APPENDIX A

SCOPE OF WORK

MOJAVE RIVER TRANSITION ZONE RECHARGE PROJECT

PHASE II

Phase II
Assessment of Current Supply and Demand, and Projection of Future Demand

This Phase will focus on two principal study aspects: (1) compiling basic water supply and demand information to determine the magnitude of the current imbalance between the available water supply and demand for water within the Transition Zone, and (2) preparing projections of future water demand specific to the area. Portions of Phase II may be conducted concurrently with Phase I, but will require completion of the following specific tasks:

Task II-1.

Review the current RWMP, MWA technical documents, USGS technical reports, and the Judgment to summarize the current status of water management in the Transition Zone, including programs, policies, infrastructure, and institutional configurations affecting water use and disposal there.

Approach to Task II-1

Task II-1. URS will review the pertinent documents and summarize the current status of water management in the Transition Zone. As part of this work, we will contact Ms. Valerie Wiegenstein, the Watermaster, and her consultant engineer, Mr. Robert Wagner, to collect additional information as needed. Some of this work may be completed as part of the data collection and review activities for Task I-1.

TASK II-2. Assemble and organize all relevant data and information. This Task will include the following subtasks:

Task II-2 (a).

Recent ground water level and ground water production data will be provided to Consultant for review. Consultant will augment data provided as may be necessary;

Approach to Task II-2(a)

URS will review the recent groundwater level and production data provided by MWA. Based on the review, we will augment data as necessary to develop a more comprehensive picture of water level conditions in the Transition Zone. At this time, we do not anticipate collecting additional water level data in the field. Augmentation is assumed to include additional review of MWA available data, or contact with other water users in the area that may have collected water level information. If other water users in the area are contacted for this task, the work will be combined with Tasks II-2(b) and II-2(c).

Task II-2 (b).

Identify existing municipal, industrial, domestic, and agricultural water users within the Transition Zone, and determine their current and projected water supply needs. Projections will be presented in 5-year increments through the Year 2020.

Approach to Task II-2(b)

As part of the work performed in Phase I, URS will have identified many of the existing municipal, industrial, domestic, and agricultural water users in the Transition Zone area. We will review Watermaster reports and records as needed to collect additional water use information. Once the users and their historic uses have been identified, we will develop projections of future water use. The projections will also incorporate information from planning documents for the area that indicate future population growth, and projected changes in land use. As part of this task, we will contact the VVWRA to better understand their future plans and discharges to the Transition Zone.

The water use projections will be made for five-year increments and will be for the years 2005, 2010, 2015, and 2020. We will summarize the projections in table form and review them with MWA before finalizing them.

Task II-2 (c).

Consult with water purveyors and individual water users to determine their future water supply plans and estimate their potential impact to the Transition Zone.

Approach to Task II-2(c)

Some of the work for this task will be included in Task II-2(b). As URS contacts the various water users and purveyors to determine their current and projected water supply needs, we will discuss with them their plans for meeting their needs, including continued reliance on municipal supplies, drilling their own wells, etc.

Based on the results of the Phase I tasks and Tasks II-1, II-2(a), II-2(b), URS will estimate the potential impact of future water uses on the Transition Zone. The impact will be evaluated by using the water budget established in Phase I studies and applying the projected extractions and artificial recharge to the Transition Zone. The overall imbalance in the water budget will be estimated for each of the five-year water use projections. The imbalance is expected to result in various types of potential impacts to the Transition Zone area including:

- changes in seasonal and long-term surface water flows;
- changes in groundwater underflows;
- changes in the amount of groundwater in storage; and
- secondary impacts to the environment as the result of surface water and groundwater flow changes.

During our evaluation of potential impacts, we will consult with MWA regarding our findings and conclusions and incorporate any insights or additional information provide by MWA.

Task II-2 (d).

Consult with the Mojave Basin Area Watermaster to determine the specific functions of the Judgment that are relevant to water demand in the Transition Zone and to determine the future potential for imported water demand there resulting from implementation of the Judgment.

Approach to Task II-2(d)

URS will consult with Ms. Valerie Wiegenstein, the Watermaster, to determine the specific functions of the Judgment that are relevant to water demand in the Transition Zone. A significant part of this work may be accomplished as part of Task I-10, the determination of the annual water supply of the Transition Zone as defined by the Judgment. We will determine how implementation of the Judgment relates to the future water demand in the area. For example, we will determine whether or not the Judgment:

- Constrains the amount or location of pumping;
- Constrains the use of imported water in any way;
- Affects the amount of water imported or its cost (i.e. creates a market for imported water); and/or
- Affects the recharge of treated wastewater in the Transition Zone.

URS will also preliminarily evaluate the viability of a recharge project in the Transition Zone as part of this task. This preliminary evaluation is a very important part of the project, as it combines the results of Phase I and Phase II studies to reach conclusions about the viability of artificial recharge projects in the Transition Zone. We will consider the findings of the Phase I studies, which relate to the baseline hydrogeology of the Transition Zone, and what physical locations might be suitable for a recharge project, along with the results of the Phase II studies that consider future projected water demand and the effects of the Judgment on artificial recharge in the Transition Zone. The results of this evaluation will be discussed with MWA and presented in the Phase II report described in Task II-3.

Task II-2 (e).

Prepare accumulated data in a format acceptable to MWA, including electronic copy.

Approach to Task II-2(e)

The data collected for this report will be incorporated into a format acceptable to MWA. URS will consult with MWA at the start of the project (i.e. with Task I-1) to determine MWA's preference for a database for the project. As the data are collected and developed, they will be selected and placed in the correct format for future MWA use. Overall, the database will give MWA a method to manipulate the data and prepare future graphics or statistical analyses to provide insights to the Transition Zone hydrogeology and water issues.

TASK II-3.

Present MWA with a Phase II summary report. The report shall summarize the results of Tasks II-1 and II-2 above, and present findings and recommendations regarding the viability of a recharge project within the Transition Zone considering supply, demand, generalized geohydrologic conditions, and a potential market for imported water. Ten (10) copies of the summary report shall be provided. An electronic copy (Adobe format) of the final draft shall be provided, in addition to individual electronic files for all figures or graphics.

Approach to Task II-3

URS will prepare a summary report that will summarize the work performed and will present findings and recommendations regarding the viability of a recharge project within the Transition Zone. Similar to the Phase I report, URS will prepare a report outline early in the project, as the components of the report become apparent. We will submit the outline to MWA for review and approval. Once the outline is agreed upon, work on the report will begin.

URS will provide MWA with three copies of a Draft Phase II Summary Report. Following MWA review, we will address all written MWA comments and revise the report as necessary. Ten hard copies of the Final Summary Report will be provided, in addition to an Adobe format electronic copy, and electronic files for all figures and graphics.

APPENDIX B

PHASE I SOURCES AND SINKS

AND WATER BUDGET

SOURCES AND SINKS

The inflow (sources) and outflow (sinks) of surface water and groundwater within the TZ are identified for the purpose of understanding the dynamics of the TZ and to develop a water budget. A balanced water budget will give an indication of basin surplus or overdraft and verify the magnitude of budget components. The water budget was prepared to show recent conditions. Past studies have generally been conducted to identify, characterize, and manage water resources in the Mojave River Basin as a whole or by subarea. Although few studies provide data specific to the TZ, several address specific water resources of the entire Alto Subarea from which TZ specific data can be gleaned. The following are significant reports having TZ-specific data that were used in identifying sources and sinks:

- Albert A. Webb Associates, 2000, *Consumptive Water Use Study and Update of Production Safe Yield Calculations for the Mojave Basin Area* (Webb, 2000),
- USGS, 2001a, S*imulation of Groundwater Flow in the Mojave River Basin, California*,
- USGS, 1996c, *Riparian Vegetation and its Water Use During 1995 Along the Mojave River, Southern California*, and
- *Annual Report of the Mojave Basin Area Watermaster* (MWA Watermaster, 1995-2001).

Inflow and Outflow components of the TZ-specific water budget assembled as part of the current evaluation are described in the following paragraphs. Values tabulated in this water budget are summarized in Table 3 [of the Phase I report].

SURFACE WATER INFLOW

Surface water inflow to the TZ comes from the following sources: Mojave River base flow, Mojave River storm flow, VVWRA discharge, precipitation, ungaged tributaries and pumped water return flows. Currently, VVWRA discharge is the only imported water released in the TZ.

Mojave River Base Flow and Storm Flow

At the Lower Narrows, USGS records daily total flow values of the Mojave River as it enters the TZ. Total stream flow consists of combined base flow and storm flow. Each year, the Office of the Mojave Basin Area Watermaster separates, or “scalps”, the storm flow value from the total flow value, resulting in a base flow value. The scalping method is set forth in Exhibit C of the Judgment. Historical base flow and storm flow at the Lower Narrows are shown in Figure 15 [Figure 3 of the Phase II report]. As described in the following paragraphs, the Mojave River base flow and storm flow values used in the TZ water budget are 8,142 AF and 33,107 AF, respectively.

The 8,142 AF base flow value used in the water budget is the average of base flow values for the 1991 through 2001 Water Years. Although the Watermaster has calculated base

flow and storm flow values for the 1931 through 2001 Water Years, a longer term average was not used because the recorded base flows at the Lower Narrows have decreased significantly since about 1950. Consequently, the average base flow value for the entire period of record is higher than would be expected of an average year under current conditions. The period 1991 to 2001 better reflects groundwater conditions immediately prior to, and following the Judgment.

The 33,107 AF storm flow value used in the water budget is the average of storm flow values for the 1931 through 2001 Water Years, the entire period of record for data provided by the Watermaster. An average of scalped storm flows for the entire period of record is used because storm flow is related more closely to precipitation than groundwater use. No long-term climatic trends have been documented which would preclude long-term precipitation and corresponding storm flows from being representative of current average conditions.

River Gain / Loss

The Mojave River is an intermittent river flowing through one of the more arid regions of Southern California. Perennial water occurs only in a few locations where it is forced to the surface by shallow bedrock such as the Mojave Narrows. A stream gage exists at the Lower Narrows, the upstream limit of the TZ, but no gage exists in the Helendale fault area, the downstream limit of the TZ. With no surface water flow data for the Helendale fault area, the amount of surface flow leaving the TZ must be estimated. Webb (2000) estimated surface water flow across the Helendale fault and did not suggest any increase in base flow relative to base flow recorded at the Lower Narrows gage. None of stream gages on the Mojave River have recorded increases in flow relative to the next upstream gage.

If the Mojave River were to gain base flow within the TZ, it would be accounted for in the total surface water outflow at the Helendale fault. However, since there is not perennial flow at the Helendale fault, any river gain must be lost again to evaporation, riparian transpiration, or infiltration to groundwater. The river gain/loss is estimated at 0 AFY.

Reclaimed Water

Within the TZ, VVWRA operates a wastewater treatment plant located on the west bank of the Mojave River channel about half a mile north of the former George AFB. Most of the wastewater treated at the VVWRA plant originates from cities outside the TZ (Hesperia, Victorville and Apple Valley). The VVWRA plant discharges secondary treated effluent to percolation ponds and tertiary treated effluent to the Mojave River channel. Although the treated wastewater is discharged to ponds and to the river, it percolates prior to reaching the downstream limit of the TZ, VVWRA discharge is included as a surface water source in the water budget because it originates as surface discharges.

The total VVWRA surface water discharge to the TZ averages approximately 8,659 AFY (MWA Watermaster, 1994 through 2000). Approximately 6.4 million gallons per day (mgd) or 7,177 AFY of tertiary effluent are discharged to the Mojave River channel. Approximately 1.5 mgd or 1,680 AFY of secondary effluent are discharged through percolation ponds that have a combined surface area of approximately 52 acres. The standard practice of VVWRA is to rotate discharge of reclaimed wastewater to about half the pond area, ideally allowing the other half to dry between discharge cycles. As discussed in the following paragraphs, the contribution of VVWRA discharge is adjusted for evaporation losses and precipitation gains, for the purposes of the water budget.

The 1994 to 2001 period for VVWRA discharge was chosen for the water budget as it reflects the period tabulated by the Watermaster and corresponds to the period of verified groundwater production. Future increases or decreases in VVWRA discharge will add to or subtract from future TZ water budgets, accordingly. Total discharge from VVWRA has increased an average of 219 AFY between 1994 and 2001. Discharge from VVWRA is expected to increase in the future, as most new construction will be connected to the sewer system rather than septic systems. The anticipated increase in discharge from VVWRA, after correction for evaporation and precipitation, can be applied directly toward the groundwater component of future TZ water budgets.

Precipitation

The Mojave River Basin receives a relatively small volume of precipitation and much of what is received is lost to evaporation or transpiration. With the exception of surface runoff, direct precipitation does not recharge groundwater under normal conditions USGS (1996c). Long-term precipitation data (1939 through 2001) indicate that an average of 5.61 inches falls at the Victorville Pumping Plant (NOAA, 2002). The Victorville Pumping Plant is located approximately 3 miles upstream from the Lower Narrows and half a mile west of the Mojave River channel.

Despite the large losses of precipitation to evaporation, precipitation falling on open water bodies is assumed to add to the water budget through direct percolation or percolation of runoff. Three major surface water bodies that exist in the TZ are the lakes at Silver Lakes, the VVWRA percolation ponds, and areas of perennial flow in the Mojave River channel. As described in the following paragraph, the TZ water budget contribution from precipitation falling on open bodies of water is approximately 96 AFY.

Silver Lakes are lined and groundwater pumped to fill them is assumed to represent a sink (outflow) from the water budget. Consequently, precipitation falling on the Silver Lakes does not enter into the water budget. During operation, the VVWRA percolation ponds as described above provide approximately 26 acres of surface water area. Based on this area and average rainfall, direct precipitation on these ponds contributes approximately 12 AFY to the TZ water budget. Although the Mojave River is dry for much of its length, several areas of the river in the TZ have perennial surface water. USGS (1996c) estimated that approximately 200 acres of surface water occur in the TZ and of that area about 10 percent (20 acres) is heavily vegetated, leaving 180 acres of open surface water. Based on this area and average rainfall, direct precipitation on areas

of perennial surface water contributes approximately 84 AFY to the TZ water budget. This estimate assumes that direct rainfall on the open bodies of water in the Mojave River channel during periods of storm flow are not accumulated with the storm flow and removed from the TZ as surface flow.

Ungaged Tributaries

Several ephemeral washes contribute surface water flow to the TZ. Webb (2000) used USGS (1996a) data to estimate that approximately 320 AFY of surface water flow are contributed to the TZ by ungaged tributaries from the upper Alto Subarea. As these flows originate from storm events, it is assumed for the TZ water budget that none of these flows are lost to evaporation and that 100 percent is recharged either in the tributary or in the Mojave River.

Pumped Water Return Flow

Water pumped from the TZ will be consumed by evaporation to the atmosphere, transpiration by vegetation, by people and animals, or return to groundwater as infiltration. Return flows occur through infiltration of irrigation and septic system water. USGS (1971) assumes 40 to 45 percent return flows from total pumping and 55 to 60 percent return flows from water pumped for irrigation. USGS (2001a) assumes that improvements to irrigation techniques since 1971 have reduced irrigation return flows to approximately 46 percent. The Silver Lake Association maintains two large lakes near Helendale in the lower TZ for recreational and aesthetic purposes. The infiltration from the lakes is not listed in the water budget because the lakes are lined.

Webb (2000) performed a detailed consumptive use study of the Mojave Basin Area based on the 1996-97 Water Year. A maximum irrigation consumptive use of 65 percent (35 percent return) was assumed when groundwater production exceeded crop requirements. Otherwise, irrigation consumption was assumed to be equal to the crop-specific consumptive use values. A 50 percent consumption (50 percent return) value was assumed for domestic and municipal production and 100 percent consumption (no return) for industrial processes. Based on these consumption and return numbers, Webb (2000), calculated a TZ consumptive use value of 10,390 AF for the 1996-97 Water Year. This is equal to approximately 60 percent of the total verified production in the TZ for the 1996-97 Water Year of 17,199 AF. The Webb (2000) calculations result in an average return flow of 40 percent on all of the groundwater production within the TZ. The annual pumping return flow value used in the water budget represents a 40 percent return flow of the total 1994 through 2001 TZ pumping as reported by the Watermaster (2001).

GROUNDWATER INFLOW

Groundwater inflow across the southern TZ boundary occurs in the Regional aquifer. Webb (2000) used 1998 USGS water level and transmissivity data to calculate that 4,590 AFY of groundwater flow across three linear segments of southern TZ boundary. Groundwater flowing across the southern TZ boundary originates in the upper Alto Subarea. Groundwater flow across the southern boundary of the TZ is affected by faults,

which occur directly south of the former George AFB and Adelanto. These faults, the Adelanto and Shadow Mountains, trend northeast to southwest, and northwest to southwest, respectively. The faults likely constitute partial barriers to groundwater flow, resulting in the steep groundwater gradient south of the former George AFB. Groundwater must flow across these partial hydraulic barriers prior to entering the TZ. These barriers are significant in that they limit the natural flow of groundwater into the TZ. Because of these faults, groundwater management practices that affect the Regional aquifer in the upper Alto Subarea up gradient of the TZ may have limited impacts on Regional aquifer groundwater conditions in the TZ. The Judgment assumes 2,000 AFY of groundwater inflow into the TZ.

The gradient used by Webb (2000) to estimate groundwater flow across the southern TZ boundary, may change as groundwater pumping from the Regional aquifer changes in the Adelanto area. However, no significant long-term change in groundwater inflow to the TZ would likely occur due to the groundwater flow barriers directly south of the southern TZ boundary.

Webb (2000) also calculated flow from the Oeste Subarea to the TZ and found that no appreciable groundwater flows between the Oeste Subarea and the TZ. Low groundwater gradients between the Oeste Subarea and the western TZ combined with groundwater use characteristics of these areas preclude any significant flow contribution to the regional aquifer of the TZ.

Under the current evaluation, URS estimated subsurface flow into the southern TZ by means of Darcy's Law, using published transmissivity values and 1998 water levels. The water levels were contoured specifically for the TZ evaluation using an updated conceptual understanding of the TZ hydrogeology. The calculations indicate that values determined by Webb (2000), USGS (2001a) and URS are essentially equivalent given existing parameter variability. A summary of the three subsurface flow estimates is presented in Appendix H [of the Phase I report]. Of the three values, the value determined by URS (4,900 AFY) for subsurface flow into the southern TZ was used for the current TZ evaluation.

SURFACE WATER OUTFLOW

Surface water outflows from the TZ include evaporation, riparian transpiration, and surface flow across the Helendale fault.

Evaporation

Free surface water evaporation in the TZ is limited by the scarcity of open bodies of water. As described previously for Precipitation Inflow, three major water bodies occur in the TZ, Silver Lakes, VVWRA percolation ponds, and areas of perennial flow in the Mojave River channel. Water pumped to fill Silver Lakes is excluded from the calculation of evaporation loss because water used to fill these lined lakes is counted as an outflow from the system as pumped groundwater. Additional outflow of that water due to evaporation is not necessary as the water is already out of the budget.

USGS (1996c) states that evaporation along the Mojave River in the Alto Subarea ranges from 60 to 75 inches per year. Evaporation outflow from the water budget is estimated at 1,159 AFY by applying the midpoint of this range, 67.5 inches, to the surface area of the remaining two surface water bodies (206 acres).

Transpiration

In the TZ, xerophytes, irrigated crops, landscape vegetation, and phreatophytes remove significant amounts of water from the system through transpiration. Although a significant portion of the TZ is vegetated only with xerophytes (e.g. creosote), transpiration from xerophytes is accounted for by the exclusion of the limited precipitation falling on those areas from the water budget. The water budget only accounts for direct transpiration from crops, landscape vegetation, and phreatophytes.

Webb (2000) estimated transpiration from crops by performing a detailed consumptive use study that sought to establish the amount of surface water flowing across the Helendale fault. The consumptive use value determined by Webb was compared to the total pumping reported by the Watermaster for the TZ for that water year, and a gross percentage value for return flow was obtained, as described above under the Pumped Water Return Flow heading. Water pumped for irrigation of crops and landscape vegetation that is not part of the consumptive use of the crop is accounted for as a return flow of total pumping. Consequently, no additional crop specific or plant specific transpiration accounting is made under the current evaluation.

USGS (1996c) conducted a detailed study of riparian water use in the TZ that included a detailed accounting of the acreage vegetated by specific riparian flora. This acreage was multiplied by established, plant specific, transpiration values to determine the amount of water lost to transpiration in the TZ. The study resulted in an estimate of 6,000 AFY of water lost to transpiration by riparian vegetation. Because transpiration by crops and landscape vegetation is accounted for as described above, riparian transpiration as estimated by USGS (1996c) is the only transpiration itemized as such in the water budget. USGS (1996c) estimated 6,000 AFY consumed by riparian transpiration in the TZ.

River Losses / Groundwater Gain

As described previously, the Mojave River is an intermittent river with perennial water occurring in only a few locations where it is forced to the surface by shallow bedrock and an incised channel. Except during storm flow, surface flows do not generally occur in the Mojave River at the Helendale fault, the northern TZ boundary. Because of the lack of surface water flow, no stream gage exists in the Helendale fault area, and without surface water flow data in the Helendale fault area, the amount of flow crossing the fault and leaving the TZ can only be estimated.

Webb (2000) estimated surface water flow across the Helendale fault as described below and suggested that ungaged surface flow across the fault is less than gaged surface water

inflow at the Lower Narrows. From the Webb (2000) estimate of surface water flow across the Helendale fault, it is evident that the Mojave River base flow decreases significantly within the TZ. Decreases in base flow are due to surface water evaporation, plant transpiration, and infiltration to groundwater. Infiltration occurs to replace groundwater removed by a combination of pumping, evapotranspiration, and subsurface groundwater outflow across the Helendale fault.

Surface Outflow Across The Helendale Fault

The Helendale fault at the Mojave River is the downstream limit the Alto Subarea and the TZ. Surface water flowing across the fault enters the Centro Subarea. Because the Helendale fault is the boundary between these subareas, an understanding of surface and groundwater water flow across the fault is important to managing water resources within the TZ and between subareas.

Perennial flow does not generally occur in the Mojave River at the Helendale fault. Faulting has not disturbed the Floodplain aquifer enough to create a groundwater flow barrier within that aquifer. Although the Helendale fault does create a partial groundwater barrier in the Regional aquifer, the barrier is not sufficient to produce sustained surface flow across the fault.

Because there is no stream gage station on the Mojave River at or near the Helendale fault surface water flow across the fault can only be estimated. Webb (2000) undertook a detailed accounting of water flux at the fault for the 1996-97 Water Year and estimated surface water flow across the Helendale fault. In the Webb accounting, all measured and estimated sources of water inflow to the TZ were totaled and then all measured consumption of water within the TZ was subtracted. The remaining water was assumed to leave the TZ as surface water flow across the Helendale fault. Webb (2000) estimated that approximately 34,720 AFY of surface flow crosses the fault. This value is equivalent to approximately 105% of the long-term average storm flow for the base period used by Webb (2000). This factor was applied to the long-term average storm flow for the period used in the current evaluation. The resulting surface outflow (34,762 AF) is used in the TZ-specific water budget.

GROUNDWATER OUTFLOW

The only significant groundwater outflow from the TZ occurs across Helendale fault at the northern TZ boundary and to direct groundwater pumping. Groundwater outflow through bedrock areas is considered to be insignificant.

Subsurface Outflows Across The Helendale Fault

The Judgment assumes that 2,000 AFY (Table C-1, Superior Court of the State of California, 1996) of groundwater flow across the Helendale fault from the TZ to the Centro Subarea. This assumption is carried forward based on the results of a Darcian flow solution calculated by DWR and published in Bulletin 84 (DWR, 1967). To calculate this flow solution, DWR used water levels observed on either side of the

Helendale fault, local permeability data and selected a cross sectional area of the Flood Plain aquifer above the Helendale fault.

Gregory Mendez of the USGS (cited as personal communication in (USGS, 2001a) estimated that significantly more than 2,000 AFY of groundwater cross the Helendale fault as subsurface flow. From water levels and hydraulic properties of the Floodplain and Regional aquifers, Mendez (USGS, 2001a) estimated as much as 5,000 to 6,000 AFY of groundwater flows across the Helendale fault in the Floodplain aquifer with a component of 1,200 AFY in the Regional aquifer. The model presented in USGS (2001a) has simulated approximately 1,566 AFY groundwater flow across the Helendale fault under average historical conditions.

Under the current TZ evaluation, URS estimated subsurface flow across the Helendale fault from the northern TZ into the Centro Subarea using Darcy's Law, 1998 groundwater elevations, and published transmissivity values. The estimate performed by URS produced a number closer to that of Mendez reported by USGS (2001a) than that produced by the USGS model (USGS, 2001a). The values determined by Mendez and URS are essentially equivalent given existing parameter variability. The value representing subsurface flow across the Helendale fault as simulated by USGS (2001a) is significantly less than those of Mendez and URS. The difference may be due to the transmissivity values used by each estimate. The difference between Regional aquifer transmissivity values of USGS (1971) and (2001a) shown in Appendix E are significant and may reflect variation used to calibrate the USGS regional flow model. Of these values, the one determined by URS under the Phase I evaluation was selected for use throughout this report because it was estimated using the current understanding of the TZ, and the estimating method is documented in Appendix H. For Subsurface Outflow of groundwater across the Helendale fault, the water budget uses the value of 4,600 AFY based on calculations performed by the current TZ evaluation. As tabulated in Appendix H, approximately two thirds of this outflow occurs in the Floodplain aquifer and one third in the Regional aquifer. Both existing and current subsurface flow estimates are presented in Appendix H [of the Phase I report]. .

Groundwater Production

Groundwater production within the TZ can be estimated for large producers and small producers. The Mojave Water Agency (personal communication, Victor Jackowich, 2002) estimates that there may be as many as 177 minimal groundwater producers (producing less than 10 AFY each) in the TZ. The minimal producers are show on a map in Appendix E [of the Phase I report]. . The majority of the minimal producers, pump for domestic water uses. Average domestic water consumption is typically about 1 AFY. For the purposes of the current evaluation it is assumed that all of the minimal groundwater producers pump 1 AFY for domestic uses. Using this assumption total minimal producer extraction from the TZ is 177 AFY.

The Watermaster has verified groundwater pumping throughout the Mojave Water Agency area beginning in 1994. Verified pumping values, broken down by use category are listed in the water budget. Groundwater production from large producers in the TZ

averaged 14,641 AFY during the 1994 through 2001 Water Years. Annual production during this period is listed by water use category in Table 3 [of the Phase I report]. . The values for municipal water use are slightly lower than values reported by producer in the Watermaster Annual Reports. The Watermaster Annual Reports address the entire Mojave Basin Area and tabulate water production by producer rather than by well location. The City of Adelanto produces water from both the TZ and the upper Alto Subarea. As a result, water production values reported in the Watermaster Annual Reports are greater than the amount produced by the City of Adelanto from within the TZ. Only City of Adelanto production from within the TZ is included in the water budget.

Much of the City of Adelanto groundwater production comes from a well field located in the southern TZ in Section 30 of Township 06N, Range 04W. Between 1996 and 2001, average groundwater production from this well field has been increasing at a rate of approximately 170 AFY. As the City of Adelanto continues to grow, both industrial and residential developments will continue to expand, and in turn will cause demand for City water to grow. For each acre-foot increase in production by the City of Adelanto, approximately 0.60 acre-feet will be removed from the TZ water supply based on assumptions associated with the water budget prepared under the current evaluation. The remaining 0.40 acre-feet returns to the TZ by discharge at VVWRA and deep infiltration of septic systems and irrigation return flow. Septic and irrigation return flow in the Adelanto area occurs to the Regional aquifer. VVWRA discharges occur as surface flow directly to the Mojave River channel and to recharge basins located in the Regional aquifer.

WATER BUDGET

Inflow and outflow components described in the previous paragraphs were compiled into a TZ specific water budget. The TZ water budget is shown in Table 3 [of the Phase I report reproduced at the end of this Appendix]. .

Total inflow to the TZ is determined to be 61,150 AFY in an average year. This value is a sum of; base flow at the Lower Narrows, storm flow at the Lower Narrows, precipitation on open bodies of water, VVWRA discharge to ponds and the river channel, surface flow and infiltration from ungaged tributaries, pumping return flows and subsurface groundwater flow. The assumptions and conditions associated with each of these inflow components have been described in the preceding section.

Total outflow from the TZ is estimated to be 61,336 AFY in an average year, leaving approximately 186 AFY unaccounted for. Total outflow is a sum of; surface water evaporation, riparian transpiration, surface outflow across Helendale fault, subsurface outflow across Helendale fault, municipal, domestic, agricultural, industrial, Silver Lakes Association and minimal producer groundwater production. Domestic groundwater producers are those that pump greater than 10 AFY. Minimal producers pump primarily for domestic uses and produce less than 10 AFY. The difference between total inflow and total outflow, although insignificant compared with the variability of the given data, may be accounted for by a change in storage.

Table 3

Transition Zone Water Budget

Components	Average Year	Subtotal
Sources (Inflow)		61,150 AF
Surface Water		
Mojave River Base Flow at the Lower Narrows	8,142 AF (1)	
Mojave River Stormflow at the Lower Narrows	33,107 AF (2)	
Precipitation	96 AF (3)	
VVWRA Discharge	8,659 AF (4)	
Ungaged Tributaries	320 AF (7)	
Pumping Return Flows	5,926 AF (6)	
Groundwater		
Subsurface Inflows	4,900 AF (5)	
Sinks (Outflow)		61,336 AF
Surface Water		
Evaporation	1,159 AF (9)	
Riparian Transpiration	6,000 AF (10)	
Surface Outflow Across Helendale Fault	34,762 AF (12)	
Groundwater		
Subsurface Outflow Across Helendale Fault	4,600 AF (11)	
Total Pumping	14,815 AF (8)	
Municipal Well Pumping	5,208 AF (8)	
Domestic Well Pumping	99 AF (8)	
Agricultural Pumping	3,819 AF (8)	
Industrial Pumping	2,224 AF (8)	
Silver Lakes Association	3,288 AF (8)	
Minimal Producers (<10 AFY)	177 AF (13)	
Difference		-186 AF

Footnotes are on the following page.

Footnotes to Table 3

1 The base flow value is an average value determined from data provided by the Mojave River Basin Watermaster for Water Years 1991 through 2001. Storm flow and base flow are derived from total flow by the Mojave River Basin Watermaster using the method outlined in Exhibit C of the Judgment After Trial (California Superior Court, 1996). Base flow and Storm flow values at the Lower Narrows are based on total flow measurements taken at the USGS stream gage at the Lower Narrows. For the water budget, a longer period average was not used because the decline in base flow values observed since 1950 would not representing average conditions over the past 10 years. The long term average base flow (1931-2001) is 18,829 AFY.

2 This value is an average of storm flow values reported by the Watermaster for Water Years 1931 through 2001. Base flow and Storm flow values at the Lower Narrows are based on stream flow measurements taken at the USGS stream gage at the Lower Narrows. The determination of storm flow and base flow was made by the Mojave River Basin Watermaster using the method outlined in Exhibit C of the Judgment After Trial (California Superior Court, 1996).

3 Precipitation falling on desert areas, in the dry river channel, and/or in riparian areas is considered lost to evapotranspiration in accordance with assumptions made by the USGS (1996c and 2001a). The value presented reflects direct precipitation on bodies of open water from which recharge can occur. The value presented was estimated by multiplying the average annual precipitation by the area of the open water body. Open bodies of water were determined from USGS (1996c) and personal communication with VVWRA to be approximately 206 acres. NOAA data collected from 1939 through 2001 at the Victorville Pumping Plant, indicate an average precipitation of 5.61 inches per year.

4 The value presented is an average of annual VVWRA discharge for the period tabulated by the Watermaster (1994-2001). This period corresponds to the verified groundwater production data tabulated by the Watermaster. VVWRA annual discharges observed during this period are the highest recorded. Future VVWRA discharges are expected to increase annually.

5 As calculated by URS for this study. Calculations are presented in Appendix H of this report.

6 Return flow value is estimated to be 40 percent of total pumping. USGS (1971) assumes 40 - 45 percent return on total pumping and 55 - 60 percent return on water pumped for irrigation. USGS (2001a) states that improvements to irrigation techniques since 1971 have reduced irrigation return flows to approximately 46 percent. Webb (2000) performed a detailed consumptive use study based on the 1996-97 water year. Webb assumed a maximum irrigation consumptive use of 65 percent when production exceeded crop requirements. Otherwise, Webb applied crop specific consumptive use values to the number of acres under cultivation with each crop. Webb assumed a 50 percent return value for water produced for domestic and municipal use. Webb assumed that 100 percent of water produced for industrial processes in the Transition Zone is consumed.

Based on these calculations and assumptions Webb determined a consumptive use value for the Transition Zone of 10,390 AFY for the 1996-97 Water Year. Total verified production in the Transition Zone for the 1996-97 Water Year was 17,199 AFY. The detailed consumptive use value determined by Webb for the 1996-97 water year is 60.4 percent which leaves a return flow of approximately 40 percent. For the purposes of this study, Pumping Return Flows are assumed to be returns of groundwater pumped from within the Transition Zone and include averaged returns from irrigation and domestic septic systems.

7 The value presented is from Webb (2000). This value for ungaged tributary stream flow in the Transition Zone was determined from data presented in *Groundwater and Surface Water Relations Along the Mojave River, Southern California, USGS (1996a)* . Described in text as occurring at the Transition Zone boundaries. Assumes 100 percent is recharged.

8 The Mojave River Basin Watermaster has tabulated Transition Zone groundwater pumping since 1994. The groundwater production values used in this water balance are average values representing the years 1994-2001.

9 This value reflects an evaporation rate of 67.5 inches per year (USGS 1996c) from 206 acres of free surface water associated with the VVWRA percolation ponds and surface water in the Mojave River Channel. Silver Lakes are not included in this value because the lakes are lined, and water pumped to fill the lakes is considered outflow from the system accounted for by Total Pumping (Footnote 8). Losses associated with agriculture, including evaporation, are accounted for in the estimate of pumping return flow, which is derived in part from agricultural consumptive use (Webb, 2000).

10 The value represents only riparian transpiration as determined by the USGS (1996c). Transpiration from vegetation irrigated in urban areas is accounted for in domestic consumptive use as calculated by Webb (2000). Transpiration from non-irrigated vegetation in urban areas is accounted for by the loss of deep infiltration from direct rainfall, similar transpiration from xerophytes in undeveloped areas as assumed by USGS (1996c). Transpiration losses associated with agriculture are accounted for as agricultural consumptive use as calculated by Webb (2000)

11 As calculated by URS for this study. Calculations are presented in Appendix H of this report. The Mojave Basin Area Adjudication, Table C-1 gives a value of 2,000 AFY.

12 This value represents 105% of storm flow measured at the Lower Narrows gage. Based on calculations performed by Webb (2000) approximately 105% of long term average storm flow leaves the Transition Zone as surface flow in an average year. There is likely a lower limit of storm flow beneath which this relationship cannot be applied. That limit has not been defined.

13 The Mojave Water Agency estimates that there are approximately 177 small producers in the Transition Zone. The small producers typically use the water for domestic purposes and use an average of 1 AFY (Webb, 2000). For this study it is assumed that the 177 small producers each use 1 AFY.