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subject: 2001-2005 Water Use in Selected Areas of the Gila-San Francisco Basin

This memo outlines the response of your inquiry regarding consumptive water use in selected Gila regions of the Gila-San Francisco basin. The data presented herein are a combination of historical survey and model estimations. During summer and fall of 2006, Sandia National Laboratories had obtained, copied, and compiled historical records from the OSE office in support of construction of the GSF Decision Support Tool. One of key objectives for creating the GSF Decision Support Tool is to provide water use information in the four-county region impacted by the 2004 Arizona Water Settlement Act. These data are used in projecting water demands into the future. The GSF Decision Support Tool has been developed through a collaborative modeling process between 2005 and 2008 and funded by the Department of Energy. It is to my knowledge that no other entities to date have made a similar effort at a temporal granularity comparable to the one taken here. As such, Sandia has disclosed all the raw data supporting the development of GSF Decision Support Tool to those who need the data.

Agriculture Consumptive Use by OSE Hydrographic Survey and Diversion Rights

Table 1 shows the historical acreage in three OSE hydrographic regions: Upper Gila, Cliff-Gila, Redrock, and the Virden Valley. The average irrigated acreage recorded are 72, 1,021, 223, and 2,285 acres, while the diversion rights are 2.40, 2.90, 2.90, and 6.00 acre-ft/acre/yr respectively. This yields an average consumptive use (CU) of 173, 2,960, 647, and 13,710 acre-ft/yr in those areas.

Table -1 Consumptive Use based on Hydrographic Survey Acreage multiplied by the Diversion Rights in the Cliff-Gila, Redrock, and Virden Valley areas.

| Total survey acreage (acres) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
|--|--------|--------|--------|--------|--------|--------|----------------|
| Upper Gila above Gila gauge | 65 | 75 | 75 | 103 | 58 | 56 | 72 |
| Cliff-Gila | 938 | 974 | 1,001 | 1,004 | 1,178 | 1,029 | 1,021 |
| Redrock | 212 | 203 | 238 | 191 | 269 | 225 | 223 |
| Virden to State Line | 2,167 | 2,149 | 1,921 | 2,261 | 3,124 | 2,087 | 2,285 |
| CU based on Acreage*Diversion Rights (AF/yr) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
| Upper Gila above Gila gauge | 156 | 179 | 179 | 248 | 139 | 134 | 173 |
| Cliff-Gila | 2,721 | 2,823 | 2,902 | 2,913 | 3,415 | 2,985 | 2,960 |
| Redrock | 613 | 588 | 691 | 555 | 781 | 652 | 647 |
| Virden to State Line | 13,005 | 12,896 | 11,527 | 13,567 | 18,742 | 12,522 | 13,710 |

Agriculture Consumptive Use Calculated by GSF Decision Support Tool

Of the total consumptive use, it is uncertain the breakdown between surface water and groundwater. Table 2 shows the consumptive use breakdown calculated by the GSF Decision Support Tool. The surface water consumptive use is based on a number of assumptions.

- Daily river flow as measured by the Gila, Redrock, and Virden gauges.
- Ditch flow as a function of gauged river flow.
- Assumed ditch dimensions and efficiencies.
- Assumed open water evaporation in the ditch.

The groundwater consumptive use is based on the volumetric difference between the amount of crop evapotranspiration and estimated surface water consumptive use. The assumptions associated with this calculations are listed below.

- Irrigated crops are defined by the breakdown from 2005 OSE’s hydrographic survey.
- Evapotranspiration is calculated for each crop type using Hargreaves equation along with daily minimum and maximum temperatures.
- Historical hydrographic survey acreage as shown in Table 1.

Table 2 - Agriculture Consumptive Use split between surface water and groundwater calculated by the GSF Decision Support Tool.

| SW CU based GSF Decision Support Tool (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
|--|-------|-------|-------|-------|-------|-------|----------------|
| Upper Gila above Gila gauge | 71 | 81 | 81 | 112 | 63 | 61 | 78 |
| Cliff-Gila | 1,502 | 1,558 | 1,590 | 1,606 | 1,878 | 1,640 | 1,629 |
| Redrock | 358 | 342 | 403 | 323 | 449 | 378 | 376 |
| Viriden to SL | 2,213 | 3,369 | 2,294 | 1,968 | 3,032 | 3,516 | 2,732 |
| GW CU based on GSF Decision Support Tool (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
| Upper Gila above Gila gauge | 109 | 123 | 130 | 166 | 100 | 96 | 121 |
| Cliff-Gila | 962 | 983 | 1,107 | 981 | 1,285 | 1,112 | 1,072 |
| Redrock | 242 | 229 | 294 | 225 | 330 | 266 | 264 |
| Viriden to State Line | 3,674 | 2,473 | 3,057 | 4,210 | 3,132 | 2,170 | 3,119 |
| Total CU based on GSF Decision Support Tool (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
| Upper Gila above Gila gauge | 180 | 205 | 211 | 279 | 163 | 156 | 199 |
| Cliff-Gila | 2,464 | 2,541 | 2,697 | 2,587 | 3,163 | 2,752 | 2,701 |
| Redrock | 600 | 571 | 697 | 548 | 779 | 645 | 640 |
| Viriden to State Line | 5,886 | 5,842 | 5,351 | 6,178 | 6,165 | 5,686 | 5,851 |

Note that the sum of surface water and groundwater consumptive use as estimated by the GSF Decision Support Tool in the Cliff-Gila and Redrock areas based on the tool are within 10% of values estimated by multiplying historical agriculture acreage by their corresponding diversion rights. However, the consumptive use estimated in the Viriden Valley using crop evapotranspiration is well below the numbers in Table 1. This points to an uncertainty of groundwater pumping specific to the Viriden Valley.

Calculated Evapotranspiration of Riparian Vegetation by GSF Decision Support Tool

Table 3 shows the estimated riparian acreage breakdown in the Upper Gila, Cliff-Gila, Redrock, and Virden Valley areas. These are again used in conjunction with the Hargreaves equation to estimate the amount of fluvial groundwater consumed in the region.

Table 3 – Riparian Vegetation Water Use calculated by GSF Decision Support Tool

(a)

| 2004 Riparian Vegetation (acres) | Bosque | Cottonwood |
|----------------------------------|--------|------------|
| Upper Gila above Gila gauge | 942 | 347 |
| Cliff-Gila | 163 | 1,947 |
| Redrock | 122 | 998 |
| Virden to State Line | 232 | 403 |

(b)

| Riparian Vegetation (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
|-----------------------------|-------|-------|-------|-------|-------|-------|----------------|
| Upper Gila above Gila gauge | 2,214 | 2,191 | 2,266 | 2,171 | 2,118 | 2,186 | 2,191 |
| Cliff-Gila | 2,044 | 2,056 | 2,092 | 1,942 | 2,170 | 2,142 | 2,074 |
| Redrock | 1,113 | 1,110 | 1,142 | 1,092 | 1,166 | 1,146 | 1,128 |
| Virden to State Line | 780 | 785 | 802 | 774 | 789 | 777 | 784 |

Non-irrigated Diversion based on OSE Hydrographic Survey Reports

Table 4 shows the non-irrigated diversion based on annual historical non-Agriculture reports provided by the OSE office.

Table 4 – Non-irrigation Diversion in selected areas of the Gila-San Francisco Basin

| Non-Irrigated Diversion (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
|--------------------------------------|-------|-------|-------|-------|-------|-------|----------------|
| Industrial & Mine Operation | 3,374 | 3,233 | 3,886 | 3,717 | 2,711 | 3,574 | 3,416 |
| Franks Well Field | 1,034 | 644 | 732 | 462 | 516 | 355 | 624 |
| Non-Irrigated Diversion - Other (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
| Upper Gila above Gila gauge | 15 | 16 | 14 | 11 | 15 | 24 | 16 |
| Cliff-Gila | 84 | 76 | 66 | 81 | 78 | 95 | 80 |
| Redrock | 0 | 3 | 1 | 12 | 20 | 16 | 9 |
| Virden to State Line | 35 | 17 | 20 | 20 | 17 | 17 | 21 |

Non-irrigated Consumptive Use Calculated by GSF Decision Support Tool

Table 5 indicates the total non-irrigated consumptive use estimated by the GSF Decision Support Tool. The breakdown is defined by sector spanning the area including the three most relevant in the Gila basin up to the state boundary. The amount estimated by the GSF Decision Support Tool include the following assumptions.

- *Livestock* –Cattle population is based on USDA’s cattle statistics in the four county region dating back to 1975. Cattle consumptive use is currently set at 25 gallons/day/head. The distribution of surface water and groundwater consumptive use is defaulted at 50%.
- *Mining* – OSE’s monthly records submitted by Phelps Dodge are used to simulate daily Bill Evans water consumptive for mining operations.
- *Population* – Projections of population in the four county area is estimated based on Bureau of Business & Economic Research (<http://www.unm.edu/~bber/>) and the US Census bureau (<http://www.census.gov/>).
- *Population: Silver City & Surrounding Municipalities* – Because of its presence, the Silver City water demand from population is further refined in the model. The model defaults to 7,066 households for the region increasing at a rate of 0.22 households/day. Per capita use within the distribution system is defaulted to 140 gal/day/person. The model defines 2.5 person per household for this region. It is assumed that each “hookup” is equivalent to a “household”.
- *Domestic Non-Consumptive Water Rights* – The model assumes 0.6 AF/year/household consumptive use for each rural household in the four-county region. The rural households are defined by the difference of county population and city population divided by 2.5 person/household. In addition, each household is assumed to own a single DNC well.
- *Adjudicated Domestic & Stockwell Water Rights* – The model assumes a 50% utilization rate of each of the water right (3 AF/yr/well).

Table 5 – Non-irrigated groundwater consumptive use calculated by the GSF Decision Support Tool.

| Gila Non-irrigated GW CU based on GSF Decision Support Tool (AF) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Avg, 2000-2005 |
|--|-------|-------|-------|-------|-------|-------|----------------|
| Domestic | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Domestic Non-CU | 241 | 240 | 241 | 242 | 282 | 306 | 259 |
| Municipality | 827 | 799 | 752 | 730 | 713 | 699 | 753 |
| Commercial | 93 | 93 | 93 | 93 | 93 | 93 | 93 |
| Mining | 2,715 | 1,990 | 3,184 | 3,024 | 2,117 | 3,125 | 2,692 |
| Livestock | 448 | 410 | 398 | 299 | 393 | 404 | 392 |

Phelps Dodge Tyrone Mining Maximum Annual and 10-yr Water Rights

Table 6 summarizes the mining water rights licensed by Phelps Dodge to operate in Tyrone Mines. Licensed water rights are assessed at a yearly and a cumulative level. The annual combined surface water and groundwater water rights cannot exceed over 13,824 AF/yr. Of that amount, it is limited to 7,634 for mining use only. The cumulative sum over ten years cannot exceed 117,911 AF for total consumptive use and out of that sum, 65,815 is for mining.

Table 6 – Phelps Dodge Tyrone water rights for consumptive use in the Gila basin. Licensed record dated in November 2000.

| | | |
|--|---------|----------|
| Annual maximum for Mining | 7,634 | AF/yr |
| Annual maximum CU (SW and GW) | 13,824 | AF/yr |
| 10-yr cumulative sum for Mining | 65,817 | AF/10 yr |
| 10-yr cumulative sum CU (SW and GW) | 117,911 | AF/10 yr |

References

OSE Annual Irrigated Acreage Report, 1979 to 2005.

USGS NWIS Web Water Data - <http://water.usgs.gov/> - Stream gauge and water well information.

New Mexico Office of the State Engineer WATERS database
<http://iwaters.ose.state.nm.us:7001/iWATERS/>.

New Mexico Office of the State Engineer website http://www.ose.state.nm.us/PDF/Maps/underground_water.pdf

New Mexico State University – New Mexico Crop Information
<http://weather.nmsu.edu/nmcrops>

National Climatic Data Center - <http://www.ncdc.noaa.gov/oa/ncdc.html> - temperature information for evapotranspiration analysis

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