CHINA LAKE

East and West Basins

Kennebec County

TOTAL MAXIMUM DAILY (ANNUAL) LOAD

Final Lakes TMDL Report

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Maine Lake TMDLs - What, Why, Where, and When?

You may be wondering what the acronym 'TMDL' represents and what it is all about. TMDL is actually short for 'Total Maximum Daily Load.' This information, no doubt, does little to clarify TMDLs in most people's minds. However, when we drop 'maximum', replace 'daily' with 'annual' and insert 'total phosphorus' before 'load' = *Annual Total Phosphorus Load* - it begins to make more sense to more people.

Simply stated, excess nutrients, or phosphorus in lakes, promote nuisance algae growth/blooms - resulting in the violation of water quality standards as measured by water clarity depths of less than 2 meters. A lake TMDL is prepared to estimate the total amount of total phosphorus that a lake can accept on an annual basis without harming water quality. Historically, development of TMDLs was first mandated by the Clean Water Act in 1972, and was applied primarily to *point sources* of water pollution. As a result of public pressure to further clean-up water bodies - lake and stream TMDLs are now being prepared for watershed-generated *Non-Point Sources* (NPS) of pollution.

Nutrient enrichment of lakes through excess total phosphorus originating from watershed soil erosion has been generally recognized as the primary source of NPS pollution. Major land use activities contributing to the **external** phosphorus load in lakes include residential-commercial developments, roadways, agriculture, and commercial forestry. Statewide, there are 38 lakes in Maine which do not meet water quality standards due to excessive amounts of in-lake total phosphorus.

The first Maine lake TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. Recently, TMDLs have been approved by US-EPA for Madawaska Lake (Aroostook County), and Sebasticook Lake (Penobscot County). TMDLs are presently being prepared by Maine DEP, with assistance from the Maine Association of Conservation Districts (MACD) and County Soil and Water Conservation Districts (SWCDs) - for East Pond (final review) and Mousam Lake (in prep.). A non-MACD supported TMDL for Unity Pond (Waldo County) is also being developed. New TMDL lake studies in Cumberland County include: Highland (Duck) Lake in Falmouth, Long and Highland lakes in Bridgton; Webber and Threemile ponds (Kennebec County). TMDL studies are also being initiated for Annabessacook Lake and Pleasant Pond (Kennebec and Sagadahoc Counties) - under contract with CWD.

Lake TMDL reports are based in part on available water quality data including seasonal measures of total phosphorus, chlorophyll-a, Secchi disk transparencies, and dissolved oxygen-water temperature profiles. Actual reports include: a lake description; watershed GIS assessment & estimation of NPS pollutant sources; selection of a total phosphorus target goal (acceptable amount); allocation of watershed/land-use phosphorus loadings - and a public participation component to allow for stakeholder review.

TMDLs are important tools for maintaining and protecting acceptable lake water quality. They are primarily designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to address the problem. *Development of phosphorus-based lake TMDLs are not intended by Maine DEP to be used for regulatory purposes*. Landowners and watershed groups are eligible to receive technical and financial assistance from state and federal natural resource agencies to reduce watershed total phosphorus loadings to the lake.

TMDL Summary Overview

This summary overview provides **China Lake** watershed stakeholders with a brief accounting of facts and figures from the attached China Lake TMDL technical report, prepared by Maine DEP with assistance from the Maine Association of Conservation Districts (MACD). Further questions or comments should be addressed to Dr. David Halliwell, Lakes TMDL Project Leader, ME-DEP, State House Station #17, Augusta, ME 04333, 207-287-7649, **david.halliwell@state.me.us)**.

Note - Phosphorus-based lake TMDLs are primarily designed to 'get a handle' on the magnitude of the *Non-Point Source* (NPS) pollution problem and to develop plans to implement *Best Management Practices* (BMPs) to address the problem. Landowners (residential, commercial, agricultural, municipal) and watershed groups are eligible to receive technical and financial assistance to effectively reduce watershed phosphorus loads to susceptible lakes (US-EPA and ME-DEP Project 319 funding and support).

Unique Properties - **China Lake** (3,937 surface acres) is a relatively large and deep (85 feet max. West basin, 33 feet average depth) *dual basin drainage lake* located in south-central Maine within the towns of China, Vassalboro. The intensively developed East basin is much shallower, averaging only 20 feet in depth. China Lake flushing rates range from 0.65 (West basin) to 0.72 (East basin) flushes per year, about 1/2 as slow as the average of 1.5 for Maine lakes. The lake watershed is heavily developed on the north and southeastern lake shore, primarily with residential homes accessed by lengthy and moderate to high gradient camp roads. China Lake gained national notoriety in the mid-1980s for experiencing rapidly declining water quality and resultant nuisance algae blooms ('China Lake Syndrome'). Since then, considerable state and federal funding and local grass roots efforts (China Region Lakes Alliance, China Lake Association, Kennebec County Soil and Water Conservation District, Kennebec Water District - water quality monitoring) have supported numerous well-planned and implemented lakeshore and watershed remedial projects designed to address and reduce the external loading of total phosphorus.

Historical vs. Current Water Quality - the overall water quality of China Lake has only slightly improved over the past decade, with intense blue-green nuisance algae blooms prevalent during most summers since the mid-1980s. Based on minimum water transparencies, intense algae blooms were not evident only during the summers of 1989-90 (2.1 m average) and 1996 (2.2 m average). Historically, a combination of both internal (sediment) and external (watershed) sources accounted for the in-lake nutrient (total phosphorus) loadings. Today, it appears that internal sources of total phosphorous are primarily responsible for nutrients loadings to China Lake. Notably, China Lake is the 5th TMDL report prepared for Maine lakes, and is only the 2nd study (see Cobbossee Lake, Table 5) in which the external watershed loading of total phosphorus is lower than the lake P-load capacity, or ability to effectively process nutrients.

Water Quality Standards and Lake Target Goals - an in-lake total phosphorus (TP) summer-time concentration target goal for China Lake of 15 ppb was selected to ensure the future attainment of water quality standards (Secchi disk transparencies 2 m or more and the general absence of nuisance *summertime* blue-green algae blooms).

Selection of Total Phosphorus Loading Coefficients - estimates of phosphorus export loadings (kg TP per hectare per year) were determined using local and regionally published export coefficients for representative land uses. Selection of actual values, ranging from low to high, reflect the relative effects of applied BMPs - as evaluated by best professional judgement. Generally, moderate level phosphorus load coefficients were chosen to reflect both the high-density residential use of the north- and south-eastern shorelines of China Lake and non-residential/commercial land uses.

Watershed Land Use & TP Load Allocations - The China Lake direct watershed is dominated (66%) by *non-cultural land areas* (non-commercial forests, wetlands, and scrub-shrub) - which contributes 14% of the non-point source TP load (286 kg). Atmospheric (lake surface area) sources comprise 19% of the watershed area and 12% of the TP load (255 kg). *Cultural NPS sources* (15% area - 74% TP load - 1,518 kg) include: China Lake agricultural practices (8% area - 30% TP load - 600 kg), shoreline development (residential and summer camp recreational (1.3% area - 8% load - 154 kg) including septic systems (4% TP load - 83 kg), and roadways (2% area - 22% TP load - 442 kg); and developed non-shoreline (4% area - 16% TP load - 322 kg), e.g., low-density residential, commercial, institutional, cemeteries, and gravel pits.

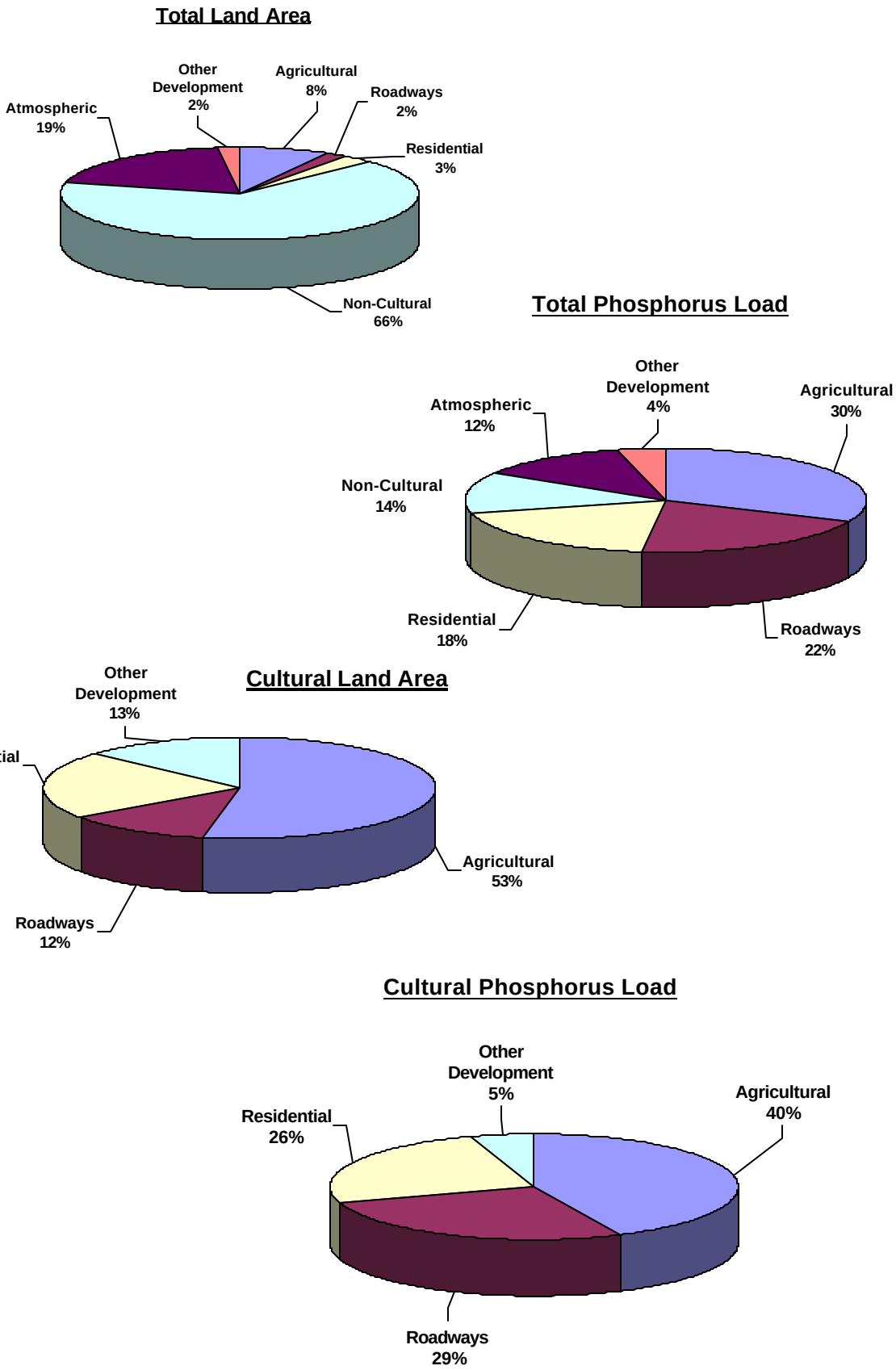
Lake Loading Capacity, Internal-External Pollutant Loads - the China Lake loading capacity, based on a phosphorus retention model, equals 2,830 kg of total phosphorus annually - at a target goal of 15 ppb. *External* (watershed) TP export is 2,059 kg per year and the *internal* (sediment) TP load model output equals ca. 1,850 kg annually. The China Lake basin TP-load capacity is ca. 800 kg more than the existing external (watershed) TP load. Subtracted from the internal load = 1,050 kg (27%) as the amount of TP needed to be reduced to meet water quality needs. This reduction in total phosphorus may be attained over time with continued reductions in external (watershed) TP loads leading to reductions in internal (sediment) TP loads via annual lake flushing.

Water Quality Problem Solving Approach - China Lake is fortunate in having very active and responsible organizations in place to deal with water quality issues. As a result of much hard work and directed efforts over the past decade by Maine DEP and active watershed stakeholders (China Lake Association, China Region Lake Alliance, with monitoring efforts by the Kennebec Water District), the water quality and watershed conditions of China Lake are fairly well known and problem areas have been addressed to eliminate watershed phosphorus sources. During the summer months, the China Lake Conservation Corps, under CRLA direction, have spent considerable time and effort in assisting China Lake shoreline residential land owners to implement nonpoint source best management practices to control shoreline zone soil erosion. Maintaining a combination of residential property and roadway BMPs will effectively reduce both the external and ultimately the internal phosphorus load within China Lake.

In-Lake Remedial Options - The flushing of phosphorus laden waters via significant fall water level drawdown is not an option for China Lake. The viability of alum treatments to reduce phosphorus recycling from lake bottom sediments in China Lake and Threemile Pond, were studied in the mid-1990s. Results indicated a much higher probability of success (in excess of 10 years) of alum treatments in the relatively deeper China Lake basins, however, the cost of application relative to the size of the treatment area was deemed prohibitive at that time.

At any rate, it is important to remember that "releases from lake bottom sediments reflect the likelihood that externally derived TP loads have historically exceeded China Lake's assimilative capacity, and that alum treatment should be viewed as a supplement to, and not a substitute for watershed management" (Walker 1994).

Figure 1. China Lake TP Load Percents by Total Watershed & Cultural Area



CHINA Lake TMDL (Kennebec County) Maine

1. DESCRIPTION of WATERBODY and WATERSHED, Priority Ranking, Pollutant of Concern, and Pollutant Sources - Relative to Natural Background Levels

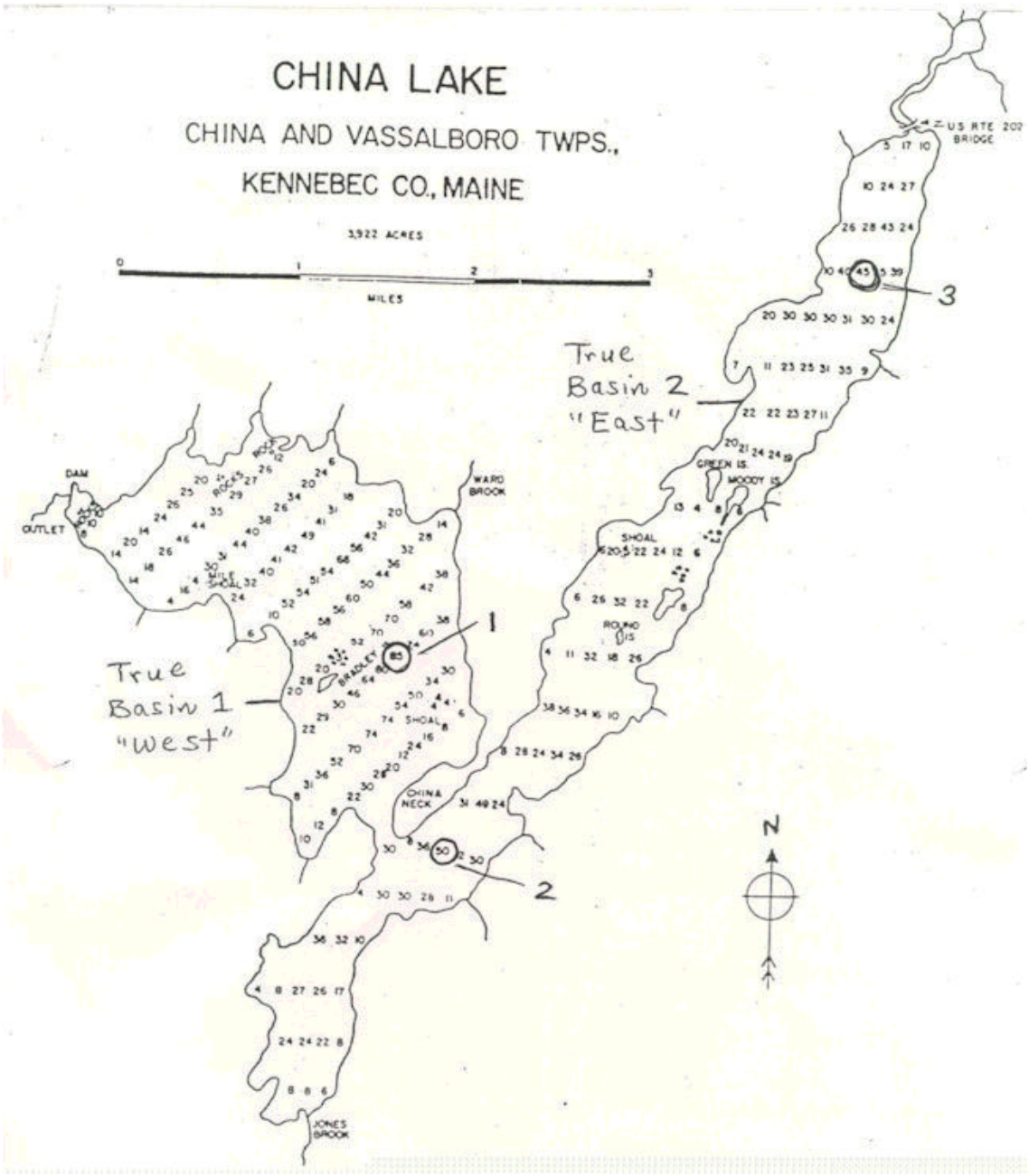
China Lake (*MIDAS #5448*) is a 1,593 hectare (3,937 acres or 15.9 km^2) two-basin (East and West) waterbody located in south-central Maine (DeLorme Atlas, Map 13), within Kennebec County. The China Lake watershed has a direct watershed area of 6,760 hectares (26.1 square miles - total of 32 sq. mi. and 8,353 ha including lake surface area) and is located within the towns of China, Vassalboro, and Albion. China Lake has a maximum depth of 26 meters (85 feet) and a mean depth of 10 meters (33 feet) in the deeper West basin, while the East basin is generally shallower, averaging only 6 meters (20 feet).

Although China Lake has only two true basins, this large waterbody has historically been divided into **three distinct basins** for monitoring purposes (Figure 2). The **West basin # 1** is 4 km long and 1.6 km wide, has a surface area of 723 ha, a flushing rate of 0.65 and a direct watershed area of 17.1 km^2 (6.6 mi^2). The **combined two East basins** - # 2 Southeast and # 3 Northeast - are approximately 11 km long and relatively narrow (0.8 to 1.2 km), with a surface area of 870 ha, a flushing rate of 0.72, and a direct watershed area of 50.5 km^2 (19.5 mi^2).

Drainage System - China Lake generally flows south from the East basin to the West basin and has four major tributaries (Figure 2). Muldoon Stream, a large wetland-stream system flows directly south into the northeastern basin. Starkey Brook flows in from the east and Jones Brook flows from the south. Ward Brook is the only major tributary that flows into the West basin. Twenty smaller tributaries also drain into China lake.

China Lake has a single outlet, a stream and low-head dam on the west shore of the West basin. The dam, owned and operated by the Town of Vassalboro, includes two flood control/drawdown gates and a 12 foot-wide spillway topped by removable metal fish screens (Maine DEP Water Level Order 1997). Lake drawdown is not an effective phosphorus control option (see Sebasticook Lake TMDL), since the lake outlet structure

Figure 2. Map of **China Lake** depicting West and East (North and South) true basins and water quality sampling locations (tri-basin).



does not allow for a significant withdrawal (Maine DEP 1989, CRLA Management Plan 1999). The outlet stream eventually drains into the Sebasticook River, just north of its confluence with the Kennebec River.

Water Level Regulations. As noted, China Lake water levels are currently managed in accordance with an existing Maine DEP Water Level Order, last issued in 1997 (originally issued in 1984 and amended 1986). Following is a digest (in part) of the pertinent annual water level regulations from the Maine DEP Water Level Order of 1997:

(1) Lake drawdown commences November 15 - on a gradual basis, to a target level of 1.5 feet below spillway level, which is reached prior to winter lake ice-in.

(2) After ice-in and until the following April 1, a level of 1.5 feet (plus or minus 6-inches) below spillway level is maintained - in order to accommodate winter/spring runoff.

(3) Between April 1 and Memorial Day, the lake is managed to refill to a high water target level of 6 inches above the spillway level.

(4) Between Memorial Day and Labor Day, the lake is managed to maintain water levels between spillway level and 6 inches above spillway level.

(5) Between Labor Day and November 15, the lake is managed to maintain water levels between spillway level and 6 inches below spillway level.

These water level regulations are deemed adequate to protect public access and use, fish habitat - including brown trout spawning, wildlife habitat, and public/private water supplies. In addition, the erosion potential of shoreline waves: (a) and ice-scouring under high water conditions is minimized; and (b) under unchanging water levels is limited. According to Maine DEP Water Level Order (1997) findings, "the preponderance of the evidence indicates that the current (1984) water level regime is not causing significant erosion of the shoreline of China Lake." This fact is further supported by the qualitative East basin shoreline erosion survey conducted by the China Lake Association during June, 2000. This survey accounted for a total of 82,300 linear feet of shorefront, of which 3,161 feet (4%) was judged to be actively eroding. The actual impact of shoreline erosion from China Lake was not quantified, nor included in the external watershed land use TP load calculations "because we (still) lack a clear definition of the mass rate of erosion and attendant P-content of soils from these sites" (Maine DEP 1989, p. 24). At any rate, it appears that shoreline erosion is responsible for a relatively minor amount of the total external loading of phosphorus to China Lake.

Public Access - There are three public boat ramps on China Lake. The Town of Vassalboro maintains a public boat launch on the West basin and there are two launch sites on the East basin: one in China Village and one in South China. The unimproved boat launch in South China is noted in the Maine Association of Conservation District (MACD 2000) watershed inventory as a high priority NPS site (see BMP implementation plan). Public access is also provided by the China Four Seasons Club, where there is vehicular access to a semi-private beach on the eastern shore of the lake. The access road to the beach is listed as a high priority on the MACD 2000 survey due to severe erosion (see BMP implementation plan). There is also a public beach situated near the northeastern basin boat launch, maintained by the China Baptist Church.

Kennebec Water District and Water Quality Monitoring - China Lake has served as the primary drinking water supply for the Kennebec Water District (KWD) since 1905. The KWD serves the municipalities of Waterville, Winslow, Benton, Vassalboro, Fairfield, and also supplies water to the town of Oakland, serving approximately 40,000 residents. Historically, the China Lake outlet stream was the water supply for the East Vassalboro Water Company (EVWC). Today, the outlet stream is no longer used as a municipal drinking water supply, as the EVWC now draws it's water from wells (Maine DEP Water Level Order 1997). The estimated capacity of the lake is 31 billion gallons. KWD demand currently averages 1.5 billion gallons annually.

As a surface water body, China Lake is susceptible to pollution and contamination from both human and natural sources. The KWD continues its watershed protection efforts by working with the China Region Lake Alliance (CRLA) and the China Lake Association (CLA) to address nonpoint pollution source loading within the watershed. The Towns of China and Vassalboro have supported the efforts of these organizations through both financial and in-kind services. The common goal of these towns and organizations is to improve China Lake water quality using a comprehensive Watershed Protection Plan (CRLA and CLA 1991).

Human Development - China Lake shoreline is highly developed on the East basin (estimated at 75% developed) while the West basin shoreline is largely undeveloped (estimated at 1% developed). There are approximately 481 dwellings on the entire shoreline, with 70% seasonal and 30% year-round (Town tax records). Almost all of

this, mostly privately owned, development (472 or 98%) occurs in the East basin. In contrast, the shoreline of the West basin is primarily owned by the Kennebec Water District (KWD). Historically, the West basin was much more developed than the East basin. However, in the early 1900's the land around the West basin was acquired by the KWD in order to protect drinking water supplies. Between 1906 and 1930, all of the cabins on the shore of the West basin were removed by the water district. The KWD currently owns all but about 600 feet of shoreline on the West basin, with an average distance back from the shore being about 200 feet (KWD 2001). In addition to land owned on the West basin, the KWD also owns considerable shore frontage in the East basin on either side of the narrows (KWD 2001).

The town of China comprises 89% of the China Lake watershed, Vassalboro 9%, and Albion 2% (KC-SWCD). Fifty-six percent of China, 7% of Vassalboro and 4% of Albion are located within the China Lake watershed. The total estimated China Lake watershed population is 2,660 -based on the year 2000 town population figures and the percentage of a given town within the watershed. Rapid population growth and increased land use activities during the last two decades have no doubt contributed to increased runoff to China Lake with a resultant increase of algae growth and the disappearance of the once healthy population of salmon, trout and togue (CRLA 1999). The town of China's population increased from 2,918 in 1980 to 3,670 in 1990 (and 4,106 in 2000, see below) and the number of households increased from 958 in 1980 to 1,334 in 1990 (China Town Comprehensive Plan, 1991). Average household sizes are decreasing from 3.1 in 1980 to 2.8 in 1990 (1980 US Census, 1990 Town of China estimates). Similar numbers were not readily available from the towns of Vassalboro and Albion, which have a current population of 4,047 and 1,946, respectively - according to the U.S. 2000 census.

According to the Maine DEP's Diagnostic Study (1989), "there are approximately 185,000 people (15% of Maine's population) living within 50 km of China Lake". The economic base of the watershed generally consists of small service business enterprises (located in neighboring towns of Waterville and Augusta), tourist-related, government employees, and farming operations. The number of active farms has declined by ~ 40% for the 1980 to 1989 time period, during which time China was one of the fastest growing towns in central Maine.

Priority Ranking and Algae Bloom History - In the mid -1980's, China Lake gained national notoriety as the lake with the most rapidly declining water quality ever documented in the State of Maine. Now when lakes turn green, it may be referred to as the 'China Lake Syndrome' (Maine Audubon Society 1986). China Lake was one of the first Maine lakes in which lake-sampling studies showed that general residential development and agricultural practices to be generating most of the phosphorus rather than a few point sources. China Lake is on the state 303(d) listing of lakes in non-attainment of water quality standards (Maine DEP 1998). China Lake is also on the Maine DEP's list of Lakes Most-At-Risk From Development "due to rapid population growth rates in the surrounding towns and the sensitive nature of the waterbody" (1999 Watershed Management Plan, p. 3). China Lake is a culturally eutrophic lake. Nuisance algae blooms have occurred since the early 1980's, severely affecting the recreational and aesthetic enjoyment of the lake while increasing the water treatment necessary to meet standards for a public drinking water supply (Maine DEP 1989). Potential for nuisance algae blooms is moderate to high (Maine DEP 1999). Colby College's China Lake water quality study in 1989 found that "phosphorus inputs appear to originate from a combination of poor soils and unsafe residential and agricultural practices, including the lack of erosion control devices or diversions resulting in direct input of runoff to the lake" (Reagan 1997).

Water Quality Information (Source: Maine DEP and VLMP) - Continuous water quality monitoring data for China Lake has been collected since 1971. Currently, all three sampling basins of China Lake are monitored by the KWD on a biweekly basis during the summer months (May through September). There are 27 continuous years of SDTs and 16 years of TP for the West basin. West basin 1 has an average SDT of 4.0 m (13.1'), a TP average of 17 ppb, and a Chl-a range from 1.9 - 40.4 ppb, with an average of 10.9 ppb. Southeast basin 2 has 26 years of SDTs and 15 years of TP: average SDT of 3.9 m (12.8'), a TP range of 15 - 32 with an average of 19 ppb, a Chl-a range of 2.1 - 46.9 ppb with an average of 11.3 ppb. Northeast basin 3 has 24 years of SDTs and 13 years of TP: average SDT of 4.2 m (13.8'), a TP range of 16 - 25 ppb with an average of 18 ppb, and a Chl-a range of 1.4 - 64.2 with an average of 11.8 ppb. The overall water quality of China Lake is considered to be poor, based on measures of SDT, TP and Chl-a (see Appendix A for Maine DEP 1999-2000 water quality update).

Natural Background levels for China Lake were not separated from the total nonpoint source load because of the limited and general nature of available information. Without more and detailed site-specific information on nonpoint source loading, it is very difficult to separate natural background from the total nonpoint source load (US-EPA 1999). There are no known point sources of pollutants to China Lake (MACD 2001).

Descriptive Land Use Information

Agriculture - Agricultural data for the previous Maine DEP Diagnostic and Feasibility 1989 study was provided by KC-NRCS staff (See Table 1). This information included a list of 18 active “cooperator” farms in the watershed, with 5 of the farms having some cropland. In summary, “at least 90% of the acreage identified as pasture, hayland, or cropland was used by farmers having a conservation plan." It is more difficult to estimate the number of acres presently not being farmed that are under a conservation plan - because they are, for the most part, either owned by inactive or non-cooperating farmers, and the information is not up to date. A reasonable estimate of "cooperating" farms in the watershed would be 50% (KC-NRCS letter to Maine DEP, 1988).

Table 1. China Lake Agricultural Land Use Breakdown (1988-1989)

Land Use	**1988 ha**
Pasture	169
Hayland	415
Cropland (corn)	93
Grassland – not presently farmed	311
Totals	**988 ha**

The Kennebec County NRCS office was consulted in 2001 to obtain the most recent and accurate agricultural data for the China Lake Watershed. According to KC-NRCS, the 1988 numbers are still a fairly accurate representation of agricultural operations currently in the watershed, with a few minor changes: There is less acreage in the pasture and hayland categories (ca. 10 ha less in each), and the category “grassland not presently being farmed” (311 ha) should now be classified as scrub/shrub – or early successional forest type. This revised data was broken down according to East or West basin of the lake. There are ca. 14 farms currently operating within the watershed, only one large commercial farm, a small commercial farm, and the remainder are smaller agricultural enterprises.

Table 2. China Lake Agricultural Land Use Breakdown (2000-2001)

Land Use	West-ha	East-ha
Pasture	79	79
Hayland	201	201
Cropland (corn)	61	32
Totals	**341**	**312**

Shoreline Camp and Residential Lots - Residential lot listings (town offices) within the shoreland zone and the corresponding town property cards were examined for acreage, number of septic systems and year-round or seasonal use. All of the residential lots in China are on the East basin of the lake. In Vassalboro, the KWD owns nearly the entire shoreline for 100-200 feet from the water's edge. The information for the West basin was not collected from a list of shoreland zone lots. Estimates of number of properties located within the 250-foot shoreland zone were made within developed areas along the China Lake shoreline. Only a few homes are found within the shoreland zone of China Lake within the town of Vassalboro.

West basin: There are 9 residential units on the shoreline (1 seasonal and 8 year-round) and 12 undeveloped lots, 10 of which are owned by the KWD.

East basin: There are a total of 472 residential units on the shoreline (325 seasonal and 142 year-round) and 86 undeveloped lots, 2 of the larger parcels (ca. 160 acres total) which are owned by the KWD.

Septic Systems - The Town of China conducted a sanitary survey of many of the structures and lots in the shoreland area during the summers of 1985 and 1986. A survey was not conducted in Vassalboro since there are relatively few cottages on the West basin, and a number of properties in the East Vassalboro area near the lake are served by a treatment facility.

Results of the 1985 - 1986 Sanitary Survey are as follows:

- Estimated 456 structures located within the shoreland zone.
- Approximately 22% of the residences are occupied year-round.
- Mean occupancy = 2.5 persons per dwelling.
- Median house distance back from the water = 45-feet.
- Only 23% of dwellings had greater than a 75-foot setback.

- Of the 270 surveys completed (many with interviews), 17% did not know septic system location and 22% did not know approximate year of construction.
- 8% of systems closer than 75-ft. to the water, with 54% between 75-100 ft.
- 53% of systems built pre-1972, with no design or construction records.
- As many as 27% of shoreline cottages were built prior to 1960.

It was concluded that, "given the age of many of the cottages, a large number have inadequate 'trench systems' or cesspools. These may be in intermittent contact with groundwater, but often give no overt indication of this, especially if they are used only in the summer months". Following the 1985-86 survey, several malfunctioning leach fields were mitigated and removal of some grey-water discharges occurred (Maine DEP 1989).

According to the Maine DEP 1989 Feasibility study, a number of the predominant soil types around the lake have high groundwater tables seasonally or may have low permeability's. The soil class covering a vast majority of the China Lake watershed is the Hollis association, which is: shallow to bedrock; excessively drained with gently to moderately steep slopes; susceptible to soil erosion; and has moderate to severe limitations for use as septic fields. The next largest soil association is Buxton, which is poorly drained to moderately well drained and found in flat areas and near waterways. The Buxton soil association is limited by some erosion liability and has severe limitations for septic system field use. The third largest soil association found in the China Lake watershed is Scantic, a hydric soil which is poorly drained (KC-NRCS communication).

In the Maine DEP 1989 study, ranges of phosphorus export (5 -10% of septic tank output) and phosphorus generation per capita (0.3 to 0.6 g P/capita/day) were coupled with average occupancy of 2.5 capita per cottage and the number of days per year occupancy to estimate P-load to China Lake from septic fields. In the East basin of China Lake, the estimated loading from septic systems was calculated to be 35 to 130 kg P/year. Septic system loading to the West basin would be negligible (Maine DEP 1989, pp. 22-23).

The town of Vassalboro required that septic systems within the 250-foot shoreland zone installed prior to July 1974 be upgraded to meet current standards. As a result of this requirement, many septic systems were replaced (CRLA Watershed Management Plan 1999). A recent review of plumbing permits for the shoreland zone of China Lake revealed that during the time period 1990 to 2000, approximately 85 existing septic

systems have been replaced (average of 8 replacements/year), 16 new septic systems have been installed, and three existing septic systems were expanded (MACD 2001). The septic system information provided on individual plumbing permits were variable. When the permit supplied information about the septic system being replaced, it was noted. Overall, replaced septic systems included 7 cesspools, 15 trenches (many older wooden structures), one lagoon, two 55-gallon barrels, and four unknown 'septic systems' that dated as far back as the 1920's (MACD 2001).

Currently, the Town of China has no public sewer system. According to China town property records, most dwellings have septic systems, with only 6 dwellings having holding tanks and 8 dwellings (5% of the residents) within Vassalboro serviced by public sewer. The town of Vassalboro has three small sewer (sand) treatment facilities located in Vassalboro. One of these discharges to the outlet stream in East Vassalboro and serves the households closest to the shore of the West basin of China Lake. According to the KWD, septic system inspections were made of the method of sewage disposal at the two cottages on the East basin of China Lake and, in one case, corrections were made.

Recreational – Shoreline (East Basin) - Candlewood Camps is a commercial rental cottage operation with 23 cottages, and is located on 1.2 hectares on the eastern shoreline of China Lake. There is also a 3.3-hectare parcel across the street (Lakeview Drive - Fire Road 202) that has some tennis courts and events center. The *China Four Seasons Club* - a Fish and Game Club located on the shores of China Lake, consists of 2.8 hectares.

China Lake's cold water fishery was negatively impacted by the decline in water quality during the 1980s, and the once-abundant landlocked Atlantic salmon and lake trout (togue) have since disappeared. Currently, dissolved oxygen levels are inadequate to support a healthy (self-sustaining) coldwater fishery (Regan 1997, p. 27). A popular holdover brown trout fishery is currently supported by annual put-and-take stocking by the Maine Division of Inland Fish and Wildlife.

Other Development and Land Uses - In 1989, major land uses in the China Lake watershed included: dairy farming, limited urban areas in China, South China and East Vassalboro, shorefront cottage development, and dispersed low-density single-family homes (Maine DEP 1989).

Commercial - Development is limited to small professional, service and retail stores. There are a total of 18 hectares of commercial lands in the watershed of the East basin of China Lake - and none in the relatively undeveloped West basin.

Institutional - Developed municipal properties in the Town of Vassalboro are limited to the boat ramp and parking lot in East Vassalboro. In the Town of China, there are 61 hectares of non-shoreline institutional lands, and 4 hectares of shoreline (Conference Center) - all within the East basin watershed. Non-shoreline institutional lands consist of school lots and municipal lands (fire stations, town office, transfer station).

Roadways - Roadway areas were determined using USGS 7.5" topographic maps, GIS land use data and field measurements. There are approximately 147 ha of roadways within the China Lake watershed (31 ha – west basin; 116 ha – east basin). Average roadway widths are 20 m for state, 12.5 m for town and 5 m for camp roads. For this lakes TMDL report - roads are divided into four different categories; state, town, camp and trail. Camp roads were broken down further to take into account for paved camp roads. The trail category includes jeep (4 x 4) and logging trails, as well as a portion of an abandoned narrow gauge railroad, which is an ongoing source of NPS pollution.

Table 3. China Lake Watershed Roadway Landuse Breakdown (2001).

Road Type	East Basin	West Basin	Total Watershed
State	48.3	8.0	56.3
Town	47.3	20.1	51.3
Camp Road (gravel)	11.3	1.2	12.5
Camp Paved	2.8	0.4	3.2
Trail	6.4	1.2	7.6
Total	**116.1**	**30.9**	**147**

As with most lake watersheds, roadways remain a serious water quality concern for China Lake. Erosion problems, ranging in severity, can be identified for all road classifications. Efforts have been made throughout the years to address road-related NPS problems. During the early 1990's, Maine DEP and the CLA, CRLA and the KWD developed a cost share program aimed at curbing the nutrient loading from all sources, including camp roads. Funding for this program came from numerous sources, including Maine DEP, US-EPA, the KWD and CLA membership dues. The CRLA provided technical assistance in implementing projects on 12 identified problem roads. The CRLA

and CLA have actively worked to mitigate road-related NPS problems throughout the watershed. Progress has been made, as evidenced by the multitude of well-maintained camp roads observed in the MACD 2000 survey. In the early to mid 1990's, a federal Maine Department of Transportation ISTEA grant addressed many problems associated with state roads and since then, needed restorative work problems on state roads have generally diminished (CRLA Management Plan 1999).

MACD 2001 Road Survey - During the recent roadway survey, it was observed that BMPs implemented in previous years on many private camp roads were in place and functioning; the shapes and crowns of roads provided for adequate dispersal of runoff and the placement of recycled asphalt on a number of roads minimizes potential impacts. The survey identified 20 road sites that may have an impact on lake water quality (4 high, 7 medium and 9 low priority sites). A number of problems have also been identified along state and town roads due to drainage-erosion problems of medium to low priority. Problems of varying severity were also identified along town roads, ranging from moderately eroding road ditches to unstable culvert outfalls.

The town and state road problems are usually the easiest to fix as there are resources (i.e., equipment and funds) in place to mitigate the NPS pollution problems. On private camp roads, however, there are usually few road associations to deal with road washouts, crowning, and ditch work and funds are limited. Normally, residents pool money together a couple of times a year to maintain the camp roadways and to fill and grade potholes. According to communications with Dave Landry (President, China Lake Association), the CLA developed by-laws to incorporate road associations to deal with maintenance and access issues, but they have largely been unsuccessful. Many residents feel that road associations were unnecessary and too much of a financial burden. Three local contractors have completed Maine DEP NPS training; they are the primary contractors in the area and are aware of water quality concerns for China Lake.

Total Phosphorus Land Use Loadings

Estimates of total phosphorus export from different land uses found in the China Lake watershed are presented in Table 4 and Figures 1a-1d and represent the extent of external total phosphorus loading to the lake. The watershed total phosphorus loadings were primarily determined using both literature and locally derived export coefficients as

found in Schroeder (1979), Reckhow et al. (1980), Maine DEP (1981 and 1989), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for low and high-density residential properties; roadways; and others types of developments (recreational, commercial, and agricultural).

Agricultural Practices - total phosphorus loading coefficients applied to agricultural practices (i.e., hayland and pasture 1.0 kg/ha, row crops 1.5 kg/ha) were initially adopted directly from the Maine DEP (1989) studies. The hayland TP loading was reduced from 1.0 to 0.75 kg/ha to reflect a 34% reduction (from 1989 to present) in the number of animal units (ca. 300 animals) and the resultant lower use of animal manure for fertilizing haylands (Ron Derosiers, KC-NRCS personal communication). These numbers also reflect use of agricultural best management practices inclusive of annual crop/field rotations (Jon VanBourg, personal communication). A comparison of 2001 to 1989 landuse estimates, indicates that the agricultural component in the China Lake watershed has decreased 15 to 18%, in terms of total and cultural total phosphorus loadings. A total of 30% of the external TP load is estimated to be derived from agricultural practices in the China Lake watershed (40% of the cultural only TP loading).

Shoreline Camp and Residential Lots – In most comparable studies, this category generally has one of the largest estimated impacts, in terms of total phosphorus loading to lakes, in comparison to its relatively small percentage of the watershed (Table 4). Such does not appear to be the case for China Lake at this time. Seasonal and year-round shoreline camp and home lots on China Lake (primarily East basin) comprise only 1.2 percent (98 ha) of the total watershed area and an average of only 67 kg of total phosphorus annually, which approximates only 3 percent of the estimated total phosphorus load (Table 4). This land use category was divided into low and high-density residential and recreational landuse areas (Table 4). The range of total phosphorus loading coefficients used (Table 4) for low-density houselots (0.25 - 0.98 kg/ha) and high-density houselots (0.35 - 1.40 kg/ha) were adopted from those used for past studies from China Lake in Kennebec County, Maine (Maine DEP 1989), Long Lake, Aroostook County, Maine (Bouchard et al. 1995), and the previously accepted Cobbossee Lake TMDL - 0.98 to 1.40 (Monagle 1995, Maine DEP 1999) and Sebasticook Lake TMDL reports (Maine DEP 2001). Shoreline development comprises 8% of the total TP load and 10% of the cultural TP load (Table 4).

Roadways - Total phosphorus loading estimates from roadways comprise 22% of the total external load and 29% of the culturally derived TP load. The TP loading coefficients chosen were based on studies from rural Maine highways (Dudley et al. 1997) and reflect potential differences in impacts between unpaved, higher gradient shoreline camp roads (3.9 kg/ha) and paved, generally lower gradient, non-shoreline roadways (2.9 kg/ha).

Total Cultural Phosphorus Loadings - A total of 74 percent (1,518 kg) of the total phosphorus loading to China Lake is estimated to have been derived from the cumulative effects of the preceding four cultural land use classes: agriculture (30% - 600 kg); **roadways** (22% - 442 kg); non-shoreline development (16% - 322 kg); and shoreline development (8% - 154 kg), including residential septic systems (3.8% - 83 kg) - as depicted in Table 4. These numbers, when compared with Maine DEP 1989 estimates, show an overall decrease in agricultural landuse and an increase in residential development, inclusive of lakeshore camp roads.

Non-Cultural NPS Sources

Forest Practices – Of the total land area within the China Lake watershed, 42 percent (3,466 ha) is forested (Table 4), most of which are privately owned deciduous and mixed forest plots (MACD 2001). Maine DEP (1989) originally assigned a relatively low total phosphorus export coefficient (0.035 kg/ha) to forested land in the China Lake watershed, based on "the high proportion of softwood and the fact that logging operations in the watershed were limited in extent." The median values for total phosphorus export from forested watersheds - nationally, is 0.21 kg/ha/yr (Reckhow et al. 1980). A total of 6.8 percent of the phosphorus load (average 139 kg) is estimated to be derived from forested watersheds within China Lake's direct drainage area (Table 4).

Other Non-Cultural - combined wetlands, grassland, and old field scrub shrub comprise approximately 24 percent of the China Lake watershed, which accounts for the remaining 7.1 percent (147 kg) of the total non-cultural total phosphorus export load - 286 kg or subtotal of 14 percent of the total TP load (Table 4).

Table 4. Estimated total phosphorus export by land use class for the **China Lake** direct watershed in towns of China, Vassalboro, and Albion.

LAND USE Human Cultural **Development**	**East Basin** ha	**West Basin** ha	**Total Area** ha	**% Total** Area	**TP Coeff. Used** kg/P/ha	**TP Exp. Avg.** kg TP	**TP Exp. Avg.** %
Agriculture Practices							
Pasture	79	79	158	1.9	1.00	158	7.7
Hayland	201	201	402	4.8	0.75	302	14.7
Cropland (Corn)	61	32	93	1.1	1.50	140	6.8
Sub-Totals	**341**	**312**	**653**	**7.8**		**600**	**30**
Shoreline Development							
Low-Density Residential	72	2	74	0.9	0.62	46	2.2
High-Density Residential	24	0	24	0.3	0.88	21	1.0
Institutional/Recreational	8	0	8	0.1	0.52	4	0.2
Septic Systems			--	(1985)	3 - 9 %	83	4.0
Sub-Totals	**104**	**2**	**106**	**1.3**		**154**	**8**
Non-Shoreline Develop.							
Low-Density Residential	126	34	160	1.9	0.15	240	11.7
Institutional	61	0	61	0.7	0.75	46	2.2
Commercial	18	0	18	0.2	1.44	26	1.3
Gravel Pits	44	0	44	0.5	0.10	4	0.2
Cemeteries	37	4	41	0.5	0.14	6	0.3
Sub-Totals	**286**	**38**	**324**	**3.9**		**322**	**16**
Roadways							
Shoreline	14	2	16	0.2	3.90	62	3.0
Non-Shoreline	102	29	131	1.6	2.90	380	18.5
Sub-Totals	**116**	**31**	**147**	**1.8**		**442**	**22**
TOTAL CULTURAL	**847**	**383**	**1,230**	**14.7**		**1,518**	**74**
NON-CULTURAL NPS							
Forests	2,546	920	3,466	41.5	0.04	139	6.8
Wetlands	590	150	740	8.6	0.02	15	0.7
Grassland	544	100	644	7.7	0.10	64	3.1
Scrub Shrub	519	161	680	8.1	0.10	68	3.3
Sub-Total	**4,199**	**1,331**	**5,530**	**66.2**		**286**	**14**
Atmospheric (Lake SA)	**870**	**723**	**1,593**	**19.1**	**0.16**	**255**	**12**
WATERSHED TOTALS	**5,916**	**2,437**	**8,353**	**100**		**2,059**	**100**

Atmospheric Deposition and Dry Fallout – is estimated to account for an estimated 255 (175 to 335) kg of total phosphorus, representing 12% of the total load entering the China Lake watershed, with lake surface waters (1,593 ha) comprising 19 percent of the total watershed area (8,353 ha). The lower total phosphorus loading coefficient chosen (0.11 kg TP/ha) is similar to that used for the Cobbossee Lake TMDL, and the upper range (0.21 kg TP/ha) generally reflects a watershed which is 50 percent forested, combined with agricultural areas interspersed with urban/suburban land uses (Reckhow et al. 1980). Similar to past Maine lake TMDLs (Sebasticook Lake and East Pond), an intermediate loading of 0.16 kg TP/ha was chosen to represent average conditions within the China Lake combined East and West basins (Table 4).

Total Phosphorus External Loading Summary Statement

It is our best professional opinion that the selected export coefficients are appropriate for the China Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from **external** nonpoint pollution sources averages **2,059 kg TP/yr**.

This 'average' annual external loading to China Lake (combined basins) generally equates to a total phosphorus loading modeled at 11-12 ppb (2,076 to 2,264 kg) - 671 kg below the TMDL target goal of 15 ppb (2,830 kg TP/yr). Notably, China Lake is the second TMDL lake studied in Maine (see Cobbossee Lake TMDL) where the external watershed total phosphorus loading was found to be less than the lake's TP carrying capacity (Table 5).

Table 5. Comparison of approximate total phosphorus loads (kg/yr) for watershed external and sediment internal and in-lake TP processing capacity models for Maine TMDL lakes - relative to reduction in phosphorus loadings required to attain water quality standards (see page 26 for internal recycling discussion).

TMDL Lake	Cobbossee Lake	Madawaska Lake	Sebasticook Lake	East Pond	China Lake
External Watershed Landuse	4,500	1,950	5,500	500	2,050
Internal Sediment Recycling	2,000*	n.a.	1,500	400	1,875
Total Phosphorus Loading	6,500	1,950	7,000	900	3,925
In-Lake TP Processing Capacity	5,500	1,850	4,500	400	2,850
External minus In-Lake Pcap.	- 1,000	100	1,000	100	- 800
TP Reduction Necessary to Meet WQS	1,000	100	2,500	500	1,075
% Reduction Required	15	5	36	56	27

* 2,000 kg TP internal load derived from Annabessacook Lake via Jug Stream input.

2. WATER QUALITY STANDARDS & WATER QUALITY TARGET

Maine State Water Quality Standard – standards for nutrients which are narrative, are as follows *(July 1994 Maine Revised Statutes Title 38, Article 4-A*): "Great Ponds Class A (GPA) waters shall have a stable or decreasing trophic state (based on appropriate measures, e.g., total phosphorus, chlorophyll a, Secchi disk transparency) subject only to natural fluctuations, and be free of culturally induced algae blooms which impair their potential use and enjoyment."

Maine DEP's functional definition of nuisance algae blooms include episodic occurrence of Secchi disk transparencies (SDTs) < 2 meters for lakes with low levels of apparent color (<26 SPU) and for higher color lakes where low SDT readings are accompanied by elevated chlorophyll a levels. China Lake is a non-colored lake (average color 24 - 29 SPUs), with characteristically low late summer minimal SDT readings (overall average of 1.0 meters), at times in association with highly elevated chlorophyll a levels (21-25 ppb 1999). From a functional perspective, Maine DEP views clearly negative trends in seasonal SDT means or minima as an indication of increasing trophic state condition. China Lake has an overall negative water quality trend, which has stabilized during the last decade. Currently, China Lake does not meet water quality standards due to annual **summertime** algae blooms. This interpretation uses historic documented conditions as the primary basis for comparison. Given the context of "impaired use and enjoyment," along with a realistic interpretation of Maine's goal-oriented Water Quality Standards (WQS), we have determined that episodic, non-**cyanophyte** based algae blooms (e.g., diatoms), limited to the fall or spring periods only, are in WQS attainment for GPA waters.

Designated Uses and Antidegradation Policy

China Lake is designated as a GPA (Great Pond Class A) water in the Maine DEP state water quality regulations. Designated uses for GPA waters in general include: water supply (after disaffection); primary/secondary contact recreation (swimming and fishing); hydroelectric power generation; navigation; and fish and wildlife habitat. No change of land use in the watershed of a Class GPA water body may, by itself or in combination with other activities, cause water quality degradation that would impair designated uses of downstream GPA waters or cause an increase in their trophic state.

Maine's antidegradation policy requires that "existing in-stream water uses, and the level of water quality necessary to sustain those uses, must be maintained and protected."

Numeric Water Quality Target

The numeric (in-lake) water quality target for China Lake is set at 15 ppb total phosphorus (2,830 kg TP/yr). Since numeric criteria for phosphorus do not exist in Maine's state water quality regulations - and would be less accurate targets than those derived from this study - we employed best professional judgement to select a target in-lake total phosphorus concentration that would attain the narrative water quality standard. **Springtime** total phosphorus levels in China Lake averaged 15 -16 ppb during 2000. In-lake (epilimnion core) total phosphorus **summertime** (June through August) measures averaged 18 -20 ppb (bloom conditions). In summary, the numeric water quality target goal of 15 ppb for total phosphorus in China Lake was based on available water quality data (average epilimnion grab/core samples) corresponding to non**-bloom** conditions, as reflected in suitable (water quality attainment) measures of both Secchi disk transparency (> 2.0 meters) and chlorophyll-a (< 8.0 ppb).

3. LINKING WATER QUALITY & POLLUTANT SOURCES

Loading Capacity - the China Lake combined basin loading capacity is set at 2,830 kg TP/yr of total phosphorus. The China Lake TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity, or other appropriate measures. It is thought appropriate and justifiable to express the China Lake TMDL as an annual load because the lake basin has a relatively long hydraulic residence time (0.65 - 0.72, 1-2 yr. flush).

Linking Pollutant Loading to a Numeric Target - the basin loading capacity for China Lake was set at 2,830 kg/yr of total phosphorus to meet the numeric water quality target of 15 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to the numeric target.

Supporting Documentation for the China Lake TMDL Analysis –includes the following: Maine DEP and VLMP water quality monitoring data; watershed/landuse maps using GIS derived data layers; literature derived export coefficients; and specification of a phosphorus retention model – including both empirical models and retention coefficients.

Total Phosphorus Retention Model (after Dillon and Rigler 1974 and others)

L = P (A z p) / (1-R) where,

2,830 = **L** = external total phosphorus load capacity (kg TP/year)

15.0 = **P** = spring overturn total phosphorus concentration (ppb)

15.9 = **A** = lake basin surface area (km^2)

7.9 = **z** = mean depth of lake basin (m) **A z p = 86.8**

0.69 = **p** = annual flushing rate (flushes/year)

0.46 = **1- R** = phosphorus retention coefficient, where:

0.54 = **R = 1 / (1+ sq.rt. p)** (Larsen and Mercier 1976)

Previous use of the Vollenwieder (Dillon and Rigler 1974) type empirical model for Maine lakes, e.g., Cobbossee, Madawaska, Sebasticook, and East Pond TMDLs (ME-DEP 2000-2001) has shown this approach to be effective in linking watershed total phosphorus (external) loadings to existing in-lake total phosphorus concentrations.

Strengths and Weaknesses in the Overall TMDL Analytical Process

The China Lake TMDL was developed using existing water quality monitoring data, derived watershed export coefficients (Reckhow et al. 1980, Maine DEP 1981 and 1989, Dennis 1986, Dennis et al. 1992, Bouchard et al. 1995, Soranno et al. 1996, and Mattson and Isaac 1999) and a phosphorus retention model which incorporates both empirically derived and observed retention coefficients (Vollenwieder 1969, Dillon 1974, Dillon and Rigler 1974 a and b, and 1975, Kirchner and Dillon 1975). Use of the Larsen and Mercier (1976) total phosphorus retention term, based on localized data (northeast and north-central U.S.) from 20 lakes in the US-EPA National Eutrophication Survey (US-EPA-NES) provides a more accurate model for northeastern regional lakes.

Strengths:

- Approach is commonly accepted practice in lake management
- Makes best use of available water quality monitoring data
- Export coefficients were derived from extensive data bases, and were determined to be appropriate for the application lake.
- Based upon experience with other lakes in the northeastern U.S. region, the empirical phosphorus retention model was determined to be appropriate for the application lake.

Weaknesses:

- ❖ Inherent uncertainty of TP load estimates (Reckhow 1979, Walker 2000) and associated variability and generality of TP loading coefficients.
- ❖ Absence of TP loading coefficients for shoreline erosion contribution.

Critical Conditions

Critical conditions in China Lake occur during the summertime, when the potential (frequency and occurrence) of nuisance algae blooms are greatest. The loading capacity of 15 ppb of total phosphorus was set to achieve desired water quality standards during this critical time period, and will also provide protection throughout the year (see Seasonal Variation section).

4. LOAD ALLOCATIONS (LA's)

The load allocation (lake capacity) for all existing and future non-point pollution sources for China Lake is 2,830 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 15 ppb (see Loading Capacity discussion). Reductions in nonpoint source phosphorus loadings are expected from the continued implementation of best management practices for camp roads & shoreline stabilization, as well as improved agricultural practices (see BMP Implementation Plan summary). As previously mentioned, it was not possible to separate natural background from nonpoint pollution sources in this watershed because of the limited and general nature of the available information. As in other Maine TMDL lakes (see Sebasticook Lake and East Pond TMDLs), in-lake nutrient loadings in China Lake originate from a combination of external and internal sources of total phosphorus. External TP sources, averaging 2,059 kg annually have been identified and accounted for in the land-use breakdown portrayed in Table 4.

Internal Lake Sediment Phosphorus Load - the relative contribution of internal sources of total phosphorus within China Lake - in terms of sediment recycling - were analyzed (using **lake volume-weighted mass differences** between early and late summer) and estimated on the basis of water column TP data from 1988, 1991, 1999, and 2000. These were the best years for which complete lake profile TP concentration measures were available to derive reliable estimates of internal lake loads. Among these years, **nuisance algae blooms were experienced** in the summers of *1988 and*

1999, when internal total phosphorus load estimates ranged from 1,740 *(1999)* to 3,365 *(1988)* kg (average 2,553 kg). In contrast, internal TP load estimates from the summers of *1991 and 2000* - non-nuisance algae bloom summers, ranged from 936 *(1999)* to 1,465 *(2000)* kg (average 1,201 kg, approximately 1/2 during non-bloom yrs.). The internal TP loading within the sediments of China Lake (1,200 to 2,550 kg) approaches the lakes capacity for in-lake total phosphorus processing (2,850 kg TP/year).

China Lake combined internal and external total phosphorus loads approximate 4,000 kg annually - less the 2,850 from in-lake processing capacity, which equals ca. 1,000 kg as the amount of TP needed to be reduced to attain suitable water quality standards. This reduction in phosphorus may be attained over time given continued reductions in external watershed phosphorus loads leading to further reductions in internal sediment phosphorus loads via annual flushing in China Lake.

5. WASTE LOAD ALLOCATIONS (WLA's)

As there are no known existing point sources of pollution in the China Lake watershed, the waste load allocation for all existing and future point sources is set at 0 (zero) kg/year of total phosphorus.

6. MARGIN OF SAFETY (MOS)

An implicit margin of safety was incorporated into the China Lake TMDL through the conservative selection of the numeric water quality target, as well as the selection of relatively conservative phosphorus export loading coefficients for cultural pollution sources (Table 4). Based on both China Lake historical records and a summary of statewide Maine lakes water quality data for non-colored (< 26 SPU lakes) - the target of 15 ppb (2,830 kg TP/yr in China Lake) represents a fairly conservative goal to assure attainment of Maine DEP water quality goals of non-sustained and non-repeated blue-green summer-time algae blooms due to NPS pollution or cultural eutrophication. The statewide data base for naturally colored Maine lakes indicate that summer nuisance algae blooms (growth of algae which causes Secchi disk transparency to be less than 2 meters) are more likely to occur at 18 ppb or above. A range of 15 to 17 ppb (2,830 to 3,208 kg TP/yr in China Lake) is unlikely to result in nuisance algae blooms, as was evidenced during the summer of 2000. The difference between the in-lake target of 15 ppb and 17 ppb represents a 12% (378 kg TP/yr) implicit margin of safety.

7. SEASONAL VARIATION

The China Lake TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year – during the summer, when conditions most favor the growth of algae and aquatic macrophytes. With an average hydraulic retention time of 1 - 2 years, the average **annual** phosphorus loading is most critical to the water quality in China Lake. Maine DEP lake biologists, as a general rule-of-thumb, use more than six flushes annually (bi-monthly) as the cutoff for considering seasonal variation as a major factor (to distinguish lakes vs. rivers) in the evaluation of total phosphorus loadings in aquatic environments in Maine. The best management practices (BMPs) implemented and proposed for the China Lake watershed have been designed to address total phosphorus loading during all seasons.

8. TMDL WATER QUALITY MONITORING PLAN

Historically, the water quality of China Lake has been monitored via measures of Secchi disk transparencies during the open water months since 1971 (DEP and VLMP). The Kennebec Water District began intensive water quality sampling in 1995 . Continued long-term water quality monitoring within the three basins of China Lake will be conducted, between the months of May to October, through the continued efforts of KWD in cooperation with Maine DEP. Under this planned, post-TMDL water quality-monitoring scenario, sufficient data will be acquired to adequately track seasonal and inter-annual variation and long-term trends in water quality in China Lake.

9. NPS/BMP IMPLEMENTATION PLAN and REASONABLE ASSURANCES

China Lake is a waterbody whose water quality is currently impaired mostly by nonpoint sources (see LA's and WLA's), and resultant internal sediment recycling of phosphorus. Hence, reasonable assurances that total phosphorus load reductions will be achieved are not required for the TMDL to be approved by EPA (U.S. EPA 1999). However, States and Tribes are strongly encouraged to provide reasonable assurances regarding achievement of load allocations in their implementation planning efforts. An updated listing of high priority non-point source (NPS) problem sites found during the Maine DEP - China Region Lakes Alliance watershed survey and MACD watershed inventory is available from Maine DEP and the CRLA.

NPS/BMP Projects and Historical Reports

The CLA performed a shoreline survey in 1987 to identify areas of eroding shoreline (1989 LEA). A volunteer watershed survey was conducted in 1988 with the assistance of the KC-SWCD, the CLA, and the LEA, with follow-up watershed BMP implementation work done in subsequent years (ME-DEP). A camp road survey was conducted by the CLA following the 1988 watershed survey. Between 1987 and 1991 all work was done on a volunteer basis. In 1991, the CLA received an NPS grant and the conservation corps was started. By 1995, 80 to 120 sites had been addressed. Overall, about 140 sites have been addressed (MACD 2001). Volunteers include high school students, Girl Scouts, the National Guard, and OUI offenders working public service hours, as well as China Lake Association members and other concerned citizens. Since 1989, the China Lake Restoration Project has been devoted to identifying and eliminating sources of NPS pollution in the watershed (CRLA brochure). An on-going 2-year project "to continue implementation of a locally-supported multi-jurisdictional lake water quality improvement program" for China Lake, Threemile and Webber ponds has been granted through the Maine DEP 319 program (Grant $96,800).

MACD Field Inventory and Survey Summary 2000-2001 (MACD 2001)

For over ten years, the China Region Lakes Alliance (CRLA), formerly known as the China Lake Restoration Project, has taken an active role in documenting and mitigating nonpoint source (NPS) pollution sites throughout the China Lake Watershed. The last documented full survey of the watershed was performed in 1989. In an effort to update this information, the MACD project team surveyed the China Lake Watershed for potential nonpoint source (NPS) pollution sites. The intent of the MACD survey is to provide additional information on NPS pollution problems in the watershed to the CRLA, the China Lake Association and the towns of China and Vassalboro. It is anticipated that the mitigation of these sites could be handled through the use of established and existing programs and resources available through the CRLA, the China Lake Association (CLA) and the Kennebec County Soil and Water Conservation District (KC-SWCD), with the support of Maine DEP 319 watershed management grants.

This survey focused primarily on the numerous camp roads around China Lake, state and town roads, especially stream and road crossings, (i.e., ditches and culverts.) as

well as numerous agricultural, residential and commercial land uses. The types of problems identified at various sites include insufficient crowns on camp roads, eroding road surfaces or shoulders, grader berms that prevent water from shedding off of the road, ditch and bank erosion, unstable culverts, animals in drainage ways, and bare and eroding soils.

The survey is not intended to be an all-inclusive watershed survey. Numerous roads, lots and properties in the watershed are private and posted "no trespassing" and, as a result, were not surveyed. Additionally, NPS pollution sources are dynamic and always changing, some being remedied while new sites are being identified (i.e., road work, lot clearing, ongoing development). The priority rankings given to identified sites are based upon best professional judgment, proximity to a protected resource and the severity and extent of the NPS pollution problem. With additional and existing available resources, the entire watershed should be more thoroughly surveyed in order to document additional potential NPS pollution sites.

Camp Roads

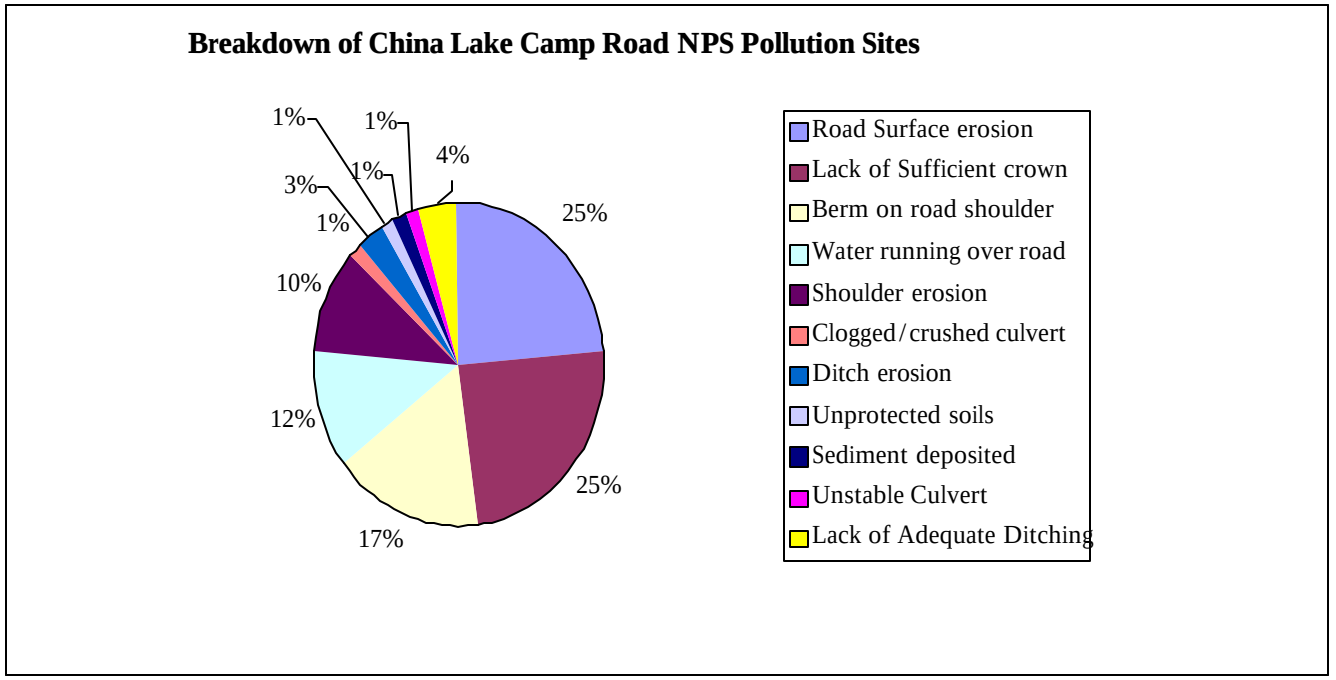
As of March 2001, thirty-eight camp roads were surveyed revealing the great deal of work that has been done by the CRLA and the China Lake Association in mitigating NPS pollution sources through technical assistance and grant funding. It is also evident that camp road maintenance is being undertaken utilizing accepted Best Management Practices (BMPs), ultimately minimizing camp road impacts on water quality. Many roads were noted for using recycled asphalt to mitigate historically severe erosion and runoff problems.

Of the 38 camp roads surveyed, 16 were identified as NPS sites – 4 high priority, 4 medium, and 8 low priority. (Note: The remaining 21 roads did not have any identified problems). Many other roads were not surveyed at all due to being posted. Roads noted as having identified sites had the following problems:

- 16 sites - road surface erosion of varying severity
- 16 sites - inadequate or insufficient crowns to adequately shed water off of the road and into vegetated buffers
- 10 sites - berms on road shoulders preventing water from draining off
- 8 sites - water running over the road

- 7 sites - shoulder erosion
- 2 sites - ditch erosion
- 3 sites - lack adequate ditching
- 4 sites – one each due to bare ditches, sediment deposits, and unstable culverts and clogged culverts. *(See figure 3).*

Figure 3. China Lake NPS Sites Identified in the MACD Camp Road Survey



Camp roads that were ranked as high priorities included two fire road locales, the *Four Seasons Club* road, and the access road to the boat ramp located in South China. Storm water runoff is able to flow unobstructed and untreated directly to the lake at the boat launch on the south end of the lake, while severe erosion and sedimentation occurs along the *Four Seasons Club* access road. All of these sites are in need of substantial mitigation work to remedy the ongoing problems. There is the possibility of funding in the near future through grant monies available through the Maine DEP. Many of the identified sites in this survey could be mitigated through improved road maintenance activities and through the existing available technical assistance provided by the CRLA and the KC-SWCD. Crowns and road shoulders should be graded to allow for the unobstructed flow of water off of the road surface and into vegetated buffer areas or into stabilized drainage structures.

The CRLA and CLA have been incredibly successful in dealing with camp road related NPS pollution problems. Programs are in place to mitigate many of the identified NPS problems through cost-share funding and/or technical assistance.

State and Town Roads

Nearly all fifty-one miles of state and town roads in the watershed were surveyed, of which seven NPS pollution problems were identified. All of these sites are ranked as either medium or low priority based on best professional judgment, the proximity of the sites to a protected resource and the extent and severity of the problem. The total number of NPS pollution sites associated with state and town roads is, obviously, much smaller than the number associated with the camp road portion of the survey. Historically, the Maine Department of Transportation (DOT) and the towns of China and Vassalboro have done a good job at minimizing impacts associated with road runoff.

Six problems were identified on town roads. Road problems range from shoulder-grader berms to road surface and ditch erosion. The severity and priority of these town road sites varied widely. For instance, the Stanley Road is identified as a low priority due to grader berms, which prevent stormwater runoff from shedding into established vegetated ditches, while ditch and shoulder erosion along the Parmenter Hill Road and at two locations on the Cross Road are ranked as medium priorities. One problem is identified on State Route 32 North, approximately 3.5 miles north of Route 3. This site is identified due to moderate ditch erosion and bare and exposed soils.

In the past, the Maine DOT has utilized Federal ISTEA funding to mitigate ongoing road runoff problems that were impacting China Lake's water quality. Recent, year 2000, drainage and ditch work along the state roads in the watershed minimized the impacts even further. All road and ditch work was conducted using accepted BMPs and erosion control measures. Most of the problems that were identified could be mitigated through inexpensive means, such as improved grading techniques and vegetation. In certain areas, appropriate reinforced measures, such as geotextile fabrics and rip-rap stone would be necessary.

Other Land Uses

Additional NPS pollution problems throughout the watershed that are potentially impacting water quality were also identified. These sites are located on private property

(i.e. house lots, farms, and commercial lots). The intent of this portion of the survey is to identify the problem, location, and prioritize each site. Enforcement action is not the intended outcome of identifying sites on private property. Mitigation of these sites would need to include landowner cooperation, town, CRLA and KCSWCD/NRCS efforts.

Many of the identified sites are ranked as high priority due to the proximity of the resource and the extent and severity of the problem. The abandoned Narrow Gauge Railroad, which has been identified in previous NPS survey and mitigation work, was again identified as having serious NPS pollution problems. A number of areas along this right-of-way remain significant sources of NPS pollution to the lake. Recent collaborative efforts between private landowners, the CRLA and the KC-SWCD were designed to address some of the concerns associated with the Narrow Gauge Railroad. The effectiveness of these efforts is at the present time uncertain, but it is assumed that there may be a reduction in the nutrient load to the lake from this site. The extent of the Narrow Gauge Railroad in the watershed is rather significant and problems associated with it are numerous.

Three commercial lots were also identified due to erosion. These problems could be mitigated through improved road and parking lot maintenance activities. Proper grading of these areas would allow runoff to shed off of these sites and allow it to get into established vegetated areas, rather than increasing the nutrient and sediment load to the lake. Additionally, two boarding-type horse farms were identified due to the proximity of the animals and the barnyard areas to China Lake drainage ways and watercourses. One timber harvest operation was also identified, due to a lack of erosion controls and the removal of vegetation along a wetland. The priority of this site is medium, due to the proximity to a protected resource and the extent of the problem site. And finally, one house lot was identified as having bare and eroding soils. This site is ranked as a medium priority, based upon the proximity of the site to a resource and the extent of the problem. This site could be mitigated through local mechanisms (i.e. codes enforcement and/or the CRLA.) This site could be simply remedied through the establishment of vegetation.

MACD Survey Summary and Recommendations (MACD 2001)

In summary, the CRLA and the communities involved have worked for years on addressing NPS pollution sources in the China Lake watershed. The CRLA has focused

much of its work on erosion control and BMP implementation. The resources available to watershed stakeholders in this watershed are great. The CRLA provides sound technical assistance to watershed stakeholders and, when available, provides grant funding to fix ongoing and problem NPS pollution sites. The sites and roads identified in this survey are meant to augment the NPS mitigation work being conducted by the CRLA. The MACD recommends continuing the cooperation and technology transfer between agencies, the CRLA and the landowners.

The MACD (2001) survey identified soil erosion problems on 16 camp roads, 6 town road problems, 1 state road, and 8 additional sites located on private property. The relatively few sites and roads that have been identified as high priority should be addressed by the CRLA and the Town of China during upcoming mitigation work. Most of the NPS pollution sites identified in this survey could be remedied simply through improved maintenance procedures (i.e., reshaping roads to allow for adequate dispersal of stormwater runoff).

The actual number of sites identified in this survey are few when compared to other surveys of other watersheds in central Maine. This watershed is fortunate in that there are existing resources available to deal with these problems. Concerned and interested landowners should contact the CRLA for further assistance.

Specific Recommendations (Best Management Practices or BMPs) and actions to further reduce external total phosphorus loadings to improve water quality conditions in the China Lake watershed are included below.

Town of China Phosphorus Control Ordinance

The unique and effective existing town of China phosphorus control ordinance to reduce total phosphorus loads from construction/development activity (new single-family residences, subdivisions and commercial development) within the China Lake watershed should be supported and enforced.

Follow-up Historical Septic System Survey

The Town of China conducted a sanitary survey of many of the shoreline structures during the summers of 1985 and 1986. The survey data provided the Town with important information about lake shore residents and the condition of their septic systems. According to the Maine DEP, a number of malfunctioning leach fields and

removal of some grey water discharges occurred as a result of this survey. In 1989, the survey data was analyzed by Maine DEP to estimate how much phosphorus was being added to the lake by shoreline septic systems. The contribution from shoreline septic systems was placed at approximately 3 to 9 percent of the total phosphorus load to China Lake (Maine DEP 1989).

The lake association may decide to follow-up this previous survey to get a better handle on the current status of lakeshore sanitary systems, depending on available resources. There will always be some amount of phosphorus load from septic systems, even new ones, but every system upgrade helps. Continued efforts to educate homeowners about how septic systems affect water quality in China Lake is important. Educational materials are available from the Maine DEP ("Septic Systems, How they work and How to Keep Them Working") as well as the University of Maine Cooperative Extension. Lakeshore residents who believe they may have a problem with their septic systems are encouraged to contact their town office or their local plumbing inspector for possible technical and/or financial assistance to make the necessary improvements. For homeowners meeting certain criteria, the Maine DEP has a Small Community Grant program that provides a funding match for faulty system replacement.

Follow up China Lake Association Shore Front Survey, East Basin 2000

David Landry, president of the CLA, conducted a shoreline survey of the East Basin during June of 2000. The shoreline of the west basin was not surveyed since it is mostly undeveloped and erosion is likely to be minimal. The goals of the survey were to estimate the amount of erosion and to identify sites that could be addressed by the CLCC. The survey was conducted by boat within 15' of the shoreline and by foot when vegetation obstructed a clear view. Site prioritization is based on (1) the amount of exposed soil actively eroding, (2) site accessibility, and (3) landowner interest when there was landowner contact. Sites with more than 5 contiguous feet of erosion were documented with a clear color photo, the date, a site description, priority ranking and, in some cases, landowner contact information. Each site also contains a notation about the water level that relates to the dam spillway at the lake outlet in East Vassalboro. As previously stated, there is an estimated 3,161 feet of eroding shoreline on the East Basin out of a total of 82,300 feet of shorefront, representing approximately 4% of the total shoreline of the East basin of China Lake (CLA 2000).

This shoreline erosion survey provides useful information for prioritizing existing NPS mitigation work in the watershed. For more information, contact CLA/David Landry (968-2856)

Follow up China Lake Association Stream and Tributary Survey 2000

This survey evaluated each of the streams, major storm flow areas and culverts on the east shore of the East Basin only. The west shore of the East basin and the West basin (3 tributaries) were not completed. The survey was conducted during the month of April 2000 following 2-3" of rainfall within a 48-hour period for the streams and culverts crossing either Route 202 or the Old China Road. The survey assessed the 16 streams and tributaries on the East shore of the East basin from the Head of Lake area down to Jones Brook at the south end of China Lake. Of the 16 tributaries, three were simply culverts under Route 202, nine were intermittent streams, and four streams that flow nearly year-round. The largest volume tributary is referred to as the Muldoon, the next would be Clark Brook, followed by Jones Brook.

This survey assessed turbidity of the water in the streams, the relative volume of water, and the nature of the watershed of the streams. The stream drainage areas were surveyed and the streams were walked to the source, when possible. A scale was devised to compare relative water volumes as well as the amount of siltation. On the water flow scale of 1-4, 1 was low volume and 4 was high volume (usually year-round streams). Siltation was scored on a scale of 0-4 with 0 being clear and 4 being heavily silted, resembling coffee with milk. Survey sites are also marked on a map of the lake that is attached to the survey.

Each of the streams/inlets was documented with clear photos, site descriptions, priority ranking, and suggestions for improvement, if necessary. The survey results suggest that areas of high priority correspond to streams that drain areas of significant development. The remainder of the East Basin Stream Survey will be conducted in the spring of 2001. (Note: there are far fewer tributaries on the west shore of the east basin than are found on the east shore of the east basin).

This tributary stream survey also provides useful information for prioritizing NPS mitigation work in the China Lake Watershed. For more information about the survey, contact David Landry (968-2856).

Continue Work with CRLA to Implement the Watershed Management Plan

China Lake is included as one of three lakes, along with Webber and Threemile ponds, in the China Region Lakes Alliance *Watershed Management Plan* (CRLA 1999). This plan can help achieve locally supported watershed management programs to facilitate widespread implementation of BMPs or other management measures in order to reduce or eliminate NPS pollution in targeted surface waters. For more information, contact Reb Manthey at the CRLA (445-5021).

Relative to External Phosphorus Loading: Maine DEP is confident that a combination of these NPS/BMPs, taking into account continued implementation of shoreline residential BMPs - and improved septic system management in high density residential areas - will continue to provide a significant overall reduction in the total phosphorus loading to China Lake - to help achieve and maintain water quality standards. This contention is strongly supported by Maine DEP's existing Nonpoint Source Pollution (NPS) Control Program Upgrade and 15 Year Strategy Plan, which was approved by EPA-New England on October 13, 1999. This plan, recognized by the EPA Washington office as "among the best" in the nation, outlines many realistic, yet aggressive, short and long-range goals and actions aimed at the reduction of pollution from major nonpoint sources, including forestry, transportation, agriculture, and development. This statewide NPS/BMP plan relies on strong partnerships and offers a commitment to provide outreach and technical assistance in priority NPS watersheds. China Lake is on both the 1998 303(d) TMDL list and Maine's NPS priority watersheds list, and has been given priority for funding under the implementation of Maine's 319 portion of the NPS program.

In conclusion, the combination of existing controls and mitigative actions to control nonpoint sources of nutrient pollution within the China Lake watershed has and will continue to provide significant reductions in external sources of total phosphorus. The presence of internal (lake sediment) phosphorus loads originating from historically derived watershed external loads is still problematic and should be further addressed.

In-Lake Remedial Options - The flushing of phosphorus laden waters via significant fall water level drawdowns **is not** an option for China Lake. The viability of alum treatments to reduce phosphorus recycling from lake bottom sediments in China Lake

and Threemile Pond, was studied in the mid-90s. Results generally indicate a much higher probability of success (in excess of 10 years) of alum treatments in the relatively deeper China Lake basins, however, the cost of application relative to the size of the treatment area may be prohibitive. At any rate, it is important to remember that "releases from bottom sediments reflect the likelihood that external phosphorus loads have (historically) exceeded China Lake's assimilative capacity, and that alum treatment should be viewed only as a supplement to, and not as a substitute for watershed management" (Walker 1994).

The prospects for attaining suitable water quality in China Lake within the next decade or so, is promising and lake watershed stakeholders should continue their vigilance and look forward to reaping the benefits of improved lake water quality conditions.

10. PUBLIC PARTICIPATION

Adequate ('full and meaningful') public participation in the China Lake TMDL development process was ensured - in addition to the numerous public meetings, newsletters, and newspaper articles published over the past two decades (particularly since the 1989 Maine DEP Diagnostic Feasibility Study) during which land use and phosphorus load reductions were discussed, through the following avenues:

1. Maine DEP Lakes TMDL Project Manager Dave Halliwell and supervisor Roy Bouchard participated in a China Lake watershed tour with Jon Van Bourg (KWD) and Reb Manthey (CRLA) during the late spring of 1999.

2. Dave Halliwell accompanied KWD late spring water quality monitoring sessions in 2000 & 2001 to perform water sampling & meter QA/QC checks.

3. MACD project team members, Jodi Michaud and Andrea Pearce attended the annual 2000 China Lake Association summer meeting attended by 40 or so lakeshore residents and provided a general briefing on the lake TMDL developmental process - including informational handouts.

4. MACD project team members, Jodi Michaud and Andrea Pearce participated in a China Lake watershed and lake tour on November 8, 2000, with Jon Van Bourg - Kennebec Water District and Dave Laundry - China Lake Association President.

5. During the summer and fall of 2000, MACD project personnel - particularly China Lake coordinators Andrea Pearce, Jodi Michaud and Jeremy Martin - paid numerous visits to town offices in the watershed and the Kennebec County SWCD-NRCS offices in order to compile necessary watershed inventory information.

A preliminary review draft TMDL was prepared and distributed to selected China Lake watershed stakeholder groups, inclusive of: China Lake Association (President - David Landry); Kennebec County SWCD - NRCS office (Nate Sylvester and Ron Desrosiers); China Region Lakes Alliance (Reb Manthey), Kennebec Water District (Jon Van Bourg), and Scott Pierz (Town of China Code Enforcement Officer). Following a 15-day preliminary review period, paper and electronic forms were made available of the Public Review draft TMDL report, including 'legal' advertising in local newspapers, posting on the Maine DEP Internet Web site, and through normal Maine DEP advertising procedures (information and education). The following ad was printed in the Morning Sentinel (Waterville) & Kennebec Journal (Augusta) over the August 18-19, 2001 weekend and the interested public given 30-days to respond (September 18th).

> In accordance with Section 303(d) of the Clean Water Act, and implementation regulations in 40 CFR Part 130 - the Maine Department of Environmental Protection has prepared a **Total Maximum Daily-Annual Load (TMDL) nutrient** report **(DEPLW 2001-20)** for phosphorus for the **China Lake watershed**, located in the towns of China, Vassalboro, and Albion within Kennebec County. This TMDL report identifies and estimates point and non-point source total phosphorus loadings within the China Lake watershed & reductions required to establish & maintain acceptable water quality standards. A Public Review draft of the report may be viewed at the Maine DEP Central Offices in Augusta (Ray Building, Hospital Street - Route 9) or on-line at : http://www.state.me.us/dep/blwq/comment.htm. Send all comments, in writing - by September 18, 2001, to David Halliwell, Lakes TMDL Project Leader, ME-DEP, State House Station #17, Augusta, ME 04333. 207-287-7649 or e-mail: david.halliwell@state.me.us.

China Lake TMDL Project Summary Statement

The considerable amount of watershed and lake information available for China Lake reflects the extensive amount of restoration work completed during the past decade. As a result of these past efforts, there is an existing framework of organizations in place able to handle future grant administration and funding (CLA, CRLA and CLCC). The "China Lake Restoration Project" began as a 314 project, emphasizing in-lake intervention with modest goals for NPS reduction and has evolved into a multi-watershed effort focused on NPS remediation and long-term watershed management. The existing Watershed Management Plan (revised January 1999) is directed by the CRLA, an effective regional lakes program that serves as a successful framework for NPS/BMP implementation projects.

ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA Region I staff (guidance), the following individuals and groups were instrumental in the preparation of this China Lake Total Maximum Daily Load report: MACD watershed inventory staff (Andrea Pearce, Jodi Michaud, and Jeremy Martin), Kennebec Water District (Jon VanBourg); China Region Lakes Alliance (Reb Manthey); China Town Office, Scott Pierz and staff; China Lake Association (President, David Landry); KC-SWCD (Rob Mohlar, Nate Sylvester); US-NRCS (Ron Derosiers and Richard Ferland), and Vassalboro town managers and office staff.

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APPENDIX A

DEP STAFF MEMO

1 May 2001

To: Dana Murch

From: Dave Halliwell, L&WQ, DEA/LAS - TMDL Project Leader

Re: China Lake Water Quality Update

The water quality in the three China Lake basins (western 1, northeastern 2, and southeastern 3) is routinely monitored by staff of the Kennebec Water District (KWD), in cooperation with the Volunteer Lake Monitoring Program (VLMP). The water clarity (Secchi disk transparency or SDT) in all three basins of China Lake was much better in 2000, than in the previous year. In 1999, an unusually dry and hot summer - historical record low summer mean SDT's of only 1.8 to 1.9 meters were recorded in all three basins. Correspondingly, historically high mean chlorophyll-a (21 to 25 ppb) & total phosphorus (23-26 ppb) epilimnion core samples were also measured. During the summer of 2000 (a wetter, more characteristic year), in contrast - mean values for SDT's ranged from 3.1 to 3.4 meters, and mean chlorophyll-a values ranged from 14 to 18 ppb, and total phosphorus (epilimnion core samples) ranged from 18 to 20 ppb.

Dissolved oxygen losses were quite similar between the past two years and comparable to past years, with only 8 meters of the water column oxygenated with 3 ppm or more in all three basins. The more disturbed northeastern China Lake basin # 3 had even lower dissolved oxygen levels (6 meters) during the late summer of 1999. Oxygen concentrations below 1 ppm were found over much of the lake bottom sediment. Internal phosphorus loadings were 10 (west basin) to 30 (east basin) percent greater in 1999, when compared to 2000. Deepwater phosphorus concentrations reflected increases in watershed human disturbance from the relatively undeveloped western basin (23-25 ppb) to the lower (south) eastern basin (46-47 ppb) to the highly developed upper (north) eastern basin (53-64 ppb) - 1st (lower) value represents 2000 and 2nd (higher) value = 1999.

The overall water quality trend in China Lake, as measured by Secchi disk readings since 1979 - is significantly negative, with a mean water transparency measurement of 3.9 meters during June, July, August and September. However, over the past 13 years - following the 1987 bloom, Secchi disk measures taken during the summer months exhibit a weakly improving trend. It appears that, in spite of the poor conditions observed during the summer of 1999, the overall decline in water quality in China Lake has been halted and the slow climb towards improving lake conditions is progressing.

APPENDIX B

Watershed Inventory & Best Management Practices Feasibility Study for Reducing NonPoint Source (Phosphorus) Pollution in Selected Maine Lakes - CHINA LAKE

This study is funded through US-EPA and implemented by Maine DEP to supplement current landuse and watershed survey information - to help us characterize the entire watershed and better define what the sediment and phosphorus sources are, where they are located in the watershed, and to evaluate the potential for implementation of Best Management Practices.

This study is carried out by highly trained natural resource professionals working with the Maine Association of Conservation Districts (MACD) in cooperation with area County Soil and Water Conservation Districts, Town Offices, Lake Associations, and related watershed/lake stakeholders.

The lake-watershed related information gathered in this study is needed to complete Total Maximum Daily/Annual Load (TMDL) reports, including total phosphorus export loadings/models and provisions for reasonable assurances in meeting load reductions through implementation of nonpoint source BMPs.

An additional six lakes will be studied this summer and fall, including: Mousam Lake, Threemile Pond, Webber Pond, Highland Lake (Bridgton), Long Lake, and Highland Lake (Falmouth). The draft TMDL for Mousam Lake is scheduled for completion by the end of September 2001, so has top priority.

Initial objectives are to complete partial watershed surveys, including: types and extent of agricultural/forestry practices, density of human habitation (residential use) around the lakeshore, measures of types of roads (paved and dirt) and septic system - shoreline erosion surveys.

All lake watershed information gathered will be handled in a confidential manner, similar to previous Maine DEP sponsored watershed survey projects. Maine DEP does not intend to use lake TMDLs for regulatory purposes, as the object of this project is to promote voluntary lake protection efforts.

APPENDIX C - Preliminary & Public Review Comment Summary

Most of the public review comments for the China Lake TMDL were verbally received during the preliminary stakeholder review process. Based on input from the Kennebec County Soil and Water Conservation District and the U.S. Natural Resource Conservation Service, phosphorus loading coefficients for agricultural practices were lowered, in the case of hayland - to reflect a 34% reduction in overall animal units and an expected decrease in the use of animal manure for hay cropland fertilization. The Kennebec Water District was also instrumental in correcting several pieces of information relating to historical land ownership in the China Lake watershed and provided overall grammatical improvements in the manuscript. Preliminary stakeholder review comments, in written form (see attached) were also received from Morten Moesswilde (Senior Planner, Department of Conservation, Maine Forest Service). Most comments received were taken into account in the final public review draft (e.g., see below).

Dear Mr Halliwell,

I have reviewed the China TMDL and commend you on the scope of the study. This study will provide a valuable guide for future work. I would point out one possible error. On page 17 it is stated China had implemented a review of septic systems placed prior to 1974. I believe only Vassalboro did this.

I would certainly like to obtain your high priority NPS sites to compare with our site list. You note the Four Season Club and the South China Boat Landing as high priority camp road sites. I agree and we hope to implement improvements to both of these roads by fall.

My thanks to you and your staff from all of us in the China Lake Association. You will expand our understanding of China Lake and help the China Community work towards cleaner water.

Sincerely, **August 12, 2001**

David Landry, President
China Lake Association

Although adequately advertised in local newspapers and left open for the complete 30-day period, the public review process was considerably less involved - with few comments received.

August 9, 2001

Dave,

Thanks for the opportunity to review the draft. I have a few minor comments/questions, but overall it seemed fine. My primary observation is that the "trails" road category (jeep trails and logging roads) is very useful and makes sense to me as a means to address forestry nps sources, since it identifies clearly the portions of harvested areas that have by far the greatest potential impact.

I don't see any discussion of how you arrived at P loadings for roadways, although apparently you've aggregated the roadway category to estimate P export. That seems a reasonable assumption, but you might mention the source for the coefficients. You later discuss some identified NPS issues associated with roads, but it seems that proximity to the shoreline is the only distinguishing criteria in estimating total export. Is that likely to continue, or are there ways to include NPS/BMP information?

You apparently relied on several sources to estimate total acreage of roadways - do you have a sense of how good your coverage was?

You also note on page 31 that the MACD survey focused on camp roads, and was not exhaustive. I may have missed it, but it's not clear if the MACD 2001 Road Survey on page 19 is the same as the MACD Field Inventory and Survey mentioned on page 31&32. You might make this clearer, in part by identifying who did them (at one point you identify the "MACD project team"), and perhaps including them both in the BMP Implementation section.

As before, I'd be open to ideas on how we could contribute to these types of assessments.

Thanks again for the opportunity to review this. I'd appreciate any followup drafts.

Morten Moesswilde
Senior Planner, Department of Conservation -
Maine Forest Service
22 State House Station
Augusta, Maine 04333
Telephone: 207-287-8430

19 September 2001 (Maine DEP e-mail reply to Craig Fortin)

Craig - I am finally getting around to responding to your request and provide the following information for your use.

China Lake corrected full basin volumes:

West Basin = 70,608,121 cubic meters or 57,277 acre-feet, 723 hectares or 1,787 acres

East Basin = 51,337,778 cubic meters or 41,645 acre-feet, 870 hectares or 2,150 acres

Total Lake = 121,945,899 cu. meters or 98,922 acre-feet, 1,593 ha or 3,937 acres

So, to keep it simple - each 1-foot drop would be 4,000 acre feet and 6" = 2,000.

Re. Dave Firmage's lake modeling work at Colby College - you would have to give me more information on which specific study you are referring to?

Increasing the lake level 1.64 to 2.46 feet during the spring should not be a problem with soil erosion, as it is our contention that significant shoreline erosion does not occur at full lake levels (within the capacity of the dam to hold back water). Best talk with Dana Murch for more substantiated details. Fortunately, I have not yet had the 'pleasure' of visiting DEPU.org, nor do I anticipate doing so in the near future.

Re. your ps. There is no typo on page 5, 4th paragraph, 4th line. I really meant to say "intense algae blooms were evident only..."

Dave Halliwell
Maine Department of Environmental Protection
Augusta, Maine

-----Original Message-----
From: Craig Fortin [mailto:craig@yes.net]
Sent: Wednesday, September 05, 2001 3:36 PM
To: Halliwell, David
Subject: TMDL Nutrient Report for Phosphorus for the China Lake Watershed.

Dave, Great report.

Roy Bouchard gave me the link and your contact information regarding China Lake. I'm a seasonal resident in the summer and I have a tremendous interest in the water quality. I've also contact Kevin Boyle at UMaine and will be speaking with him when he returns from Alaska.

I charted the Secchi data I was able to get from Maine.edu for stations 1,2 & 3 since 1971 and there doesn't seem to be any significant improvement at least not nearly at the rate of deterioration. I'm also looking at other environ-mental correlation to see if there is any significant data points.

After reading your report, I would agree that correcting the roadway issues appears to be the "low hanging fruit" of all source which are loading the lake. I'm still poking around and looking at some data from New York and New Hampshire lake management reports and I'm toying with some other modeling. Believe me there is no threat to your job here!

I was wondering if you could provide me with a couple of numbers:

First, water volume estimates for each of the Water Level cited on page 10.

Second, does your calculation model differ from Prof. David Firmage's work at Colby College?

Third, in practical terms what would the effect be on the TDML if the lake lever was increased by .5 - .75 m during 4/1 - 5/30 timeframe. Specifically, on shoreline erosion? (I don't buy the www.depu.org arguments)

I appreciate your time.

Craig Fortin
ps. I think there is a typo on page 5, 4th paragraph, 4th line. I think you meant to say "intense algae blooms were evident only..."

APPENDIX D

Albert Althenn
Rt. 202 Box 860
South China, ME 04358

September 20, 2001

RE: China Lake

Dear Al:

I hope you are well in these trying times.

Over the past several months, I have received some new information from the Kennebec Water District (KWD) relating to China Lake water levels and the height of the outlet dam. I have finally had the opportunity to review this information and want to pass it on to you.

I have been looking for information to respond to your claim that the height of the China Lake outlet dam was raised when the dam was last rebuilt in the late 1960's. The DEP has always assumed that the spillway of the dam was at elevation 171.5 feet, as referenced to the KWD intake house gage. You have suggested that the dam is in fact several feet higher than this. If true, then the current water level regime would be holding the lake at levels higher than existing historically.

I had a conversation last spring with Jeff LaCasse of KWD to see what information he might have. A subsequent search of KWD's files has uncovered several relevant documents.

In a letter dated March 1, 2001, KWD discussed the documents that were found and attached several excerpts from reports and various water level readings made over the years. A copy of this letter, with attachments, is enclosed.

There are several pertinent facts in the materials attached to the March 1, 2001 KWD letter, which I will summarize here.

First, in a 1906 report to the Trustees of the Kennebec Water District by Leonard Metcalf, Consulting Civil Engineer, the crest of the outlet dam is cited as being at elevation 171.6 feet, as referenced to the City of Waterville datum. All plans for the entire KWD water system are referenced to this datum, which has as a result often been referred to as the KWD datum.

[As an aside, I note that the use of a local datum is a common occurrence. For example, the S.D. Warren mill in Westbrook and the Great Northern Paper mill in Millinocket were both built to a local datum, and all of these companies' plans for their dams on the Presumpscot River and West Branch Penobscot River are referenced to the local datum. The use of a local datum to tie new equipment or buildings into old ones has value because the local datum, once

established, doesn't change, whereas the official U.S. datum has changed several times over the years.]

The 1906 report contains a footnote (see page 9) with the following conversion formula: "To convert given elevation to the old U.S. Geological Survey datum add 25.1 ft., to new U.S. Geological Survey datum of 1904 as 23.1 ft." Adding 23.1 feet to the elevation of the dam (171.6 feet KWD datum) yields a height of 194.7 feet USGS datum. This compares favorably to the oldest USGS topographic map I have, a 1956 15 minute map for the Vassalboro Quadrangle (copy attached), which gives the elevation of China Lake as 194 feet (and I note that all lake levels on USGS topographic maps have been rounded to the nearest foot).

[I note here that you have often cited the level of China Lake as being 196 feet, as reported on the most recent 7.5 minute USGS topographic map. However, if you compare the 1956 map with the current ones, you will find that every lake on the maps—including China Lake, Webber Pond, Threemile Pond, and Togus Pond— has a water level one or two feet higher on the current maps than on the 1956 map. This is not because all the dams on these lakes were raised; rather, this is because the USGS reference datum changed once again (I think in the early 1980's) and all the water levels were adjusted to the new datum.]

Second, included in a report prepared in 1921 by Metcalf and Eddy, Consulting Engineers, is a plan of the outlet dam. The plan gives the elevation of the spillway of the dam as 171.54 feet, KWD datum. Though the report doesn't say, I suspect that this new figure was the result of a more accurate survey of the dam. This is where the DEP's assumed elevation of 171.5 feet (KWD datum) comes from.

Third, the 1921 Metcalf and Eddy report includes a graph of China Lake water levels for the years 1916-1920. (As stated in the report, the dam was at the time owned by the American Woolen Company and operated to provide water for use at several downstream mills.) Two things are of note here. First, the lake level varied much more widely during the 1916-1920 period than it does today, ranging from a maximum level about a foot above the spillway to a minimum level almost 4 ½ feet below the spillway. Second, the average water levels for the 1916-1920 period, ranging from a high a few inches above spillway to a low 2-2 ½ feet below spillway, are close to the average water levels for the 1998-2000 period under the current water level regime.

Finally, one of the attachments to the March 1, 2001 KWD letter is a table of water levels recorded by KWD for the period December 1996 through July 2000. The table is titled "China Lake Water Levels Recorded at KWD intake." When I inquired about how the water levels were measured, I was informed by Jefferson Longfellow, the District Engineer, that he actually measured the water levels at the dam, and then reported the results assuming the spillway was at elevation 171.5 feet KWD datum. Historically, water levels were measured at the KWD

intake house using a float assembly. I then asked Mr. Longfellow if he could verify lake levels based on the historic KWD datum.

The results of Mr. Longfellow's efforts are reported in his letter to me dated June 8, 2001 (copy enclosed). Mr. Longfellow reports that on March 26, 2001, he measured the lake level from a known reference point in the intake house as 170.55 feet KWD datum. He then measured the water level at the dam and, assuming a spillway elevation of 171.5 feet KWD datum, got a reading of 171.13 feet. The difference of about 7 inches between the two measurements could be due to inaccuracies in the measurements and to the rounding of elevations in the intake house. At any rate, no large discrepancies were found by Mr. Longfellow in the height of the dam today as compared to its historic elevation.

In a subsequent letter dated August 29, 2001, Mr. Longfellow forwarded to me a copy of the Town of Vassalboro's Water Level Management Plan for China Lake, dated October 1984. This is a welcome addition to my files, as I have never seen it before, and I am enclosing a copy. This plan was apparently developed in response to the original water level order issued in 1984 by the Board of Environmental Protection.

I note that the appendices to the plan do clear up one matter. There is a bronze USGS benchmark on the dam that I had hoped could be used to verify the elevation of the spillway. However, according to the October 2, 1984 letter to the Town of Vassalboro from the USGS, the benchmark was put there as a reference mark for the stream gaging effort being conducted by the USGS, and that the elevation of the benchmark is referenced to the assumed height of the spillway, 171.5 feet KWD datum. So, no measurement of the height of the spillway in current USGS datum is known to exist.

Finally, I have reviewed the DEP's files from the 1984 water level proceeding, and I can only find one reference to any work done on the dam. Our files include the minutes of a joint meeting of the Selectmen of the Towns of Vassalboro and China held on June 3, 1970 (copy enclosed). One of the attendees at the meeting was Herman Masse of the Vassalboro Water Company, who for many years operated the dam. At one point in the meeting, Mr. Masse is asked to comment on the possibility of letting more water through the dam, and part of this response reads as follows:

> "…and I do know that its been said, its got back to me, that when we rebuilt the dam in the fall of '68, that we raised the heigth [sic] of the dam and the spillway. Now, the top of the dam may be a little higher because we surfaced over the granite that was there, but the spillway…we were very particular to keep it at the same elevation, so, whoever started that story, that's absolutely not true."

There are no other contemporary records that I can find that refer to the height of the dam, nor were any questions raised about the height of the dam during the 1984 water level proceeding.

Based on the information discussed above, it is the DEP's conclusion that the current height of the China Lake outlet dam is within six inches of the height of the dam as it existed in 1906, and as verified in 1921. However, a definitive answer to this question would require the following additional information:

- First, a verified formula to convert KWD datum to current USGS vertical datum; and
- Second, a professional survey to determine the elevation of the existing dam as referenced to the current USGS vertical datum.

Please let me know if you feel that it would be useful to pursue this additional information, and I will see what I can do. And I suggest that you contact the Kennebec Water District directly if you would like to review the documents that have been found to date. Finally, as always, please feel free to call me at 287-7784 if you have any questions.

Sincerely,

Dana Paul Murch
Dams & Hydro Supervisor

Attachment & Enclosures

cc w/o enc.: David Van Wie
Service List

[Note to Service List: To save paper, I have not copied the enclosures cited above to you at this time. Please let me know if there are any documents you would like to see, and I will be happy to send you copies.]

\china20