

A YEAR IN THE LIFE OF LAKE MERRITT



The Lake Merritt Institute

September, 2002

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Tide Graph: Week of November 19, 2001

A YEAR IN THE LIFE OF LAKE MERRITT

Prepared by The Lake Merritt Institute: September, 2002

INTRODUCTION

Just as summer, fall, winter and spring sweep across the land, so do these seasons effect Lake Merritt. As one month changes into the next, the appearance of the Lake changes; one day murky and brown, the next sparkling and clear. Algae, trash and waterfowl appear as if out of nowhere, and then vanish. Throughout the year, these natural cycles are blended with man-made events, forming a collage that is relatively unique to this lagoon, but also common to other aquatic worlds. This "panorama of time" unfolds before us every year, although much of it cannot be easily seen.



Glen Echo Cove - January, 2001

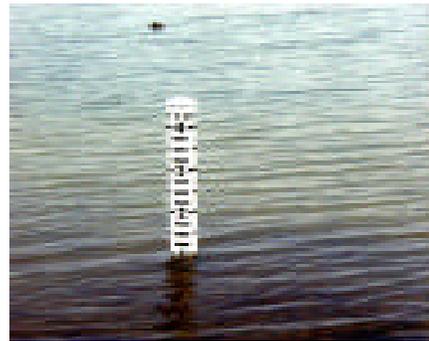
Underwater, a myriad of plants and animals follow natural laws and instincts as they cope with the changes that we have imposed on their life cycles. Sometimes we marvel at their beauty and fecundity; sometimes we complain about the smell. The seasons present both opportunities and challenges. Why do these things occur, and what can we learn from them?

This calendar is an attempt to capture with words some of the natural phenomena that the Lake exhibits to us. It is however, only accurate to the extent that we have observed and understand these events. Many of these themes have been poorly studied at the Lake, and are therefore not well understood. There is much to be learned, such as how much nitrogen cycles through the Lake and its impact on seaweed growth. It is our hope that publishing this calendar will help people better understand how Lake Merritt works, thereby leading to a better understanding, appreciation and management of this multiple-use, natural resource.

FUNDAMENTAL ELEMENTS OF A LAKE CALENDAR

Rainfall / Runoff: More than anything else, Lake Merritt is effected by rainfall and urban runoff from the 4,670 acre watershed. Water from this area flows downhill and enters the Lake through 60 storm drains, diluting salt water from the Bay and bringing trash, car wash soap and anything else dumped on the pavement into the Lake. The Lake Merritt Institute maintains a rain gauge to help us predict how much trash will be in the Lake after a storm. Recent monthly averages in inches at our gauge have been: January - 6.42; February - 9.77; March 2.28; April - 1.44; May - 1.09; June - 0.07; July - 0.05; August - 0.24; September - 0.34; October - 0.97; November - 3.84 and December - 3.43.

Tidal Flows: Most of the water you see in Lake Merritt came from San Francisco Bay via twice daily tidal flows. Computer modeling by a professional hydrological firm has shown that Lake water has an average residence time of about four days. Actual flows however, are highly variable. For a better understanding of tides, click on the "Tidelines" button at our website.



One of our five tide gauges

Unfortunately, tidal flows are muted by the shallow channel connecting our Lake to the Oakland Inner Harbor. Narrow constrictions where the tidal channel crosses 10th and 12th Streets limit flows to and from the Lake. While the Bay experiences a tidal range of 6.4 feet, the range in the Lake is only 1.5 - 2.0 feet. For more details, see the White Paper on Tidal Flows at our website <http://www.lakemerrittinstitute.org/>

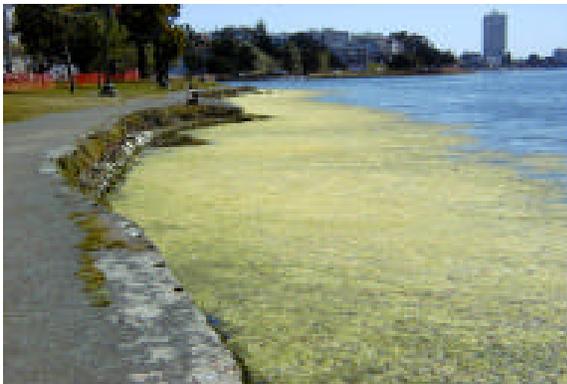


All tidal water entering and leaving the Lake must flow under 10th Street through these restrictive culverts. Replacement with a bridge would allow better tidal circulation and passage for boats, fish and wildlife.

Flood Control: Water levels at Lake Merritt are controlled by a flood control station using tide gates and pumps operated by Alameda County. The station is designed to handle storms up to those statistically likely to occur once in 25 years. Larger storms, such as a 50 or 100 year event, will cause flooding. Lake Merritt floods when the water exceeds 3.0 feet as shown on the Lake's six tide gauges. When this level is exceeded, there will be water on the shoreline path in a few locations, offices at the Boating Centers may flood, and the parking lot by the boat ramp will be slightly inundated. However, during much of the rainy season, you will see the Lake at an elevation of only 1.0 feet because the Lake is held artificially low for flood control. The two foot difference is flood control capacity over the Lake's 140 acres.

Floods can occur when runoff from rainstorms coincides with an incoming tide. To reduce the chance of this happening, The County Flood Control District operates tide gates and a pumping station along the Estuary Channel. Although the pumps are almost never used and tide gates are normally kept open, incoming tides are restricted if there is a 50% chance of rain in a forecast received twice weekly by the District. Restriction of incoming tides exacerbates the low oxygen problem that often occurs in the winter. Low oxygen occurs in the bottom layer of water, which cannot drain because the outlet is five feet higher than the Lake bottom. This bottom layer is not flushed when high tides are kept out of the Lake due to flood control.

Plant Growth (plankton, algae and widgeon grass): Lake Merritt exhibits dramatic changes in appearance as aquatic plants go through their natural cycles. Although unseen except through a microscope, one celled plants called plankton dominate the Lake during most of the year. They are the reason the water typically appears murky, green, brown and even almost red.



Algae grows only in shallow water



The harvester boat unloads

Algae (mostly Enteromorpha and Cladophora) grows in large quantities during the spring and early summer, but only in the shoreline area where depths are four feet or less. Although a very beneficial part of the food chain, it becomes a nuisance when there is too much of it, causing odors and depleting oxygen levels when it decays. Algae is kept in check by removal with the harvester boat, operated by

the Oakland Public Works Agency.

Widgeon grass is a rooted plant that grows from tubers across much of the Lake bottom, reaching lengths of 10 feet and requiring removal by the harvester boat. Each year this plant spreads to ever increasing areas of the Lake making it harder to control. For details on its growth patterns, see the discussion under spring and summer below.



Algae growing on widgeon grass creates towers which billow up from the Lake bottom in the spring.

Urban Runoff: Every month the Institute removes between 1,000 and 7,000 pounds of trash from Lake Merritt. During months when there is less than one inch of rain, the average removed is 1,840 pounds. During months when there is more than one inch, the average removed is 4,475. Obviously, most of the trash is carried in by rain. This trash includes dozens of cigarette lighters (we made them into a sculpture) thousands of plastic bags and wrappers, hundreds of bottles and cans, uncountable pieces of styrofoam and thousands of cigarette butts. Interestingly, we have also removed dentures, a cell phone, a no littering sign, a safe, a television set, an armchair, a parking meter, unmentionable clothing, a football trophy, a hand carved pumice candle holder, a fire extinguisher, an assault rifle, a clay mask, drugs, numerous car parts, and a magic wand.



Oakland's first storm drain filter was installed at Lake Merritt in September, 2001. This new technology has no moving parts and requires minimal maintenance. It removes many pollutants from urban runoff before they reach the Lake.

Water Quality (oxygen, salinity, visibility and bacteria): Lake Merritt's water quality is constantly changing in response to tidal flows, urban runoff, plant growth, numbers of waterfowl, and management activities such as lake level control and plant harvesting. Based on monthly bacterial monitoring by Alameda county, the Lake is suitable for body contact such as swimming and windsurfing during the dry season. After a heavy rain, the Lake stratifies into an upper, fresh water layer and an lower, salty layer. The United States Environmental Protection Agency has listed Lake Merritt as an impaired body of water due to trash and low oxygen conditions, which occur in the bottom layer. The salinity ranges from fresh water behind barriers at creek outlets to near that of sea water at the Lake center during the summer. Visibility is determined by plankton density, which is determined by nutrient availability and competition with seaweed. Overall, the Lake is a highly enriched tidal lagoon, over-fertilized by urban runoff.

Biological Activity: In 1870 the California legislature passed a law making it illegal to take, kill or destroy any wild animal in Lake Merritt and within 100 rods of the high water mark. Although this law created the nation's first wildlife refuge, these restrictions have since been generally extended to the entire County, thus making the refuge status similar to other areas of Oakland. But preservation of natural habitat (even though only in remnants) and continual feeding has created a refuge for waterfowl and many forms of aquatic life in the midst of a high density urban area. The park's wild (and semi-domestic) animals are admired and enjoyed by thousands of people every day.



Topsmelt; a common Lake fish



About 90 species of birds are known to visit or permanently inhabit the refuge, including Canada geese that number over 1,500 during the early summer molting season. Fish species include small leopard sharks, topsmelt, sticklebacks, gobies, sculpin, surfperch, pipe fish, striped bass, salmonids, bat rays and halibut.

This is not an ice cream sundae. Tubeworms, mussels, barnacles and other encrusting organisms have grown onto this styrofoam cup while it drifted upside down in Lake Merritt. In addition, shrimp, clams, bryozoans, sea squirts, sea anemones, comb jellies, sponges and sea slugs are known to inhabit the Lake. Most of these sea creatures thrive mainly in the summer months when urban runoff and flood control practices do not limit their ability to survive.

A MONTHLY CALENDAR OF LAKE EVENTS

Month	Rainfall (Avg. '98 - '01)	Tidal Flow Control	Plant Growth	Urban Runoff	Water Quality	Biological Activity
January	6.42	Restricted if rain forecast is 50% or higher	Plankton dominant	Trash, woody debris: High creek flows	Trash and low oxygen / odor problems	▲ Waterfowl activity; minimal underwater life; large fish die
February	9.77	"	Plankton dominant	Trash, woody debris: High flows	Trash and low oxygen problems	▲ Waterfowl activity; minimal underwater
March	2.28	"	Plankton dominant	Trash: Moderate creek flows	Transitional	Transition: Migratory bird #'s declining
April	1.44	Seldom restricted	Shoreline Algae dominant	Less trash	Improving	Goslings appear; fish spawning
May	1.09	Lake held high 2 days/wk for plant harvesting	Shoreline Algae fades; Widgeon Grass Grows	Less trash: Decreasing creek flows	Better	Mallard ducklings; Rapid shellfish growth.
June	0.07	Lake held high 2 days/wk for plant harvesting	Widgeon Grass peak growth	Minimal trash; mostly from shoreline: uses	Good; Visibility up to 10 feet. OK for body contact	Peak: Halibut, rays enter Lake. Goose #'s greatly increase
July	0.05	Lake held high 2 days/wk for plant harvesting	Decaying Widgeon Grass	Minimal trash: Residual creek flow	Becoming murky; Odors; OK for body contact	Geese dominate; pelicans, terns dive for fish
August	0.24	Lake held high 2 days/wk for plant harvesting	Plankton levels increase, then decline	Minimal trash: Minimal creek flow	Good; OK for body contact	Red algae appears; Goose #'s decline
September	0.34	Seldom restricted	Possible red tides	Paint, cement etc. often a problem	Clear; OK for body contact	Cormorant numbers greatly increase;
October	0.97	Restricted if rain forecast is 50% or higher	Plankton levels increase	The "Big Flush" of trash, road chemicals etc.	Bacterial levels increase	Cormorants & coots increase; fish numbers decline
November	3.84	"	Plankton dominant	Trash, leaves	Trash and low oxygen problems	1,000+ migratory waterfowl
December	3.43	"	Plankton dominant	Trash, leaves	Trash and low oxygen problems	▲ Waterfowl activity; minimal underwater

SPRING (March - May)

Summary: Life blooms in the water as warmer temperatures and longer days stimulate breeding by fish, birds and plants. Plankton flourishes while barnacle and shellfish growth begins. Worms can be seen spiraling underwater in their spawning dance. As rainfall diminishes, trash becomes less visible, and water quality improves. Normal tidal flows become more common as the threat of floods subsides, reducing the chance of odors. Underwater, widgeon grass growth begins in April and becomes noticeable in May. Algae, absent in March, dominates the shallows in May. From highrise buildings the shallow shoreline may appear as green as a lawn. By late spring, goslings and baby mallards delight almost everyone, including seagulls that feed on them.

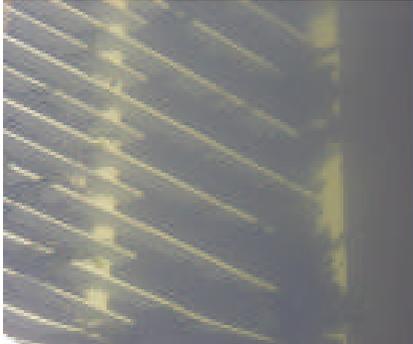


Goslings Drink Fresh Water From a Storm Drain

Rainfall: The average precipitation measured in our gauge at Lake Merritt between 1998 and 2001 dropped from 2.28 inches in March, to 1.44 inches in April, and 1.09 inches in May. Big storms less common, and rainfall typically occurs on ten, four and three days in these spring months. Creek

and storm drain flows are cleaner, with little woody debris and few leaves.

Tidal Flows and Flood Control: As rainfall and the threat of floods both diminish, the County Flood Control District allows the tide gates to remain open during high tides more often. Salt water inflow occurs more frequently, mixing with the bottom waters of the Lake and improving oxygen levels in this layer. This increased flushing removes urban runoff pollutants and stimulates biological growth.



At the 7th Street flood control station, all tidal flows must pass through bars that are only 4 inches apart. Every other bar at the bottom is cut to provide 7.5 inch openings as shown here at the right side of the photograph. This is known to limit large bat rays from entering the Lake.

Plant Growth: In May, several types of algae grow vigorously in the shallow waters. Most common are light green filaments of *Cladophora* and *Enteromorpha*, along with the darker green sea lettuce (*Ulva*). This growth is limited to 20 - 25 feet of the shoreline where the water is only zero to four feet deep. At greater depths, light penetration is not sufficient for growth. By mid-May, algae may cover the entire shoreline area out to deeper water, blanketing the area in bright green where only murky water existed just a month before. Towers of algae billow up, providing both shelter and food for both fish and invertebrates. Patches of black, velvet like material (probably bacteria) grow on the bottom and break off, floating around and giving the Lake a bad reputation from those who do not understand that this is a natural event.



Algae Dominates the Shoreline in spring

Urban Runoff: The average amount of trash removed between 1998 and 2001 for both March and April exceeded 3,500 pounds, but by May this figure drops to 1,885 pounds. Since trash removed is a measure of trash in the water, the Lake looks cleaner in late spring, a welcome sight after months of litterbug leavings on display in the shallows. As the season ends trash seen in the water is mostly hand thrown and wind blown, not washed in through storm drains.



Storm drains such as this one carry litter, animal waste and road film to Lake Merritt. Illegally dumped oil, cement, paint, anti-freeze et cetera also flow (un-treated) to the Lake, entering it through sixty storm drain outfalls, which are numbered around the shoreline. If you see illegal dumping of hazardous waste, call 911. For other illegal dumping and littering, call the City Litter Enforcement Officer at 434-5101.

Water Quality: Water quality improves dramatically in the spring. The combination of less urban runoff and increased tidal flows results in fewer man-made chemicals (oil, soap, fertilizer etc.) entering the Lake and a healthier bottom environment. The stratification into top and bottom layers that marked wet winter months occurs less often. Oxygen levels are less of a problem during this time as photosynthesis (which produces oxygen) increases in response to longer day length and warmer temperatures.



Students from the Oakland High School Environmental Academy take weekly water quality samples during the school year.

In 2002 the City of Oakland installed two continuously recording water quality monitoring buoys to measure oxygen, temperature and salinity at the surface and bottom.

As the season progresses, the water becomes saltier, allowing marine organisms to flourish. Nutrients however, are plentiful, having been deposited in the sediment from leaves and other organic matter washed in all winter. Spring applications of lawn fertilizer at golf courses, cemeteries and homes also end up in the Lake, especially if excessively used and applied before a rain.



The Bandstand Fountain aerates water

Biological Activity: Just as March roars in like a lion and goes out like a lamb, spring sees the diminishing of winter's migratory ducks. At winter's end the embayment by the Nature Center still hosts hundreds (or more) of them. By late May they are gone, leaving the Lake to the year round residents, most of whom are busily breeding. By early April the first goslings of the season have hatched, followed later by mallard ducklings, which often end up as dinner for voracious seagulls. The boat barrier across the Trestle Glen arm is removed as rowers go where rafts of scaup, teal and coots recently slept.

Little is known about when the Lake's various fishes spawn here, but by mid-April the shallows are full of tiny fish fry. On calm nights the surface is alive with ripples as breeding activity increases. Juvenile surf perch have been found in the Lake, and it is likely that topsmelt and sticklebacks also breed at this time.



Juvenile fish found in Lake Merritt



Fishing is legal at Lake Merritt

Those who stroll around the shoreline may see the curious spiraling dance of reddish polychaete worms as they go through their spawning ritual. Other invertebrates (animals without backbones) are also busy flooding the water with eggs which hatch into larvae and swim around. Barnacle and mussel growth is quite rapid in the spring and tens of thousands of half inch long mussels can be seen in the shallow waters. Within only a few months they will be full grown at 3 - 4 inches long.



During the molting season, 1,896 geese were counted at the Lake on July 2, 2002

SUMMER (June - August)

Summary: June is a month of transition as algae disappears and widgeon grass takes over. By July, boating classes have started and the Lake is filled with colorful sailboats, kayaks and canoes. Wind surfers sail, fall and climb back up again. Goose numbers increase dramatically as molting birds from elsewhere seek out the sanctuary of the park (and leave large quantities of fecal material on the lawns and sidewalks). Pelicans and terns return, amazing us with their aerial acrobatics as they dive for topsmelt and other small fish. Lake waters become extremely clear, then revert back to their murkiness. Water temperatures rise and clumps of red algae appear, as do crabs and shrimp. Trash removed from the shoreline is minimal but still exceeds 1,000 pounds per month. Spills of paint are sometimes seen entering the Lake from storm drains as home improvement activity and illegal dumping increase. Flood control is not a problem, but the tide gates are still typically closed for two days a week so that Lake elevation can remain high for the harvester boat. By August, the widgeon grass is gone and increased numbers of cormorants can be seen diving on schools of fish.



Summertime Means Boating on Lake Merritt

Rainfall: Rain is essentially absent during these summer months, averaging less than 0.1 inch in June and July and less than 0.25 inch in August. This is

both good and bad as urban runoff is greatly reduced, but trash builds up on the streets, in storm drains and in creeks, waiting to be flushed into the Lake. When an unusual summer storm does occur, it can wash large quantities of trash as well as bacteria from avian feces into the water.

Tidal Flows and Flood Control: Without rain, there is no threat of floods. But the tide gates are still closed for two days during the week so that water levels can be kept high for operation of the harvester boat. This allows it to work closer to the shoreline where cut pieces of widgeon grass and algae accumulate. During these days, the Lake is prohibited from draining, and high tidal flows are kept out. Other exceptions occur when the flood control structure is cleaned of barnacles, mussels and tube worms by divers, and when Oakland requests continued high water on a weekend for boat races.

Plant Growth: Just as shoreline algae dominates the Lake in late spring, so does widgeon grass dominate in early summer. This grass is not a type of algae, but a rooted plant that produces seeds. It became prominent in the Lake in the 1970's, was mostly removed by dredging in 1985, and has been growing back ever since then. It flourishes during periods of maximum day length and light intensity, and grows up from the bottom to lengths of eight or more feet across parts of the Glen Echo arm and much of the Lake center.



Widgeon grass grows from roots



In June & July, un-counted tons of widgeon grass are removed from the Lake.

If uncontrolled by the City's harvester boat, it can severely restrict boating, foul the waters when it rots, and produce odors. Uncounted tons of it are removed as the Public Works Agency works seven days a week during the

peak growing season. As the Lake slowly fills with sediment and the grass spreads, control by the harvester becomes more demanding. Eventually, widgeon grass growth will exceed the capacity of the harvester to remove it. In recent summers large quantities of the rotting grass have accumulated along the shoreline. By late July to early August, it finishes its growing cycle and is gone.

Long term control can be achieved by dredging, which removes the roots from which the plant grows. An ideal situation would be to harvest from May - July, and dredge during August and September. This is recommended in the Lake Merritt Master Plan, and would require the City to obtain its own small dredge boat at a cost of about \$100,000. Shoreline algae reappears in August, but at much lower quantities than in the spring.

Urban Runoff: Trash in the Lake is at a minimum during the summer, but litterbugs still manage to deposit about 1,000 pounds per month. Some of this comes from vandals who throw City trash containers directly into the Lake. In the summer of 2001, five of the cardboard boxes were pulled from the shallow waters after their accumulated trash had sunk or drifted away.



Soap and grease on its way to Lake Merritt via a storm drain

Unfortunately with the reduction in trash comes an increase in pollution from oil, soap, paint, cement, plaster and other home improvement activities. This is most often visible near the outfall of Glen Echo creek, where the channel leading to the Lake sometimes turns white, fish die and plants are killed. In 2001, nine such spills were recorded from Glen Echo creek and an additional 21 spills were recorded from other storm drain outfalls around the Lake.

With increased summer activity around the Lake, unusual items also find their way into the water. Among our "Catches of the Day" are: A bowling ball, a bridal veil, a 3.5 foot long striped bass, a clay mask, a metal toilet

paper dispenser, a folding chair, a 15 inch dildo, and a four inch thick foam mattress and a fire extinguisher. Shopping carts are another favorite of vandals; three of them were removed in the summer of 2001.

Water Quality: Except for bacterial levels, no recent data on water quality exist for the summer, but this information is being gathered in 2002. The absence of this information prevents conclusions from being drawn regarding stratification and oxygen levels.

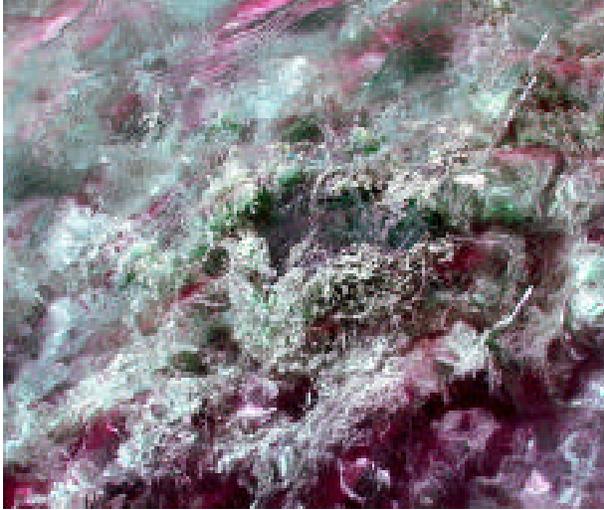


Water quality in Lake Merritt during the summer is adequate for body contact sports, including wind surfing and swimming.

Use of a snorkel and mask allow underwater inspection of the summer widgeon grass beds.

Water clarity however, increases to as much as 7 - 10 feet in June during the peak growing season for widgeon grass. Along the shoreline and across much of the Lake's center the bottom is visible, showing us a myriad of plants, fish, mud and shells. This clarity is thought to result from greatly reduced plankton (microscopic plant life) growth, which is probably due to a reduction of available nitrogen. Where does the nitrogen go? A simple glance at the widgeon grass gives the answer. But when the grass finishes its growing cycle and dies in July, nitrogen is returned to the system, plankton again flourishes and water clarity decreases. During the summer, the Lake essentially shifts from a system dominated by plankton to a system dominated by rooted plants, and back to plankton domination again. This is why water clarity changes.

Biological Activity: "Gee, there really are fish in the Lake" is often heard during the summer as millions of gobies, sculpins, sticklebacks, topsmelt and even pipefish move into the warm, shallow waters where they can be seen. And there to feed on them are the wading birds; snowy and common egrets by day and black crowned herons by night. In July of 2002, 197 snowy egrets were counted at the Lake, shaking their yellow feet to scare up fish.



Patches of pink - purple bacteria are sometimes seen along the shallow shoreline in areas where widgeon grass and algae are decaying. The bacteria breaks down plant material, just like composting.

Geese however, now dominate Lake Merritt in the summer. When their molting season begins in late May - early June, numbers of these birds at the Lake increase from several hundred to as many as 1,800 or more. Since each bird defecates about as much as an adult person, many areas of lawn and sidewalk become fouled with fecal material during the summer. Lawns become impossible to use for picnics, and large areas of the shoreline are covered with excrement.



Excessive goose droppings

It wasn't always this way: Prior to the mid-'40s, Canada geese appeared only rarely at Lake Merritt. By the mid-90's, their numbers had grown to about 300 - 400 birds. This increase mirrors the national situation, and at numerous golf courses, athletic fields and other cities with too many geese, their numbers have been reduced by management practices.

At Lake Merritt however, the birds are not managed, and the numbers keep increasing. By summer's end the molting season is over, some two year old birds fly away, and the number of geese at the Lake declines to a level that is less likely to spread diseases such as avian cholera and botulism. These threats however, are very real during the summer.

LAKE MERRITT WATER QUALITY

The following two pages depict temperature, salinity and dissolved oxygen levels near the center of Lake Merritt. These data were recorded by the City of Oakland's water quality monitoring probes, which were installed in June of 2002. Measurements are recorded every 15 minutes, seven days per week both near the surface, and near the bottom (at about 8 feet deep).

Information is downloaded weekly by a consultant operating under contract to the City. The data are entered into a computer, analyzed by software, and transmitted to the City on a quarterly basis. Over the course of several seasons, this information will be valuable in determining how often the Lake is stratified into fresh and salty layers, the intensity of the stratification, and the duration that stratification lasts. This monitoring is part of Oakland's planning efforts to improve water quality, and hopefully to eventually remove the Lake from EPA's list of impaired bodies of water.

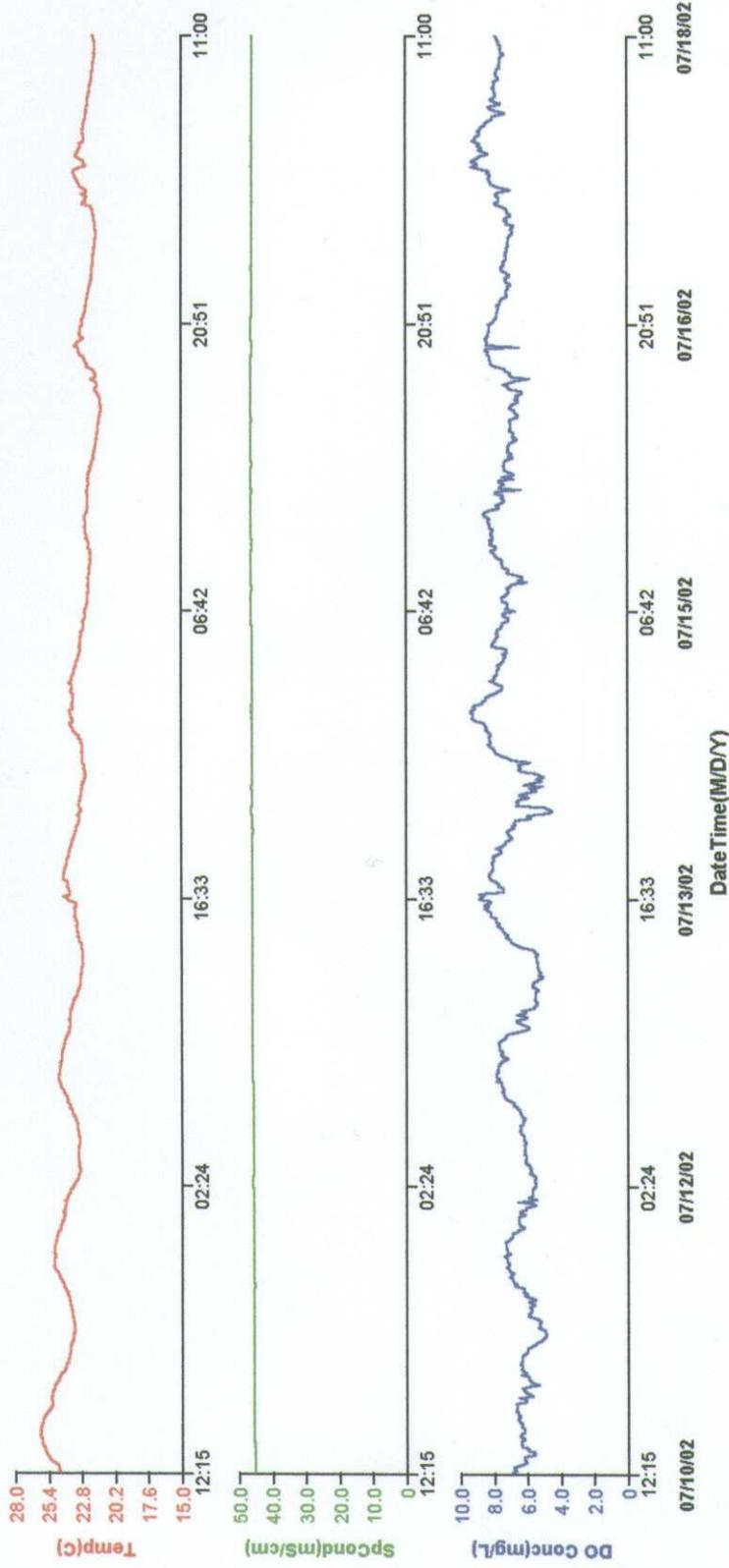
Temperature: Daily variations in temperature are clearly visible in the 24 hour rise and fall as shown on the graph. During cloudy days, this change is less visible. Temperatures at the bottom closely mirrored the surface, but were typically 1 - 3° cooler during mid-day.

Oxygen: Oxygen levels are seen to rise during the day, and fall at night. This is because plants produce oxygen when there is light, but utilize it during darkness. The levels shown here are adequate for all forms of life at the surface, but in the bottom layer (which is 2 - 4 mg/L lower than the surface) levels dropped below 3 mg/L on four nights. These low levels create stress for many forms of aquatic life.

Salinity: Salinity has been measured as electrical conductivity, not directly as parts per thousand (ppt) of salt in water. To compare these units, consider that sea water is 35 ppt, which is about 53 units of the scale shown in the graphs. Fresh water is close to zero ppt (about zero on the scale) and brackish water of 20 ppt is about 30 units. During the week of July 10, 2002, Lake water (at the center) was about 27 - 32 ppt, somewhat below that of sea water.

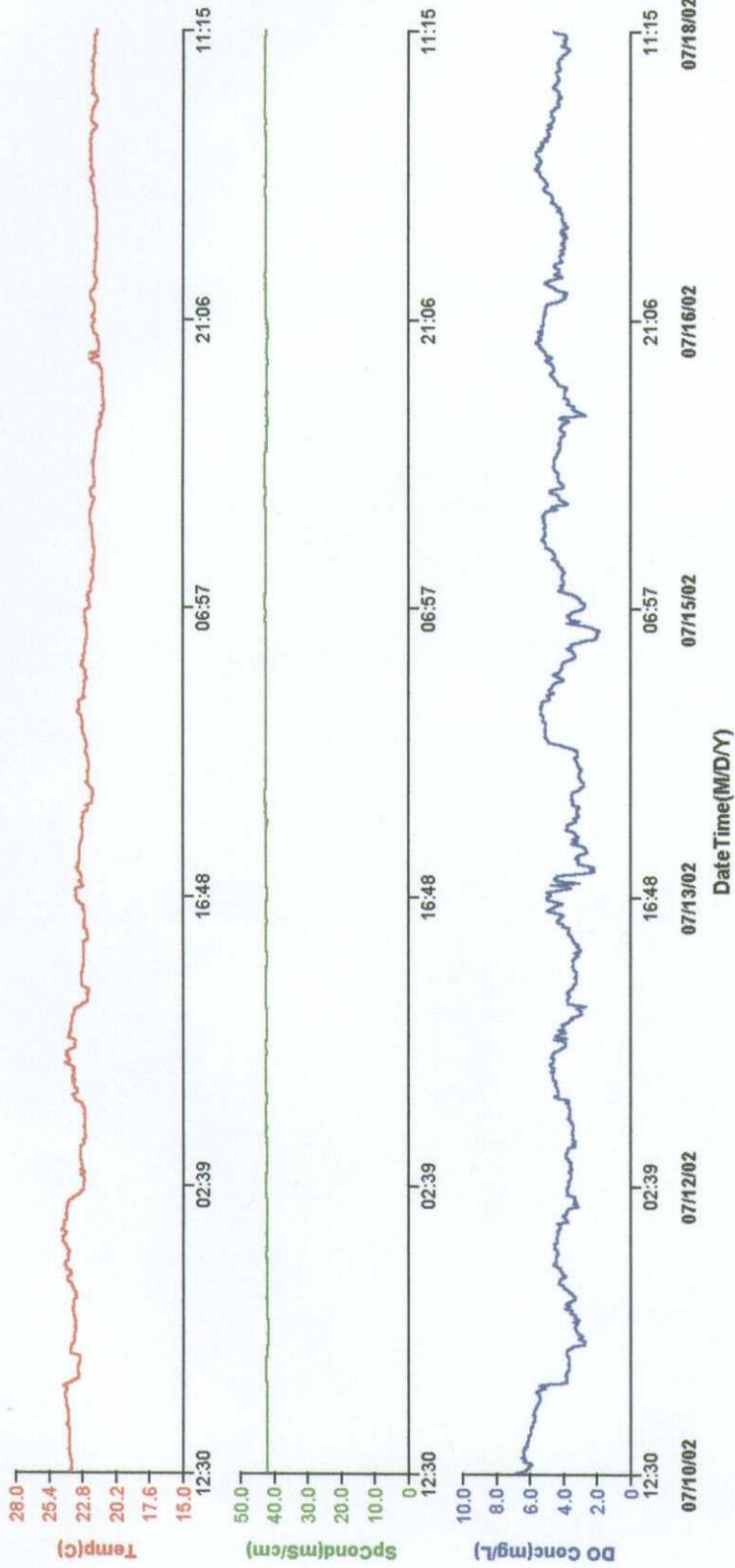
Lake Merritt Water Quality; Surface

Week of July 10, 2002



Lake Merritt Water Quality; Bottom

Week of July 10, 2002



AUTUMN (September - November)

Summary: The season begins quietly as westerly winds diminish and day length becomes shorter. Storm drain flows are minimal, originating mainly from irrigating lawns and washing cars. Slight algal blooms return after the last of the widgeon grass has decayed away. Spawning is over for most species, but cormorant numbers increase and coots appear.

Autumn is a season of change at Lake Merritt as summer birds fly south, winter migrants arrive and urban runoff begins to cause deteriorating water quality. While Lake visibility is often good in September, it will always drop to 3-4 feet by late fall due to increased blooms of plankton. School resumes and sailboats are seen less frequently on the water, replaced by colorful floating leaves. Someone usually throws a pumpkin in the Lake after Halloween, and the Lake is sometimes a topic of fall political campaigns or bond measures.



By autumn, trash has been building up for several months in storm drains, on streets, sidewalks and elsewhere in the watershed.

When the first rainstorm hits, it will be mobilized into "The Big Flush" and flow downstream into Lake Merritt.

Rainfall: The rains begin slowly with a recent average of only 0.34 inches in September. By October precipitation has increased to 0.97 inches, and in November bigger storms hit, dropping an average of 3.84 inches. Because a large percentage of Lake Merritt's watershed is impervious, the water runs off quickly. As fast as the water falls, storm drains and what few creeks remain carry it down to one of the 60 outfalls, and into the Lake.

Millions of dollars are spent on bringing water to the Bay Area and Oakland

from as far away as the Sierra mountains. Almost equally large sums are spent to carry water away in storm drains and flood control channels, getting rid of it as soon as possible. Storing rainfall in the watershed for later re-use as irrigation could provide many benefits, including:

- Reduction of imported water and associated costs
- Less cost for flood control and fewer floods
- More natural stream flows and healthier riparian systems
- Diminished negative impacts to water quality in Lake Merritt and beyond.

Such storage could take the form of fences that hold 10,000 gallons of water, underground tanks at individual houses or small wetlands and retention basins. These tools are currently being employed in the Los Angeles basin, but are scarce in the Bay area.

Tidal Flows and Flood Control: Because there is little rain in the first few months of fall, flood control is seldom required. Muted tidal flows enter and leave the Lake twice daily through tunnels at 12th Street, and the shallow, narrow channel leading to the Oakland Inner Harbor. By late autumn however, a 50% chance of rain may cause the tide gates to be closed during high tides, keeping the Lake level constant at 1.0 feet.



All tidal flows entering and leaving the Lake pass through these tunnels at 12th Street.

These boaters were “rescued” after their boat drifted into the tunnel. They didn’t realize the water was only 2-3 feet deep and they could walk out.

The bottom of this outlet is about 5 feet above the Lake bottom.



The County operated flood control station is located on the estuary channel at 7th Street. Almost all flood control is done by preventing high tides from entering the Lake, but four diesel operated pumps are also available to prevent flooding.

Plant Growth: Shoreline algae may make a brief appearance in September, but will be essentially gone by October, a victim of cooling water temperatures and decreased daylight. Widgeon grass is but a memory, and when the first fresh water runoff reaches the Lake (carrying a load of nutrients with it) plankton responds with a big bloom, typically turning the Lake a copper, bronze color for several days or until the high tides are allowed to flow back in and restore higher salinity. As plankton blooms reassert their hold on the Lake, the water loses its clarity, becoming murky.

During this time of the year, plankton growth is more noticeable in the upper arms of the Lake, closer to the storm drain / creek outfalls. At times the water behind the black and yellow trash barriers will be pea soup green, while immediately outside the barrier visibility will be 2 - 3 feet.

Urban Runoff: Storm drain flows increase only gradually in early autumn as thirsty soil soaks up the first rains. It is not until the soil becomes saturated by several inches of rain that runoff dramatically increases. With the first storm drain flows come the lightest, most easily floatable street debris, especially ubiquitous pieces of styrofoam packing material and balls. Plastic bottles and cigarette butts are also commonly found in the first flush of the season.

There have been no measurements of the volume of flow that enters Lake Merritt on a monthly or seasonal basis. This could be accomplished but governments typically do not have hydrologists on staff, and there are no stream gauges or other flow monitoring devices in the creeks and storm drains leading to Lake Merritt.



With the first rains of autumn, hundreds of balls are washed down through storm drains and into Lake Merritt. Shown here are a small number of them collected in a few months during the fall of 2001.

Water Quality: Diminishing is the word for water quality as the season progresses. When several tenths of an inch of rain fall, runoff forms a layer of fresh water over the heavier, salty water. Stratification occurs. The bottom layer becomes isolated from the surface, which is being oxygenated by photosynthesis from plankton. To make matters worse, storm drain flows carry in large quantities of material that use up oxygen. These materials settle into the mud at the bottom and continually deplete oxygen from the lower layer of water. Cut off from surface, the bottom layer reaches critically oxygen low levels, often as low as 2 milligrams per liter, and sometimes even less.

Because of low oxygen levels in the bottom layer, the U. S. Environmental Protection Agency has listed Lake Merritt on its 303(d) list as an impaired body of water. The Lake is also listed as impaired due to trash.

Leaves, shown here clogging an uncleaned storm drain inlet, move in mass quantities into Lake Merritt in the fall.

After sinking to the bottom, they decay, using up oxygen from the bottom layer of Lake water.

Citizens are encouraged to adopt a storm drain inlet and keep it clean.



Biological Activity: Decreasing light and temperature trigger changes in life at the Lake as the summer terns depart. They are replaced by cormorants, coots, and later a myriad of ducks from the northern latitudes. As the season progresses, the number of birds increases. At least 100 and up to 400 coots have been counted at the Lake in the fall. Several scaup, ruddy ducks, canvasbacks and goldeneyes can be found by the end of November, but most of them arrive in December.

Many of the migratory birds are born in the Canadian wilderness, fly several days non-stop, and arrive at our urban estuary in the dark of night. Then, when the sun rises, they are greeted by buildings, cars and people; things they have never seen before. No wonder they are afraid of us!



Cormorant numbers are limited to a small, breeding population at the Lake during the summer, but build up to hundreds or thousands in the fall. They are often seen "herding" schools of fish into the shallow waters where they dive and feast on topsmelt, sculpin and other fish.

Underwater, a different pattern emerges. As algae gives way to plankton, fish and some invertebrates depart the shallow waters for deeper areas, or leave the Lake completely. This trend accelerates as rainfall increases. Others, such as salmon and steelhead begin to move upstream from the ocean and bay toward fresh water spawning grounds.

It is not positively known that steelhead trout (which is type of rainbow trout which migrates to the sea and returns several times to fresh water to spawn) passed through Lake Merritt on their way upstream, but it is very likely they did. Unlike salmon, which require a larger watershed and river, steelhead are able to colonize smaller streams, and probably utilized the lower portions of Glen Echo creek before most of it was converted into storm drains. Juvenile rainbow trout have been found in Glen Echo creek, perhaps the ancestors of steelhead.

An occasional salmon is still found in Lake Merritt, but they are probably stray fish that became lost trying to find the stream in which they were

born. Steelhead are also seen in the Lake during the fall. Some may be fish released into the Lake from hatcheries in the late 1990's as part of the "Fishing in the City" program, but some have intact adipose fins, indicating they may be of wild origin. These wild fish have been found at the mouth of Glen Echo creek, and may spawned, or tried to spawn, in the Richmond Park area.

For some invertebrates, autumn is also a time to spawn. These include the sea slug, a member of the snail family, but which doesn't have a shell. In October of 2001, almost the entire shoreline was coated with the yellow, gelatinous egg masses of this creature. Most people probably never noticed this phenomenon, and others probably considered it to be another form of pollution. But it is just one more example of the myriad of life that the Lake supports.



The sea slug Haminoea and its eggs.



Millions of sea slug egg masses were found in the Lake in October, 2001.

WINTER (December - February)

Summary: Urban runoff dominates the Lake in winter as rainfall washes trash and chemicals down from the streets. This litter is often visible where it concentrates along the shoreline and behind storm drain barriers. Water clarity is typically low and the Lake level is often kept down to provide capacity for potential floods. Dead animals are relatively common as the water stratifies into layers and the bottom layer loses oxygen. Odors occur when oxygen levels in the bottom layer reach near zero. After heavy rainstorms you may even observe duckweed in the Lake (see photo on page 1) carried down from ponds upstream on Glen Echo creek. But you will not see algae or widgeon grass which grow mainly in the spring and summer. Migratory waterfowl are abundant, attracting many bird enthusiasts from around the Bay Area.



Rainfall washes urban runoff from 4,650 acres into Lake Merritt

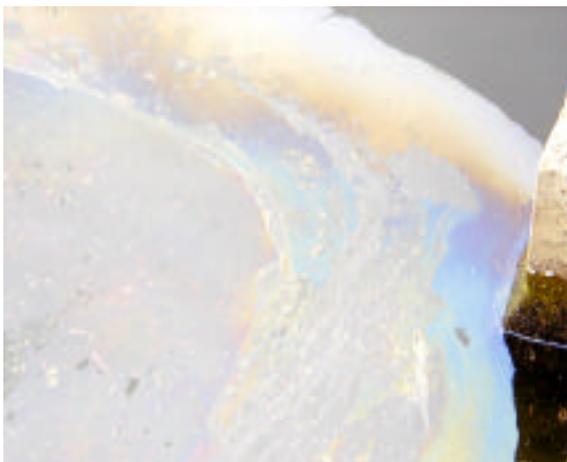
Rainfall averages about 3 - 4 inches per month in the winter, and typically occurs on ten days per month, scouring the watershed and creeks. When El Nino conditions exist, as much as ten inches of precipitation or more may wash into the Lake. Heavy rainfall creates high water and fast flows in the creeks, mobilizing debris that normally does not move (including the television set we once found). Creek banks are purged, washing away brambles, branches and tree limbs.

Although enormous volumes of fresh water pour into the Lake, there is no data on creek flows. This information would be very useful for both creek management and improving water quality in the Lake. Stream flow gauges are needed.

Flood Control: Because of frequent rainfall, the Lake is very often kept in a flood control mode, held at an elevation of 1.0 feet. This is accomplished by keeping high tides out of the Lake, which is done whenever there is a 50% chance of rain in the forecast. Twice weekly weather forecasts are used by the Alameda County Flood Control District to decide if the tide gates should be kept closed during high tides. Typically the Lake is kept at a level of 1.0 feet for the duration of the forecast, or until the county crew can get back to the flood control station and re-set the controls. Water entering the Lake from rainfall is allowed to drain out to the Bay, but salt water inflow at high tides is often greatly reduced.

Plant Growth: Plankton dominates Lake Merritt during the winter, making the water appear murky. For several days after each rain the Lake takes on a bronze color due to a bloom stimulated by fresh water and nutrients washed in from the watershed. Algae and widgeon grass are typically not found due to cold temperatures and short day length.

Urban Runoff: An average of 5,244 pounds of trash per month was removed from Lake Merritt during January of 1998, 1999, 2000 and 2001. Plastic bags, styrofoam, leaves, paper, bottles, cans, cigarette butts and woody debris from creeks may be found floating, or on the Lake bottom. Where contained by barriers at storm drain outfalls, trash concentrates in impressive quantities. The longer the duration between rainstorms, the more trash accumulates in the watershed to be washed downstream. More intense storms wash in larger quantities of trash.



Storm drain flows carry enormous quantities of urban runoff from the watershed into Lake Merritt. Sixty storm drain outfalls enter the Lake, ranging in size from 12 inches to 6 feet across. They drain a watershed of 4,650 acres, which is 33 times the size of the Lake. Most trash comes from shopping areas and fast food restaurants. Shown here is oil or gas entering the Lake.

Water Quality reaches its worst due to runoff and fecal matter from increased waterfowl populations. Fecal coliform concentrations rise above the levels not safe

for body contact. Visibility is typically only a few feet, especially in the arms of the Lake near large storm drain outfalls. Salinity is highly variable, approaching that of fresh water after big storms, and often half that of sea water when high tide flows are allowed to enter the Lake. Stratification occurs as the lighter, fresh water runoff remains at the surface, trapping the denser, saltier water at the bottom.

But it is dissolved oxygen that presents the worst problem during the winter. When the Lake stratifies into separate surface and bottom layers, the bottom layer often becomes extremely low in oxygen. Readings in the arms of the Lake are frequently below 3 parts per million and have occasionally been measured at 0 - 1. These areas of low oxygen near the bottom often extend into the center area of the Lake.

Biological activity is at a minimum when New Year's Day dawns cold and dim. Temperature, daylight and aquatic life are at a low ebb as the Lake's waters can drop as low as 43° and darkness lasts for 16 hours or more. Nutrients washed in as leaves from storm drains build up in the sediments, ready for the spring bloom.

Migratory waterfowl are the main attraction at the Lake in the winter as their numbers increase to over 1,000 birds. Coots, scaup and goldeneye ducks are the most common winter migrants. Several hundred of them are counted every winter, and smaller numbers of ruddy ducks, canvasbacks, widgeon and pintails may also be found.

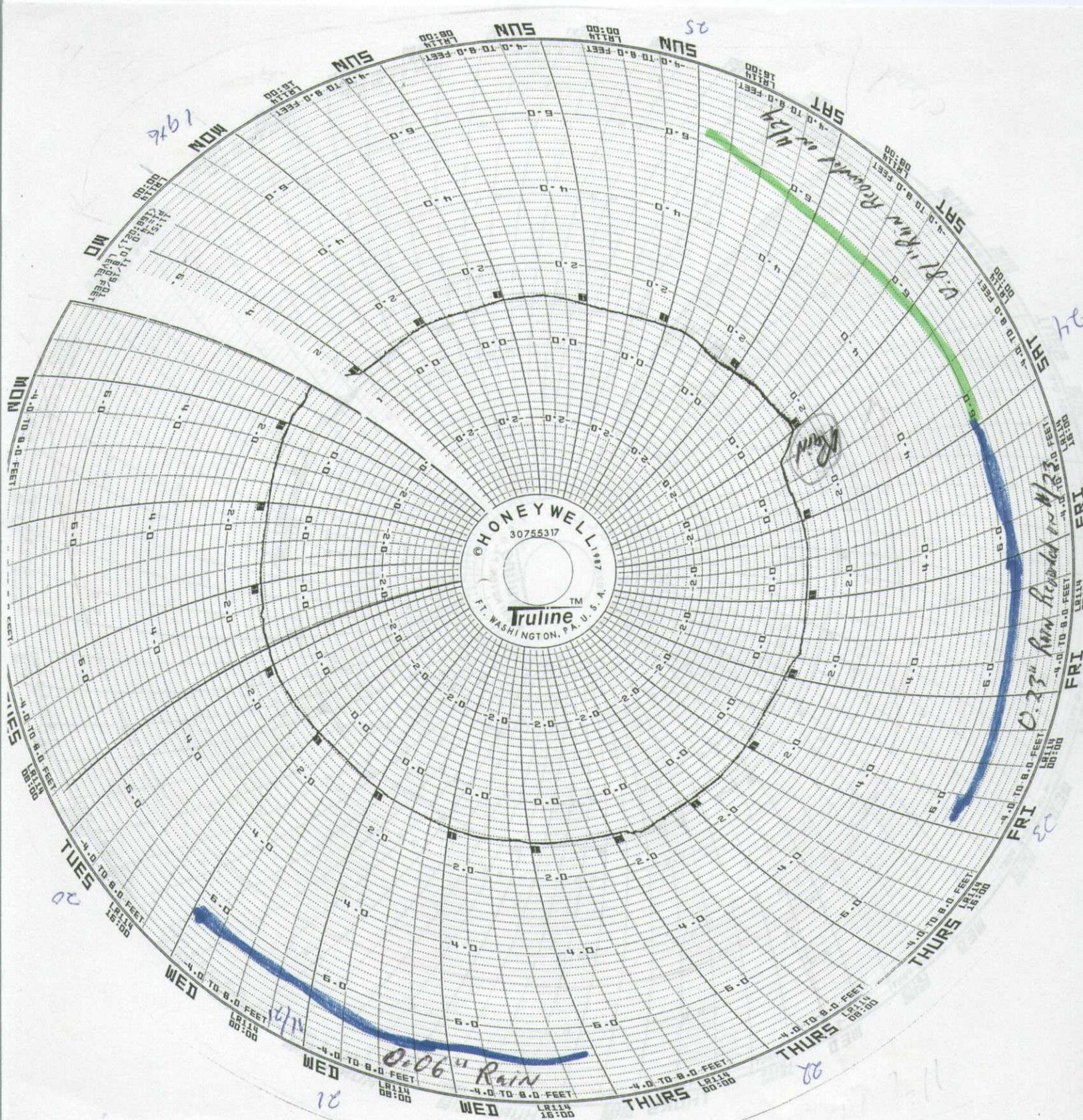


Lake Merritt is a refuge for hundreds of migratory birds in the winter. To minimize their disturbance, boat access to the Trestle Glen arm of the Lake is prohibited from November 1 to May 1. Protection of game birds and wild animals at the Lake began in 1870 after passage of a state law.

Under the surface, aquatic life struggles to survive poor water quality, or moves out of the Lake into the Bay. Animals that can't leave the Lake (like mussels and barnacles and shrimp) or animals which are too large to pass through the 7.5 inch wide bars at the flood control station, typically die. Death occurs in many ways:

Death by low oxygen; death by starvation; death by chemical pollution; by ingesting trash in the false hope it is food; by cold temperatures; and death by a marine, tidal lagoon suddenly turning into fresh water. Life becomes hard, and by winter's end, populations are at an annual low. Large bat rays, salmonid fish and striped bass are sometimes found dead during the winter at Lake Merritt. Myriads of small fish survive however, and provide food for winter waterfowl.

This tide graph shows the level of Lake Merritt during the week beginning Monday, November 19th, 2001. During the week, 0.06 inches of rain fell on the 21st, 0.23 inches on the 23rd, and 0.81 inches on the 24th. A break in the line on Monday is caused by changing the graph paper.



Lake Level Held Constant: Except for a rise of 0.8 foot on November 24th due to rainfall, Lake level was held constant (see dark line in middle of chart) at about 1.0 foot. Flooding occurs above 3.0 feet, which is 1.2 feet above the highest level reached all week. Despite an absence of rain on 4 of the 7 days, and only minimal rain on one day, high tides were kept from entering the Lake all week. Such tidal restrictions can intensify low oxygen levels in the bottom layer of the Lake.

Twice Weekly Weather Forecasts vs. Computer Modeling: Although tidal control is essential to prevent damaging floods, more frequent decisions on when to close the tide gates would improve water quality in Lake Merritt. These decisions could be based on computer models such as the U.S. Army Corps of Engineers - Hydrologic Engineering Center's River Analysis System, rather than the twice weekly weather forecasts currently used by Alameda County.

Re-design the Flood Control Station: Additional improvement to low oxygen levels in the bottom layer could also be achieved by re-designing the flood control station to draw water from the bottom of the Lake, rather than the top.

EPILOGUE

Lake Merritt is not a Lake, but a tidal lagoon. Although it has been modified by the hand of man for over 150 years, it is in many ways still part of the natural world. The open space, relative quiet and serenity stand in sharp contrast to the highways, highrises and high expectations of streets and buildings that surround its waters. To the extent that it retains these natural qualities is a testament in part to the resilience of life, and also to the people who have helped to preserve them.

Lake Merritt is many things to many people; the jewel of Oakland to some, a wildlife refuge to others; a big smelly pond to a few, and a jogging path to many. It is the view out their window to tens of thousands of people, and the peace that calms their soul. On a more practical note, it is a climate buffer, moderating the extremes of temperature in the City. Hydrologists look upon it as a flood control basin and boaters as a recreational resource.



As the first years of the new century begin to pass by, efforts to restore this “urban estuary” are gathering force. Plans are being developed to re-establish a small wetland along its shores. A master plan has been written and brave, new proposals have been created to restore part of the natural tidal flows that once carried large ships to its banks. To the extent they are successful, these efforts will enhance the Lake, as well as property values around it.

Through it all, the seasons continue; ever changing, ever reminding us of our relationship to the Lake. For 10,000 years the creeks and tidal waters have flowed here. For the next 10,000 they may continue their cycles, provided we understand what we have been given, what we have created, and how they can work together.