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KERN GROUNDWATER AUTHORITY COORDINATION AGREEMENT COMPONENTS WHITE PAPER SERIES

Item D
Total Water Use

Introduction

There are seven components to Groundwater Sustainability Plan (GSP) coordination agreements. The coordination components are further described in the Department of Water Resources (DWR)'s GSP regulations, which were released in draft form in February, 2016. The seven components are:

a. **Groundwater Elevation Data.**
b. **Groundwater Extraction Data.**
c. **Surface Water Supply.**
d. **Total Water Use.**
e. **Change in Groundwater Storage.**
f. **Water Budget.**
g. **Sustainable Yield.**

The Coordination Committee of the Kern Groundwater Authority (KGA) is preparing a series of white papers addressing each of the coordination elements identified above. This white paper addresses ***Item d) Total Water Use.*** The information presented in this white paper provides a suggested methodology and protocols for the consistent collection of total water use data throughout the Kern Subbasin. The intent of this white paper is to advance the dialogue between participating members of the KGA on the development of a coordination agreement required under the Sustainable Groundwater Management Act (SGMA). The information presented herein is draft and subject to the input and revision from members of the Coordination Committee.

Water Budget Components

Water budgets calculate change in groundwater storage by comparing supplies to consumptive uses and outflows. This section explains the supply and consumptive use components that need to be

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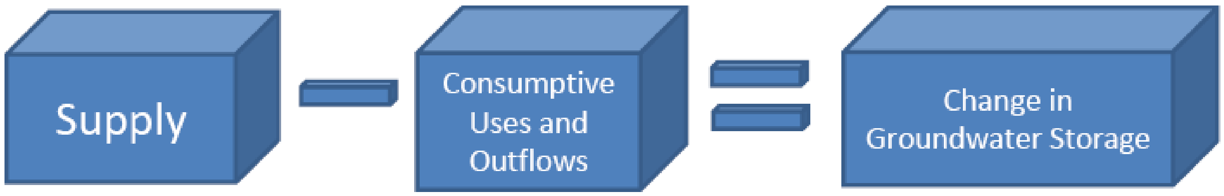
considered when developing a water budget for the Kern Subbasin. Figure 1 shows the summary equation.



Supply can be calculated by documenting and adding together water supply inputs into the Kern Subbasin, which include:

- Kern River.
- Minor streams.
- CVP imports.
- SWP imports.
- Precipitation.
- Groundwater inflows from small watersheds.
- Groundwater inflows from the Tule Subbasin.
- Groundwater inflows from Kings Subbasin.
- Produced water from oil extraction.
- Withdrawals from groundwater storage (groundwater extractions).

Consumptive use can be calculated by documenting and adding together consumptive uses and outflows, which include:

- Managed habitat evapotranspiration.
- Undeveloped land evapotranspiration.
- Soil moisture evapotranspiration.
- Agriculture evapotranspiration.
- Groundwater outflows to small watersheds.
- Groundwater outflows to Tule Basin.
- Groundwater outflows to Kings Basin.
- Municipal consumptive use (municipal use minus municipal discharge).
- Evaporation during energy production.
- Contributions to groundwater storage (deep percolation).

This white paper discusses methods that can be used to measure or estimate total water use. Other components of the water budget are discussed in other white papers.

Definition of Total Water Use

Total water use is defined as "the net total volume of water leaving the basin," including outflows, exports and consumptive uses / evapotranspiration.

Data and Monitoring Protocols

This section describes elements of the total water use data component of coordination agreements. This white paper proposes total water use would be broken into three categories, each of which has one or more quantification methods associated with them:

- Evapotranspiration / consumptive use.
- Sub-surface outflow.
- Water exports.

Evapotranspiration / Consumptive Use

This component of the water budget includes evapotranspiration (agricultural, urban, habitat uses, surface water bodies, and soil moisture evaporation on undeveloped land), and other municipal and industrial consumptive uses (such as evaporation from cooling towers). Several methods maybe equally valid and accurate to quantify consumptive uses within the basin or management areas of the basin, described in more detail below.

Remote Sensing

Remote sensing technology uses thermal imagery to estimate evapotranspiration (ET) occurring on the land surface. Theoretically, if calibrated and processed properly, the imagery could capture all ET in the basin or in smaller management areas, including agricultural, native vegetation, urban land use types, water bodies, and soil moisture on undeveloped land.

An example of the remote sensing technology is Cal Poly's Irrigation Training and Research Center (ITRC) satellite imagery, for which the KGA currently has one year of basin-wide ET data. ITRC imagery has been used in scientific research to determine spatial computation of actual ET at 30 meter resolution. The ITRC Mapping EvapoTranspiration at high Resolution with Internal Calibration (METRIC) ET outputs can account for alternative cropping management, plant vigor, bare spots, and plant stress, along with other factors that will impact water consumption (Howes, 2014).

It is not yet fully understood what limitations or accuracy issues may exist with ITRC's (or similar) datasets for the Kern Subbasin. The ITRC ET information can be compared with site visits and other information such as department of agriculture information to identify which areas are irrigated. If the basin can collectively vet and agree upon a remote sensing technology to use basin-wide, it may serve as one of the lowest cost and consistent options, that will allow ET to be estimated at a district (GSP Chapter) level and also combined to estimate subbasin wide water use.

It is anticipated that for areas of the basin where remote sensing data is not used or is found to be inaccurate, one of the other methods described below would be used.

Crop Surveys

Crop Surveys are surveys performed to determine ET by field. Crop surveys typically involve field surveys to identify which crops are growing in which fields. Each crop's ET is estimated using DWR

Standards or FAO5G standards. The ET for each crop is then multiplied by the size of each field and summed up for the area being evaluated.

Municipal & Industrial Water Balance

For land use types where remote sensing data may be less accurate (such as M&I), a "water balance" approach may be used to determine consumptive use, relying on metered water delivery data. Municipal consumptive use for a given water system can be calculated by identifying the amount of water entering the distribution/delivery system and subtracting return flows to the basin, such as wastewater flows. Additional consumptive uses may need to be adjusted for, such as treated wastewater effluent that is then applied to landscape or crop irrigation. For water deliveries with no return flow component (i.e. evaporative cooling towers), metered water deliveries can be used.

Sub-Surface Outflows

Sub-surface outflows occur between basins when the groundwater elevation gradient is such that groundwater moves from the basin to an adjacent basin (such as may occur at the northern boundary line of the Kern Subbasin).

To calculate groundwater outflows between subbasins, this white paper proposes using a groundwater model (C2VSIM, CVHM or other). The model information will be evaluated and compared with groundwater gradients and aquifer parameters. Aquifer parameters would be identified from existing aquifer tests near the subbasin boundaries. The model used would need to be verified and evaluated, as the existing models have not been evaluated for this purpose.

Water Exports

Occasionally water is exported from the basin. A number of groundwater banks exist within the basin, and some have been developed with banking partners located outside of the basin. Significant amounts of this banked water can be pumped out of the basin and into the California Aqueduct. In addition, during extreme flood events Kern River water can be pumped into the CA Aqueduct. Exports from the basin will be accounted for with flow meter records.

Reporting of Total Water Use Data

SGMA requires annual reporting of groundwater elevation data, groundwater extraction, surface water use, total water use, and change in groundwater storage. Total water use data can be calculated annually by using remote sensing data, crop surveys, metered deliveries, and modeled sub-surface outflows.

Quality Control and Assurance

Additional research is probably merited to evaluate the accuracy of, and to calibrate, remote sensing tools. Crop coefficient and remote sensing methods can be validated by checking against each other and against actual water delivery data.

Total water use data can also be compared to data collected during the investigation of change in groundwater storage and surface water deliveries. Trends in calculated basin-wide water balance should mirror trends in actual groundwater levels.

References

Howes, D. J. 2014. Evaluating *Net Groundwater Use from Remotely Sensed Evapotranspiration and Water Delivery Information*. IA Irrigation Show, Nov. 17-21, 2014, ITRC Paper No. P 14-005.