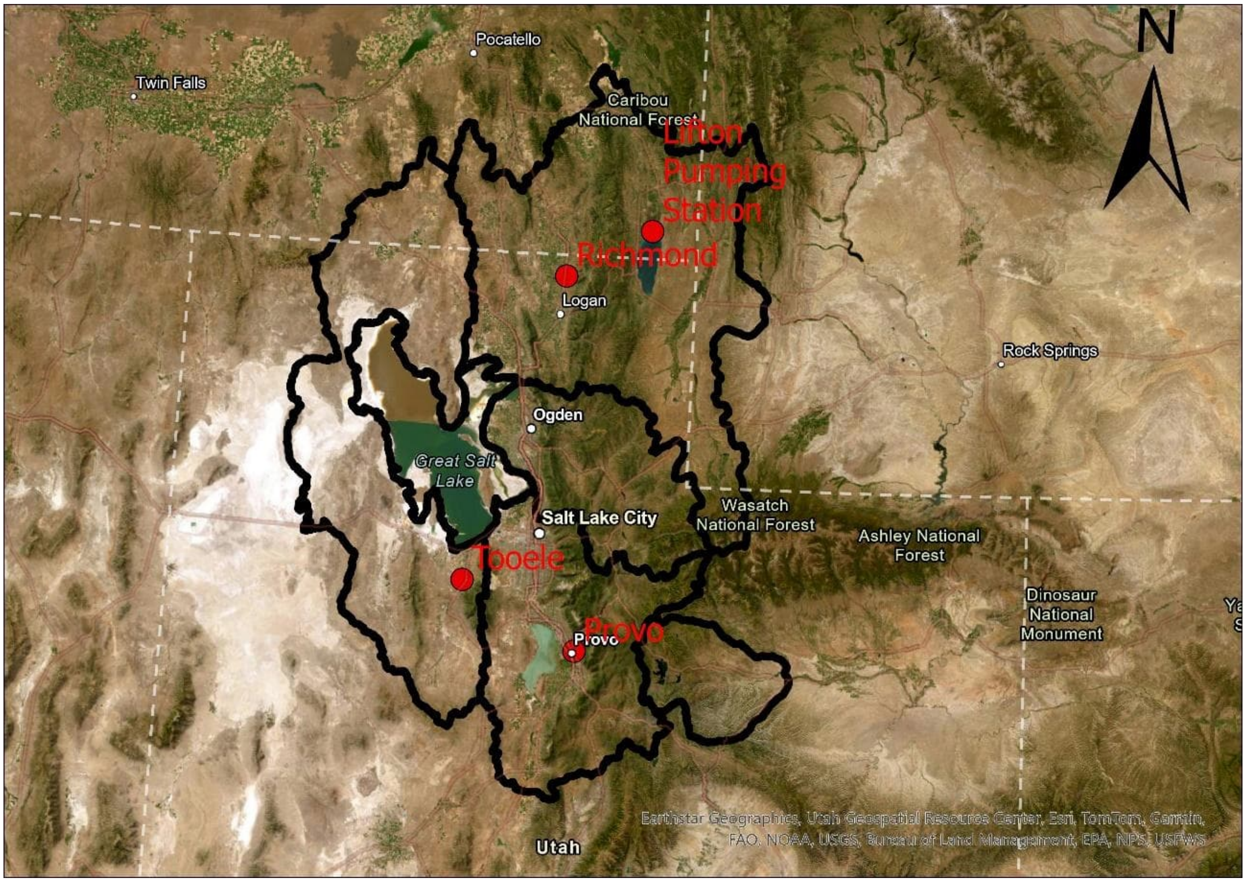
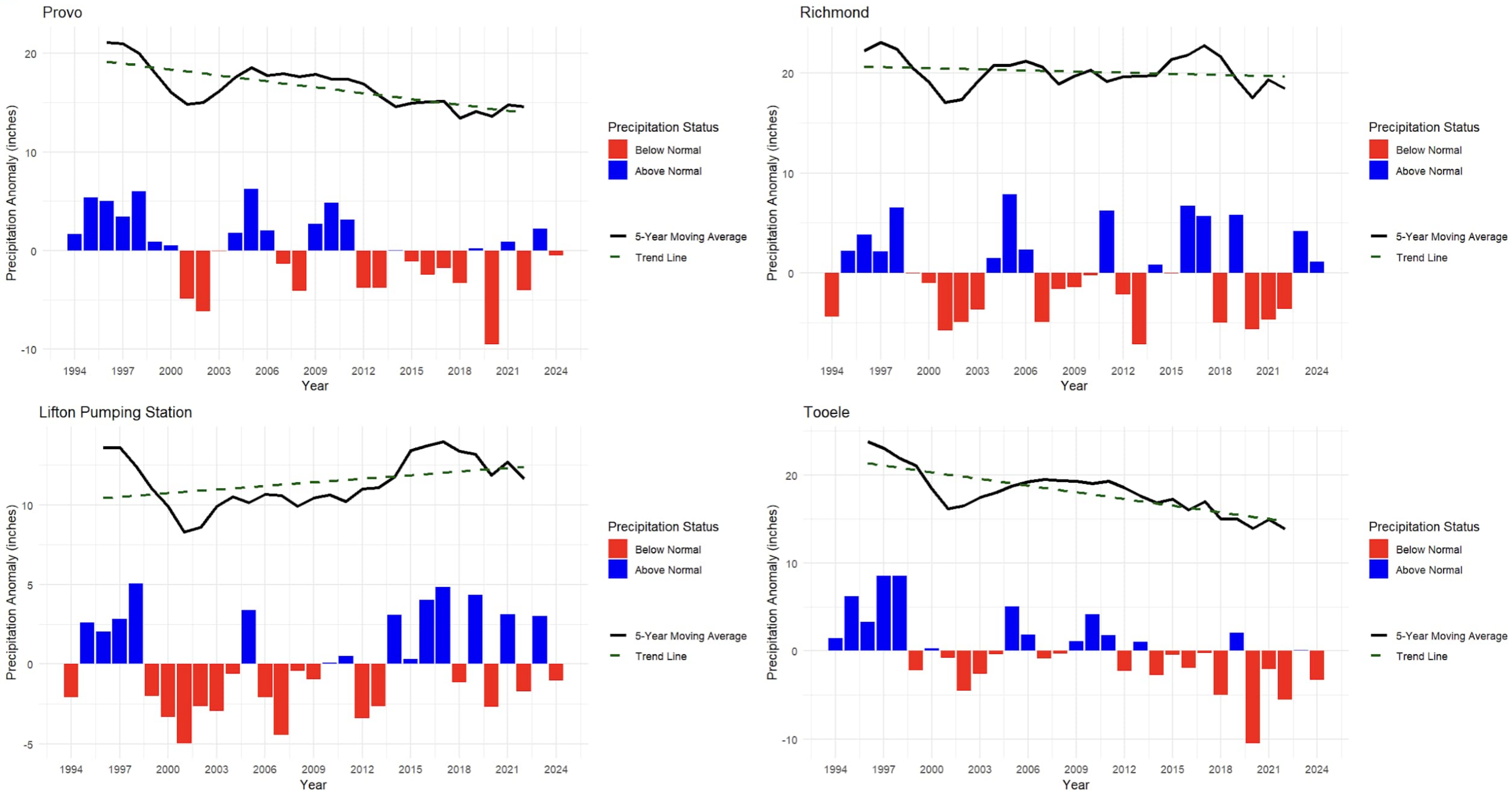


Figure A-2 provides the precipitation anomaly data for Tooele, Provo, Richmond, and Lifton Pumping Station locations between 1994 and 2023. Tooele displayed a clear long-term decline in precipitation, marked by a persistent downward trend and an increase in the frequency and intensity of below-normal years, especially after 2005. Provo showed mixed conditions, with several above-normal years in the late 1990s and early 2000s, followed by more frequent dry years in the 2010s. The overall trend was slightly negative. Richmond exhibited relatively stable precipitation patterns, though dry years have become more common in recent years. The trend line was nearly flat, indicating little long-term change. Lifton Pumping Station demonstrated less pronounced variability, with the 5-year moving average suggesting a slight increase in precipitation over time.

Figure A-2. Precipitation Anomalies (inches) from 1994 to 2023 at four Utah locations: Provo, Richmond, Lifton Pumping Station, and Tooele



Notes:

Blue bars = above-average precipitation (wet years)
Red bars = below-average precipitation (dry years)
Solid black line = 5-year moving average
Green dashed line = overall trend

Tooele shows a clear downward trend, indicating increasingly drier conditions, while the other stations exhibit more variability.

A.2 Fields with Zero Depletion Values

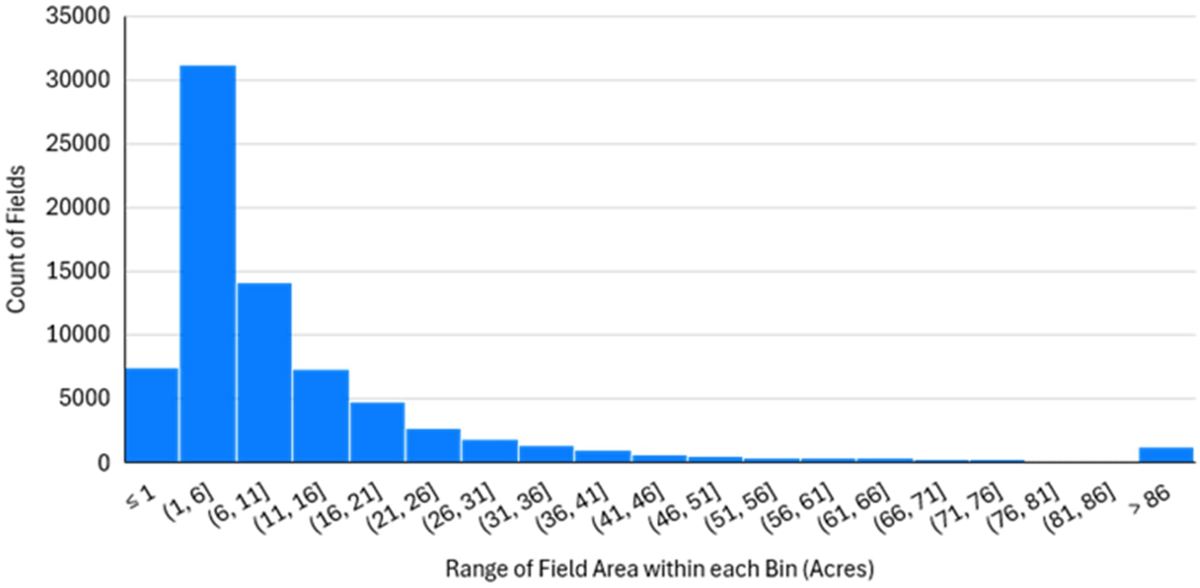
Table A-1 summarizes WRLU fields with zero depletion values during study period. Zero depletion values are more prevalent in northern portion of the GSL Basin where higher precipitation and lower temperatures are common. Zero depletion values may be caused by effective precipitation and soil moisture exceeding evapotranspiration for particular fields, poor irrigation practices, or erroneous data used in depletion estimation. Errors in depletion calculations are more likely to be found on smaller fields, where the field could be biased by nonirrigated ET values due to cell size of gridded ET datasets. These errors have a minimal impact on Basin-wide depletion estimates due to relatively small, impacted area.

Number of fields with zero depletion values without missing ET or precipitation data ranged from 94 fields (0.1% of fields by count) in 2020 to 1,731 fields (2.2% of fields by count) in 2019. The median field area of fields with zero depletion values was lowest based on potential ET from the GridET model and highest based on Ensemble ET. On average, area of fields with zero depletion values is just over 5 acres. Most irrigated agricultural fields included in WRLU layer in GSL range from 1 to 11 acres in area (Figure A-3).

Table A-1. Fields with Zero Depletion Values in the Great Salt Lake Basin by Year and Evapotranspiration Model

Year	eeMETRIC		Ensemble		GridET	
	Number of Fields	Median Area (acres)	Number of Fields	Median Area (acres)	Number of Fields	Median Area (acres)
2019	1731	2.80	322	4.14	381	0.27
2020	504	6.97	94	10.94	373	0.26
2021	968	7.90	222	11.72	252	0.35
2022	1189	6.78	239	9.56	249	0.35
2023	1032	5.31	229	7.46	239	0.35
Average	1085	5.95	221	8.76	299	0.31

Figure A-3. Irrigated Agricultural Field Acreages within Great Salt Lake Basin in 2023



A.3 Irrigation System Changes

This study considers converting fields from surface (border irrigation); wheel line, hand line and solid set; or pivot/lateral mid-elevation spray application (MESA) irrigation systems to pivot/lateral MESA, pivot/lateral low-energy precision application (LEPA), pivot/lateral low-elevation spray application (LESA), or Subsurface Drip Irrigation (SDI). The Team is planning to evaluate the impact of automated surge irrigation as a method for reducing depletion in surface irrigated land. Estimates of the depletion reduction potential of automated surge irrigation is not yet available. This option should be considered in the future. The following steps were used to compute the depletion reduction opportunity of these irrigation system changes:

- Compute the difference between 2019 through 2023 average depletion in acre-feet (AF) per acre (AF/acre) of starting (from) irrigation system and the depletion in AF/acre of ending (to) irrigation system using depletion values. Depletion changes were based on a similar study performed in Utah's Colorado River Basin, as shown in Table A-2 (Jacobs 2024). The underlying assumptions for these depletion changes are listed in Table A-3.
- Apply the difference to the 2023 potential irrigated acreage within the irrigation system to determine the depletion reduction potential in AF:
  - Pivots and nonpivot sprinklers are separated based on the 2023 National Agricultural Statistics Service Sprinkler Irrigation Fields in the Open Utah and Idaho irrigated acreage (NASS 2023). The average Utah and Idaho fraction of pivot irrigated to total sprinkler irrigated acreage is applied to the 2023 sprinkler irrigated acreage to separate out pivot and nonpivot sprinkler irrigated acreage.
  - The potential irrigated acreage for Pivot/Lateral LEPA and Pivot/Lateral LESA alternatives are limited to fields with a slope less than or equal to 2% due to the limitations of LEPA/LESA irrigation.

Table A-2. Estimated Depletion Change Results for Investigated Conversions

From	To	Depletion Change (%)
Basin/border	Pivot/lateral MESA	0
	Pivot/lateral LEPA	-2
	Pivot/lateral LESA	-5
	SDI	-18
Pivot/lateral MESA	Pivot/lateral LEPA	-1
	Pivot/lateral LESA	-4
	SDI	-29
Wheel line, hand line, solid set	Pivot/lateral MESA	-16
	Pivot/lateral LEPA	-17
	Pivot/lateral LESA	-20
	SDI	-29

Note: Results are theoretical in nature and based on assumptions relevant to similar study in Colorado River Basin (Jacobs 2024); actual results may vary.

Table A-3. Investigated Irrigation System Conversion Assumptions

From	To	Assumptions
Basin/border	Pivot/linear MESA	21% reduction in irrigation area[a] 10% yield improvement[b] Change in area and yield linearly related to ETc[c] 12% cap of MESA WDE losses[d]
	Pivot/linear LEPA	21% reduction in irrigation area[a] 10% yield improvement[b] Change in area and yield linearly related to ETc[c] 12% cap of LEPA WDE losses[d]
	Pivot/linear LESA	21% reduction in irrigation area[a] 10% yield improvement[b] Change in area and yield linearly related to ETc[c]
	SDI	Field production held constant[e] 25% yield improvement[f] 22% water productivity (ton per ETc in) improvement[f]
Pivot/linear MESA	Pivot/linear LEPA	12% cap of LEPA WDE losses[d] No change in geometry or yield
	Pivot/linear LESA	No change in geometry or yield
	SDI	Constant field production[e] 15% yield improvement[g] 22% water productivity (ton per ETc in) improvement[h]
Wheel line, hand line, solid set	Pivot/linear MESA	21% reduction in irrigation area[a] 7% yield improvement[b] Change in area and yield linearly related to ETc[c] 12% cap of MESA WDE losses[d]
	Pivot/linear LEPA	21% reduction in irrigation area[a] 7% yield improvement[b] Change in area and yield linearly related to ETc[c] 12% cap of LEPA WDE losses[d]
	Pivot/linear LESA	21% reduction in irrigation area[a] 7% yield improvement[b] Change in area and yield linearly related to ETc[c]
	SDI	Constant field production[e] 22% yield improvement[g] 22% water productivity (ton per ETc in) improvement[h]

[a] When applying a circular or semicircular irrigation pattern to a square field, the field corners fall outside of the irrigated area. Field corners represent 21% of the starting area and are not assumed to be irrigated following conversion to center pivot.

[b] Assumption based upon yield data included in O'Brien et al. (2000), Ehlig and Hagemann (1980), and Sanden et al. (2011).

[c] Assumption is supported by Lamm (2016).

[d] Assumption is per Jacobs (2024).

[e] This likely program assumption supports the producer and maximizes the reduction in depletion. Production may be controlled by a reduction in irrigated area that offers a reduction in irrigation system costs.

[f] Assumption is per Montazar (2020).

[g] Difference of note f and b

[h] Assumption based on gravity (surface)-to-SDI conversion in Montazar (2020) and supported by deficit irrigation results in Lamm (2016).

A.4 Leasing

Seven leasing scenarios were evaluated in this report. In this report, leasing is the temporary cessation of irrigation. The scenarios were selected by the Team and other partners. They included a full-season lease where no irrigation is applied for the entire growing season (April – October) and six split-season leases with early or late irrigation. To compute the depletion reduction opportunity of the split-season leasing cases, depletion is calculated at the field-scale as described by Jacobs (2025) with a growing season of April 15 to October 15. Two split-season scenarios evaluated ceasing irrigation to alfalfa after June or July. The remaining four split-season evaluated starting irrigation in June or July for both alfalfa and corn. The two corn scenarios were selected due to interest from farmers that may be interested in leasing early season water and then planting short-season corn. In all six split-season scenarios, nonirrigated crop growth could occur outside the irrigation period. In scenarios with alfalfa, we accounted for additional depletion of alfalfa shortly before or after the irrigation period by including depletion for 15 days before or after irrigation ceased. Farmers may have interest in planting nonirrigated crops before or after a split-season lease. This could include many different options, so no additional depletion for these potential crops were estimated or included in this report. Split-leasing that allows crop production within the nonirrigated portions of the growing season (that is, before or after the lease) will need to account for additional depletion. Likewise, the economic aspects of leasing would need to be adjusted if nonirrigated crop production is allowed. Alfalfa and corn yield data from Utah State University trials and cooperating farmers within the GSL Basin were used to estimate the effects of split-season leasing on yield and economic returns.

A.5 Crop Substitution

One of many options for crop substitution includes converting alfalfa to spring grain, winter wheat, or corn. These options are examples and were selected because they match assessments conducted in the Colorado River Basin. Spring grain is assumed for fields in the Upper Valleys shown on Figure 1-1, otherwise winter wheat is assumed. The small grains could be used for forage or grain production. Small grain forage production is already prevalent in many parts of Utah. It is a more feasible option than grain production for many farmers because they already have the equipment to produce and harvest forages, and there is existing demand for forages in the GSL Basin. Small grain forage production also usually requires one or two less irrigations than grain production because it is harvested earlier. This was not accounted for in this report but is an important consideration that should be explored further. It is also important to note that crop substitution can be difficult at large scales. Ability to market crops, equipment needed to manage and grow new crops, and many other factors need to be considered. This BIP report is an example of technical possibilities of a few crop substitutions and does not yet consider all these factors. The following steps were used to compute the depletion reduction opportunity of these crop substitution alternatives:

- Calculate the ratio between the net irrigation requirements (NIR) calculated by Hill et al. (2011) at each NOAA consumptive use station nearest GSL agricultural lands for spring grain (upper valley) or winter wheat (lower valley) to alfalfa.
    - If the NIR for winter wheat is not available at a lower valley consumptive use station, the NIR of spring grain is used.
    - Spatially join each field to its nearest NOAA consumptive use station and sum the total depletion per consumptive use station.
    - Apply the ratio to the depletion per consumptive use station in AF/acre to obtain the depletion in AF/acre for the new option.

- Apply the difference between depletion in AF/acre of the original and new crop type options to the 2019 through 2023 average irrigated acreage of alfalfa to calculate the potential depletion savings in AF.

A.6 On-Farm Conveyance Systems

The estimates are for 85% of all surface-irrigated fields in the Basin and were computed for fields that were irrigated during 2019 through 2023 and then averaged across years. The 85% was an assumption that 15% of the fields were already piped. The ditch length was computed as the square root of each individual field. This produced less of a high bias in the estimate than dividing the perimeter by four. Ditches were assumed to be 5 feet wide, on average with half that distance, 2.5 feet of well-watered vegetation on the outer bank (away from the field). The depletion from these two areas was assumed to be zero after conversion to pipe. The field side of the conveyance corridor would be wetted even after conversion. The ditch channel was assumed to be open water evaporation for two out of every 14 days, as an approximation of water turns. For the other 12/14 days, the ditch was assumed to have depletion similar to grass pasture. The outer bank was assumed to be similar to grass pasture for the entire calculation period. Calculations were performed for April 15 – October 15, as was done for all full-season depletion estimates herein. Net evaporation for “deep” water (open water evaporation less precipitation) and net irrigation for pasture (ET minus 80% of precipitation) were obtained from Hill et al. (2011). This is a monthly product, so half of April and half of October values were included. The depletion from the open ditches and surrounding banks was assumed to be a subset of the estimated ET from the OpenET products for the surface-irrigated fields. Therefore, these estimates represent an estimate of depletion reduction capacity rather than additional depletion. The methods used to estimate ditch length, width, and canal bank are very approximate, perhaps within the nearest order of magnitude at best. The results should be interpreted accordingly.

A.7 References

Ehlig, Carl F. and Robert W. Hagemann. 1980. *Sprinkler Irrigation Raises Yields-and Costs-of Imperial Valley Alfalfa. California Agriculture.* Accessed January 11, 2024. https://web.archive.org/web/20190429004221/http://calag.ucanr.edu/archive/?type=pdf&article=ca.v034n01p8.

Hill, Robert W., J. Burdette Barker, and Clayton S. Lewis. 2011. *Crop and Wetland Consumptive Use and Open Water Surface Evaporation for Utah*. Appendix I: Updated Consumptive Use Estimates at NWS Stations. Report 213. Prepared for Utah Agricultural Experiment Station, Utah State University, Logan, Utah.

Jacobs Engineering Group Inc. (Jacobs). 2024. *Quantify the Possible.* Final Technical Memorandum. Prepared for Central Utah Water Conservancy District Agriculture Water Efficiency Plan Task Order No. 2, Subtask 2.3. September 2024.

Jacobs Engineering Group Inc. (Jacobs). 2025. *Depletion Calculation Methodology.* Final Technical Memorandum. Prepared for Utah Division of Water Resources Opportunities and Costs for Agricultural Water Optimization and Leasing Task Order No. 2, Subtask 2.a. July 10.

Lamm, Freddie. 2016. “Subsurface Drip Irrigation and Possibilities in Alfalfa.” In: *Proceedings, 2016 California Alfalfa and Forage Symposium*, Reno, Nevada, November 29 – December 1, 2016. UC Cooperative Extension, Plant Sciences Department, University of California – Davis, California. Accessed January 11, 2024. https://www.ksre.k-state.edu/sdi/reports/2016/SDIPossibilitiesAlfalfa_Lamm16.pdf.

Montazar, Ali. 2020. “A Viability Assessment of Subsurface Drip Irrigation in the Desert Southwest.” In: *Proceedings, 6th Decennial National Irrigation Symposium*, San Diego, California, December 6 – 8, 2021. Accessed January 11, 2024. https://elibrary.asabe.org/abstract.asp?aid=52890&t=2&redir=&redirType=.

National Agricultural Statistics Service (NASS). 2023. *2022 Census of Agriculture, Sprinkler Irrigation in* Fields *in the Open: 2023 and 2018*. Access November 2024. https://www.nass.usda.gov/Publications/AgCensus/2022/Online_Resources/Farm_and_Ranch_Irrigation_Survey/fris_2_033_033.pdf.

O’Brien, Daniel M., Freddie R. Lamm, Loyd R. Stone, and Danny H. Rogers. 2000. *The Economics of Converting from Surface to Sprinkler Irrigation for Various Pumping Capacities.* MF-2471. K*State Irrigation Management Series, y Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, Manhattan, Kansas. November 2000. Accessed January 11, 2024. https://krex.k-state.edu/server/api/core/bitstreams/dccd2696-64d0-465e-ad26-b8f5467c56a8/content.

Sanden, B., K. Klonsky, D. Putnam, L. Schwankl, and K. Bali. 2011. “Comparing Costs and Efficiencies of Different Alfalfa Irrigation Systems.” In: *Proceedings, 2011 Western Alfalfa and Forage Conference*, Las Vegas, Nevada, December 11 – 13, 2011. UC Cooperative Extension, Plant Sciences Department, University of California – Davis. Accessed January 11, 2024. https://ucanr.edu/sites/Kern22/files/133511.pdf.

Appendix B
Economic Assessment Methods and Details

Appendix B. Economic Assessment Methods and Details

On-farm depletion reduction opportunities were evaluated using two complementary economic approaches:

- **Implementation cost of each strategy was assessed.** This cost was defined as the minimum payment a farmer would be willing to accept (WTA) to adopt the strategy, calibrated to ensure the farmer breaks even relative to current farm returns. To support comparison and ranking, WTA payment levels are expressed both on a per acre and a per acre-foot (AF) of depletion savings basis, allowing assessment of each strategy's cost-effectiveness. It is important to note that not all decisions that farmers make are profit-based and that other factors also influence their decisions surrounding water use and agricultural operations. These should be considered as strategies for depletion reduction are developed.
- **Regional economic impacts of implementing each strategy at scale were estimated.** Specifically, the Team modeled the effects of achieving a 10% reduction in agricultural depletions across the GSL Basin. Impacts were expressed in terms of changes to regional employment, income, and value added (analogous to GDP), and were estimated using a multiregion input-output (MRIO) economic model developed for the Basin.

Both implementation costs and regional economic impacts were assessed for the following four depletion reduction strategies:

- Full- and split-season leasing
- Crop substitution
- Irrigation system changes
- Balanced implementation

Each strategy was optimized to minimize the cost of achieving a 10% reduction in on-farm depletion. Balanced implementation combines elements of the other three approaches, with one-third of depletion savings coming from each of the three primary reduction strategies.

All of the economic analysis was conducted in real (inflation-adjusted) prices and discount rates. Further, the assessment was a with/without option or policy analysis. Some costs such as equipment costs would be present under both policy regimes and thus net to zero when considering the difference. Where this is not the case, such as with irrigation technology substitution, the differences in equipment costs are explicitly addressed.

B.1 Implementation Cost Assessment

Implementation costs were assessed separately for depletion reduction strategies listed above. In each case, implementation cost is defined as the minimum WTA payment a farmer would require to adopt the strategy, calculated to ensure the farmer breaks even relative to existing farm returns.

B.1.1 Full- and Split-Season Leasing

The WTA for leasing strategies reflects the foregone revenue from not producing or only partially producing a crop, minus avoidable operating costs, plus any additional costs associated with land management during lease period (for example, weed control, cover cropping, or compliance expenses).

B.1.1.1 WTA Formula: Full-Season Leasing

Under full-season leasing (that is, no irrigation for the entire season), the WTA is calculated as follows:

$$\text{WTA} = A \times [P \times Y - PC + LC]$$

Where:

A = number of acres removed from production
P = expected price for the crop
Y = expected yield if the crop were planted and harvested
PC = avoidable production costs
LC = additional costs during leasing period

B.1.1.2 WTA Formula: Split-Season Leasing

Under split-season leasing, a partial crop is produced. The WTA formula incorporates adjustment factors for yield and cost reductions:

$$\text{WTA} = A \times [P \times (1-\alpha)Y - (1-\beta)PC + (1-\gamma)LC]$$

Where:

A = number of acres removed from production
P = expected price for the crop
Y = expected yield if the crop were planted and harvested
β = adjust factor for production costs
α = adjustment factor for yield
PC = avoidable production costs
γ = adjustment factor for maintenance costs
LC = additional costs during leasing period

Accurate WTA estimation requires reasonable assumptions for crop prices, yields, production costs, and leasing-related expenses. These estimates are detailed in the following sections.

B.1.1.3 Leasing Scenarios Considered

In addition to full-season leasing of alfalfa (no irrigation all season), six split-season leasing scenarios involving partial-season irrigation were evaluated (Table B-1).

Table B-1. Evaluated Full- and Split-Season Leasing Scenarios

Leasing Scenario	Crop	Description
Full-Season	Alfalfa	No irrigation during entire season
Scenario 1	Alfalfa	Cease irrigation after June 30
Scenario 2	Alfalfa	Cease irrigation after July 31
Scenario 3	Alfalfa	Begin irrigation June 1
Scenario 4	Alfalfa	Begin irrigation July 1
Scenario 5	Corn	Begin irrigation June 15
Scenario 6	Corn	Begin irrigation July 15

For the cost assessment, alfalfa fields were classified by irrigation method (flood, wheel line, pivot) and elevation zone (two or four cuttings per season). Corn fields were classified by irrigation method only. The acreage distribution is provided in Table B-2.

Table B-2. Distribution of Great Salt Lake Basin Irrigated Alfalfa and Corn Acreage

		Flood		Wheel Line		Pivot		
Subbasin	**Crop**	**Two Cuts**	**Four Cuts**	**Two Cuts**	**Four Cuts**	**Two Cuts**	**Four Cuts**	**Total**
Bear River, Idaho	Alfalfa	26,835	30,428	4,198	6,787	19,325	31,244	118,816
Bear River, Wyoming	Alfalfa	1,416	0	1,316	0	6,450	0	9,182
Bear River, Utah	Alfalfa	2,809	40,819	2,887	23,767	6,146	50,599	127,028
Jordan River, Utah	Alfalfa	0	1,067	0	232	0	493	1,791
Utah Lake, Utah	Alfalfa	0	20,680	0	9,788	0	20,838	51,307
Weber River, Utah	Alfalfa	961	17,143	1,105	2,382	2,353	5,071	29,014
West Desert, Utah	Alfalfa	0	823	0	4,555	0	9,697	15,075
West Desert, Nevada	Alfalfa	0	221	0	59	0	1,463	1,742
Total		32,021	111,180	9,505	47,569	34,274	119,405	353,955
Bear River, Idaho	Corn	808		1,200		5,526		7,582
Bear River, Wyoming	Corn	0		0		0		0
Bear River, Utah	Corn	16,192		2,839		6,044		25,117
Jordan River, Utah	Corn	74		9		20		103
Utah Lake, Utah	Corn	2,636		1,985		4,225		8,865
Weber River, Utah	Corn	3,999		89		190		4,278
West Desert, Utah	Corn	1		272		579		853
West Desert, Nevada	Corn	0		5		136		141
Total		23,709		6,400		16,720		46,828

B.1.1.4 Benchmark Crop Prices

Alfalfa prices vary from year to year and are influenced by crop grade. Over the past 25 years, the average alfalfa price in Utah has ranged from $161 to $273 per ton in 2023 constant dollars. Based on United States Department of Agriculture (USDA) data, the average price during this period was $212 per ton, with a standard deviation of $34 per ton. For the WTA assessment, this 25-year average—$212 per ton—was used as the benchmark alfalfa price. Corn grain prices are influenced by federal farm programs and global commodity markets. To reflect recent policy and market conditions, the WTA assessment used average corn grain price in Utah over past 5 years ($6.76 per bushel, expressed in 2023 constant dollars).

B.1.1.5 Benchmark Crop Yields

Alfalfa

According to USDA data, the average irrigated alfalfa yield in Utah is approximately 4 tons per acre. However, actual yields vary substantially due to soil quality, climate, water availability, and management practices. A special tabulation of 2012 Census of Agriculture data for more than two thousand Utah farms revealed yields ranging from under 1 ton to more than 12 tons per acre. The median yield was 3.4 tons, and the average was 4 tons per acre. To reflect this variation, WTA calculations incorporated yield adjustments based on irrigation method and elevation. Specifically:

- **Wheel line sprinkler irrigation** was assumed to produce yields 3% higher than flood irrigation
- **Pivot sprinkler irrigation** was assumed to produce yields 10% higher than flood irrigation.
- **Lower-elevation fields**, which support four cuttings per season, were assumed to produce 80% higher yields than higher-elevation fields with only two cuttings.

Yield assumptions were calibrated so that the acreage-weighted average across all alfalfa acreage in the GSL Basin aligned with an average of 4 tons per acre. These assumptions are summarized in Table B-3.

Table B-3. Alfalfa Yield Assumptions used for Cost Assessments

Cuttings	Irrigation Method	Yield (tons per acre)
2	Flood	2.36
2	Wheel Line Sprinkler	2.43
2	Pivot Sprinkler	2.59
4	Flood	4.24
4	Wheel Line Sprinkler	4.36
4	Pivot Sprinkler	4.66

Corn

Corn grain yields were also differentiated by irrigation method. As with alfalfa, wheel line and pivot sprinkler systems were assumed to yield 3% and 10% more than flood-irrigated corn, respectively. Yield assumptions were calibrated to the Utah statewide average of 157 bushels per acre, based on data from the last five Censuses of Agriculture (2002 through 2022). Table B-4 summarizes these assumptions.

Table B-4. Corn Grain Yield Assumptions used for Cost Assessments

Irrigation Method	Acres	Yield (bushels per acre)
Flood	23,709	151
Wheel Line Sprinkler	7,389	156
Pivot Sprinkler	15,731	166
Total/Average	46,828	157

B.1.1.6 Benchmark Crop Production Costs and Returns

Crop production cost budgets for irrigated alfalfa and corn were adapted from University of Idaho Extension studies prepared in 2019 for southern and southeastern Idaho. These budgets were updated to 2023 constant dollars using USDA National Agricultural Statistics Service production cost indices (NASS 2023).

The WTA assessment grouped production costs into the following categories:

- **Fertilizer**: Cost of fertilizer materials (excluding application)
- **Pesticide**: Cost of pesticide materials (excluding application)
- **Custom**: Includes custom costs for application of chemicals, harvesting, and hauling. Some costs vary with yield (for example, baling), others with acreage.
- **Irrigation**: Includes water assessments, electricity for pumping, and irrigation system maintenance. Assessment costs are fixed per acre; power and repair costs vary with applied water.
- **Machinery**: Fuel, lubrication, and repair costs, calculated on a per-acre basis.
- **Hired labor**: Differentiated between irrigation labor and equipment operator labor. Irrigation labor varies by irrigation method.
- **Operating capital**: Interest on seasonal operating loans, assumed to vary with total operating costs.

Table B-5 summarizes the benchmark production costs used in the WTA assessment.

Table B-5. Benchmark Alfalfa and Corn Grain Production Costs

	Alfalfa						Corn Grain		
	Four Cuttings			Two Cuttings					
Operating Cost	Flood	Wheel	Pivot	Flood	Wheel	Pivot	Flood	Wheel	Pivot
Seed	0.00	0.00	0.00	0.00	0.00	0.00	159.71	159.71	159.71
Fertilizer	113.55	113.55	113.55	113.55	113.55	113.55	91.11	91.11	91.11
Pesticide	26.10	26.10	26.10	26.10	26.10	26.10	13.01	13.01	13.01
Custom	241.62	244.65	251.72	135.98	137.66	141.60	157.98	158.95	161.23
Irrigation	74.76	68.52	71.89	64.49	66.60	69.84	75.20	62.68	65.65
Machinery	12.87	12.87	12.87	12.87	12.87	12.87	64.55	64.55	64.55
Hired labor	124.13	122.96	54.23	73.52	72.94	38.58	201.13	199.97	131.24
Operating interest	15.75	15.64	14.09	11.33	11.42	10.69	26.08	25.65	23.48
Total operating costs	608.78	604.29	544.46	437.84	441.14	413.23	788.77	775.63	709.98

B.1.1.7 Additional Leasing Costs

Farmers who temporarily lease water are likely to incur additional costs, including the following, associated with land stewardship, program compliance, and water rights management:

- Weed control or planting of cover crops for erosion and dust control
- Reporting and monitoring to comply with program rules
- Filing a change-of-use application with the Utah Division of Water Rights
- Other incidental costs related to temporary fallowing

Although difficult to quantify precisely, prior research suggests that land management costs for fallowed fields typically range from $20 to $100 per acre, depending on site conditions and management intensity (WestWater Research 2024).

For this assessment, the following were considered:

- A flat $50 per acre was added for full-season leasing to account for additional leasing-related costs
- For split-season leasing, this amount was prorated by scenario:
  - Scenarios 1 and 4 (half-season): additional cost = $25/acre
  - Scenarios 2 and 3 (one-third season): additional cost = $17/acre
  - Scenario 5 (corn, June 15 start): $25/acre
  - Scenario 6 (corn, July 15 start): $17/acre

These additional costs were added to the foregone income in the WTA calculation, ensuring a more complete estimate of what farmers would require to participate in leasing programs.

B.1.1.8 Yield and Cost Adjustments for Split-Season Scenarios

To estimate the WTA for each split-season leasing scenario, both crop yields and production costs were adjusted to reflect changes in water application, timing, and management intensity. These adjustments were based on empirical data and expert input from USU Extension.

Yield Adjustments

Yields for split-season scenarios were expressed as a percentage of benchmark yields under full-season irrigation. Alfalfa estimates were developed by USU Extension using field data from Box Elder and Rich Counties and reflect reductions in biomass production resulting from delayed irrigation start dates or early cessation. For corn, yield adjustments were based on agronomic modeling and expert judgment. Table B-6 summarizes the assumed percentage of full-season yield achieved under each scenario.

Table B-6. Percentage of Benchmark Yield Achieved by Split-Season Leasing Scenario

Leasing Scenario	Crop	Description	Four Cuttings	Two Cuttings
Split-Season Scenario 1	Alfalfa	Cease irrigation after June 30	56%	55%
Split-Season Scenario 2	Alfalfa	Cease irrigation after July 31	68%	78%
Split-Season Scenario 3	Alfalfa	Begin irrigation June 1	56%	72%
Split-Season Scenario 4	Alfalfa	Begin irrigation July 1	44%	44%
Split-Season Scenario 5	Corn	Begin irrigation June 15	88%	
Split-Season Scenario 6	Corn	Begin irrigation July 15	76%	

Production Cost Adjustments

Production costs were adjusted for each split-season scenario to reflect changes in input use, timing, and labor requirements. The adjustments were made by cost category as follows:

- **Chemical costs (fertilizer and pesticide):** Chemical costs were prorated based on the share of full-season production anticipated under each scenario. USU Extension developed adjustment factors that reflect reduced need for fertilizer and pesticide applications when irrigation is delayed or terminated early. These adjustments are the same in percentage terms as the yield adjustments shown in Table B-6.

- **Custom services:** Custom service costs were divided into two categories:
  - **Yield-dependent costs** (for example, baling, stacking, and hauling) were adjusted in proportion to the estimated yield for each scenario.
  - **Cutting-dependent costs** (for example, swathing and raking) were adjusted according to the reduced number of cuttings associated with shortened irrigation seasons in alfalfa production.
- **Irrigation costs:** Irrigation costs include both fixed and variable components:
  - **Water assessment fees,** charged on a per-acre basis regardless of water use, were assumed unchanged.
  - **Variable irrigation costs** (for example, energy for pumping and irrigation system repairs) were reduced in proportion to the amount of water applied under each split-season scenario, based on typical irrigation schedules.
- **Machinery costs:** Machinery costs—covering fuel, lubrication, and repairs—were assumed to be fixed on a per-acre basis and **not adjusted** for split-season scenarios.
- **Hired labor costs:** Labor costs were split into two categories:
  - **Equipment operator labor** was assumed to be fixed per acre and not adjusted.
  - **Irrigation labor** was adjusted based on the number of irrigation events expected under each scenario (for example, scenarios involving earlier cessation of irrigation or delayed start required fewer irrigation labor hours).
- **Operating interest costs:** Interest expenses for operating capital were recalculated based on total adjusted variable costs for each scenario. As operating costs decline under split-season leasing, so does the associated interest expense.

B.1.1.9 WTA Estimates

Table B-7 summarizes the WTA estimates for each leasing scenario expressed on a per-acre basis. For full-season leasing, WTA equals the foregone return plus additional leasing costs. For split-season scenarios, it equals the difference in returns between full and partial production, plus prorated additional costs.

Table B-7. Willing-to-Accept Estimates for Full- and Split-Season Leasing

Leasing Scenario	Crop	Description	Willing-to-Accept Estimate (cost per acre)
Full-Season	Alfalfa	No irrigation during entire season	$355
Scenario 1	Alfalfa	Cease irrigation after June 30	$181
Scenario 2	Alfalfa	Cease irrigation after July 31	$125
Scenario 3	Alfalfa	Begin irrigation June 1	$194
Scenario 4	Alfalfa	Begin irrigation July 1	$250
Scenario 5	Corn	Begin irrigation June 15	$64
Scenario 6	Corn	Begin irrigation July 15	$119

The values in Table B-7 represent break-even compensation levels for farmers participating in each leasing strategy. While informative, these figures do not indicate cost-effectiveness in terms of water conserved. For that, implementation costs must be expressed per AF of depletion saved, which is discussed in the next section.

B.1.1.10 Cost-Effectiveness of Leasing Options

To evaluate the relative cost-effectiveness of the leasing scenarios, each option was ranked according to its implementation cost per AF of depletion savings, calculated by dividing the minimum WTA payment per acre by the associated depletion savings per acre. The results indicate that in terms of cost-effectiveness, the leasing scenarios fall into three categories:

- **Low-cost leasing scenarios**: The lowest cost leasing options are full season alfalfa fallowing, ceasing alfalfa irrigation after June (Scenario 1), and ceasing it after July (Scenario2). Full season leasing yields the largest reduction in depletion per acre—1.5 AF/acre—followed by ceasing irrigation after June (Scenario 1)—0.77 AF/acre—and then ceasing it after July (Scenario 3)—0.52 AF/acre. Together, these three options can provide depletion savings at a cost of about $236 per AF, making them the most affordable of the seven leasing options evaluated.
- **Moderate-cost leasing scenarios**: Scenarios 3-6, which delay the start of alfalfa or corn irrigation have an average cost of $356 per AF, making them moderate-cost leasing options. Of these four options, starting alfalfa irrigation in July (Scenario 4) is the least costly, at $345/AF, while starting corn irrigation in June (Scenario 5), at $371/AF, is the costliest.

Overall, modeling results indicate that full season fallowing, and early cessation of alfalfa irrigation (Scenarios 1 and 2) are the most cost-effective leasing options; these scenarios deliver the greatest water savings per dollar and offer a practical focus for program design. In contrast, delaying the start of irrigation for alfalfa and corn are more expensive options, costing about 50% more on a per AF basis. Table B-8 summarizes these results.

Table B-8. Leasing Options Ranked by Cost per Acre-Foot of Depletion Savings

Leasing Scenario	Crop	Description	Depletion Savings (AF per acre)	WTA (cost per AF)
Scenario 1	Alfalfa	Cease irrigation after June 30	0.77	$235
Full Season	Alfalfa	No irrigation during entire season	1.50	$236
Scenario 2	Alfalfa	Cease irrigation after July 31	0.52	$237
Scenario 4	Alfalfa	Begin irrigation July 1	0.73	$340
Scenario 6	Corn	Begin irrigation July 15	0.35	$345
Scenario 3	Alfalfa	Begin irrigation June 1	0.53	$367
Scenario 5	Corn	Begin irrigation June 15	0.17	$371

B.1.2 Crop Substitution

WTA estimates were developed for three crop substitution strategies:

- Switching from alfalfa to winter wheat
- Switching from alfalfa to spring wheat
- Switching from alfalfa to corn

Benchmark yields and prices for wheat were based on USDA data for Utah:

- **Winter wheat**: Average yield of 94 bushels per acre and price of $7.40 per bushel
- **Spring wheat**: Average yield of 77 bushels per acre and price of $7.79 per bushel

As for alfalfa and corn, wheel line and pivot irrigation are assumed to increase yields by 3% and 10%, respectively, relative to flood irrigation, and winter and spring wheat production costs were adapted from

2019 University of Idaho Extension studies for southern and southeastern Idaho. WTA estimates for each substitution strategy are based on the difference in expected returns between alfalfa and the substitute crop. Winter wheat and corn grain are suitable only in lower-elevation zones, while spring wheat can be grown in both lower- and higher-elevation areas. The expected alfalfa return for each substitution reflects these production constraints. Table B-9 summarizes the expected returns and WTA estimates.

Table B-9. WTA Estimates for Crop Substitution Depletion Reduction Strategies

	Expected Returns (cost per acre)		
Switch from Alfalfa to:	Alfalfa	Substitute Crop	WTA (cost per acre)
Winter wheat	$361	$191	$170
Spring wheat	$304	$57	$247
Corn grain	$361	$135	$226

Crop substitution strategies were evaluated for cost-effectiveness based on the cost per AF of depletion savings, calculated by dividing the WTA per acre by the expected depletion reduction associated with switching crops. Table B-10 presents the results.

Table B-10. Crop Substitution Options Ranked by Cost per Acre-Foot of Depletion Savings

From	To	Depletion Savings (AF per acre)	WTA (cost per AF)
Alfalfa	Winter wheat	0.61	$276
Alfalfa	Spring wheat	0.50	$493
Alfalfa	Corn	0.53	$424

Among the three options, **substituting winter wheat for alfalfa is the most cost-effective**, with an average cost of $276 per AF of depletion savings. This option also delivers the highest rate of savings (0.61 AF/acre) among the three crop substitutions considered.

The next-best option is switching from alfalfa to corn, which produces lower water savings (0.53 AF/acre) at a higher cost of $424 per AF.

The least cost-effective substitution is from alfalfa to spring wheat, which delivers the smallest water savings (0.50 AF/acre) and requires the highest payment to offset lost returns. With a cost of $493 per AF, this option is almost 80% more expensive than substituting winter wheat for alfalfa.

In summary, replacing alfalfa with winter wheat is the lowest cost crop substitution option, with a per AF cost falling between the low- and moderate-cost leasing options. By comparison, the other two crop substitution options–spring wheat and corn—with an average cost of about $460 per AF are significantly more expensive than any of the leasing options. As mentioned in Section 4 of the report, this analysis does not account for marketability of crop substitutions. This is a critical aspect of successful crop substitution and will need to be considered when implementing this practice as an option for water optimization.

B.1.3 Irrigation System Changes

WTA estimates were calculated for the following irrigation system changes:

- Flood irrigation systems to the following:
  - Pivot mid-elevation spray application (MESA)
  - Pivot low-energy precision application (LEPA)
  - Pivot low-elevation spray application (LESA)
  - Subsurface drip irrigation (SDI)
- Wheel line, hand line, solid set systems to:
  - Pivot LEPA
  - Pivot LESA
  - SDI
- Pivot MESA systems to:
  - Pivot LEPA
  - Pivot LESA
  - SDI

The required compensation to secure depletion savings through irrigation system changes is linked to the lifecycle cost incurred by growers to upgrade their irrigation systems. Consequently, the valuation of depletion savings is based on the lifecycle cost associated with transitioning to more efficient irrigation technologies.

For this assessment, the Team considered the cost for farms currently using border/furrow flood irrigation or a wheel line or pivot MESA irrigation system.

B.1.3.1 Depletion Savings from Irrigation System Changes

Depletion rates for pivot irrigation systems are typically higher than for flood irrigation systems. Thus, converting acreage one-for-one from flood irrigation to pivot irrigation will increase rather than decrease depletion in the Basin. In the case of conversions to SDI, one-for-one acreage conversions from flood to SDI result in negligible savings. This minor change in depletion is mainly due to increased crop production and transpiration with SDI compared to flood irrigation despite reduced evaporation. To counteract this, a program could implement one of two strategies:

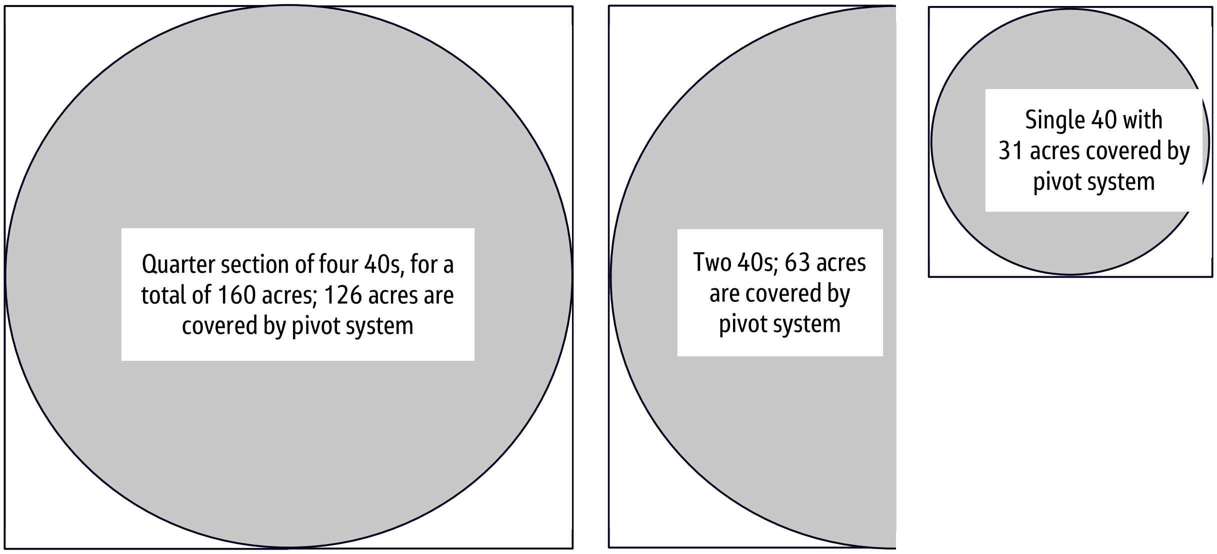
- **Deficit irrigation requirement:** participating farmers are required to irrigate below the crop's optimal water demand in order to achieve depletion reductions. If this were to occur, the effects on crop yield and profits would need to be considered as some forms of deficit irrigation on some crops can completely decimate yield (e.g., grain crops like corn and small grains) and result in little or no profit.
- **Acreage fallowing requirement:** participating farmers are required to retire or dry farm a portion of the enrolled acreage in order to achieve depletion reductions.

From an administrative perspective, an acreage reduction requirement would be easier to monitor and enforce compared to a deficit irrigation strategy. The assessment therefore focuses on acreage reductions.

Conversion to Pivot

For conversions from flood or wheel line irrigation to pivot irrigation, a simple method leverages the geometry of pivot systems to implement acreage restrictions. Figure B-1 illustrates typical pivot system configurations used on 40-acre quarter-quarter sections. Requiring farmers to remove field corners from irrigated production reduces the irrigated area by 21.5%.[1] When converting from flood irrigation, this approach can reduce depletion by 0.4-4.7% per enrolled acre compared to flood irrigating the entire field, depending on the pivot system installed. If the irrigated land that is reduced is not owned by a farmer, the debt for the non-irrigated land will need to be considered as this would be a reoccurring cost that would need to be compensated.

Figure B-1. Typical Pivot Irrigation System Configurations



With conversions from wheel line irrigation, removal of field corners from irrigation reduces depletion by 17-18% per enrolled acre compared to irrigating the entire field with the wheel line system.

As noted above, yields using pivot systems are expected to be 10% higher compared to flood irrigation and 7% higher compared to wheel line. Thus, the higher yield obtained from pivot irrigation offsets a portion of the production loss caused by the acreage restriction. The remaining production loss is factored into the WTA estimate.

Conversion to Subsurface Drip Irrigation

Converting to SDI will also require acreage restrictions to achieve meaningful depletion savings. For this assessment, a program design that keeps production from changing was used. Based on the yield estimates discussed above, this translates to a 20% acreage retirement requirement when transitioning from flood to SDI, a nearly 18% requirements when going from wheel line to SDI, and a 12% requirement when moving from pivot to SDI.

Summary of Depletion Savings with and without Restrictions on Planted Acreage

Table B-11 compares estimated depletion savings with and without these acreage restrictions. Positive savings values in the table indicate an increase rather than a decrease in depletion. Values in parentheses indicate the percentage reduction in depletion, with positive values again indicating an increase rather than a decrease in depletion.

---

[1] Many farmers with pivot systems irrigate field corners using flood irrigation or handset or wheel line sprinklers. The range of the pivot system can also be increased with the use of an end gun, which is a large sprinkler that attaches to the end of the pivot arm and can deliver water a100 feet or more beyond the arm’s radius.

Table B-11. Depletion Savings from Irrigation System Changes With and Without Acreage Restrictions

From	To	Acreage Restricted (%)	Change in Depletion (AF/acre enrolled)			
			Without Restriction		With Restriction	
Flood	Pivot MESA	21.5	+0.382	(+26.9%)	-0.006	(-0.4%)
	Pivot LEPA	21.5	+0.359	(+25.2%)	-0.024	(-1.7%)
	Pivot LESA	21.5	+0.305	(+21.4%)	-0.067	(-4.7%)
	SDI	20.0	+0.038	(+2.6%)	-0.257	(-17.9%)
Wheel line	Pivot LEPA	21.5	+0.082	(+5.5%)	-0.236	(-17.2%)
	Pivot LESA	21.5	+0.035	(+2.3%)	-0.270	(-19.7%)
	SDI	17.6	-0.201	(-13.5%)	-0.394	(-28.7%)
Pivot MESA	Pivot LEPA	0	-0.021	(-1.3%)	NA	NA
	Pivot LESA	0	-0.068	(-4.3%)	NA	NA
	SDI	12	-0.303	(-19.1%)	-0.422	(-28.8%)

B.1.3.2 WTA Formula: Irrigation System Changes

The WTA calculation for irrigation system changes is more complicated than for other depletion reduction strategies as it must consider differences in the up-front costs of the competing systems, differences in their life expectancy, and differences in production costs and yields under the competing systems. Additionally, when acreage restrictions are assumed, it must account for their impact on expected returns.

The formula for calculating WTA for irrigation system changes is as follows, where all values are expressed on a dollar per acre basis:

$$\begin{aligned} WTA = {} & [Annualized\ Cost\ of\ New\ Efficient\ System - Annualized\ Cost\ of\ Replacing\ Existing\ System] \\ & - [Crop\ Return\ with\ Efficient\ System - Crop\ Return\ with\ Existing\ System] \end{aligned}$$

Conceptually, it is possible for WTA to be negative, indicating the new efficient system is expected to increase net income. Indeed, this is usually a necessary condition for the voluntary adoption of new technology. Positive WTA values, on the other hand, indicate the amount of payment needed to offset the anticipated income loss and encourage adoption. The basis for the values used to calculate WTA are discussed in the following sections.

B.1.3.3 Real Cost of Capital

In the WTA formula, the real cost of capital is used to annualize upfront capital and installation costs over the useful life of the irrigation system.[2] For this evaluation, the real cost of capital is based on an expected inflation rate of 2% and a nominal borrowing rate of 8%, yielding a real cost of capital of approximately 6%. These rates come from USU Extension’s irrigation system cost-benefit calculator (USU n.d.).

---

[2] If C is the upfront cost of the system with a useful life of T years, the annualized cost of the system for real cost of capital r is:

Annualized Cost = rC1-1 + r-T

B.1.3.4 Irrigation System Costs

In the case of flood irrigation, it was assumed that a well-maintained system could continue to operate indefinitely. In the case of existing wheel line or pivot sprinkler irrigation, the system is assumed to be nearing the end of its useful life and will soon need replacing. In either case, the farmer is choosing between continuing with their existing irrigation regime versus adopting more efficient technology.

Table B-12 summarizes annualized costs of irrigation systems used for the WTA assessment. These values are based on the following:

- **Pivot system costs** are based on price quotes for purchase and installation from a Utah-based irrigation dealership. Separate costs for small (50 acres), medium (75 acres), and large (120 acres) systems were estimated. The average of these costs is used to estimate the cost when a pivot system is replacing flood irrigation since there is wide variability in the size of fields currently being flood irrigated. For wheel line conversions, the cost for a small pivot system is used since wheel line systems are more likely to be used on smaller fields. Normal life expectancy of a pivot system is typically cited to be 20-30 years (Martin et al. 2017; Rogers et al. 2003; ASABE 2012). A useful life of 25 years was assumed for this report. This assumption is motivated by both the literature and review of the ages of 55 used pivot systems listed for sale on the PIVOTS+PLUS website (n.d.). The systems for sale ranged between 5 to 46 years old, with an average age of 25 years and a median age of 24 years.
- **Wheel line systems** are estimated to cost 80% of the average cost of a new pivot MESA system and have similar useful life.
- **SDI systems** are estimated to have an installation cost $5,031 per acre, per the USU Irrigation Investment Calculator.[3] Normal life expectancy for a well-maintained SDI system is 10-20 years (Netafim USA 2014; Reich et al. 2014; Larson 2021; UW-Madison 2025). For this report, a useful life of 15 years was assumed.
- **Acreage restrictions** are incorporated into the annualized cost of the new system. For example, the footprint of a new SDI system would be about 20% smaller than the flood system it replaces, 17.6% smaller than a wheel line system, and 12% smaller than a pivot system.

Table B-12. Annualized Irrigation System Costs

Existing Irrigation System	Annualized Replacement Cost ($/acre)	New Efficient Irrigation System	Annualized Installation Cost ($/acre)	Difference in Annualized Cost ($/Acre)
Flood	$0	Pivot MESA	$173	$173
Flood	$0	Pivot LEPA/LESA	$189	$189
Flood	$0	SDI	$414	$414
Wheel	$138	Pivot LEPA/LESA	$220	$82
Wheel	$138	SDI	$427	$289
Pivot MESA	$173	Pivot LEPA/LESA	$189	$16
Pivot MESA	$173	SDI	$456	$283

Note: Flood irrigation does have maintenance costs that include touch-up laser leveling, and maintenance and replacement of control boxes, ditching and dams. These would need to be considered when evaluating changes in irrigation systems.

---

[3] Source: https://extension.usu.edu/crops/tools/irrigation-technology-cost-benefit-calculator.

B.1.3.5 Change in Crop Returns

The changes in expected return per acre for each irrigation system are summarized in Table B-13. These values are based on alfalfa production—the dominant crop in the GSL Basin—and account for the acreage restrictions noted in Table B-11.

Table B-13. Change in Alfalfa Return Per Acre

Existing Irrigation System	Return under Existing System ($/acre)	New Efficient Irrigation System	Return under New System ($/acre)	Difference in Return ($/Acre)
Flood	$238.75	Pivot MESA	$288.72	$49.97
Flood	$238.75	Pivot LEPA	$293.18	$54.44
Flood	$238.75	Pivot LESA	$295.12	$56.37
Flood	$238.75	SDI	$392.67	$153.93
Wheel	$279.88	Pivot LEPA	$312.16	$32.28
Wheel	$279.88	Pivot LESA	$313.87	$33.99
Wheel	$279.88	SDI	$368.00	$88.12
Pivot MESA	$375.30	Pivot LEPA	$380.31	$5.01
Pivot MESA	$375.30	Pivot LESA	$382.47	$7.18
Pivot MESA	$375.30	SDI	$377.00	$1.71

B.1.3.6 WTA Estimates

Table B-14 summarizes the estimated WTA values for the irrigation system changes. When expressed as cost per AF of depletion savings, the conversions fall into three groups:

- **Low-cost conversions:** Wheel line → pivot LEPA/LESA and pivot MESA → pivot LESA, at $148 to $209 per AF.
- **Moderate-cost conversions:** Wheel line → SDI and pivot MESA → pivot LEPA or SDI, at $509 per$667 per AF.
- **High-cost conversions:** All flood system conversions, ranging from $1,014 to more than $22,000 per AF. The least expensive is flood → SDI, but even this is about 1.5 times costlier than the most expensive **wheel line or pivot MESA conversion.**

Table B-14. WTA Estimates for Irrigation System Changes

From	To	Depletion Change (AF/acre)	WTA Estimate	
			$/Acre	$/AF
Flood	Pivot MESA	-0.006	$122.85	$22,094
	Pivot LEPA	-0.024	$134.88	$5,550
	Pivot LESA	-0.067	$132.94	$1,985
	SDI	-0.257	$260.47	$1,014
Wheel line	Pivot LEPA	-0.236	$49.22	$209
	Pivot LESA	-0.270	$47.51	$176
	SDI	-0.394	$200.45	$509
Pivot MESA	Pivot LEPA	-0.021	$11.49	$599
	Pivot LESA	-0.068	$9.32	$148
	SDI	-0.422	$281.31	$667

Note: Negative values indicate greater water savings.

B.1.4 Summary of Cost-Effectiveness Estimates

The cost-effectiveness assessment evaluated a range of depletion reduction strategies using a common metric: the cost per AF of depletion savings, expressed as the annualized WTA payment a grower would require. Strategies included full- and split-season leasing, crop substitution, and irrigation system changes. The results, summarized in Table B-15, indicate substantial variation in cost-effectiveness across strategies and scenarios:

- **Most cost-effective strategies (less than $300/AF):** The **lowest-cost options** were found in a select set of leasing, crop substitution, and irrigation system upgrade scenarios:
    - **Converting wheel line systems to LEPA/LESA or MESA pivots to LESA** yielded the most cost-effective savings, with costs of $148–$209 per AF.
    - **Ceasing alfalfa irrigation early** and **full-season leasing** were the top-performing leasing options, with an average cost of $236 per AF.
    - **Substituting winter wheat for alfalfa** was the most cost-effective crop substitution strategy, with an expected cost of $276 per AF.
- M**oderate-cost strategies ($300 to $500/AF):** Delaying the start of irrigation (split-season leasing scenarios 3-6) showed moderate cost-effectiveness, with costs ranging from $340 to $371 per AF. Replacing alfalfa with corn or spring wheat are also moderate-cost strategies, with costs of $424 and $493 per AF, respectively.
- **Higher-cost strategies ($500 to $1,000/AF):** Wheel line to SDI conversion and converting pivot MESA to LEPA or SDI have costs ranging from $509 to $667 per AF. These strategies may still be feasible in specific contexts but are less favorable from a cost standpoint.
- Least **cost-effective options (more than $1,000/AF)**: All the flood irrigation conversions have costs exceeding $1,000 per AF and are the least cost-effective of all the options evaluated.

Overall, the results indicate that a **balanced approach**—prioritizing high-performing leasing and irrigation upgrades while selectively using crop substitution or SDI in appropriate contexts—can achieve meaningful depletion reductions at relatively low cost per AF.

Table B-15. Summary of Cost-Effectiveness of Depletion Reduction Strategies

Unit Cost Range	Depletion Reduction Strategy	From	To	Savings Rate (AF/acre)	Unit Cost (cost per AF)
Less than $300 per AF	Irrigation system changes	Pivot MESA	Pivot LESA	0.063	$148
	Irrigation system changes	Wheel line	Pivot LESA	0.270	$176
	Irrigation system changes	Wheel line	Pivot LEPA	0.236	$209
	Split-season leasing	Alfalfa	Scenario 1 (cease irrigation after June)	0.770	$235
	Full-season leasing	Alfalfa	Full Season Fallow	1.504	$236
	Split-season leasing	Alfalfa	Scenario 2 (cease irrigation after July)	0.525	$237
	Crop substitution	Alfalfa	Winter Wheat	0.614	$276
$300 to $500 per AF	Split-season leasing	Alfalfa	Scenario 4 (begin irrigation in July)	0.735	$340
	Split-season leasing	Corn	Scenario 6 (begin irrigation in July)	0.345	$345
	Split-season leasing	Alfalfa	Scenario 3 (begin irrigation in June)	0.527	$369
	Split-season leasing	Corn	Scenario 5 (begin irrigation in June)	0.173	$371
	Crop substitution	Alfalfa	Corn	0.533	$424
	Crop substitution	Alfalfa	Spring Wheat	0.502	$493
$500 to $1,000 per AF	Irrigation system changes	Wheel line	SDI	0.394	$509
	Irrigation system changes	Pivot MESA	Pivot LEPA	0.019	$599
	Irrigation system changes	Pivot MESA	SDI	0.422	$667
More than $1,000 per AF	Irrigation system changes	Flood	SDI	0.257	$1,014
	Irrigation system changes	Flood	Pivot LESA	0.067	$1,985
	Irrigation system changes	Flood	Pivot LEPA	0.024	$5,550
	Irrigation system changes	Flood	Pivot MESA	0.006	$22,094

B.1.5 Implementation Cost of 10-Percent Reduction in On-Farm Basin Depletion

To evaluate the feasibility and cost of achieving a 10% reduction in on-farm agricultural depletion across the GSL Basin, five depletion reduction strategies were analyzed:

- Full- and split-season leasing
- Crop substitution
- Irrigation system changes
- A balanced implementation strategy combining elements of the first three
- Least Cost Implementation

Each strategy was evaluated for its ability to achieve the depletion reduction target of 10% at the lowest possible cost. In the balanced implementation strategy, seasonal leasing, crop substitution, and irrigation system changes each account for one-third of the savings. The least-cost strategy reflects the specific mix of approaches that minimizes overall implementation cost. Results are summarized in Table B-16.

Table B-16. Costs of Alternative Strategies for 10-Percent Reduction of Great Salt Lake Basin On-Farm Depletion

Depletion Reduction Strategies	Treatable Acres	Treated Acres	Basin-Irrigated Acres (%)	Depletion Savings (AF)	Basin Depletion (%)	Unit Cost (cost per AF)	Annual Cost ($million)
Strategy 1: Seasonal Leasing							
Scenario 1 (cease irrigation after June)	353,955	172,334	18.3	132,620	10.0	$235	$31.1
Strategy 2: Crop Substitution							
Alfalfa to winter wheat	278,155	215,856	22.9	132,620	10.0	$276	$36.6
Strategy 3: Irrigation System Changes							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.7
Pivot MESA to LESA	272,748	24,471	2.6	1,537	0.1	$148	$0.2
Pivot MESA to SDI	272,748	248,277	26.4	104,694	7.9	$667	$69.8
Strategy 3 total		**370,543**	**39.4**	**132,620**	**10.0**	**$563**	**$74.7**
Strategy 4: Balanced Implementation							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.6
Pivot MESA to LESA	272,748	270,843	28.8	17,014	1.3	$148	$2.5
Pivot MESA to SDI	272,748	1,904	0.2	803	0.1	$667	$0.5
Alfalfa to winter wheat	278,155	71,952	7.6	44,207	3.3	$276	$12.2
Scenario 1 (cease irrigation after June)	353,995	57,445	6.1	44,207	3.3	$235	$10.4
Strategy 4 total		**499,940**	**53.2**	**132,620**	**10.0**	**$228**	**$30.3**
Strategy 5: Least Cost Implementation							
Wheel line to pivot LESA	97,795	97,795	10.4	26,389	2.0	$176	$4.4
Pivot MESA to LESA	272,748	14,018	1.5	881	0.1	$148	$0.1
Full Season Fallow	353,995	12,970	1.4	19,509	1.5	$236	$4.6
Scenario 1 (cease irrigation after June)	353,995	111,548	11.9	85,842	6.5	$235	$20.1
Strategy 5 total		**145,543**	**25.1**	**132,620**	**10.0**	**$223**	**$29.5**

The comparison of alternative strategies shows clear differences in both cost and flexibility. Strategies that rely on a **single approach**—such as seasonal leasing, crop substitution, or irrigation system changes—are more expensive, with annual costs ranging from about $31 million for leasing to more than $74 million for irrigation upgrades.

By contrast, strategies that **combine multiple approaches** achieve the same reduction at lower cost. The balanced implementation strategy costs about $30 million annually, while the least-cost strategy is slightly less at $29.5 million. In addition to lower costs, these mixed strategies provide greater **implementation flexibility**, allowing program managers to adjust the blend of leasing, crop shifts, and irrigation upgrades in response to landowner interest, funding constraints, or evolving Basin conditions. Moreover, the Basin comprises farmers with diverse preferences and constraints; a single strategy will not suit everyone. A portfolio of complementary strategies will create more opportunities for farm households and improve policy implementation.

Overall, the results indicate that **mixed strategies offer the most cost-effective and adaptable pathway** for reducing agricultural depletion in the Great Salt Lake Basin.

B.2 Regional Economic Impacts of 10-Percent Great Salt Lake Basin On-Farm Depletion Reduction

To evaluate the broader economic implications of reducing on-farm agricultural depletion by 10%, an IMPLAN MRIO model of the GSL Basin was developed.[4] This model was used to estimate how each of the five strategies would affect regional value added (a measure analogous to GDP), income, and employment. The assessment translates changes in agricultural production into wider economic ripple effects, providing essential insights for informed policy decisions and transparent communication with the public, particularly in communities where conservation programs would be implemented.

An input-output (I-O) model is an economic tool that captures the interdependencies among different sectors of an economy. It quantifies how goods and services flow between industries and is commonly used to estimate the economic effects of changes in economic activity—such as shifts in consumer demand, changes in public policy, or technological adoption.

B.2.1 How an Input-Output Model Works and What it Measures

I-O models provide a systematic way to quantify how changes in one part of the economy ripple through other sectors. Originally developed by Nobel laureate Wassily Leontief, this framework maps the economic interrelationships between industries, businesses, and households. I-O models are particularly useful for assessing how policy changes, like agricultural water conservation programs, influence the broader economy—both directly and through cascading supply chain and spending effects.

At its core, an I-O model is a detailed accounting framework that tracks the flow of goods and services among sectors. Each industry not only produces outputs but also purchases inputs from other industries to carry out its operations. These interdependencies mean that a change in one sector—such as a reduction in crop production or an investment in irrigation infrastructure—can propagate throughout the economy in measurable ways.

---

[4] IMPLAN is a software application that uses input-output economic modeling to estimate the economic impacts of economic events and policies. I-O modeling is a quantitative technique that traces the economic linkages between different sectors of the economy. It is commonly used in a variety of research, including by government agencies, economic development organizations, businesses, and academic researchers.

The I-O model captures three types of effects:

- **Direct effects** represent the immediate change in economic activity. For example, if a farm switches to a less labor-intensive crop, the resulting reduction in farm employment and input purchases constitutes a direct effect.
- **Indirect effects** arise from supply chain responses. When a farm reduces purchases of seeds, fertilizer, or irrigation services, the businesses that supply those inputs experience declines in sales, production, and employment. These secondary changes are captured as indirect effects.
- **Induced effects** stem from changes in household income and spending. When workers and business owners earn less due to reduced farm activity, they spend less on goods and services like groceries, housing, or healthcare. These downstream impacts on the broader consumer economy are reflected as induced effects.

Together, these three channels provide a comprehensive picture of how a change in one sector of the economy—such as agriculture—can affect employment, income, and value added across the entire region. This approach is especially valuable in rural or agricultural communities, where many local jobs and businesses are linked, either directly or indirectly, to farming activity.

For this assessment, the IMPLAN MRIO model was used to assess regional economic impacts of a 10% reduction in on-farm agricultural depletion across the GSL Basin. The model tracks how each of the four proposed conservation strategies affects not just the agricultural sector, but also input suppliers, service providers, and households.

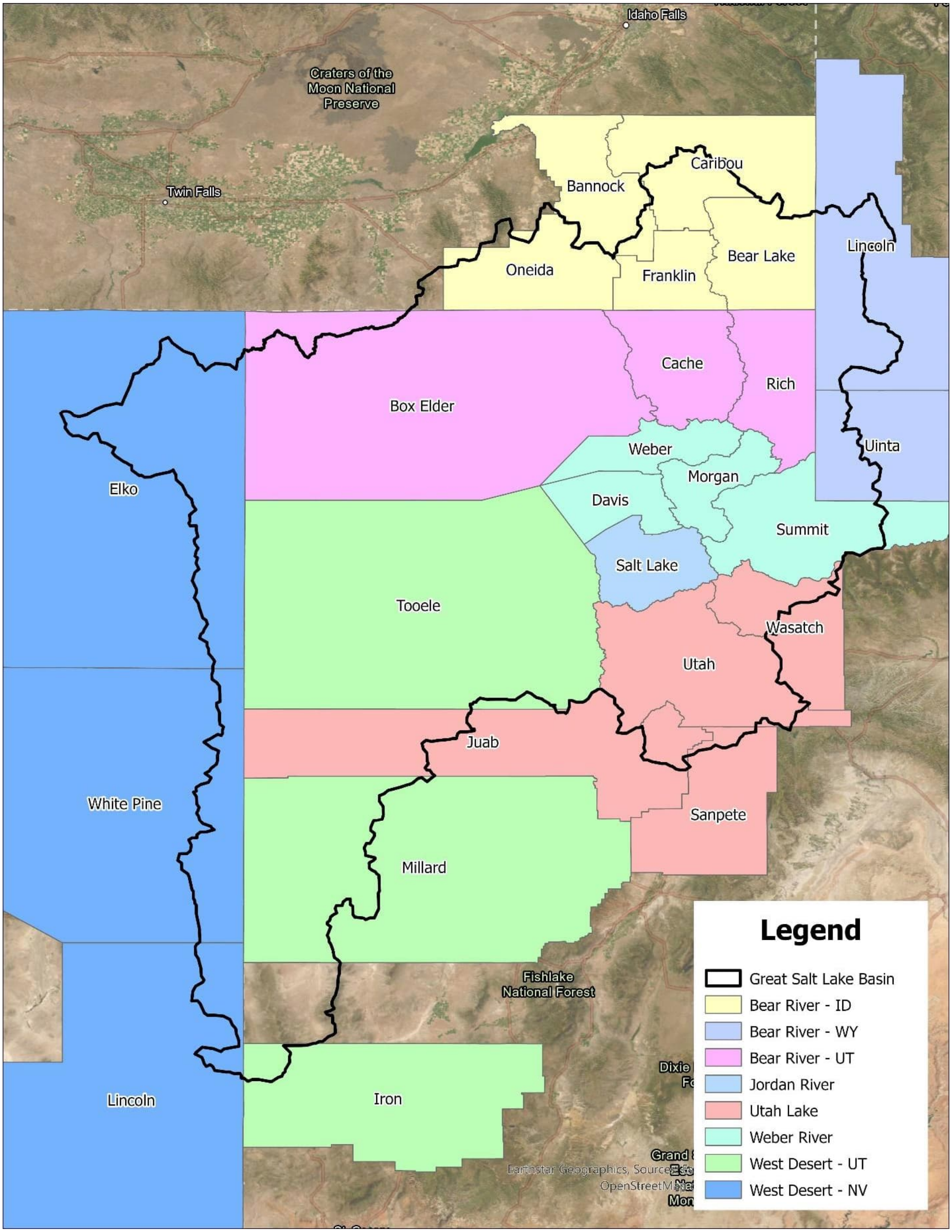
An MRIO model builds on the basic I-O framework by incorporating interactions not only within a single region but also across multiple subregions. This feature enables the model to estimate both direct impacts within each subregion and spillover effects on neighboring areas. For example, a reduction in agricultural production in one subregion may reduce demand for inputs or transportation services in adjacent regions.

The MRIO model used for this report includes seven of the eight subregions shown in Table B-17 and Figure B-2. The West Desert counties located in Nevada were excluded due to their minimal irrigated acreage and peripheral location in the Basin. Their exclusion is not expected to meaningfully affect the results, as they are unlikely to experience significant economic impacts under the evaluated depletion reduction strategies.

Table B-17. IMPLAN Multiregion Input-Output Model Regions

Great Salt Lake Subbasin	Counties in Region	Included in MRIO
Bear River, Idaho	Bannock, Bear Lake, Caribou, Franklin, Oneida	Yes
Bear River, Wyoming	Lincoln, Uinta	Yes
Bear River, Utah	Box Elder, Cache, Rich	Yes
Jordan River, Utah	Salt Lake	Yes
Utah Lake, Utah	Juab, Sanpete, Utah, Wasatch	Yes
Weber River, Utah	Davis, Morgan, Summit, Weber	Yes
West Desert, Utah	Iron, Millard, Tooele	Yes
West Desert, Nevada	Elko, Lincoln, White Pine	No

Figure B-2. Counties Included in IMPLAN Model Regions



B.2.2 Regional Economic Impact Estimates for Alternative Depletion Reduction Strategies

The IMPLAN MRIO model was used to estimate the regional economic impacts associated with the five depletion reduction strategies described in Section B.1.5. Regional impacts were estimated in two distinct categories:

- **Impacts from changes in crop production**: These reflect reductions in farm output due to decreases in irrigated acreage (as in full-season leasing or irrigation system changes involving acreage restrictions), partial production from split-season leasing, or crop substitution, which alters the crop mix and associated input purchases. All four strategies involve changes to crop production, and the resulting economic impacts are ongoing for as long as those acreage changes persist.
- **Impacts from irrigation system investment**: These reflect temporary increases in economic activity resulting from capital investments in new irrigation systems. Such impacts are transitory—they occur in the years when new systems are installed and then dissipate. These investment-related impacts apply only if irrigation system changes are part of the depletion reduction strategy.

This distinction is critical in understanding both the **short-term stimulus** effects of infrastructure investments and the **longer-term implications** of changes in agricultural output on the regional economy. This section quantifies these impacts across employment, income, and value added for each strategy.

The economic impact assessment is based on two key assumptions:

- **Voluntary Enrollment with compensation**: All depletion reduction strategies are assumed to be implemented through voluntary participation, with participants compensated for changes in income, as outlined in Section B.1. As a result, farm income is unchanged and therefore farm income changes are not modeled. Instead, the modeled economic effects stem from changes in purchased farm inputs, such as hired labor, custom services, fertilizers, and other operating expenses, and the resulting ripple effects these changes in farm purchases generate throughout the regional economy.
- **10-year rollout of irrigation system changes**: It is assumed that irrigation system upgrades are implemented evenly over a 10-year period. Accordingly, the impacts associated with these investments are reported as annual average values over that timeframe, based on a consistent level of spending each year. This assumption allows for a meaningful comparison between the temporary economic stimulus generated by infrastructure investment and the longer-term impacts associated with changes in crop production. The 10-year rollout period is used solely for analytical purposes and does not represent a proposed or recommended schedule for implementation.

B.2.3 Regional Economic Impact Summary

Regional impacts to employment, wage income, and value added are summarized in the tables that follow. Two tables are provided for each regional economic indicator, one summarizing the long-term impact due to changes in crop production in the Basin and the other summarizing the transitory impact due to irrigation system investments during a 10-year rollout period.

B.2.3.1 Employment Impacts

The IMPLAN model assesses the impacts of crop production changes on all types of employment in a regional economy. This includes employment on and off the farm. Employment losses may be low on farms as most farms implementing water optimization strategies may be compensated for losses to crop production or would pursue other employment opportunities for farm owners and employees. Furthermore, new markets could arise from some of the changes in crop production, such as employment related to leasing programs, crop markets, and irrigation system changes.

The IMPLAN model estimated that the potential long-term employment impacts varied widely across the five strategies (Table B-18). The irrigation system changes (Strategy 3) had the lowest impact on employment in the GSL basin. Seasonal leasing (Strategy 1) impacted employment losses about 5 times more than irrigation system changes, and the other three strategies (2, 4, and 5).

Table B-18. Long-Term Employment Impacts from Changes in Crop Production (number of jobs)

Subbasin	Strategy 1 Seasonal Leasing	Strategy 2 Crop Substitution	Strategy 3 Irrigation System Changes	Strategy 4 Balanced Implementation	Strategy 5 Least Cost Implementation
Bear River, Wyoming	-14	-19	5	-12	-19
Bear River, Idaho	-107	-128	0	-117	-128
Bear River, Utah	-199	-288	-45	-308	-288
Jordan River, Utah	-4	-5	-3	-4	-5
Utah Lake, Utah	-87	-132	-22	-143	-132
Weber River, Utah	-43	-52	-9	-51	-52
West Desert, Utah	-21	-38	-7	-43	-38
Total	-474	-663	-80	-677	-663
Utah Only	-353	-516	-85	-548	-516

During the 10-year investment period, irrigation system installations regionally generate substantial, though temporary, employment gains. These gains **fully** offset crop-related losses under irrigation system changes (Strategy 3) and offset roughly 20% of crop-related losses under the balanced (Strategy 4) and least-cost (Strategy 5) strategies (Table B-19).

Table B-19. Transitory (First 10 Years) Employment Impacts from Irrigation System Changes (number of jobs)

Subbasin	Strategy 1 Seasonal Leasing	Strategy 2 Crop Substitution	Strategy 3 Irrigation System Changes	Strategy 4 Balanced Implementation	Strategy 5 Least Cost Implementation
Bear River, Wyoming	0	0	32	4	3
Bear River, Idaho	0	0	306	45	29
Bear River, Utah	0	0	254	56	45
Jordan River, Utah	0	0	48	10	8
Utah Lake, Utah	0	0	103	23	18
Weber River, Utah	0	0	40	9	7
West Desert, Utah	0	0	40	9	7
Total	0	0	822	156	117
Utah Only	0	0	484	107	85

From a regional perspective, employment impacts are largest in the Bear River Subbasin in Utah, which accounts for the majority of crop-related job losses and a significant share of irrigation-related employment gains. The Utah Lake and Bear River, Idaho subbasins also experience notable impacts, though at smaller scales. In contrast, the Jordan River Subbasin has the smallest absolute changes, with few changes in jobs across all strategies. Overall, the bulk of employment impacts—both losses and temporary gains—are concentrated in Utah subbasins, reflecting their larger irrigated acreages and role in depletion reduction efforts.

Considering both crop-related losses and irrigation system-related gains, crop substitution may lead to the greatest net employment loss, followed by the two mixed strategies. Seasonal leasing reduces losses but provides no offsetting employment gains, while irrigation system changes yield the smallest overall impact on long-term employment. These results are encouraging given that the current Agricultural Water Optimization program has invested in changing irrigation systems, which may have the least impact on employment within the GSL Basin.

B.2.3.2 Wage Income Impacts

Long-term wage income losses from changes in crop production (Table B-20) range from about $4 million under irrigation system changes (Strategy 3) to roughly $17 million under crop substitution (Strategy 2), balanced implementation (Strategy 4), and least-cost implementation (Strategy 5). Seasonal leasing (Strategy 1) results in intermediate losses of about $12 million, roughly 30% lower than the mixed strategies. As with employment effects, strategies relying on crop substitution or a mix of approaches produce the largest income reductions for hired labor.

Table B-20. Long-Term Wage Income Impacts from Changes in Crop Production (million dollars)

Subbasin	Strategy 1 Seasonal Leasing	Strategy 2 Crop Substitution	Strategy 3 Irrigation System Changes	Strategy 4 Balanced Implementation	Strategy 5 Least Cost Implementation
Bear River, Wyoming	-0.1	-0.1	-0.1	-0.1	-0.1
Bear River, Idaho	-3.0	-3.6	-0.8	-3.2	-3.6
Bear River, Utah	-4.4	-6.3	-1.5	-6.7	-6.3
Jordan River, Utah	-0.2	-0.3	-0.2	-0.2	-0.3
Utah Lake, Utah	-2.3	-3.5	-0.9	-3.7	-3.5
Weber River, Utah	-1.5	-1.8	-0.4	-1.7	-1.8
West Desert, Utah	-0.7	-1.3	-0.3	-1.5	-1.3
Total	-12.4	-17.0	-4.2	-17.1	-17.0
Utah Only	-9.2	-13.2	-3.3	-13.7	-13.2

During the 10-year irrigation investment period, temporary income gains from system installations are significant but insufficient to fully offset crop-related losses, except under the irrigation system change strategy (Table B-21). Strategy 3 generates about $32.7 million in transitory labor income, exceeding its associated crop-related wage losses by a wide margin. Under the balanced (Strategy 4) and least-cost (Strategy 5) strategies, temporary gains of $6.4 million and $4.8 million respectively offset only a small share—about 20–25%—of crop-related losses.

Table B-21. Transitory (First 10 Years) Labor Income Impacts from Irrigation System Changes (million dollars)

Subbasin	Strategy 1 Seasonal Leasing	Strategy 2 Crop Substitution	Strategy 3 Irrigation System Changes	Strategy 4 Balanced Implementation	Strategy 5 Least Cost Implementation
Bear River, Wyoming	0	0	1.0	0.2	0.1
Bear River, Idaho	0	0	10.9	1.6	1.1
Bear River, Utah	0	0	9.4	2.1	1.7
Jordan River, Utah	0	0	3.5	0.7	0.6
Utah Lake, Utah	0	0	4.5	1.0	0.8
Weber River, Utah	0	0	1.8	0.4	0.3
West Desert, Utah	0	0	1.7	0.4	0.3
Total	0	0	32.7	6.4	4.8
Utah Only	0	0	20.8	4.6	3.7

Regionally, the largest wage income impacts occur in the Bear River and Utah Lake Subbasins, together accounting for more than half of both crop-related losses and transitory gains. The Bear River, Utah Subbasin alone experiences the single largest reductions in labor income, while the Jordan River Subbasin consistently has the smallest absolute changes across all strategies. In summary, strategies that depend heavily on crop substitution or combine multiple approaches generate the largest and most persistent wage income losses, while irrigation system changes produce the smallest long-term losses and the greatest opportunity for offsetting gains through temporary installation-related employment.

B.2.3.3 Value Added Impacts

Long-term losses in value added from crop production changes (Table B-22) range from about $8.6 million under irrigation system changes (Strategy 3) to roughly $29 million under crop substitution (Strategy 2), balanced implementation (Strategy 4), and least-cost implementation (Strategy 5). Seasonal leasing (Strategy 1) produces intermediate losses of about $22.6 million, 20–25% lower than the mixed strategies. These results mirror the wage income impacts, with crop substitution and mixed approaches driving the largest regional economic contractions.

Table B-22. Long-Term Value Added Impacts from Changes in Crop Production (million dollars)

Subbasin	Strategy 1: Seasonal Leasing	Strategy 2: Crop Substitution	Strategy 3: Irrigation System Changes	Strategy 4: Balanced Implementation	Strategy 5: Least Cost Implementation
Bear River, Wyoming	-0.3	-0.3	-0.2	-0.2	-0.3
Bear River, Idaho	-6.1	-7.2	-1.4	-6.1	-7.2
Bear River, Utah	-7.2	-10.1	-3.1	-9.9	-10.1
Jordan River, Utah	-0.5	-0.7	-0.4	-0.4	-0.7
Utah Lake, Utah	-3.7	-5.4	-1.9	-5.5	-5.4
Weber River, Utah	-2.4	-2.9	-0.9	-2.2	-2.9
West Desert, Utah	-1.0	-1.9	-0.6	-2.0	-1.9
Total	-22.6	-29.3	-8.6	-26.8	-29.3
Utah Only	-16.2	-21.8	-6.9	-20.5	-21.8

Temporary value-added gains in the first 10 years of implementation from irrigation system installations are substantial, though they vary by strategy (Table B-23). Irrigation system changes (Strategy 3) generate about $81 million in transitory value added over the 10-year investment period, more than offsetting associated production losses in the short term. In comparison, the balanced (Strategy 4) and least-cost (Strategy 5) strategies yield temporary gains of $16 million and $12 million, offsetting only a fraction—roughly 20–25%—of the crop-related reductions.

Table B-23. Transitory (First 10 Years) Value Added Impacts from Irrigation System Changes (million dollars)

Subbasin	Strategy 1 Seasonal Leasing	Strategy 2 Crop Substitution	Strategy 3 Irrigation System Changes	Strategy 4 Balanced Implementation	Strategy 5 Least Cost Implementation
Bear River, Wyoming	0	0	2.8	0.4	0.3
Bear River, Idaho	0	0	24.4	3.6	2.4
Bear River, Utah	0	0	26.4	5.9	4.7
Jordan River, Utah	0	0	6.7	1.3	1.0
Utah Lake, Utah	0	0	11.6	2.6	2.1
Weber River, Utah	0	0	4.8	1.1	0.8
West Desert, Utah	0	0	4.5	1.0	0.8
Total	0	0	81.1	16.0	12.1
Utah Only	0	0	53.9	12.0	9.5

From a regional perspective, the Bear River and Utah Lake Subbasins account for the largest shares of value-added impacts, both in terms of crop-related losses and irrigation-related gains. The Bear River, Utah Subbasin has the single greatest decline in value added, while the Jordan River Subbasin consistently exhibits the smallest changes. Overall, most of the economic impacts are concentrated in Utah subbasins, reflecting their larger irrigated acreages and higher levels of depletion reduction activity.

Taken together, the results indicate that strategies emphasizing crop substitution or combining multiple approaches impose the greatest long-term reductions in regional economic activity, while irrigation system changes produce smaller long-term losses and the largest opportunity for temporary offsetting gains.

B.3 References

Alam, Mahbub, Danny Rogers, and Troy J. Dumler. 2009. Subsurface Drip Irrigation for Alfalfa, Kansas State University. Accessed June 25, 2025. https://bookstore.ksre.ksu.edu/download/subsurface-drip-irrigation-for-alfalfa_MF2867

American Society of Agricultural and Biological Engineers (ASABE). 2012. *ASABE Standards: Engineering Practices for Irrigation Equipment*.

Ayars, J.E., C.J. Phene, R.B. Hutmacher, K.R. Davis, R.A. Schoneman, S.S. Vail, and R.M. Mead. 1999. Subsurface drip irrigation of row crops: A review of 15 years of research at the Water Management Research Laboratory. *Agricultural Water Management, 42*(1), 1-27.

Great Salt Lake Strike Team. 2025. *Great Salt Lake Data and Insights Summary: A synthesized Resource Document for the 2025 General Legislative Session*. https://d36oiwf74r1rap.cloudfront.net/wp-content/uploads/2025/01/GSL-Jan2025.pdf

Hanson, B.R., S. Orloff, and D. Peters. 2000. Monitoring soil moisture helps refine irrigation management. *California Agriculture, 54*(3), 38-42.

PIVOTS+PLUS. n.d. Used Center Pivot and Linear Listings. Accessed June 25, 2025. https://pivotsplus.com/used-irrigation-equipment/pivots-linears.

Lamm, F.R. and T.P. Trooien. 2003. Subsurface drip irrigation for corn production: A review of 10 years of research in Kansas. *Irrigation Science, 22*(3), 195-200.

Larson, Douglas. 2021. “Alfalfa on Subsurface Drip Irrigation (SDI) – Pros and Cons.” Proceedings UC Davis Alfalfa Symposium.

Martin, D.L., D.M. Heeren, and S. Irmak. 2017. *Irrigation Management for Center Pivots*. University of Nebraska-Lincoln Extension.

Montazar, Ali. 2020. “A Viability Assessment of Subsurface Drip Irrigation in the Desert Southwest.” In: *Proceedings, 6th Decennial National Irrigation Symposium*, San Diego, California, December 6 – 8, 2021. Accessed January 11, 2024. https://elibrary.asabe.org/abstract.asp?aid=52890&t=2&redir=&redirType=.

National Agricultural Statistics Service (NASS). 2023. *2022 Census of Agriculture, Sprinkler Irrigation in Fields in the Open: 2023 and 2018*. Access November 2024. https://www.nass.usda.gov/Publications/AgCensus/2022/Online_Resources/Farm_and_Ranch_Irrigation_Survey/fris_2_033_033.pdf.

Netafim USA. 2014. Alfalfa Production Manual Using Subsurface Drip Irrigation https://agresearch.montana.edu/wtarc/producerinfo/agronomy-nutrient-management/Alfalfa/AlfalfaProductionManual.pdf.

Reich, D., R. Godin, J.L. Chávez, and I. Broner. 2014. *Subsurface Drip Irrigation (SDI)*. Colorado State University Extension Fact Sheet No. 4.716. https://extension.colostate.edu/docs/pubs/crops/04716.pdf.

Rogers, D.H, F.R. Lamm, M. Alam, and P.L. Barnes. 2003. *Center Pivot Irrigation and Management*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

University of Wisconsin-Madison (UW-Madison). 2025. Understanding Crop Irrigation: Subsurface Drip Irrigation (SDI). UW-Madison Crops and Soils Division of Extension. Accessed June 25, 2025.

Utah State University (USU). n.d. Irrigation Technology Cost/Benefit Analysis Calculator. Accessed June 25, 2025. USU Crop Resources Extension. https://extension.usu.edu/crops/tools/irrigation-technology-cost-benefit-calculator.

WestWater Research. 2024. Personal Communication via Email from Brett Bovee, WestWater Research to Bart Leeflang, Central Utah Conservancy District. May 1.