United States Department of the Interior

FISH AND WILDLIFE SERVICE

KLAMATH BASIN NATIONAL WILDLIFE REFUGES

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Memo to: John Hamilton, Assistant Field Supervisor, Yreka Field Office

From: Ron Cole, Project Leader, Klamath Basin National Wildlife Refuge

Subject: KBRA - Refuge effects report

Attached is the report titled "Effects of the Klamath Basin Restoration Agreement to Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges" authored by Dave Mauser, Supervisory Wildlife Biologist, Klamath Basin NWR and Timothy Mayer, Regional Hydrologist. The report has been reviewed by Dr. Mark Petrie, Waterfowl Biologist, Ducks Unlimited, Vancouver, Washington, Dr. Joe Fleskes, Waterfowl Research Biologist, U.S. Geological Survey, Dixon, California, and Susan Keydel, U.S. Environmental Protection Agency, San Francisco. All comments were carefully reviewed and incorporated where appropriate. Review by these individuals improved the content and clarity of the report. This report is consistent with Department of Interior Policy; Integrity of Scientific and Scholarly Activities (305 DM 3, dated January 28, 2001). Please include the report into the record for the Secretarial Determination process.

Effects of the Klamath Basin Restoration Agreement to Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges

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1.0 Introduction

For over three years, the Klamath Settlement Group, representing over 30 organizations worked to develop a comprehensive agreement for the Klamath River Basin. The Klamath Basin Restoration Agreement (KBRA) is intended to result in effective and durable solutions which will: 1) restore and sustain natural fish production and provide for full participation in ocean and river harvest opportunities of fish species throughout the Klamath Basin; 2) establish reliable water and power supplies which sustain agricultural uses, communities, and National Wildlife Refuges; and 3) contribute to the public welfare and the sustainability of all Klamath Basin communities. The KBRA was signed by the parties on February 18, 2010. However, prior to implementation of the KBRA and its companion Klamath Hydroelectric Settlement Agreement (KHSA), the environmental and economic impacts must be assessed. To that end, the following report represents an analysis of potential biological impacts of the KBRA to Klamath Basin National Wildlife Refuges compared to present conditions. Although the document only analyzes provisions of the KBRA relevant to refuge biological resources, it is recognized that the KBRA and KHSA are linked companion documents which would be implemented together.

1.1 History: The Klamath Basin of Northern California and Southern Oregon historically contained over 350,000 acres of wetlands (Akins 1970). The primary lake and wetland habitats in the Upper Klamath Basin consisted of Upper Klamath (including Agency Lake), Tule, and Lower Klamath Lakes. Biological resources utilizing the Basin were undoubtedly extensive. In 1905 noted naturalist William Finley toured Lower Klamath Lake and wrote:

"*We cruised over a large part of the lake, and found that the large rookeries of cormorants, grebes, white pelicans, great blue herons, California gulls and Caspian terns form one of the most extensive bird colonies we have ever seen. Doubtless this locality has never been disturbed to any extent by Man. This is the great breeding ground of that whole region.*", and "*[t]he Lake region of Southern Oregon" was "perhaps the greatest feeding and [breeding ground for water fowl on the Pacific coast*" (Finley 1905).

By the turn of the century, the large bird populations attracted intense commercial hunting activities. Finley (1905) documented market hunting activities present in the Lower Klamath and Tule Lake Basins at the time:

> "*the last year that Grebes were hunted in this locality was in 1903. The two years previous great numbers were shipped from this point. One of the hunters told us he saw $30,000 worth of skins piled up ready for one shipment from Merrill. At the time there*

were twelve different hunters along the north end of Tule Lake. One of the hunters told us he shot 135 Grebes at one sitting."

"There are from twenty to thirty camps of these professional hunters, stationed along the border of Lower Klamath and the north end of Tule Lake every winter, and shooting is carried on the entire season. When the Ducks are flying, each hunter will bag from 100 to 150 birds a day. These hunters keep two wagons at work the entire season. When the weather is moderate the wagons visit the camps three times a week and collect the Ducks in sacks, which are sent to Montague, California, where they are expressed to San Francisco... We were told there were 120 tons of ducks shipped from this point winter before last."

2.0 Regulatory Framework

2.1 Refuge establishment: During the early 1900's, the potential of the region for settlement and agricultural development was also recognized. To that end, the U.S. Bureau of Reclamation (Reclamation) initiated the Klamath Reclamation Project (Project) in 1905 and shortly thereafter began work to reclaim the lands under the Basin's lakes and marshes for agriculture, and to construct the infrastructure necessary to store and convey irrigation water to over 200,000 acres of land. Despite the desire to create agriculturally productive lands for settlement, the biological resources of the region were also recognized. Thus, despite the seemingly contradictory mandates of the Project, four National Wildlife Refuges (NWRs) were established via Executive Orders, either within Project boundaries or that were directly affected by the Project. These include Lower Klamath NWR (established 1908), Clear Lake NWR (1911), Upper Klamath NWR (1928), and Tule Lake NWR (1932).

2.1.1 Tule Lake NWR: Tule Lake NWR was established on October 4, 1928, by Executive Order Number 4975 and was amended by two subsequent Executive 0rders Number 5945 dated November 4, 1928, and Number 7341 dated April 10, 1936. The Executive Order language states that the lands are to be managed "... as a refuge and breeding ground for wild birds and animals". The Kuchel Act (Public Law 88-567, dated September 2, 1964) further declared that lands within Tule Lake NWR were "dedicated to the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith."

2.1.2 Lower Klamath NWR: Lower Klamath NWR was established as the United States first waterfowl refuge via Executive Order 924, dated August 8, 1908, and is managed to achieve the purposes of this Executive Order (... as a preserve and breeding ground for native birds.") as well as the Kuchel Act (Public Law 88-567), dated September 2, 1964. The Kuchel Act declared that lands within Lower Klamath NWR were "dedicated to the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith."

2.1.3 Upper Klamath NWR: Upper Klamath NWR was established via Executive Order 4851, dated April 3, 1928, "...as a refuge and breeding found for birds and wild animals...". Additional refuge purposes are derived from the Kuchel Act (Public Law 88-567, dated

September 2, 1964) which dedicated the lands, "... to the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith." Refuge purposes are also derived from the Migratory Bird Conservation Act, "... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." (16 U.S.C. § 715d).

2.2. National Historic Preservation Act: In addition to its designation as a National Wildlife Refuge, Lower Klamath NWR was listed as National Historic Landmark on January 12, 1965.

> "Established in 1908, this was the first large area of public land to be set aside as a wildlife refuge. Superimposed on an existing federal reclamation project, the marshes and lakes of the wildlife reservation were drained for agricultural purposes until intensive water management measures were initiated in 1940 to bring the refuge back to productivity. The refuge is an outstanding illustration of the 20th-century conflict between utilitarian (or reclamation) interests and conservation interests in the use of public lands and of the introduction of scientific management principles into wildlife conservation." (Statement of significance, National Historic Landmarks database, National Park Service).

2.3 Kuchel Act: Although Lower Klamath and Tule Lake NWRs were established for wildlife purposes, they exist on lands that had been already withdrawn by the Federal government for reclamation purposes. In the 1950's, the Bureau of Reclamation proposed homesteading and transferring areas of both refuges into private ownership. This proposal resulted in intense debate between agricultural interests and conservationists over the future of the Refuges. After more than a decade of debate, the Kuchel Act (Public Law 88-567) (Appendix 1) was enacted on September 2, 1964. The Act declared that the lands within Tule Lake, Lower Klamath, and Upper Klamath NWRs were dedicated to wildlife conservation for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent with waterfowl management. The Act permanently placed the Refuges in governmental ownership and allowed for the continued leasing of specific refuge lands for agricultural use, consistent with waterfowl management.

2.4 Migratory Bird Treaty Act (16 U.S.C. §§ 703-712, July 3, 1918, as amended 1936, 1960, 1968, 1969, 1974, 1978, 1986 and 1989).

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful. The U.S. Fish and Wildlife Service (Service) is the primary federal agency responsible for enforcing provisions of the MBTA and is responsible for conservation and management of 832 species of migratory birds. The broadest authority and mandate for providing habitat for migratory birds is contained in the 1976 US/USSR Convention. This agreement went beyond the original Act's regulation of hunting to preservation of habitat (FWS Manuel, 101 FW2). "To the extent possible, the contracting parties shall undertake measures necessary to protect and enhance the environment of migratory birds and prevent and abate the pollution or detrimental alterations of that environment." (Article IV, Convention Between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment, T.I.A.S. 9073, implemented as P.L. 95-616 (92 Stat. 3110)). Table 1 depicts migratory bird species found on Tule Lake, Lower Klamath and Upper Klamath NWRs.

2.5 North American Waterfowl Management Plan (NAWMP): The NAWMP, signed by the U.S., Canada, and Mexico seeks to maintain and enhance waterfowl populations throughout the North American continent. Habitat conservation works through a series of regional and, in several cases, species specific joint ventures. The joint ventures are partnerships of State and Federal agencies, tribes, business, conservation groups and individuals that combine resources and expertise to enhance waterfowl habitats (NAWMP 1986). The Klamath Basin resides within the Intermountain West Joint Venture (IMWJV).

The overall aim of this continental habitat program is to maintain and manage an appropriate distribution and diversity of high quality waterfowl habitat in North America that will (1) maintain current distributions of waterfowl, and (2) under average environmental conditions, sustain an abundance of waterfowl. The NAWMP overall goal is to maintain waterfowl populations similar to the 1970s which translates to sufficient habitat for 62 million breeding ducks and a fall flight of 100 million ducks and six million wintering geese (NAWMP 1986). One of the Plan's specific goals is to maintain habitat values of designated areas of international significance to waterfowl. Klamath Basin wetlands are identified as such, within the NAWMP.

3.0 Purpose of document

Of the six refuges within the Klamath Basin NWR Complex, Lower Klamath, Tule Lake and Upper Klamath NWRs are the most directly affected by the KBRA. Provisions within the KBRA, particularly those related to water, potentially effect refuge biological resources. This document seeks to explore effects to these refuges under current Project operations, (termed No Action) compared to management under provisions of the KBRA. The analysis will focus on effects to water availability, wetland habitats, and migratory birds with an emphasis on wetland dependent species. Other refuges in the Klamath Basin NWR Complex including Clear Lake, Bear Valley, and Klamath Forest NWRs are outside the scope of the KBRA and effects to these refuges are not anticipated.

4.0 Issues relevant to the Refuges and addressed within the KBRA.

4.1 Water needs for Lower Klamath, Tule Lake, and Upper Klamath NWRs: Water availability is critical to providing wetland habitats to refuge wildlife. Water must be delivered in quantities sufficient to support an abundance of wildlife, and at specific times to serve specific life history stages during periods of migration and breeding. Although, water needs of the Refuges are currently a relatively low priority in the Project, water delivery prior to 1992 was usually in sufficient supply to meet the needs of refuge wildlife. Tule Lake and Lower Klamath NWRs benefited from abundant agricultural return flows and were situated down-slope from large areas of Project agricultural lands.

Upper Klamath NWR is adjacent to Upper Klamath Lake which is a primary water storage source for the Project. The desire by the Project to maintain a water supply in the lake kept water levels relatively high which maintained water in the marshes of Upper Klamath NWR in most years. Increasing quantities of water dedicated to ESA listed fish, beginning in 1992, has reduced the quantity of water to the Project and wildlife refuges resulting in significant shortages to refuge wetland habitats.

4.2 Walking Wetlands program: "Walking wetlands" is a program that incorporates wetlands into commercial crop rotations on Tule Lake and Lower Klamath NWRs as well as private lands. These wetlands provide significant habitat benefits for those wildlife species dependent on early successional wetlands. In addition, wetlands within crop rotations sequester nutrients and suppress soil pathogens and weeds, thus enhancing crop productivity and reducing pesticide and fertilizer inputs.

4.3 Upper Klamath NWR wetlands: Wetlands of Upper Klamath NWR are connected to the open waters of Upper Klamath Lake. As such, water elevations in the marsh are dependent on lake levels. Water management (Klamath River flows and water allocations for irrigation and Refuges) under KBRA may effect Upper Klamath Lake elevations and; therefore, water elevations within the wetlands of Upper Klamath NWR. In addition, reconnecting former wetlands at the north end of Agency Lake, as proposed by the KBRA, may affect water storage and elevations of Upper Klamath Lake, thus effecting Refuge wetlands. There is no water allocations in the KBRA associated with Upper Klamath NWR.

4.4 Project Purpose: Currently, Project purposes do not include fish or wildlife. Thus, delivery of water to the refuges through Project facilities is tenuous. Amending Project purposes, as proposed in the KBRA, to include fish and wildlife and refuge purposes, allows for the Service to develop contracts with irrigation districts for delivery of water.

4.5 D Plant: By removing excess water from the Tule Lake sumps, D Plant is one way of regulating water levels in the sumps of Tule Lake NWR. The water removed is also a primary source of water for wetlands on Lower Klamath NWR. Currently, over 90% of pumping costs are provided by Tule Lake Irrigation District (TID). In recent years, increasing electrical costs and water efficiency has reduced output from D Plant, especially during the irrigation season. Flexibility in operating D Plant and utilizing D Plant as a timely water supply source for Lower Klamath NWR would be beneficial to this refuge.

4.6 Lease land farming: Lease land farming is provided on Lower Klamath and Tule Lake NWRs consistent with the Kuchel Act of 1964. The Act states that this 22,000 plus acre farming program shall continue in specific refuge areas consistent with "proper waterfowl management". Farmers bid competitively for lease lots on a 5-year basis with the annual option to renew. The program currently generates from 1.5 to 3.1 million dollars annually, which is retained by Reclamation. The Service currently receives no direct revenues from the program and thus has limited ability to accomplish conservation actions within the lease lands.

4.7 Water rights: Water rights for the refuges are crucial to the long-term ability of the refuge to provide wetland habitats for wildlife. The United States, on behalf of Reclamation and the Service, respectively, filed state water right claims with a 1905 priority in the Oregon water rights adjudication. The vested claims are for irrigation of lands within the Project and include (i) Project non-refuge agricultural lands; and (ii) refuge wetlands and leaselands on Lower Klamath and Tule Lake NWRs. In addition, the United States filed federal reserved water right claims on behalf of the Service, with priority dates of 1908 and 1928, respectively, for the refuges for the same wetlands and leaselands, and also for ponds that are not irrigated. All of these water right claims were granted in a Proposed Order, subject to final approval by the Adjudicator and possible rehearing by the Oregon circuit court.

In sum, the non-refuge Project agricultural lands and certain irrigated refuge lands (including wetlands and leaselands) are similarly situated at this time, i.e., all have valid and initially-approved Adjudication claims but, until the Adjudication is complete, water rights are not administered by the State.

4.8 Water quality: (Note: Water quality improvements related to implementation of the Lost River and Upper Klamath Lake Total Maximum Daily Load (TMDL) process will continue regardless of whether the KBRA is implemented, and is, therefore, not considered in this report.)

Currently, water quality in the Upper Klamath Lake is considered poor, primarily as a result of eutrophication. The source of excessive nutrients (primarily phosphorus) is believed to be a combination of relatively high background concentrations combined with nutrient inputs from anthropogenic factors. Phosphorus loading to Upper Klamath Lake is estimated as 61% from internal sources (sediment inputs from re-suspension) and 39% from external sources (ODEQ 2002). Upper Klamath Lake represents the source water for most of the Project including both Tule Lake and Lower Klamath NWRs. Both Refuges exist at or near the terminus of the Project with most refuge water inputs being return flow from upstream agricultural use. Most of the water for Upper Klamath NWR is from springs from the east slope of the Cascade Mountains with the remainder from the open waters of Upper Klamath Lake.

4.9 Groundwater: Lower Klamath NWR utilizes ground water to some degree in years of water shortage; however, the relatively small quantities of ground water available, relative to Refuge demand, and the high cost of pumping limit its utility. No ground water resources on Tule Lake or Upper Klamath NWRs are currently used for Refuge water needs. For those reasons, affects to Klamath Basin ground water resources from Refuge management is not considered in this report.

5.0 Description of the No Action and KBRA Alternatives relative to Refuges

In this analysis, the effects of implementation of the KBRA on relevant issues described above will be compared to the current management regime (termed the No Action Alternative). The KBRA and No Action Alternatives are summarized below relative to identified issues:

Issue	No Action Alternative	KBRA Alternative
Water availability, Lower Klamath NWR (effects to wetlands and migratory birds)	Refuge is fourth in priority among other Klamath Project water obligations. Delivery priorities established by 1995 Solicitor's Opinion.	Refuge receives 48-60 TAF (Mar-Oct) and 35 TAF (Nov-Feb). Allocations reduced in drought years. Co-equal priority with Klamath Project irrigators.
Water availability, Tule Lake NWR (effects to wetlands and migratory birds)	Water levels in Sumps subject to 1992 Biological Opinion. Water for agricultural lands is subject to current agricultural water priorities.	Water for lease lands and sumps derived from irrigator allocation. Water needs to refill sumps intentionally lowered for wildlife purpose derived from Lower Klamath NWR allocation.
"Walking wetlands" program	Water for program last in priority among other Klamath Project water users.	Water for program shared between Lower Klamath allocation (1 ft/acre) and irrigator allocation (2 ft/acre).
Upper Klamath NWR wetlands. (Effects to migratory birds)	Upper Klamath NWR wetlands are dependent on lake elevations and become dry at approximately 4139.50'	Upper Klamath NWR wetlands are dependent on lake elevations and become dry at approximately 4139.50'
Klamath Project purpose	Klamath Project purpose limited to agricultural irrigation.	Klamath Project purposes expanded to include fish and wildlife and Refuge purposes.
D-Plant pumping	TID pays nearly all D-Plant pumping charges.	D-Plant pumping charges shared among TID, Reclamation, and the Service.
Lease land farming	Lease land farming consistent with Kuchel Act. Service receives no revenues from leasing program.	Lease land farming remains consistent with Kuchel Act. Refuge receives 20% of net lease revenues.
Water rights	Water rights for LKNWR, TLNWR, and UKNWR determined through ongoing Oregon water rights adjudication process.	Water rights settled among major parties within KBRA consistent with KBRA water allocations.

6.0 Refuge resources

This Section describes those significant resources that may be affected by implementation of either the No Action Alternative or the KBRA Alternative.

6.1 Water resources: Anthropogenic forces have dramatically changed the historic ebb and flow of rivers, lakes, and marshes in the Upper Klamath Basin (Akins 1970). Changing lake levels and stream flows through naturally occurring wet and dry cycles, has been replaced with a highly managed environment in which water is stored and used for specific purposes. Tule Lake and Lower Klamath NWRs are located within and are directly affected by Project water management, and water levels within Upper Klamath NWR are dependent on the Project's management of Upper Klamath Lake elevations.

Traditional (prior to 1992) water delivery priorities within the Project began to change with listing of the Lost River and shortnose suckers in 1988 and the increased awareness of the responsibilities of the Federal Government to meet tribal subsistence rights guaranteed by treaty. Severe drought conditions in 1992 and 1994 and issuance of the first Biological Opinion under the Endangered Species Act (ESA), brought water priority issues to the forefront. A Federal Solicitor's Opinion was issued in 1995 which reordered the previous priorities for water. Prior to this time, Upper Klamath Lake and the Klamath River were manipulated to supply the irrigation needs of the Project. Lower Klamath and Tule Lake NWRs received return flows from Project agriculture (as well as direct diversion from the Klamath River).

The change in water priorities placed the needs of ESA listed fish first followed by Tribal subsistence, irrigated agriculture, and the needs of National Wildlife Refuges. Minimum lake levels and river flows to protect ESA listed species removed a large quantity of water previously available to Project agriculture and refuge. As a result, significant water shortages to the refuges, particularly in summer and fall have occurred on several occasions between 1992 and 2010.

6.1.1 Lower Klamath NWR: There are two main water delivery points to Lower Klamath NWR (Fig. 1), excluding the Area K lease lands north of State Hwy 161: 1) D Plant, which pumps water from Tule Lake through the Sheepy Ridge tunnel and 2) the Ady Canal at State Hwy 161, which supplies water directly diverted from the Klamath River. Inflow from D Plant pumping, a function of runoff and irrigation return flows in Tule Lake, is controlled by TID and the timing and quantity of these inflows reflects their management needs more than it reflects refuge water needs. When available, the Ady refuge inflows are requested and controlled by the refuge and the timing and quantity of these deliveries more accurately reflects refuge water needs. There is one main outflow from Lower Klamath NWR, the Klamath Straits Drain at State Hwy 161.

There is an inverse relationship between Ady refuge inflows and D Plant refuge inflows for both the water year and the irrigation season. Generally, as D Plant refuge inflows decrease, Ady refuge inflows increase. Ady refuge inflows have comprised about 30 to 35% of the total refuge inflows. But since the Ady flows are controlled by the refuge, the timing of these flows is more favorable than D Plant inflows, which are not controlled by the refuge.

Historic deliveries to the refuge through the Ady Canal at State Hwy 161 from 1962 to 2009 are depicted in Fig. 2. Ady refuge inflows increase through the 1980s, although the inflows in the 1960s and early 1970s appear particularly low and may be questionable. Ady refuge inflows for the irrigation season seem to have stabilized in the last 15 to 20 years while inflows for the water year have increased slightly. This is because water availability has become limited in summer and fall in recent years and the refuge has used more of its water use outside of the irrigation season. The two exceptionally dry years, 1992 and 2001, stand out as years with very low inflows for the irrigation season and for the entire water year. The refuge was shut off or shorted water for a substantial period during both of these years. The average Ady refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 22 thousand acre feet (taf) for the irrigation season (range 11 to 31 taf) and 30 taf for the water year (range 19 to 43 taf).

Fig. 3 depicts historic inflows to the refuge through D Plant from 1962 to 2009, calculated from total D Plant pumping minus deliveries to the P Canal lands. Deliveries to the P Canal lands are diversions from D Plant that go to a small acreage of private farm lands in the Lower Klamath area. Most of these private lands have been acquired by the refuge in recent years, meaning that there are decreasing P Canal land deliveries. D Plant refuge inflows, which are mainly controlled by TID, have been declining in recent years during the irrigation season and the entire water year. The decline may be due to concern over water availability, more efficient water use on the Project, the implementation of minimum water levels on Tule Lake sumps for endangered species, or, most recently, the increase in electrical rates and pumping costs. As with the Ady refuge inflows, the two exceptionally dry years, 1992 and 2001, stand out as years with very low refuge inflows for the irrigation season and for the entire water year. However, the more recent years, 2007-2009, have been equally low, in terms of D Plant pumping. The average D Plant refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 43 taf for the irrigation season and 71 taf for the water year.

Fig. 4 depicts the total refuge inflow from both water sources (calculated as Ady refuge inflow plus D Plant pumping minus P Canal deliveries). The figure shows that over the 1962 to 2009 period, total refuge inflow has remained fairly constant for both the irrigation season and the water year. The decrease in D Plant refuge inflows have been compensated for with an increase in Ady refuge inflows. Using the 1988 to 2009 averages given above, Ady refuge inflows have comprised about 30-35% of the total refuge inflows, with the remaining 65-70% coming from D Plant inflows. The average total refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 65 taf for the irrigation season and 101 taf for the water year. This is an upper estimate of total water use on the refuge since typically, not all the inflow is used on the refuge in a given year. Unused water released to the Straits Drain at the control gates at State Hwy 161.

A lower estimate of water use on the refuge can be obtained from the difference in total refuge inflow and refuge outflow. The calculation, inflow minus outflow, is a simplification and does not include non-consumptive water use on the refuge. Therefore, the total refuge water requirement is greater than represented by net inflow. Refuge net inflow for the period 1962 to 2009 is shown in Fig. 5. There was an increase in refuge net inflow until the mid-1980s, both for the irrigation season and the water year. Since that time, net inflow for the irrigations season has declined slightly while net inflow for the water year has increased and become more variable. The exceptionally dry years of 1992 and 2001 are indicated on the figure.

The average net inflow on the refuge for the period 1988 to 2009, excluding 1992 and 2001, is 40 taf for the irrigation season and 58 taf for the water year. The maximum net inflow for the period 1988 to 2009, excluding 1992 and 2001, is 54 taf for the irrigation season and 80 taf for the water year. Deliveries to the refuge in recent years (since about 2002) have been limited by the Project and the refuge has been shorted water. The area of habitat on LKNWR varies annually but is generally about 30,000 acres. Net inflow expressed on a per acre basis averages 1.33 ac-ft/acre for the irrigation season and 1.93 ac-ft/acre for the water year. A more detailed description of water resources on Lower Klamath NWR can be found in Appendix 2.

6.1.2 Tule Lake NWR: Tule Lake NWR (Fig. 1, Fig. 6) receives primarily return flows from private agricultural lands north and east of the refuge. The refuge is comprised of Sumps 1(A) and 1(B) which act as collecting basins for agricultural return flows during the spring/summer irrigation season and runoff during winter and spring precipitation events. Sumps 1(A) and 1(B) are surrounded by agricultural lands (Sumps 2 and 3) which are leased to local farmers under provisions within the Kuchel Act of 1964. Excess water in Sumps 1(A) and 1(B) is removed via a tunnel (D-Plant) through Sheepy Ridge to Lower Klamath NWR.

Farm lands in Sump 2 (5,657 acres) are served by the Q and R Canals. Both canals divert water from a single source: Tule Lake. The average annual inflow to Sump 2 is 22,364 ac-ft and the average annual outflow is 15,844 ac-ft. Almost all of the inflow and outflow (94%) occurs during the April-October irrigation season. Average annual crop evapotranspiration (ET) is 11,793 ac-ft in the April-October irrigation season.

Farm lands in Sump 3 (11,275 acres) are served by the North N Canal system. The total supply to the N Canal averages 83,330 ac-ft annually and 74,567 ac-ft April-October. Water not used to irrigate crops or is lost to evapotranspiration is returned to Sumps 1(A) and 1(B). Average annual crop evapotranspiration in Sump 3 averages 20,490 a-f during the April-October irrigation season.

Tule Lake Sumps 1(A) and 1(B) (13,021 acres) receive water from the Lost River via Anderson Rose Dam spills; N Canal spills; return flow pumps adjacent to the lake, and precipitation. Sources of inflow to Tule Lake vary by season. Return flow pumps are the largest source of water to Tule Lake, averaging 81,248 ac-ft annually, but most of this inflow (73,704 ac-ft) arrives during the April-October irrigation season. Most of the Anderson Rose Dam inflow (24,556 ac-ft) is outside of the irrigation season. N Canal spills (18,241 ac-ft) are almost entirely during the irrigation season. Precipitation is a relatively small component of inflow (13,095 ac-ft annually). D Plant pump is the largest source of outflow from the lake (84,186 ac-ft annually and 51,321 ac-ft April-October). Evaporation is the second largest source of outflow at 50,055 ac-ft annually. Irrigation diversions from the lake total 32,254 ac-ft, almost all of which occur April-October. Most of the irrigation diversions go to Sump 2, followed by Sump 3. The difference between inflows and outflows in Tule Lake is considerable. Outflows have exceeded inflows an average of 30,331 ac-ft annually and 21,151 ac-ft April-October for the ten-year period of record. The difference may be due to measurement error or groundwater inflow.

6.1.3 Upper Klamath NWR: Upper Klamath NWR consists of two units, Upper Klamath Marsh and Hank' Marsh which represent relatively undisturbed remnant wetlands. Because emergent wetlands of Upper Klamath NWR are not separated from the open waters of the lake by perimeter levees, water elevations in the lake have a direct effect on wetland water levels. Water elevations in the marsh reach a peak in spring of approximately 3.8 feet. Much of the marsh acreage on Upper Klamath NWR becomes dry in late summer and early fall as lake elevations decline with reduced lake inflows, evapotranspiration, agricultural diversions and downstream releases to maintain Klamath River flows. Historically, a reef near the outlet of the lake maintained a minimum lake elevation of approximately 4140.00'; however, elevation of the reef was lowered by approximately 3.0 ft in the early 1900s to enhance the ability of Reclamation to deliver water to the Project (USFWS 2008).

6.2 Biological Resources

6.2.1 Migratory waterfowl: Migratory waterfowl use four major migration routes (Pacific, Central, Mississippi, and Atlantic Flyways) in North America. The Pacific Flyway represents both a geographic migration corridor in the western U.S (Fig. 7), and an administrative management unit comprised of the western states, Federal government, Alaska natives, and

Canada, Mexico, and Russia. In order to coordinate management and protection of Pacific Flyway waterfowl populations, 26 Flyway Management plans have been developed, most of which are species specific. These plans typically establish population goals for each species and recommend management actions necessary to reach plan goals. Flyway waterfowl management plans in which Lower Klamath and Tule Lake NWR habitats play a pivotal role include:

- Pacific white-fronted goose
- Tule white-fronted goose
- Wrangel Island snow goose
- Western Canadian Arctic snow goose
- Ross' goose
- Western tundra swan
- Central Valley sandhill crane

The Klamath Basin forms a natural funnel for the Pacific Flyway (Fig. 7) as migratory waterfowl transition from northerly breeding areas to major wintering sites in the Central Valley of California and Mexico (Gilmer et al. 1982, Jarvis 2001). Tule Lake and Lower Klamath NWRs are considered some of the most important waterfowl refuges in the United States (Gilmer et al. 1986) and are major fall and spring staging area within the Pacific Flyway (Jarvis 2001) (Fig. 7). Both refuges are somewhat unique in the Refuge System in having a long history of periodic aerial waterfowl surveys (see Gilmer et al. 2004). A recent comparison of 1970's and 1990's population trends indicates that populations of waterfowl at Lower Klamath and Tule Lake NWRs have changed significantly over time (Dugger et al. 2008). Dabbling duck numbers have increased slightly on Lower Klamath NWR (Fig. 8a) while numbers on Tule Lake NWR has experienced a significant decline in use (Fig. 8b). Dabbling duck species on both refuges consist primarily of mallards *(Anas platyrhynchos)*, northern pintail *(A. acuta)*, wigeon *(A. americana)*, and green-wing teal (*A. creca*). Goose use (primarily white-fronted *(Anser albifrons)* and snow (*Chen caerulescens*)/Ross geese (*C. rossii*) of Lower Klamath NWR has increased in spring (Fig. 9a) while numbers on Tule Lake NWR have declined in all seasons (Fig. 9b). Diving ducks (canvasback *(Aythya valisinaria)*, redheads *(A. americana)*, lesser scaup *(A. affinis)*, ruddy (*Oxyura jamaicensis*), and buffleheads *(Bucephala albeola)* have increased in all seasons on Lower Klamath NWR (Fig. 10a) and during fall and early spring on Tule Lake NWR (Fig 10b). Tundra swan *(Cygnus columbianus)* use of both refuges has increased in the spring period (Figs 11a, b).

Gilmer et al. (2004) summarized waterfowl use of the Klamath Basin NWR complex from 1953-2001 and determined that Tule Lake and Lower Klamath NWRs supported 92% of the waterfowl use of the Klamath Basin Refuge Complex. Upper Klamath NWR supports approximately 4%. Similar to Dugger et al. (2008), Gilmer et al. (2004) reported a change in waterfowl use of Tule Lake and Lower Klamath NWRs. Both refuges experienced a decline in fall waterfowl use from the 1950s and 1960s to the 1980s. Spring use, however, has increased from the 1950s and 1960s through the 1990s, particularly on Lower Klamath NWR. In the 1950s and 1960s Tule Lake supported the highest numbers of fall migrant waterfowl. By the 1980s, the majority of fall and spring use had switched to Lower Klamath NWR, presumably due to the greater wetland habitat diversity and productivity of Lower Klamath NWR (Gilmer et al. 2004).

In recent years, Lower Klamath NWR has become increasingly important to spring migrant waterfowl (Fleskes and Yee 2007). The Southern Oregon and Northeastern California (SONEC) region is a major spring-staging area for Pacific Flyway waterfowl. At least half of all waterfowl and about 80% of the pintails that winter in California spend up to several weeks during spring in SONEC, feeding in wetlands and flooded hayfield/pastures to obtain food resources necessary to continue migration and improve their body condition for breeding. Lower Klamath NWR receives the greatest overall waterfowl use during spring of any area in SONEC and resources there are especially critical to early nesting species such as the northern pintail. A significant reduction in spring habitat availability on Lower Klamath NWR, unless mitigated by increases in availability of similarly high-quality wetland habitat elsewhere in the region, would likely result in poorer body condition, reduced productivity, and lower survival of northern pintails and other waterfowl and waterbirds that depend on those habitats (J. Fleskes, USGS, pers. comm).

6.2.2 Breeding waterfowl: Lower Klamath and Tule Lake NWRs are considered among the premiere managed wetland areas in the west for waterfowl production, producing up to 50,000 ducklings per year (Jensen and Chattin 1964). In the more recent period, duck production has averaged 28,528, 6,670, and 1,490 on Lower Klamath, Tule Lake, and Upper Klamath NWRs, respectively (Tables 2-4). Goose production has averaged 789, 142, and 765 birds on Lower Klamath, Tule Lake, and Upper Klamath NWRs, respectively (Tables 2-4).

6.2.3 Molting waterfowl: As the result of a total molt of wing feathers, adult waterfowl become flightless for a 30-day period each summer (Weller 1976). Waterfowl often leave breeding areas and may fly large distances to seek secure habitat during this time period (Ringelman 1990). Male mallards begin the molt in mid-July with females initiating the molt approximately 30 days later. The molting period for mallards extends from mid-July through September.

Generally, the Service does not conduct aerial waterfowl surveys during the late summer molting period; however, an aerial survey conducted 26 July, 2003 estimated that 95,000 and 90,100 mallards were present on Lower Klamath, and Tule Lake NWRs, respectively, for a total of 185,100 mallards (Klamath Basin NWR data). An additional 15,050 and 70,200 gadwall (*A. strepera)* on Lower Klamath and Tule Lake NWRs, respectively, was counted on this survey. This total would represent approximately 55% of the mallards counted in California during the preceding May 2003 mallard breeding population survey (Breeding waterfowl population estimates from California Department of Fish and Game data).

About half of the mallards that breed in California's Central Valley (Yarris et al. 1994; S. L. Oldenburger, California Department of Fish and Game, unpublished data), nearly all that breed in the Klamath Basin (Mauser 1991), and other duck species (Miller et al. 1992) use Klamath Basin wetlands during late summer to undergo wing molt. Of the female mallards that molt in the Klamath Basin, 37% use the marshes of Upper Klamath Lake, 37% use Tule Lake NWR, and 26% use Lower Klamath NWR (Yarris et al. 1994; Fleskes et al. (2010); S. L. Oldenburger, California Department of Fish and Game, unpublished data). Yarris et al. (1994) determined that mallards tend to molt in permanently flooded wetlands and were likely attracted to the relatively large acreage of this wetland type in the Klamath Basin, especially given the near total loss of large emergent wetlands in the Central Valley of California.

6.3 Nongame waterbirds: Nongame waterbirds are broadly grouped as shorebirds, gulls, terns, cranes, rails, herons, grebes, egrets, and ibis. Loss of historic wetlands and unregulated market hunting of waterbirds at historic Tule and Lower Klamath Lakes, early in the 20th Century, resulted in major declines in waterbird abundance in the Klamath Basin, particularly colonial nesting species. Lower Klamath NWR, in particular, was established largely to protect nesting colonies from unregulated hunting (Weddell et al. 1998). Intensive habitat management on remaining wetland areas of both Tule Lake and Lower Klamath NWRs has offset some losses and provides habitat for remaining populations. Lower Klamath NWR is considered the most significant waterbird nesting site in California (Ivey and Herziger 2006). Within the IMWJV's Waterbird Conservation Plan, wetlands of Klamath Basin are identified as significant waterbird habitat areas. Securing a reliable water supplies for Lower Klamath NWR is considered a "critical conservation need" (Ivey and Herziger 2006).

For some species, Klamath Basin wetlands are considered of regional and continental significance (Shuford et al. 2006, Shuford 2010) (Table 5). Shuford et al. (2006) conducted comprehensive surveys of nongame waterbirds throughout the Klamath Basin during May, June, and August of 2003 and 2004. For the Klamath Basin above Keno, observed numbers ranged from 52,737 to 89,799 individuals (Table 6) representing 50 species (Table 7). These counts are considered minimums for two reasons; 1) many species of nongame waterbirds are extremely secretive or small and/or cryptically colored making them difficult to observe, and 2) counts in July and August were conducted during the migratory phase for many species. Waterbirds using the Basin in migration either before or after surveys were not counted (Shuford et al. 2006).

Based on Shuford et al. (2006), Tule Lake and Lower Klamath NWRs support 9-24% and 25-41%, respectively, of the nongame waterbirds in the Klamath Basin (Table 6). Lower Klamath NWR is particularly important to migrant and breeding shorebirds, breeding American white pelicans (*Pelecanus erythrorhynchos*) (one of only two breeding colonies in California), eared grebes (*Podiceps nigricollis*), breeding white-faced ibis (*Plegadis chihi*) (one of the largest colonies in the Intermountain West), Franklin's gulls (*Leucophaeus pipixcan*), and Forster's (*Sterna forsteri*) and black terns (*Chlidonias niger*). Tule Lake NWR is notable for breeding eared and western (*Aechmophorus occidentalis*)/Clark's grebes (*A. clarkii*), migrant shorebirds, and fall staging black terns. Upper Klamath NWR supports large numbers of breeding western/Clark's grebes, American white pelicans, double-crested cormorants (*Phalacrocorax auritus*), and Forster's and black terns (Shuford et al. 2006).

Historically large numbers of waterbirds bred on islands within Klamath Basin wetlands (see Weddell et al. 1998 for historic accounts). Because nearly all of the historic islands are gone, in 2010 the Service, Oregon State University, Realtime Research, Inc, and the Army Corps of Engineers partnered in the construction of three artificial nesting islands on Tule Lake (one island) and Lower Klamath NWRs (two islands). The overall aim of the project is to redistribute nesting Caspian terns (*Hydroprogne caspia*) from the Columbia River estuary to other suitable locations in the western U.S. (USFWS 2005). In addition to Caspian terns, constructed nesting islands also serve other nesting species. Because of Project water shortages in 2010, only one island on Lower Klamath NWR was functional supporting 258 Caspian tern nests (167 fledglings), as well as 151 and 744 California (*Larus californicus*) and ring-billed gull (*L. delawarensis*) nests, respectively (A. Patterson, Oregon State University, pers comm.).

6.4 Wintering bald eagles: In addition to waterfowl and nongame waterbirds, the mild winters and abundant food resources in the Upper Klamath Basin attract the largest wintering population of bald eagles (*Haliaeetus leucocephalus*) in the U.S. outside of Alaska (Keister et al. 1987, Manning and Edge 2001). Lower Klamath and Tule Lake NWRs with their large wintering populations of waterfowl attract the largest numbers of eagles in the Basin (Table 8). Waterfowl represents a very high quality food item for eagles due to its high digestibility and fat content (Stalmaster 1987); however, the number of waterfowl required in the diet is relatively high (135/year) because of the small amount of food within each carcass (Stalmaster and Gessaman 1984). In addition to waterfowl, wintering eagles forage on small mammals which are forced from their burrows when agricultural fields are flood irrigated in late winter (Keister 1981).

Eagles begin arriving in the Klamath Basin in November with peak populations usually occurring in February. Although the Basin winters large populations of local birds, eagles have been documented to use the Basin from as far as Northeastern Alaska and Northwest Canada (Young 1983) and from throughout the Northwest, California and Arizona (Frenzel 1985). There are three primary foraging areas in the Upper Klamath Basin for wintering eagles; Lower Klamath and Tule Lake NWRs and lands within the Klamath Drainage District. In addition, five additional sites, near Lower Klamath and Tule Lake Basins, are used as communal night roosts (Keister et al. 1987).

Areas in the Pacific Northwest that support large wintering concentrations of eagles are relatively uncommon with all sites sharing unique habitat characteristics. These sites contain adequate food resources on a consistent basis, are relatively free from human disturbance, are generally open in nature, and contain adequate roosting sites nearby (Stalmaster 1987). The Upper Klamath Basin possesses all of these characteristics. Prior to European settlement, large number of wintering eagles congregated on salmon spawning streams in the Pacific Northwest. Unfortunately, declining salmon populations have eliminated many of these former wintering sites (Stalmaster 1987).

6.5 Breeding bald eagles: In addition to wintering eagles, the Klamath Basin hosts large numbers of nesting eagles particularly around Upper Klamath Lake. From 2003 to 2007, the number of active nests in the Klamath Basin ranged from 126-136. Successful nests fledged an average of 1.53 eaglets per year (Isaacs and Anthony 2008). In 2009, the first bald eagle nest in at least 30 years was initiated on Lower Klamath NWR. The pair successfully reared one young each in 2009 and 2010.

6.6 Sensitive species: Lower Klamath, Tule Lake, and Upper Klamath NWR support a number of species that are considered threatened or endangered by the Federal and/or State governments (Oregon/California). In addition, the refuges also support focal or priority species identified by Federal or State governments as well as several conservation organizations (Table 9). These focal or priority species, while not listed as endangered or threatened, are generally facing one or more threats to their populations or habitats.

7.0 Refuge habitats

7.1 Upper Klamath NWR: Upper Klamath NWR is located in Klamath County, Oregon, approximately 35 miles north of the California border and consists of 24,762 acres divided into three units; Hank's Marsh (approximately 1,191 acres), Upper Klamath Marsh (13,775 acres), and the Agency/Barnes Unit (9,796 acres) (Fig. 12). These areas serve as important nesting areas for waterfowl and colonial water birds such as American white pelicans, double-crested cormorants, and various heron species. Upper Klamath NWR is also an important stopover area for migrating waterfowl and provides foraging habitat for nearby nesting bald eagles and ospreys. Refuge objectives include:

- Manage for the conservation and recovery of endangered, threatened, sensitive species and the habitats on which they depend.
- Provide and enhance habitat for fall and spring migrant waterfowl.
- Protect native habitats and wildlife representative of the natural biological diversity of the Klamath Basin.
- Provide high quality wildlife-dependent visitor services.

Marshes of Upper Klamath NWR represent some of the last remnant marshes adjacent to Upper Klamath Lake. These wetlands are dominated by several emergent plant species including sedges (*Carex sp.*) as well as wocus (*Nuphar sp*), hardstem bulrush (*Scirpus acutus*), cattail (*Typha sp.*), burred (*Sparganium sp.*), and willow (*Salix sp*). Submergent plant species include coontail (*Ceratophylum demersum*), bladderwort (*Utricularia sp.*), and several species of pondweeds (*Potomgeton sp.*). Because there are no peripheral levees surrounding these wetlands, water levels are dictated by water levels in the open lake. Upper Klamath NWR wetlands are flooded at lake levels above 4139.50'. Presently, the Agency/Barnes Unit exists behind levees and is managed for water supply augmentation; however, future planning calls for opening the properties to Upper Klamath Lake via breaching of perimeter levees.

7.2 Lower Klamath NWR: Lower Klamath NWR (Fig. 13) represents the remnants of historic 80,000 acre Lower Klamath Lake. Legislated Refuge purposes (see Section 2.1.2) are used to develop a series of refuge objectives including:

- Maintain habitat for endangered, threatened and sensitive species.
- Provide and enhance habitat for fall and spring migrant waterfowl.
- Protect native habitats and wildlife representative of the natural biological diversity of the Klamath Basin.
- Integrate the maintenance of productive wetland habitats and sustainable agriculture.
- Ensure that the refuge agricultural practices conform to the principles of integrated pest management.
- Provide high quality wildlife-dependent visitor services.

Lower Klamath NWR is divided into a number of management units ranging from 63 acres to over 4,000 acres (Fig 13). Water in these units is manipulated to meet refuge purposes and goals as set forth by the establishing Executive Order and the Kuchel Act. Basic wetland habitat types consist of seasonal and permanently flooded marshes and winter irrigated grain fields.

7.2.1 Seasonally Flooded Wetlands: This habitat type was likely a significant proportion of the original Lower Klamath Lake and is critical to meeting the migratory waterfowl needs within the Refuge as well as the Pacific Flyway (see Fleskes and Battaglia 2004). In addition, this habitat provides brood areas for early nesting waterfowl species such as mallards (Mauser et al. 1994) and pintails and is extensively used by spring migrant shorebirds and other wildlife species.

Management of seasonally flooded wetlands requires flooding during the early fall (Sept-Nov) period and dewatering in late spring to early summer by gradually lowering the water level either by draining or by evaporation or a combination of both. This water management develops a productive wetland habitat that can be optimally utilized by migratory waterfowl and other wildlife.

The protracted removal of water during the growing season yields a complex mosaic of vegetative communities. Plant diversity is enhanced by uneven bottom contours which are exposed by a declining plane of water. As these "patches" of the bottom are exposed, they warm allowing germination of various plant species. Since these "patches " dry at different times, a specific plant association develops on each and results in a "patchwork" of differing plant associations in the unit.

The red goosefoot (*Chenopodium botryodes*) community in particular produces large numbers of seeds which are utilized by fall migrating mallards, pintails (Pederson and Pederson 1983), and other dabbling ducks. The invertebrate populations that develop on the foliage after flooding are sought by many species of migrating waterfowl (Pederson and Pederson 1983), shorebirds (Helmers 1992), and other marsh birds during spring migration and subsequent breeding season. Aquatic invertebrates in particular are used by young waterfowl (Sugden 1973) and other breeding wetland wildlife species.

Smartweed (*Polygonum sp.*) is another important plant produced by seasonal flooding. This plant is found in association with other plant species or in extensive monotypic stands. During the fall, it is readily used by migrating waterfowl for food and cover. It, like other seasonally flooded wetland plants, provides good substrate for aquatic invertebrates.

7.2.2 Permanently Flooded Wetlands: This habitat emulates the permanently flooded emergent wetlands which typified much of the historic Lower Klamath Lake. Permanent wetlands are flooded year-round and are crucial to meeting the refuge goals of waterfowl production and habitat for fall and spring migrant waterfowl. In addition, permanently flooded wetlands provide key breeding habitat for colonial nesting waterbirds such as several heron and egret species. These wetland units are characterized by two major plant communities. The emergent community is composed of hardstem bulrush and cattail with minor inclusions of river bulrush (*Scirpus fluviatilis*). The emergent vegetation provides nesting substrate for many species of waterfowl, wading birds, and passerine birds and acts as cover for resting waterfowl during periods of inclement weather.

The submergent plant community is dominated by sago pondweed with lesser amounts of baby pondweed (*P. pusillus*) and coontail (*Ceratophyllum demersum*). This community is found in open water zones where water depths range from 6 inches to 3 feet. Sago pondweed is a major food source to migrating canvasbacks which feed almost exclusively on sago tubers during their 3 month stay in the fall. Other species of waterfowl such as the redhead, American wigeon , lesser scaup, mallard, American coot (*Fulica americana*), and tundra swan consume the vegetative parts and seeds of this as well as other submergent plants.

The submergent plant community supports a diverse and productive invertebrate community. These are sought by many species of migratory waterfowl and other marsh birds. During the summer months, invertebrates are a high protein food which meets requirements of breeding and molting waterfowl, grebes, and most ducklings. Breeding eared and western grebes as well as coots utilize vegetative parts of submergent plants to construct their nests.

Colonial nesting species such as white pelicans, double-crested cormorants, and great blue herons (*Ardea herodias*) utilize permanent wetland units for nesting. These units provide secure and remote sites required for nesting, and provide an abundant supply of fish, the primary food item for these birds. The western pond turtle (*Clemmys marmorata*) is frequently sighted in Unit 2, a permanently flooded wetland.

An additional use of permanently flooded wetlands is by molting waterfowl (July-September). Because these birds are flightless during this period, food, water, and cover must be in close proximity. Large permanently flooded marshes on Lower Klamath are heavily utilized for this purpose. Ducks have been documented to travel over 300 miles from their nesting areas to these marshes to molt (Yarris et al. 1994).

7.2.3 Agricultural habitats: In addition to wetland habitats, Lower Klamath NWR also contains approximately 9,000 acres of agricultural lands. As per the Kuchel Act, 5,526 acres is located north of the Stateline in Oregon (Klamath Straits Unit) and is cash leased, via a competitive bidding process, by Reclamation under a 1977 Cooperative Agreement with the Service. In combination with the leasing program on Tule Lake NWR, the cash lease program typically generates from 1.5 to 3.1 million dollars per year in gross revenues to Reclamation. These funds are used to offset administrative costs of the program, and a portion is sent to Siskiyou and Modoc Counties and the TID consistent with provisions within the Kuchel Act. Remaining funds are sent to the Federal Treasury.

The eastern half of the leased land is farmed as small grains and the western half as grass hay. All lands are flood irrigated with grain fields requiring a single irrigation in fall/winter and hay fields requiring several irrigations in spring and summer. When flood irrigated, grain fields are extremely attractive to fall migrant and wintering waterfowl. This practice has the added benefit of driving mice and voles from burrows which attracts large numbers of wintering raptors, with bald eagles being the most conspicuous. Refuge hay fields attract large populations of spring migrant geese which alleviate potential damage to private farmlands off the refuge.

A second agricultural program of approximately 4,000 acres of grain fields are directly administered by the Service and are located on the California portion of the Refuge (Fig. 13). Growers agree to leave a proportion of small grain crops (typically 25-33%) standing for wildlife consumption. Similar to the leasing program above, grain fields are irrigated only once in winter which stores enough water in the soil profile to produce a crop. Most crop-share farm lands are currently in organic status. Farmers enrolled in this program are selected based on their ability to provide conservation benefits on their private lands. In this case, most farmers elect to flood their private lands as wetland habitats for two to three years in exchange for a farm lot on the refuge. This allows farmers to transition their private lands to organic status.

The high energy value of agricultural crops complements the more nutritionally balanced but lower energy content of foods available in refuge wetlands. Taken together, this balance of "natural" and agricultural foods supports hundreds of thousands of waterfowl and other waterbirds each year.

7.3 Tule Lake NWR: Tule Lake NWR (Fig. 6) lies at an elevation of approximately 4,034 ft, and is comprised of 39,116 acres, consisting mostly of lands "reclaimed" from under the waters of historic Tule Lake. Generally, the topography is gentle with surrounding lands containing sparsely timbered hills, uplifts, and cinder cones. A small portion of the Refuge lying along the west boundary includes the steep hillsides and rock outcrops of Sheepy Ridge.

Legislated Refuge purposes (see Section 2.1.1) are used to develop refuge goals which include:

- Maintain habitat for endangered, threatened and sensitive species.
- Provide and enhance habitat for fall and spring migrant waterfowl.
- Protect native habitats and wildlife representative of the natural biological diversity of the Klamath Basin.
- Integrate the maintenance of productive wetland habitats and sustainable agriculture.
- Ensure that the refuge agricultural practices conform to the principles of integrated pest management.
- Provide high quality wildlife-dependent visitor services.

Tule Lake NWR's habitats are comprised of approximately 17,000 acres of croplands and 13,000 acres of wetlands contained with Sumps 1(A) and 1(B). Consistent with the Kuchel Act, approximately, 15,000 acres of croplands are cash leased, via competitive bidding, to local farmers under a program administered by Reclamation under a 1977 Cooperative Agreement with the Service. The cash lease program typically generates from 1.5 to 3.1 million dollars per year in gross revenues to Reclamation. Consistent with the Kuchel Act, no more than 33% of each lease may be planted to row crops (typically potatoes and onions). These funds are used to offset administrative costs of the program, and a portion is sent to Siskiyou and Modoc Counties and TID consistent with provisions of the Kuchel Act. Remaining funds are sent to the Federal Treasury. Primary crops grown include barley, oats, wheat, potatoes, onions, and alfalfa.

A second agricultural program is directly administered by the Service and is comprised of approximately 2,500 acres of crop share lands. Rather than paying for farm lots, growers agree to leave a proportion of small grain crops (typically 25-33%) standing for wildlife consumption. The high energy content of agricultural crops used by waterfowl provides an important energy source for migrating waterfowl as they travel northward and southward in the Pacific Flyway.

Within both agricultural areas, the Service and Reclamation have been experimentally inserting wetlands into commercial crop rotations. Under the program, selected farm lots are retired for one to four years as wetland habitat and then returned to farming. This program not only provides wildlife habitat, but also allows farmers to reduce their use of fertilizers and pesticides and enhance crop yields. In addition, the program has allowed for the expansion of organic farming on the refuge. In recent years, program acreage increased to include several thousand acres of private lands in the Tule Lake and Lower Klamath Lake basins. Typically, from 1,000 to 2,000 acres of refuge farmlands are flooded under the program each year.

Sumps 1(A) and 1(B) are managed under agreement among the Service, Reclamation, and TID. The sumps function to capture return flows during the spring/summer irrigation season, protect private property from flooding, and provide wildlife habitat. Most of the area is comprised of open water dominated by submergent plant communities with extensive periodic blooms of filamentous green algae. Minimum water levels in the sumps are mandated by a 1992 Biological Opinion to protect the endangered Lost River and shortnose sucker. High fish densities in Sumps 1(A) and 1(B) make them important foraging areas for fish eating birds such as white pelicans, western and Clark's grebes, and double crested cormorants. Large areas of submerged aquatic vegetation make the area important to migrating diving ducks, especially canvasback, ruddy ducks and lesser scaup.

8.0 Effects of the KBRA provisions compared to the No Action Alternative to Lower Klamath NWR

Analysis of effects of the KBRA and the No Action Alternatives are focused in three areas: projected water delivery, comparison of wetland habitats provided, and the effects of those wetland acres on wetland dependent migratory birds. A summary table of estimated water deliveries, habitats provided, and estimated carrying capacity for waterfowl and nongame waterbirds under both alternatives can be found in Tables 10 and 11.

8.1 Estimating Lower Klamath NWR water demand: To estimate total water need on Lower Klamath NWR, demand was calculated for 17 separate time steps (Fig 14). At each time step, demand was calculated for each habitat type, based on the area of habitat and the estimated water use of the habitat type. These were then summed to calculate the total refuge demand at each time step. The habitat acreage used to estimate demand was 11,000 acres of permanently flooded wetlands, 10,000 acres of fall seasonal wetlands, and 10,000 acres of farm units and spring seasonal wetlands. Permanently flooded wetlands require water for evapotranspiration (ET) from Apr-Oct and non-consumptive flushing flows from Nov-Mar. The fall seasonal wetlands require water mostly in Sept and Oct (3.0 ac-ft/ac), with some water requirements in Nov. The farm units and spring seasonal wetlands require water (2.5 ac-ft/ac) Nov-Mar. Permanent marshes are flooded year-round and require 3.6 ac-ft/ac(See Section 8.4).

8.2 Modeled water availability under the No Action and KBRA Alternatives: Using the WRIMS model, estimated quantities of water are delivered to the refuge under both alternatives through both the Ady Canal and D Plant. D Plant inflows are an important source of water for the refuge representing from 65-70% of the total water supply from 1988 to 2009. Any future changes in D Plant pumping will greatly affect refuge water supply. However, there are some limitations to the WRIMS model relative to the refuge as it is currently used. The WRIMS model does not include an explicit representation of D Plant inflows to the refuge. To accurately reflect refuge demand in WRIMS, it is necessary to make assumptions about refuge inflows from D Plant, assumptions that are critical to the future refuge water supply. For the KBRA and No Action Alternatives, refuge modeling involved two different assumptions about future D Plant pumping (see Appendix 2 for more discussion of the differences). Comparing the results and impacts to the refuge under the two Alternatives is complicated by this difference. Model output cannot be relied on solely without making some further modifications of refuge demand and deliveries. Model demand and modifications are discussed below.

8.2.1 The KBRA Alternative: For the KBRA Alternative, the refuge demand was modeled using the same approach as in the KBRA settlement. For each time step in the model, the total refuge demand was estimated based on the area of habitat and the water requirement for that habitat (See Fig 14). Using this method, the estimated total water demand is 60 taf for the irrigation season and 95 taf for the entire year. Under the KBRA Alternative, deliveries to the refuge, as with agriculture, are under an allocation system with the allocation being limited in drier years. As per the settlement agreement, the 60 taf of modeled refuge demand (and allocation) during the irrigation season is reduced linearly to 48 taf as the Mar 1st UKL net inflow forecast drops from 570 taf to 286 taf or less.

For modeling the KBRA Alternative, the proportion of total refuge demand met through D Plant inflows is estimated, based on assumptions about future D Plant pumping. Briefly, winter D Plant pumping is related to winter precipitation, with an average of 11 taf and a range from 4 taf to 20 taf. Summer D Plant pumping is related to Apr-Sep net inflows to Upper Klamath Lake, with an average of 11 taf and a range from 0.6 taf to22 taf. The estimated D Plant pumping is subtracted from the total water requirements at each time step and any remaining unmet water requirements are represented in the model as Ady Canal refuge demands.

8.2.2 No Action Alternative: Modeled Ady demand is based, in part, on past deliveries from D Plant. There is an implicit assumption in the modeling that future D Plant pumping will be similar to past D Plant pumping. This D Plant assumption is questionable given future increased pumping costs at D Plant and the likelihood of limited water allocations to agriculture under future biological opinions. Limited irrigation water and elevated pumping costs will cause future D Plant pumping to be reduced relative to historic operations (E. Danosky, Tule Lake Irrigation District, pers. comm).

Another problem with the modeled refuge demand under the No Action Alternative is that, regardless of D Plant assumptions, the range of historic annual (Apr-Mar) Ady refuge diversions in the model, 15 to 30 taf, is too small compared to historic observed values (19 to 43 taf). Thus, the modeled Ady refuge demand under the No Action Alternative is too small. Because the modeled demand is too small, the modeled shortages are unrealistically low. Put another way, the model simply does not "request" enough water for the refuge under this Alternative, because it implicitly assumes historic D Plant pumping and an unrealistically low Ady demand. To address these limitations in modeled output for the No Action Alternative, we have "modified" the No Action Alternative output with the same assumptions about future D Plant pumping used in the KBRA Alternative and have re-estimated the refuge deliveries based on these assumptions. However, Ady Canal deliveries in the model remain the same. Because the model underestimates Ady demand, the refuge is unnecessarily shorted water in some wetter years when water would have been available for the refuge. The effect this has on estimated wetland habitats and birds is discussed in the relevant sections below.

8.2.3 Comparing estimated water availability to Lower Klamath NWR under the No Action and KBRA Alternatives: Water delivery to Lower Klamath NWR is greater under the KBRA Alternative for both the April to October and November to March time periods (Fig. 15). The 35 taf allocation for the November to March period in the KBRA is met in all but the 5% of driest years. The 48 to 60 taf is met in all but approximately 10% of years. Given identical water year types, the quantities of water delivered to the refuge under the No Action Alternative never reaches the quantities delivered under the KBRA Alternative.

The difference between Alternatives in wetter years (80th percentile years) may be an artifact of model input (See Appendix 2 and/or Section 8.2.2 for further discussion). Modeled deliveries, via the Ady Canal, in wetter years (No Action Alternative) are curtailed at 20 taf with the remainder of water assumed to be available from D-Plant. In the model, if limited water is available from D-Plant and the Ady Canal is capped at 20 taf, there are years in which the refuge receives insufficient water even though water above the 20 taf cap may be available from the Klamath River via the Ady Canal. It is probably reasonable to assume that in the wettest 20% of years the difference between the No Action and KBRA Alternatives is small.

8.3 Water quality: Water for Lower Klamath NWR is comprised primarily of return flows from agricultural lands upstream and within the Tule Lake Basin, which are delivered to the Refuge by the D pumping plant. Under the No Action or KBRA Alternatives, it is expected that upstream agricultural water use will continue and return flows from that land use will continue as a major source of refuge water. Under the KBRA, significantly more effort will be placed on restoration of wetlands and riparian habitats in the Upper Klamath Lake watershed, which should help reduce external nutrient loading to the lake (ODEQ 2002). These efforts should improve the quality of irrigation source water for the Project; however, since this water is typically used and re-used several times before reaching the Refuge, water quality reaching the Refuge may not improve significantly. Thus, under either alternative, it is unlikely that the quality of water from return flows will improve significantly.

Under the KBRA Alternative, however, some of Lower Klamath NWR's water allocation may occur as direct diversions from Upper Klamath Lake to the Tule Lake Sumps, thereby bypassing much of the irrigated lands in the Project. Under this scenario, there may be water quality improvements for the Refuge under the KBRA Alternative compared to the No Action Alternative.

Ady Canal water, historically approximately one-third of Refuge water, is diverted directly from the Klamath River below Upper Klamath Lake. The KBRA contains significant measures to restore and enhance wetland and riparian habitats associated with Upper Klamath Lake and its tributaries. These measures are expected to reduce phosphorus inputs to the lake and may improve water quality (ODEQ 2002). Thus, the KBRA Alternative may improve water quality diverted at the Ady Canal and used for Refuge wetlands.

8.4 Comparing wetland habitats provided under the No Action and KBRA Alternatives: The quantity and distribution of water for each habitat type was based on work done by Service hydrologists for water rights claims in the Oregon adjudication. The application rates are 3.6 ac-ft/ac for permanently flooded wetlands (which includes 0.6 ac-ft/ac or 20% of the annual ET for a salinity flushing flow, to be met during Nov-Mar, and 3.0 ac-ft/ac for ET), 3.0 ac-ft/ac for fall seasonal wetlands, and 2.5 ac-ft/ac for farm units and spring seasonal wetlands. Refuge wetlands include 11,000 acres of year round flooded wetlands, termed permanent wetlands, 10,000 acres of fall seasonal wetlands, and 10,000 acres of winter seasonal wetlands and pre-irrigated grain fields. Each of these habitats has a wildlife purpose; permanent wetlands are the primary habitats for breeding and migratory nongame waterbirds and habitat for fall migrating diving ducks, fall seasonal wetlands are used primarily by dabbling ducks, and spring seasonal wetlands and flooded grain fields are key habitats for sandhill cranes and spring migratory waterfowl. Water for flooding and maintaining refuge habitats originates from both the Klamath River via the Ady Canal and return flows from Tule Lake via the D-Pumping Plant.

Hydrologic output from the model was converted to wetland acres for both alternatives using the following procedures:

- Water available for Apr-August was divided by 3.6 to arrive at acres of summer flooded permanent wetlands. Three feet of water is used to offset ET assuming an open water to emergent vegetation ratio of 30:70. (see Table 12 for ET and precipitation rates). Remaining water (0.6 feet) is used to maintain a flushing flow and prevent the accumulation of salts.
- Water available in September and October is first reduced to offset ET in permanent wetlands for those two months. The remaining water is used to flood fall seasonal wetlands at a rate of 3.0 ft/ac. We attempted to fill 88% of the fall seasonal wetlands within the September and October time frame. Unfilled fall seasonal wetlands become available for filling in the November to March period.
- Water to flood spring seasonal marshes and grain fields is split evenly with 2.5 ac-ft/ac used for both habitats.

Wetland habitat acres provided under the KBRA Alternative exceeds habitat acres provided under the No Action Alternative (Fig. 16). As discussed in Section 8.2.3, habitat acres under the No Action Alternative in the wettest 20% of years may be negatively biased due to limitations on modeled Ady Canal deliveries in these year types.

8.5 Estimated carrying capacity for diving and dabbling ducks on Lower Klamath NWR under the No Action and KBRA Alternatives: Migratory waterfowl use of Lower Klamath NWR can be divided into two major time periods including fall migration (Sep-Nov) and spring migration (February-April). Water deliveries needed to provide fall wetland habitats is consistently the primary limitation for fall migratory waterfowl on Lower Klamath NWR. In addition, it is also a time of year when other wetlands in the Klamath Basin are at their lowest water levels. Water delivered in winter/spring provides habitat for spring migratory waterfowl. With the exception of 2010-11, generally there has been enough carry-over water coupled with spring deliveries to provide for spring migratory waterfowl. For that reason, we focused our analysis of waterfowl carrying capacity on wetland habitats in the critical fall months of September through November. Carrying capacity is described as the number of birds per day that the habitat is capable of supporting for a given period of time. We narrowed our analysis further to diving and dabbling ducks as diving ducks are foraging primarily on food resources found in permanent wetlands and dabbling ducks in fall seasonal wetlands and November flooded small grain fields. Although dry refuge grain fields represent an important food component for waterfowl, their use by ducks in fall is generally minor. Goose use of Lower Klamath NWR in fall was also excluded because fall goose numbers on Lower Klamath NWR are generally low and they typically forage in dry grain fields.

To estimate the fall carrying capacity for waterfowl on Lower Klamath NWR under the two alternatives, we used an energetics approach based on work conducted on Lower Klamath NWR by Dugger et al. (2008). Our analysis assumes that food resources are the major component influencing waterfowl use of the refuge and that all food resources for waterfowl using the refuge are obtained on the refuge. Although these assumptions are not completely accurate, they allow for a straight-forward comparison between alternatives. The comparison of alternatives centered on the estimated acres of flooded wetlands and November irrigated grains and their ability (based on food resources) to support dabbling and diving duck guilds during the September through November period. By the end of November marshes begin to freeze and most waterfowl have moved south into the Central Valley of California. Dabbling ducks on Lower Klamath NWR are primarily comprised of mallards, northern pintail, American wigeon, and green-wing teal. Diving ducks are primarily comprised of canvasback, redhead, lesser scaup, ruddy, ringneck, and bufflehead. The process to determine carrying capacity included the following steps:

- Estimate the acres of permanent and seasonal wetlands flooded during September through November based on hydrologic modeling. Water delivered in September and October is first used for offsetting evapotranspiration losses in permanent wetlands and then used to flood seasonal wetlands at a rate of 3.0 feet per acre. One half of water delivered in November is used to flood seasonal wetlands and the other half is used to flood grain fields.
- Assume that seasonal marshes are 20% early successional and 80% late successional. Early successional seasonal wetlands produce 875 lbs/ac and late successional wetlands produce 489 lbs/ac (Dugger et al. 2008, Table 4-2) for a weighted average of 566.2 lbs/ac (634.6 kg/ha) of available seeds.

- Assume that flooded seasonal wetland foods provide 1.76 kcal/gram in metabolizable energy. This represents the weighted average between 2.4 kcal/gm in early successional seasonal wetlands and 1.6 kcal/gm in late successional wetlands (Dugger et al. 2008, Table 4-3).
- Using the above two steps, the kcal/ha provided in seasonal wetland is equal to 1,116,896 kcal/ha, or 455,760 kcal/acre.
- For permanent wetlands that produce leafy aquatic vegetation and roots/tubers as foods for diving ducks, Dugger et al. (2008) estimates that permanent wetlands on Lower Klamath NWR produce 218 lbs/ac and 214 lbs/ac, respectively or a total of 432 lbs/ac (484.2 kg/ha).
- Roots/tubers and leafy aquatic vegetation contain 2.5 and 2.0 kcal/gram (Dugger et al. 2008, Table 4-3). For both alternatives a value of 2.3 kcal/gram was used to approximate the combined metabolizable energy value for root/tubers and aquatic leafy vegetation in permanent wetlands. Using this value, permanent wetlands on Lower Klamath NWR produce an estimated 450,683 kcal/acre.
- For flooded grain fields, assume that 25% of the crop is left standing with the remaining acreage harvested. Standing grain (in this case barley) produces 4,960 lbs/acre of available foods (Dugger et al. (2008) and harvested grain fields yield 269 lbs/acre (J. Fleskes, USGS, unpublished data). This later estimate is reduced to 255.8 lbs/acre by subtracting a foraging threshold of 13.2 lbs/acre (Dugger et al. 2008). Combining these estimates into a weighted average equals 1,432 lbs/acre or 649 kg/acre. Since barley has a TME value of 3.0 kcal/gram this equates to 1,947,000 kcal/acre.
- From Dugger et al. (2008, Table D-4), the average dabbling duck during Sep-Nov has a daily energy requirement of 273 kcal/day or a 91 day requirement of 24,843 kcals. A diving duck has an average daily energy requirement of 329 kcal/day or 29,939 kcals for the September through November period.

Knowing food energy produced per acre in each wetland habitat type, the daily energy requirement per bird, the period of use (in this case Sep-Nov) and the estimated acres flooded allows for the estimation of the carrying capacity of the wetland for foraging dabbling and diving ducks.

The equation for estimating diving duck carrying capacity for the September-November time period is:

acres of permanent wetlands x 450,683 kcal/acre / (329 kcal/day x 91 days)

Because dabblers forage in both seasonal wetlands and flooded grain fields the equation is:

acres of fall seasonal wetlands x 455,760 kcal/acre) + (acres of flooded grain x 1,947,000 kcal/acre) / (273 kcal/day x 91 days)

Similar to the water and habitat availability analysis, the KBRA Alternative provides habitats that would support more fall migratory dabbling and diving ducks than the No Action Alternative (Fig. 17). The difference between the alternatives was greatest in the drier years.

Again, the difference between alternatives was probably less pronounced than depicted in the wettest 20% of years due to limitations to water deliveries in modeled output from the Ady Canal (see Section 8.2.2). None the less, the KBRA Alternative greatly improves the carrying capacity of Lower Klamath NWR for fall migrating ducks. In drier years, the difference between alternatives is greater than 100,000 diving ducks and approximately 300,000 dabbling ducks (Fig. 17).

Similarly, more acres of permanent emergent marshes will be provided under the KBRA Alternative (Table 11) compared to the No Action Alternative (Table 10), thus habitats for late summer molting waterfowl (as well as many other species of waterbirds) will be provided with greater abundance under the KBRA Alternative.

8.6 Estimating numbers of nongame waterbirds supported under the No Action and KBRA Alternatives: Lower Klamath NWR was established to support both waterfowl and a host of nongame waterbird species. While Lower Klamath NWR is a migratory staging area for fall and spring migrant waterfowl, the refuge is important to nongame waterbirds as both a spring-summer breeding area and a fall migration staging area. Most waterbirds breeding in the western U.S. begin congregating at migrational staging areas in late July through August.

During the months of May, June and August, 2003-04, (Shuford et al. 2006) conducted Klamath Basin-wide comprehensive waterbird surveys. During these surveys, all major wetlands of the Upper Klamath Basin above Keno were surveyed including the Refuges. To compare the numbers of waterbirds that might be supported under the No Action and KBRA Alternatives, the total number of waterbirds counted on Lower Klamath NWR in August of 2003-04 (Table 6) was averaged (26,493) and divided by the average number of wetland acres (9,484 acres) flooded in August of 2003-04 resulting in a birds/acre index of 2.8. The birds/acre index was then multiplied by the estimated number of permanent wetland acres from Table 10 and 11. This approach allows for a comparison of the approximate number of waterbirds that could be supported in late summer on the Refuge under either Alternative in different water year types. It is important to remember that the 2.8 birds/acre is an index and likely represents a minimum number of birds actually present. Of 46 species of nongame waterbirds surveyed, each species has a different probability of being detected during surveys. For example, white pelicans are highly visible and easily counted, whereas American bitterns and several species of rails are extremely secretive and rarely seen.

Using this method of analysis, carrying capacity of wetlands for nongame waterbirds is a linear reflection of estimated wetland acres. Although this may not accurately estimate absolute numbers of birds that could use the respective habitats, it allows for an approximate comparison of numbers of birds supported under the two alternatives. Using this method, the KBRA Alternative provided for a greater number of nongame waterbirds compared to the No Action Alternative (Fig. 18). This difference was greatest in the drier years, approaching 23,000 birds in driest 15% of years (Fig. 18).

8.7 Wintering bald eagles: Because wintering bald eagles in the Klamath Basin forage predominantly on waterfowl, and the KBRA Alternative provides for a greater quantity of waterfowl during fall, and presumably into winter, it is probable that the KBRA Alternative would provide for a larger food resource base for wintering eagles compared to the No Action Alternative. Wintering bald eagles are known to congregate during winter in areas of large waterfowl concentrations (Stalmaster 1987) and wintering eagle numbers are often correlated with the abundance of prey (Servheen 1975).

8.8 Water rights for Lower Klamath NWR: The United States, on behalf of the Bureau of Reclamation and the Fish and Wildlife Service, respectively, filed state water right claims (1905 priority date) and Federal Reserved rights (1908 priority date) for lands on Lower Klamath NWR in the State of Oregon's adjudication proceedings. All of these water right claims were granted in the Proposed Orders, subject to final approval by the Adjudicator and possible rehearing by the Oregon circuit court. Until the Adjudication is complete, the water rights are not administered by the State, either in favor of or against the water rights. Under the KBRA, water rights contests among major claimants (parties to the KBRA) would be dropped in favor of agreed upon allocations, thus removing the uncertainty for the refuge as well as potentially accelerating completion of the adjudication.

8.9 D Plant and Lower Klamath NWR: D Plant is a major source of water for Lower Klamath NWR (see Appendix 2) and is critical to serving the needs of some marsh units that cannot be reached from the Ady Canal. Under the No Action Alternative, D Plant is not operated solely for the benefit of Lower Klamath NWR. D Plant removes water from the Tule Lake sumps for flood control, to meet sump elevations consistent with the 1956 TID Contract, and to maintain required minimum lake levels for ESA listed suckers. Thus, water from D-Plant often does not arrive at Lower Klamath NWR in a timely manner and in the quantities needed. Recent significant increases in pumping costs coupled with shortages of agricultural water have forced TID to become ever more efficient in water use. Thus, D Plant pumping, especially in the irrigation season, has been declining over time. Currently, the Service does not pay for D-Plant operations, unless special pumping ($14/acre-foot) is ordered, but only if water is available under the current priority system.

Under the KBRA Alternative, the Lower Klamath NWR water allocation can be delivered through either the D Plant or the Ady Canal or a combination of both at the times and quantities needed for optimal management of wetland habitats. In return, the Service would pay 31.25 percent of year-long D-Plant pumping costs, regardless of the proportion of water the refuge received or the total costs.

8.10 Leased agricultural lands: Certain lands (Area K) on the refuge are leased to local growers using a competitive bidding process. Revenues (Tule Lake and Lower Klamath NWR combined) range from 1.5 to 3.1 million dollars. Under provisions of the KBRA, 20% of the net lease revenues would be available to the refuge for habitat enhancement. Currently, (No Action Alternative) all lease revenues are under the jurisdiction of BOR, some of which may or may not be available for habitat enhancement work on the refuge.

9.0 Effects of the No Action and KBRA Alternatives to Tule Lake NWR

9.1 Water resources and management: Water on Tule Lake NWR is managed differently than on Lower Klamath NWR. Tule Lake NWR is comprised of Sumps 1(A) and 1(B) (13,000 acres) surrounded by approximately 17,000 acres of agricultural lands. A small proportion of the agricultural lands (500-1,500 acres) are managed as "walking wetlands": a program whereby certain agricultural fields are periodically flooded as wetland habitats on a rotational basis. Day-to-day water management of the refuge is conducted by TID under a 1956 contract with the Federal Government.

The major wetland habitat features on Tule Lake NWR are Sumps 1(A) and 1(B). Both sumps act to collect agricultural return flows from private lands and as flood control basins. Water elevations are tightly controlled for flood control, as a water source for refuge agricultural lands and "walking wetlands", and to provide suitable habitat for endangered fish. Overall, wetlands on Tule Lake NWR are much more of a byproduct of Project operations than wetlands on Lower Klamath NWR. However, recent cooperative projects with Tule Lake Irrigation District, Bureau of Reclamation, and the Fish and Wildlife Service is beginning to change management of refuge habitats. Under the KBRA Alternative, water for both wetlands and agricultural lands on the refuge are primarily derived from the Project agricultural allocation.

Under the No Action Alternative, water shortages to Project agricultural lands will occur more frequently than under the KBRA Alternative. Shortages to Project agriculture reduce the availability of return flows to Tule Lake NWR, thus under the KBRA, more water will be available to Refuge lands compared to the No Action Alternative.

Water for Tule Lake NWR is primarily return flows for agricultural lands within and north of the Tule Lake Basin. Under the No Action or KBRA Alternatives, it is expected that upstream agricultural use will continue, to a greater or lesser extent, and return flows from that land use will continue as the major source of refuge water. Although, there may be a difference in the quantity of water available the Refuge, a change in the quality of that water is not expected between the two alternatives.

9.2 Refuge agricultural lands: Under provisions of the Kuchel Act, most of the upland portions of Tule Lake NWR are managed for agricultural crop production. Grains and potatoes remaining in fields after harvest are an important food resource for migratory waterfowl. Currently lands on the refuge are leased to local growers using a competitive bidding process. Revenues generally range from 1.5 to 3.1 million dollars. Under provisions of the KBRA, 20% of the net lease revenues would be available to the refuge for habitat enhancement. Currently, (No Action Alternative) all lease revenues are under the jurisdiction of BOR, some of which may or may not be available for habitat enhancement work on the refuge.

Under the No Action Alternative, water shortages are much more likely to affect Project agriculture compared to the KBRA Alternative (Fig. 19). If 2010 is indicative of Project priorities in water limited years, then refuge agricultural lands will receive disproportionally less water compared to private agricultural lands. In 2010, most water supplies in the Project were delivered to private lands rather than Refuge agricultural lands. In viewing Fig. 19, Project water shortages sufficient to curtail agricultural deliveries to refuge farmlands occur in approximately

20% of future years. The reduction in water deliveries to Refuge agriculture will certainly mean less revenue for local growers; however, determining the effects to waterfowl is difficult. In examining two previous years in which water was curtailed to refuge lease lands (2001 and 2010), small grain cover crops were planted to protect the fields from wind erosion and weed infestations. Although these cover crops produced significantly less grain than a conventionally irrigated field, most were not harvested leaving substantial foods for migratory waterfowl. Peak fall waterfowl numbers on the Refuge in 2001 and 2010 were 339,540 and 273,380 waterfowl, respectively. Average fall peak populations using the Refuge in 2000-2010 (excluding 2001 and 2010) was 283,804 birds. Provided that efforts/incentives to plant cover crops in future years of water shortage to the lease lands remain, effects to waterfowl are likely negligible.

Under the KBRA Alternative, water for Refuge agricultural is derived from the Project agricultural allocation. It is likely that water shortages to lease land agriculture will be minimal under KBRA and thus agricultural food resources should be sufficient for migratory waterfowl.

9.3 Wetlands of Sumps 1(A) and 1(B): Sumps 1(A) and 1(B) comprise the majority of wetland habitats on Tule Lake NWR. To provide both flood protection and to maintain a population of endangered Lost River and shortnose suckers, water levels in Sump 1(A) are maintained between a minimum of 4034.00' and 4035.50'. Sump 1(B) is not known to support adult suckers and has had the infrastructure installed to allow for water level management for migratory birds.

Under the No Action Alternative, water levels in Sump 1(A) are protected because of concerns for endangered suckers. However, Sump 1(B) will increasingly be used as a water supply source to irrigate refuge agricultural lands, particularly in years of water shortage. This occurs because use of water for agriculture is the primary purpose of the Project, despite its location on the Refuge. Resulting water management may not be entirely conducive to enhancing habitat conditions for migratory birds

Under the KBRA Alternative, water to maintain elevations in Sumps 1(A) and 1(B) is derived from the irrigation allocation. Use of the agricultural allocation under the KBRA, is dictated by the On-Project Water Plan which will specify that Refuge agricultural lands are not to be treated disproportionately, relative to private agricultural lands. In addition, under the KBRA Alternative, Project purposes will be amended to include refuge purposes, thus allowing for use of water for wildlife purposes on the refuge. When managed specifically for migratory birds, Sump 1(B) is the most productive habitat on Tule Lake NWR. The increased ability to manage Sump 1(B) under the KBRA Alternative will mean improved habitat conditions for migratory waterfowl and nesting nongame waterbirds.

9.4 "Walking Wetlands": "Walking Wetlands" is essentially the rotation of wetland habitats within a commercial crop rotation. The program exists primarily on Tule Lake NWR as well as private lands within the historic Tule Lake and Lower Klamath Lake beds. Some additional private lands adjacent to Upper Klamath Lake have also participated in the program.

Under the No Action Alternative, it is more likely that water shortages will occur to Project agriculture including refuge agricultural lands (Fig. 19). Water for "Walking Wetlands" on the refuge and on private lands is typically curtailed in years of agricultural water shortage. Under the KBRA Alternative, water shortages are predicted to occur in relatively few years; therefore, it is much more likely that water for "Walking Wetland" both on and off the refuge will be available. The KBRA specifically allows, subject to Refuge Manager approval, for a portion of the Lower Klamath NWR water allocation to be used for "Walking Wetlands". Water for "Walking Wetlands" under the KBRA is shared; one foot per acre from Lower Klamath NWR allocation and two feet per acre from Project agricultural allocation.

9.5 Migratory waterfowl: Tule Lake NWR functions primarily as a fall and spring migrational staging area for waterfowl of the Pacific Flyway, and is also important to breeding waterfowl during the spring-summer period and for molting waterfowl in late summer. Waterfowl use of the refuge currently depends upon wetland habitats provided in Sumps 1(A) and 1(B) and the "Walking Wetlands" program as well as food resources provided from Refuge agricultural lands. Water for both wetlands and agricultural lands are primarily provided as return flows from private lands in the Project.

Under the No Action Alternative, water shortage are expected in >20% of years which would reduce return flows to refuge wetlands and agricultural lands. If water is curtailed to agricultural lands, this food resource for waterfowl will be minimized unless small grain cover crops are planted as occurred in previous years of restricted water delivery. Restricted inflows into the Sumps, particularly Sump 1(B), would reduce emergent marsh molting habitat for waterfowl, thus reducing the number of birds supported.

Under the KBRA Alternative, water for refuge wetlands and agricultural habitats is derived from the Project agricultural allocation and shortages are expected to occur relatively infrequently (Fig. 19.). Thus adequate agricultural and wetland derived food resources for waterfowl would be expected in most years. Emergent marsh habitats for molting waterfowl in late summer would also be provided with greater frequency and acreage compared to the No Action Alternative.

9.6 Nongame waterbirds: With few exceptions, nongame waterbirds are completely dependent on wetland habitats on Tule Lake NWR. Because wetlands on Tule Lake NWR are dependent on agricultural return flows, shortages to agriculture in the Project will have a negative effect on wetland habitats. Shortages to Project agriculture are much more likely under the No Action Alternative compared to the KBRA Alternative (Fig. 19).

10.0 Effects of the No Action and KBRA Alternatives to biological resources of Upper Klamath NWR

10.1 Water resources: Water levels in Upper Klamath NWR wetlands are dependent on water elevations within Upper Klamath Lake with Refuge wetlands largely dry below lake elevation 4139.50'. Under the No Action Alternative, the potential to reach this lake elevation occurs in 11 of 12 months, while under the KBRA Alternative the potential exists in 6 of 12 months (Fig. 20). Thus, more water is available under the KBRA Alternative for Refuge wetlands compared to the No Action Alternative.

Water for refuge wetlands is comprised primarily of spring inflows from the Cascade Mountains to the west with remainder from the open waters of Upper Klamath Lake. Water quality in spring sources is unlikely to be effected by the KBRA. However, the KBRA contains significant measures to restore and enhance wetland and riparian habitats associated with Upper Klamath Lake and its tributaries. These measures are expected to reduce phosphorus inputs to the lake and may improve water quality (ODEQ 2002). Thus, the KBRA Alternative may improve water quality in those portions of Upper Klamath NWR that receive water from the lake.

10.2 Wetland habitats: Emergent wetlands of Upper Klamath NWR are approximately 90% dry when lake elevations are below 4139.50'. Projected lake elevations modeled for future years (2012 to 2111) indicate that the frequency in which Upper Klamath lake levels fall below 4139.50' is greater under the KBRA Alternative (82% of years) compared to the No Action Alternative (68% of years) (Fig. 20). However, the duration of low water events is greater under the No Action Alternative (Fig. 20); in some extreme dry years extending over an 11 month period. Under both Alternatives, lowest Upper Klamath Lake elevations are reached in September or October.

10.3 Migratory waterfowl: Wetland habitats on Upper Klamath NWR support migratory waterfowl during both the spring (March-April) and fall (September-October) migratory period. Generally, the marshes of Upper Klamath NWR freeze from mid November through early February depending on weather conditions. During this period, waterfowl migrate south to southern wintering areas. Using modeled water elevations for future years as a guide (Fig. 20), both alternatives will have relatively little impact on spring migrant waterfowl during the March-April period. For the fall migration period (September-October), water elevations in Upper Klamath Lake would be low enough to leave refuge wetlands dry in 82% of years under the KBRA alternative compared to 68% of years under the No Action Alternative. Thus, the KBRA Alternative would have a 14% higher probability of negatively effecting fall migrant waterfowl compared to the No Action Alternative.

The Refuge's emergent wetlands are important to molting waterfowl from throughout the western U.S.; particularly for mallards breeding in California (Yarris et al. 1994, Fleskes et al. 2010). Male mallards begin the molt in mid July with females initiating the molt approximately 30 days later. Thus, the molting period for the species extends from mid July through September. During the 30 day molting period, mallards (and other waterfowl species) lose all wing feathers and are incapable of flight. In examining modeled Upper Klamath Lake elevations (Fig. 20), the No Action Alternative will have a greater negative effect on molting male mallards in July (20% of years) and August (59% of years) compared to the KBRA Alternative (July = 3% of years, August = 38% of years). The effect is the opposite for female mallards, in that Refuge wetlands are dry in a higher proportion of years in September under the KBRA Alternative (82% of years) compared to the No Action Alternative (68% of years). It is important to note that breeding mallards are monogamous and females (due to lower survival rates) form a smaller proportion of the population. Thus, the welfare of female mallards is more important to the viability of the species.

10.4 Nongame waterbirds: Marshes of Upper Klamath NWR are important breeding habitat for nongame waterbirds in the Upper Klamath Basin. The breeding period for each species occurs during different time periods. However, when all species are considered collectively, the primary breeding period extends from March – July. For successful breeding, refuge wetlands must remain flooded during this time period. In examining Fig. 20, the KBRA Alternative results in water elevations in Upper Klamath Lake sufficient to support breeding nongame waterbirds in proportionally more future years than under the No Action Alternative. Under the KBRA Alternative water is present in refuge wetlands in all but 3% of future years in July. Under the No Action Alternative, refuge wetlands become dry in a small proportion of future years in March, May, and June (<5% of years) and July (20% of years).

11.0 Summary of effects

Location	No Action Alternative	w/KBRA Alternative
UKNWR		
Wetland habitat	Fall (Sep-Oct) marsh habitats dry in 68% of years.	Fall (Sep-Oct) marsh habitats dry in 82% of future years
Waterfowl	More years of fall waterfowl habitat flooded. Greater negative effects to molting male mallards.	Fewer years of fall waterfowl habitat flooded. Greater effects to molting female mallards.
Nongame waterbirds	Slightly larger impacts to breeding waterfowl and nongame waterbirds	Fewer impacts to breeding waterfowl and nongame waterbirds
TLNWR		
Wetland habitat	Fewer acres of "Walking Wetlands" and agricultural production in 20% of future years.	"Walking wetlands and agricultural relatively unaffected except in the very driest of years.
Waterfowl	Fewer "Walking Wetlands" and agricultural production mean less food resources for dabbling ducks and geese. Greater negative effect to molting waterfowl.	Greater likelihood of water delivery means better wetland habitat conditions and ag food resources for waterfowl.
Nongame waterbirds	Fewer nongame waterbirds due to lack of "Walking Wetlands" and less than optimal management of Sump 1(B) for nongame waterbirds.	Greater numbers and production of nongame waterbirds due to larger "Walking Wetlands" program and optimal wetland management of Sump 1(B).
Lease land farming	Lease land farming to continue under provisions of the Kuchel Act. Agricultural lease revenues managed by Reclamation. Revenues not obligated to Refuge habitat work.	Lease land farming to continue under provisions of the Kuchel Act. 20% of net lease revenues available for Refuge habitat improvements.
Water rights	The Proposed Orders in the Oregon Water Rights Adjudication confirmed a state water right with a 1905 priority and a Federal Reserved water right with a 1928 priority for Tule Lake NWR. The Proposed Order is subject to final approval by the Adjudicator and possible rehearing by the Oregon circuit court. Final status of refuge water rights remains uncertain.	Water rights among other major claimants in the adjudication settled under KBRA. Refuge to receive certainty of sufficient water under KBRA allocations.
Klamath Project purpose	Refuge does not have a legislated purpose within the Klamath Project. Delivery of water through Klamath Project infrastructure is a low priority.	Klamath Project purpose amended to include refuge purposes. Allows for an elevated water priority in the Klamath Project and development of contracts with irrigation districts to allow for that delivery.

LKNWR		
Wetland habitats	Permanent wetlands 0-11,000 acres Fall seasonal wetlands 144-3,587 acres Winter seasonal/grain irrigation 1,408-6,556 acres	Permanent wetlands 6,018-11,000 acres Fall seasonal wetlands 6,044-10,000 acres Winter seasonal/grain irrigation 10,000 acres
Waterfowl	Diving ducks: 0-165,587 birds potentially supported. Dabbling ducks: 0-103,478 birds potentially supported. Greater effect to molting waterfowl compared to KBRA Alternative.	Diving ducks: 90,594 – 165,587 potentially supported. Dabbling ducks: 276,306-364,104 potentially supported.
Nongame waterbirds	0-30,800 birds potentially supported.	16,851-30,800 birds potentially supported with the greatest difference in dry years
Lease land farming	Lease land farming to continue under provisions of the Kuchel Act. Agricultural lease revenues managed by BOR. Revenues not obligated for habitat work on refuge.	Lease land farming to continue under provisions of the Kuchel Act. 20% of net lease revenues available for habitat improvement work.
Water rights	The Proposed Orders in the Oregon Water Rights Adjudication confirmed a state water right with a 1905 priority and a Federal Reserved water right with a 1908 priority. The Proposed Order is subject to final approval by the Adjudicator and possible rehearing by the Oregon circuit court. Final status of water rights remains uncertain.	Water rights among major claimants in the adjudication settled under KBRA. Refuge to receive certainty of sufficient water under KBRA allocations.
D-Pumping Plant	Water from D Plant available only when needed to evacuate excess water from Tule Lake, leading to limited water availability and uncertain timing. Refuge does not pay pumping costs.	Water available to refuge from D-Plant as needed consistent with refuge allocation. Refuge pays 31.25 percent of yearly D-Plant costs.
Klamath Project purpose	Refuge does not have a legislated purpose within the Klamath Project. Delivery of water through Klamath Project infrastructure is a low priority.	Refuge purposes added to Klamath Project purpose. Allows for an elevated water priority in the Klamath Project and development of contracts with irrigation districts to allow for that delivery.

12.0 Literature Cited

Akins, G. J. 1970. The effects of land use and land management on the wetlands of the Upper Klamath Basin. M.S. Thesis, Western Washington State College, Bellingham, Washington. 122 pp.

Dugger, B. D., M. J. Petrie, and D. Mauser. 2008. A bioenergetic approach to conservation planning for waterfowl at Lower Klamath and Tule Lake National Wildlife Refuge. Report prepared for U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuges. 110pp.

Finley, W. L. 1905. State report for Oregon. Pp. 336-342 *in* Dutcher, W., ed., Annual report of the National Association of Audubon Societies for 1905. Bird-Lore 7:295-344.

Fleskes, J. P., and D. S. Battaglia. 2004. Northern pintail habitat use and waterfowl abundance during spring migration in southern Oregon-Northeast California (SONEC). Final Report. U.S. Geological Survey, Dixon, California. 58pp.

Fleskes, J. P., and J. L. Yee. 2007. Waterfowl distribution and abundance during spring migration in Southern Oregon and Northeastern California. Western North American Naturalist 67: 409–428.

Fleskes, J. P., D. M. Mauser, J. L. Yee, D. S. Blehert, and G. S. Yarris. 2010. Flightless and post-molt survival and movements of female mallards molting in Klamath Basin. Waterbirds 33: 208-220.

Frenzel, R. W. 1985. Environmental contaminants and ecology of bald eagle south central Oregon. Ph.D. Diss., Oregon State University, Corvallis.

Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Trans. N. Amer. Nat. Resour. Conf. 47:441-452.

Gilmer, D. S, J. M. Hicks, J. C. Bartnonek, and E. H. McCollum. 1986. Waterfowl harvest at Tule Lake National Wildlife Refuge. 1936-41. Calif. Fish and Game 72: 132-143.

Gilmer, D. S., Yee. J. L., Mauser, D. M., and J. L. Hainline. 2004. Waterfowl migration on Klamath Basin National Wildlife Refuges 1953-2001, U.S. Geological Survey, Biological Resources Discipline Biological Science Report USGS/BRD/BSR—2003-0004, 66pp.

Helmers, D.L. 1992. Shorebird management manual. North American Waterfowl Management Plan. Western Hemisphere Shorebird Reserve Network. Manomet, MA. 58pp.

Isaacs, F. B. and R. G. Anthony. 2008. Bald eagle (Haliaeetus leucocephalus) nest locations and history of use in Oregon and the Washington portion of the Columbia River recovery zone, 1971 through 2007, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, 48pp.

Ivey, G.L., and C.P. Herziger. 2006. Intermountain West Waterbird Conservation Plan, Version 1.2. A plan associated with the Waterbird Conservation for the Americas Initiative. Published by U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon, 205pp.

Jarvis, R. L. 2001. Effects on waterfowl of the 2001 water allocation decisions, pages 313-325 *in,* Water allocation in the Klamath Reclamation Project, 2001: An assessment of natural resource, economic, social, and institutional issues with a focus on the Upper Klamath Basin. Oregon State University Extension Service, Special Report 1037, 401 pp.

Jensen, G. H., and J. E. Chattin. 1964. Western production areas, *in* Waterfowl tomorrow, J. P. Linduska, and A. L. Nelson, editors. U.S. Fish and Wildlife Service, 770pp.

Keister, G. P., Jr. 1981. Characteristics of winter roosts and populations of bald eagles in the Klamath Basin. M.S. Thesis, Oregon State University, Corvallis.

Keister, G. P., R. G. Anthony, and E. J. O'Neil. 1987. Use of communal roosts and foraging areas by bald eagles wintering in the Klamath Basin. J. Wildl. Manage. 51:415-420.

Manning, J., and W. D. Edge. 2001. Relationships between bald eagle biology and Federal environmental decisions on the Klamath Reclamation Project. pages 285-312 *in,* Water allocation in the Klamath Reclamation Project, 2001: An assessment of natural resource, economic, social, and institutional issues with a focus on the Upper Klamath Basin. Oregon State University Extension Service, Special Report 1037, 401 pp.

Mauser, D. M. 1991. Ecology of mallard ducklings on Lower Klamath National Wildlife Refuge, California. Ph.D Dissertation, Oregon State University, Corvallis, 104pp.

Mauser, D. M., R. L. Jarvis, and D. S. Gilmer. 1994. Movements and habitat use of mallard broods in Northeastern California. J. Wildl. Manage. 58:88-94.

Miller, M. R., J. P. Fleskes, D. L. Orthmeyer and D. S. Gilmer. 1992. Survival and other observations of adult female Northern Pintails molting in California. Journal of Field Ornithology 63: 138-144.

North American Waterfowl Management Plan, Plan Committee. 1986. North American Waterfowl Management Plan: a strategy for cooperation. Canadian Wildlife Service, U.S. Fish and Wildlife Service.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake drainage and total maximum daily load (TMDL) and water quality management plan (WQMP). Oregon Department of Environmental Quality, Portland, Oregon. 204pp.

Pederson, B, and R. L. Pederson. 1983. Feeding ecology of pintails and mallards on Lower Klamath marshes. Final report on Contract # 14-16-0001-79106 to the U.S. Fish and Wildlife

Service, Klamath Basin National Wildlife Refuges, from Humboldt State University Foundation. 89pp.

Ringelman, J. K. 1990. Habitat management for molting waterfowl., in Fish and Wildlife Leaflet 13.4.4, Waterfowl Management Handbook, U.S. Fish and Wildlife Service, Washington D.C, 6pp.

Servheen, C. W. 1975. Ecology of the wintering baled eagles on the Skagit River, Washington. Master's Thesis, University of Washington, Seattle.

Shuford, W. D., D. L. Thomson, D. M. Mauser, and J. Beckstrand. 2006. Abundance and distribution of nongame waterbirds in the Klamath Basin of Oregon and California from comprehensive surveys in 2003 and 2004. Final Rep. to U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuge, Tulelake, Calif. 87 pp.

Shuford, W. D. 2010. Inland-breeding pelicans, cormorants, gulls, and terns in California: A catalogue, digital atlas, and conservation tool. Wildlife Branch, Nongame Wildlife Program Report 2010-01. Claifornia Department of Fish and Game, Sacramento 112pp.

Stalmaster, M. V. 1987. The bald eagle. Universe Books, New Yourk, 227pp.

Stalmaster, M. V., and J. A. Gessaman. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. Ecological Monographs 54:407-428.

Sugden, L. G. 1973. Feeding ecology of pintail, gadwall, American widgeon, and lesser scaup ducklings in southern Alberta. Can. Wildl. Serv. Rep. 24. 45pp.
U.S. Fish and Wildlife Service. 2005. Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement. Portland, Oregon.

United States Fish and Wildlife Service (USFWS). 2005. Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Final Environmental Impact Statement. Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 2008. Formal consultation on the Bureau of Reclamations proposed Klamath Project Operations for 2008-2018. U.S. Fish and Wildlife Service, Klamath Area Office, Klamath Falls, Oregon. 233 pp.

Weddell, B. J., K. L. Gray, and J. D. Foster. 1998. History and ecology of Lower Klamath, Tule Lake, Upper Klamath, and Klamath Forest National Wildlife Refuges, Oregon and California, Draft Report to USDI, Fish and Wildlife Service, Portland, Oregon. Draba Consulting, Pullman, WA. Contract Nos. 10181-5-1035 (PM), 10181-6-1199(EM), 10181-6-2148 (DS), 207 pp.

Weller, M. W. 1976. Molts and plumages of waterfowl, pages 34-38 *in*, Ducks, geese, and swans of North America, F. C. Bellrose, editor. Stackpole Books, Harrisburg, Pa., 544pp.

Yarris, G. S., M. R. McLandress, and A. E. H. Perkins. 1994. Molt migration of postbreeding female mallards from Suisun Marsh, California. Condor 96:36-45.

Young, L. S. 1983. Movements of bald eagles associated with autumn concentrations in Glacier National Park. M.S. Thesis, University of Montana, Missoula. 102pp.

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Table 1. Wetland related migratory birds occurring within the boundaries of Lower Klamath, Tule Lake, and/or Upper Klamath National Wildlife Refuges.

Type of Migratory Bird	Birds
Loons	Pacific Loon, Common Loon
Grebes	Pied -billed grebe, horned grebe, red-necked grebe, eared grebe, Western grebe, Clark's grebe
Pelicans	American white pelican
Cormorants	double-crested cormorant
Bitterns, egrets, herons	American bittern, least bittern, great blue heron, great egret, snowy egret, cattle egret, green heron black-crowned night-heron
Ibis	white-faced ibis
Swan, geese, ducks	tundra swan, trumpeter swan, greater white-fronted goose, lesser snow goose, Ross's goose emporer goose, Pacific brant, Great Basin Canada goose, cackling Canada goose, lesser Canada goose, Aluetian Canada goose, wood duck, green-winged teal, mallard, Northern pintail, blue-winged teal, cinnamon teal, Northern shoveler, gadwall, Eurasian wigeon, American wigeon, canvasback, redhead, ring-necked duck, greater scaup, lesser scaup, oldsquaw, surf scoter, white-winged scoter, common goldeneye, Barrow's goldeneye, bufflehead, hooded merganser, common merganser, red-breasted merganser, ruddy duck
Osprey, kites, eagles, hawks	osprey, bald eagle, Northern harrier, sharp-shinned hawk, Cooper's hawk, red-tailed hawk, rough-legged hawk, golden eagle, peregrine falcon, prairie falcon
Rails, coots	yellow rail, Virginia rail, sora rail, American coot
Cranes	greater sandhill crane
Plovers	black-bellied plover, American golden plover, snowy plover, semipalmated plover, killdeer
Stilts, avocets	black-necked stilt, American avocet
Sandpipers, phalaropes	greater yellowlegs, lesser yellowlegs, soltary sandpiper, willetspotted sandpiper, whimbrel, long-billed curlew, marbeled godwit, ruddy turnstone, red knot, sanderling, Western sandpiper, least sandpiper, Baird's sandpiper, pectoral sandpiper, dunlin, short-billed dowitcher, long-billed dowitcher, common snipe, Wilson's phalarope, red-necked phalarope
Gulls, Terns	Franklin's gull, Bonaparte's gull, ring-billed gull, California gull, herring gull, Thayer's gull, glaucous -winged gull, Sabine's gull, Caspian tern, Forster's tern, black tern
Owls	short-eared owl
Nighthawks, poorwills	common nighthawk, common poorwill
Swifts	Vaux's swift, white-throated swift
Kingfishers	belted kingfisher
Flycatchers	olive-sided flycatcher, Western wood-pewee, willow flycatcher, Hammond's flycatcher, dusky flycatcher, gray flycatcher, cordilleran flycatcher, Say's phoebe, ash-throated flycatcher, Western kingbird, Eastern kingbird
Swallows, martins	purple martin, tree swallow, violet-green swallow, Northern rough-winged swallow,

	bank swallow, barn swallow, cliff swallow
Nuthatches	red-breasted nuthatch, white-breasted nuthatch, pygmy nuthatch
Pipits	American pipit
Warblers, tanagers, sparrows, grosbeaks, buntings, blackbirds	orange-crowned warbler, Nashville warbler, yellow warbler, yellow-rumped warbler, black-throated gray warbler, Townsend's warbler, hermit warbler, Macgillivray's warbler, American redstart, yellow-breasted chat, Western tanager, black-headed grosbeak, lazuli bunting, green-tailed towhee, California towhee, fox sparrow, dark-eyed junco, lapland longspur, red-winged blackbird, tricolored blackbird, yellow-headed blackbird, Brewer's blackbird, Northern oriole

Table 2. Estimated production among ducks, geese, and coots, Lower Klamath NWR, 2001-06.

Year	Duck	Coot	Goose
2001	32,874	20,903	778
2002	39,706	28,274	943
2003	32,587	21,317	595
2004	43,439	10,114	755
2005	13,219	12,263	1,121
2006	9,345	4,052	544
Average	**28,528**	**16,154**	**789**

Table 3. Estimated production among ducks, geese, and coots, Tule Lake NWR, 2001-06.

Year	Duck	Coot	Goose
2001	6,808	13,548	131
2002	6,798	6,108	150
2003	7,204	10,710	141
2004	6,762	2,918	151
2005	4,922	5,016	138
2006	7,523	1,607	138
Average	**6,670**	**6,651**	**142**

Table 4. Estimated production among ducks, geese, and coots, Upper Klamath NWR, 2001 - 2006.

Year	Duck	Coot	Goose
2001	1,005	750	686
2002	1,226	607	652
2003	1,149	243	907
2004	1,840	643	381
2005	2,456	435	844
2006	1,266	357	1,119
Average	1,490	506	765

Table 5. Priority nongame waterbird species of regional or continental importance found on Lower Klamath, Tule Lake, and Upper Klamath NWRs. Rationale from Shuford et al. (2006).

Species	Rationale
eared grebe (breeding)	**Largest breeding population in California (TLNWR) and combined with LKNWR, largest breeding site in K-Basin. Priority species North American Waterbird Conservation Plan**
western grebe/Clark's grebe (breeding)	**K-Basin supports an estimated 5% and 15-30% of the continental population of western and Clark's grebes, respectively. LKNWR, TLNWR, and UKNWR are major breeding habitat areas in K-Basin. TLNWR supports 17% of breeding population of 13 major survey sites in CA (Ivey 2004). Priority species North American and Intermountain West Waterbird Conservation Plans.**
American white pelican(breeding)	**K-Basin supports 16% of breeding population west of the Rockies and 5% continentally (King and Anderson 2005). LKNWR and UKNWR represent two of the three breeding sites in K-Basin and one of 2-3 sites in CA. Priority species North American and Intermountain West Waterbird Conservation Plans.**
double-crested cormorant (Breeding)	**Regionally important, Lower Klamath and Tule Lake NWRs represents 69% of cormorants nesting in NE – CA (Shuford 1998).**
great egret (breeding)	**K-Basin one of most important breeding area in Oregon (Herziger and Ivey 2003) as well as NE CA (Suford pers. comm.).**
snowy egret (breeding)	**Although breeding population is small in K-Basin, it represents a substantial proportion of SE OR and NE CA (Herziger and Ivey 2003 and Shuford pers. Comm.) Oregon Sensitive Species. Priority species North American Waterbird Conservation Plan.**
white-faced ibis (breeding)	**One of only four sites in Intermountain West holding >2000 nests (Earnst et al. 1998). Priority species North American and Intermountain West Waterbird Conservation Plans.**
sandhill crane (migrant/breeding)	**Minimum of 15% of Central Valley population of greater sandhill cranes stage on LKNWR (Ivey and Herziger 2003). Important CA breeding site. CA state threatened species. Priority species North American and Intermountain West Waterbird Conservation Plans.**
black-necked stilt (breeding)	**K-Basin second only to Great Salt Lake for breeding (Oring et al. 2000) and represents 2% of the continental population (Morrison et al. 2000). LKNWR supports 60-78% of breeding population in K-Basin. Priority 1 species U.S. and Intermountain West Shorebird Conservation Plans.**
American avocet (breeding)	**LKNWR supports 60-74% of breeding population in K-Basin. K-Basin population exceeds other key sites in Intermountain West (Oring et al. 2000). Priority 2 species U.S. and Intermountain West Shorebird Conservation Plans.**
least/western sandpiper (migrant)	**Migratory population of regional importance. Priority 2 species U.S. and Intermountain West Shorebird Conservation Plans.**
Dunlin (migrant)	**Migratory population of regional importance. Priority 2 species U.S. and Intermountain West Shorebird Conservation Plans.**
dowitcher spp.	**Migratory population of regional importance. Priority 2 species U.S. and Intermountain West Shorebird**

(migrant)	**Conservation Plans.**
Franklin's gull (breeding)	**Western most breeding location at Lower Klamath NWR. Priority species North American and Intermountain West Waterbird Conservation Plans.**
ring-billed/California gull (breeding)	**Regionally significant; K-Basin supports 56-59% of CA statewide breeding population with LKNWR one of several breeding sites (Shuford and Ryan 2000).**
Forster's tern (breeding)	**K-Basin supports 4-5% of the continental breeding population with LKNWR supporting 16-24% of June K-Basin breeding population. Priority species North American and Intermountain West Waterbird Conservation Plans.**
black tern (breeding and migration)	**TLNWR one of the only consistent staging areas for the species in the west (Shuford et al. 2001). Up to 19,000 birds have been documented in peak years. Priority species North American and Intermountain West Waterbird Conservation Plans.**

[1] 2003 data from refuge files.

Table 6. Total numbers of nongame waterbirds observed during comprehensive surveys conducted in the Klamath Basin, 2003-04. Data from Shuford et al. (2006).

Survey Date	**Tule Lake NWR (%)**	**Lower Klamath NWR (%)**	**Klamath Basin total**
May 1-6, 2003	14,811 (24)	15,471(25)	62,561
Apr 29-May 4, 2004	9,061 (10)	34,778(39)	89,799
Jun 12-27, 2003	7,890 (13)	21,170 (36)	59,392
Jun 9-16, 2004	8,105(15)	14,365 (27)	52,735
Aug 12-25, 2003	12,781 (15)	36,028 (41)	87,727
Aug 9-17, 2004	5,953 (9)	16,631 (25)	65,465

Table 7. Mean numbers of nongame waterbirds by species using Lower Klamath, Tule Lake, and Upper Klamath NWRs. Upper Klamath NWR. Numbers are averaged from May, June and August, 2003-04 surveys presented in Shuford et al. (2006).

Species	**Upper Klamath NWR**			**Lower Klamath NWR**			**Tule Lake NWR**		
	May	**June**	**Aug**	**May**	**June**	**Aug**	**May**	**June**	**Aug**
Common loon	1								
pied-billed grebe	61	79	75	38	49	266	**13**	**19**	**198**
eared grebe	1254	930	560	3736	6147	2189	**3027**	**4761**	**1922**
Horned grebe	2								
Red-necked grebe		2							
western/Clark's grebe	5108	5697	3916	310	369	289	**831**	**1277**	**1371**
American white pelican	1329	1026	2324	470	466	1180	**250**	**426**	**237**
double-crested cormorant	1369	1310	1026	441	444	275	**71**	**21**	**69**
American bittern		4	1	3		5	**0**	**1**	**1**
great blue heron	96	115	92	11	19	22	**2**	**2**	**9**
great egret	131	235	663	209	406	337	**105**	**75**	**87**
snowy egret	4	2	16	5	22	30	**2**	**1**	**10**
Green heron			1						
black-crowned night heron	38	36	71	58	211	86	**13**	**18**	**9**
white-faced ibis	14	324	741	595	2981	1230	**103**	**205**	**357**
Virginia rail	1	1	3	4	3	4	**0**	**0**	**1**
sora	1	8	7	3	5	1	**0**	**0**	**11**
sandhill crane	32	24	8	16	31	28	**1**	**1**	**1**
black-bellied plover	8		1	313	0	1	**3**	**0**	**0**
snowy plover				5	0	1	**0**	**0**	**0**
semipalmated plover	12	1		56	0	17	**3**	**0**	**1**
killdeer	40	91	116	70	131	310	**12**	**19**	**12**
black-necked stilt	107	497	771	1933	2053	2538	**139**	**206**	**1081**
American avocet	24	160	199	1358	1328	326	**41**	**166**	**111**
yellowlegs spp.	12		42	14	2	58	**0**	**0**	**3**
solitary sandpiper			1				**0**	**0**	**1**

willet			1	160	159	10	**2**	**2**	**0**
spotted sandpiper		15	8		3	3	**4**	**1**	**2**
long-billed curlew				37	72	47	**0**	**0**	**0**
marbled godwit				19		7	**0**	**0**	**1**
western sandpiper	55		797	983		710	**73**	**0**	**86**
least sandpiper	154		107	876		443	**104**	**0**	**201**
least/western sandpiper			296	3612	1	832	**5600**	**0**	**9**
dunlin	9		1	6337		1	**14**	**0**	**0**
dowitcher spp.	8	5	4134	2432		12931	**699**	**0**	**981**
common snipe	2	9	15	6	4	2	**0**	**0**	**3**
Wilson's phalarope	17	215	166	109	127	1227	**17**	**7**	**349**
red-necked phalarope	7		186	2	3	372	**0**	**0**	**141**
phalarope spp.		1	71	0	2	161	**0**	**0**	**0**
Franklin's gull	1		1	33	79	1	**1**	**1**	**0**
Bonaparte's gull	68	41	142	31		35	**63**	**31**	**1**
ring-billed gull	43	100	2673	314	899	288	**339**	**526**	**177**
California gull	2	42	261	6	189	3	**0**	**60**	**2**
gull spp.	152	175	6278	136	709	20	**105**	**0**	**42**
Caspian tern	28	86	143	19	7	19	**150**	**21**	**147**
Forster's tern	489	1290	63	102	467	35	**143**	**156**	**503**
black tern	194	751	283	274	382	156	**13**	**0**	**1200**

[1] Includes counts for entire Upper Klamath Lake area including Upper Klamath NWR. Data were not separated during surveys.

Table 8. Number of wintering bald eagles (February counts) using Lower Klamath and Tule Lake NWRs compared to the larger Klamath Basin above Keno, Oregon, 1984-2010. Counts are from aerial waterfowl surveys.

Year	Lower Klamath NWR	Tule Lake NWR	Klamath Basin Total
1984	43	295	338
1985	35	352	387
1986	38	19	57
1987	133	187	320
1988	405	295	700
1889	68	398	466
1990	253	30	307
1991	86	266	385
1992	502	56	654
1993	51	12	96
1994	184	12	213
1995	No data	No data	No data
1996	260	7	326
1997	356	17	432
1998	468	35	552
1999	193	3	206
2000	131	17	214
2001	351	23	442
2002	321	31	383
2003	108	51	195
2004	165	66	290
2005	209	16	256
2006	69	46	186
2007	309	15	414
2008	269	33	314
2009	88	31	149
2010	159	28	229

Table 9. Sensitive vertebrate species found on Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges. Sensitive species include those species listed as threatened or endangered under Federal and State law as well as focal or priority species identified by Federal or State governments and conservation organizations. These later species, while not listed as endangered or threatened, are generally facing one or more threats to their populations or habitats. Sensitive species are frequently priorities for landscape conservation planning efforts.

Species	Species	Species
Tule white-fronted goose[1,2,10,11,]	Wrangel Island Snow goose[1,2]	American Wigeon[1,2]
Northern pintail[1,2]	Mallard[1,2]	Tundra swan[1]
Bufflehead[11]	Redhead[1,2,10,11,16]	Lesser Scaup[1,2]
Trumpeter swan[1,9]	Pac. white-fronted goose[1,2]	Canvasback[1,2]
Cackling Canada goose [1,2,11]	Black-necked stilt[3,5]	American avocet[3,5,16]
Marbled godwit[3,5,13]	Black-bellied plover[3,5]	Solitary sandpiper[3,5]
Dunlin[5]	Greater yellowlegs[5]	Red-necked phalarope[5]
Wilson's phalarope[3,5,16]	Semipalmated plover[5]	Spotted sandpiper[5]
Least sandpiper[5]	Killdeer[5]	Long-billed dowitcher[5]
Lesser yellowlegs[5]	Wilson's snipe[5]	Longbilled curlew[3,5,13,14,16,19]
Willet[5]	Western sandpiper[5]	Western snowy plover[3,5,10,11,13,1619]
Double-crested cormorant[14]	American white pelican[3,6,7,10,11,16,24]	Common loon[7]
Great blue heron[4]	Snowy egret[6,24]	Great egret [4]
Black-crowned night heron [6,7]	Western grebe[6,7]	Clark's grebe[6,7]
Eared grebe[6,7, 13,16]	Red-necked grebe[23]	Sora rail[11]
American bittern[11,17]	Least bittern[10,11,16]	White-faced ibis[3,6,7,14,16]
Black tern[6,7,10,11]	Caspian tern [6,13]	Forster's tern[6,7]
California gull [6,14,16]	Franklin's gull[6,7,16,24]	Greater sandhill crane[3,7,8,9,16,1720,24]
Lesser sandhill crane[6,10,11]	Short-eared owl [3,10,11,19]	Swainson's hawk[8,13,16,17,19,20,25]
American peregrine falcon[8,9,13,16,24]	Bald eagle [4,8, 9,1317]	Golden eagle[4,9,13,14,18]
Prairie falcon[11,16]	Merlin[14]	Northern harrier[3,10,11,16,25]
Yellow-headed blackbird[3,10,11]	Bank swallow[8,25]	Marsh wren[3]
Yellow warbler[3,10,25]	Common yellowthroat[25]	Tricolored blackbird [3,10,13,17,18,19]
Blue chub[10]	Shortnose sucker[8,9,12]	Lost River sucker[8,9,12]

Redband trout (Upper Klamath Basin)[24]	Little brown bat[22]	Long-eared myotis[18,22]
Townsend's big-eared bat[10, 18, 20,21]	Long-legged myotis[18, 21]	Yuma myotis[18, 22]
Small-footed myotis[18, 22]	Hoary bat[22]	Silver-haired bat[22]
Fringed myotis[18,21]	Western pond turtle [10,15,23]	American badger[10]

[1] North American Waterfowl Management Plan and the Intermountain West Joint Venture Strategic Plan (2005) Priority Waterfowl Species.
[2] North American Wetlands Conservation Act Priority Waterfowl Species, Bird Conservation Regions 9, 15, and 33.
[3] North American Wetlands Conservation Act Priority Bird Species - Non-waterfowl species, Bird Conservation Regions 9, 15, and 33.
[4] California Department of Forestry and Fire Protection - Sensitive
[5] U.S. Shorebird Conservation Plan and Intermountain West Regional Shorebird Plan.
[6] North American Waterbird Conservation Plan
[7] Intermountain West Waterbird Conservation Plan - Bird Conservation Regions 9 and 15
[8] State of California threatened or endangered species
[9] State of California Fully Protected Animals List
[10] California Department of Fish and Game Species of Special Concern List (2009)
[11] California Bird Species List (PRBO)
[12] Federal Endangered Species List
[13] U.S. Fish and Wildlife Service (2008), Birds of Conservation Concern, BCR 9.
[14] California Department of Fish and Game Watch List
[15] International Union for the Conservation of Nature – Vulnerable species
[16] Great Basin Ecoregional Conservation Blueprint (TNC)
[17] Klamath Mountains Ecoregional Plan (TNC)
[18] Bureau of Land Management Sensitive
[19] American Bird Conservancy – U.S. WatchList of Birds of Conservation Concern
[20] U.S. Forest Service Sensitive
[21] Western Bat Working Group – High priority
[22] Western Bat working group – Low-medium priority
[23] Oregon Sensitive Species List – Critical
[24] Oregon Sensitive Species List – Vulnerable

Table 10. Modeled water availability, habitats flooded, and projected waterfowl (Sep-Nov), and summer (Aug) nongame waterbirds supported on Lower Klamath NWR under the No Action Alternative. Driest year types are represented by the lowest percentiles.

Percentiles	Apr-Oct (a-f)	Nov-Mar (a-f)	Annual (a-f)	Permanent wetlands (acres)	Seasonal wetlands (Sep-Nov)	Farmed units/winter wetlands	Total Wetland acres	Dabbling ducks	Diving ducks	August waterbirds
0.00	**0**	**3519**	**3519**	**0**	**144**	**1408**	**1408**	**0**	**0**	**0**
0.05	2559	4576	7134	604	458	1685	2673	9709	9089	1691
0.10	3924	5458	9381	940	623	1957	3474	14384	14153	2633
0.15	4669	5954	10623	1172	669	2100	3918	15250	17638	3281
0.20	9759	6738	16497	3201	428	1927	5894	5336	48193	8964
0.25	17470	7194	24665	5367	915	1590	8610	22377	80799	15029
0.30	20527	7791	28317	6490	874	1559	9849	19815	97698	18172
0.35	22035	8156	30191	7065	829	1567	10500	17809	106354	19782
0.40	23916	9155	33071	7439	1143	1877	11509	24428	111975	20828
0.45	25691	10060	35751	7779	1432	2157	12455	36913	117106	21782
0.50	**26678**	**10474**	**37152**	**8062**	**1501**	**2255**	**12946**	**38908**	**121361**	**22574**
0.55	27712	11113	38825	8324	1618	2448	13542	42188	125307	23308
0.60	29494	11753	41247	8657	1925	2623	14386	52055	130314	24239
0.65	30918	12510	43428	9035	2055	2835	15166	55969	136009	25298
0.70	32590	13194	45784	9582	2095	2978	15978	56925	144248	26831
0.75	34174	13797	47971	10025	2216	3113	16741	60519	150903	28069
0.80	36409	15365	51774	10745	2271	3567	18100	62184	161751	30086
0.85	38100	17415	55515	11000	2458	4326	19326	68090	165587	30800
0.90	40008	19979	59987	11000	2640	5352	20498	73428	165587	30800
0.95	42254	21413	63667	11000	2998	5925	21372	84338	165587	30800
1.00	**48205**	**22991**	**71196**	**11000**	**3587**	**6556**	**22529**	**103478**	**165587**	**30800**

Table 11. Modeled water availability, habitats flooded, waterfowl populations (Sep-Nov), and summer nongame waterbirds (Aug) supported on Lower Klamath NWR under the KBRA Alternative. Driest year types are represented by the lowest percentiles.

Percentiles	Apr-Oct (a-f)	Nov-Mar (a-f)	Annual (a-f)	Permanent wetlands (acres)	Fall seasonal wetlands (Sep-Nov)	Farmed units, spring wetland (acres)	Total acres	Dabbling ducks	Diving ducks	August waterbirds
0.00	30374	33234	63608	6018	6044	10000	20305	276306	90594	16851
0.05	43075	35231	78306	8542	7979	10000	26263	325947	128589	23918
0.10	46417	35300	81717	9203	8463	10000	27525	335915	138539	25769
0.15	47979	35300	83279	9497	8699	10000	28111	340239	142963	26592
0.20	49874	35300	85174	9871	8968	10000	28827	345175	148589	27638
0.25	51081	35300	86381	10109	9139	10000	29282	348311	152176	28305
0.30	52073	35300	87373	10306	9278	10000	29656	350866	155145	28858
0.35	52990	35300	88290	10489	9407	10000	30003	353230	157891	29368
0.40	53484	35300	88784	10587	9477	10000	30190	354502	159369	29643
0.45	54386	35300	89686	10766	9603	10000	30530	356827	162070	30146
0.50	55607	35300	90907	11000	9776	10000	30982	360002	165587	30800
0.55	56094	35300	91394	11000	9864	10000	31000	361601	165587	30800
0.60	56906	35300	92206	11000	10000	10000	31000	364104	165587	30800
0.65	58450	35300	93750	11000	10000	10000	31000	364104	165587	30800
0.70	59410	35300	94710	11000	10000	10000	31000	364104	165587	30800
0.75	59620	35300	94920	11000	10000	10000	31000	364104	165587	30800
0.80	59826	35300	95126	11000	10000	10000	31000	364104	165587	30800
0.85	59974	35300	95274	11000	10000	10000	31000	364104	165587	30800
0.90	60207	35300	95507	11000	10000	10000	31000	364104	165587	30800
0.95	60498	35300	95798	11000	10000	10000	31000	364104	165587	30800
1.00	60848	35300	96148	11000	10000	10000	31000	364104	165587	30800

Table 12. Water demand (feet), permanent wetlands, Lower Klamath National Wildlife Refuge. Evapotranspiration is assumed to equal precipitation from November through March.

	April	May	June	July	August	September	October	Apr-Oct
Evapotranspiration[1]	0.3	0.48	0.56	0.67	0.60	0.46	0.24	3.29
Precipitation[2]	0.07	0.08	0.05	0.02	0.03	0.04	0.075	0.38
Net Evapotranspiration[3]	0.22	0.39	0.50	0.65	0.56	0.42	0.16	2.91

[1] Assumes a 30/70 mix of emergent wetland vegetation and open water.
[2] Average precipitation, Klamath Falls, Oregon, 1960-2008.
[3] Evapotranspiration minus average Klamath Falls, Oregon precipitation.

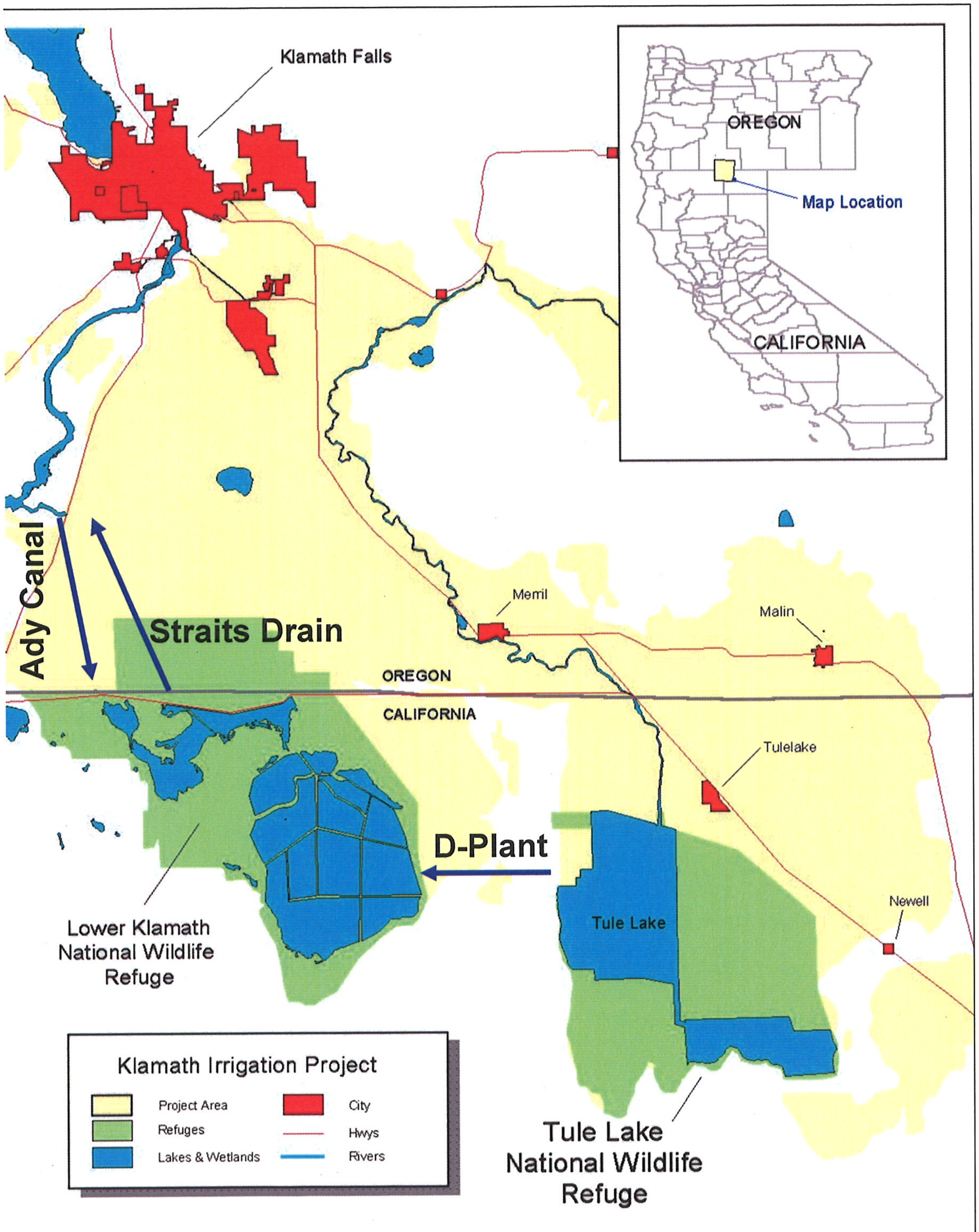


Fig. 1. Location of Lower Klamath and Tule Lake National Wildlife Refuges within the Klamath Reclamation Project. Blue arrows depict major delivery and drainage points for Lower Klamath National Wildlife Refuge.

Fig 2. Ady Refuge Inflow - Historical Deliveries to Lower Klamath NWR
1962 to 2009 (does not include deliveries to Area K lease lands)

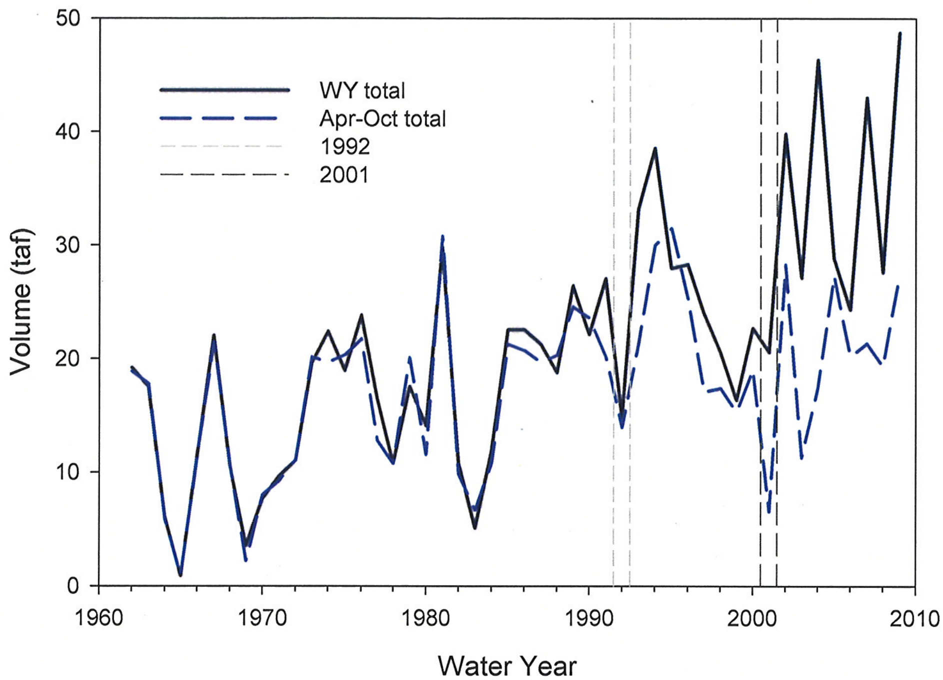


Fig. 3 D Plant Refuge Inflow - Historical Deliveries to Lower Klamath NWR
1962 to 2009 (does not include deliveries to P Canal deliveries to private lands)

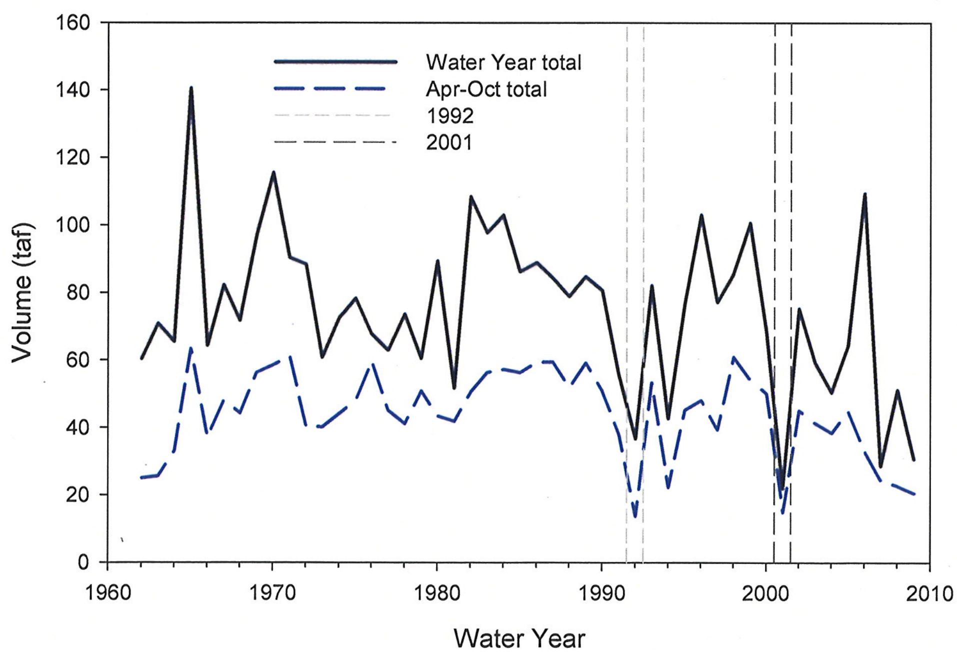


Fig. 4 D Plant Refuge Inflow and Ady Refuge Inflow
Historical Deliveries to Lower Klamath NWR 1962 to 2009
(does not include deliveries to P Canal deliveries to private lands)

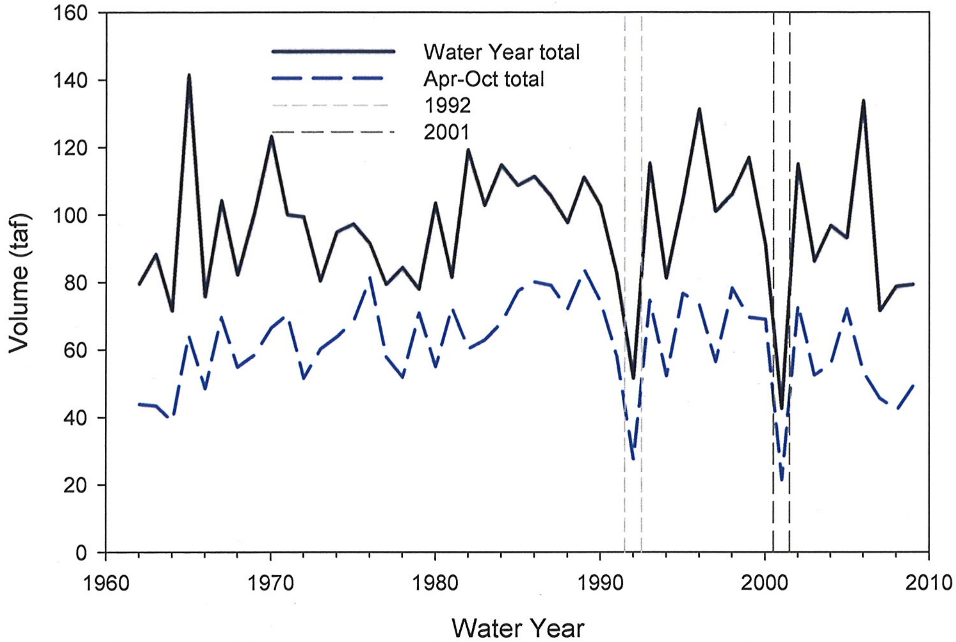
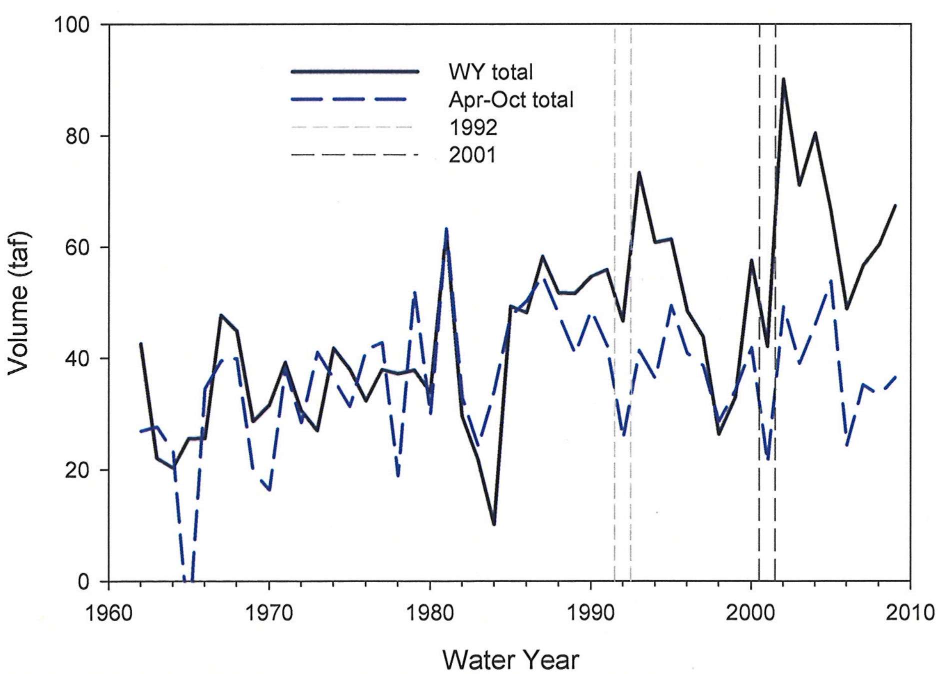


Fig. 5 Estimated Refuge Water Use - Lower Klamath NWR
1962 to 2009 Estimated from the difference of total inflow and outflow
(does not include Area K lease lands)



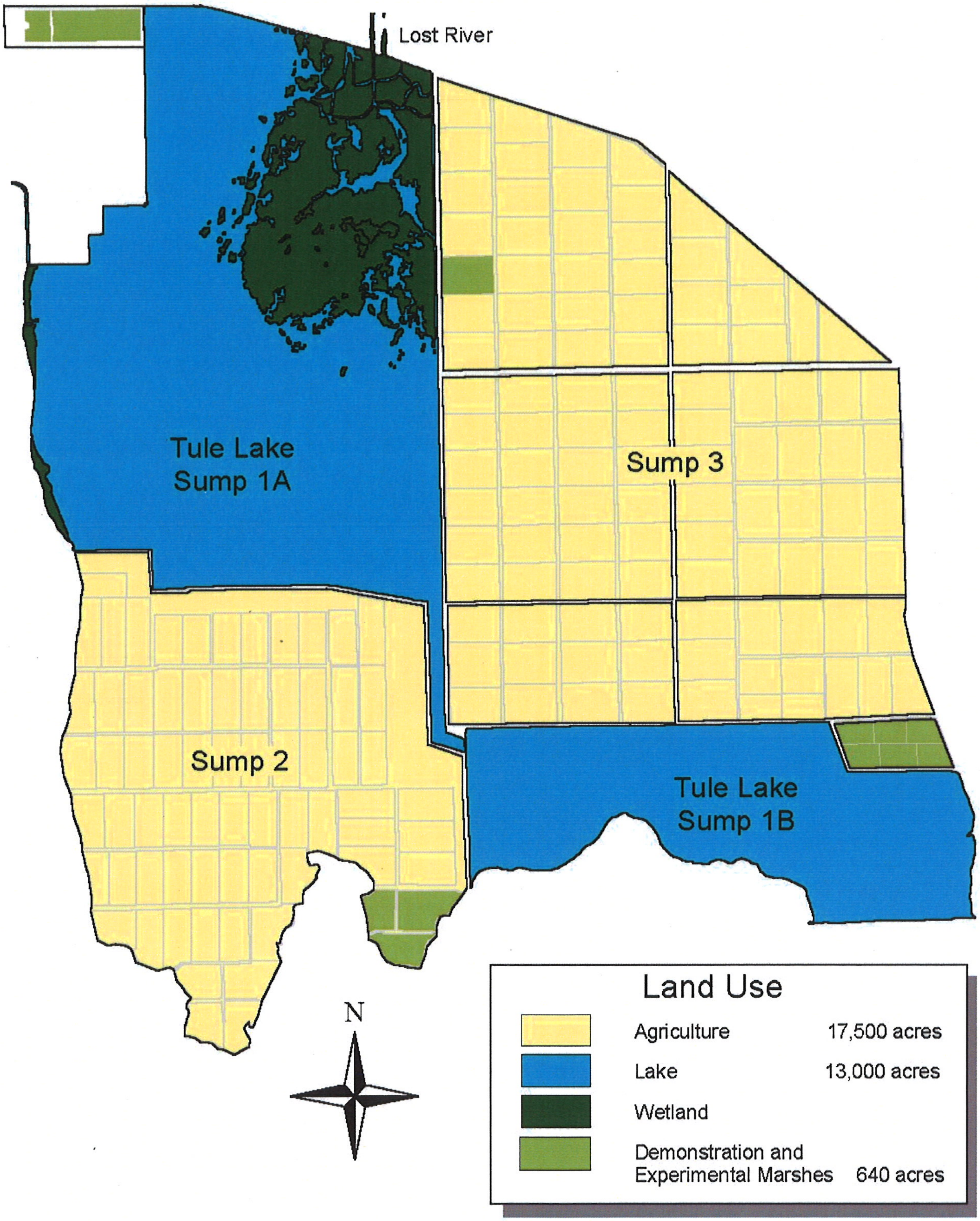


Fig. 6. Land use and habitats, Tule Lake National Wildlife Refuge, California.

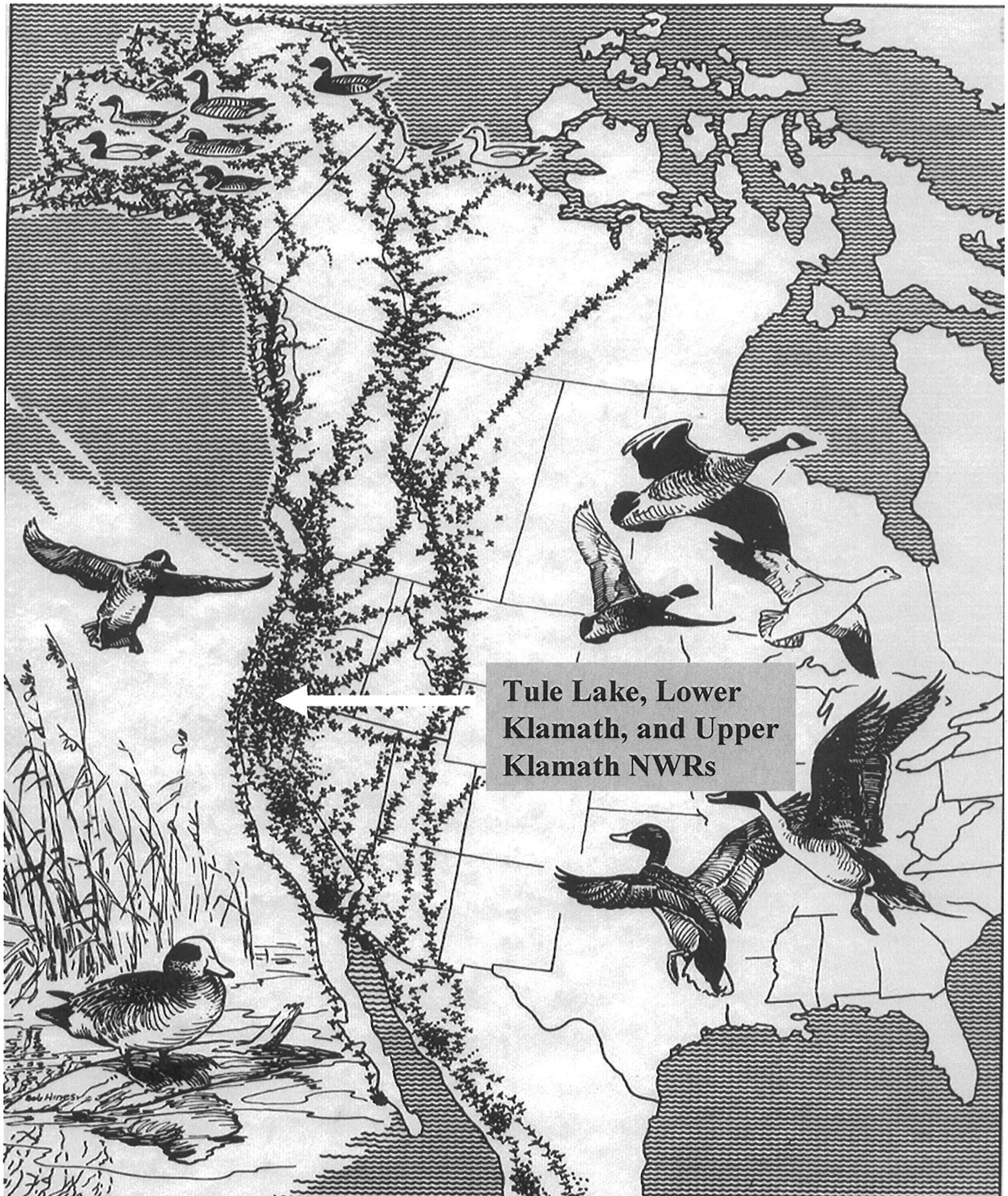


Fig. 7. Location of Tule Lake, Lower Klamath, and Upper Klamath National Wildlife Refuges within the Pacific Flyway.

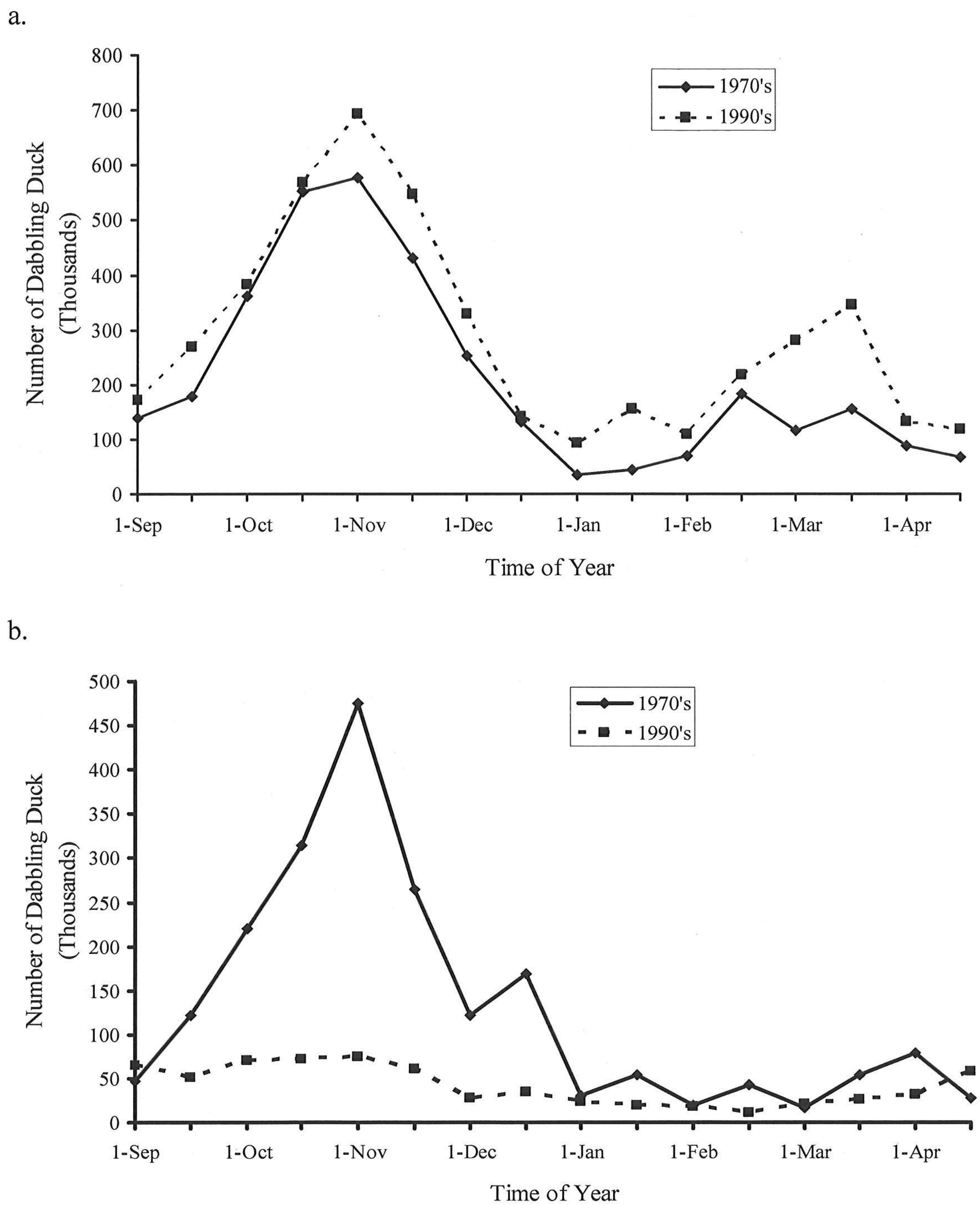
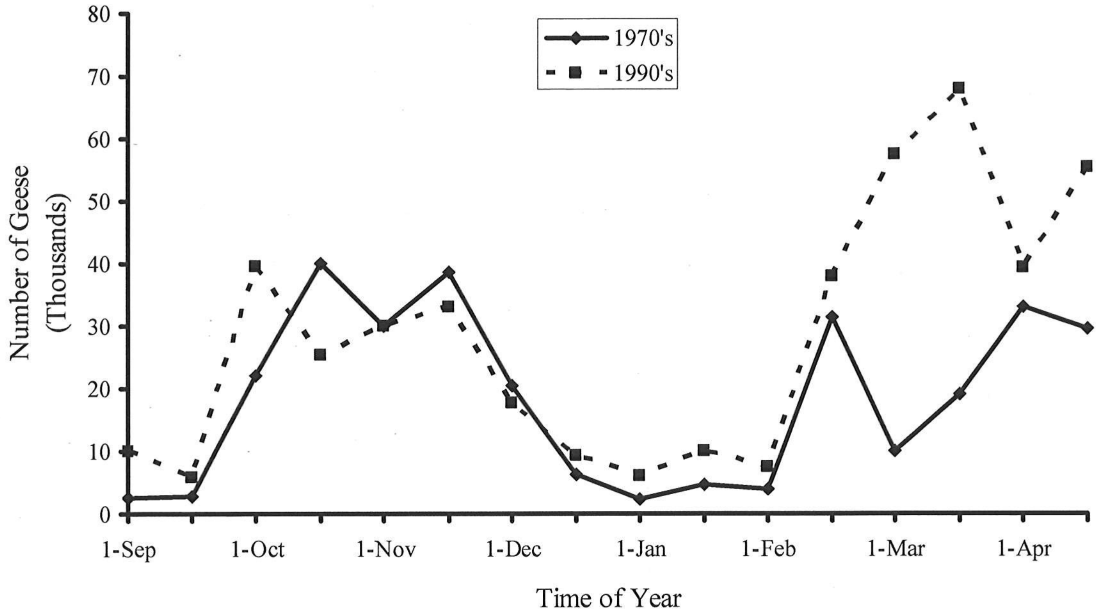


Fig. 8. Mean counts of dabbling ducks by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys. (From Dugger et al. (2008))

a



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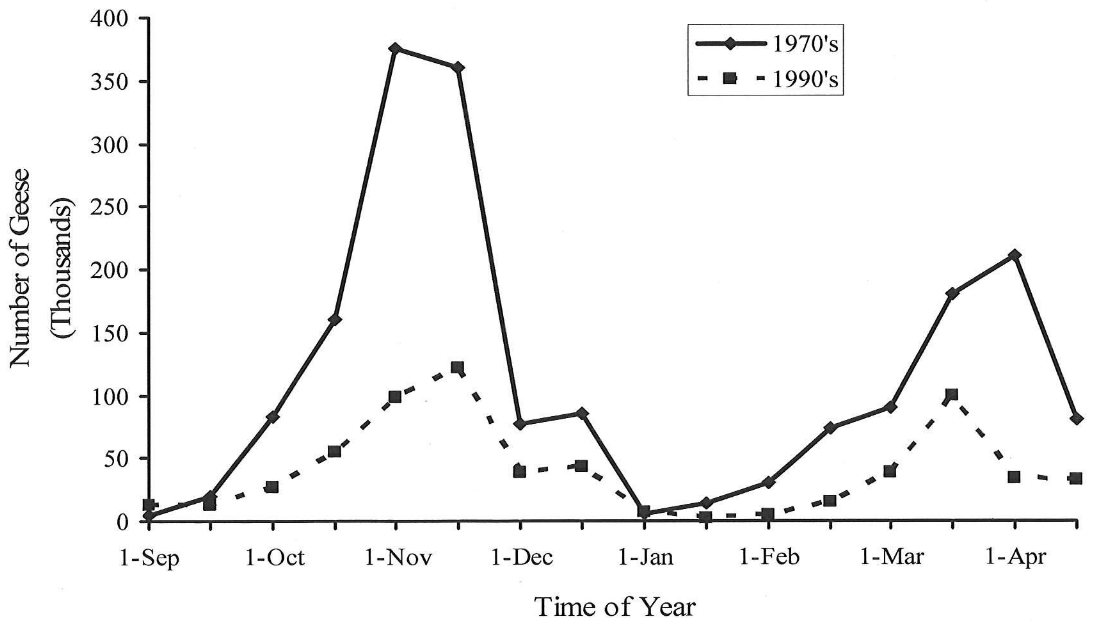
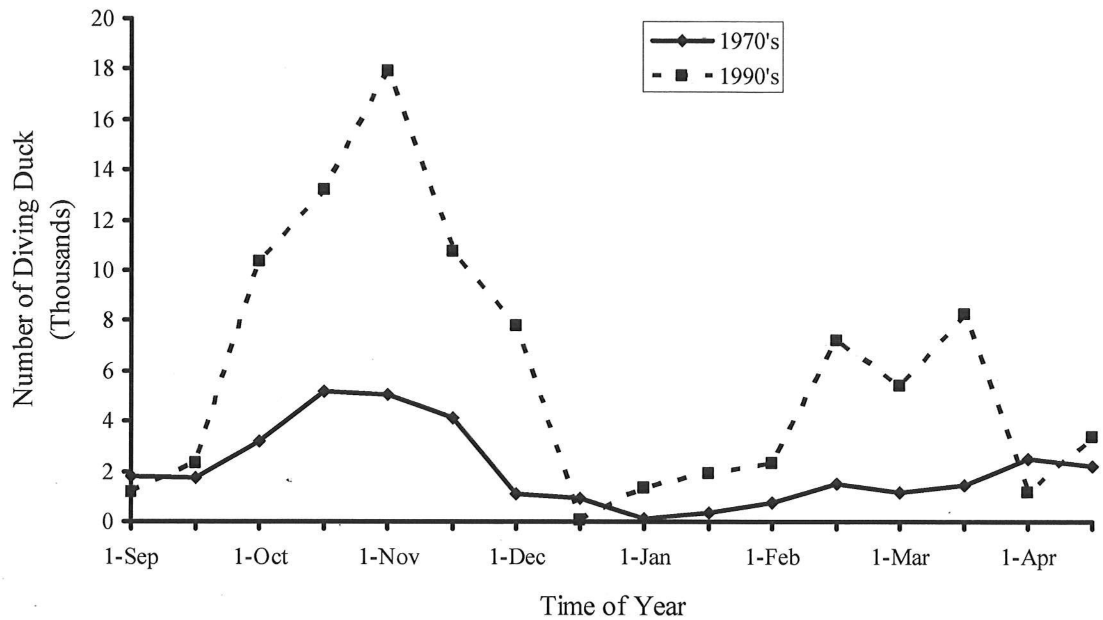


Fig. 9. Mean counts of geese by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys. (From Dugger et al. 2008).



a

b

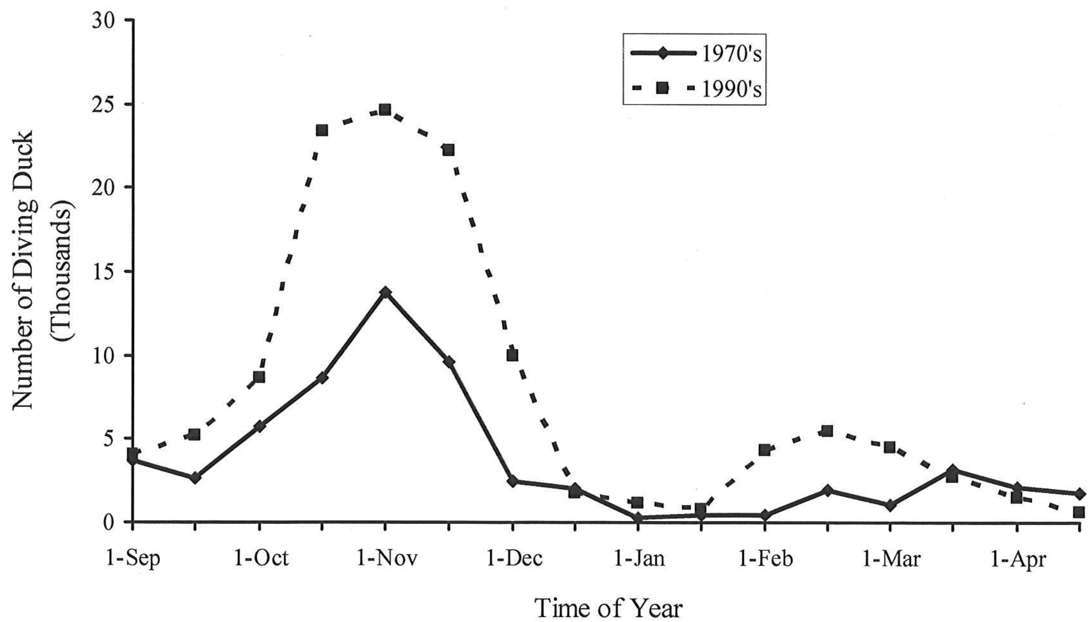
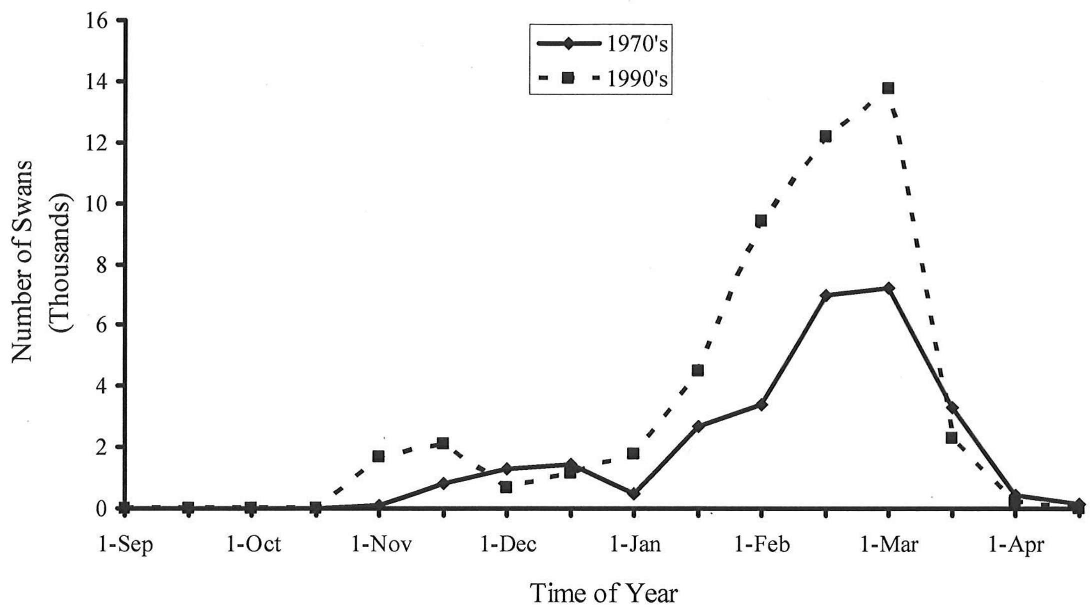


Fig. 10. Mean counts of diving ducks by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys. (From Dugger et al. 2008)

a



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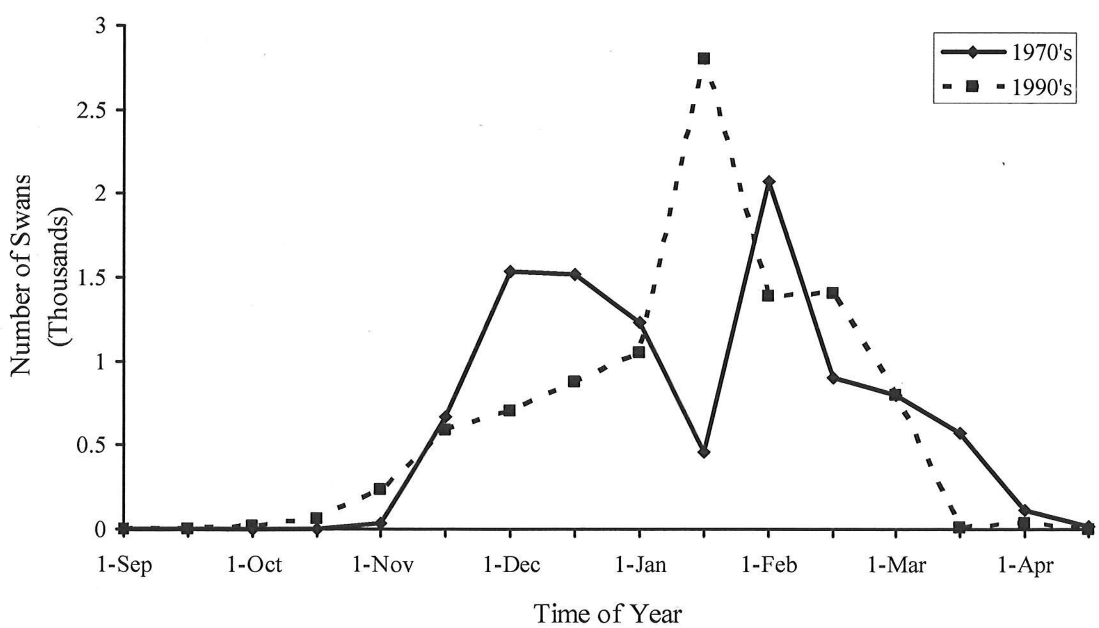

Fig. 11. Mean counts of swans by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys. (Dugger et al. 2008)

Fig. 12. Upper Klamath National Wildlife Refuge.

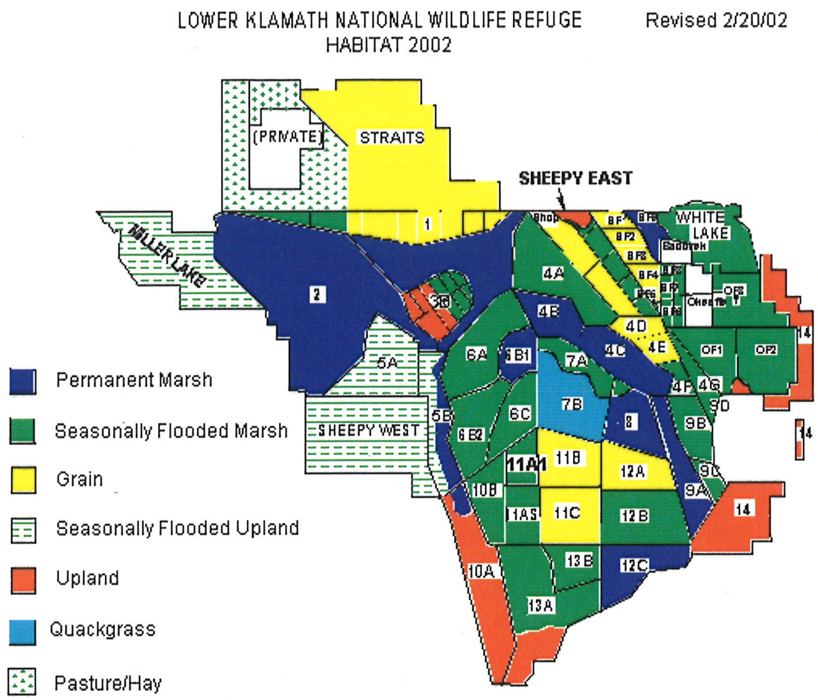

Fig. 13. Lower Klamath National Wildlife Refuge depicting typical array of habitats across multiple management units.

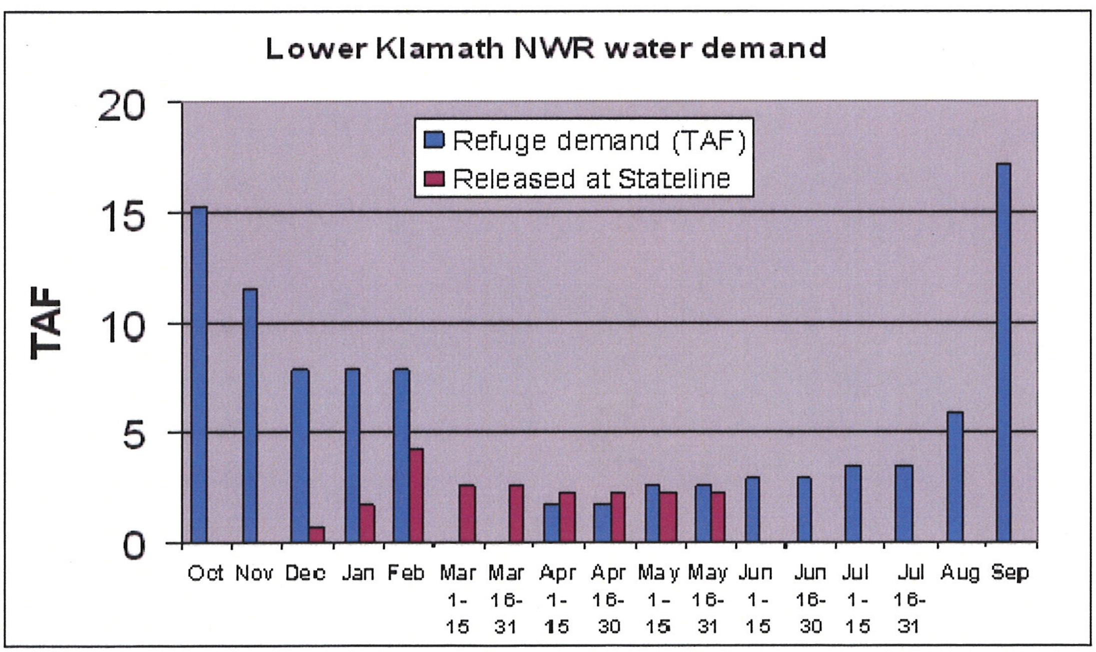

Fig. 14. Water demand for Lower Klamath National Wildlife Refuge by time steps. Red bars represent typical releases from the refuge into the Straits Drain.

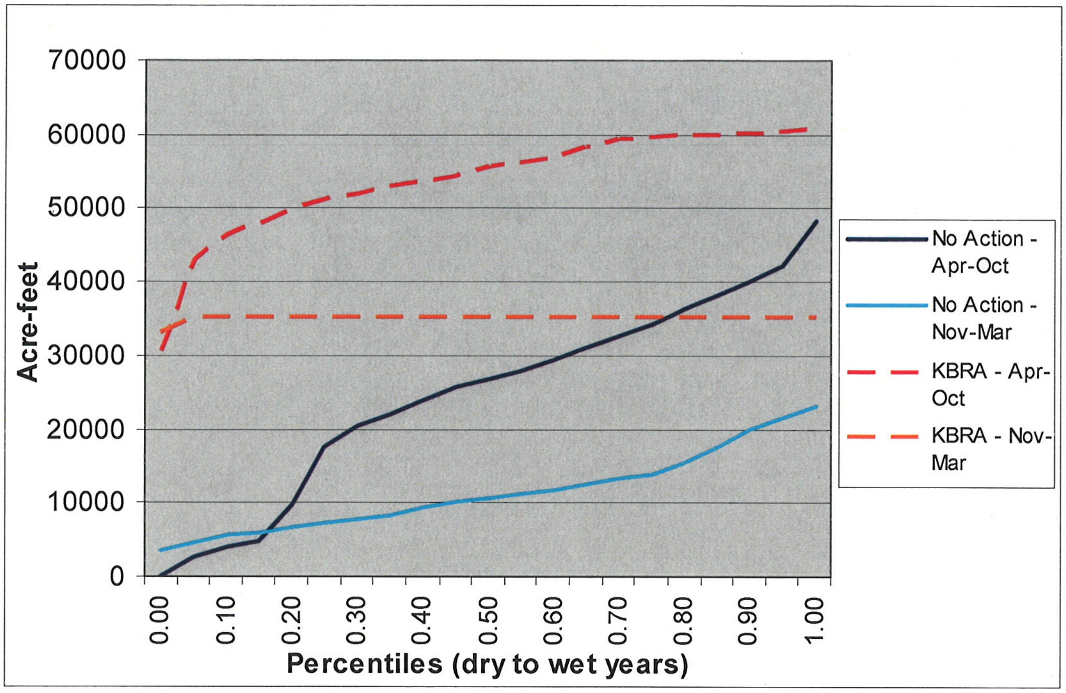

Fig. 15. Comparison of water deliveries (ac-ft) to Lower Klamalth NWR under the No Action and KBRA Alternatives.

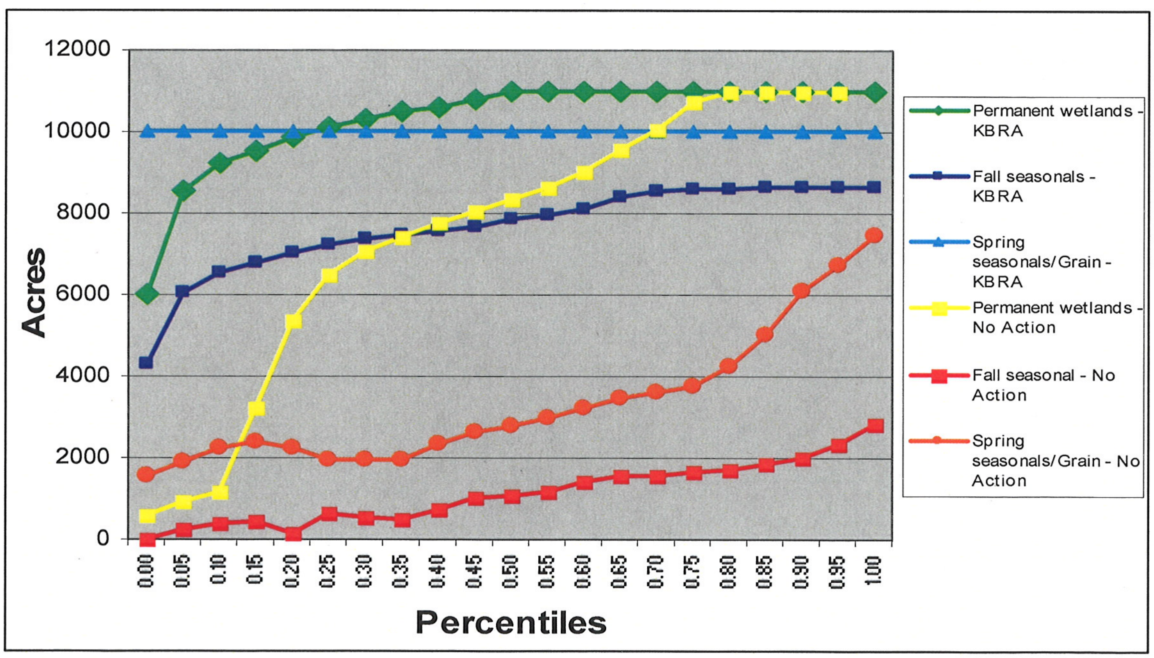

Fig. 16. Comparison of estimated acres of habitats provided under the No Action and KBRA Alternatives, Lower Klamath National Wildlife Refuge. Smallest percentiles represent driest years.

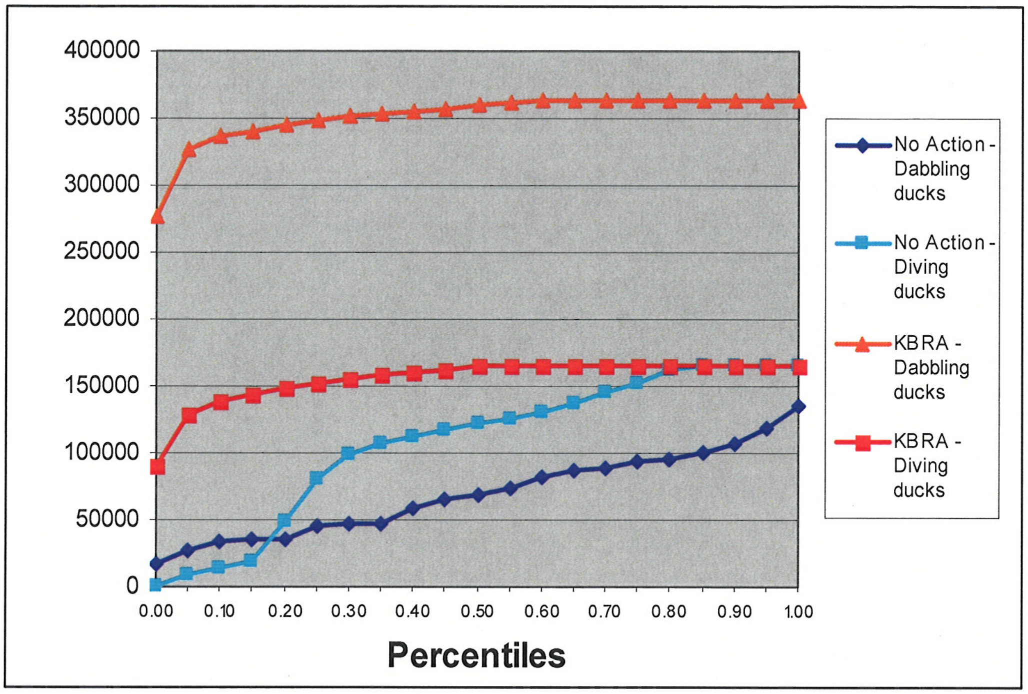

Fig. 17. Comparison of estimated carrying capacity (birds/day) for diving and dabbling ducks during fall migration (Sep-Nov) on Lower Klamath National Wildlife Refuge under the No Action and KBRA Alternatives. Smallest percentiles represent driest years.

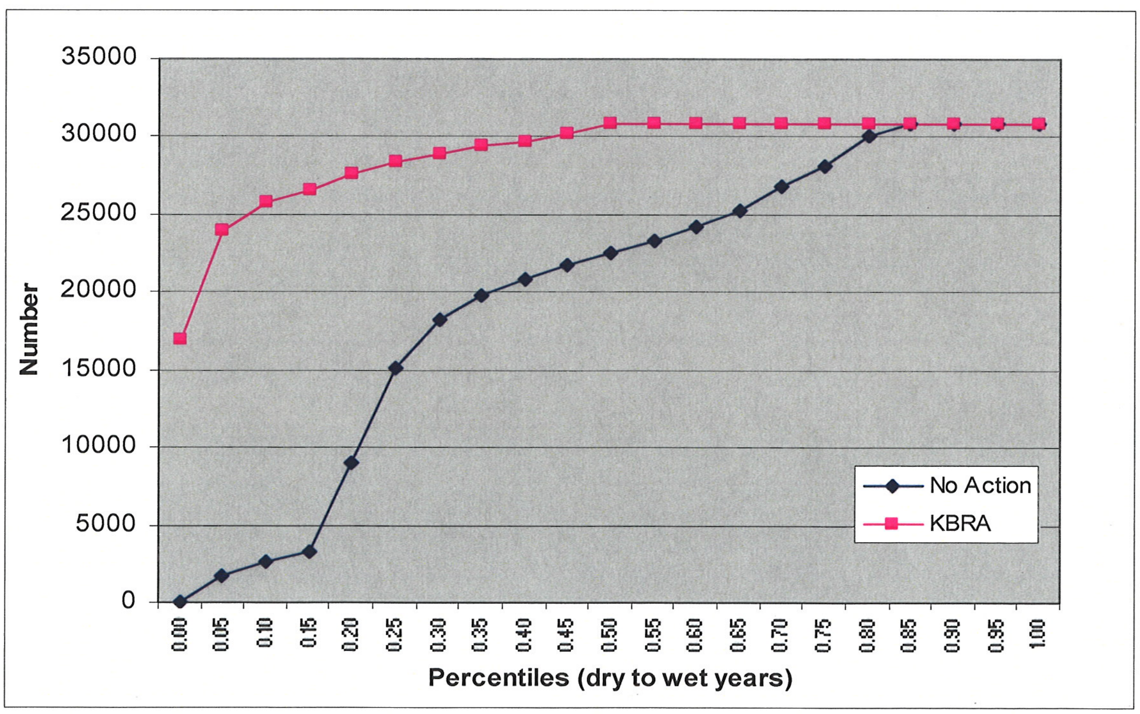

Fig. 18. Comparison of estimated number of nongame waterbirds supported by August permanent wetland habitats on Lower Klamath National Wildlife Refuge under the No Action and KBRA Alternatives.

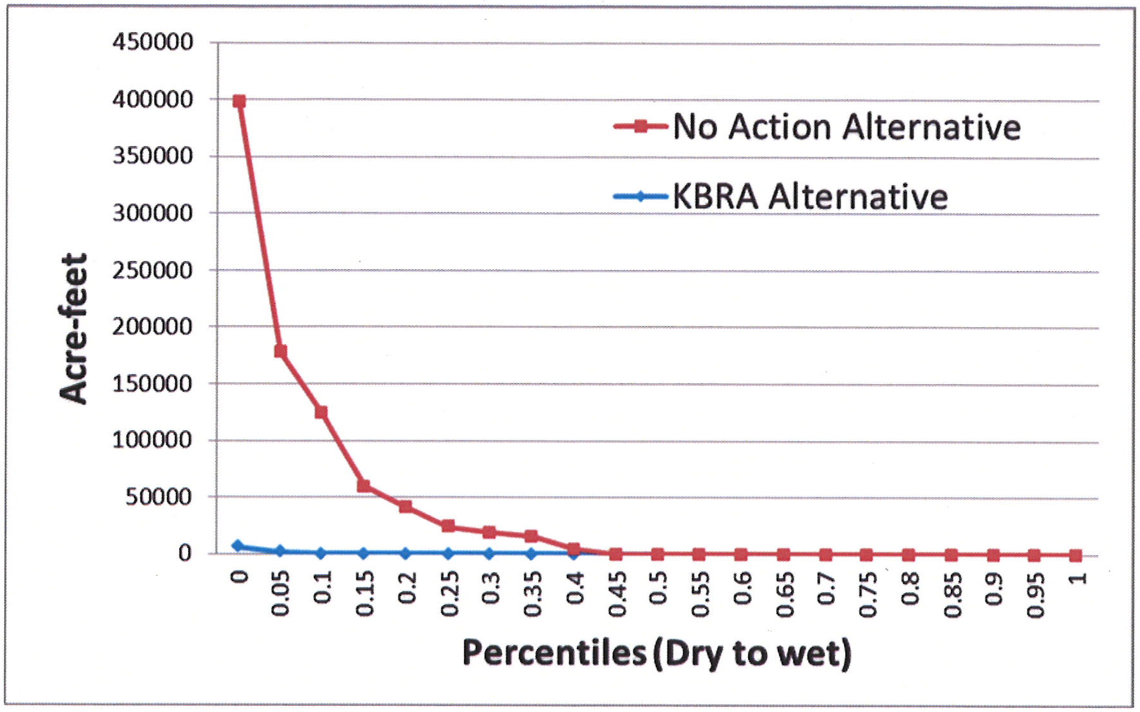

Fig. 19. Estimated water shortages to Klamath Project agriculture under the No Action and KBRA Alternatives

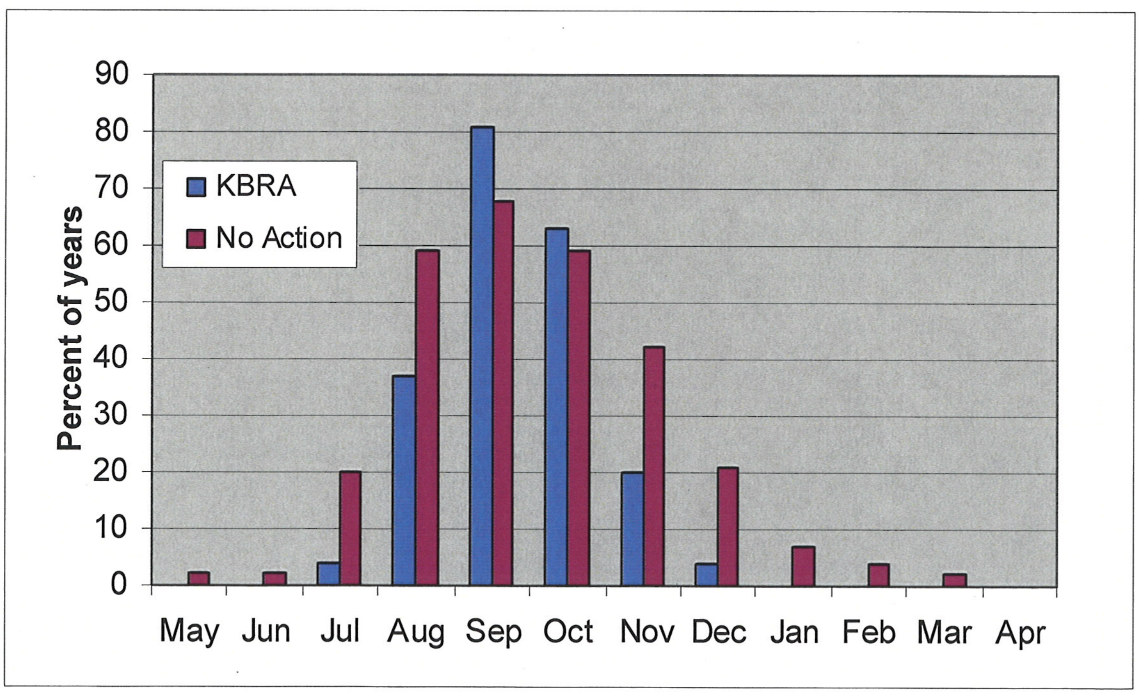

Fig. 20. Frequency histogram of the estimated proportion of future (2012-2111) years and months that Upper Klamath Lake elevations fall below 4139.50 feet under the No Action and KBRA Alternatives.

Appendix 1.

KUCHEL ACT (PL 88-567)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

An act to promote the conservation of the Nation=s wildlife resources on the Pacific Flyway in the Tule Lake, Lower Klamath, Upper Klamath, and Clear Lake National Wildlife Refuges in Oregon and California and to aid in the administration of the Klamath Reclamation Project. (Act of September 2, 1964, Public Law 88-567, 78 Stat. 850)

Sec. 1. [Policy of the Congress.] - It is hereby declared to be the policy of the Congress to stabilize the ownership of the land in the Klamath Federal reclamation project, Oregon and California, as well as the administration and management of the Klamath Federal reclamation project and the Tule Lake National Wildlife Refuge, Lower Klamath National Wildlife Refuge, Upper Klamath National Wildlife Refuge, and Clear Lake National Wildlife Refuge, to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific Flyway, and to prevent depredations of migratory waterfowl on agricultural crops in the Pacific Coast States. (78 Stat. 850; 16 U.S.C. '695k)

Sec. 2. [Areas preserved for migratory waterfowl - Agricultural use.] - Notwithstanding any other provisions of law, all lands owned by the United States lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge, the Lower Klamath National Wildlife Refuge, the Upper Klamath National Wildlife Refuge and the Clear Lake National Wildlife Refuge are hereby dedicated to wildlife conservation. Such lands shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith. Such lands shall not be opened to homestead entry. The following public lands shall also be included within the boundaries of the area dedicated to wildlife conservation, shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith, and shall not be opened to homestead entry: Hanks Marsh, and first form withdrawal lands (approximately one thousand four hundred and forty acres) in Klamath County, Oregon, lying adjacent to Upper Klamath National Wildlife Refuge; White Lake in Klamath County, Oregon, and Siskiyou County, California; and thirteen tracts of land in Siskiyou County, California, lettered as tracts >A=, >B=, >C=, >D=, >E=, >F=, >G=, >H=, >I=, >J=, >K=, >L=, and >N= totaling approximately three thousand two hundred and ninety-two acres, and tract AP@ in Modoc County, California, containing about ten acres, all as shown on plate 4 of the report entitled *APlan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California,@* dated April 1956, prepared by the United States Fish and Wildlife Service. All the above lands shall remain permanently the property of the United States. (78 Stat. 850; 16 U.S.C. ' 695l)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

Explanatory Note

Klamath Project and Klamath Compact. All lands referred to in Section 2 above lie within, adjacent to or nearby the Klamath Federal reclamation project, Oregon-California. The project was authorized by the Secretary of the Interior, pursuant to the Reclamation Act of June 17, 1902, 32 Stat. 388, on May 15, 1905. The consent of Congress to the negotiation of a compact relating to the waters of the Klamath River by the States of Oregon and California was given by the Act of August 9, 1955, 69 Stat. 613. The consent of Congress to the resulting compact was given by the Act of August 30, 1957, 71 Stat. 497. Each of these acts appears herein in chronological order.

Sec. 3. [Payments to counties in lieu of taxes.] - Subject to conditions hereafter prescribed, and pursuant to such regulations as may be issued by the Secretary, 25 per centum of the net revenues collected during each fiscal year from the leasing of Klamath project reserved Federal lands within the Executive order boundaries of the Lower Klamath National Wildlife Refuge and the Tule Lake National Wildlife Refuge shall be paid annually by the Secretary, without further authorization for each full fiscal year after the date of this Act to the counties in which such refuges are located, such payments to be made on a pro rata basis to each county based upon the refuge acreage in each county: *Provided,* That the total annual payment per acre to each county shall not exceed 50 per centum of the average per acre tax levied on similar lands in private ownership in each county, as determined by the Secretary: *Provided further,* That no such payments shall be made which will reduce the credits or the payments to be made pursuant to contractual obligations of the United States with the Tulelake Irrigation District or the payments to the Klamath Drainage District as full reimbursement for the construction of irrigation facilities within said district, and that the priority of use of the total net revenues collected from the leasing of the lands described in this section shall be (1) to credit or pay from such revenues to the Tulelake Irrigation District the amounts already committed to such payment or credit; (2) to pay from such revenues to the Klamath Drainage District the sum of $197,315; and (3) to pay from such revenues to the counties the amounts prescribed by this section. (78 Stat. 850; 16 U.S.C. ' 695m)

Sec. 4. [Leasing of reserved lands continued.] - The Secretary shall, consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands of the Klamath Straits unit, the Southwest sump, the League of Nations unit, the Henzel lease, and the Frog Pond unit, all within the Executive order boundaries of the Lower Klamath and Tule Lake National Wildlife Refuges and shown in plate 4 of the report entitled *APlan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California@*, dated April 1956. Leases for these lands shall be at a price or prices designed to obtain the maximum lease revenues. The leases shall provide for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops. All other reserved public lands included in section 2 of this Act shall continue to be managed by the Secretary for waterfowl purposes, including the growing of agricultural crops by direct planting and sharecrop agreements with local cooperators where necessary. (78 Stat. 851; 16 U.S.C. ' 695m)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

Sec. 5. [Areas not to be reduced.] - The areas of sumps 1(a) and 1(b) in the Klamath project lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge shall not be reduced by diking or by any other construction to less than the existing thirteen thousand acres. (78 Stat. 851; 16 U.S.C. ' 695o)

Sec. 6. [Water levels to be maintained.] - In carrying out the obligations of the United States under any migratory bird treaty, the Migratory Bird Treaty Act (40 Stat. 755), as amended or the Migratory Bird Conservation Act (45 Stat. 1222), as amended, waters under the control of the Secretary of the Interior shall be regulated, subject to valid existing rights, to maintain sump levels in the Tule Lake National Wildlife Refuge at levels established by regulations issued by the Secretary pursuant to the contract between the United States and the Tulelake Irrigation District, dated September 10, 1956, or any amendment thereof. Such regulations shall accommodate to the maximum extent practicable waterfowl management needs. (78 Stat. 851; 16 U.S.C. ' 695p)

Explanatory Notes

Reference in the Text. The Migratory Bird Treaty Act of July 3, 1918, 40 Stat. 755, as amended, which is referred to in the text, does not appear herein. The Act is codified in 16 U.S.C. ' 703, *it seq.*
Reference in the Text. The Migratory Birds Conservation Act of February 18, 1929, 45 Stat. 1222, as amended, which is referred to in the text, does not appear herein. The Act is codified in 16 U.S.C. ' 715, *it seq.*

Sec. 7. [Clear Lake National Wildlife Refuge studies continued.] - The Secretary is hereby directed to complete studies that have been undertaken relating to the development of the water resources and waterfowl management potential of the Clear Lake National Wildlife Refuge. The results of such studies, when completed, and the recommendations of the Secretary shall be submitted to the Congress. (78 Stat. 851; 16 U.S.C. ' 69rq)

Sec. 8. [Regulations to implement Act.] - The Secretary may prescribe such regulations as may be necessary to carry out the provisions of this Act. (78 Stat. 851; 16 U.S.C. ' 695r)

Explanatory Notes

Editor=s Note, Annotations. Annotations of opinions are not included because none were found dealing primarily with the activities of the Bureau of Reclamation under this statute.
Legislative History. S. 793, Public Law 88-567 in the 88th Congress. Reported in Senate from Interior and Insular Affairs June 28, 1963; S. Rept. No. 341. Passed Senate July 15, 1963. Reported in House from Interior and Insular Affairs Dec. 19, 1963; H.R. Rept. No. 1072. Passed House, amended, Apr. 20, 1964. Senate asks for a conference Apr. 23, 1964. House agrees to a conference May 7, 1964. Conference report filed Aug. 17, 1964; H.R. Rept. No. 1820. House agrees to conference report Aug. 18, 1964. Senate agrees to conference report Aug. 19, 1964.

Appendix 2.

(Note: In this report the term "DamsIn" is equivalent to the No Action Alternative and the term "DamsInDamsOut" is equivalent to the KBRA Alternative)

Historic Water Use and Modeled Water Requirements on Lower Klamath NWR

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Summary

The basic water distribution and delivery system is described for Lower Klamath NWR. Trends and summary statistics (averages, maximums, minimums) are presented for inflows, outflows, and net water use on the refuge from 1962 to 2009, with a specific focus on the last two decades from 1988 to 2009, because this recent period more accurately represent refuge water management in the future. Following this is a discussion of refuge water use modeling and the two approaches used in the Secretarial Determination under the DamsIn and DamsInDamsOut scenarios. There are three main problems with the modeling approach used in the DamsIn scenario: 1) the assumption that historical D Plant pumping can represent future D plant inflows is not valid, 2) the range of modeled Ady refuge inflows is smaller than the historical observed inflows and, 3) the relationship between Feb-Mar precipitation and Ady refuge water use assumed in the modeling is non-existent. Finally, there is a discussion of the modeling approach used in the DamsInDamsOut scenario and the KBRA settlement agreement, which more correctly represents the refuge water demand.

Introduction

There are two main inflows to Lower Klamath NWR, excluding the Area K lease lands: 1) D Plant, which pumps water from Tule Lake through the Sheepy Ridge tunnel and 2) the Ady Canal at Stateline Hwy, which supplies water directly diverted from the Klamath River for the refuge. Inflow from D Plant pumping, a function of runoff and irrigation return flows in Tule Lake, is controlled by Tulelake Irrigation District and the timing and quantity of these inflows reflects their management needs more than it reflects refuge water needs. The Ady refuge inflows are requested and controlled by the refuge and the timing and quantity of these deliveries more accurately reflects refuge water needs. There is one main outflow from Lower Klamath NWR, the Klamath Straits Drain at Stateline Hwy.

The following analysis examines inflows and outflows on the refuge from 1962 to 2009. Flow and diversion data are from the Bureau of Reclamation's updated modsum.xls file and monthly precipitation and temperature data are from the United States Historical Climatology Network (USHCN) station at Klamath Falls, OR. Since both the timing and quantity of water use on the refuge have changed since records began in 1962, averages and ranges have been calculated for the period 1988 to 2009, with the idea that these more recent years better represent water management on the refuge. The years 1992 and 2001 were excluded from these statistics for this period because there were substantial water shortages to the refuge during these years. The refuge has experienced smaller shortages in several other years, mostly since 2004. The irrigation season has been defined as Apr-Oct for simplicity in this report, even though irrigation deliveries to agricultural lands on the Project may begin in March or extend through November in some years. This should make no difference for the discussion here.

Historic Inflows, Outflows, and Net Inflows, 1962 to 2009

Historical deliveries to the refuge through the Ady Canal at Stateline from 1962 to 2009 are shown in Figure 1. Ady refuge inflows increase through the 1980s, although the inflows in the 1960s and early 1970s appear particularly low and may be questionable. Ady refuge inflows for the irrigation season seem to have stabilized in the last 15 to 20 years while inflows for the water year have increased slightly. This is because water availability has become limited in summer and fall in recent years and the refuge has begun taking more water outside of the irrigation season. The two exceptionally dry years, 1992 and 2001, stand out as years with very low inflows for the irrigation season and for the entire water year. The refuge was shut off or shorted water for a substantial period during both of these years. Smaller shortages to refuge supply have occurred in more recent years as well. The average Ady refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 22 taf for the irrigation season (range 11 to 31 taf) and 30 taf for the water year (range 19 to 43 taf).

Fig 1. Ady Refuge Inflow - Historical Deliveries to Lower Klamath NWR
1962 to 2009 (does not include deliveries to Area K lease lands)

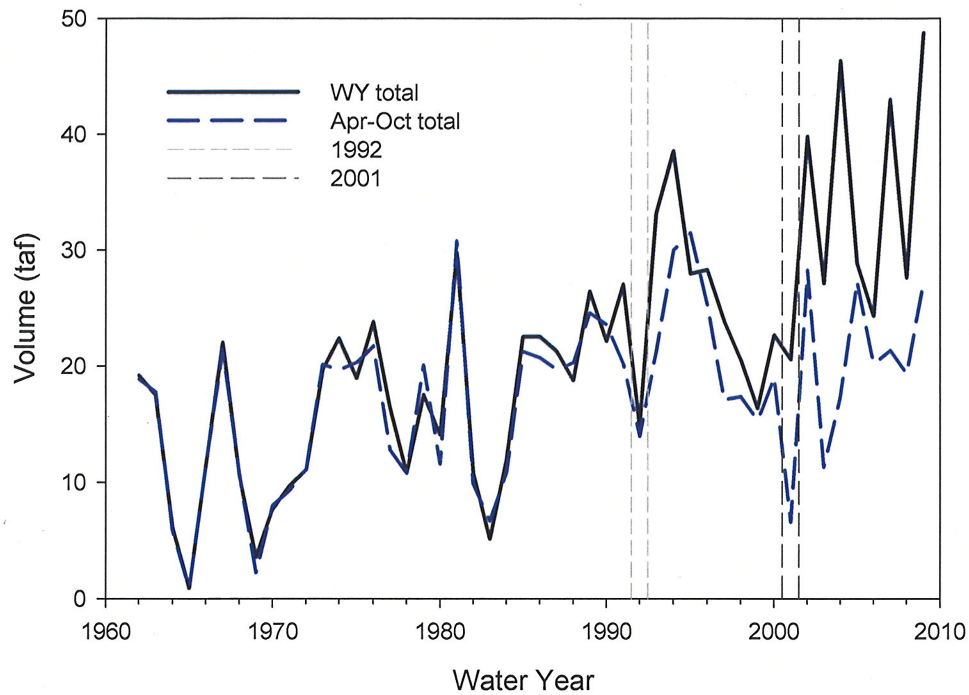


Fig. 2 D Plant Refuge Inflow - Historical Deliveries to Lower Klamath NWR
1962 to 2009 (does not include deliveries to P Canal deliveries to private lands)

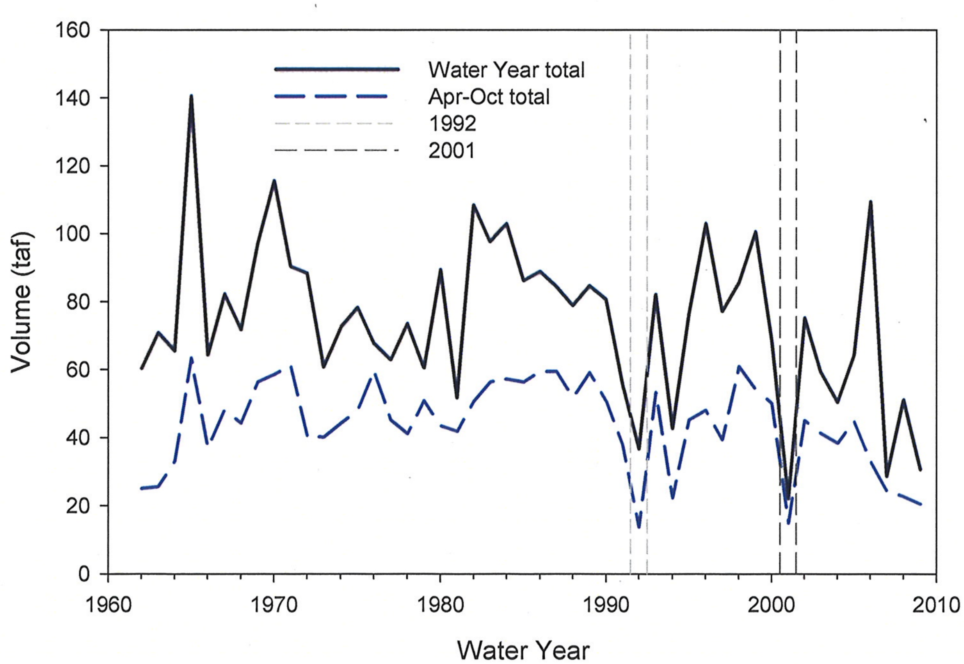


Figure 2 shows the historical inflows to the refuge through D Plant from 1962 to 2009, calculated from total D Plant pumping minus deliveries to the P Canal lands. (Deliveries to the P Canal lands are diversions from D Plant that go to a small acreage of private farm lands in the Lower Klamath area. Most of these private lands have been acquired by the refuge in recent years, meaning that there are decreasing P Canal land deliveries.) D Plant refuge inflows during the irrigation season and the entire water year have been declining in recent years. The decline may be due to concern over water availability, more efficient water use on the Project, the implementation of minimum water levels on Tule Lake sumps for endangered species, or, most recently, the increase in electrical rates and pumping costs. As with the Ady refuge inflows, the two exceptionally dry years, 1992 and 2001, stand out as years with very low refuge inflows for the irrigation season and for the entire water year. However, the more recent years, 2007-2009, have been equally low, in terms of D Plant pumping. The average D Plant refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 43 taf for the irrigation season and 71 taf for the water year.

Figure 3 shows that over the 1962 to 2009 period, total refuge inflow (calculated as Ady refuge inflow and D Plant pumping minus P Canal deliveries) has remained fairly constant for both the irrigation season and the water year. The decrease in D Plant refuge inflows have been compensated by the increase in Ady refuge inflows. Using the 1988 to 2009 averages given above, Ady refuge inflows have comprised about 30-35% of the total refuge inflows. Most of the P Canal lands have been acquired by the FWS, meaning that those deliveries from the D Plant pumping that were formerly counted as private P Canal deliveries are now counted as refuge deliveries. The average total refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 65 taf for the irrigation season and 101 taf for the water year. The slight decline in total refuge inflow in recent years may reflect small shortages to the refuge during these years, usually during summer and early fall. Typically, not all the inflow is used on the refuge in a given year so total refuge inflow is an upper limit estimate of refuge water requirements.

The refuge outflow, as measured at Stateline Hwy for the period 1962 to 2009, is shown in Figure 4. There has been a general decrease in outflow over the period, especially in winter outflows. The refuge has used more winter water over the period. During the two exceptionally dry years of 1992 and 2001, there was almost no outflow for the year. From 2002 to 2009, the outflow from the refuge has been comparatively low, especially considering that these were not particularly dry years. This reflects more winter water use by the refuge recently because of the acquisition and winter flooding of the former P Canal lands and limited water availability for the refuge during the irrigation season. The average refuge outflow for the period 1988 to 2009, excluding 1992 and 2001, is 26 taf for the irrigation season and 44 taf for the water year.

Fig. 3 D Plant and Ady Refuge Inflow
Historical Deliveries to Lower Klamath NWR 1962 to 2009
(w/o deliveries to Area K lease lands or private P Canal lands)

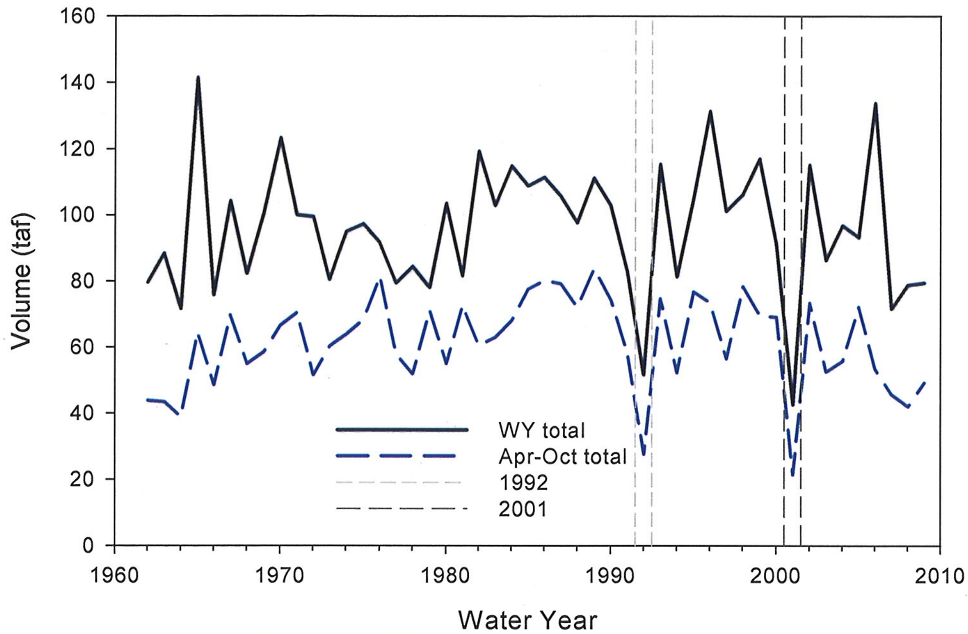
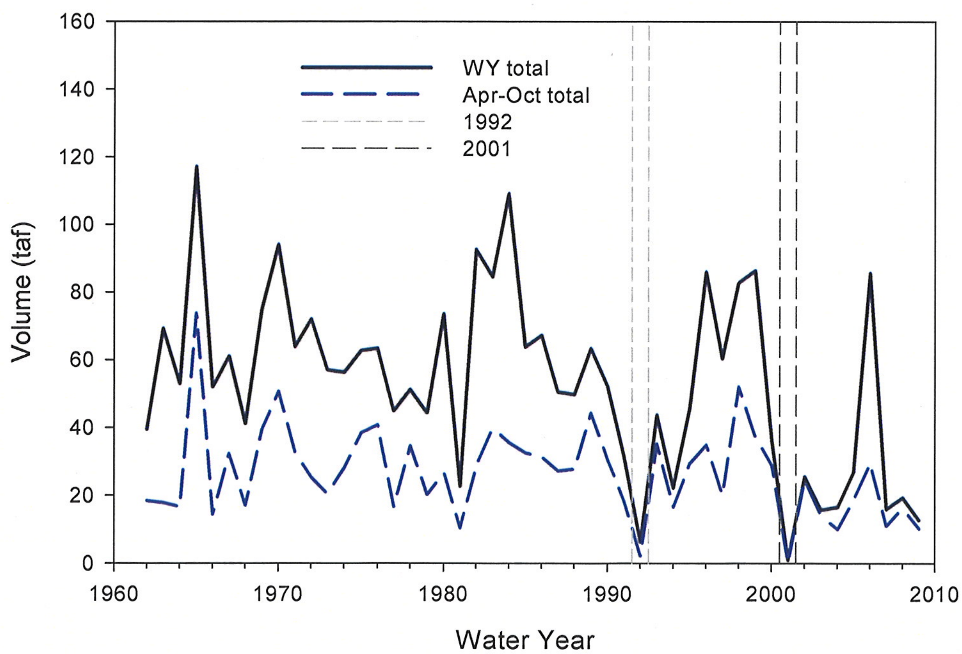


Fig. 4 Refuge Outflow at Stateline Hwy Lower Klamath NWR
1962 to 2009 (includes outflows from P Canal lands but
not from Area K lease lands)



A lower limit estimate of refuge water requirements can be obtained from the difference in total refuge inflow and refuge outflow. This is calculated as the sum of Ady refuge inflows + the D Plant pumping minus outflows at Stateline + 0.75*P Canal deliveries. The 75% factor on P Canal deliveries accounts for consumptive use on the private P Canal lands. Refuge net inflow for the period 1962 to 2009 is shown in Figure 5. There was an increase in refuge net inflow until the mid-1980s, both for the irrigation season and the water year. Since that time, net inflow for the irrigations season has declined slightly while net inflow for the water year has increased and become more variable. The exceptionally dry years of 1992 and 2001 are indicated on the figure.

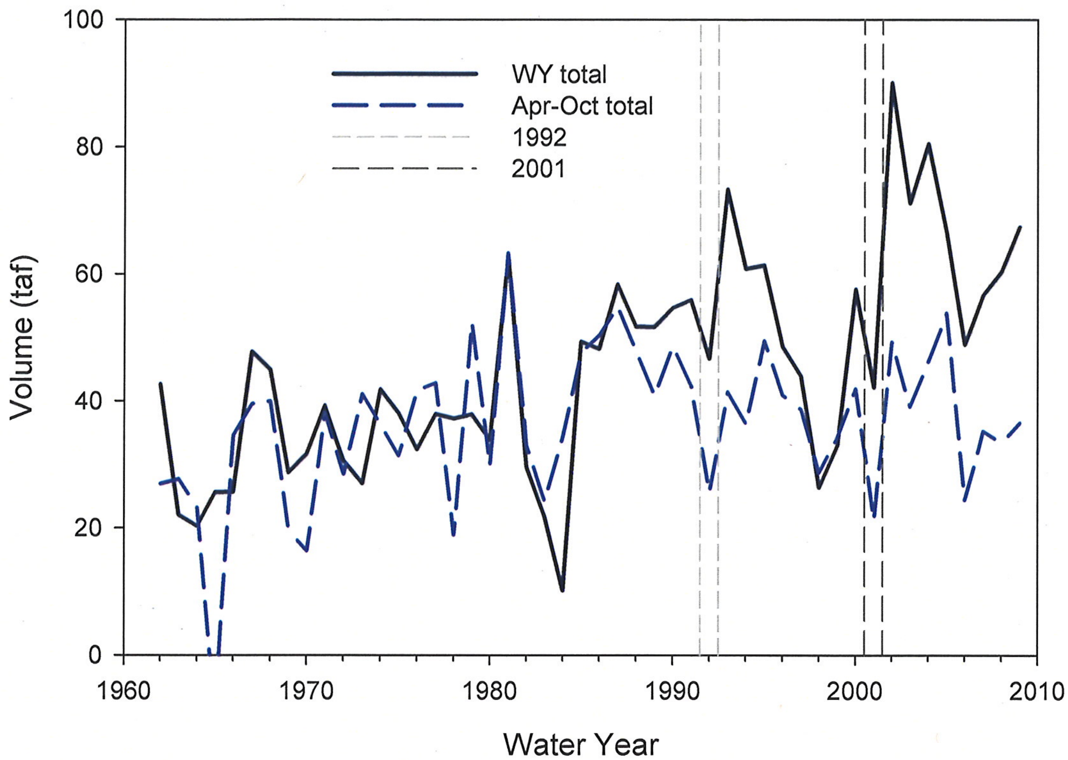
Net inflow calculated this way will give negative numbers when outflow exceeds inflow. This condition occurs most frequently in the winter and spring when the refuge is draining wetlands or farm units or when there is a lot of runoff from precipitation on the refuge. Just because there is an excess of outflow over inflow doesn't mean there is no water use on the refuge. The refuge often uses water in some wetlands while simultaneously draining water from others. The calculation, inflow minus outflow, is a simplification and doesn't really represent water use on the refuge under all conditions.

The average net inflow on the refuge for the period 1988 to 2009, excluding 1992 and 2001, is 40 taf for the irrigation season and 58 taf for the water year. The maximum net inflow for the period 1988 to 2009, excluding 1992 and 2001, is 54 taf for the irrigation season and 80 taf for the water year. Deliveries to the refuge in recent years (since about 2002) have been limited by the Project and the refuge has been shorted water. Therefore, average net inflow in recent years may be lower than needed and may not reflect total water requirements. The area of habitat on LKNWR varies annually but is generally about 30,000 acres. Net inflow expressed on a per acre basis averages 1.33 ac-ft/acre for the irrigation season and 1.93 ac-ft/acre for the water year.

Net inflow accounts for evapotranspiration losses and seepage losses to soils and sediments but not for non-consumptive water uses on the refuge. These non-consumptive uses include flooding of seasonal wetlands and farm fields and flushing flows for permanently flooded wetlands. Because not all the water use on the refuge is consumptive, the refuge water requirements are greater than represented with net inflow. Most of the non-consumptive uses occur outside of irrigation season.

As stated above, the average total refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 65 taf for the irrigation season and 101 taf for the water year. This represents an upper limit on refuge water requirements. The average net inflow on the refuge (inflow minus outflow) for this same period is 41 taf for the irrigation season and 58 taf for the water year. This represents a lower limit of refuge water requirements. There is no means to distinguish consumptive and non-consumptive uses on the refuge from the historic flow data.

Fig. 5 Estimated Refuge Water Use - Lower Klamath NWR
1962 to 2009 Estimated from the difference of total inflow and outflow
(does not include Area K lease lands)



Relationship of Refuge Inflows, Outflows and Net Inflows to Precipitation

The average water year precipitation for the 1962 to 2009 period of record at the USHCN station in Klamath Falls, OR, is 1.1 ft. Two-thirds of the precipitation falls from Nov-Mar, outside of the irrigation season. Precipitation on the refuge can affect inflows and outflows, but the effect is not the same for all sites (Figure 6). Ady refuge inflows decrease slightly with increased precipitation while D Plant refuge inflows and refuge outflows at Stateline Hwy increase strongly with precipitation. Ady refuge inflows are controlled by the refuge and there is less need for deliveries in a wet year, explaining the slight decrease with precipitation. However, since much of the Ady refuge inflow is used during the Apr-Oct irrigation season, when there is little precipitation anyway, the relationship between precipitation and Ady inflows is weak. D Plant refuge inflows are much greater in wet years because increased runoff and return flows are being pumped from Tule Lake, especially during winter and spring. Since there is little storage on the refuge, more of this water is passed through the refuge, resulting in much higher refuge outflows in wet years too. Some of the refuge outflow during wet years is probably runoff from precipitation falling directly on the refuge too.

Fig 6. Relationship of Precipitation at USHCN Station Klamath Falls, OR to Ady Refuge Inflow, D Plant Refuge Inflow, and Refuge Outflow at Stateline Hwy Water Years 1962 to 2009

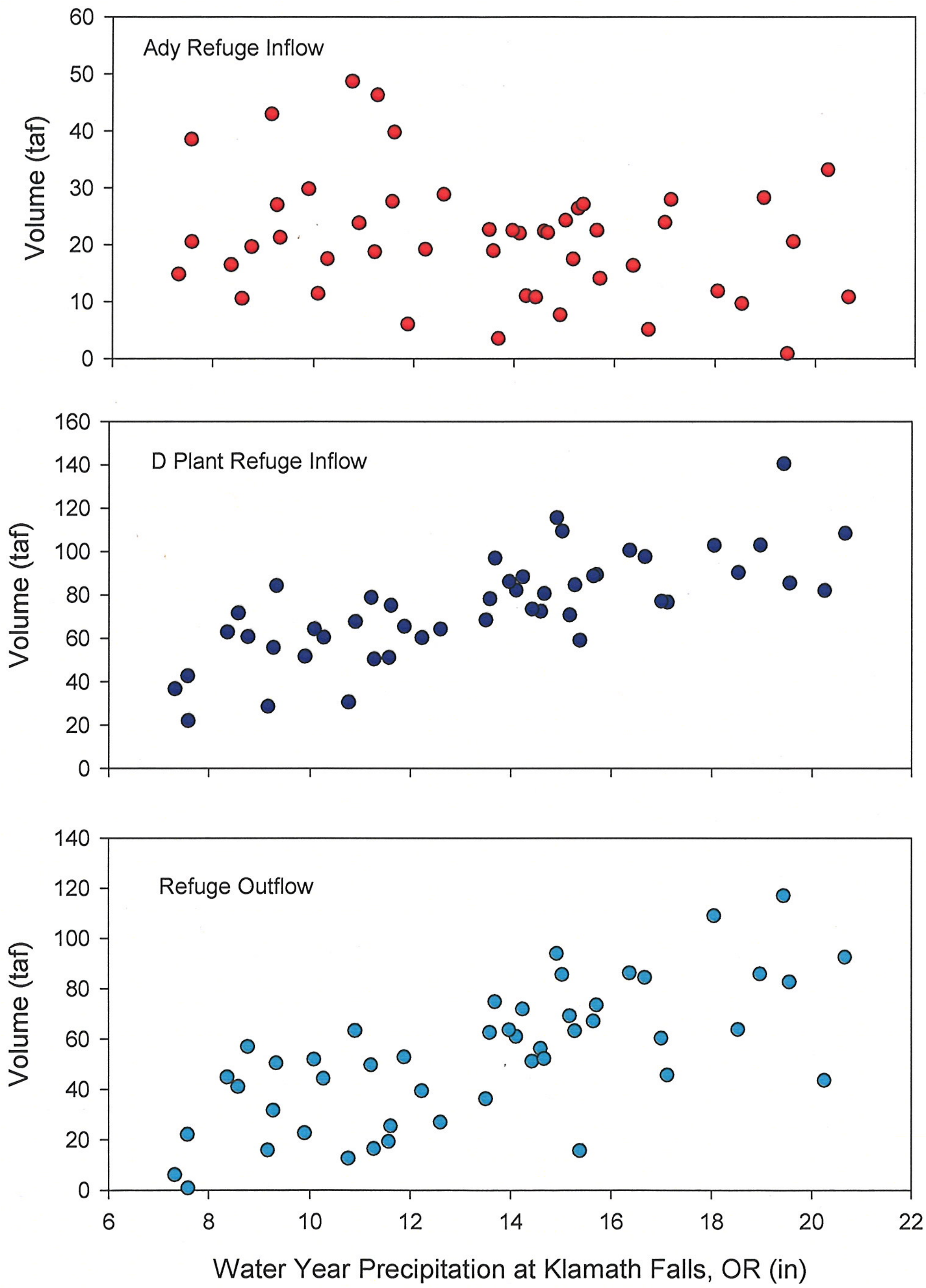
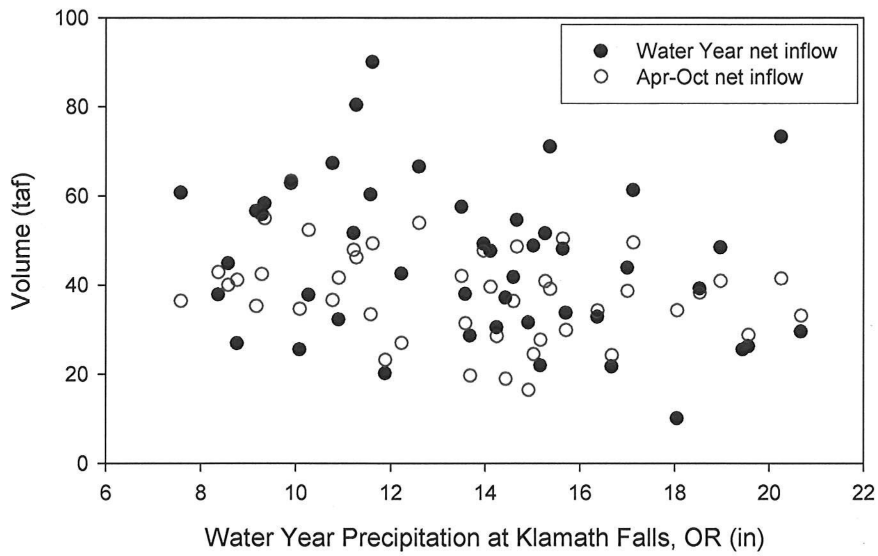


Figure 7 is a plot of refuge net inflow versus precipitation for the period 1988 to 2009, for both the irrigation season and for the water year. There appears to be a slight decrease in irrigation season and water year net inflow with greater precipitation but the relationship is weak and variable.

Fig. 7 Relationship of Precipitation at Klamath Falls, OR to Estimated Refuge Net Inflow (does not include Area K lease lands or P Canal lands) 1962 to 2009 (without 1992 and 2001)

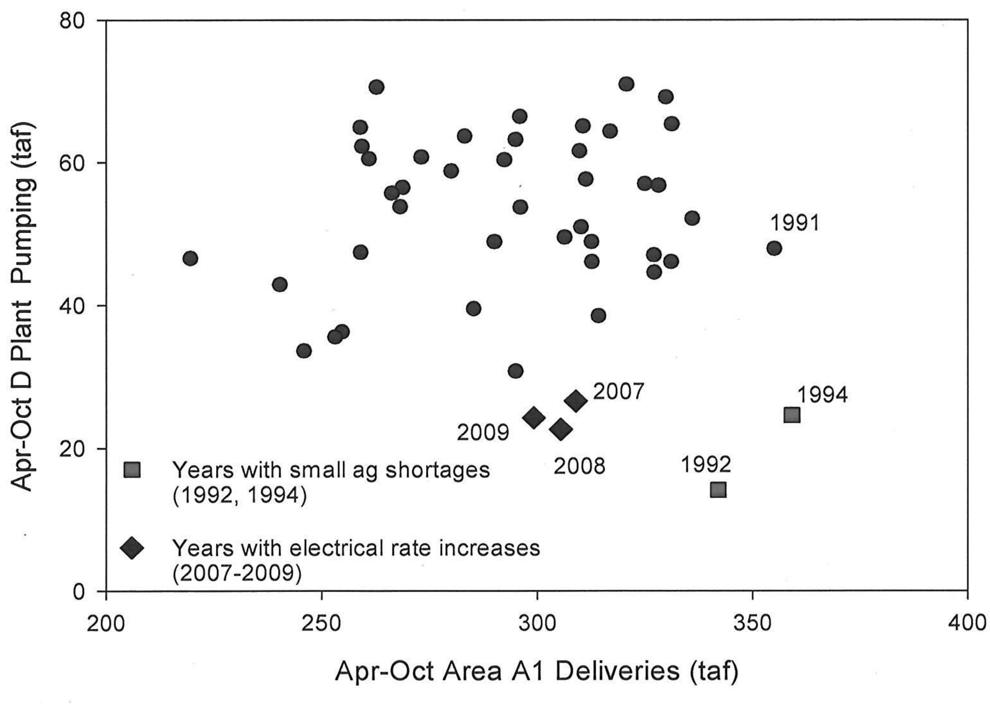


Modeling Refuge Water Requirements

There were two different approaches used to model refuge water requirements in the WRIMS model under the DamsIn and DamsInDamsOut scenarios for the Secretarial Determination. The modeling under the DamsIn scenario does not correctly represent refuge water use and demand. There are several assumptions in the refuge modeling under this scenario that appear to be questionable. First, only Ady refuge demand/deliveries are represented in the model. Since 65-70% of the total water supply to the refuge has come from D Plant inflows, historical Ady refuge diversions are far less than total refuge demand. The model does not explicitly include any D Plant refuge inflows. It is implicitly assumed that future D Plant deliveries to the refuge can be represented by historical D Plant pumping. The problem with this assumption is that D Plant pumping appears likely to decreasing significantly in the future, in response to limited agricultural allocations for Area A1 and the increased electrical costs for pumping. To the extent that it does occur, more water will be needed from the Ady deliveries.

Area A1 is the agricultural area that is upstream of Tule Lake and D Plant. Tulelake Irrigation District (TID) has said that they can and will minimize the volume of pumping in the future due to increased costs or water shortages or limitations (Earl Danowsky, *per comm.*). There is evidence in the record that this this has happened already. (see Figures 2 and 7). The effect of water limitations to agriculture (even perceived limitations) on D Plant pumping is shown in Figure 8. In the extremely dry years of 1992 and 1994, there were potential shortages to agriculture (although actual shortages to Area A1 appear to have been minimal if not nonexistent since these are some of the highest Apr-Oct Area A1 diversions). The Apr-Oct D plant pumping during those years is some of the lowest on record, despite the very high Area A1 deliveries. This appears to be due to increased efficiency by the Project irrigators as well as increased use because of the hot, dry year. 1991 was another dry year with Area A1 deliveries similar to 1992 and 1994 but no shortages (perceived or real). In this year, D Plant pumping was at least twice the volume of 1992 and 1994, implying that in years without threatened shortages or water restrictions, efficiency is not great. Based on these data, it seems likely that future limitations or shortages (real or potential) will mean increased efficiency by the Area A1 users and much more limited D Plant pumping.

Fig. 8 Apr-Oct D Plant Pumping as a Function of Apr-Oct Area A1 Deliveries 1962 to 2009 (2001 not included)



TID now has an economic incentive to increase water use efficiency and limit D Plant pumping. Electrical rate increases for pumping have been phased in beginning in 2005. TID has typically paid for 90% or more of the D Plant pumping costs and the increases mean much higher costs for the district. The result is that TID has minimized pumping to the fullest extent possible (Earl Danosky, *per comm.*). The reduction in D Plant pumping can be seen in the last 3 years (2007-2009) as highlighted in Figure 8. D Plant pumping in these years is much lower in comparison to other years with similar Area A1 diversions (see Figure 2 as well). In 2010, a year with both restrictions to Area A1 allocations and high electrical rates, Apr-Oct D Plant pumping was 3.8 taf. This represents the lowest Apr-Oct D-Plant pumping since at least 1962.

Because of electrical rate increases and potential limitations to allocations, it seems likely that the Area A1 users will continue to become more efficient and there will be much less pumping of return flows at D Plant. This means that Ady refuge deliveries will need to be increased to compensate for reduced D plant inflows. If refuge deliveries through the Ady are not increased in the model, then reduced deliveries to agriculture will result in less D Plant pumping and shortages to LKNWR that are not captured in the model output. To appropriately represent the refuge in the model, the total refuge demand needs to be estimated, the assumed future D Plant refuge inflows subtracted from the total demand, and the remaining demand through the Ady refuge inflows explicitly modeled in WRIMS. This was the approach used in the DamsIn_DamsOut scenario for the KBRA modeling.

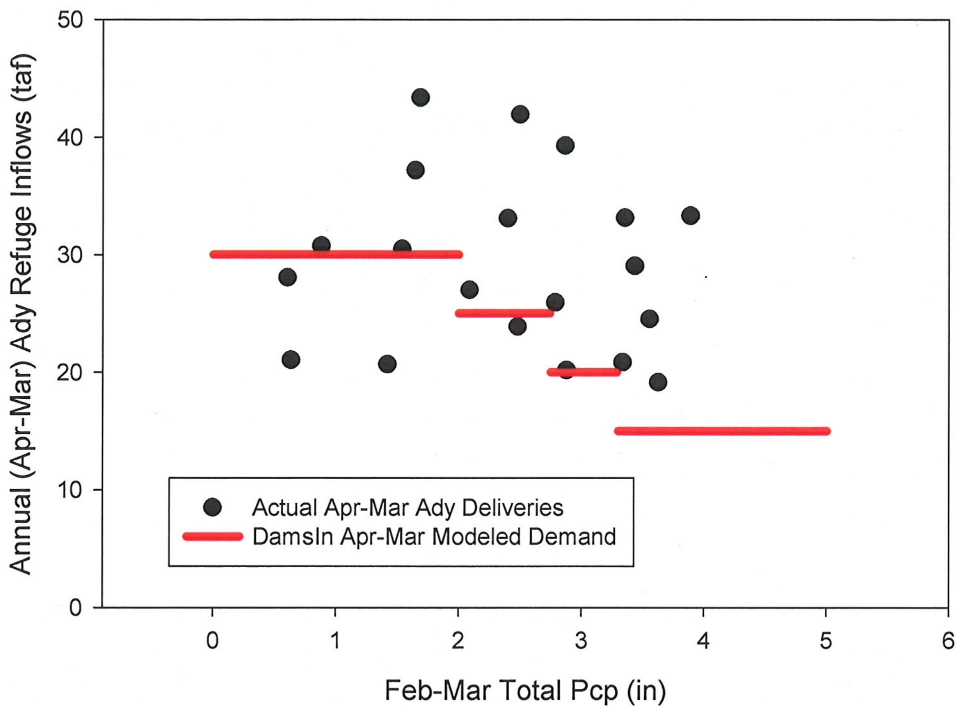
The second problem with the representation of refuge demand under the DamsIn scenario is that, regardless of any assumptions about D Plant pumping, the range of annual Ady refuge diversions is too small when compared to historic observed deliveries. The modeled range is 15 to 30 taf annually and is related to Feb-Mar total precipitation (Table 1). This range is loosely based on historical Ady refuge deliveries from 1962 to the 1990s and reflects much higher D plant pumping than has been experienced in the last 20 years. The average annual (Apr-Mar) Ady delivery for the period 1988 to 2009 is 29 taf, with a minimum of 19 taf and a maximum of 43 taf. Again, the 1988 to 2009 period reflects substantial D Plant inflows which are not expected to be available in the future. Figure 9 shows the discrepancy between the modeled range and the actual 1988 to 2009 annual Ady deliveries. In almost all years, the modeled range is generally much lower than recent Ady deliveries from 1988 to 2009. Ady refuge demand in the model needs to be increased to reflect observed and expected decreases in D Plant pumping, particularly when attempting to analyze future periods.

Table 1. Modeled Annual Ady Refuge Demand as a Function of Feb-Mar Total Precipitation.

Feb-Mar Total Pcp (in)	Apr-Mar Modeled Ady Refuge Demand (taf)
0 to 1.99	30
2.0 to 2.75	25
2.76 to 3.29	20
3.3 and above	15

The third problem with the modeling under the DamsIn scenario is that Ady refuge deliveries are related to winter precipitation (Feb-Mar total), as shown in Table 1 and Figure 9. But there is almost no relationship between Ady refuge deliveries and Feb-Mar precipitation nor is there much physical reason to think that there should be. Variability in Ady refuge inflows has been more strongly related to D Plant pumping rather than Feb-Mar precipitation. Because D Plant pumping has been declining and is expected to decrease much more so in the future, Ady refuge demand needs to be increased.

Fig. 9 1988 to 2009 (excluding 1992 and 2001) Annual Ady Refuge Deliveries and Modeled Ady Refuge Demand (DamsIn) as a Function of Feb-Mar Pcp (drier years may reflect some shortages to the refuge)



The modeling under the DamsInDamsOut scenario more correctly represents refuge water demand. To model the Ady refuge demand under this scenario, the total demand for Lower Klamath NWR was estimated for each of the 17 separate time steps in the model. This is easily estimated, based on the acreage of various habitats on the refuge. Although future D Plant pumping is not predicted by the model, the range of D Plant inflows to the refuge was estimated using reasonable assumptions. The difference between the estimated total refuge demand and assumed D Plant pumping inflows was represented as the Ady refuge demand in the model.

To estimate total demand on Lower Klamath NWR for KPSIM modeling, the refuge demand was calculated for the 17 separate time steps in the model. At each time step, demand was calculated for each habitat type, based on the area of habitat and the estimated use of the habitat type. These were then summed to calculate the total refuge demand at each time step. The habitat acreage used to estimate demand was 11,000 acres of permanently flooded wetlands, 10,000 acres of fall seasonal wetlands, and 10,000 acres of farm units and spring seasonal wetlands. The permanently flooded wetlands require water for ET from Apr-Oct and non-consumptive flushing flows from Nov-Mar. The fall seasonal wetlands require water mostly in Sept and Oct, with some water requirements in Nov. The farm units and spring seasonal wetlands require water Nov-Mar. The calculations are shown on the KPSIM Refuge_Demand_no_Big_Pond worksheet of the KPSIM 2006 refuge demand.xls spreadsheet.

The quantity and distribution of water for each habitat type was based on the work done for the claims in the water rights adjudication. The application rates are 3.6 ac-ft/ac for permanently flooded wetlands (which includes 0.6 ac-ft/ac or 20% of the annual ET for a salinity flushing flow, to be met during Nov-Mar, and 3.0 ac-ft/ac for ET), 3 ac-ft/ac for fall seasonal wetlands, and 2.5 ac-ft/ac for farm units and spring seasonal wetlands. The total water requirement for the refuge is 60 taf for Apr-Oct and 95 taf for the water year. Not all of this water is used consumptively and some of the demand will likely be met through D Plant pumping and precipitation. Habitat acreage and the rate and distribution of water use can be varied in the tables in KPSIM 2006 refuge demand.xls spreadsheet (greyed out cells in the spreadsheet indicate values that can be changed).

As stated above, the average total refuge inflow for the period 1988 to 2009, excluding 1992 and 2001, is 65 taf for the irrigation season and 101 taf for the water year. This represents an upper limit on refuge water requirements. The average net inflow on the refuge (inflow minus outflow) for this same period is 41 taf for the irrigation season and 58 taf for the water year. This represents a lower limit of refuge water requirements. There is no means to distinguish consumptive and non-consumptive uses on the refuge from the historic flow data. The estimates of refuge water demand above (60 taf for the irrigation season and 95 taf for the water year), while derived from independent data and studies, are within the observed range of total inflow and net inflow and appear reasonable.