DUPLICATE

ENVIRONMENTAL ASSESSMENT FOR STURGEON LAKE RESTORATION PROJECT

SPONSORED BY

WEST MULTNOMAH SOIL & WATER CONSERVATION DISTRICT

FEBRUARY 1987

PREPARED BY

PETER C. KLINGEMAN
WATER RESOURCES RESEARCH INSTITUTE
OREGON STATE UNIVERSITY
CORVALLIS, OREGON 97331
(503) 754-4022

RETURN TO:

WEST MULTMOMAH SOIL & WATER CONSERVATION DISTRICT
2701 NW VAUGHN, SUITE 450
PORTLAND, OR 97210

ENVIRONMENTAL ASSESSMENT FOR
STURGEON LAKE RESTORATION PROJECT

IN SUPPORT OF APPLICATION
BY
WEST MULTNOMAH SOIL & WATER CONSERVATION DISTRICT
TO
OREGON WATER RESOURCES DEPARTMENT
FOR
PUBLIC BENEFIT FUNDS

Location

Sturgeon Lake at Sauvie Island
Multnomah County Oregon

Proposed Action

Reopen and shorten Dairy Creek between Sturgeon Lake and Columbia River to reestablish natural flushing of the lake and to reverse the sedimentation process that has been occurring in Sturgeon Lake in recent decades.

Public Benefit

Increased flushing of the lake to former levels will improve its water quality and reverse sedimentation to enhance waterfowl habitat, warm-water fisheries and public recreational uses.

Studies Made

The physical, biological and chemical characteristics of Sturgeon Lake were studied intensively during 1980-82 as part of an EPA-funded Phase I lake restoration feasibility investigation. Supplemental data are being collected in 1986-87 as part of Phase II lake restoration monitoring. The resulting reports are listed later in this environmental assessment.

The fish and wildlife resources of Sturgeon Lake and vicinity have been studied extensively and reported by the Oregon Department of Fish and Wildlife (ODFW). Public recreation at Sturgeon Lake and on adjacent lands has also been studied and reported by ODFW.

PAGE – 2 –

IS A PULL-OUT MAP

OF SAUVIE ISLAND

WILDLIFE AREA

THAT COULD NOT

BE SCANNED

Need for Action

Sturgeon Lake, during the past four decades, has become an off-channel sedimentation basin for suspended sediment from the Willamette and Columbia Rivers. Diking, dredge spoil disposal, blocking of creeks, and reservoir flood control operations have contributed to this change. In addition to rapid sedimentation and locally encroaching shore vegetation, water quality in the lake is poor due to relatively large amounts of organic matter and seasonally-high bacteria levels.

Sediment-laden river water fills the lake after each big storm. Deposition has caused the lake bed to become predominantly fine silt. The rate of sedimentation is such that boats can no longer use the lake in late summer and autumn. Wildlife, cattle, waterfowl, fish, and other aquatic life add organic matter to the lake. Wind-waves keep the system stirred up and cause currents that, together with tidal action, distribute sediment and organic matter throughout the lake.

In winter, the lake remains usable by waterfowl, which seldom feed on the lake but use it as a resting area and sanctuary. But shoaling is permitting local encroachment of willows along the shore. This will gradually diminish the lake's size and usability by waterfowl.

A warm water fishery presently exists and is diverse. But some species formerly common in the lake are now infrequently found there, including the sturgeon for which the lake was named.

Recreation is adversely affected by shoaling of the lake and by poor water quality. Coliform bacteria levels in the lake are seasonally higher than desirable for water contact activities.

The critical problem is inadequate flushing of the lake. This situation occurred when Dairy Creek became filled with debris and its mouth was blocked by dredge spoils from the Columbia River. This markedly reduced the daily and seasonal flushing of the lake.

Data collected from 1980 to 1986 show that if no action is taken to improve flushing in the near future, the lake will slowly continue to shoal due to a net sediment input. The water quality will become poorer as water exchange with the outside rivers diminishes. Bacteria levels and shallow water will seasonally prevent recreational use of the lake. Wind-wave agitation will continue to resuspend the shallow settled sediment and organic matter and keep the lake turbid. But tidal flows will become less effective in purging the lake as the tidal volume of the lake diminishes due to net sedimentation. As it shoals, Sturgeon Lake will remain seasonably usable for waterfowl habitat as long as nearby lands continue to be available as feeding grounds, but the lake surface area will slowly shrink. Without good flushing, siltation and poor water quality will continue to contribute to a slow deterioration of the lake.

Alternatives Considered

Many options exist for attempting to remedy the shoaling and water quality problems at Sturgeon Lake. Some are better than others at dealing with the causes of lake problems. Some only deal with symptoms. Other are little more than short-term maintenance efforts.

Ten major categories for options have been evaluated. These are: (1) dredge the lake; (2) reopen Dairy Creek to improve flushing; (3) use dikes in the lake to flush the lake; (4) control the inflow through the Gilbert River; (5) completely isolate the lake; (6) use settling basins to desilt the entering water; (7) control shoreline vegetation; (8) control the input of organic nutrients; (9) consolidate and shrink the bottom sediments; and (10) leave the lake alone.

Proposed Action

A long-term solution has been recommended for implementation that will let the lake take care of itself as much as possible. The recommended action is to reopen Dairy Creek at the location where it was previously blocked by dredge spoils from the Columbia River. The flushing benefit of reopening the creek can be maximized if a short-cut channel is excavated from Reeder Road into the south part of Sturgeon Lake east of Coon Point. This shortened route will maximize the flushing effect. The clearer water from the Columbia River will mix with the turbid lake water on incoming tides or rising river levels and help carry suspended sediment, organic matter, algae and bacteria out of the lake on outgoing tides -- just as used to happen years ago.

Other options can be implemented as well. Removal of encroaching willows can arrest their spread, but some bird and wildlife habitat may be lost. Localized excavation of exposed unvegetated shore sediment will help maintain the lake volume and simultaneously provide a source of soil that is suitable for growing crops.

The recommended solution has been partly implemented to date. The short-cut channel has been excavated and the mouth of Dairy Creek has been reopened. However, the benefits of these initial restoration steps will not be realized until the connecting segment of Dairy Creek is unblocked. This needed step will allow Columbia River water to again enter Sturgeon Lake from the Columbia River and revitalize the flushing mechanisms in the lake.

The Affected Environment

The following information is summarized from reports listed at the end of this environmental assessment. Supporting data are found in those reports.

Lake Size

Sturgeon Lake has shrunk in size and changed in shape since the mid-1800's. Major alterations can be associated with human activities, particularly diking, dredge spoil disposal, compartmentalizing of some water bodies formerly part of the lake, and drainage of low lands that had been seasonal extensions of the lake. Natural processes also have affected the lake shape, although less rapidly. Sediment movement through Dairy Creek and across low lands overtopped by Columbia River floods has contributed to shoreline extension into the lake on the east side. Sediment input from Multnomah Channel via Gilbert River and during overbank flooding has caused shoreline extensions on the west side. Local drainage through small creeks has carried sediment and resulted in natural levees extending into the lake as long fingers (e.g., Coon Point).

The size of Sturgeon Lake is controlled by the levels of the Columbia and Willamette Rivers, as transmitted through the Gilbert River. Local precipitation, local runoff, and lake evaporation have virtually no influence over lake levels, due to the Gilbert River connection with Multnomah Channel.

Presently, Sturgeon Lake has a very flat bottom over extensive areas, a few deeper drainage patterns through this flat bottom, and gradually sloping lake margins and shorelines. In particular, a submerged flat zone occurs between elevations of 3 and 4 feet, msl, and a seasonally exposed flat zone occurs between 7 and 8 feet, msl. These flat zones may represent areas of silt accumulation during low and high water periods, respectively; the transition between 4 and 7 feet, msl, may indicate areas where summer wind wave scour removes high-water deposits.

The lake surface elevation commonly ranges from 5 feet to 10 feet, msl. This gives the lake an average depth of 1.5 feet to 4.0 feet. The average surface area of the lake varies from 1,900 to 4,800 acres.

Water Exchange, and Circulation

Heavy midwinter storm runoff from the Willamette Basin causes discharges from the Willamette River into the Columbia River to remain unmixed for several miles downstream. At such times, Sauvie Island is totally surrounded by Willamette River water, which also fills Sturgeon Lake. In late spring or early summer, large snowmelt runoff from the Columbia River tends to surround Sauvie Island. During this period, Sturgeon Lake fills with Columbia River water, diluted by Willamette River water.

When both the Willamette and the Columbia River discharges are moderate or low, mixed Columbia and Willamette River water flows along both sides of Sauvie Island. At these times, tidal exchange between Multnomah Channel and Sturgeon Lake involves mixed Columbia and Willamette River water.

During times of year when lake and river levels are low, tidal fluctuations, transmitted up the Columbia River from the Pacific Ocean, cause typical water level changes of one-to-three feet twice daily at the mouth of the Gilbert River. These fluctuations are dampened as they are transmitted up the Gilbert River to the lake. Nevertheless, the lake level fluctuates in response to the tide and there is tidally-induced water inflow and outflow at the lake, together with mixing and exchange of river and lake water.

Water exchange through the Gilbert River may briefly exceed 2,000 cfs during most flood and ebb tides. This allows the exchange of several hundred thousand cubic feet of water at each part of the tidal cycle, the exact amount varying with tidal range and mean tidal level. The maximum capacity of the Gilbert River is estimated to be 5,000 cfs. Such large flows are only likely to occur during rising river stages from storm runoff and snowmelt floods, when the river rise may be 2 feet per day or more.

The water movement to and from the lake during the short period of hours, up to a day, therefore has a considerable range of variation. The lower limit can be essentially zero exchange (at high river levels when the tides are dampened out and river flow is changing only slowly — e.g., at flood crest). Small tidal exchanges can also occur at low river levels if tidal fluctuations are small. The upper limit for water exchange is estimated to be 9,000 acre-feet (400×10^6 ft^3) per day at full-capacity Gilbert River flow with a two-foot river rise as the Gilbert River approaches overbank flow (about 10 feet, msl). This latter condition represents roughly a 40 percent change of lake volume.

The Gilbert River sufficiently constricts the tidally induced flows between the Multnomah Channel and Sturgeon Lake so that the external tidal range of up to 3 feet is greatly diminished. Generally, the lake tidal fluctuations are 0.5 foot or less. The neck between the north and south portions of Sturgeon Lake further constricts the tidally induced flows, such that the tidal range in the south part of Sturgeon Lake is less than that in the north part of the lake by about 0.1 foot.

Within Sturgeon Lake, the tidally-induced currents are larger in the north part of the lake than in the south part. Currents exhibit some circulatory motion in the north compartment, rather than a straight in-and-out motion. The current at the lake neck causes a fill-and-drain water movement in the south compartment of the lake. The exchange is less in the south part than in the north part of the lake due to the constricting effect of the lake neck.

During high river and lake levels (above 10 feet, msl), most of the Gilbert River banks at the lake are overtopped. At such times, the lake responds more-nearly like a single body of water than as a two-compartment system; inflows and outflow occur along the length of the flooded Gilbert River, not just at The Wash and the lake neck.

Wind is a major factor in causing currents and in altering tidally-induced currents in Sturgeon Lake. The prevailing winds are from the north in summer, when the lake is receding to its lowest levels. They tend to force additional water into the shallow south compartment of the lake and hold it there against the ebb currents. The long fetch allows sizeable waves to develop near the south end of the lake. Thorough mixing and a considerable amount of lake-bed disturbance occurs. During winter months, the prevailing winds are from the south. Because the water is usually deeper than in late summer, the waves probably have less effect in laterally moving much water. Nonetheless, the effects of wind on mixing are pronounced at all seasons.

The residence or exchange time for water in the lake varies with season. In late summer it may be only a few days. In winter it may be a week or more. Some outflowing water returns on the following flood tide, so that exchange is incomplete. The north part of Sturgeon Lake has a shorter residence time for water than does the south part of the lake, where particles of water may be retained for several weeks or even longer. For general descriptive purposes, an exchange time of about one week appears to be appropriate.

Suspended Sediment Exchange and Accumulation

The Gilbert River is now the only significant connection between the lake and external rivers. Sediment-laden water enters the lake through the Gilbert River whenever the Willamette or Columbia River rises appreciably. The rivers remain high for many days at a time, allowing extensive sedimentation to occur.

At times when the river and lake levels are low, tidal fluctuations allow twice-daily exchange of water and suspended sediment through the Gilbert River. The tidally-induced exchange may allow a slight net outflow of suspended sediment, due to mixing of cleaner river water with turbid lake water.

Winds blowing across Sturgeon Lake create waves which agitate shallow sediment deposits. The disturbed material is resuspended and transported about the lake by tidal and wind-induced currents. Some of the material is carried out of the lake in this manner. The resuspension process is most effective when the lake level is low, because wind-wave energy being propogated downward dissipates with depth. As waves pass, the motion causes shear stresses that scour the bed and resuspend exposed sediment particles. The seasonal switch of predominant wind direction may keep the suspended sediment from being carried to only one end of the lake. Tidally induced currents in the lake also prevent accumulation of suspended sediment only at the downwind end of the lake.

During individual periods of storm runoff, suspended sediment concentrations for water entering the lake may reach or exceed 100 mg/l. When the lake level falls with receding river levels, the outflowing water typically has suspended sediment concentrations on the order of 30 mg/l. Thus, a storm event that causes a lake level rise of several feet might add a water volume of 30,000 acre-feet and a net sediment concentration of 70 mg/l. This corresponds to approximately 1 acre-foot of sediment added to the lake. Thus, each storm could cause an unconsolidated accumulation of several millimeters. The particle sizes would correspond mainly to fine silts.

Between storm periods, the typical suspended sediment concentrations are much lower. Concentrations for inflowing and outflowing water are roughly equal. Therefore, little net input or output occurs at these times.

When the lake level is low and wind agitation is strong, such as during late summer, the outflowing water has a larger concentration of suspended sediment than does the inflowing water. The difference is likely to exceed 10 mg/l, resulting in a net loss of sediment from the lake at such times. Particles being transported are in the fine-silt size range.

Suspended sediment concentrations within the lake are highly variable. During winter months at times of fair weather, typical concentrations are about 20 mg/l. Concurrent suspended sediment concentrations in both the Columbia and Willamette Rivers are about 15 mg/l. During winter storm runoff, the concentrations in both rivers may reach 50-to-90 mg/l and be about the same in the lake. During late-summer periods of low lake levels, suspended sediment concentrations in the Columbia and Willamette Rivers are about 10-to-15 mg/l whereas the concentrations in the lake reach 140 mg/l on windy days. At such times, wind-wave and fish-induced stirring of the shallow lake keeps the water turbid and the bottom disturbed and unconsolidated.

Lake Sedimentation

Sturgeon Lake has been converted from an occasionally-flushed lake to an off-channel sedimentation pond of the Willamette and Columbia Rivers. This has come about over the past four decades through blocking of Dairy Creek, diking near the lake, closing or diverting local creeks, and flood control operations in the Columbia River basin. Under the natural state, Columbia-Willamette flooding and runoff from local creeks caused some net sediment deposition in parts of the lake; but the more rapid exchange of water probably helped keep most of the lake well scoured, particularly near the Gilbert River. Now, reduced flushing allows the suspended sediment to be retained; those particles are mixed with organic matter and are not well consolidated.

Sediment-laden water enters Sturgeon Lake through the Gilbert River whenever the Willamette or Columbia River rises appreciably due to storm runoff. Because the rivers remain high for many days, there is time for extensive sedimentation to occur.

At times of year when lake and river levels are moderate or low, the lake level fluctuates in response to the tides. Tidally-induced water inflow and outflow at the lake cause mixing and exchange of river and lake water. In addition, winds blowing across Sturgeon Lake create waves which agitate shallow sediment deposits. The disturbed material is resuspended and transported about the lake by the tidal and wind-induced currents. Some of the material is carried out of the lake in this manner. However, the amount of such sediment export does not match the seasonally heavy import and deposition of sediment. Hence, a net sedimentation is occurring in Sturgeon Lake.

The cumulative effect of slow shoaling over several years can be a severe loss of water depth and lake size. Furthermore, other factors besides net sediment accumulation are of concern in Sturgeon Lake, as mentioned in the following paragraphs.

Bottom Sediment Disturbance and Consolidation

The relatively flat lake bottom and the size-distribution of lake sediment are indicative of a well-mixed sedimentation environment. The lake bottom is consistently dominated by the silt-size sediment throughout the lake, except for locally coarser sediment near the Gilbert River. There are no lake zones dominated by clay-size bottom sediments. Hence, no "quiet" zones of the lake are indicated where enhanced sedimentation occurs. Instead, sedimentation is occurring throughout the lake.

Wind-wave agitation of bottom sediment, coupled with wind-generated and tide-generated currents, is a major process in keeping the water turbid and the lake bed disturbed. Fish, benthic (bottom) organisms, and occasional boat traffic also contribute to the disturbance of bottom sediment.

The density of lake bed sediment is not uniform through the lake. Sediment which is seasonally exposed to air along the lake margin tends to shrink when drying and to become denser than sediment that is continually submerged in the lake.

A relatively large amount of organic matter is added to the lake from aquatic and terrestrial plants and animals. This results in a high percentage of organic matter accumulating in bottom sediment.

As sediment gradually accumulates on the lake bed over the years, the added weight of new material should partly consolidate the underlying material. However, with continually submerged finer-sized sediment containing organic matter, This consolidation occurs only very slowly over many years. Furthermore, while consolidation of deeper deposits is occurring, there is a steady input of new sediment above. The net effect is a continued loss of water depth.

Water and Sediment Chemistry

Sturgeon Lake turbidity and suspended solids concentrations are generally high for a lake and are more indicative of river levels. These high lake levels are influenced by resuspension of bottom sediment. Most of the suspended solids are inorganic solids (e.g., small silt and clay) that originate from riverine sources. Organic matter is also found suspended in lake water.

Dissolved oxygen levels remain near saturation through the water column, with no signs of water stratification or oxygen depletion in deeper zones. The pH of the water is generally in the near-normal range of 7-8, with fluctuations in the pH 8-9 range that are apparently due to photosynthetic activity by algae.

Conductivity and dissolved-ion values for Sturgeon Lake are typical of dilute fresh waters in the Pacific Northwest having relatively low total dissolved solids. Alkalinity and hardness of the lake water are also in the range typical of the relatively soft, low-alkalinity waters of the Pacific Northwest (25-50 mg/1 as $CaCO_3$).

The observed 5-day biochemical oxygen demand of lake water is low but indicative of some input of organic matter, probably algae and plant matter and fecal matter from aquatic birds, fish, and shore-grazing cattle.

The observed chemical oxygen demand of lake water is higher than expected from data for biochemical oxygen demand. This suggests that much of the organic matter in the water column is in a refractory form (e.g., humic substances).

Concentrations of total phosphorus and orthophosphorus are indicative of a moderate level of enrichment of lake water. Most of the measured values exceed the general limits above which eutrophication may occur. However, this has not been a problem due to the short residence time that results from tidally-induced water exchange at Sturgeon Lake.

Observed nitrogen levels also appear to indicate a moderate level of enrichment of lake water. Much of the nitrogen present is associated with algae and other organisms (i.e., organic nitrogen) and their degradation products.

Measurable levels of sulfides in bottom sediment are a clear indication of anaerobic conditions and subsequent sulfate reduction. The measured concentrations may be typical of anaerobic lake sediments but are much lower than for estuarine sediments where sulfate is much more available.

Concentrations of heavy metals (cadmium, cooper, lead, zinc) in bottom sediment are above those to be expected clean sediment but are much below those levels to be expected for highly contaminated sediment. Hence, heavy metals should not be of major concern if sediment is excavated for spreading on farmland, but may warrant some monitoring. Residues from DDT breakdown products are present in bottom sediment. Concentrations are at trace levels and thus not high enough to be of major concern in terms of toxicity.

Changed Lake Levels

Sturgeon Lake has become subject to lower water levels than in the past during spring and summer months, due to upstream reservoirs. Floow control in the Columbia River basin through use of multiple-purpose storage reservoirs has virtually eliminated the high river stages that formerly occurred. Flood control operations in the Willamette Basin generally reduce flood peaks but prolong the time of high-water runoff. This prolonged high runoff keeps the Willamette stages near Sturgeon Lake higher than natural for several days during the winter and allows more sedimentation to occur in the lake.

Water stored in reservoirs is released for hydropower generation, navigation, and fish passage over several months after the snowmelt season. This schedule has altered monthly average river levels compared to natural conditions. Thus, the mean river level near Sturgeon Lake is now higher than formerly in some months (e.g., late summer and early autumn) and lower than formerly in other months (e.g., winter, spring and summer). Nevertheless, sedimentation has caused enough shoaling to make much of the lake unusable by boat in late summer and autumn.

The closure of the mouth of Dairy Creek contributed to a slight reduction of level in Sturgeon Lake. In former years, inflow through Dairy Creek and outflow through the Gilbert River probably resulted in an intermediate lake level between levels in the creek and river. But now the mean lake level is controlled only by the mean level of Gilbert River at Multnomah Channel. Thus, the mean lake level now is about 0.25 foot lower than formerly at low-to-average river discharges due to closure of Dairy Creek. Because of the flatness of the lake shoreline, this reduction in lake level would cause a perceptible shrinkage in the surface area of the lake.

Diking

Diking has had a mixed effect upon the lake. A detrimental aspect is that dikes prevent local runoff and main-river flows from washing through the lake and flushing out the accumulating sediment. Diking of remote parts of Sturgeon Lake itself has also hindered flushing and self-scour of the lake during outflow periods. But diking of local streams prevents sediment-laden island runoff from continuing to build finger-like deltas at the stream mouths and dispersing sediment throughout the lake.

Closure of the mouth of Dairy Creek evidently occurred due to dredge spoil disposal there as part of Columbia River navigation channel maintenance. This appears to have happened soon after the devastating 1948 flood.

Encroachment of Shoreline and Aquatic Vegetation

The dominant shoreline vegetation varies between grasses and trees. In most places, its growth zone appears to have been relatively stable over the past several years. However, there are several flat shoreline and nearshore areas where new vegetation is encroaching upon the lake. The cause of encroachment may be partly sedimentation and partly a lowering of lake level during the growing season. The year-around high turbidity of the lake water greatly limits light penetration of the lake and may thus inhibit the growth of rooted aquatic plants in water more than several inches deep.

Useability of Lake for Waterfowl

The lake is moderately deep with a large surface area during most winter months when migratory waterfowl are present. However, wintering waterfowl seldom feed on the lake, but rather use it as a resting area and sanctuary. Sparce aquatic vegetation and low diversity of macroinvertebrates restrict food abundance in the lake. Hence, most wintering waterfowl feed on private lands and on refuge wildlife management lands, especially on crops specifically planted to attract waterfowl. Other waterbirds dependent on aquatic foods (e.g., various species of diving ducks, gadwalls, shovelers, grebes, and loons) infrequently use Sturgeon Lake. Thus, while large numbers of waterfowl use Sauvie Island during winter, only species that are capable of feeding on terrestrial foods (which may be shallowly flooded in winter) are present on Sturgeon Lake.

Small nesting populations of several species of ducks are present on Sauvie Island, but their use of Sturgeon Lake is not well documented. Fluctuating water levels in Sturgeon Lake may adversely affect ground-nesting ducks but do not appear to be a serious problem. Most species of ducks that nest on Sturgeon Lake also nest along the lower Columbia River and in coastal wetlands where water level fluctuations are much greater than at Sturgeon Lake. Scarcity of aquatic food, both for nesting females and for ducklings, is probably more restrictive than fluctuating water levels on nesting populations.

Lake Organic Matter and Bacteria

The amount of fine organic matter in Sturgeon Lake, both in suspension and in solution, is greater than that in Multnomah Channel and the Willamette and Columbia Rivers. During most of the year organic matter occurs in the lake at levels more than twice those in the rivers. Probable internal sources of organic matter include algal growth and die-out, shoreline vegetative matter, and wastes from water birds, fish and cattle.

Coliform bacteria levels in the lake are sometimes higher than desirable for swimming and other aquatic sports. These bacteria do not present any particular hazared to fish and waterbird health but are indicative of water quality conditions potentially hazardous to humans, especially in late summer and early autumn when warm air and water temperatures may encourage lake use. The cause of high levels for coliform bacteria is unknown but may be associated with the autumn arrival of migratory waterfowl and inundation of cattle-grazing areas.

Composite Condition of Ecosystem

Sturgeon Lake exhibits characterisitics of a eutrophic system. Sturgeon Lake is beta-mesosaprobic, according to biological indications such as algae and the condition of the lake bottom. A lake in which blue-green algae predominates in the summer plankton is typical of mud or muck bottomed lakes with high organic content in the sediment. While this condition fits Sturgeon Lake, neither the species nor quantity of blue-green algae found there are indicative of polluted waters.

The lack of extensive aquatic vegetation is most likely due to a combination of physical and biological factors. Reduced light levels, as a result of high turbidities, may be a factor. Unstable bed sediment and fluctuating water levels may also inhibit the establishment of rooted aquatic and terrestial vegetation. Carp and other fish may inhibit plant growth by their "rooting" activities and grazing.

Macroinvertebrate sampling suggests an abundant but not particularly diverse benthic fauna. This infauna serves as an important food resource for warm water fish, amphibians, and migratory shorebirds. Emergent adult insects (with aquatic larval stages) provide food for aquatic vertebrates as well as for songbirds and bats that forage near or over the water.

Although the 1981 ODFW fish survey did not measure absolute population numbers, the relatve abundance of species has changed very little since an earlier undated survey. As already noted, fish may be involved in maintaining high turbidity levels and in the inhibition of aquatic plant growth. The fish in Sturgeon Lake are an important food resource for diving ducks (mergansers and cormorants), waders (herons and egrets), gulls, and bald eagles.

The palustrine lowlands surrounding Sturgeon Lake provide food, refuge, nesting cover, and perch sites for many terrestrial animals and birds. The area supports an especially rich avifauna of insectivorous birds and raptors (birds of prey). Deer and other mammals use shoreline vegetation for food and cover. These lowlands are a probable source for some of the nutrients found in the lake system. Detrital material from leaf-drop and plant die-back, as well as fecal material contributed by birds and other animals, represent a concentrated source of phosphorus, nitrogen and bacteria. Fall and winter rains and regular high water flooding transmit these nutrients to the lake.

Anticipated Environmental Effects of the Proposed Action

General Effects

If the proposed action is fully implemented, the resulting changes at Sturgeon Lake will be gradual and generally subtle rather than dramatic. This is because the proposed action will make no severe physical alterations to the lake, other than the changes where the shortened channel is excavated. The visual impact will be very localized; observers a few hundred feet away from the shortened creek will not be aware of it unless specifically seeking it.

The most important (and most desirable) effect expected is an immediate halt to the present net sedimentation condition in Sturgeon Lake. Winter sedimentation due to flood waters will still be prevalent. But because of the improved lake flushing at other seasons of the year, there will be an increase in the outflow of suspended sediment from the lake in summer and autumn when the water level in the lake is lower and tidal currents remove the unconsolidated sediment stirred up by wind-waves. The net effects will be to stop the net annual accumulation of sediment in the lake and to cause a net loss of sediment from the lake. This net loss of sediment should continue until the bottom depth of the lake increases to the point where scouring of the bed by wind-waves and tidal currents diminishes.

The second important effect expected is that the water quality of Sturgeon Lake will be improved. This will occur due to increased water exchange between the lake and the Columbia and Willamette Rivers on each tidal cycle. A net removal of organic matter and nutrients will begin immediately. After the first one or two years of suspended sediment outflow, there will also be a reduction in water turbidity.

These important effects on shoaling, turbidity and water quality will preserve and enhance the existing fish and wildlife habitat, which is now slowly diminishing. The will significantly improve the public recreation opportunities by providing a longer season of potential use and better health and safety conditions for persons boating or windsurfing on the water or fishing along the shore.

Relation to External Events

Sand transport in the Columbia River is on ongoing natural process, albeit influenced by human river activities. Sand transport occurs in the channel near the mouth of Dairy Creek and may cause shoaling there. If so, this will require local maintenance dredging.

Cumulative Effects

Full implementation of the proposed action will make it possible to maintain or slightly increase the lake depth, thus achieving the important goal of the project--preventing the slow loss of the lake by its gradual conversion into a winter-spring marsh and summer-fall dry lakebed. There will be some overall redeepening of the lake. In addition, tidal currents draining water from the lake on ebb tide will cause some local rescouring of channels within the lake.

However, over time Sturgeon Lake cannot be expected to become appreciably deeper than it is now. This is because as the lake redeepens, the wind-wave agitation of bottom sediment will diminish in effectiveness, achieving a balance between seasonal sediment deposition and seasonal sediment scour.

Nevertheless, the lake's primary use as a waterfowl refuge will be protected as long as Dairy Creek remains open and there is some increase in water depth over the present lake depths. Also, fishery benefits will be protected and somewhat improved because of the greater lake flushing, improved water depths, and greater water clarity. This may permit increases in the numbers and varieties of fish species present in the lake. Furthermore, water-related recreation will benefit from these same changes in lake condition through better use opportunities and greater safety.

Secondary Effects

Better flushing of suspended sediment from the lake during winter and spring periods of large river discharges will not cause off-site river turbidity levels to differ noticeably from present levels, since the main effect of flushing at such times will be to keep part of the river suspension load from settling out in the lake. However, at times when river discharges are small there will be some increase over the existing turbidity plume that leaves Gilbert River and extends downstream along the Sauvie Island bank of Multnomah Channel. Dissipation of that turbidity plume will be more gradual than at present but should still occur before such water reaches the Columbia River because of the large discharges in Multnomah Channel. Presently, much of this turbid water reenters Gilbert River on flood tide -- it moves back and forth between Gilbert River and Multnomah Channel. Reopening Dairy Creek will diminish the amount of this "shuffling" at Gilbert River.

It is also expected that as each ebb tide begins, at times of low river flows, some of the Columbia River water that had earlier entered the lake via Dairy Creek and mixed with turbid lake water will drain back out Dairy Creek. This more-turbid ebb flow from Dairy Creek will slowly mix with the Columbia River current; hence, some turbidity may be faintly evident for several hundred feet downstream from the mouth of Dairy Creek. This effect should be most apparent during the initial year of project operation and should diminish quickly as flushing action in the upper end of the lake removes the erodible particles during the next two or three years.

References for Data and Analyses

Klingeman, P. C., Jarvis, R. L., Bella, D. A., and Nelson, P. O.; Physical, Chemical and Biological Description of Sturgeon Lake; Technical Report 1; Water Resources Research Institute, Oregon State University, Corvallis; August 1982; 124 pp. (Main report)

plus 16 appendices in four volumes:

Volume 1; 53 pp.
- App. A: Schedule of Field Sampling and Laboratory Analyses;
- App. B: Biological Resources of Sturgeon Lake

Volume II; 145 pp.
- App. C: Staff Gage Readings for Sturgeon Lake and Adjacent Rivers;
- App. D: Descriptions of Temporary Bench Marks Used for Staff Gage Network;
- App. E: Water Level Records for Multnomah Channel, Gilbert River, and Sturgeon Lake, Based on Water Level Recorders;
- App. F: Historical Data on River Stages and Water Discharges for the Columbia and Willamette Rivers;
- App. G: Discharge Measurements in Gilbert River;
- App. H: Circulation Patterns in Sturgeon Lake and Gilbert River;
- App. I: Gilbert River and Sturgeon Lake Bottom Profiles, Based on Fathometer Traverses;

Volume III; 44 pp.
- App. J: Basic Water Quality Data for Sturgeon Lake and Adjacent Rivers;
- App. K: Supplemental Water Quality Data for Sturgeon Lake and Adjacent Rivers;
- App. L: Light Extinction Data for Sturgeon Lake and Adjacent Rivers;
- App. M: Concurrent Water Quality Data Collected by Oregon Department of Environmental Quality, Sturgeon Lake and Gilbert River;

Volume IV; 179 pp.
- App. N: Grain Size Analyses for Suspended and Bed Sediment, Sturgeon Lake and Adjacent Rivers;
- App. O: Sediment Chemistry Data for Sturgeon Lake and Adjacent Rivers;
- App. P: Clay Mineralogy Analysis for Sturgeon Lake, Sauvie Island, and Adjacent Rivers.

Klingeman, P. C., Jarvis, R. L., Bella, D. A., and Nelson, P. O.; Sturgeon Lake Problem Diagnosis, Options for Restoration, and Recommendations; Technical Report 2; Water Resources Research Institute, Oregon State University, Corvallis; August 1982; 52 pp.