SUBMIT OPTION SUBMITTAL FORM BY:
1. EMAIL TO: COLORADORIVERBASINSTUDY@USBR.GOV
2. U.S. MAIL TO: BUREAU OF RECLAMATION, ATTENTION MS. PAM ADAMS, LC-2721, P.O. BOX 61470, BOULDER CITY, NV 89006-1470
3. FACSIMILE TO: 702-293-8418

Option Submittal Form

Contact Information (optional): ☐ **Keep my contact information private.**

Contact Name: ____________________ Title: ____________________
Affiliation: ____________________
Address: ____________________
Telephone: E-mail Address:

Date Option Submitted: January 27, 2012

Option Name:

Conversion to Controlled Environment Agriculture (CEA) (also known as greenhouse production) with Hydroponic and/or Aquaponic Production Methods for growing fresh vegetables and also forage for livestock. This is also known as CEH (Controlled Environment Hydroponics).

Description of Option:

The use of hydroponic and aquaponic (aquaculture + hydroponics) production methods in greenhouses has existed since the 1970's and continues to expand world-wide as a means to feed the rapidly growing world population while aiming to improve crop yields and to more efficiently use water resources.

Controlled Environment Agriculture simply means to grow crops in greenhouses. By covering acreage with greenhouses, farmers are able to increase productivity from 3-6 times over traditionally farmed acreage. Hydroponics is the soil-less culture of plants through recirculating systems. Aquaponics is "organic" hydroponics – where fish production is combined with growing plants. Microbes convert the fish "waste" into safe, organic fertilizer for the plants in the recirculating systems. When CEA and hydroponics/aquaponics are combined, studies have shown production increases of anywhere from 10-15 times traditional farming methods.

CEH research demonstrates anywhere from 70-99+% water savings over traditional (uncovered, soil) farming practices, depending on crop type. In certain states (New Mexico, for example), 50% or more of the water usage is attributable to growing forage for livestock. Mexican hydroponic forage research demonstrates 0.2% of water use compared to traditional methods, or a water difference of about 50:1. Furthermore, these methods save land, produce uniform crops and maximize yield in an efficient and environmentally friendly way.

These tools save water by constantly recirculating the same water throughout the system. Hydroponic/aquaponic systems only require the producer to top off the water (approximately 1-2% of the total water volume) on a daily basis. The minor loss is attributed to evaporation of the water from the systems and transpiration of the water by the plants.

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Location: Describe location(s) where option could be implemented and other areas that the option would affect, if applicable. Attach a map, if applicable.

These tools are in use in many locations throughout the world – Mexico, Canada, Asia, Israel, Netherlands, Spain, and many other countries. Of over 50,000 acres of hydroponic production worldwide, about 1,200 acres are in the U.S. Most of the domestic hydroponic production comes from California, Arizona and Texas. Significant investment in greenhouses and hydroponics exists in southern Arizona and in other isolated areas throughout the Colorado River Basin, but the vast majority of irrigation systems in use where the supply originates in the Colorado River are gravity-fed. This option could be expanded across the Basin.

Quantity and Timing: Roughly quantify the range of the potential amount of water that the option could provide over the next 50 years and in what timeframe that amount could be available. If option could be implemented in phases, include quantity estimates associated with each phase. If known, specify any important seasonal (e.g., more water could be available in winter) and/or frequency (e.g., more water could likely be available during above-average hydrologic years) considerations. If known, describe any key assumptions made in order to quantify the potential amount.

The total quantity of reduced consumptive use from conversion to CEH has not been calculated basin-wide. There are examples of per-acre water savings of nearly 50:1 for CEH produced forage and estimates of 70-99% water savings on vegetables and other crops over traditional irrigated agriculture.

Additional Information

Technical Feasibility: Describe the maturity and feasibility of the concept/technology being proposed, and what research and/or technological development might first be needed.

These are existing tools, so technical feasibility is high. As it relates specifically to growing forage for livestock (which accounts for a very high percentage of the water usage attributable to agriculture in many Midwest and Southwest states), more research needs to be done on the economic feasibility. Technical feasibility of CEH is well established.

Costs: Provide cost and funding information, if available, including capital, operations, maintenance, repair, replacement, and any other costs and sources of funds (e.g., public, private, or both public and private). Identify what is and is not included in the provided cost numbers and provide references used for cost justification. Methodologies for calculating unit costs (e.g., $/acre-foot or $/million gallons) vary widely; therefore, do not provide unit costs without also providing the assumed capital and annual costs for the option, and the methodology used to calculate unit costs.

The cost of installing these tools varies by crop type, hydroponic or aquaponic system and installation technique. Initial capital costs are higher than traditional agricultural operations. However, increased yields, decoupling from the commodity market (CEA produces non fungible crops, so "premium-quality" crops that command higher price-points) and reduced labor and water costs make this tool more economically viable.

Typically producers in the Colorado River basin may not find the initial costs feasible because their water costs are low and they do not stand to gain from conserved water. However, when considering the broad-scale application of these tools as a means to reduce existing water use so that new demands may be met elsewhere, the costs should be considered in comparison to other new supply options rather than in the context of producer feasibility.

Permitting: List the permits and/or approvals required and status of any permits and/or approvals received.

CEH require no additional permits above and beyond what the farm already needs. If aquaponics is chosen as the main production method for crops, then the operator needs a fish farm license. In Illinois, the cost is less than $100.

Legal / Public Policy Considerations: Describe legal/public policy considerations associated with the option. Describe any agreements necessary for implementation and any potential water rights issues, if known.

It is important to note that in most states in the basin, water users are not able to market or expand their operations with conserved water, and thus the adoption of conservation practices is not as prolific as might be expected in an arid region. Some states have enacted statutory provisions allowing for the sale or lease of conserved water or, alternatively, exemptions from forfeiture for water saved through efficiency and conservation practices. Public subsidies for conservation practices and legal changes such as those listed may incentivize expanded adoption of practices that reduce consumptive use of water.

Implementation Risk / Uncertainty: Describe any aspects of the option that involves risk or uncertainty related to implementing the option.

The policy and application considerations listed above are significant. However if these could be adequately addressed conversion to CEH to conserve water is a low-risk proposition.

Reliability: Describe the anticipated reliability of the option and any known risks to supply or demand, such as: drought risk, water contamination risk, risk of infrastructure failure, etc.

CEA/CEH provides extremely reliable savings of water. These are high-tech methods developed over the last 40+ years to ensure reliability from the final product to the efficiencies of production.

Water Quality: Identify key water quality implications (salinity and other constituents) associated with the option in all of the locations the option may affect.

CEH eliminates all chemical fertilizers, soil-borne pest and disease, all herbicide and pesticide sprays, runoff issues into natural water sources, elemental risk factors for the producer, and the heavy water burden required in traditional crop production. Typically, CEH results in improvements in water quality, as these tools allow for reductions in applied and returned water, thus minimizing the interaction of water with saline soils.

Energy Needs: Describe, and quantify if known, the energy needs associated with the option. Include any energy required to obtain, treat, and deliver the water to the defined location at the defined quality.

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Energy Required	Source(s) of Energy
Energy needs vary widely due to the myriad methods and models for CEH production, processing and distribution of crops.	

Hydroelectric Energy Generation: Describe, and quantify if known, any anticipated increases or decreases in hydroelectric energy generation as a result of the option.

Location of Generation	Impact to Generation
	To the extent that broad-scale application of CEH would reduce the quantity of water diverted for agricultural use, nominal increases in hydroelectric power generation may be expected.

Recreation: Describe any anticipated positive or negative effects on recreation.

Location(s)	Anticipate Benefits or Impacts
	To the extent that broad-scale application of CEH would reduce the quantity of water diverted for agricultural use, river recreation resources would be expected to improve.

Environment: Describe any anticipated positive or negative effects on ecosystems within or outside of the Colorado River Basin.

Location(s)	Anticipated Benefits or Impacts
	To the extent that broad-scale application of CEH would reduce the quantity of water diverted for agricultural use, river environmental resources would be expected to improve.

Socioeconomics: Describe anticipated positive or negative socioeconomic (social and economic factors) effects.

As noted above in the section on legal/public policy concerns, the costs of conversion to CEH at a broad scale needs to be shared, either by taxpayers, or by stakeholders benefiting from the conserved water. Expecting agricultural producers to foot the full bill for these technologies, given today's policy framework, is not reasonable. Public investment in infrastructure should provide economic benefits to irrigators and local economies that depend upon their production. In addition, higher yields may be expected from CEH than from traditional agricultural methods.

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Other Information: Provide other information as appropriate, including potential secondary benefits or considerations. Attach supporting documentation or references, if applicable.

References

Rohl, P., Pate, R., Shaw, R., and Drayer, D. 2004. Identifying Technologies to Improve Regional Water Stewardship: A Conference Series Featuring Intersections of Technology and Water Management North-Middle Rio Grande Corridor. *Systems Assessment of Water Savings Impact of Controlled Environment Agriculture Forage Production.* University of New Mexico, Center for Science, Technology and Policy. Available at *www.unm.edu/~cstp/Reports/H2O_Session_2/2-3_Drayer.pdf*