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SEP 14 1984

Mr. Vernon Valantine
Chief Engineer
Colorado River Board of California
107 South Broadway, Room 8103
Los Angeles, California 90012

Dear Mr. Valantine:

Enclosed is our report entitled, "Procedure for Determining Return Flow Credits to Nevada from Las Vegas Wash." This procedure was discussed at the August 28, 1984 meeting of the Task Force on Unmeasured Return Flows to the Lower Colorado River.

Accordingly, the "Compilation of Records in Accordance with Article V of the Decree of the Supreme Court of the United States in Arizona V. California dated March 9, 1964," will utilize the enclosed methodology commencing with calendar year 1983.

We appreciate the cooperation of each of the members of the Task Force, while working with the Bureau of Reclamation, in arriving at a mutually acceptable methodology for this specific area's return flow credits.

Sincerely yours,

ROY D. GEAR
Acting For

N. W. Plummer
Regional Director

Enclosure

bc: Commissioner, Washington, D.C., Attention: 109 and 400 (in duplicate)
Project Manager, Yuma, Arizona
Project Manager, Phoenix, Arizona
(w/encl. to ea.)

Identical letters sent to those on attached list.

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AContreras:mjs

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Procedure for Determining Return Flow Credits to Nevada from Las Vegas Wash

INTRODUCTION

The Colorado River Commission of Nevada (Commission) has presented a formal request that the Secretary of the Interior fulfill the responsibilities of the United States set out in Article V of the Supreme Court Decree of Arizona vs. California regarding the preparation of complete, detailed, and accurate records of "Diversions from the mainstream, return flow of such water to the stream as is available for consumptive use in the United States or in satisfaction of the Mexican treaty obligation, and consumptive use of such water," with specific reference to the crediting of both measured and unmeasured return flows of Colorado River diversions accruing to Lake Mead through the Las Vegas Wash (Wash).

The objective of the State of Nevada is effective water resource management through maximization of creditable Colorado River return flow to extend as far into the future as possible the availability for consumptive use of the State's 300,000 acre-foot apportionment of Colorado River water. Forecasts of increasing demands for both primary potable use and secondary (non-potable) use within the Las Vegas Valley (Valley) and in areas outside the Valley indicate the need for an equitable determination of the State's return flow credits.

To date, with the exception of unmeasured subsurface returns, the Bureau of Reclamation (Reclamation) has compiled the records in accordance with Article V of the Decree listing the measured diversions of Colorado River water to several entities in the Valley using this water. The entities are the Las Vegas Valley Water District (District), city of North Las Vegas, city of Henderson, Nellis Air Force Base, and Basic Management Industries (BMI). The city of Henderson does not permit any direct surface return flow to accrue to the Wash. In all other instances, the waters excess to the initial consumptive use needs are available to other users, following treatment in wastewater treatment plants. Currently, part of the treatment plant effluent is used for powerplant cooling water, irrigation of parklands and golf courses, etc., and farms. Minor amounts of these surface applications and some distribution system leakage accrue to the aquifer underlying the Valley, subsequently contributing to minor unmeasurable subsurface flows returning to the Colorado River as underflow.

The major recipient of Colorado River water in the State is the Robert B. Griffith Water Project (Project) (formerly the Southern Nevada Water Project). Major use of Colorado River water began with the completion of the first stage of the Project sometime in June 1971. Prior to this time, residents of the Valley obtained most of the potable water supply from ground waters under the Valley. In 1969, total ground-water withdrawals amounted to about 87,000 acre-feet. The total natural recharge to the Valley ground-water basin averages between 25,000 and 35,000 acre-feet annually, and a significant overdraft of the basin was in progress as evidenced by continued declining artesian pressure levels and land subsidence.

Since June 1971, the water demands in the Valley have been met by: (1) measured diversions of Colorado River water to the District, city of North Las Vegas, city of Henderson, Nellis Air Force Base, and BMI; (2) measured ground-water pumping by the city of North Las Vegas, Nellis Air Force Base, and the District; (3) unmeasured ground-water pumping by small domestic and commercial users; and (4) measured and unmeasured diversions of effluent from secondary treatment plants using commingled wastewaters following use of the first three listed sources through secondary water rights issued by the Nevada State Engineer. One additional water use existing in the area is the estimated annual use of ground and surface waters by phreatophytes in the Wash amounting to about 12,000 acre-feet. Prior to 1971, the State Engineer had granted water rights totaling about 68,000 acre-feet in primary rights to wastewater effluent. Secondary rights amounting to about 48,000 acre-feet were issued for irrigation and powerplant cooling purposes. Less than 25 percent of these secondary rights have been put to actual use annually. These uses and phreatophyte uses reduced the amount of return flow from ground-water sources accruing to the Wash, the only drainageway leading from the Valley to the Colorado River mainstream.

The Wash now accumulates water from the following sources: (1) surface runoff from sporadic precipitation events; (2) sewage effluent from pumped ground water used in the Valley; (3) sewage effluent from Colorado River water used in the Valley; (4) shallow ground-water accretions, due to recharge by precipitation in the Valley, and its subsequent discharge into the Wash at locations where the Wash intercepts the shallow aquifer underlying the Valley; and (5) shallow ground-water accretions from man-induced surface applications and seepage from both distribution and sewage collection systems of that water introduced and delivered to the Valley from both ground-water pumping and Colorado River diversions. Only sources (2) and (3) above are capable of reasonably accurate measurement. The net discharge from the Wash and attendant accrual to the Colorado River in the Las Vegas Bay of Lake Mead is measured at the United States Geological Survey's "Las Vegas Wash near Boulder City, Nevada," gaging station, known locally as the "North Shore Road gage." The gage is located near the intersection of the Wash and State Highway 147, which is about 2 miles upstream of the confluence of the Wash with Lake Mead.

Reclamation has developed estimated water budgets[1/] for both the surface water in the Wash and the near-surface aquifer underlying the Wash for the period 1976 through 1979. The annual water budgets averaged for the 4-year period are shown in Tables 1 and 2.

1/ Las Vegas Wash Unit, Nevada, United States Bureau of Reclamation, October 1982.

Table 1
Near-Surface Aquifer Water Budget[1/]
(acre-feet)

	Average Annual Volume	
Inflow Item		
Seepage from Valley Surface Diversions		8,790
Regional Ground-Water Inflow	4,700	
Upward Leakage from Deep Aquifers	1,970	
Aquifer Depletion in Pittman Area	2,125	
Total Ground-Water Inflow		8,795
Seepage from Storm Runoff and Surface Diversions Accrued in Wash		5,965
Total Inflow to Near-Surface Aquifer		23,550
Outflow Item		
Seepage into Sewers	1,300	
Seepage into Wash	8,550	
Underflow Passing North Shore Gage	1,460	
Total Seepage Outflow		11,310
Total Consumptive Use by Phreatophytes		12,240
Total Outflow from Near-Surface Aquifer		23,550

1/ Four-year average 1976-1979.

Table 2
Las Vegas Wash Above North Shore Road Gage Surface Water Budget 1/
(acre-feet)

	Average Annual Volume	
Inflow Item		
Inflow from Floodways*	1,630	
Accrual of Surface Runoff	3,770	
Total Inflow from Precipitation		5,400
City of Las Vegas STP Effluent*	22,380	
Clark County STP Effluent*	29,460	
Cooling Water from BMI (Alpha Ditch)*	3,400	
Sunrise Powerplant Effluent	270	
Total Effluent		55,510
Runoff from Irrigation		355
Subtotal of Surface Originated Inflow		61,265
Seepage Inflow from Near-Surface Aquifer		8,550
Total Inflow above the North Shore Gage		69,815
Outflow Item		
Seepage Loss to Near-Surface Aquifer		5,965
Evaporation from Water Surface in Wash		430
Surface Outflow at North Shore Gage*		63,420
Total Outflow of Surface Water		69,815

1/ Four-year average 1976-1979.
* Measured flow.

DISCUSSION

Analysis of Tables 1 and 2 indicate that the specific data necessary for accurate determination of return flow is not completely available. The problem of determining the appropriate credits of Colorado River return flow is compounded by several factors. Among these are:

1. Ground water from the aquifers in the Valley for delivery to the municipal distribution system is accurately measured, whereas, the uses by individual domestic and commercial wells, etc., are estimated.

2. The total water delivered for use in the Valley is made-up of both non-Colorado River ground water and Colorado River mainstream water commingled in the distribution systems and further mixed in the collection system delivering water to the secondary wastewater treatment plants.

3. The surface flows in the Wash are hydrologically interconnected with the ground waters in the near-surface aquifer in the Valley.

4. Both productive and nonproductive consumptive use takes place in the Valley using ground water, Colorado River water, secondary treatment plant effluent, and naturally occurring surface flows.

5. The discharge of the Wash at the North Shore Road gaging station is made-up of naturally occurring local ground water, pumped ground water, Colorado River mainstream water, and runoff from naturally occurring storm precipitation.

6. The gaging station records, although for the most part considered as excellent, are limited to a 95 percent accuracy; that is, the measurements as reported are subject to measurement errors of plus or minus 5 percent.

7. Unmeasured flows occurring to Lake Mead are estimated to be from 2 to 3 percent of the measured surface flows. These unmeasured flows (underflow past the gaging station) consist of regional ground water, upward seepage from underlying deep aquifers, seepage from the surface flows in the Wash and man-induced surface applications in the Valley, and from changes in storage within the near-surface aquifer.

8. Historically, secondary uses of wastewater treatment plant effluent with ground-water diversions as the sole source, prior to the delivery of Colorado River water to the Valley, have been authorized by the State Engineer through the water right appropriation process.

9. Nonproductive consumptive use by phreatophytes adjacent to the Wash and by aquatic plants within the Wash channel have been taking place in unmeasured and varied amounts based principally upon the amount of water introduced into the Wash and the resultant depth to ground water in the near-surface aquifer.

10. As indicated in item 2 above, the effluent from the wastewater treatment plants consists of commingled non-Colorado River ground water and Colorado River mainstream water. The effluent supplies the uses listed in items 8 and 9 above with the excess returning to Lake Mead through the Wash. Therefore, subsequent to the introduction of Colorado River mainstream water to the Valley through the Project, the secondary and phreatophyte uses are supplied by the commingled waters.

11. Return flow credits are allowable only for those Colorado River waters that return to the mainstream (Lake Mead) and are available for consumptive use in the United States or deliverable to Mexico to meet Treaty obligations.

12. It is necessary to determine that amount of the recorded flow measured at the North Shore Road gage and the unmeasured flow that bypasses the gage which is ground water (tributary water) and therefore not creditable as Colorado River return flow.

It is a recognized fact that prior to July 1, 1971, ground water pumped in the Valley historically was the major source of potable water supply for the residents of the Valley, and return flows therefrom were the almost exclusive source of supply used to meet the secondary uses, evapo-transpiration by phreatophytes, and evaporation from water surfaces in the Valley. Consequently, in the interest of equity, it is considered that the aforementioned reuses continue to be fully met in the future by the return flows from ground water. This annual quantity is to be limited to that amount, if available as ground-water identified effluent from the wastewater treatment plants, that was actually delivered for secondary uses in the 1-year period July 1, 1970 through June 30, 1971 (9190 acre-feet)[1/] and estimated as satisfying evapo-transpiration in the Wash (12,000 acre-feet).

Beginning in July 1971, secondary effluent sales and diversions thereof in excess of the 21,190 acre-feet described above are considered to be made from the return flows of commingled waters delivered to the Valley. Return flow accruing to the Wash as wastewater treatment plant effluent is considered to contain the same proportions of ground water and Colorado River water, as the proportions of each that are used to supply the total Valley potable water demands.

As the potable water demands increase in the future, the proportion of ground-water effluent will decline, and as actual ground-water pumping declines the total amount of ground water that will be available in the future will also decline. It is foreseen that as secondary uses of effluent increase there will be a specific point in time when the proportionate secondary uses of effluent will exceed the available ground-water fraction of this effluent. At this point in time, provided that the secondary uses do not decline, the water remaining in the Wash would consist of only Colorado River water, very minor amounts of local ground water, and runoff from naturally occurring precipitation.

1/ From the monthly records of the City of Las Vegas Wastewater Treatment Plant and the Clark County Sanitation District No. 1.

METHODOLOGY FOR DETERMINING RETURN FLOW CREDITS FROM LAS VEGAS WASH

Reclamation has adopted the following methodology as the most equitable means of determining the allowable amount of return flow credit of Colorado River water as a result of diversions of such waters to the Valley.

A. Measured Flows at North Shore Road Gage

1. Determine the total annual volume of ground-water pumped for all uses in the Valley. This volume includes the volume of ground-water pumped for primary uses in the Valley by municipal wells and the volume that is delivered by privately-owned domestic and commercial wells. Data regarding these volumes are furnished to the Commission by the water treatment plant operators and the State Engineer's Office, respectively.

2. Determine the annual volume of Colorado River water diverted to the Valley by the Project, BMI, and others, if any. These volumes are obtained from the diversion records of Reclamation.

3. Determine the ratio of ground-water volume to total water volume delivered to the Valley. Item 1 divided by the sum of Items 1 and 2.

4. Determine the total volume of effluent available from the wastewater treatment plants that can be discharged to the Wash. The individual treatment plants maintain effluent records which are furnished to the Commission.

5. Determine the annual volume of ground-water effluent available to meet secondary water-right uses and phreatophyte use in the Wash. The ground-water fraction of the total treatment plant effluent is estimated to be in the same ratio as the ground-water volume supplied to the Valley (Item 1 above) is to the total water volume supplied to the Valley (sums of Items 1 and 2 above). Item 5 equals Item 3 multiplied by Item 4.

6. Determine the historic maximum 12-month total volume of secondary water-rights uses delivered from treatment plants prior to July 1971, the first full month of operation of the Project. Data from the records of Clark County Sanitation District No. 1 and the Las Vegas Wastewater Treatment Plant indicate that in each instance the maximum annual effluent sales occurred in the 12-month period July 1, 1970 through June 30, 1971. The individual plant effluent volumes delivered to users were 1,297 million gallons and 1,697 million gallons respectively or an annual total of 9,190 acre-feet.

7. Utilize 12,000 acre-feet as the current annual consumptive use by phreatophytes. This value is subject to recalculation as the areal extent of the phreatophytes undergoes change in the future.

8. Determine, from data maintained by the wastewater treatment plants, the total annual volume of effluent diverted to satisfy secondary uses in the reporting year.

9. Determine the volume of the net secondary uses provided by the commingled effluent of Item 4. This volume is equal to the difference between Items 8 and 6.

10. Determine the maximum annual volume of available ground-water effluent remaining in the commingled effluent, after historic and phreatophyte use, to meet demands of secondary uses determined in Item 9 above. This volume is equal to the difference determined by subtracting the sum of Items 6 and 7 from Item 5.

11. Determine the ratio of remaining ground-water effluent to commingled effluent remaining to supply additional secondary uses. The commingled effluent remaining consists of Colorado River effluent (Item 4 less Item 5) and ground-water effluent remaining after historic and phreatophyte uses (Item 10). The ratio is equal to Item 10 divided by the algebraic sum of Item 10 + Item 4 - Item 5.

12. Determine the annual volume of available ground-water effluent used to meet demands of secondary uses determined in Item 9 above. This volume is equal to Item 9 multiplied by Item 11 and cannot exceed Item 10.

13. Determine the remaining annual volume of ground-water effluent in the Wash at the gage. This volume is non-Colorado River water and would equal Item 10 less Item 12.

14. Determine the annual flow of the Wash at the gage from data provided by the Geological Survey of monthly recorded flows.

15. Determine surface runoff from excess Valley precipitation accruing to the Wash above the gage. It is computed by determining the difference between the discharge hydrograph at the gage and the estimated hydrograph of the base flows in the Wash (essentially the discharge of the treatment plant effluents less all known effluent diversions).

16. Determine the annual volume of the unmeasured accrual to the surface flows in the Wash above the gage. The total unmeasured accrual to the Wash is assignable to surface runoff and local and regional ground-water seepage surfacing in the Wash above the gage. The proportionate parts of Colorado River water, commingled Colorado River water and ground water, and isolatable ground water are determined from an itemized analysis of the surface water and near surface aquifer water budgets as presented in Reclamation's 1982 Status Report "Las Vegas Wash Unit." It was determined that 78 percent of the unmeasured surface and subsurface accruals of combined Colorado River water and ground water is Colorado River water and 22 percent of these same unmeasured accruals is ground water. It is assumed that the ratio will be utilized until such time as the change in the ratio of Colorado River water exceeds 3 percent. (A reanalysis of the unmeasured accruals will be made when the ratio of Colorado River water amounts to 70 percent of the total water delivered to the Valley).

17. The measured Colorado River return flow credits are determined by deducting the sum of the noncreditable tributary flows (Items 13, 15, and 16) from the recorded flow at the gage (Item 14).

B. Unmeasured Flows Bypassing the North Shore Road Gage

Underflow that bypasses the gage contains both ground water and Colorado River water that has accrued to the near-surface aquifer. Return flow credits are estimated to be in direct proportion to the ratio of the total Colorado River water delivered to the Valley (Robert B. Griffith Water Project deliveries to the District, the city of North Las Vegas, the Nellis Air Force Base, and the city of Henderson, plus deliveries to BMI) and the total volume of ground-water pumped for use in the Valley. The underflow credit is the Colorado River portion of the estimated annual underflow.

Underflow bypassing the gage will be affected each year by the change in the total volume of storage in the underlying aquifers. If possible, these changes would be determined each year based on ground-water observation well readings and accounted for as in the tabulations on pages 3 and 4.

a. Determine the ratio of Colorado River water delivered to the Valley to the total water delivered to the Valley. Item 2 divided by the sum of Items 1 and 2 in the preceding section.

b. Calculate the Colorado River portion of the estimated underflow bypassing the gage. The Colorado River portion is the product of Item "a" above and the underflow estimated from a water budget analysis similar to that provided in "Status Report, Las Vegas Wash Unit, Nevada," Reclamation, 1982.

c. Calculate the quantity of consumptive use of Colorado River water by the phreatophytes located in the Wash area between the North Shore Gage and the shoreline of Lake Mead. The Colorado River portion is the product of Item "a" above and the estimated consumptive use by phreatophytes that have access to the near surface aquifer underflow bypassing the North Shore Gage.

The annual volumes of unmeasured underflows accruing to Lake Mead from the near-surface aquifer averaged about 1,500 acre-feet during the 1976 through 1979 period, do not vary by as much as 100 percent and currently are less than 1 percent of the total volume of water delivered to the Valley.

C. Total Las Vegas Wash Colorado River Return Flow Credit

The total return flow credit for Colorado River water from the Wash is the sum of the remaining measured surface flow volume determined in Item 17 and the unmeasured underflow volume determined in Item "b" above and less the phreatophyte use determined in Item "c" above.

A sample compilation of the return flow credit and consumptive use associated with the Valley based on data available for 1981 is shown on Table 3.

Table 3
Return Flow Credit Compilation - Las Vegas Wash - Recommended Historic Use Method

Line	Item	1981 Volume (acre-feet)
	Measured Flows at North Shore Gage	
1.	Ground Water Pumped to Valley Users[1/]	68,940
2.	Colorado River Water Delivered to Valley[2/]	134,000
3.	Ratio of Ground Water to Total Water Delivered to Valley (Line 1 / (Line 1 + Line 2))	34%
4.	Total Effluent Available from Wastewater Treatment Plants[3/]	72,700
5.	Ground-Water Effluent Available for Secondary Water Rights and Phreatophyte Use (Line 3 x Line 4)	24,720
6.	Water Right Uses for Agriculture, Powerplants, and Parks, etc. (Limited to Historic Uses - Pre-Robert B. Griffith Project)[4/] (constant)	9,190
7.	Phreatophyte Consumptive Use (current)	12,000
8.	Total Secondary Uses Provided by Effluent in Line 4[3/]	10,770
9.	Additional Secondary Uses Provided by Commingled Effluent in Line 4 (Line 8 - Line 6)	1,580
10.	Maximum Ground-Water Effluent Remaining After Historic Use (Line 5 - Lines 6 + 7)	3,530
11.	Ratio of Remaining Ground-Water Effluent to Commingled Effluent Remaining to Supply Additional Secondary Uses (Line 10/Line 10 + Line 4 - Line 5)	7%
12.	Ground-Water Effluent Used to Supply Additional Secondary Uses (Line 9 x Line 11), if available	110
13.	Ground-Water Effluent Remaining at North Shore Gage (Line 10 - Line 12)	3,420
14.	Annual Flow - North Shore Road Gage (measured)	70,060
15.	Surface Runoff from Valley Precipitation (computed from Hydrograph)	2,580
16.	Unmeasured Ground-Water Accrual at North Shore Gage (20%[5/] of 17,550 acre-feet[6/])	3,360
17.	Surface Water Credits as Colorado River Return Flow from Las Vegas Wash (Line 14 - Lines 13 + 15 +16)	60,200
	Unmeasured Flows Bypassing North Shore Gage	
A.	Ratio of Colorado River Water to Total Water Delivered to Valley (Line 2 / (Line 1 + Line 2)	66%
B.	Underflow of Colorado River Water Bypassing North Shore Road Gage (Line A x 1,500 acre-feet)[7/]	990
C.	Phreatophyte Consumptive Use of Colorado River Water Below North Shore Gage (Line A x 260 acre-feet)	170
18.	Total Colorado River Return Flow Credits from Las Vegas Wash (Line 17 + Line B - Line C)	61,020
19.	Consumptive Use of Colorado River Water in Las Vegas Valley (Line 2 - Line 18)	72,980

1/ Data furnished annually through the Colorado River Commission of Nevada.
2/ From USBR records.
3/ Data from Wastewater Treatment Plants.
4/ Data from 3/ for 12-month period July 1, 1970 through June 30, 1971.
5/ Computed from itemized analysis of surface water and near surface aquifer water budgets for the period 1976-1979.
6/ Line 14 - Line 13 - Line 15 - (Line 4 - Line 5 - [Line 9 - Line 12]).
7/ Underflow from Water Budget Analysis from "Las Vegas Wash Unit, Nevada," USBR, 1982.

Staff's Report
Colorado River Water Quality Improvement Program (WQIP, CRWQIP)
Las Vegas Wash Unit, Planning (700)