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Water quality trends in the Las Vegas Wash wetlands

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CHAPTER 9

WATER QUALITY TRENDS IN THE LAS VEGAS WASH WETLANDS

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INTRODUCTION

The Las Vegas Wash is a wetlands ecosystem that acts to buffer the effects of wastewater discharges on the receiving waters of Lake Mead. The wash is the terminus for the 4,144 km^2 Las Vegas Valley drainage basin, emptying into Las Vegas Bay of Lake Mead (Colorado River). It is in the northern Mojave desert, which receives an average of only 10 cm of rainfall annually. The Las Vegas Wash is technically an artificial wetland supported almost entirely by the perennial flows from sewage treatment plants. These flows contribute an average of 3.7 t of nutrients (nitrogen and phosphorus) and 4 t of oxygen consuming organic material (BOD_5) to Lake Mead per day. High nitrate and total dissolved solid loads (2.7 and 603 t/day respectively) are derived primarily from groundwater inputs in the lower wash [1,2,3]. The contaminated groundwater originates from large underground salt mounds that were formed from discharges of industrial effluents into unlined evaporation ponds until 1978.

Conflicting interests among municipal, recreational, and down-river users make the Las Vegas Wash a focal point in current legal disputes regarding the need for advanced wastewater treatment (AWT). In light of rapidly escalating costs, especially for energy and chemicals needed for AWT, many municipalities nation-wide are investigating alternative treatment techniques. Public Law 92-500, Section 210 (parts d and f) specifically encourages the reclamation and recycling of wastewaters. Operation of treatment facilities to produce revenue through the production of agriculture, silviculture, or aquaculture products is encouraged. Combinations of open space and recreational uses with waste treatment management techniques are also emphasized in PL 92-500.

The Las Vegas Wash ecosystem has been identified as a potential wastewater treatment system. Previous investigations [4,5] indicate that the ecosystem could be removing substantial amounts of nutrients from wastewaters. Goldman and Deacon [5] recommended "that a specifically designed nutrient removal management program be developed and implemented with the flow distribution and erosion control program necessary to maintain wetland wildlife habitat."

The purpose of this paper is to describe historical and current water quality and to quantify the degree of nutrient removal presently occurring in the Las Vegas Wash.

DESCRIPTION OF THE STUDY AREA

Las Vegas Wash is located in Clark County, Nevada, between the City of Las Vegas and Lake Mead (Figure 1). The boundaries of the Wash are defined by a large drainage system that was once part of the pluvial Las Vegas River [6]. Our research was focused in the 18 km stretch downstream of the City of Las Vegas sewage treatment plant (STP) to Las Vegas Bay of Lake Mead.

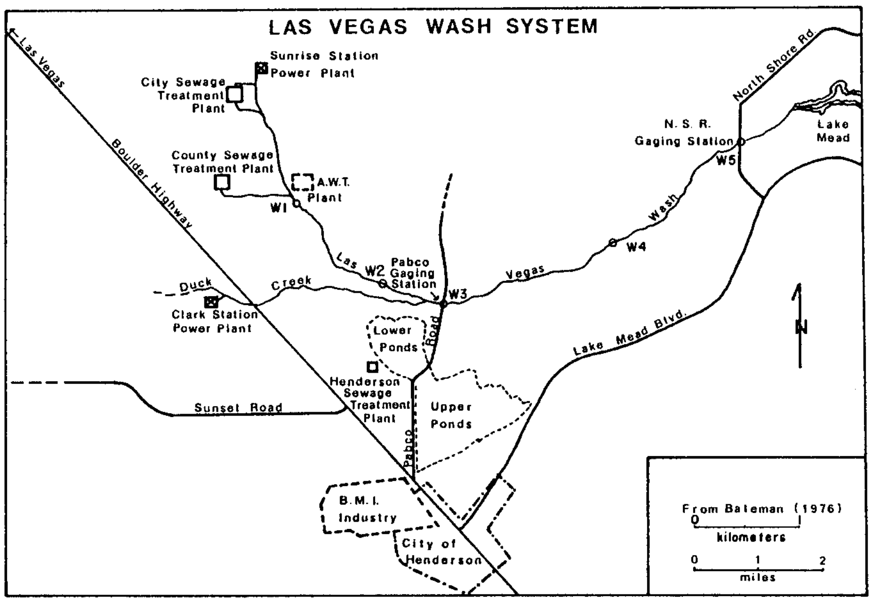

Figure 1. Sampling Site Location Map.

The water in Las Vegas Wash is comprised of 90% secondarily-treated wastewater from the City of Las Vegas and Clark County STPs. Vegas Creek, the last natural creek in the Las Vegas Valley, dried up in the late 1940's [7]. Flows in the present riparian and marsh wetland have increased with the population of Las Vegas Valley. The Valley is home to nearly one-half million permanent residents and host to approximately nine million tourists annually. Las Vegas has become one of the fastest growing urban areas in the United States. Concomitant with this growth has been an increase in wastewater discharges to Lake Mead. Total discharges currently average 2.8 m^3/sec (100 cfs). This amount is twice the flow rate measured at Northshore Road in 1970 (Figure 2).

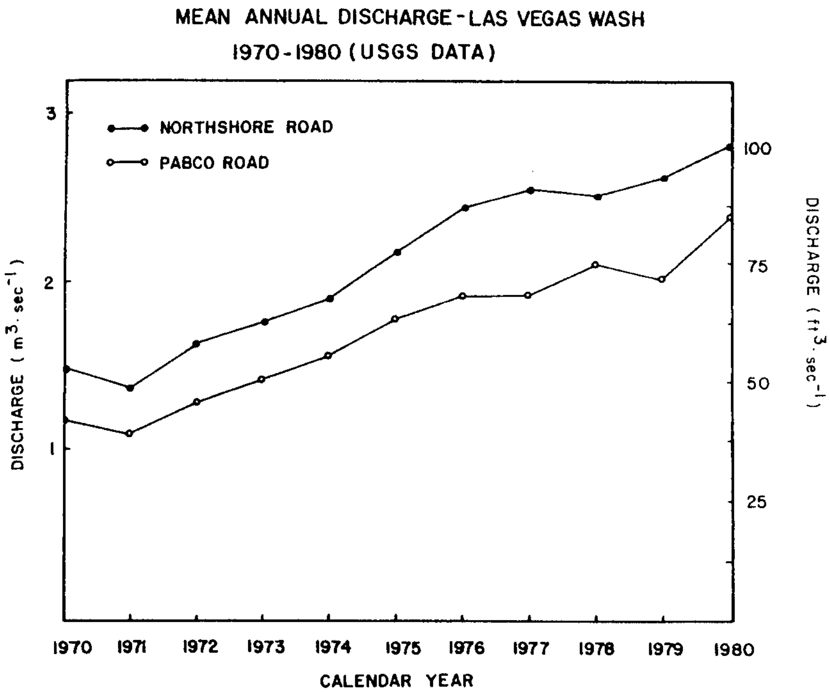

Figure 2. Historical Discharges From Las Vegas Wash.

Increasing volumes of perennial surface water as well as stormwater discharges have transformed sparse desert shrub and mesquite woodland habitats into dense growths of hydrophytic wetland vegetation dominated by Typha domengensis (cattail) and Phragmites communis (common reed). Extensive growths of the introduced phreatophyte Tamarix petandra (salt cedar) border the wetland and riparian zones.

In 1975, a channelization program was initiated in the upper reach of the wash from the City and County STPs to 1.6 km downstream. This man-made channelization has steadily decreased the extent of wetland from the 1969 to 1975 maximum of approximately 730 ha to 120 ha in 1979. Increased flow velocities and unstable soils in the lower portion of the wetland have also facilitated increased erosion rates at areas known as "headcut" regions for the past 5 yr. Sediment transport in 1979 and 1980 was particularly large. Erosion and headcutting in the lower reach of the Las Vegas Wash is especially prominent during flash flooding and accelerated erosion occurred during this study. The principal headcut region advanced approximately 1.5 km upstream during a single storm event of February 1980. Upstream progression of erosion has resulted in the draining of another 50 ha of wetland creating a riparian habitat with channel depths often exceeding 6 m. Present areal extent of wetland vegetation is 65 ha with 6 ha of shallow (1 m deep) ponds.

Routine collections were taken from five sample stations; W1: confluence of the existing secondary sewage treatment plant effluents (14 km above Las Vegas Bay (LVB)); W2: marsh above Pabco Road (10.7 km above LVB); W3: Pabco Road at culverts (10 km above LVB); W4: headcut area (6.3 km above LVB); W5: Northshore Road (State Highway 41, 1.6 km above LVB) (Figure 1). U.S. Geological Survey (USGS) gaging stations are located at or in close proximity to Stations W1, W3, and W5, facilitating loading rate computations.

Morphologically, the wash can be divided into two components, the Upper (above Pabco Road) and Lower (below Pabco Road) Wash. The stream gradient between Stations W1 and W3 is gradual, dropping 31.7 m in 4 km. The largest extent of Typha occurs in this reach of stream. After crossing Pabco Road via culverts, waters collect in the previously mentioned shallow ponds. Culverts drain these irregularly shaped ponds, emptying into the lower, smaller expanse of wetland vegetation. The gradient between stations W3 and W5 is steeper, dropping 80.5 m in 8.4 km. The major inflows of salt and nitrate laden groundwater occur between Stations W3 and W5 [2].

MATERIALS AND METHODS

These five sampling stations were monitored biweekly from July 1979 to December 1980. Special studies were also conducted to determine diurnal variations in nutrients and flow regimes. Over 40 sampling rounds were conducted during the 18 month study.

Field measurements and sample collections were performed under contractual agreement between the Lake Mead Limnological Research Center, University of Nevada, Las Vegas, and Brown and Caldwell Consulting Engineers of Sacramento, California. Water samples were collected with a large plastic bucket, and subsamples were collected in plastic bottles and preserved on ice. Samples for soluble nutrient analyses were filtered through GF/C filters upon return to the laboratory. The samples were iced and shipped to the Brown and Caldwell laboratory in Emeryville, California for analysis. All analyses were performed as prescribed by U.S. EPA [8].

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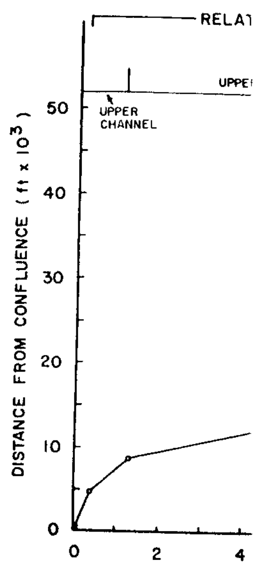

Figure 3. Hydra

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In addition to physical and chemical measurements, rhodamine WT dye was introduced into segments of the wash during a special study to determine hydraulic retention time. The dye was tracked using a Turner Designs Model 10 fluorometer, and Instrumentation Specialty Corporation (ISCO) automatic water samplers.

RESULTS AND DISCUSSION

Hydraulic retention studies performed jointly by us and Brown and Caldwell Consulting Engineers, during mid-November, 1980, indicate that the wash has a short time of travel from the STPs to Lake Mead (Figure 3). Channelized flows above and below the wetland act to increase flows, and travel time is less than 20 h to Lake Mead. As might be anticipated, the greatest residence time was in the wetlands and ponds (15 h).

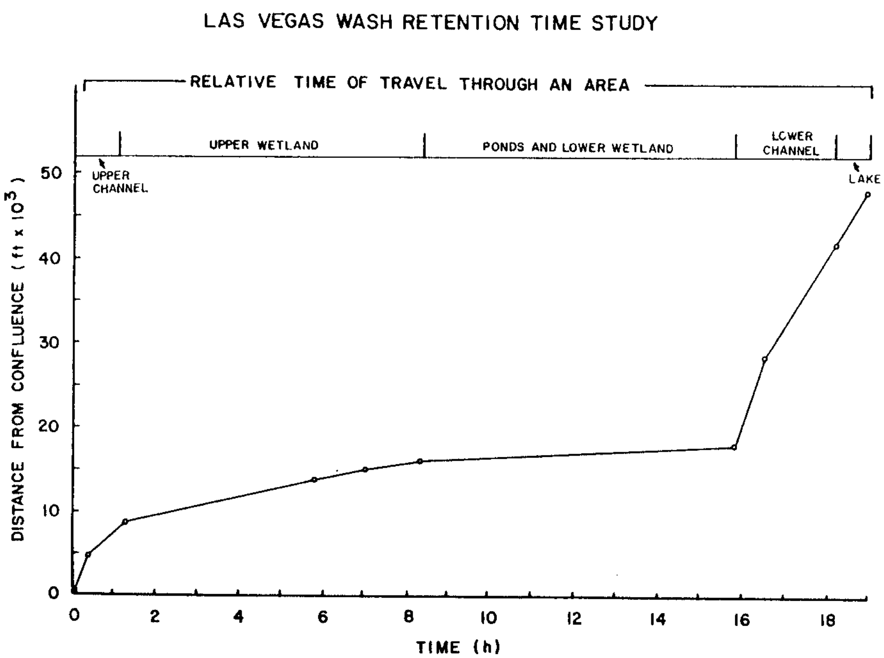

Figure 3. Hydraulic Retention Time Within Las Vegas Wash.

Relatively complete historical nutrient data are available in the USGS records for Las Vegas Wash. Summaries of past data indicate that some dramatic changes have occurred during the last 6 yr of monitoring. Nitrogen loads at Northshore Road have steadily increased since 1977, a drought year (Figure 4). Discharges of industrial wastes into unlined ponds, constructed in the 1940's, was discontinued in the mid-1970's. This has led to a gradual decline of nitrate loads contributed by shallow groundwater aquifers. Ammonia, however, has steadily increased. Ammonia loads at Northshore Road were less than 10% of the total nitrogen load prior to 1977, while current levels exceed 60%.

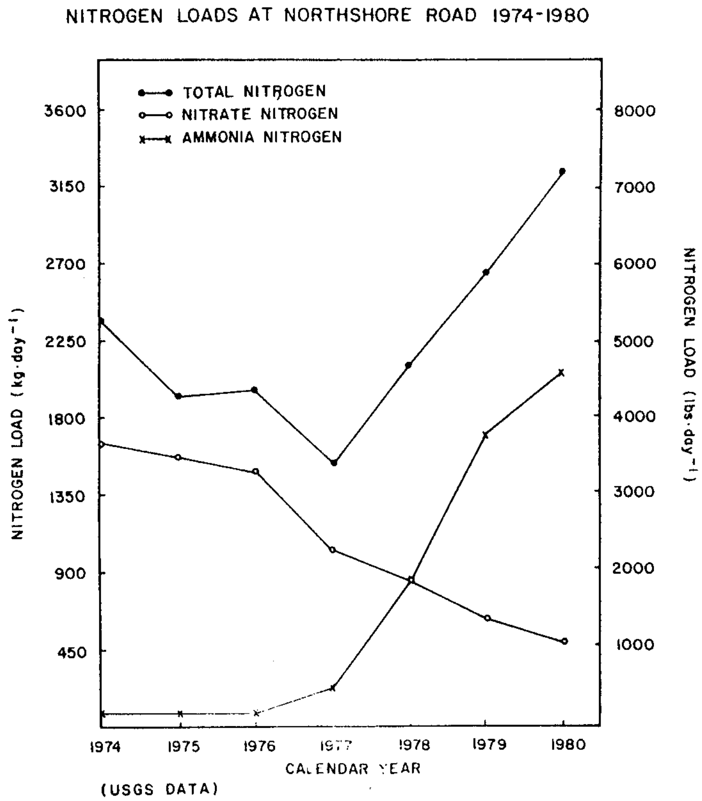

Figure 4. Historical Nitrogen Loads from Las Vegas Wash.

As flows progress downstream into stands of cattail, water velocities slow and bacterial decomposition of wastes causes a depletion of oxygen. These anaerobic conditions favor denitrifying bacteria that effectively convert nitrate to nitrogen gas. No rate measurements are currently available on this, but it appears to result in decreased nitrate concentrations in the upper marsh throughout the year (Figure 5). Denitrification has been generally cited as the major reason that wetlands are nitrogen traps or sinks. Ammonia concentrations increased slightly in this area, apparently due to bacterial decomposition of organic nitrogen compounds.

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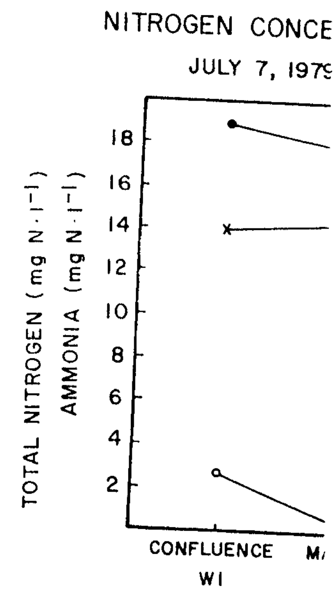

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decreased within the wash system. Total nitrogen was reduced by 27% between Stations W1 and W5 during the summer of 1980. This was as high as 47% removal on some occasions and averaged 15.4% during the entire study. Nitrate concentrations at Northshore Road increased to 12 mg/l on three occasions. One event on March 4, 1980 was traced to a leaking pipe which transports industrial wastes to lined evaporation ponds in upland areas of the wash. This resulted in six to seven-fold increases over normal nitrate loads to Lake Mead. Because of these perturbations, the mean removals of nitrogen are conservative.

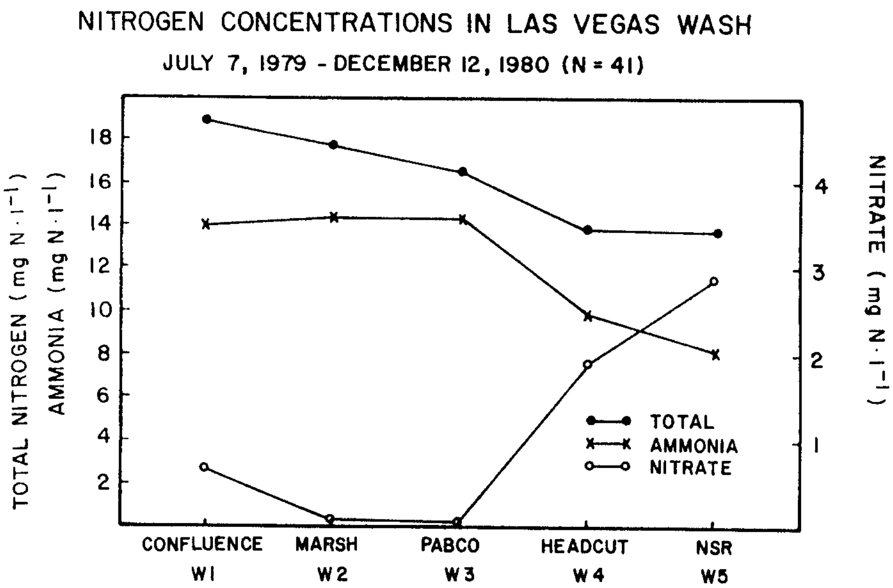

Figure 5. Mean Concentration of Nutrients Within Las Vegas Wash.

Average nitrogen loads for various seasons are depicted in Figure 6. Loads were calculated from average flows recorded by USGS for the day water samples were taken. There were net removals of total nitrogen and ammonia in the wash. However, there was a net contribution of nitrate, primarily as a result of groundwater inputs in the lower wash. The effects of perturbations discussed earlier can be seen in peaks of nitrate loads during fall of 1979 and spring of 1980.

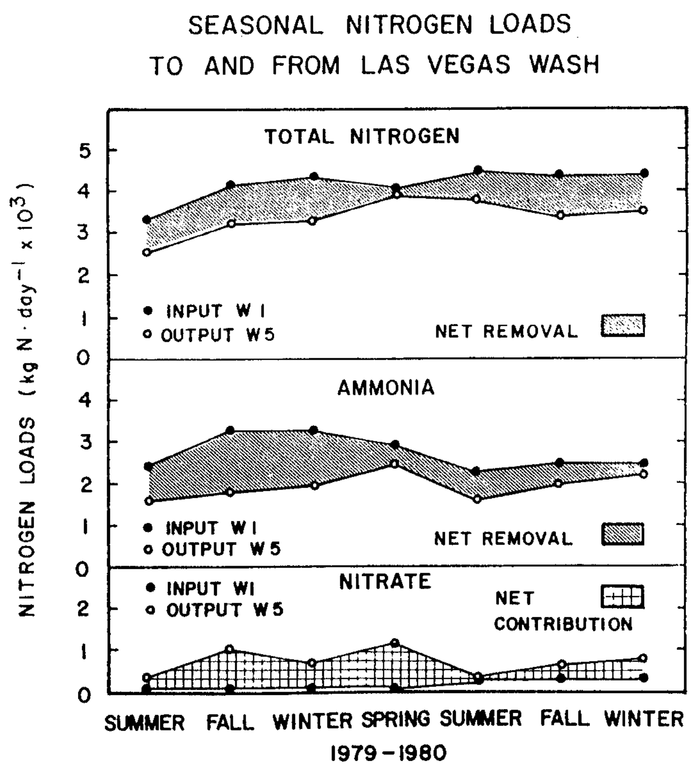

Figure 6. Seasonal Nitrogen Loads to and from Las Vegas Wash.

A decreasing trend in ammonia removals within the wash occurred during this study. There are many possible explanations for this. First, loadings of ammonia from the STPs were lower during later portions of the study. Second, storm events of winter 1979-1980 caused a major upstream advancement of erosion. Decreased removal efficiencies during lower loadings were also observed by Morris et al. [9] in related wetland studies in the Lake Tahoe Basin. They found the most dramatic nutrient and sediment removals occurred when loads were greatest. Another relevant conclusion was that one of the most important factors in determining the effectiveness of wetland treatment was the degree of sheet flows across the wetland. In the case of the Las Vegas Wash, channelization limits spatial and temporal contact of waters with wetland vegetation and, therefore, limits nutrient reducing capabilities.

Goldman and Deacon [5] suggested that one mechanism that may be responsible for ammonia removals within the Las Vegas Wash is the adsorption to clay particles. These investigators indicated 90% reductions in ammonia loading as measured at Northshore Road in comparison to lower (31%) reductions seen during this study. It is possible that active headcutting zones may be eroding strata of less clay content than historical headcut zones. Based on elevational differences between past and present headcut zones, it seems that this may be true. However, a more detailed analysis of the system is required to give a definitive answer as to what mechanism plays a dominant role.

Historical phosphorus data measured at Northshore Road (Figure 7) indicate that recent upgrading of sewage treatment facilities is reducing total phosphorus loads in comparison to previous years. Seasonal analysis of phosphorus (Figure 8) shows a net contribution of total phosphorus in the spring of 1980. This is attributable to high sediment discharges during active headcutting that resulted from the February floods. The apparent removal of dissolved phosphorus during periods of high sediment discharge was probably due to adsorption of inorganic phosphorus to sediments eroded from the headcutting areas.

The results of our study can be summarized with data presented in Table I. Total nitrogen was reduced by an average of 1000 kg/day, and most of this was ammonia. However, there was a net contribution of 697 kg/day of nitrate. Total phosphorus loads were reduced by approximately one-third, and there was a slight decrease in soluble phosphorus.

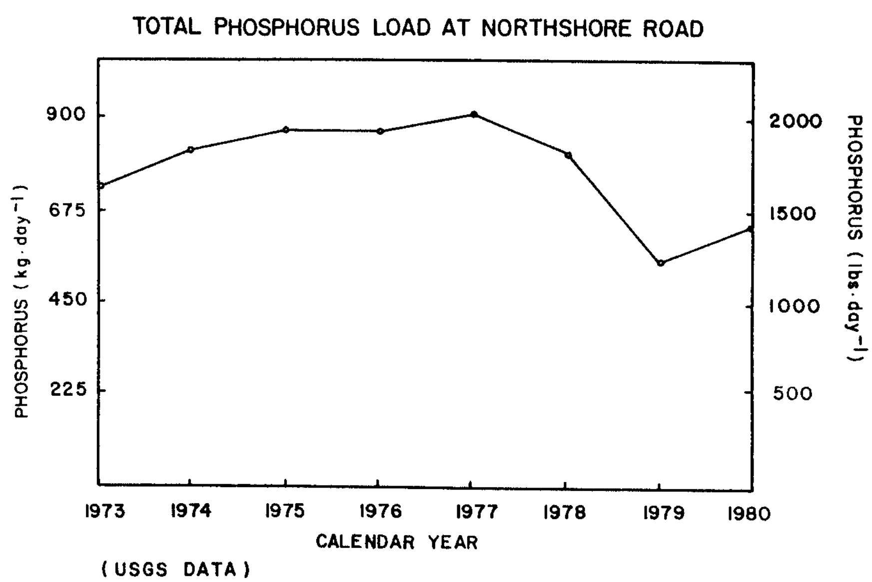

Figure 7. Historical Phosphorus Loads from Las Vegas Wash.

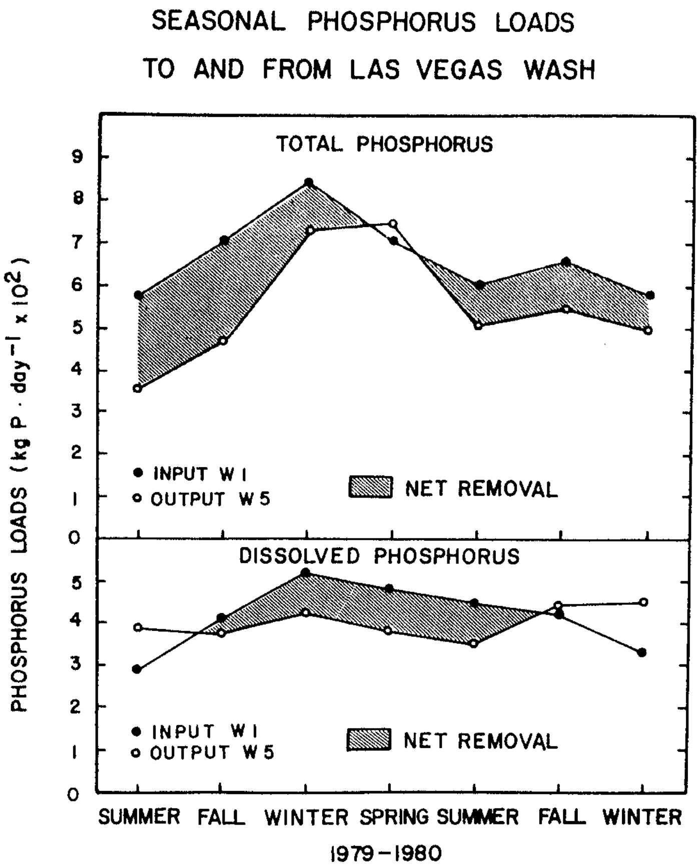

Figure 8. Seasonal Phosphorus Loads to and from Las Vegas Wash.

Table I. Mean Loading and Removal Rates of Nutrients in Las Vegas Wash (as Measured at Northshore Road, 1.6 km from Lake Mead, July 23, 1979 to December 18, 1980).

Nutrient*	N	Mean Loading Rate (kg/day)	Standard Error (kg/day)	Mean Removal Rate (kg/day)
Total nitrogen	41	3172.0	164.4	1001.1
Nitrate	41	696.9	107.8	-
Ammonia	41	1874.4	82.1	992.0
Total phosphorus	40	539.6	45.0	156.9
Soluble phosphorus	41	380.4	16.7	49.4

*Expressed as elemental form

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Although the wastewaters are retained within the Las Vegas Wash wetlands for a relatively short period of time, this ecosystem is behaving seasonally as a nitrogen and phosphorus trap. This results in an improvement of the quality of water discharged to Lake Mead. Efficiency of nitrogen and phosphorus removal is a function of the loads entering the system and the degree of contact of waters with the wetland. Increasing velocities and volumes of flows have decreased retention time resulting in less contact time with the wetland. Rates of nutrient removal in the Las Vegas Wash as described by URS and Clark County Department of Comprehensive Planning in 1978 [10] appear to be declining as a result of changes in flow regimes. Improving the efficiency of nutrient removal by proper management of this wetland appears to be feasible. Further studies should be conducted to elucidate specific mechanisms of nutrient removals.

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