4.0 STUDY RESULTS

4.1 Lake Seasonal Water Loss and Need for Supplemental Water

To evaluate the lake's holding capacity, the project team examined historical rainfall data and calculated runoff volumes for the contributing watersheds. This resulted in an estimate of the lake's water balance. Since specific data is not available for Lagoon Valley Lake, historical rainfall data were examined for the City of Vacaville. This was used to estimate the amount of runoff that is expected to be generated by the mean annual precipitation.[2]

Runoff was calculated using the HEC-1 computer model. For this study the HEC-1 model was used to model a two-year storm event. The two-year storm was chosen because it has a 50% chance of occurrence in any given year. The results of the HEC-1 study indicated that approximately 49% of the two-year storm precipitation is lost through infiltration and surface storage. The remaining 51% results in runoff. Runoff volume reaching the lake was then calculated as follows:

> Mean annual precipitation for Vacaville is approximately 25.88 Inches/Year (Western Regional Climate Center).
>
> Runoff = 0.51(25.88 Inches/Year) = 13.19 Inches/Year
>
> Total Watershed Area = 2.34 Sq. miles = 1,497.6 Acres
>
> $$\text{Runoff Volume} = \frac{13.19\ \text{Inches/Year}}{12\ \text{Inches/Ft}} \times 1{,}497.6\ \text{Acres} = 1{,}647\ \text{Acre Feet/Year}$$

The amount of water lost by evapotranspiration was then determined based on available data relevant to other lakes in the area (*i.e.* Folsom Lake and Lake Berryessa). According to historical records, the 9 year average evaporation for these two lakes is 45.8 inches per year. Applying this evaporation rate to Lagoon Valley Lake and assuming an average lake surface area of 100 acres, approximately 382 acre-feet of water are lost annually from Lagoon Valley Lake due to evaporation.

> Evaporation = 59.5 Inches/Year (9 Year average)
> Pan Conversion Factor = 0.77
> Evaporation = 0.77(59.5 Inches/Year) = 45.8 Inches/Year
>
> $$\text{Evaporation Volume} = \frac{45.8\ \text{Inches/Year}}{12\ \text{Inches/Foot}} \times 100\ \text{Acres} = 382\ \text{Acre-Feet/Year}$$

Finally, the holding capacity for the lake was determined based on the 1997 survey data. Using this depth survey information, the lake's holding capacity was determined

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[2] These calculations do not take into account the non-potable irrigation water supplied by the Solano Irrigation District (SID) to Hines Nursery. These SID waters may modestly increase the volume that enters the lake via groundwater seepage to the nursery's collection ditches as well as via bypass flows from the nursery (see Section 4.2.1). During the dry season, these SID waters appear to be largely responsible for the flow in the "Perennial Tributary" that flows into the southeast corner of the lake.

to be 288 acre-feet at elevation 213 (Spillway Crest). This is the maximum detention storage that can be assumed to be available.

The amount of seepage and outflow from the lake is inflow less evaporation less lake storage:

Seepage + Outfall = 1647 AF - 382AF - 288AF = 977 AF.

4.1.1 Summary: Lagoon Valley Lake is currently receiving an adequate supply of water, and under current conditions has the potential to supply approximately 977 acre-feet of water per year for other uses. No supplemental water inflow is currently needed. However, for the purposes of increasing lake depth and water surface area for non-detention related purposes (*e.g.* increase shoreline or tributary wetland inundation zones, increase lake depth), the lake would have more than adequate water to accommodate increasing the height of the spillway by at least one foot.

4.2 Watershed Management and 100 Year Storm Analysis

Understanding the various components of the contributing watershed is critical to formulating management strategies for the lake. Before sediment can be controlled, the major sources have to be identified. These sources were identified by studying the upstream conditions of each of the contributing watersheds.

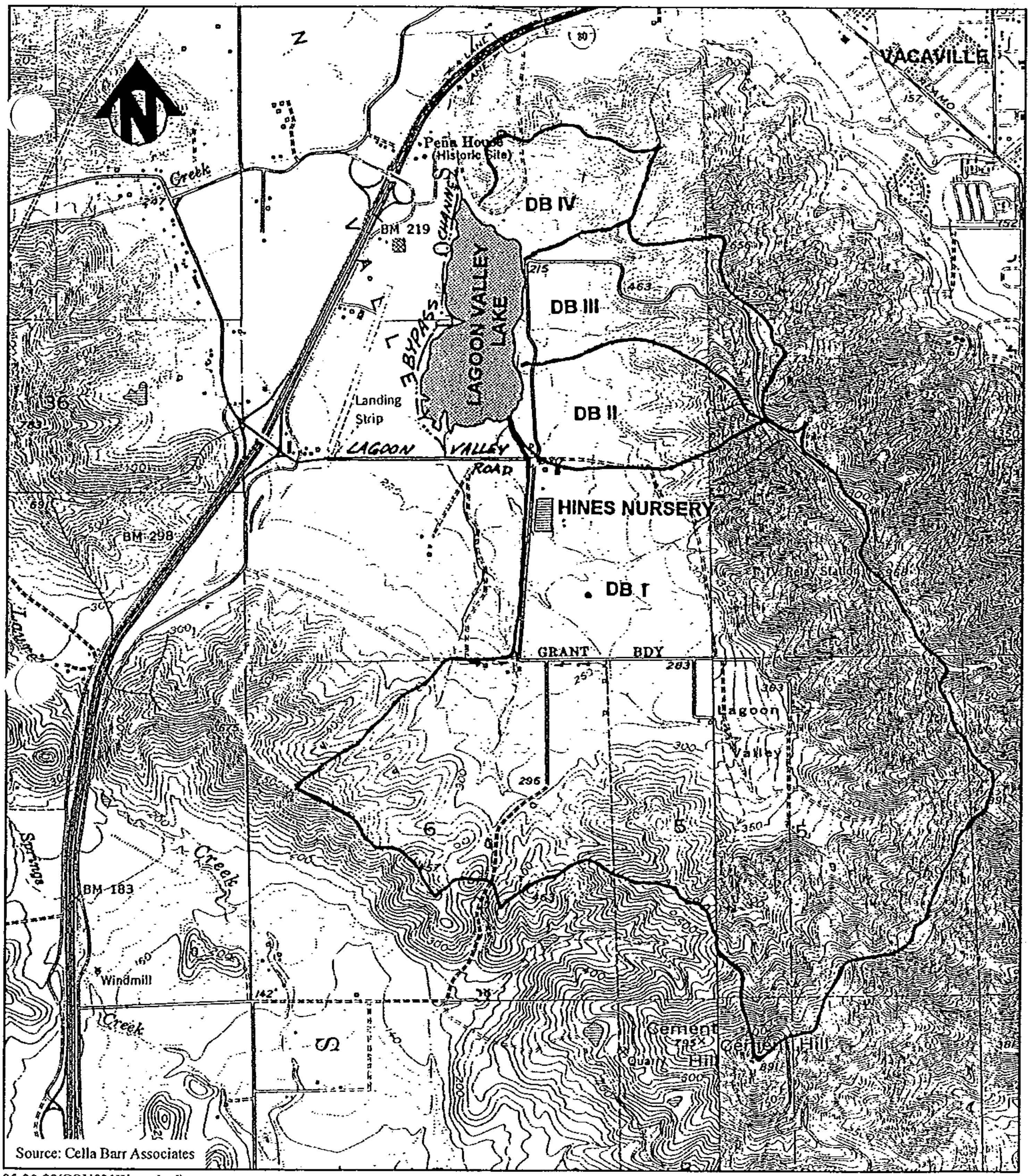
4.2.1 Existing Contributing Watershed Descriptions: There are four local drainage basins that contribute runoff to Lagoon Valley lake during any major storm event. These drainage basins are shown on Figure 5. The total watershed area consists of approximately 2.34 square miles and is located to the south and east of the lake. A bypass channel located on the western side of the lake diverts additional runoff from the west and south and prevents it from reaching the lake.

In general, the contributing drainage basins drain the western and northern slopes of the hills surrounding the lake. The basins consists of steep slopes, alluvial fan areas at the base of the slopes and flatter areas in the valley floor. Slopes vary widely and range from approximately one percent (1%) in the lower areas near the lake, to a maximum of twenty two percent (22%) near the headwater to Basin DB-II. Drainage basins range in size from 70 to 1178 acres and in elevation from 215 feet to 968 feet. Vegetation cover consists of seasonal grasses, bushes and some scattered trees.

According to the U. S. Department of Agriculture, Natural Recourses Conservation Service (NRCS), "Soil Survey of Solano County, California" dated May 1977, the soil within the watershed are of hydrologic soil groups C and D which have medium to high runoff potential.

The four sub-basins account for the majority of sediment that reaches the lake, with a smaller contribution attributed to shore line erosion (see Section 4.6). Of the four drainage basins, Basin DB-I is by far the largest and appears to be the source for most of the sediment that is reaching the lake. This basin is 1.84 square miles and generates a peak runoff rate of approximately 924 cfs during a 100 year storm. This accounts for 88% of the total runoff reaching the lake.

Figure 5 – watershed map



05-20-99(COV831Watershed)

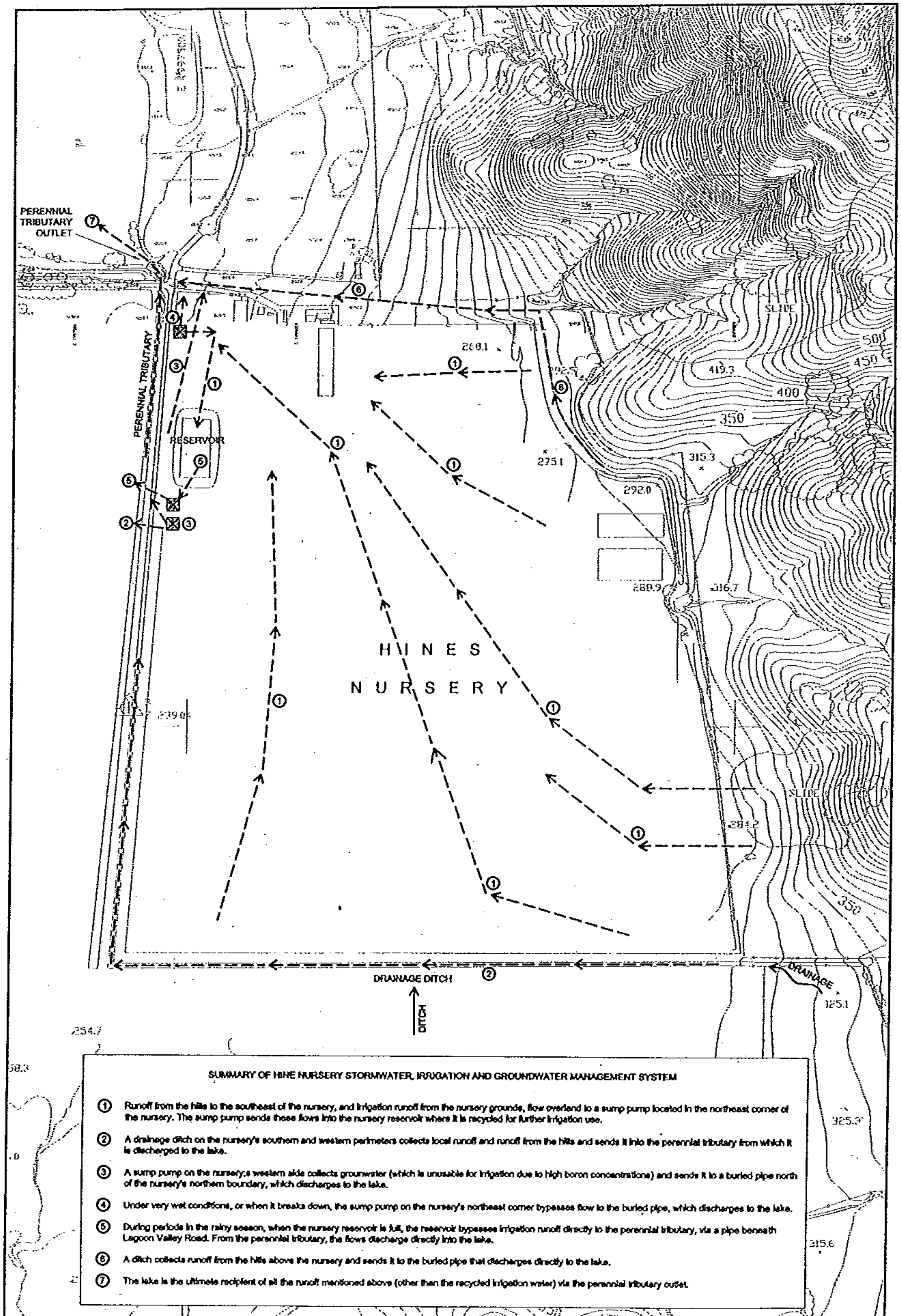
Figure 5

LSA

Scale in miles
0 2000

Watershed Map - Lagoon Valley Lake

Figure 6 – drainage system in vicinity of Hines Nursery



05-21-99(COV831drainage)

N

LSA

Scale in feet
0 400

⊠ Sump Pump or Water Control Structure

Figure 6

Drainage System in Vicinity of Hines Nursery

Figure 6A - Hines Nursery Drainage System Key

During a storm event, runoff from DB-I is collected into two major collection systems. First, the Hines Nursery has an interceptor system located along its eastern perimeter (above the nursery facilities) that flows by gravity to a collection point to the northeast of the nursery (Figure 6). Stormwater then flows westerly through a buried culvert on the north side of the nursery to a 48-inch pipe that enters the lake at the discharge point of the perennial tributary at Lagoon Valley Road. This system handles the majority of runoff from the hills within DB-I and is a major source of sediment inflow to the lake. The 1997 lake survey data shows that substantial amount of sediment deposition has occurred at the south end of the lake where flow from the perennial tributary discharges into the lake (Figure 6). Included in this drainage system to the lake is groundwater from the nursery area (routed though a French drain) that is collected in a sump on the west side of the nursery and pumped into a buried culvert draining the east side of the property. The nursery is unable to use this water for irrigation because it is too high in boron, a plant toxin.

The second runoff collection system for DB-I is the channel that runs for almost 6500 feet along the south and west side of Hines Nursery and discharges into the perennial tributary via a culvert beneath Lagoon Valley Road (Figure 6). Due to the concentration of flow in this channel, higher velocities are present, and sediment carried by influent storm water is conveyed directly into the lake. Channel erosion has also contributed to the total sediment volume entering the lake from DB-I.

This perennial tributary also receives surface flow directly from the nursery grounds, including irrigation return flows, via a bypass pipe that passes beneath Lagoon Valley Road from a collection and diversion structure on the nursery grounds. The nursery has an internal irrigation return flow collection system that sends nearly 100 percent of all nursery runoff to an internal 3-acre reservoir, where it is recycled for nursery use and also evaporates over time (Figure 6). However, once the reservoir is full, these collected waters from the nursery enter an overflow pipe and are discharged directly to the lake via the perennial tributary on the west side of Lagoon Valley Road. Much of the nursery's storm event runoff occurring during January through April cannot be contained in the nursery and therefore flows to the lake.

Local drainage basins to the east of the lake (DB's II, III, and IV) are relatively small compared to DB-I. The combined peak rate of runoff from these three basins is 481 cfs during the 100-year storm event. In the upper areas of these basins, runoff is conveyed by natural depressions, without the existence of defined channels. This condition allows much of the sediment originating from the steeper slopes near the headwaters to deposit across wide, and somewhat flatter areas east of the lake. As the flow spreads, its depth and velocity decrease which in turn reduces its ability to transport sediment. As a result, most of the sediment generated by the upper portions of these watersheds (at least during frequent storm events) is deposited along the slopes adjacent to the east of the lake and doesn't reach the lake. During major storm events, however, sustained velocities will be higher and some of the suspended sediment will enter the lake.

In the lower reaches of DB-II, III, and IV, headcutting has occurred at several locations where semi-concentrated runoff enters the lake. The headcuts have migrated upstream to the east at a very flat grade originating from the lake itself, and will continue to do so during storm events unless mitigation measures are implemented to control and prevent further migration. All of the material from existing headcuts have been directly into the lake.

4.2.2 Peak Discharge Calculation: The U. S. Army Corps of Engineers' HEC-1 computer model was used to develop a rainfall/runoff computer simulation for the drainage basins contributing to the lake. The HEC-1 computer model develops a runoff hydrograph for individual sub-basins through the input of numerical representations of their physical and hydrological characteristics. The computed hydrographs are then routed and/or combined with other sub-basins to yield a dynamic numerical analysis of peak discharges that may be expected to occur at a concentration point along a given flow path. The HEC-1 model was used to estimate flow discharges that would expected at key locations during the 100-year storm event.

Detailed hydrological analysis of the Lower Lagoon Valley was performed by Camp Dresser & McKee Inc. (CDM) in 1990. The study included HEC-1 analysis of the watershed contributing runoff to Lagoon Valley Lake under existing conditions. In April of 1992, Mackay & Somps Civil Engineers, Inc. performed a hydrologic study for Lower Lagoon Valley using the original HEC-1 model developed by CDM. The original HEC-1 model prepared by CDM was unavailable at the time that this report was prepared, and hence a new HEC-1 model for the watershed contributing runoff to Lagoon Valley Lake was developed. The new model, prepared as a part of this study produces slightly lower values than the CDM study.

The selection of input parameters for the new HEC-1 analysis is described in the following paragraphs:

- ***Drainage Basin Delineation*** - The U. S. geological Survey's(USGS) "Fairfield North" and "Elmira" quadrangle maps at 1"=2000' scale formed the basis for delineation of the overall watershed and sub-basins shown on Figure 5.

- ***Rainfall*** - Rainfall for the 100-year runoff event utilized in the hydrologic model was determined from NAOA Atlas, California. Rainfall distribution is based on the standard NRCS 24 hour, Type I distribution.

- ***Unit Hydrograph*** - For runoff computation from each sub-basin, the NRCS dimensionless Unit Hydrograph option was utilized in the HEC-1 computer model. Input data for the NRCS dimensionless Unit Hydrograph include the parameter, TLAG, which is equal to lag (in hours) between the center of the mass of rainfall excess and the peak of the unit hydrograph. The following equation (NRCS Curve Number Method) was used to estimate the lag time for each sub-basin:

$$TLAG = L^{0.8} \frac{(S+1)^{0.7}}{1900\, Y^{0.5}}$$

$$S = \frac{1000}{CN} - 10$$

TLAG = Lag time (hours).

L = Hydraulic length of watercourse (feet).
Y = Watershed slope (percent).
S = Maximum retention in the watershed (inches).
CN = Curve Number.

- **Curve Number (CN)** - Rainfall excess is that part of the precipitation depth that appears as surface flow during and after a storm event. Rainfall excess equals the total rainfall depth minus losses due to interception by vegetation, infiltration into the soil and surface depression storage. The NRCS Curve Number method uses a soil cover complex number (CN) for estimating watershed losses. The curve number (CN) is related to the underlying hydrologic soil group (A, B, C and D), land use, cover density and antecedent moisture condition.

- **Lake Routing** - A lake routing of the 100-year runoff through the lake was performed using the Modified Puls method option of lake routing of the HEC-1 computer program. Storage capacity of the lake was determined using the 1980 "as built" plan and the 1997 lake survey data.

The results of the HEC-1 analysis are presented in the following tables. Table 1 shows hydrologic parameters used in HEC-1 analysis and Table 2 presents the resultant 100-year peak discharges for existing conditions.

Table 1
Hydrologic Parameters used in HEC-1 Analysis

Drainage Basin	Area (Sq. Mi.)	Curve Number	% Impervious	Lag Time (hr.)
DB-I	1.84	80	13	1.55
DB-II	0.18	79	0	0.36
DB-III	0.21	79	0	0.42
DBI-V	0.11	79	0	0.28

Table 2
Summary of 100-Year Peak Discharges

Drainage Basin	Location	Area (Sq. Mi.)	Discharge (cfs)
DB-I	Lagoon Valley Rd.	1.84	924
DB-II	Lake	0.18	174
DB-III	Lake	0.21	191
DB-IV	Lake	0.11	116
TOTAL	Lake	2.34	1050

4.2.3 Evaluation of the 100 Year Storm: Lagoon Valley Lake presently serves a dual function of flood control and recreation. Based on an "as-built" grading plans, the lake covers an area of approximately 100 acres at elevation 215. An earthen dam forms almost the entire western boundary of the lake. The top of the dam is at elevation 217.5 and the spillway crest elevation is 213. The spillway is located at north end of the lake and consists of weir section approximately 30 feet wide. The low flow outlet is a slide gate underneath the weir section and has an invert elevation of 204.5 which can be opened to drain the lake. The maximum permanent water surface in the lake is at elevation 213 which is the elevation of the spillway crest. During major storm events, the water surface elevation would be temporarily higher as inflow increases the storage elevation until water can be discharged over the spillway.

In order to evaluate water surface elevation in the lake during the passage of the 100-year storm event, a lake routing was performed utilizing the HEC-1 computer model. Typical pre-storm lake stage-storage elevations and stage-outflows were selected as existing conditions/assumptions from which to run the model. The 100-year discharges from each of the drainage basins contributing runoff to the lake were then combined and routed through the lake. Initially, a water surface elevation of 213 (which is the crest of the spillway) was assumed. The lake stage-storage volume relationship used in the lake routing was based on the 1997 lake survey data. The stage-outflow data was established utilizing the equation for flow over a broad.crested weir. Tables 3 and 4 existing peak inflow, stage-storage and stage-outflow that occur in the lake during the passage of 100-year storm event.

Table 3
Lagoon Valley Lake 100-Year Peak Inflow
Pre-Storm Lake Level at Spillway

Peak Inflow (cfs)	1050
Assumed Pre-Storm Water Surface Elevation	213
Peak Outflow (cfs)	369
Peak Storage (ac-ft) Above Elevation of 213	243
100-year Water Surface Elevation	215.56

Table 4
Lagoon Valley Lake 100-Year Peak Inflow
Pre-Storm Lake Level 1 Foot Below Spillway

Peak Inflow (cfs)	1050
Assumed Pre-Storm Water Surface Elevation	212
Peak Outflow (cfs) Above Elevation of 212	291
Peak Storage (ac-ft)	293
100-year Water Surface Elevation	215.18

Summary: Based on the elevations of its earthen berm and spillway, the lake is currently capable of adequately detaining water from a 100-year storm under conditions of both low and high pre-storm lake levels. However, in the absence of watershed erosion mitigation measures, a relatively high rate of sedimentation will likely continue in future years, causing the lake's storage capacity to decline (see Section 4.4 below).

4.3 Lake Water Quality

All lakes are closely connected to the lands within their watersheds. The waters that feed a lake through surface and ground flow, transport and metabolize components of the surrounding land to the lake. Once in the lake, the effect of these water-borne chemicals and sediment on the lake is, in turn, influenced by the physical characteristics of the lake. In Lagoon Valley Lake, the water quality is affected by the following factors:

- inflow from the perennial tributary that enters the lake at its southeast corner;
- seasonal inflow from intermittent tributaries;
- springs that feed the perennial tributary and two springs that surface in the lake bottom north and south of the island;
- animal waste, organic debris, and fertilizer in the watershed that enter the lake via tributaries or sheet runoff;
- extensive waterfowl use of the lake and its shoreline;
- extensive growths of sago pondweed and both filamentous and planktonic algae during late spring, summer, and early fall;
- sedimentation from tributaries;
- solar radiation and temperature;
- water depth; and
- wind-produced turbidity.

4.3.1 Existing Water Quality: Results of water quality analyses for various parameters are discussed below.

Alkalinity - The waters of Lagoon Valley Lake originate mostly from surface runoff during the winter rainy season. While inflow from intermittent tributaries enter along the lake's eastern shoreline during the rainy season, the only perennial (year-round) inflow is from the tributary entering the southeastern corner of the lake. It is reported that the primary source of water for this perennial tributary during the summer months are several springs that occur in the drainage south of the lake. These springs and two springs occurring within the lake are described as "alkali " springs, meaning they have a relatively high concentration of mineral salts (Duane Davis, *pers. com.*). The presence of alkaline groundwaters is verified by the presence of halophytic (salt tolerant) vegetation along the lakes shoreline, such as salt grass (*Distichlis spicata*) and *Atriplex* sp.

Lagoon Valley lake has higher than normal dissolved mineral salts, as indicated by high specific electrical conductivity levels. Specific electrical conductance (EC) is a

Table 5 (Scott Table 1)

Table 5

Lagoon Valley Lake Water Quality Characterisitcs: Fall, Winter and Spring, 1997-1998

Date	Location	Nitrate as N	pH	Conductivity	Temperature	Turbidity
		mg/L	Units	umhos/cm	Degrees C	NTU
16-Oct-97	Near Inlet	5.30	8.7	1165	2	23
	Mid-Lake					
	Near Dam	1.25	9.0	785		20
13-Nov-97	Near Inlet	7.30	7.5	1242	10	37
	Mid-Lake					
	Near Dam	2.00	8.6	.670		75
11-Dec-97	Near Dam	0.75	9.0	555		28
	Wading Pool		8.1	3910		
	Adjacent Lake*		8.1	785		
26-Feb-98	Near Inlet	1.00	8.9	649	16	20
	Mid-Lake	9.00	7.1	284	8	7
	Near Dam					
12-Mar-98	Stream		7.7	397	26	12
	Near Inlet		7.5	952		9
	Mid-Lake	0.80	9.3	541	15	16
	Near Dam	4.00	8.0	325		90
	Wading Pool		9.3	1335		
	Adjacent Lake*		8.7	387		
7-May-98	Near Inlet					
	Mid-Lake	18.00	9.3	474	14	
	Near Dam		8.5	435		25
	Wading Pool		8.2	1455		
	Adjacent Lake*		7.7	384		
17-May-98	Stream		7.7	522	26	12
	Near Inlet		7.6	1202		9

* Adjacent lake refers to the lake in the vicinity of the wading pool.

Source: Will C. Wood High School (9th Grade) in conjunction with the City of Vacaville's Water Quality Laboratory.

common measure of dissolved salts in water. McKee and Wolf (1963) report studies that found that 50 percent of the waters of the United States supporting a "good " fish fauna have an EC of less than 270 umhos/cm and that 95 percent of these same waters have an EC of less than 1,100 umhos/cm. Table 5 shows several water quality parameters that were collected in 1997 and 1998 by a 9th Grade class of a local high school and analyzed with the help of the City of Vacaville's Water Quality Laboratory. The Table 5 column entitled "Conductivity" provides examples of fall, winter, and spring EC readings in several parts of the lake, the perennial tributary ("stream"), and the wading pool adjacent to the lake. The EC reported for the lake range from 284 to 1,202 umhos/cm with an average of 678 umhos/cm. It is not known the extent to which this elevated level of dissolved mineral salts is derived from alkali springs or from the salt accumulated in the underlying sediments of the lake (the lake sits on a former alkali flat).

The alkali characteristic of the lake water is also evident in the pH readings shown in Table 5 and in Table 6 which contains water quality data collected and analyzed by the City of Vacaville's Water Quality Laboratory in the summer of 1998. The pH values commonly exceed 9.0, and the dissolved oxygen levels in the lake ranged from 7.3 to 10.9. A pH reading of 7 is neutral, with less than 7 being more acidic and greater than 7 being more alkaline. McKee and Wolf (1963) cite findings that, of the United States waters supporting a good fish fauna, 50 percent have a pH of less than 7.6 and that 95 percent of these waters have a pH of less than 8.3. Lagoon Valley lake's pH readings were often between 8 and 9.

Turbidity - As shown in Table 5, Lagoon Valley Lake turbidity levels typically range from moderate to moderately high. During most of the year, strong winds from either the north (winter months) or south (summer months) blow across the lake. These winds in combination with a maximum water depth of about 8 feet keep the finer sediments of the lake bottom in suspension throughout the water column and greatly reduce water clarity. During the dry season, the water clarity may be further reduced when a bloom of planktonic (microscopic and free-floating) algae occurs.

Dissolved Oxygen - City of Vacaville's water quality data from the summer of 1998 (Table 6) indicate that dissolved oxygen levels in the lake ranged from 7.3 to 10.9. Based on the even higher dissolved oxygen levels in the wading pool, the July samples appear to have either been taken at a time of day when abundant aquatic plants elevated the dissolved oxygen levels through photosynthesis, or the wave action of the lake kept these levels up through a constant mixing with the atmosphere. A winter sampling of the mid-lake (January 20, 1999) found the dissolved oxygen to be 9.2 mg/L when the water temperature was 11.0 degrees C. Therefore, the City's August reading of 7.3 mg/L dissolved oxygen is suspected of being more typical of summer conditions in the lake. The lake's shallow depth and the strong wind conditions during the summer are assumed to prevent thermal stratification of the lake. Because the lake is reported to have extensive growths of sago pondweed and algae during the summer (Duane Davis, *pers. com.*), a diurnal (daily) fluctuation of dissolved oxygen levels is likely with the lowest concentration occurring just before sunrise. The water quality control basin plan for this region has a warm water dissolved oxygen objective of 5.0 mg/L (California RWQCB 1998).

Table 6 (Scott Table 2)

Table 6
Lagoon Valley Lake Dissolved Oxygen and Coliform Bacteria Characteristics - Summer 1998

				Coliform Bacteria	
Date	Location	pH	Dis. Oxygen	Total	Fecal
		Units	mg/L	MPN/100 mL	
22-Jul-98	Boat Dock*	4.6	9.2	>20,000	145
	Wading Pool	7.9	10.3	>20,000	1
	Near Dam	11.0	9.9	>20,000	3
29-Jul-98	Boat Dock	9.4	10.9	8,700	74
	Wading Pool	10.3	14.3	>200,500	0
	Near Dam	9.9	8.4	7,500	2
5-Aug-98	Boat Dock	9.2	7.3	31,000	12,000
	Wading Pool	10.0	3.2	101,000	15
	Near Dam	9.6	7.3	31,000	4
* The pH value of 4.6 is suspected of being in error.					
Source: City of Vacaville Water Quality Laboratory					

Bacteria - Total coliform bacteria levels are indicative of decaying organic matter, while fecal coliform bacteria levels are indicative of animal waste in the water. In waters designated for contact recreation, the fecal coliform concentrations based on a minimum of not less than five samples for a 30-day period shall not exceed a geometric mean of 200 MPN/100 mL, nor can more than 10 percent of the samples exceed 400 MPN/100 mL (California RWQCB 1998). The geometric mean of the six fecal coliform bacteria samples from the lake presented in Table 6 exceeds the above water quality objective because of one very high reading of 12,000 MPN/100 mL. The large numbers of domestic, cross-breed, and wild waterfowl using the lake for foraging and resting through most of the year results in substantial input of waste material to the lake. Some of this waste material is deposited directly into the lake, and the waterfowl waste deposited on the adjacent lands is washed into the lake during storm events. This waterfowl waste not only raises bacteria concentrations to levels unsafe for water contact recreation, but it is also is a source of nutrients that allow excessive growth of algae and rooted aquatic plants.

Nutrients - Appropriate amounts of nutrients are essential to the natural processes of a healthy aquatic ecosystem. However, excessive nutrient loading of an aquatic ecosystem will result in excessive growths of aquatic vegetation, phytoplankton, and algae. The over-abundant plants and algae lead to declines in dissolved oxygen levels, fish kills, noxious odors from decaying plant matter, public health concerns, and a degradation of fishing, boating, and swimming. The primary nutrients typically responsible for algae blooms and excessive plant growth are forms of nitrogen and phosphorus that are available for biological uptake. Nitrate and dissolved orthophosphate are forms of these nutrients that can be easily assimilated by plants. Because dissolved orthophosphate is so readily assimilated by plant life, it typically occurs in very low concentration in most natural waters. Relatively high levels of dissolved orthophosphate in water are usually a result of man's excessive use of fertilizer in the watershed.

The high nitrate levels shown in Table 5 are indicative of a eutrophic lake having an over-abundance of nutrients and excessive growth of rooted aquatic plants and algae. To avoid algae blooms, nitrate levels should be less than 0.3 mg/L and dissolved orthophosphate levels be less than 0.01 mg/L (McKee and Wolf 1963; USEPA 1973; Gangstad 1986). A further discussion of nutrient levels is provided below.

To determine the source of nutrients entering Lagoon Valley Lake, water samples from the lake and its tributaries were collected in 1999 on three occasions: 1) prior to rainfall (January 12), 2) immediately following the first moderate rain that resulted in the intermittent tributaries flowing to the lake (January 20), and 3) immediately following a heavy rain (February 9). These water samples were analyzed for nitrate and dissolved orthophosphate, and the results are presented in Table 7 and Figures 7 through 13. Note that the only tributary that had flow and could be sampled prior to the rain was the perennial tributary (PT1) entering the south end of the lake. The locations of the sampling stations are shown on Figure 7. Sampling results are summarized below:

- ***Nutrients in Lake Waters*** - Prior to the first rains, nitrate levels were mostly below 0.3 mg/L with the highest level (0.51 mg/L) near the inlet (Figure 8). During the first rains, nitrate levels decreased slightly near the inlet, but rose to 0.32 – 0.67 mg/L at other sites with the highest being the western shore. The increase in nitrate levels

Table 7 (Scott Table 3)

Table 7
Lagoon Valley Lake and Tributaries Nutrient Levels, January and February, 1999

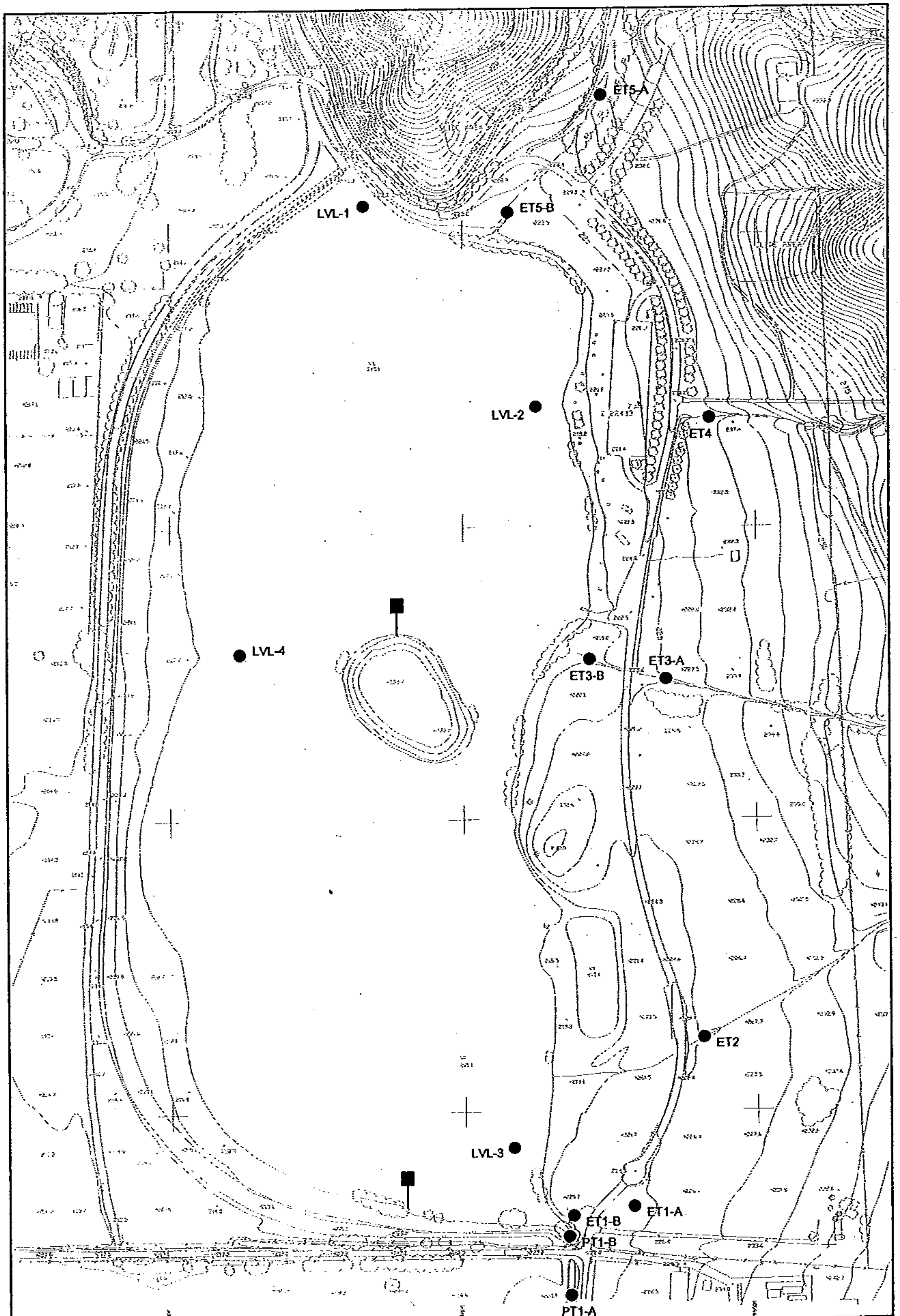
	January 12, 1999 Prior to Rainfall		January 20, 1999 After Moderate Rainfall	
Lake Stations	**Nitrate as N (mg/L)**	**Dis. Ortho-P (mg/L)**	**Nitrate as N (mg/L)**	**Dis. Ortho-P (mg/L)**
LVL1	0.27	1.09	0.32	0.82
LVL2	0.28	1.19	0.46	0.76
LVL3	0.51	1.14	0.46	0.82
LVL4	0.29	1.16	0.67	1.48
Average	0.34	1.15	0.48	0.97

	January 12, 1999 Prior to Rainfall		January 20, 1999 After Moderate Rainfall		February 9, 1999 After Heavy Rainfall	
Tributary Stations	**Nitrate as N (mg/L)**	**Dis. Ortho-P (mg/L)**	**Nitrate as N (mg/L)**	**Dis. Ortho-P (mg/L)**	**Nitrate as N (mg/L)**	**Dis. Ortho-P (mg/L)**
PT1-A	16.40	0.66	9.30	19.60	0.80	1.20
PT1-B	19.40	0.69	10.40	20.40		
ET1-A					0.05	0.20
ET1-B			0.31	0.42		
ET2					0.05	0.60
ET3-A			0.21	0.28		
ET3-B			0.14	0.31		
ET4			0.68	0.58	0.90	0.10
ET5-A			0.60	0.38	0.40	0.10
ET5-B			5.10	0.35		

Note: Dis. Ortho-P is dissolved orthophosphate.

Source: Field sampling by LSA Associates with analysis by ETS Labs and CalTest Analytical.

Figure 7



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● PT1-A Sampling Sites

■ Trap Net

N

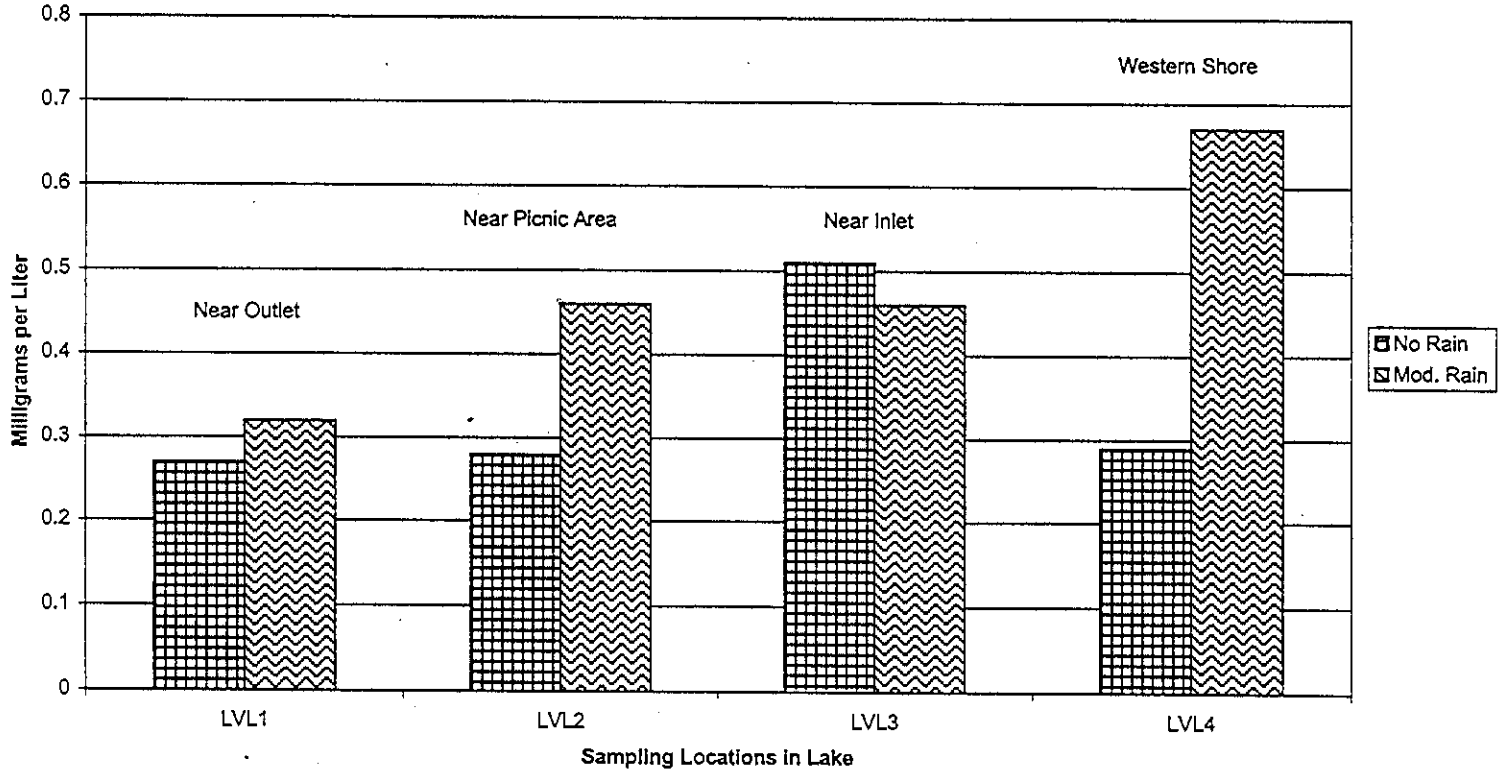
LSA

Scale in feet 0 300

Figure 7

Location of Water Quality and Fish Sampling Sites

Figure 8 -- Nitrate levels - lake



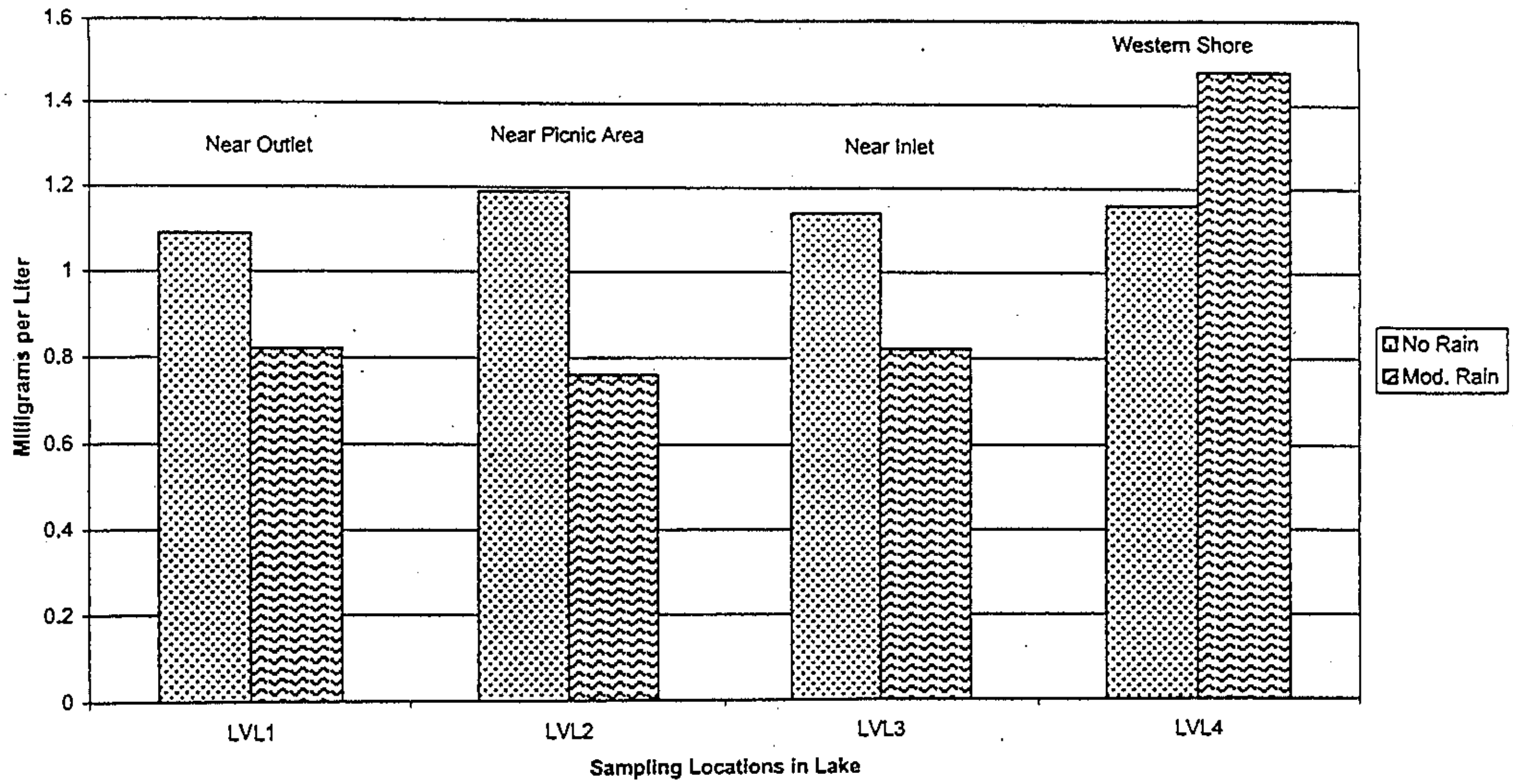
05-20-99(COV831nitrate)

Figure 8

LSA

Nitrate Nitrogen Levels in Lagoon Valley Lake,
January 12 and 20, 1999

Figure 9 – Orthophosphate levels - lake



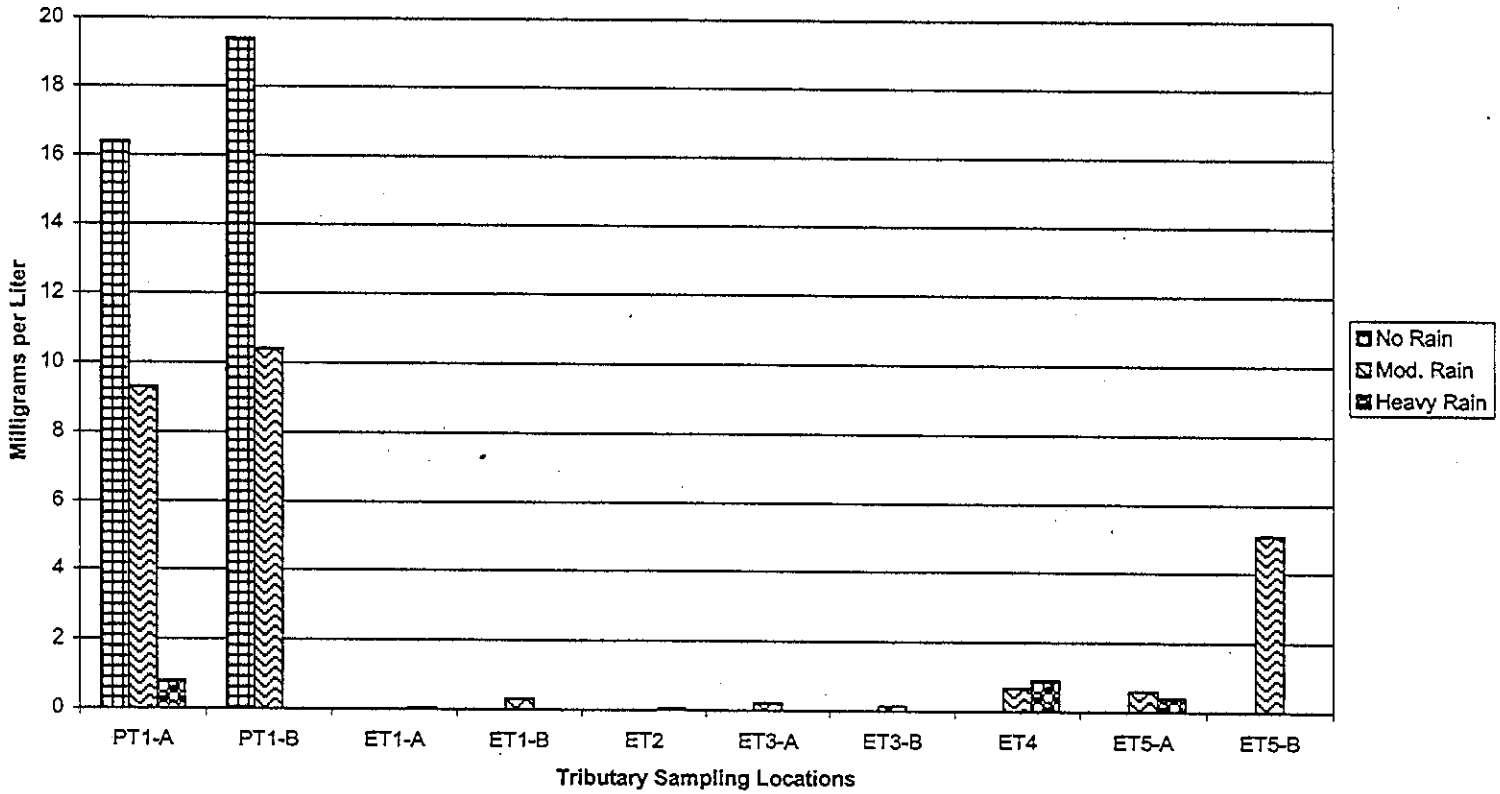
05-20-99(COV831orthophosphate)

Figure 9

LSA

Dissolved Orthophosphate Levels in Lagoon Valley Lake, January 12 and 20, 1999

Figure 10 – Nitrate levels in perennial tributary



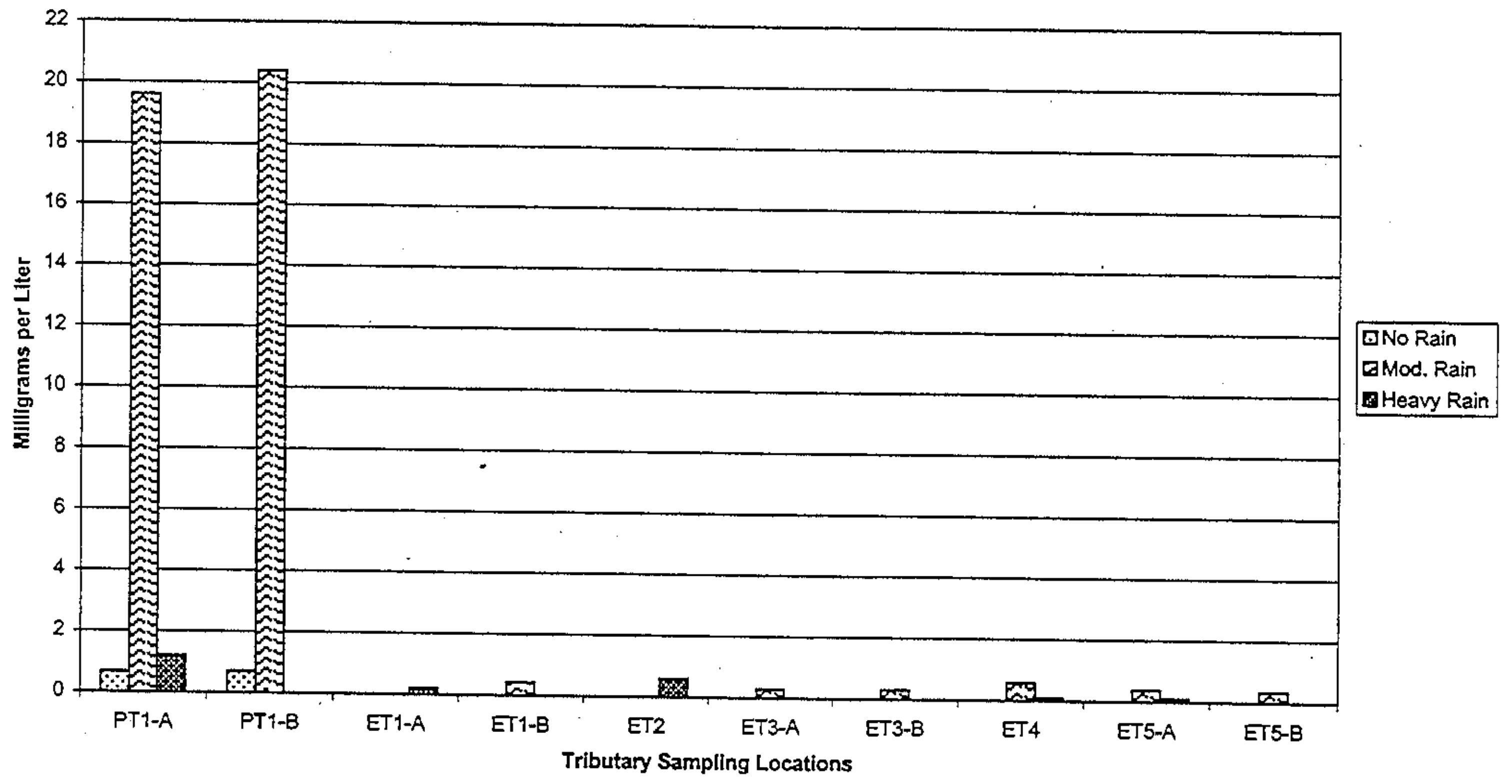
05-20-99(COV831Tributaries-Nitrate)

Figure 10

LSA

Nitrate Nitrogen Levels in Tributaries to Lagoon Valley Lake, January 12 and 20, 1999

Figure 11 – Orthophosphate levels in perennial tributary



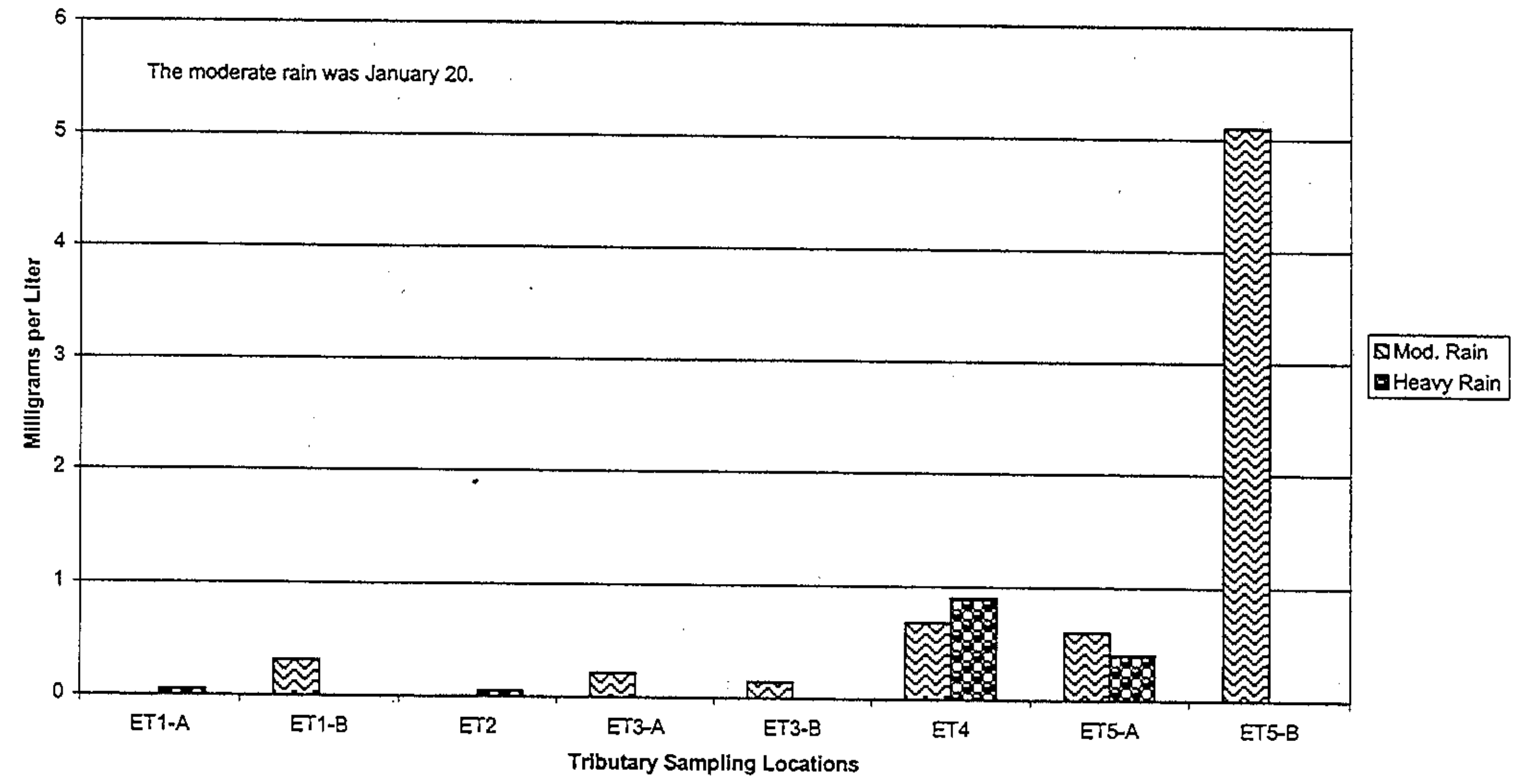
05-20-99(COV831Tributaries-Ortho)

Figure 11

LSA

Dissolved Orthophosphate Levels in Tributaries to Lagoon Valley Lake, January 12 and 20, 1999

Figure 12 – Nitrate levels – intermittent tributaries



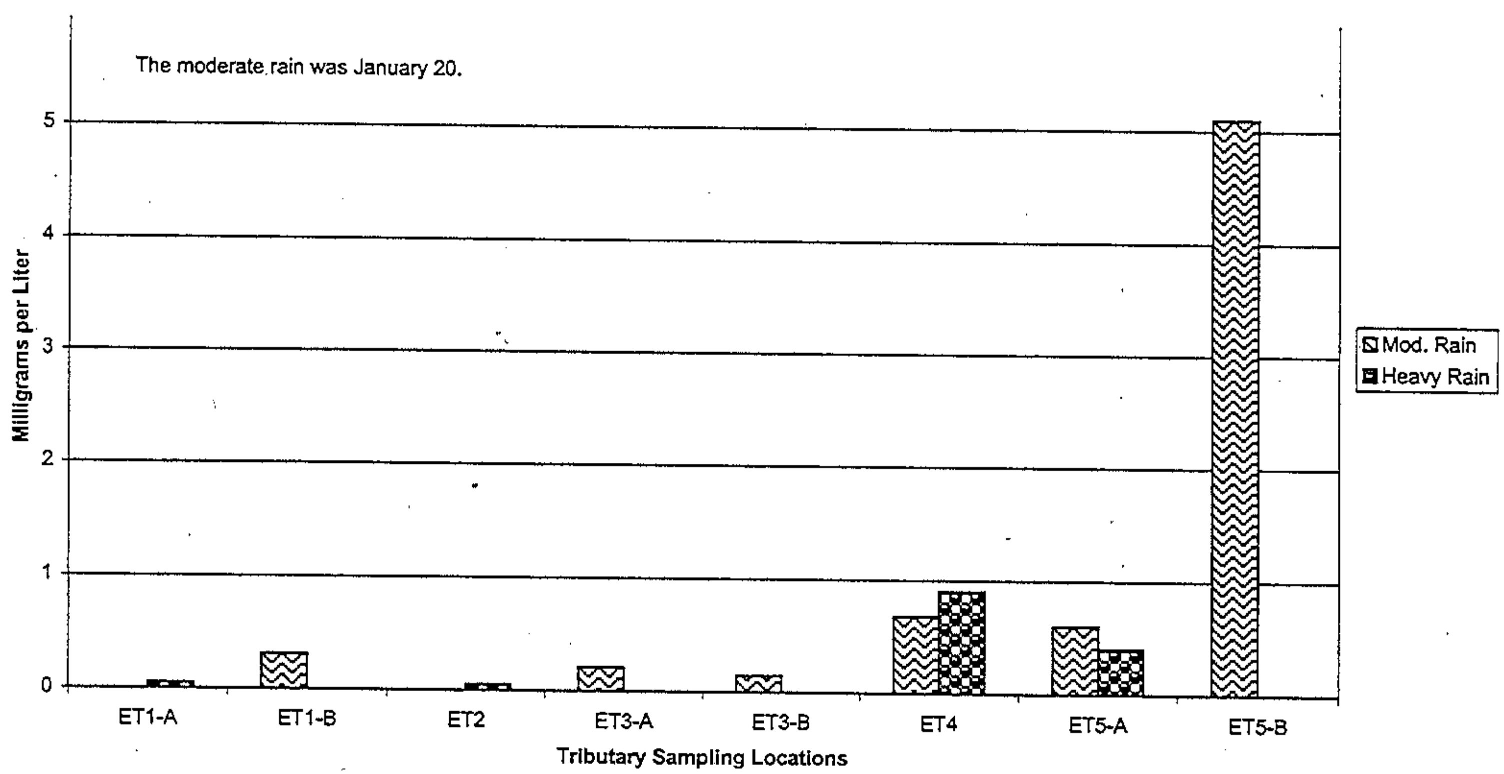
05-20-99(COV831Ephemeral-Nitrate)

Figure 12

LSA

Nitrate Nitrogen Levels in Ephemeral Tributaries to Lagoon Valley Lake, January 12 and 20, 1999

Figure 13 – Orthophosphate levels in intermittent tributaries



05-20-99(COV831Ephemeral-Ortho)

Figure 13

LSA

Dissolved Orthophosphate Levels in Ephemeral Tributaries to Lagoon Valley Lake, January 12 and 20, 1999 is probably reflecting the waterfowl waste contribution. The rains likely caused a runoff of waterfowl waste from the land into the lake, raising nitrate levels in various portions of the lake. The drop in nitrate levels near the inlet (LVL3) is small, and may be a result of the large drop in nitrate levels in the perennial tributary that occurred with the rain (see the tributary discussion below).

Lake water dissolved orthophosphate concentrations prior to the first rain were relatively consistent across the lake (1.1 – 1.2 mg/L). Runoff from the first rainfall diluted the lake concentration at three of the four sampling stations (0.76 – 0.82 mg/L), but it rose from 1.16 to 1.48 mg/L at Station LVL4 on the lake's western shore (Figure 9). No explanation is offered regarding the Station LVL4 rise in dissolved orthophosphate levels. The drop in this nutrient at the other three stations suggest either that the runoff inflow diluted the lake concentration of dissolved orthophosphate or that lake conditions became favorable for phytoplankton growth which then consumed a portion of the available phosphorus. However, a notable increase in planktonic algae was not noticed during the sampling.

- ***Nutrients in Tributary Waters*** - Figures 9 and 10 illustrate the significance of the perennial tributary as a contributor of nutrients. Nitrate levels were highest before the first rain, which suggests the following: 1) the groundwater that feeds this stream may have naturally high levels of nitrate, or 2) the nitrate fertilizers used at the nursery are entering the groundwater or the sump basins from which they pump water to the stream. Although waterfowl waste is another possible source of nitrates, no flocks of waterfowl have been observed in the perennial tributary channel.

  The dissolved orthophosphate levels rose dramatically with the first rains. This strongly suggests that runoff from the nursery is the source of this nutrient, given the association of orthophosphate with fertilizers. First rain concentrations of contaminants in stormwater runoff are typically higher than later rains that occur after much of the accumulated chemical have been washed away.

  The intermittent tributary nutrient concentrations are plotted in Figures 11 and 12 at a scale more suitable to these relatively low levels. Prior to the first rain there was no flow in these creeks, so the plotted data are for the first rain (moderate rain) and the heavy rain that was sampled in February when the creeks were flowing strongly.

  Most nitrate concentrations are less than 1 mg/L, but Station ET5-B stood out with a reading of 5.1 mg/L. This station is located at the lower end of the northernmost tributary in the park. A sample taken from this tributary at the same time but slightly upstream of the paved entrance road (ET5-A) had a reading of 0.6 mg/L nitrate. This difference in nitrate levels is likely the result of the waterfowl waste that littered the grounds on the lake-side of the road.

  The next highest levels of nitrate came from stations ET4 and ET5-A (0.68 and 0.6 mg/L). Unless there is more waterfowl use of the land above the paved access road than it appeared during the sampling, these nitrates may be from cattle waste in the upper watershed.

Dissolved orthophosphate levels in the intermittent tributaries were 0.6 mg/L or less with the highest concentrations associated with stations ET2 and ET4, both of which are located on the upland side of the entrance road. For those stations that were sampled during both storm events, the higher levels of dissolved orthophosphate occurred during the first storm. Compared to the dissolved orthophosphate concentrations in the perennial tributary, the contributions of the intermittent tributaries are relatively minor.

Summary of Lake Water Quality Problems: There are two major problems concerning the water quality of the lake. First, excessive nutrient loading, in combination with much of the lake being less than 6 feet in depth, creates massive growths of aquatic plants and algae that cover most of the lake during the summer. These growths interfere with beneficial uses such as swimming, boating, fishing, and general aesthetics, and may lead to dissolved oxygen depletion and fish kills. Based on sampling data, the primary source of these nutrients is the perennial tributary that receives direct runoff from the Hines Nursery during the rainy season. Domestic waterfowl wastes also play a role in nutrient enrichment of the lake. The limited data available suggests that cattle grazing in the lake's watershed, at least for the lands draining the intermittent tributaries, is not a significant contributor of nutrients to the lake. The second water quality issue is the periodically high levels of fecal coliform bacteria that prohibit water contact recreation. Domestic waterfowl are also the most probable cause of this problem.

4.4 Sedimentation, Water Depth, and Need for Lake Deepening

In addition to determining the major sources of sediment contributing to the lake, it is important to understand the significance of the cumulative amount of sediment that is being deposited. All lakes and lakes formed by dams on natural water courses are subject to some degree of sedimentation. Sediment is the end product of erosion or wearing away of the land surfaces by the action of water, wind and gravity. Lakes and lakes are most affected by sediment that is transported by water. The cumulative volume of sediment can be determined by determining the lake's present capacity (storage volume) and subtracting this from its original capacity storage volume. For the purposes of this assessment, storage capacity was evaluated at the lake level of elevation 215 feet NGVD, which is 2 feet above the spillway crest and 2.5 feet below the top of the dam embankment. The volume of accumulated sediment deposited in the lake can then be used to determine an average annual sedimentation rate and to better understand the need for sediment control measures.

In order to determine the amount of sediment accumulation in Lagoon Valley Lake, the "as- built" grading plan dated 1980 and the most recent lake survey data dated January 1997 (performed by Johnson Land Survey) were obtained from the City and reviewed in detail. According to the "as-built" grading plan, the original lake surface area was 90 acres at elevation 210 and the lowest original lake bottom elevation was 204.5. Based on the 1997 survey, the lake now covers an area of approximately 77 acres at elevation 210 and the lowest bottom elevation is 207.5. This indicates an average of three (3) feet of sediment accumulation has occurred at the bottom of the lake since the lake was created.

Using the above-mentioned topographic information, a Stage-Storage relationship was developed to determine storage capacity of the lake at different elevations for the original (1980) and more current (1997) conditions. Table 8 and Table 9 represent the Stage-Storage relationship of the lake for 1980 and 1997 data respectively.

Table 8
Lagoon Valley Lake Stage Storage Relationship -1980

Elevation	Storage (acre-feet)
*204.5	0
208	130
210	306
215	773
* = Lake Bottom Elevation	

Table 9
Lagoon Valley Lake Stage Storage Relationship – 1997

Elevation	Storage (acre-feet)
*207.5	0
210	83
215	424
* = Lake Bottom Elevation	

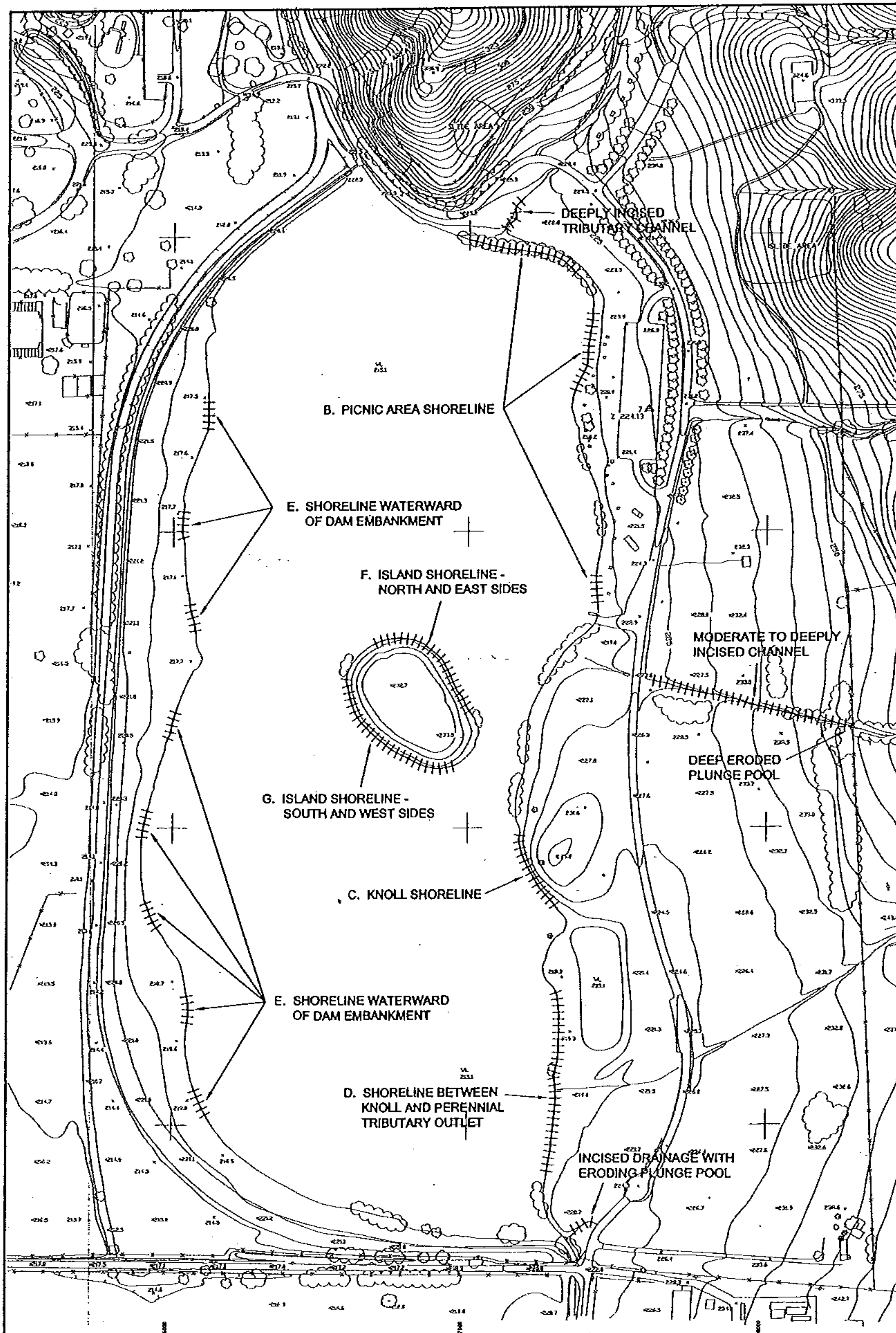
Summary: Elevation-Storage relationships indicate that Lagoon Valley Lake has lost approximately 130 acre-feet (AF) of storage at elevation 208, 223 AF at elevation 210 and 349 AF at elevation 215 (storage capacity) in the past 17 years. This amounts to an average annual sedimentation rate of 20.5 AF/year. As identified in Section 4.2 above, the main sources for this sediment is soil erosion associated with the contributing watersheds and channel bank erosion from channels, and headcuts that feed directly into the lake. The largest drainage basin (DB-I) is the primary source of these sediments.

4.5 Shoreline Erosion

In general, shoreline erosion to the lake itself does not appear to be a significant cause of lake sedimentation problems at this time. The majority of the shoreline is moderately-well vegetated and the slopes to the water's edge are gradual. However, some segments of the lake's shoreline are experiencing some degree of bank failure or slumping of material into the lake. Most lake shoreline erosion problems can be attributed to wind and wave action against the water's edge. Failure to take shoreline stabilization actions will likely cause these problems to get worse. The most significant shoreline erosion problems are shown on Figure 14 and are described below:

A. ***Northeast Shoreline*** - This stretch of shoreline is characterized by the presence of mature willow and cottonwood trees with heights of 10-25 feet. Despite the

Figure 14 – Shoreline and tributary erosion problem areas



05-21-99(COV831erosion)

N
LSA

Scale in feet
0 300

Figure 14

Shoreline and Tributary Erosion Problem Areas success of woody shoreline vegetation in this area, prevailing wind and wave action have caused intermittent zones of steep cut banks, with 2 to 4-foot vertical drops to below the ordinary high water line (OHWL). In several locations willow and cottonwood roots have become exposed due to bank undercutting. Unless shoreline stabilization actions are taken, this problem will likely become worse, ultimately resulting in the toppling of mature trees into the water.

B. ***Picnic Area Shoreline*** - This shoreline has two segments of minor erosion problems separated by a segment of non-eroded shoreline with sapling and mature willows and cottonwoods. The eroded segments have a 2 to 3-foot vertical cut bank to below the OHWL, where a more gradual slope begins.

C. ***Knoll Shoreline*** - South of the boat ramp, the shoreline is protected from prevailing wind and wave action by the island and is in good condition with gradual slopes and mature willows and cottonwoods. A small sediment delta from an intermittent tributary has also developed in this area. However south of the island, the shoreline is again exposed to wind and wave action and becomes eroded in the area waterward of the knoll. Steep cut, poorly vegetated banks with 5 to 8 foot vertical drops occur in this area. Unless shoreline stabilization actions are taken, this problem will likely become worse.

D. ***Shoreline between Knoll and Perennial Tributary Outlet*** - This stretch of shoreline has a low level of erosion problems, due to the partial protection from winds provided by a mature stand of willows along the lake's south shore. Erosion problems consist of a 1 to 2-foot vertical cut bank to below the OHWL, where a more gradual slope begins. Occasional cottonwood and willow trees have taken hold.

E. ***Shoreline Waterward of the Dam Embankment*** - A 50 to 200-foot wide zone of sediment and fill material occurs waterward of the compacted dam embankment along the west shoreline of the lake (Figure 14). This zone is very gently sloped and well vegetated with grasses and ruderal species. However, at the edge of the water, occasional segments of minor erosion occur above the OHWL. The eroded segments have a 1 to 3-foot vertical cut bank to below the OHWL, where a more gradual slope begins.

F. **Island – North and East Sides** - Moderately eroded banks, with 2-3 foot vertical drops, are found on these sides of the islands. A number of sapling and mature willows have become established along these banks.

G. **Island – South and West Sides** - Due to exposure to wind and wave action, these sides of the island are more heavily eroded, with steep cut banks of 3 to 5 feet and fewer trees. Unless shoreline stabilization actions and/or windbreak measures along the west shoreline are taken, this problem will likely become worse.

4.6 Fisheries

4.6.1 Historical Conditions: When Lagoon Valley Lake was completed in 1982, it was stocked with redear sunfish and largemouth bass and is reported to have been a good recreational fishery (Fred Meyer, *pers. com;* Duane Davis, *pers. com.*). In the mid-1980's, a wet winter caused the outlet stream to back up and overtop the lake's spillway. Sacramento blackfish, a species native to the Sacramento-San Joaquin River Delta, entered the lake at that time. Blackfish populations rapidly flourished while bass and sunfish populations declined for several reasons. First, blackfish are able to successful reproduce in the lake at a higher rate than bass or sunfish. Second, blackfish young grow at a significantly faster rate than the juvenile largemouth bass (they quickly became too large to serve as prey for juvenile largemouth bass). Finally mature blackfish out-compete juvenile largemouth bass.

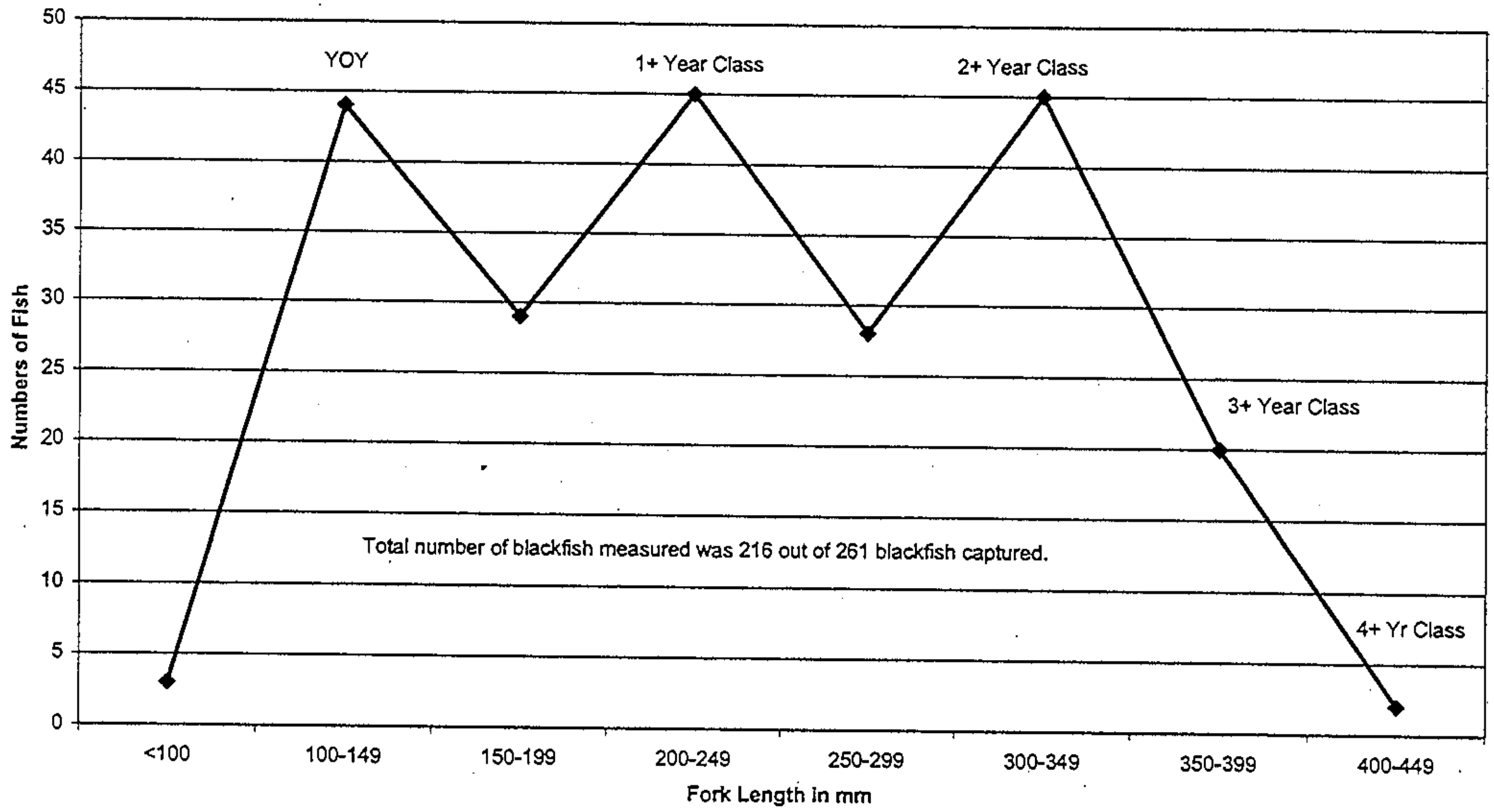
Sacramento blackfish are well adapted to existing water quality conditions in Lagoon Valley Lake. Blackfish favor warm, shallow and turbid waters and are tolerant of high levels of dissolved solids. They are primarily filter feeders on planktonic algae and zooplankton, but they may also feed on invertebrates on the bottom. Blackfish mature at 2 and 3 years of age. Spawning occurs April through July at 12 – 24 degrees C in shallow water with heavy growth of aquatic plants. The eggs are extruded onto plants or rocks in water depths of 18 to 90 cm (7 to 35 inches). The young-of-the-year (YOY) blackfish occur in small schools close to shore and feed mostly on the bottom for midge larvae (Moyle 1976). Sacramento blackfish are not considered to be a sport fish, but are commercially harvested for the live fish markets of urban Chinese communities.

California Department of Fish and Game has tried a variety of approaches to resurrect the sport fishery. Channel catfish and striped bass were introduced in the hope that they could control the numbers of blackfish. Habitat structures for largemouth bass were constructed and placed in the south end of the lake. These approaches failed, so the lake was chemically treated in October 1988 to kill all the fish. The lake was then stocked with crappie, bluegill, redear sunfish, Sacramento perch, channel catfish, and striped bass were introduced to the lake. All of these approaches failed to create a productive sport fishery because the following winter, the outlet stream again flooded and allowed blackfish to re-establish themselves in the lake.

4.6.2 Existing Conditions: To provide a current assessment of the lake's fish composition, the lake was sampled January 21, 1999 using two trap nets with a 100-foot lead net (all netting was 3/8-inch mesh). The nets, fished for 22 hours before retrieval, yielded a combined total of 261 blackfish, 425 Sacramento perch, and one channel catfish (see Figure 7 for trap net locations). The blackfish were mostly YOY, 1+, and 2+ year class fish with lesser numbers of 3+ and 4+ year class fish (Figure 15). The Sacramento perch were mostly 1+ year class fish followed by YOY and lesser numbers of 2+, 3+, and 4+ year class fish (Figure 16). Year class size information for these two species was obtained from Moyle (1976), Carlander (1969), and Carlander (1977). The maximum fork length of the fishes captured was 420 mm (16.5 inches) for the blackfish and 255 mm (10 inches) for the Sacramento perch.

Sacramento perch are the only native member of the sunfish family occurring west of the Rocky Mountains. This California native was originally an inhabitant of Central Valley sloughs, sluggish rivers, and lakes. They evolved to withstand high turbidity, temperature, salinity, and alkalinity. Their habitat preference is rooted and emergent aquatic vegetation, which also serves as spawning and nursery habitat. Sacramento perch mature during their 2nd or 3rd summer and spawn when the water temperature is 21-29 degrees C, usually from late March to early August. Spawning occurs in 20-50

Figure 15 – Sacramento blackfish – size distribution



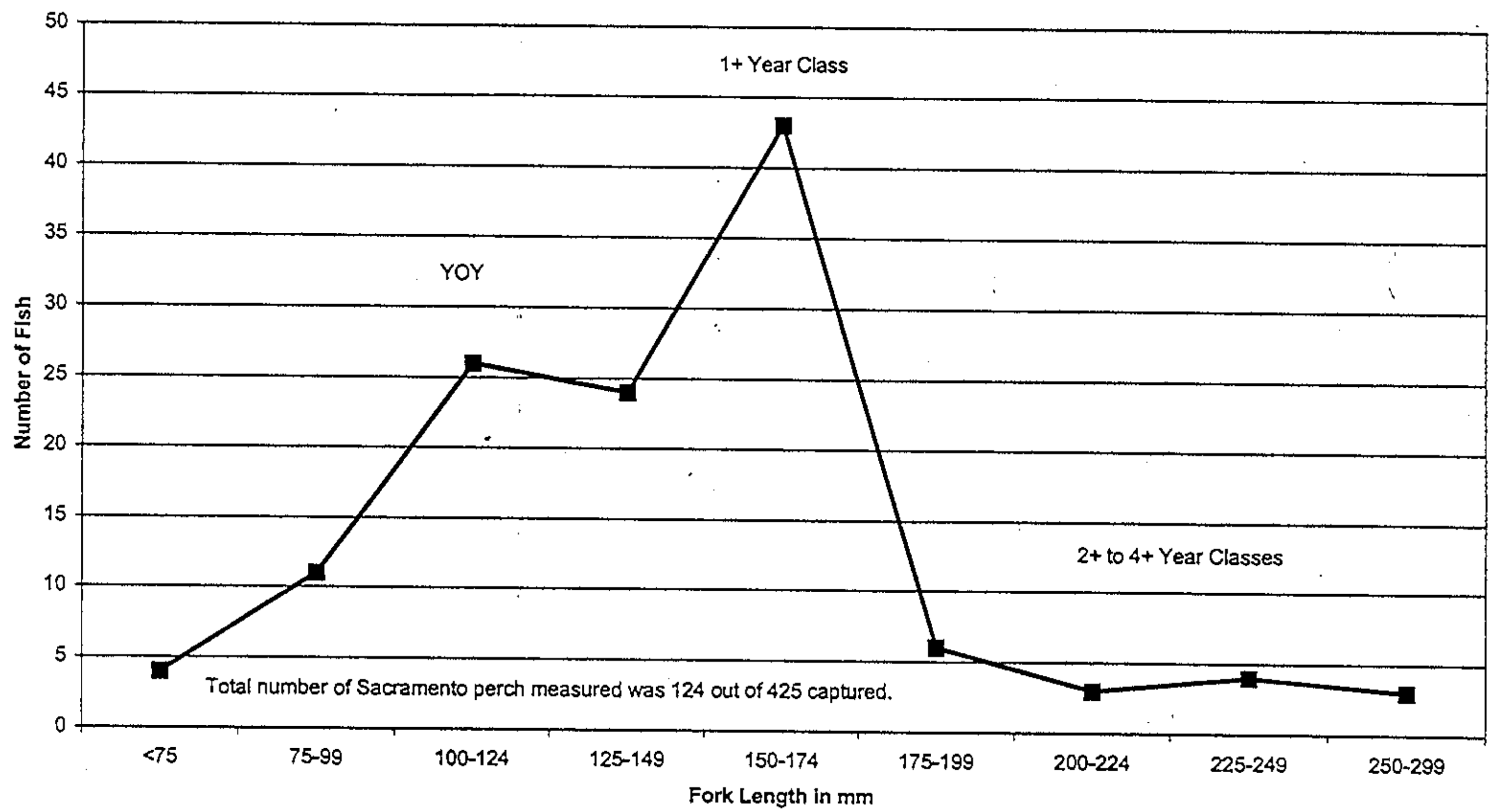
05-20-99(COV831blackfish)

Figure 15

LSA

Sacramento Blackfish Size Distribution,
Lagoon Valley Lake, January 21, 1999

Figure 16 – Sacramento perch – size distribution



05-20-99(COV831perch)

Figure 16

LSA

Sacramento Perch Size Distribution, Lagoon Valley Lake, January 21, 1999 cm (8-20 inches) deep water over heavy growths of plants or algae, or occasionally rock piles, sticks, or roots. The YOY feed mostly on small crustaceans, then insect larvae. Sacramento perch spend most of their time close to the bottom near submerged objects (Moyle 1976). California's Sacramento perch population has declined dramatically because of habitat loss and competition from introduced species. The California Department of Fish and Game uses Lagoon Valley Lake as one of their sources of Sacramento perch when they need to stock this species in other waters.

For the past 5 years, a commercial fisherman has been annually seining nearly the entire lake during early February for the purpose of removing the larger blackfish to sell live to the Chinatown markets. His operation uses seines (3.5-inch stretch mesh) that are 600 to 1,000 feet in length and 10 feet in depth. His lake seining of January 26, 1999 yielded the usual large numbers of blackfish and Sacramento perch, plus one carp and two goldfish (Mark Meadows, *pers. com.*).

4.6.3 Summary of Fisheries Problems: All attempts to establish a productive sport fishery in Lagoon Valley Lake have been adversely impacted by the presence of large numbers of Sacramento blackfish. Although the Sacramento perch is a sport fish and is present in the lake in large numbers, they are reported to be surprisingly difficult to catch by anglers (Fred Meyer, *pers. com;* Duane Davis, *pers. com.*). The lack of a predator species that would prey on young Sacramento perch may be causing a predominance of small perch and far fewer numbers of the more desirable larger perch. A key to creating a productive sport fishery in Lagoon Valley Lake is to eliminate or greatly reduce the numbers of Sacramento blackfish in the lake. Another impediment to recreational angling in the lake is the extensive growths of sago pondweed and filamentous algae that fills much of the lake each summer. There is very little open water that can be fished from shore, as only the deepest portions of the lake are free of pondweed.

4.7 Waterfowl Studies; Special Status Species Observations

Waterfowl studies were conducted at Lagoon Valley Regional Park on February 10, 1999 and March 5, 1999. Each survey required approximately three to four hours to complete, and involved recording and mapping all waterfowl and other waterbird species observed and the number of individuals of each species. The area searched included the lake, bypass channel and upland areas surrounding the lake. Other wildlife species observed were also recorded in field notes.

4.7.1 Waterfowl and Waterbirds: Twelve species of waterfowl and thirteen species of other waterbirds were observed on the Lagoon Valley Regional Park. In addition, domestic geese and ducks were observed. The total number of individual waterfowl and other waterbirds observed on February 10 and March 5, 1999 was approximately 825 and 693 individuals, respectively. Approximately 92 percent (a maximum of approximately 777 individuals) of all waterfowl and waterbirds observed on each site visit were geese, ducks and American coots, including 52 domestic geese, 174 wild geese (predominantly Canada geese [large form]), 279 ducks (including 110 mallards and domestic ducks and 120 ruddy ducks) and 283 American coots. A maximum of approximately 620 waterfowl and American coots were observed foraging at upland sites near the lake, primarily on the east shore where the grass was maintained by mowing. These include 225 geese, 110 mallards and domestic ducks, and 283 coots. In addition, approximately 55 gulls (ring-billed and herring gulls) were observed foraging at upland sites on the east shore of the park. Table 10 provides a summary of waterfowl and other waterbirds observed, their numbers and the general location of observations.

The maximum number of waterfowl and other waterbirds that could occur at any time at the park may exceed 2,000 birds. The number of species and individuals of waterbirds at the park would vary seasonally, and other waterbirds have occurred at the lake in high numbers in the past, including: over 100 American white pelicans observed for short periods of time in the fall and winter; 200 or more lesser snow geese/Ross' geese, between January and March; an undetermined number of "grebes or loons" (possibly western/Clark's grebes) in July and August; and an undetermined number of diving ducks (*e.g.* ruddy duck) during the winter months (Dwayne Davis *pers. com.*). Because of the size and depth of the lake, the numbers of diving ducks using the lake during the winter for resting and foraging could vary considerably.

4.7.2 Waterfowl Concentrations in Relation to Lake Bacterial Levels:

Waterfowl can be a major source of bacterial contamination of small or shallow lakes. Relatively low numbers of resident and/or seasonal migratory waterfowl produce disproportionately high fecal coliform bacterial levels as a result of direct waste excretion into the waters and from runoff from upland roosting areas. This problem becomes compounded when waterfowl become domesticated due to feeding of them by people. Such feeding causes waterfowl to become near-permanent "residents" of picnic grounds, increasing and concentrating waste excretion in these areas.

As discussed in Section 4.3 above, limited sampling data suggest that fecal coliform levels in Lagoon Valley Lake greatly exceed the maximum allowed under state health regulations for waters designated for contact recreation. These high bacterial level are consistent with both the large number of hybrid and domesticated ducks occurring along the eastern shoreline, and with the overall large number of migratory waterfowl that occur seasonally (up to 2,000 birds) in the lake. By contrast, Lake Temescal in the Berkeley Hills, a relatively shallow small lake (approximately 10 surface acres) that allows swimming, is able to maintain acceptable coliform levels as long as waterfowl numbers are below a 20-25 limit. This would translate to a maximum of 200-260 waterfowl for Lagoon Valley Lake. However this assumes relatively even distribution around the lake. Based on site observations (Table 10), approximately 25 percent of waterfowl concentrations occur in and along the eastern shore picnic area, which is also the potential area for a wading beach. This suggests that a goal of greatly limiting or fully eliminating waterfowl along the eastern shoreline is needed to have any realistic possibility of attaining safe coliform levels for a wading beach. Assuming the eastern shoreline and adjacent lake waters encompass about 25 percent of the lake surface area, the maximum number of waterfowl in this area should be in the range of 50-60 birds.

It should also be noted that coliform levels could be reduced by an overall deepening of the lake. There is somewhat of a synergistic relationship between bacterial levels and shallow lake depth with high nutrient levels. Deep lakes do not support the extensive growths of aquatic weeds because such weeds are generally restricted to the photic zone (< 6 feet), and they are better able to dilute nutrient concentrations. This is turn creates less suitable conditions for sustaining high bacterial counts. For example, Lake

Anza, which allows swimming, has a depth of 55 feet but does not have a coliform problem despite waterfowl usage comparable to Lagoon Valley Lake.

4.7.4 Summary: Lagoon Valley Lake and the adjacent uplands provide significant resting and foraging seasonal habitat for migratory waterfowl, particularly geese, ducks and American coots. Foraging activities by both migratory, domesticated birds and gulls tends to be concentrated on the east shore where the grass is maintained by mowing. The concentration of birds in these areas corresponds to the limited coliform bacterial data which shows extremely high levels in the waters below the eastern shore.

Table 10
Summary of Water Bird Survey Results

Species	Upland – East Shore Between Dam and Boat Ramp	Upland – East Shore, South of Boat Ramp	Pond (old swim lagoon)	Lake	Upland – West Shore	Marsh	Bypass Channel	Island	Total
Pied-billed Grebe							2/1		2/1[1]
American White Pelican	0/2							2/0	2/2
Double-crested Cormorant				0/4				2/9	2/13
Great Blue Heron								1/0	1/0
Great Egret								0/1	0/1
Snowy Egret								1/0	1/0
Black-crowned Night Heron								0/1	0/1
Swan (unidentified)								1/0	1/0
Domestic Goose	45/35[2]	7/6						0/6	52/47
Greater White-fronted Goose	2/0	0/2							2/2
Snow Goose		0/1							0/1
Canada Goose (large form)	50/14[2]	102/81			17/10		0/10	0/25	169/140
Canada Goose (cackling)	2/0	0/2							2/2
Mallard/Domestic Ducks	44/31[2]	7/0	8/4	14/55		17/4	18/6	0/10	108/110
Cinnamon Teal			0/3						0/3

Table 10
Summary of Water Bird Survey Results

Species	Upland – East Shore Between Dam and Boat Ramp	Upland – East Shore, South of Boat Ramp	Pond (old swim lagoon)	Lake	Upland – West Shore	Marsh	Bypass Channel	Island	Total
Canvasback			1/0	12/0					13/0
Ring-necked Duck			1/0						1/0
Lesser Scaup				6/0					6/0
Common Goldeneye							1/0		1/0
Bufflehead			13/25				1/0		14/25
Ruddy Duck				103/120		4/0			107/120
Sora (rail)							0/1		0/1
American Coot	128/70		90/38	29/43	20/20		16/1	0/15	283/187
Killdeer	4/0	6/5							10/5
Common Snipe		0/1							0/1
Ring-billed Gull	18/20	0/6		30/0					48/26
Herring Gull		0/2		0/3					0/5
TOTAL	293/172	122/106	113/70	194/225	37/30	21/4	38/19	7/67	825/693

(1) Numbers represent number of individuals seen on the February 10/March 5, 1999 survey. (2) Geese and ducks were observed at upland sites and on the lake. (3) American coots observed both on upland and in pond.