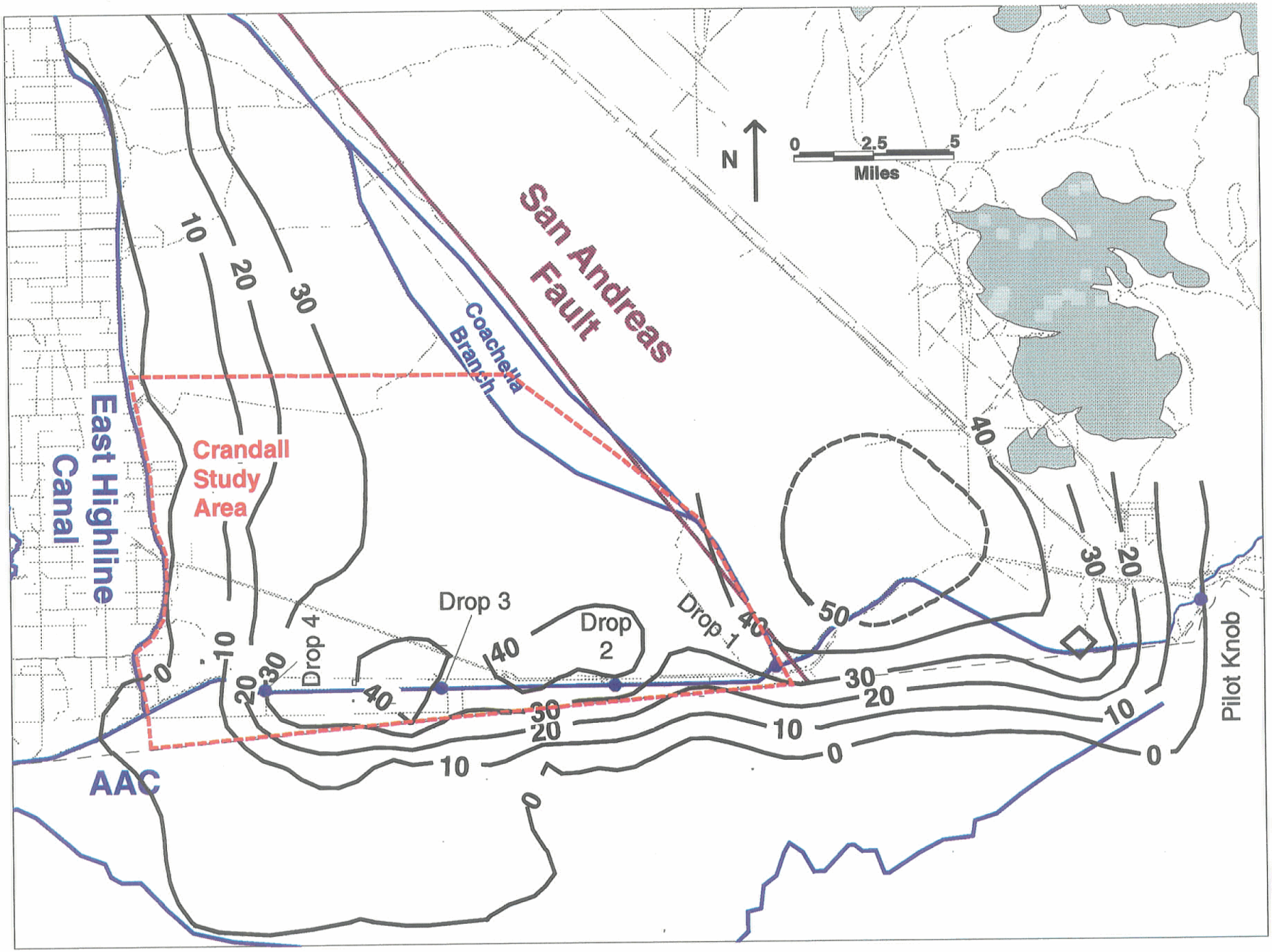

Figure 4-10. Change in Groundwater Levels Between 1939 and 1993

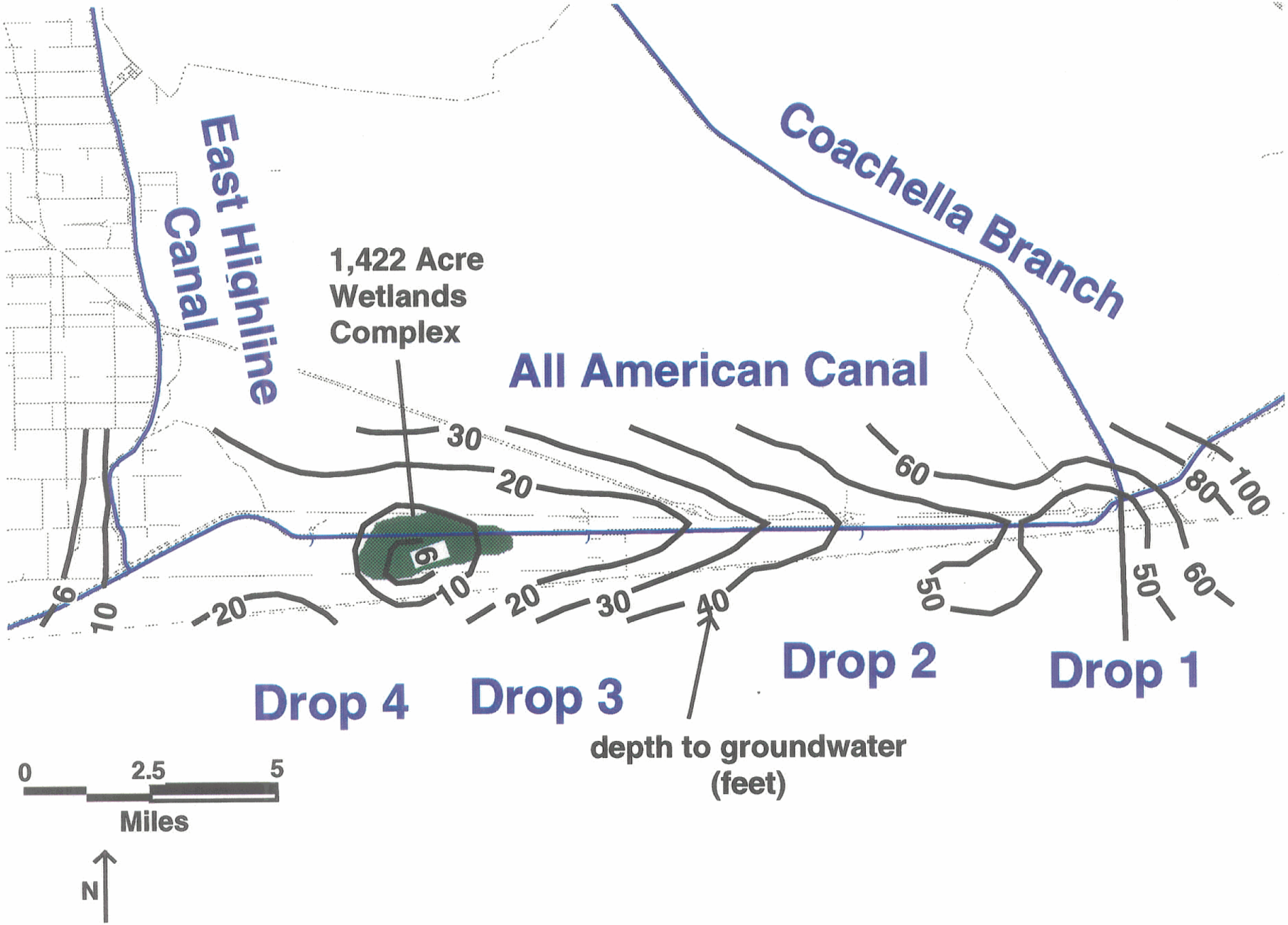

Figure 4-11. Depth to Groundwater and Mapped Wetlands Along the AAC

the average specific yield of 0.223 presented in the Crandall and Associates study (1983). The difference between the 700,000 acre-feet value presented in the Crandall and Associates study (1983) and the 1,500,000 acre-feet value estimated here is primarily due to data derived from areas south of the international border, east of Drop 1, and north of County Highway S28, which were excluded from the analyses conducted by Crandall and Associates.

The change in water storage between 1939 and 1993 is estimated to be 1,450,000 acre-feet using the data presented in Figure 4-10. This lower value reflects the declining water table beneath the Coachella Branch attributable to its lining in 1979 and a rising water table near the Cargo Muchacho Mountains. If the rising water table near the Cargo Muchacho Mountains is excluded from the analysis, the change in water storage would be 1,350,000 acre-feet per year. The change in storage for only the area referenced in the Crandall Study is 530,000 acre-feet per year. These values are only slightly lower than the 1960s storage estimate, despite the declining water table along the CB since its 1979 lining. Apparently, this is because water levels have declined very little in the southern East Mesa since 1960. Although there were large declines along the CB, these declines were observed over only a small area while water levels elsewhere in the southern East Mesa did not change very much since 1960. Because water levels stabilized in the late 1980s following the lining of the first 49 miles of the CB, the 1993 water levels depicted in Figure 4-9 are thought to represent steady state and current conditions.

The canal-induced groundwater storage of roughly 1,500,000 acre-feet is significantly less than the 4,929,000 acre-feet of seepage water from the AAC and the 4,810,000 acre-feet of seepage water from the CB. The difference between the amount of water that seeped from the canals and the increased groundwater storage in the vicinity of the canals is attributed to one of the following several factors:

- Water consumed by evapotranspiration from wetlands along the canal;
- Water collected by recovery drains immediately adjacent to the canal;
- Groundwater discharge into the East Highline Canal;
- Groundwater underflow into central Imperial Valley;
- Groundwater discharge into La Mesa Drain at the Andrade Mesa escarpment; and
- Groundwater underflow into Mexicali Valley.

The following sections summarize the rates associated with these processes.

4.4.2 Water Use by Phreatophytes

The main wetland area along the AAC is the 1,422-acre complex between Drops 3 and 4 identified in Figure 4-11. Total annual evapotranspiration rates were previously estimated to be 6,941 af/yr for the salt cedar (53%), mesquite (18%), cottonwood/willow (3%), arrowweed (16%), and marsh (9%) vegetation identified in the 1,422-acre complex. A secondary 100 acres of scattered wetlands comprised primarily of arrowweed (50%), salt cedar (30%) and mesquite (20%) occurs between Drop 2 and Drop 3, due to the shallow water table along the section between Drop 2 and Drop 3 (Figure 4-11). Total evapotranspiration rates for the scattered wetlands are estimated at 488 af/yr assuming the same loss rate of 4.88 feet per year that applied to the Drop 3/Drop 4 complex. This estimate for the 100 acres of scattered wetlands is likely to be somewhat overstated because the depth to groundwater in the Drop 2/Drop 3 area is greater than the depth to groundwater in the Drop 3/Drop 4 area.

In addition to these two seepage induced wetlands, there are roughly 30 acres of canal bank vegetation that also consume water by evapotranspiration. Assuming the 8 feet per year evapotranspiration rate estimated for marsh vegetation in the Drop 3/Drop 4 complex, the canal bank vegetation would consume an additional 240 af/yr of seepage water.

Total consumption of seepage by evapotranspiration is estimated to be 7,669 af/yr, which accounts for only 7 percent of the 106,500 af/yr of seepage from the AAC between Pilot Knob and the East Highline Canal.

4.4.3 Water Collected By Recovery Drains

There are several recovery drains that intercept canal seepage water adjacent to the AAC for return to the IID canal system. The most easterly of these drains (All American Drains 2 and 2A) is located approximately 1.5 miles east of the East Highline Canal. These drains return recovered canal water to the EHC one-half mile north of its turnout from the AAC.

All American Canal Drains 4 and 5 intercept seepage water west of the East Highline Canal; however, that recovered canal water is seepage that originated west of the gauged reach, located between Pilot Knob and the East Highline check. Seepage recovery and return from these drains is in the IID service

area, which is outside the East Mesa area considered in this AAC water balance. Water balances for the aquifer within the IID service area are presented in Section 3.

4.4.4 Underflow North into East Mesa

Previous investigations have estimated either the amount or proportion of AAC seepage that flows north of the AAC into the East Mesa. The analysis presented by the Republic of Mexico (Bureau of Reclamation 1991) estimated that only 8,900 af/yr, or 8.4 percent of the total AAC seepage, flows north into East Mesa. The AAC EIS/EIR presented a similar estimate of 10 percent of the total AAC seepage, or 10,650 af/yr, for the AAC seepage that flows into East Mesa (Bureau of Reclamation 1991). A modeling study of Coachella Canal seepage between its turnout at the AAC (Drop 1) and Check 6A estimated that 4,000 af/yr of AAC seepage were discharged into the East Highline Canal (Fogg 1989). This latter study also indicated that all groundwater discharging into the first 9 miles of the East Highline Canal originated from AAC seepage and that groundwater discharging into the East Highline Canal farther north originated from the CB.

The groundwater gradient from the water table contour map (Figure 4-9) and the aquifer transmissivity values presented in the East Mesa groundwater model (Bureau of Reclamation 1984) were used to estimate seepage rates for several sections along the AAC between Pilot Knob and the East Highline Canal. The groundwater aquifer along the canal was broken into 16 segments (see Figure 4-9), with each segment having a fairly uniform groundwater gradient and aquifer transmissivity. Total AAC seepage was then apportioned to each segment as summarized in Table 4-2. Total groundwater flow into the East Mesa is estimated to be 8,609 af/yr, based on the 1993 water levels. Groundwater flow rates in 1993 are comparable with those in 1965.

4.4.4.1 Discharge into the East Highline Canal

A total of 4,000 af/yr of AAC seepage was estimated to discharge into the East Highline Canal in the Coachella Canal seepage modeling study (Fogg 1989). While no other studies have estimated the amount of groundwater discharged into the East Highline Canal, an earlier report regarding the East Mesa groundwater system indicated that the canal appeared to be acting as a drain in some areas (LeRoy Crandall and Associates 1983).

Table 4-2

AAC Flow into East Mesa and Mexicali

Segment Name	Length (miles)	Gradient Across Segment	Transmissivity[1] (ft^2/day)	Fraction of Flow	Groundwater Flow (af/yr)
EHC-Drop 4, north (6)	3.4	0	15,000	0	0
Drop 4-Drop 3, north (5)	1.8	0.0025	20,000	0.0147	1,383
Drop 4-Drop 3, north (4)	3.9	0	45,000	0	0
Drop 3-Drop 2, north (3)	6.3	0.0008	45,000	0.0370	3,485
Drop 2-Drop 1, north (2)	5.1	0	45,000	0	0
Drop 1-Bend, north (1)	5.0	0.0009	45,000	0.0330	3,111
Bend-Pilot Knob, north (0)	4.1	0.0005	20,000	0.0067	630
EHC-Drop 4, south (8)	3.6	0	15,000	0	0
Drop 4-Drop 3, south (9)	5.4	0.0025	38,000	0.0837	7,882
Drop 3-Drop 2, south (10)	5.5	0.0036	40,000	0.1292	12,169
Drop 2-Drop 1, south (11)	4.6	0.0030	110,000	0.2476	23,324
Drop 1-Bend, south (12)	3.8	0.0025	110,000	0.1704	16,056
Bend-Pilot Knob, south (13)	6.6	0.0022	110,000	0.2605	24,541
south EHC, west(7)	2.5	0.0008	8,600	0.0028	264
Pilot Knob, east (14)	4.3	0	20,000	0	0
Cargo Muchacho, east (15)	4.9	0.0009	20,000	0.0144	1,355
Sum				**1**	**94,200**
to Mexico (8 thru 14)				0.8914	83,972
to East Mesa (0 thru 6)				0.0914	8,609
to Yuma (15)				0.0144	1,355
to IID (7)				0.0028	264
Sum				**1**	**94,200**

Notes: [1] Transmissivity based on USBR model values.

[2] Total groundwater flow based on total canal seepage.

An unknown fraction of the AAC seepage entering the East Highline Canal may eventually discharge to the Salton Sea after: (1) transport through IID canals, (2) application as irrigation, (3) collection in IID drains, and (4) subsequent discharge either to the New River, Alamo River, or the Salton Sea. However, because AAC seepage is recovered as canal water and applied to irrigate crops, lining the canal would probably not result in a net reduction in the amount of water discharged to the Salton Sea. An equal volume of additional canal water would need to be applied to crops to offset the AAC seepage previously recovered in the East Highline Canal. As a consequence, net discharge to the Salton Sea would likely be unchanged due to the AAC canal-lining project.

4.4.4.2 Underflow into Central Imperial Valley

The amount of AAC seepage that underflows the East Highline Canal into central Imperial Valley may be estimated as the difference between the total AAC seepage that flows north into East Mesa (8,900 to 10,650 af/yr) and the AAC seepage intercepted by the East Highline Canal (4,000 af/yr). This difference is 4,900 to 6,650 af/yr and represents the volume of AAC seepage that may flow into central Imperial Valley. An unknown portion of this underflow is likely to be intercepted in the Alamo and New Rivers. Regional groundwater in the north-central IID area has also been shown to discharge under confining conditions into irrigation return drains (Michel and Schroeder 1994).

As a consequence of low permeability lake sediments in the IID area, artesian discharge areas between the Alamo River and the East Highline Canal, and large groundwater volumes discharged into the New and Alamo Rivers, a large fraction of the AAC seepage that underflows into the central Imperial Valley is believed to discharge into rivers or drains. Because such AAC seepage is recovered as unusable drain water, the water would not be replaced with water imported from another source. Consequently, the AAC lining may result in some net reduction in the amount of water discharged to the Salton Sea. However, it is not possible to estimate what fraction of this AAC seepage will discharge into the drains and rivers, what fraction will be lost by evapotranspiration in the IID service area, or what fraction will enter the Salton Sea without using a groundwater model.

Since most of the AAC seepage underflowing into the central Imperial Valley is discharged into rivers or drains, only a small fraction is believed to discharge directly into the Salton Sea. This discharge would not be subject to consumption by evapotranspiration prior to entering the Salton Sea.

4.4.5 Underflow South Towards Mexico

Previous investigations by the Republic of Mexico (Bureau of Reclamation 1991) estimated that 78,600 af/yr, or 74 percent of the total AAC seepage, flows south towards Mexico. The AAC EIS/EIR presented a similar estimate of 90 percent of the total AAC seepage, or 83,160 af/yr, for the AAC seepage that flows into East Mesa. In the current study, a value of 83,972 af/yr is estimated in Section 4.4.4 (Table 4-2), based on 1993 water level conditions.

4.4.5.1 Discharge into La Mesa Drain

The La Mesa Drain was constructed in 1960 along the escarpment of the Andrade Mesa in order to reclaim wetlands associated with a shallow water table. Gauged flow rates in the La Mesa Drain range as high as 50,700 af/yr, with approximately 50 percent attributable to agricultural return water in Mexicali Valley. The remainder of the inflow into La Mesa Drain (24,300 af/yr) is attributed to AAC canal seepage water that discharges into the first 9 miles of La Mesa Drain.

4.4.5.2 Underflow into Mexicali Valley

The amount of AAC seepage that underflows the La Mesa Drain into Mexicali Valley is estimated as the difference between the total AAC seepage that flows south into Andrade Mesa (78,600 to 84,000 af/yr) and the AAC seepage intercepted by the La Mesa Drain (24,300 af/yr). This difference, 54,300 to 59,700 af/yr, represents the volume of AAC seepage that may flow into Mexicali Valley.

4.4.6 Net Water Loss to Salton Sea from AAC lining

Based on the conceptual models presented here, it is difficult to estimate with certainty the amount of AAC seepage that will be lost to the Salton Sea. Based on the data presented, up to 6,650 af/yr may potentially be lost from river and drainage system flows that discharge into the Salton Sea. Given that a significant fraction of this seepage could be consumed by evapotranspiration, it is likely that the actual volume of water lost to the Salton Sea would be significantly less than 6,650 af/yr. The groundwater model will be used to refine this estimate.