STATE OF COLORADO

Colorado Water Conservation Board
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December 2, 2008

Frank Jaeger
Parker Water and Sanitation District
19801 East Mainstreet
Parker, Colorado 80138

RE: Notice to Proceed—Lower South Platte Irrigation Research and Demonstration Project

Dear Frank:

This letter is to inform you that the contract for your grant request of $477,500 to assist in the funding of the Lower South Platte Irrigation Research and Demonstration Project has been signed on November 25, 2008. With the executed contract, you are now able to proceed with the project and begin invoicing the State of Colorado for costs incurred from November 25, 2008 through XXXXXXX. Upon receipt of your invoice(s), the State of Colorado will provide payment no later than 45 days. I wish you much success in your project.

Sincerely,

/s/

Todd Doherty, CWCB
(303) 866-3441 x3210

Exhibit A
Scope of Work
(Lower South Platte Irrigation Research and Demonstration Project)

The scope of work will form the basis for the contract between the Applicant and the State of Colorado. In short, the Applicant is agreeing to undertake the work for the compensation outlined in the scope of work and budget, and in return, the State of Colorado is receiving the deliverables/products specified.

I. <u>Phase 1</u>

- **Description of tasks in Phase 1**

This phase's objective is to identify and evaluate the "feasible set" of cropping systems, including rotational cropping, that meet M&I demands for water while sustaining agricultural production. Since rotational cropping (fallowing) has already been identified as a potential water savings alternative, it will serve as a benchmark in the feasibility study by which the profitability and performance of other systems are measured. For a cropping system to part of the feasible set, it must have the potential to:

- Reduce consumptive use by 20% from an historical baseline. This includes the option of total fallowing 20% of the irrigated land.
- Consumptive use savings can be scientifically documented for use in court proceedings.
- The cropping system is profitable for farmers under expected prices and yields.
- The cropping system can be adapted with existing technology, equipment, capital and labor in the South Platte River Basin.

Cropping system alternatives will likely include water-conserving crop rotations (e.g., fallowing or a corn-wheat-sunflower rotation), limited irrigation practices for forage and grain crops (water spreading in space and time), alternative crops and markets, drought tolerant crops and crop varieties, irrigation methods and timing, and conservation tillage practices.

Initially, farmers leasing land from PWSD will be the key contacts used to develop concepts and screen ideas for practical utility. Beginning in the summer of 2006, willing farmers will participate in a detailed, face to face survey designed to characterize baseline farm information and to solicit innovative water savings concepts. Innovative ideas obtained from farmers will be combined with concepts from agricultural scientists, extension agents, and agricultural professionals. This project will evaluate all cropping strategies regardless of Colorado statute governing the transfer of "saved" water. In fact, the project may inform the process needed to revise Colorado statute to allow transfer of savings. Thus, the outcomes from this initial survey are a list of potential water saving cropping alternatives and detailed information about the resources and limitations that must be considered in selecting practical cropping options from the list.

Potential cropping alternatives, including fallowing, will then go through a screening and feasibility evaluation. This evaluation will be based on the four criteria listed above, on farm operator input and farm level profits and on economic and water use analysis performed by CSU scientists. Existing economic information, such as South Platte specific crop enterprise budgets will be applied in the screening process. Evaluation will reduce the concept list to a feasible set of practices. This feasible set will be used to prioritize specific cropping practices to be included in on farm demonstrations and the farm level research components of the study (Phase 2). In other words, this phase of the project will assure that cropping systems chosen to be part of the detailed field research will have been carefully selected to meet the criteria listed above and to be practical for implementation by farmers.

- **Method or procedure that will be used or followed to accomplish the task and identify who will undertake the task**

See description of tasks in Phase 1 for the procedures to be followed. Personnel needed to complete Phase 1 include a ½ time research associate located in Logan County (Heather Amen, daughter of Ken Amen, has been identified as a potential associate) to assist in basic data collection, surveys, and interviews; salary for two agricultural economists at one month each (Drs. James Pritchett and Marshall Frasier) so that they may assist in data collection, development of enterprise budgets, construction of mathematical programming model and compilation of results, soil and water analysis, travel funds and basic supplies.

- **Description of the major deliverables/products that will be produced upon successful completion of the task:**

A technical report outlining the feasible set will be presented to the PWSD. The merits and drawbacks of the feasible set will be discussed with particular comparison to rotational cropping (fallowing) benchmark. Knowledge gaps to be filled in Phase 2 will be presented.

Specific elements of this project phase include:

1. Inventory of all land resources including acreage, soil type, water table, etc. using existing information with new data collection where needed (e.g., soil testing).
2. Inventory of water resources including quantity, timing, historical supply and quality.
3. Inventory of equipment resources including irrigation equipment, planting, tillage and harvest equipment.
4. Inventory of labor and managerial requirements for farm(s).
5. Collection of weather, yield, cost, price, farm program payment, insurance indemnity and other relevant data (see note below).
6. Interview of current operators to better understand current cropping practices, irrigation management practices, potential innovative limited irrigation best management practices and future alternatives. Interview of regional farm managers and technical experts considered as well.
7. Development of a whole farm budget including needed water, labor, capital, and resource requirements. Timing of resource use will also be included.
8. Development of enterprise budgets for cropping system alternatives.
9. Construction of a rudimentary mathematical programming model to optimize profits subject to resource constraints, especially the consumptive use constraint. Sensitivity analysis will be performed with particular attention to crop-water response functions, crop prices and energy costs.
10. Ranking of cropping systems according to the mathematical optimization model mentioned previously. Discussion of cropping system advantages and disadvantages will accompany the ranking.
11. Technical report outlining the farm resources, potential cropping systems and those alternatives that comprise the feasible set.
12. Assessment of potential research locations, to include assessment of groundwater depth during growing season.
13. Final location for the Irrigation Research and Innovation Farm and setup of the linear move sprinkler irrigation system.

II. <u>Phase 2</u>

- **Description of tasks in Phase 2**

While Phase 1 establishes a feasible set of alternatives, actual demonstration, basic research and replication are needed to scientifically document water savings and profitability. Consequently, the primary objective of Phase 2 is to document the water savings and profitability. Two types of field demonstrations will be conducted; on-farm demonstrations and controlled research. On-farm demonstrations will be done on full sized fields with farmers managing the system. These on-farm demonstrations will not be replicated and will be done to evaluate the practicality and feasibility of the cropping systems. The second approach will be controlled research done under a state of the art linear move sprinkler irrigation system. The linear move sprinkler system will allow scientifically-defendable, replicated research plots to be established with individualized control of irrigation amounts. Details of the on-farm demonstrations and the controlled field research follow.

On-Farm Demonstrations

On-farm demonstration of cropping systems will be used to test water saving concepts while recording profit potential. The demonstrations are particularly useful for illustrating how systems might be adopted throughout the South Platte River Basin and to the Basin's farmers a practical, hands-on illustration of these systems.

Farmer led demonstrations will be conducted on three fields selected from farms owned by PWSD. PWSD farm operators will participate voluntarily, and Parker will underwrite the economic risk associated with demonstrating reduced water use cropping practices. Therefore, an agreement will be made between PWSD, the cooperating farmer and CSU regarding the scope and concepts tested for all demonstrations conducted in farmers' fields. Individual producers that participate in Phase 1 will be selected as potential demonstration sites. However, the overarching goal will be to represent the wide range of cropping systems, soil types, and marketing approaches that exist in the South Platte River Basin. We expect that practices such as alternative crops and crop rotations, fallowing, limited irrigation, conservation tillage, fertilizer and pest management will be included in the demonstrations performed. As part of the on-farm fallowing demonstration, we will evaluate the productivity of land that is returned to an irrigated crop following a period of non-irrigated fallow. These demonstrations will be conducted on parcels within a center pivot irrigation system rather than on the entire field. Farmers will conduct all crop management practices and CSU researchers will monitor the demonstrations, assist in water use measurements, yield measurement, and production cost determination to obtain detailed economic and water use data. A project manager will oversee the data collection and coordinate the projects with the participating farmers.

Controlled Research and Innovation Farm with Linear Sprinkler Irrigation System

A state-of-the-art irrigation research site will be created to intensively test and evaluate new and innovative water conservation practices, including rotational cropping (fallowing). The research farm will be designed for scientifically defendable evaluations of cropping systems identified as viable alternatives in Phase 1 and a more detailed quantification of water use, crop productivity, and economic evaluations than is feasible in the on farm demonstrations. Installation of a linear move sprinkler irrigation system is critical to development of a facility where irrigation can be controlled, quantified, and uniformly applied in a research setting with multiple irrigation levels. The linear move has particular advantages relative to other irrigation methods including:

- Side-by-side treatments of water application levels under similar soil, climatic and geographic conditions.
- Intensive comparison of many different irrigation and crop regimes.
- Precise control and documentation of water savings.
- Efficient use of land and labor resources in the research area.

PWSD owns the linear move sprinkler. An Advisory Committee will be organized which will be made up of local farmers, county agents, Parker personnel and the interdisciplinary CSU research and extension team. The Advisory Committee will provide guidance in all aspects of Phase 1 and Phase 2 of this project.

A full time manager will oversee operations and coordinate field activities and data collection. The project will pay for production inputs such as seed, fertilizer, and herbicides, while farmer cooperators will assist with field operations, market crops, and will be compensated by PWSD for their time and use of their equipment. All revenue from crop sales will go to the farmer cooperator as part of the contract arranged between PWSD and participating farmers. The research farm chosen during Phase 1 was the Hurst farm (see Exhibit D). Among the research concepts to be evaluated at the research farm are water conserving crop rotations, rotational cropping (fallowing), rotating fallowed land back to irrigated crops, limited irrigation practices for forage and grain crops, alternative crops and markets, drought tolerant crops and crop varieties, irrigation methods and timing, and conservation tillage practices. A systems approach will be used when evaluating the various research concepts tested, therefore all aspects of crop production will be considered during this research phase. Specific elements of the first three years of Phase 2 (2007-2009) include:

1. Three to five on-farm demonstration of cropping approaches that reduce historic consumptive water use by 20%.
2. Evaluation of rotational cropping (fallowing), including evaluation of irrigated crop production following fallow periods of different durations (1, 2, 3 yrs fallow) and different fallow period management
3. Creation of a state-of-the-art irrigation research and innovation farm with a linear move sprinkler irrigation system where the various cropping systems research concepts identified above will be tested.
4. Detailed economic analysis of the water savings practices including input costs, labor, yields, and price, and net returns of the various systems.
5. Detailed measurements of the water balance for innovative cropping systems including precipitation, applied irrigation, soil moisture dynamics, and consumptive water use.
6. Annual public field days to share information with the agricultural community as well as all interested parties in the greater water community.

For the fourth year of the study (2010), Phase 2 will continue with minor change, based on what is being learned and on input from the Advisory Committee. Phase 2 will continue to be comprised of two types of field demonstrations: on-farm demonstrations conducted in full-sized fields with farmers managing the system and controlled research done under the state of the art linear move sprinkler irrigation system installed on PWSD-owned land near Iliff. Continuing this research at the on-farm demonstrations and the controlled research in 2010 will be exceedingly beneficial because 1) the crop rotations initiated in 2007 will have an additional year's data on which to base interpretation and 2) data will be available under an additional year's weather; insect pest, plant disease, and weed pressure, as well as evaluating other variables. .

- **Method or procedure that will be used or followed to accomplish the task and identify who will undertake the task**

Cropping systems research and demonstration require a significant amount of time to document the outcomes of new cropping systems. Five or more years is a likely time frame for this project phase. However, this proposal and the associated budget is for four years to allow an interim project assessment with the expectation that the project will be continued beyond four years. PWSD will purchase and own the linear move sprinkler irrigation system and, therefore, cost estimates for this are not included in this project budget. CSU assisted in developing specifications and helped to oversee installation. The system includes the associated collection pond, pumps, controllers, and nozzles. Risk underwriting for participating farmers is expected to be negotiated directly between farmers and PWSD and associated costs are not included in this project budget. In addition, arrangements for some office and equipment storage space will be needed but are not budgeted for in this proposal.

Hiring a full time project manager to oversee Phase 2 of this study is vital to the success of the project. A highly qualified candidate was hired by CSU in early 2007, Mr. Mike Stephens. Mr. Stephens lives and has an office in the project area, but reports to the CSU project principal investigators. Salary will be needed for CSU faculty acting as principal investigators on the project (equivalent of 5 months of salary). As an educational component of Phase 2, a graduate student will be supported and will have responsibility for conducting an academic study on irrigation water savings for the cropping system being evaluated. Support is requested for the student stipend and in-state graduate tuition. Other salary will be needed for hourly labor during the cropping season to assist with field activities, data collection, and analysis. Equipment needed for the project are anticipated to include a dedicated row-crop tractor, a hooded pesticide sprayer, a precision weigh wagon for grain yield analysis, a leased vehicle for the project manager, and monitoring equipment. Cropping systems inputs such as seed, fertilizer, and herbicides are needed for the irrigation research and innovation farm, and are included in the budget. Other expenses will include travel costs, materials supplies, and costs associated with publications and field day activities.

- **Description of the major deliverables/products that will be produced upon successful completion of the task**

Field scale demonstrations of cropping practices that reduce consumptive water use and a high visibility state-of-the-art irrigation research and innovation farm will be developed. Appropriate signs showing the cooperation between PWSD and CSU will be installed at each demonstration site as well at the research and innovation farm. Appropriate press releases will be made as progress is made on the project. Detailed economic analysis of each practice will be performed. We will produce an annual technical report documenting the results of the on-farm demonstrations and the cropping systems research projects including water balance data and economic outcomes. In addition, farmer-oriented CSU Extension fact sheets on the individual practices demonstrated will be developed. Additional CSU Extension fact sheets will be produced for interested non-farm audiences such as regulatory agencies, elected officials, M&I water users, and water suppliers. All of this information will also be made available on the internet. An annual field day will be held where the latest research results will be presented and a field tour of the on-farm demonstration sites will occur. Extension meetings will be held in the winter to inform the cooperating farmers, other stakeholders and interested parties of the details of the results and project implications on the farm and regional level economic viability as a result of water transfer by PWSD. Information generated by CSU personnel is generally considered to be openly available to the public. However, to assure coordination, CSU and PWSD will inform each other of the content of information to be released to the public in advance of release.

III. <u>Phase 3</u>

- **Description of tasks in Phase 3**

Phase 1 of the project involves an economic feasibility of cropping systems for PWSD's representative farms. However, adoption of innovative cropping systems may extend throughout the South Platte Basin to satisfy the water needs of growing municipalities. But, how many farms are likely to adopt these innovative systems, and what are the critical barriers to adoption? To answer these questions, a farmer survey is needed to capture variation in the likelihood of system adoption associated with farm-specific characteristics such as soil type or water rights, or by demographic issues such as irrigator age and off-farm employment. The specifics of the adoption study are listed in **Part A** below. Additionally, a strong potential for spillover effects into the regional economy exists because adopting alternative irrigation systems will have effects on farm cash flow and productivity. Altered cash flows create ripple effects that include, but are not limited to, agribusinesses that sell inputs directly to adopting farms, businesses that receive revenues from adopting farms' and agribusiness employees that spend wages their wages locally and a changing sales/property tax base. A regional economic impact model will quantify these effects as discussed in **Part B.**

Part A: Determine Adoption of Innovative Cropping Systems in the South Platte Basin

Information is needed to capture variations in the likelihood of system adoption associated with farm specific characteristics. To forecast the likely adoption rate, irrigators in Morgan, Logan, Sedgwick, Phillips, Yuma, and Washington counties (the region surrounding the PWSD-owned properties) will be surveyed about their irrigation technology preferences. Much of the focus of the survey will be on how irrigators expect adopting less water-intensive irrigation systems to influence farm cash flow and labor needs. Additional questions will focus on why irrigators are or are not choosing specific technologies, their time horizon for making changes in irrigation systems, and what levels of cost-sharing, if any, are needed to promote adoption of less water-intensive irrigation systems. As such, this survey will provide a much more precise understanding of why, when and how irrigators in the region adopt different irrigation systems. It will also reveal what producers might need to be paid in order to participate in a rotational fallowing program

This survey will also leverage pre-existing surveys of irrigation technology adoption used during the 2002 drought and the Arkansas River Valley. Once the survey data are gathered, it will be used to provide more realistic estimate of the anticipated benefits and costs of innovative cropping systems. It will also provide more specific understanding of what irrigators' value in an irrigation system.

The lessons learned from the survey effort will inform stakeholders as to the barriers to adoption that may exist in other reaches of the South Platte Basin and the Arkansas River Basin. In particular, the economics of irrigated agriculture are consistent in the South Platte basin so that strategies to overcome adoption barriers in Morgan County will be quite similar in Weld County. Some differences exist between irrigated agriculture in the South Platte Basin and the Arkansas River Basin, but the survey results will also provide key insights into whether Arkansas Valley farmers will be able to adopt limited irrigation practices.

Part B. Regional Economic Impacts of Adopting Innovative Cropping Systems

A strong potential for spillover effects into the regional economy exists because adopting alternative irrigation systems will have effects on farm cash flow and productivity. The effects on regional employment and income stemming from changes in on-farm income and cash flows will be estimated using a regional planning model (such as IMPLAN) and drawing on the expected changes in farm profitability and production practices indicated by the results from Phases 1 and the adoption survey. This will provide an estimate of the off-farm benefits of improvements in on-farm productivity and ensure that the estimation of benefits from this project is assessed at a social and not simply a private scale. It will also provide estimates of what levels of support might be available from the regional economy to support changes in on-farm irrigation efficiency if the expected benefits to the regional economy of such changes are positive.

The regional economic analysis in the South Platte Basin will provide a significant foundation for similar modeling in the Arkansas River Basin. Key relationships regarding the purchase of local inputs, use of local labor and their impact on the economy can be used to build an IMPLAN model for the Arkansas basin. However, estimated regional impacts for the fallowing of a similar area of land (e.g., 25,000 acres) will likely have significantly different impacts between the South Platte and Arkansas River Basin economies, due to differences in the diversity of the economic base, the amount of goods and services exported out of the regional economy, and differences in crop rotations and other agronomic factors.

- **Method or procedure that will be used or followed to accomplish the task and identify who will undertake the task**

See descriptions of tasks in Phase 3 for procedures to be followed. Survey expenses are anticipated along with a dedicated effort from a gradate research assistant to implement and analyze the survey data (stipend and tuition). Faculty effort will be needed as well to coordinate, direct and present results.

- **Description of the major deliverables/products that will be produced upon successful completion of the task**

Survey and regional economic impact results will be presented to a meeting of interested stakeholders, especially PWSD members, the PWSD Board of Directors, and the Colorado Water Conservation Board. Published materials will included a technical bulletin from Colorado State University Agricultural Experiment Station and fact sheets via Cooperative Extension.

IV. Phase 4

- **Description of tasks in Phase 4**

This phase of the project will address administration and hydrologic consideration necessary for the successful implementation of rotational fallowing and limited irrigation cropping practices as water savings approaches in Colorado. The two sub-objectives outlined below are seen as critical components to the successful implementation of these innovative approaches to water savings.

Sub-objective 1: Administration, quantifying, and monitoring, consumptive water use savings.

Remote Sensing of ET

Rotational fallow and limited irrigation cropping systems, addressed in other phases of this study, are innovative potential solutions to the changing water needs in Colorado. Adoption of these practices will require that state agencies have confidence that consumptive water use savings are real and that they can be quantified. Practical means of documenting these savings need to be developed. We will evaluate an approach to demonstrating consumptive water use savings based on analysis of satellite imagery for limited irrigation fields. We will compare this method of deriving ET values with standard water balance methods. Satellite image methods have been documented and used by Bastiaanssen, et al. (1998a and b and 2000). They developed SEBAL that uses Landsat 5/7 imagery and can be used with other image formats as well and METRIC that stems from SEBAL (Allen et al., 2005) but adds an internal calibration and a better method for calculating seasonal ET. A model called Remote Sensing of Evapo-transpiration (ReSET), has been developed at Colorado State University (Elhaddad and Garcia, 2008). It expands the capabilities of SEBAL and METRIC and has been applied using Landsat 5/7 imagery.

Energy Balance Methods

Evaporation of water requires energy, either in the form of sensible heat or radiant energy. That is why the evapo-transpiration process is reliant on energy exchange at the vegetation surface and is governed by the amount of energy available at this surface. This concept makes it possible to predict the evapo-transpiration rate using the surface energy balance: the energy arriving at the surface should equal the energy leaving the surface for the same time period. The equation for an evaporating surface can be written as:

$$\square ET = Rn - G - H \qquad (1)$$

where, Rn is the net radiation, H is the sensible heat, G is the soil heat flux and $\square$ ET is the

In our proposed research, this energy balance relationship will be used to obtain an estimate of ET. A remote sensing-GIS based model (ReSET) (Elhaddad and Garcia, 2008) has recently been developed for this purpose and will be used in our study. ReSET is a model that uses a surface energy balance algorithm based on reflectance information from Landsat satellite imagery. The model and processing of the imagery uses ERDAS Imagine 8.7. Model output is a raster layer containing an estimate of the 24-hour ET value for each pixel of interest.

<u>Calculating the ET Surface</u>

Several Landsat 5 images for the study area that have been purchased or will be purchased for the project will be used to calculate the ET. The Landsat 5 spectrum contains seven bands: three visible bands, a near infrared, a mid-infrared, an infrared, and a thermal band. All the bands have a nominal cell size of 30m by 30m except for the thermal band that has a nominal cell size of 120m by 120m. Satellite images in the July time period will be selected for processing because in that period the corn will be near full cover. Once the image is georectified and processed using the ReSET model, estimates of ET for each pixel will be available.

Figure 1 shows the results of the RESET model for a Landsat 5 image for part of the South Platte basin. The image on the left shows the whole Landsat frame, and the image on the right shows a zoomed-in view of a few fields. Studying the image on the right, we can see the spatial variability of ET within some of the fields. Using GIS tools that IDS has developed, we can generate an average ET for each field and compare it to the values computed using IDSCU. The figure clearly shows the significant variation in ET for these fields, which other energy balance methods would have assumed to be uniform.

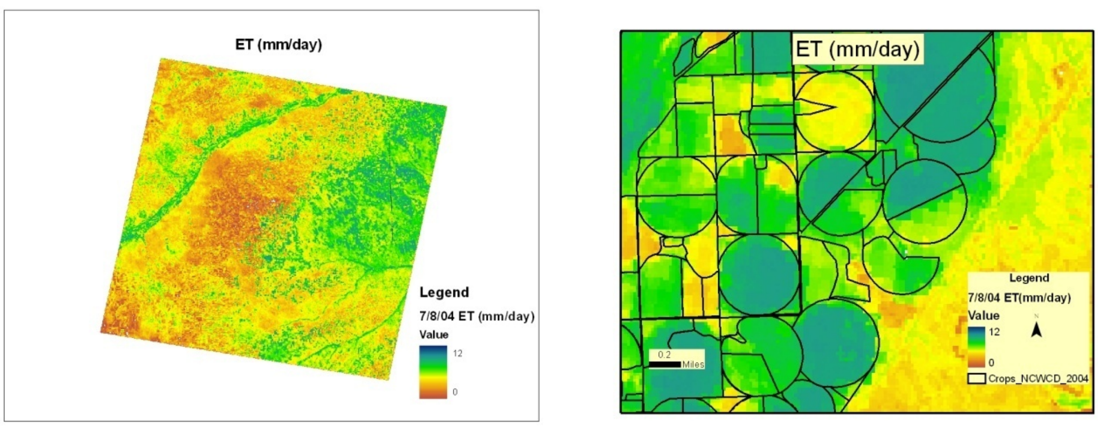


Figure 1. ReSET results for 7/8/04 Landsat 5 image for part of the South Platte.

IDS is currently working with the NCWCD and the US Bureau of Reclamation developing remote sensing of ET results for 2004 and 2006. As part of this work, comparison between ReSET values and IDSCU are being calculated for these two years. Information from those studies can be used in the effort we are proposing here because there are fields in which actual irrigation amounts applied in 2004 and/or 2006 are available (center pivots that are metered).

In the Arkansas River basin, CSU has been involved in a project with the CWCB in which irrigation amounts are monitored in a number of fields. With funding from the USBR, IDS is currently generating ReSET results for 2006 for part of the Arkansas River Basin and will be comparing the remote sensing of ET values to estimate water budgets. These results will likely be useful to our proposed project, especially in the instances where water deficits are identified based on the measured inflow amounts.

The remote sensing of ET work is currently being conducted in the South Platte and the Arkansas River Basin in Colorado as well as the Palo Verde Irrigation District in California. This work will allow us to compare the remote sensing of ET values that reflect "actual" conditions versus the traditionally calculated ET values (such as those computed from Penman Monteith, ASCE Combination Equation or Blaney Criddle).

Crop coefficients based on growing degree days take into account weather conditions during the growing season (such as cool spring conditions that would cause crops to grow slower). The ReSET results will be used to develop crop coefficients using data from both the Arkansas (2006) and South Platte (2004 and 2006) as well as the data that will be collected in the South Platte in 2008, 2009, and 2010. In addition, work that is currently taking place in the Arkansas and which is getting underway in the South Platte will study the impact that increasing soil salinity has on ET. This research is expected to generate stress coefficients related to deficit irrigation and salinity. Both of these issues are known to have an impact on ET and can be studied using lysimeters. However only now that remote sensing technology is available we have the ability to quantify these impacts on a large scale. The ability to document the reduction of ET due to deficit irrigation (and other factors such as salinity) will be valuable for many places facing water shortages throughout western US and around the world.

The results of the ET estimation from remote sensing, as described above from the test plots where innovative water savings irrigation approaches are used, will be a means to develop accepted approaches to administer water savings and transfers from Colorado farms adopting limited irrigation and rotational fallow management. The intent of the project is to validate the use of Water Court-accepted consumptive use equations, such as the Penman-Montieth equation, when farmers adopt limited irrigation and rotational fallowing as part of an alternative agricultural water transfer method. The results of this project will assess the use and the values of a stress coefficient (Ks), which will be used in conjunction with already accepted crop coefficients (Kc) and consumptive use equations. When a stress coefficient is used in conjunction with the crop coefficient for a fully-irrigated crop, the resultant coefficient will define the consumptive use associated with limited or partial season irrigation. Validation and acceptance of these approaches will pave the way for an acceptable procedure for Water Court, and will results in a sustainable means for agricultural water transfers in Colorado.

Sub-objective 2: Basin Scale Impacts of Leasing and Rotational Fallowing Scenarios.

Wide spread adoption of consumptive use leasing and rotational fallowing will impact the timing and flow of water in the South Platte River Basin as well as irrigation networks emanating from the river. The purpose of this sub-objective 2 is to forecast the likely adoption of rotational fallowing and limited irrigation in the South Platte River Basin using results from the producer survey of Phase 3, and then examine the basin level impacts of various adoption scenarios. The survey results' forecasted adoption will serve as a base case, and using the advice of water professionals, we will outline likely scenarios for limited irrigation and rotational fallowing at the basin level.

How will the basin's hydrology be impacted by water leasing adoption and rotational fallowing? A water economist at CSU has designed a tool that can be adapted for determining how best to meet this sub-objective 2. This tool, the South Platte Regional Assessment Tool (SPRAT) will be used to examine likely water leasing scenarios. SPRAT models the movement and allocation of water throughout the Basin, allowing users to make relative comparisons of the water supply and demand impacts associated with various population growth, climate/hydrologic, and agricultural land-use scenarios, and by allowing the merits of various water management alternatives (adaptations) and infrastructure changes to be similarly compared.

- **Method or procedure that will be used or followed to accomplish the task and identify who will**

undertake the task

Dr. Luis Garcia, Head, Department of Civil and Environmental Engineering will be the lead investigator on this sub-objective 1. Two research associates (Dr. Aymn Elhaddad and Dr. David Patterson) and a PhD graduate student also will be heavily involved.

Dr. Christopher Goemans, Department of Agricultural and Resource Economics (Water Economist), will be the lead investigator on sub-objective 2. A PhD graduate student will also be heavily involved.

- **Description of the major deliverables/products that will be produced upon successful completion of the task**

For sub-objective 1, ET maps for 2008, 2009, and 2010 using Landsat 5 imagery will be developed. Imagery will be purchased for the 32/32 scene (covers from west of Brush to the state line). Satellite imagery will be purchased (6-8 images) and processed. Then following the ReSET process (Elhaddad and Garcia, 2008) a seasonal ET map will be generated.

The ET for selected fields will be calculated (IDS has developed a set of GIS tools that aggregate the ET from individual pixels (30m x 30m) into a total for a field). These fields will be identified based on knowledge of irrigation amounts and practices.

The ET calculated from ReSET for selected fields with reduced water supplies will be compared to the ET calculated using traditional methods (ASCE, Penman Monteith, Blaney Criddle, etc.). This analysis will be done using the IDSCU which is a model that has been developed by IDS and is widely used and accepted by the state and water users. This analysis will help document reductions of ET below those obtained through traditional ET calculation methods, and it will demonstrate the impact of limited irrigation on actual ET. The goal would be to generate a distribution of reduced ET related to reduced water availability.

The data collected from the multiple sites and multiple years of the project will be used to develop water reduction crop coefficients that can be applied to currently used crop coefficients. The goal is to document and develop enough data so that a reduced ET crop coefficient would be accepted. Initially we will target two amounts of irrigation reduction (e.g. 25% and 50%).

A technical bulletin and multiple presentations will be delivered as a result of sub-objective 2. The technical bulletin will consider several water leasing and rotational fallowing arrangements, and then report the basin level impacts of these arrangements using the SPRAT tool. The technical bulletin will included background information, an outline of leasing scenarios, documentation of the model, description and interpretation of results, and an analysis of opportunities for future research. A synthesis of these results will be presented to stakeholders whenever appropriate, but the following will be specifically targeted: the South Platte Forum, the Lower South Platte Forum, and the Colorado Water Congress. In addition, CSU Extension Fact Sheets will be written describing model results, and these will be made available on the project website.

V. Phase 5

- **Description of tasks in Phase 5**

Phase 5 will provide a final report at the completion of all of the work related to this project, including the research results, conclusions related to the on-farm demonstrations, local and regional economic analyses, preliminary planning studies related to delivery of water, and the proposed administrative and hydrologic procedures that are proposed to support change of use proceedings in Water Court. The final report shall be a collaborative effort among CSU, Parker Water and Sanitation District, Lytle Water Solutions, Robert Krassa, States West Water Resources Corporation and Integra Engineering.

- **Phase 5 Deliverables**

The project final report will include the following deliverables:

1) Description of the elements of the study, including the purpose and need of the study, maps of the studied areas, crop plots for each year of the study, summary of the overall studies completed, etc.

2) Presentation of the results of the research, including alternative cropping systems, limited irrigation practices, partial season irrigation practices, and rotational fallowing. Results will be assessed based primarily on water savings and effects on crop yields compared to more conventional irrigation methods.

3) Presentation of the results related to other aspects of the irrigation research, such as pest management, fertilizer management, water balance issues (e.g. soil moisture profiles relative to return flows), ground water level fluctuations during the irrigation and non-irrigation seasons, and the range of climatic conditions studied.

4) Presentation of the results from on-farm demonstrations, including evaluation of partial season irrigation of forage crops, limited season irrigation of corn, and the effects of gypsum treatments on salt build-up in the soils.

5) Evaluation of the on-farm results relative to water savings and effects on crop yields, and compare these data to the controlled research data collected from the linear sprinkler research conducted by CSU.

6) Evaluation of the applicability and the acceptance of innovative irrigation techniques by local farmers involved in the on-farm demonstrations.

7) Presentation of the analyses of economic feasibility of innovative irrigation techniques, including (a) analysis of survey results, (b) assessment of interest by farmers to participate in such a program, (c) estimated costs for farmers to commit land and water rights to this type of program, (d) identification of economic barriers to participation and the means to overcome these barriers, (e) the acceptance of leasing water rights versus outright sale of water rights, and (f) assessment of regional adoption of alternative irrigation systems.

8) Presentation of the results from regional economic model, including effects on farm cash flow and productivity, as well as regional employment effects.

9) Presentation of the results of evaluation of satellite imagery on demonstrating partial consumptive use savings, including results from the ReSET model.

10) Presentation of the methodology, or methodologies, for developing modified crop coefficients for use in generally-accepted consumptive use models, by developing stress coefficients from the satellite imagery and ReSET model work, that would be used in conjunction with crop coefficients for fully-irrigated lands.

11) Presentation of the methodologies that could be used to demonstrate the quantification of partial consumptive use savings in a change of water right proceeding. It is anticipated that a set of general terms and conditions can be developed as a template for any change of use proceeding.

12) Identification of the conditions under which the quantification methodology for partial consumptive use savings was developed so others can assess its applicability at other locations and other climatic conditions.

13) Presentation of the methodologies that will be used to assure that historic return flow patterns will be maintained even if water is transferred from agricultural to municipal use.

14) Presentation of the results on water quality issues related to a change of use that would remove water from the river system and make it available for municipal use.

15) Presentation of the results on water quality issues related to the potable nature of the water being delivered to municipal water users. Water treatment issues will be evaluated on a pre-feasibility level relative to providing a suitable water quality at the point of use.

16) Presentation of the pre-feasibility water delivery system that would move water from farms in Logan County to the initial point of delivery at Rueter-Hess Reservoir. This will include the preliminary design of pipelines, pump stations, pipeline routes, and water collection methods from the South Platte River to deliver water to the pipeline, and the proposed location and method of water treatment.

17) Presentation of the results on the institutional framework(s) that could potentially be used for setting up contractual relationships for the lease or sale of water rights to facilitate agricultural water transfers.

18) Identification of the potential end users of water transferred from the agricultural sector to the municipal sector.

19) Inclusion of appendices to include minutes from Advisory Committee meetings, data compilations, ground water level elevation graphs and tables, survey results, the annual technical reports, ET analyses, CSU Extension Service fact sheets distributed regarding the project, summaries of annual field days, copies of press releases during the study, etc.

VI. <u>Personnel</u>

Provide a list of key water activity/project participants and their qualifications to accomplish the water activity/project. If specific individuals or firms have not yet been identified indicate the types of expertise that will be sought (i.e. professional engineering firm, registered land surveyor, aquatic biologist etc.).

The following is the list of the personnel on the CSU Project Team.

Principal Investigator:
- Dr. Thomas Holtzer, Head, Department of Bioagricultural Sciences and Pest Management

Co-Principal Investigators:
- Dr. Neil Hansen, Department of Soil and Crop Sciences (Cropping Systems)
- Dr. James Pritchett, Department of Agricultural and Resource Economics

Co-Investigators:
- Mr. Troy Bauder, Department of Soil and Crop Sciences (Extension Water Quality Specialist)
- Mr. Bruce Bosley, Department of Soil and Crop Sciences (Extension Forage Specialist)
- Dr. Joe Brummer, Department of Soil and Crop Sciences (Forage Crop Specialist)
- Dr. Stephen Davies, Chair, Department of Agricultural and Resource Economics
- Dr. Aymn Elhaddad, Research Associate, Department of Civil and Environmental Engineering
- Dr. Marshall Frasier, Department of Agricultural and Resource Economics (Integrated Resource Management)
- Dr. Luis Garcia, Head, Department of Civil and Environmental Engineering
- Dr. Christopher Goemans, Department of Agricultural and Resource Economics (Water Economist)
- Dr. David Patterson, Research Associate, Department of Civil and Environmental Engineering
- Dr. Frank Peairs, Department of Bioagricultural Sciences and Pest Management (Field Crops Entomologist)

Dr. Gary Peterson, Head, Department of Soil and Crop Sciences
Mr. Joel Schneekloth, Department of Soil and Crop Sciences (Extension Irrigation Specialist)
Dr. Reagan Waskom, Department of Soil and Crop Sciences (State Water Resources Extension Specialist)
Dr. Dwayne Westfall, Department of Soil and Crop Sciences (Soil Scientist and Cropping Systems)

Professional Staff:
Ms. Heather Amen, Staff Assistant, Lower South Platte Irrigation Research and Demonstration Project
Mr. Mike Stephens, Manager, Lower South Platte Irrigation Research and Demonstration Project

VII. Budget

A detailed budget by task, which includes level of effort (hours), and rates. Any unit costs or other direct costs must be specified (i.e. mileage, number of miles, dollars per mile). (For an example budget format – See Attachment 1 at the end of this application.)

If applicable, the budget should also detail the source and amount of matching funds and/or in-kind contributions, if any. If applicable, the budget should also include any other outstanding or previously applied for funding that also supports the water activity:

The following table presents a summary of the costs for this study. The detailed breakout of these costs is presented in the tables in Exhibit F.

Description	Estimated Cost ($) in Year					
	2006	2007	2008	2009	2010	Total
Personnel						
Faculty/Staff	$15,491	$39,207	$64,052	$66,507	$80,578	$265,835
Project Manager		$42,432	$44,129	$45,894	$45,894	$178,349
Graduate Students		$32,448	$33,746	$43,791	$44,496	$154,481
R.A. and Hourly	$5,650	$18,343	$19,241	$20,646	$16,015	$79,895
Fringe	$4,292	$20,593	$26,164	$27,584	$29,859	$108,492
TOTAL	$25,433	$153,023	$187,332	$204,422	$216,842	$787,052
Other Direct Costs						
Equipment		$69,680				$69,680
Materials	$1,900	$29,224	$19,934	$20,561	$20,186	$91,805
Travel	$1,500	$7,488	$8,588	$8, 899	$7,093	$33,568
Grad. Tuition		$7,749	$8,136	$8,543	$8,543	$32,972
Other		$6,240	$6,490	$6,749	$6,749	$26,228
TOTAL	$3,400	$120,381	$43,148	$44,752	$42,571	$254,253
Total Direct Costs	$28,833	$273,404	$230,480	$249,174	$259,413	$1,041,305
Modified Total Direct Costs (TDC minus Equipment and Tuition)	$28,833	$195,975	$222,344	$240,631	$250,870	$938,653
Indirect Costs	$7,208	$48,994	$55,586	$60,158	$62,718	$234,663

(F&A) (25% of MTDC)						
TOTAL (Total Direct Costs plus Indirect Costs)	$36,041	$322,398	$286,066	$309,332	$322,131	$1,275,968

Since the Lower South Platte Irrigation and Research Demonstration Project is currently underway, some of the costs shown in this table have already been incurred. The costs incurred by PWSD include $306,539.60 in direct costs paid to CSU, as well as $57,986.50 in indirect costs paid to CSU. In addition, PWSD has paid $107,379.07 in direct equipment costs for the purchase and installation of the linear sprinkler system at the Hurst farm and has paid Lytle Water Solutions $17,120.24 for project management. Therefore, PWSD has paid $489,025.41 in in-kind contributions to this project, of which $364,526.10 has been paid from the total budget shown above of $1,275,968.

In addition to the costs that PWSD has already incurred, many of the CSU faculty that is contributing to this study is doing so pro bono. It is estimated that CSU faculty has already contributed approximately $70,000 to the value of this study, and will continue to do so throughout this study. The total in-kind services provided by CSU throughout the 4-year study are estimated to be approximately $270,000.

PWSD has also received a grant through the Water Supply Reserve Account in the amount of $150,000, $20,000 from the South Metro Water Supply Authority and $15,000 from the Town of Castle Rock. Based on the fees paid to date, the grants received, and the total estimated cost of the project, PWSD is requesting a grant under the Alternative Agricultural Water Transfer Methods grant program of $ 500,000. The allocation of this money by task is shown in the following table.

BREAKOUT OF ALLOCATION OF GRANT MONEY [1)]

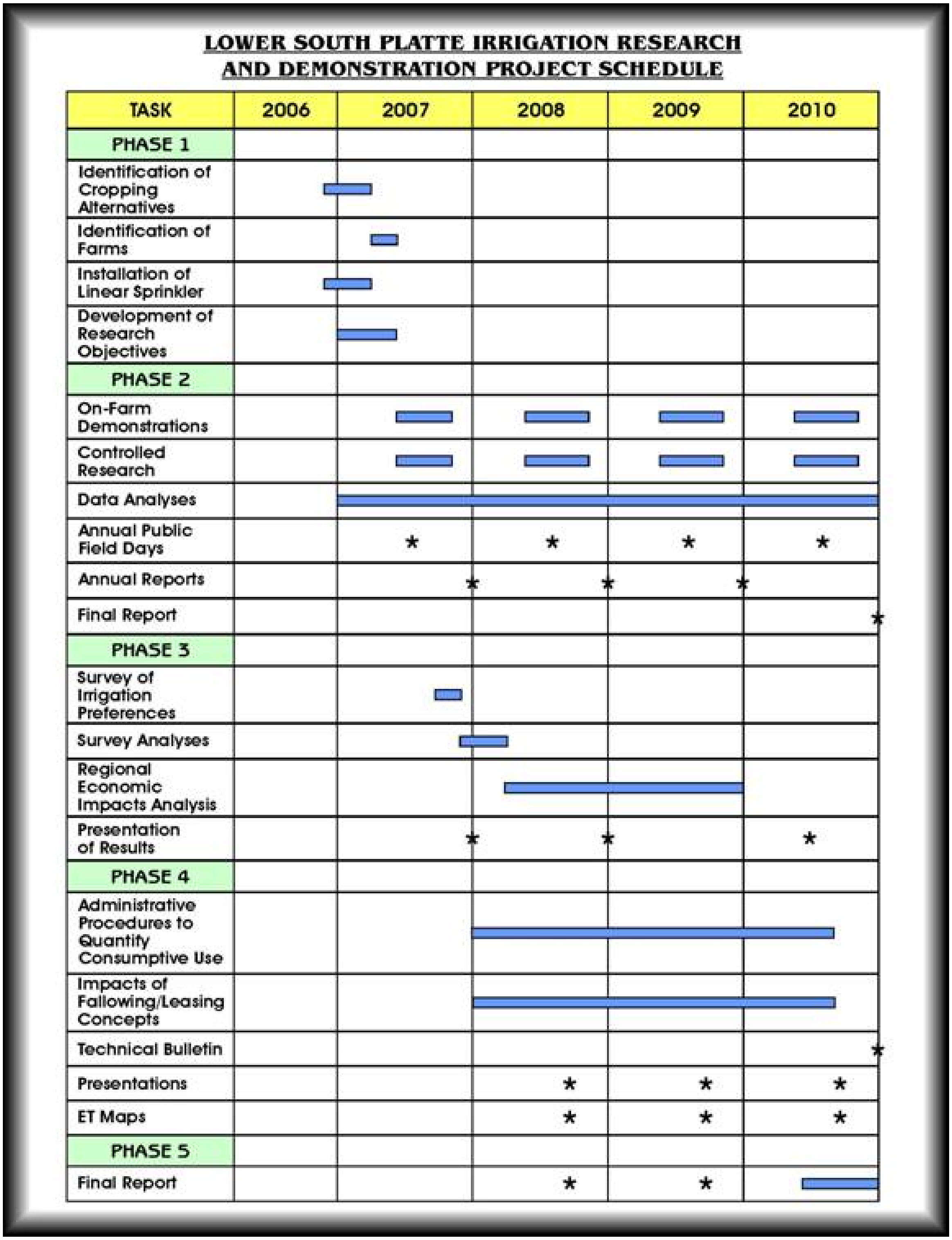
TASK	ESTIMATED COST ($) IN 2008	2009	2010	TOTAL
On-farm demonstrations, data collection, and analysis	**$0**	**$10,267**	$32,891	$ 43,158
Controlled irrigation research, data collection, and analysis	**$0**	**$ 50,452**	$151,342	$201,794
Regional economic and adoption surveys/analyses	**$0**	**$42,294**	$0	$ 42,294
Quantification of consumptive use savings	$50,000	$50,000	$50,000	$ 150,000
Basin-scale economic impact assessment	$20,918	$20,918	$20,918	$62,754
Facilities and administration 2)	$0	$0	$0	$ 0
Total	$70,918	$ 173,931	$255,151	$ 500,000

1) Reduced to account for expenses to be paid by WSRA grant, shown in blue.
2) Included with specific tasks described in Table. Further breakout is shown in Exhibit F tables.

August 8, 2008

VII. Schedule

A detailed project schedule including key milestones and the dates these are expected to be completed.



PAYMENT

Payment will be made based on actual expenditures and invoicing by the applicant. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed.

All products, data and information developed as a result of this grant must be provided to CWCB in hard copy and electronic format as part of the project documentation.

August 8, 2008