RECLAMATION

Managing Water in the West

Twin Buttes Reservoir Ecosystem Restoration Project

Upper Colorado River Authority, San Angelo Project, Texas

Draft Environmental Assessment

U.S. Department of the Interior
Bureau of Reclamation
Great Plains Region
Oklahoma-Texas Area Office

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Introduction

Project History

Twin Buttes Dam is a Bureau of Reclamation (Reclamation) facility completed in the Concho River basin about 9 miles southwest of San Angelo, (Tom Green County) Texas in 1963. The Twin Buttes Dam impounds waters from the Middle and South Concho rivers and Spring Creek and creates Twin Buttes Reservoir. The prime purposes of the lake are to provide flood protection, municipal and irrigation water, and recreational opportunities.

Purpose and Need

Tom Green County is experiencing a long-term drought, which has contributed to decreasing lake levels at Twin Buttes Reservoir. Reduced lake levels have subsequently resulted in an infestation of numerous phreatophytic (water loving) vegetation species including saltcedar, mesquite, and willow baccharis in and around Twin Buttes Reservoir. The high rates of evapotranspiration from these species have worsened the drought's effects and contributed to even lower reservoir levels. Therefore, a need exists to remove these species in a way that has long-term success while also not having adverse impacts to the local economy or environment. The primary purpose of the proposed restoration project is to utilize helicopter herbicide treatment and mechanical plowing to remove undesirable phreatophytic vegetation species with the objective of increasing water availability and restoring the native ecosystem within and around Twin Buttes reservoir.

Objectives of Treatment

The spread of noxious, phreatophytic vegetation throughout the project area largely occurred because of widespread removal of native vegetation during construction of Twin Buttes dam and reservoir, prevention and control of naturally occurring grassfires, and the failure of the reservoir to maintain conservation pool levels throughout the years. The invasion of phreatophytes has resulted in degradation of the quantity and quality of aquatic habitats, lowering of groundwater tables, and a cycle of ever-increasing proliferation of these harmful species. The primary objectives of treatment are to:

- Protect against damage to the structural integrity of the dam caused by root systems of woody trees and vegetation, primarily mesquite.

- Conserve groundwater and protect aquatic habitat by controlling the proliferation of phreatophytic vegetation.
- Prevent the proliferation of phreatophytic vegetation in areas not yet impacted.
- Reduce competition of undesirable woody plants with native plants and grasses needed to protect groundwater sources.
- Restore native grasslands in areas now dominated by mesquite.
- Restore healthy, native habitat for use by wildlife, including endangered, threatened, and migratory species.

Alternatives

Preferred Alternative – Combination of Helicopter Herbicide Application and Plowing

A combination of helicopter herbicide spraying and plowing would be the preferred Integrated Pest Management (IPM)[1] approach (Appendix A.) Aerial spraying with fixed wing aircraft (airplanes) results in fairly large droplets being dispersed over wide areas. Croplands are located near the lake and many crops, especially cotton, are extremely sensitive to herbicides. Helicopters, on the other hand, deliver smaller droplets over compact areas, resulting in little drift and better coverage of target species. Minimizing drift helps protect wildlife near the targeted area and puts more of the herbicide on the target. All herbicides proposed for use are approved by the US Environmental Protection Agency (USEPA). Chemicals would be applied only by licensed or State-certified applicators and in compliance with all herbicide labels. Plowing would be used in areas where plant size and density allow it, especially in areas where cotton fields lie adjacent to the treatment area or where human exposure to herbicides cannot be prevented.

Saltcedar

Saltcedar grows extremely thick around Twin Buttes Reservoir, with an estimated average density of 3,000 stems per acre. The preferred method would have to kill or remove root crowns located about 18 inches beneath the ground surface. Ground spraying and mechanical removal, including plowing, would be impractical because of thick growth and a high density of mature trees. In addition, saltcedar often inhabits low areas where moisture at or near the surface would make tractor use difficult. Even if plowing or ground herbicide application

[1] The IPM approach involves the most economical, coordinated use of pest, pest control, and environmental information to choose pest control strategies that will prevent unacceptable levels of pest damage while causing the least amount of hazard to people, property, and the environment.

were effective, more than one treatment spread over a period of a few years would be needed to kill all remnants capable of sprouting. Therefore, spraying *Habitat* herbicide by helicopter is the recommended and preferred method of treatment.

Figure 1: Typical dense, saltcedar stand along Twin Buttes shoreline 3/10/2010

Saltcedar should remain undisturbed for about two years after initial spraying for optimum treatment. Follow-up treatments could then be used

Mesquite

Mesquite also has a deep root crown ranging from 13-18 inches underground. Unless the crown is killed, treatment is ineffective. Due to the density, areal extent, plant height and terrain across more than 2,400 acres, aerial spraying with *Reclaim* and *Remedy* herbicides would be the only effective method of treatment. In the remaining 2,200 acres, despite its disadvantages, plowing would be the preferred method due to the proximity of residences and/or cotton fields.

Figure 2: Thick mesquite with prickly pear spreading rapidly underneath

Willow baccharis

Willow baccharis is similar to saltcedar in its growth and is also present in densities of up to 3,000 stems per acre, although it does not grow as tall. Removal through mechanical means, including plowing, is impractical and would require multiple treatments. Helicopter application of *Weedmaster* and *Spider* herbicides would be the preferred method. These pesticides are about 90% effective on this species. An individual plant treatment would likely be required two years after initial treatment. About 1,544 acres would be treated.

Figure 3: Willow baccharis and mesquite dominate the landscape surrounding Twin Buttes Reservoir

No Action Alternative

No herbicide application or plowing would occur and saltcedar, mesquite, and willow baccharis would be allowed to grow uncontrolled in the project area.

Actions Considered but Discarded

Fixed wing aerial herbicide application, ground herbicide application, prescribed burning, and several mechanical methods, including powergrubbing[2], hydraulic shearing[3] with subsequent herbicide application, excavation, and chaining/cabling were considered but discarded. Fixed wing spraying was discarded due to significant droplet size, coverage, and spray drift problems. These issues seriously undermine the efficacy of the method and could pose a threat to proximal human and wildlife inhabitants, cotton, and other croplands. In addition, plant densities in the area would greatly increase the amount of time and money needed to use ground herbicide application, powergrubbing, hydraulic shearing, excavation, or chaining/cabling. Prescribed burning and shearing would be ineffective against mesquite, as these techniques would destroy only the canopy. These techniques would not prevent vegetative sprouting from below ground.

Adoption of Existing Environmental Assessment (EA)

Council on Environmental Quality (CEQ) regulations (40 CFR 1500.4(n)) direct Federal agencies to reduce excessive paperwork and duplication by adopting appropriate environmental documents prepared by other agencies. To do this, the responsible Federal agency must independently review the document(s) and take full responsibility for scope and content. Reclamation herein adopts the U.S. Army Corps of Engineers (USACE) EA titled **"Detailed Project Report and Integrated Environmental Assessment for O.C. Fisher Lake Ecosystem Restoration Project, San Angelo, Texas"** (USACE 2005). This report can be accessed at http://www.swf.usace.army.mil/pubdata/notices/EA/OCFisher/OCFisherdraftDPR19JUL_PUBLIC_REVIEW.pdf. The document was completed for a reservoir located about eight (8) miles from Twin Buttes Reservoir that was experiencing nearly identical environmental conditions and similar invasive plant infestations. The document does not directly address conditions at Twin Buttes Reservoir. For

[2] Powergrubbing refers to pushing trees and plants out of the ground using special attachments on tractors or other heavy equipment

[3] Hydraulic shearing uses hydraulically powered shears attached to tractors or other heavy equipment to cut trees off at the base

this reason, Reclamation has chosen to supplement the O.C. Fisher EA to assess conditions and potential impacts at Twin Buttes Reservoir.

USACE conducted their study to determine the most environmentally friendly, effective, and economic way to deal with invasive phreatophytes at O.C. Fisher Lake. Both reservoirs are within the Concho River basin and lie in a transitional zone between several ecosystems. Most scientists agree that the lakes are situated predominantly in the Rolling Plains ecological region. Except for areas surrounding the reservoirs where invasive plants have taken over, the region supports a tremendous diversity of plants and animals. About 350 species of birds and 50 species of mammals can be found in this transitional zone (TPWD 2004).

Existing Conditions and Potential Impacts

Phreatophytic plant species, climate, topography, soils, land use, air quality, socioeconomic conditions, recreation, scenic and esthetic resources, cultural resources, hazardous waste (including toxic and radioactive waste), and surface water were adequately discussed in the USACE O.C. Fisher report. A brief review of the report and additional information where needed is presented below.

Phreatophytic Plant Species

Invasive brushy species of concern include saltcedar (*Tamarix ramosissima*) and two natives, mesquite (*P. glandulosa*) and willow baccharis (*B. salicina*). Though historically native to the area, mesquite and willow baccharis occupied only a small niche in the historical climax community. The ability of these species to remove large amounts of ground water to meet transpiration needs is the primary factor reducing water availability for riparian and aquatic ecosystems (USACE 2005).

Saltcedar

This invasive phreatophytic shrub or small tree grows rapidly to a height of 30 feet, forming dense, impenetrable thickets. It's a native of Europe and Asia, introduced in the U.S. in the early 1800s as an ornamental. It escaped from domestic cultivation by the 1870s and was subsequently planted along southwestern streams to replace disappearing riparian vegetation. It invaded most suitable western riparian areas by 1965 (DeLoach 1997). The USACE lists seven primary undesirable traits for this species.

Undesirable saltcedar impacts:

- It consumes more water that comparable native plants.
- It crowds out native stands of riparian and wetland vegetation.
- It dries up springs, wetlands, riparian areas and small streams by lowering surface groundwater tables.
- It widens floodplains by clogging stream channels.
- It increases sediment deposition due to the abundance of saltcedar stems in dense stands.
- It increases the salinity of surface soil through salt exudation from its leaves, rendering the soil inhospitable to native species.
- It provides lower wildlife habitat value than native vegetation.
- Reproduction occurs through both sexual and vegetative pathways. Each plant produces up to 500,000 small, wind-disseminated seeds from April through October. The plant also reproduces by sprouting from removed stems and root collars when disturbed. Seedlings grow faster than most native plants, extending a tap root rapidly into the groundwater zone. The root branches sparingly until it reaches the saturated area. Saltcedar roots with 3/16" diameter have been known to reach depths of at least 16'. The roots exploit groundwater by filling the groundwater capillary zone with rootlets and extending some roots down into the saturated zone (Merkel 1957). This results in a lowering of the groundwater table.
- Saltcedar possesses the highest evapotranspiration among the three (3) species of concern in the project area. A mature tree can evapotranspire up to 200 gallons of water per day (McGinty 2001). One acre of saltcedar on the Pecos River of Texas was estimated to use 5-7 acre-ft. of water every year (Hart 2003). The longer saltcedar occupies an area, the drier the area becomes. Saltcedar currently dominates 1,092 acres in the project area.

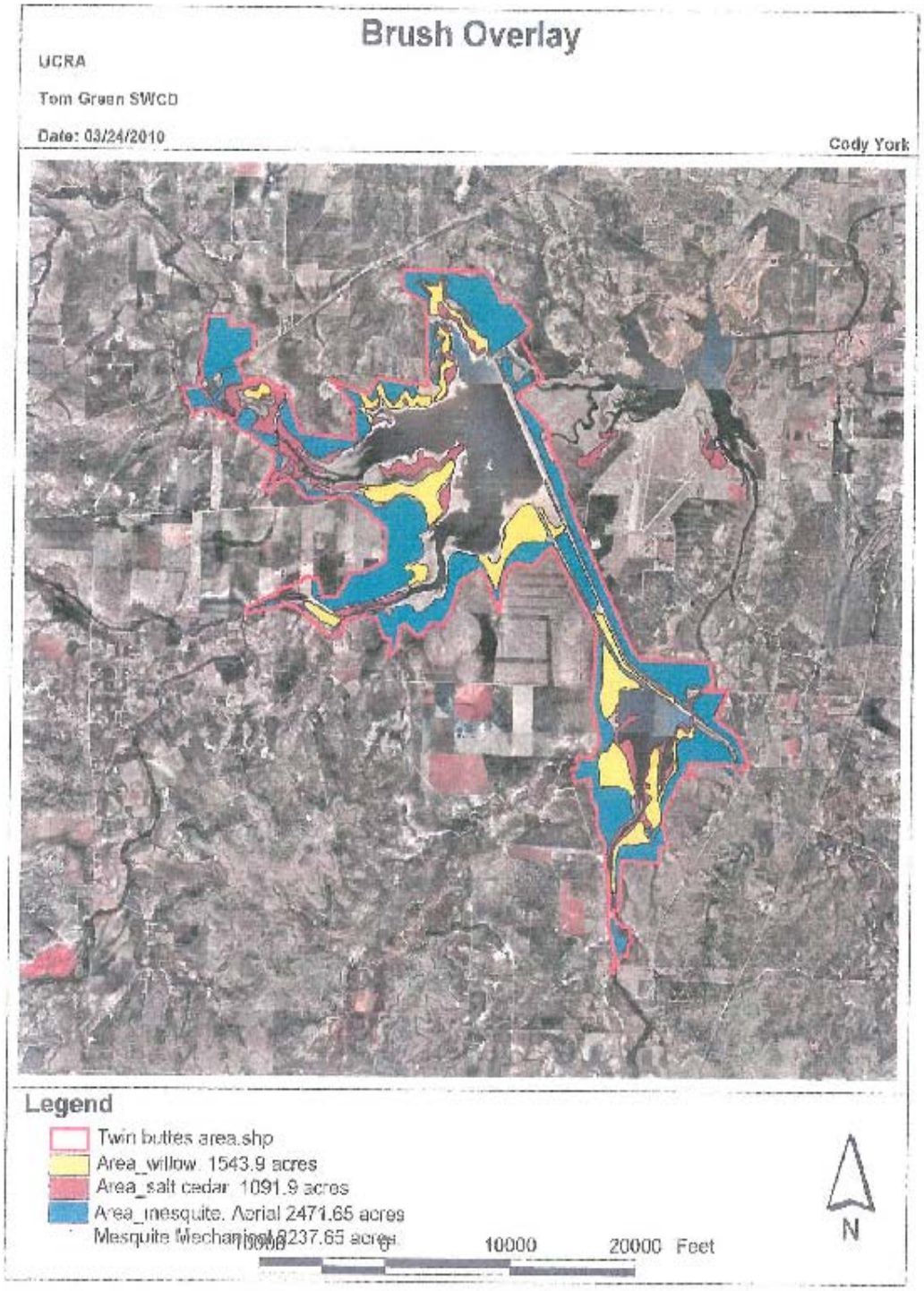

Figure 4: Phreatophytic plant communities surrounding Twin Buttes Reservoir

Mesquite

Mesquite is a native plant, but it was historically limited to lowland areas. The species is now so dense on millions of acres of both uplands and lowlands that it is often considered to be a noxious plant. It is a facultative[4] phreatophyte that can grow to heights of 60 feet and develop trunks three (3) feet in diameter (Sosebee 1987). It is adaptive to both wet and dry conditions once established. If the canopy is damaged or killed, the tree re-sprouts from the basal bud zone (root collar) into multi-trunks that are very resistant to control. Mesquite easily dominates suitable habitat because of its extensive dual root system including both extensive lateral and deep tap roots. Tap roots are known to penetrate at least 60 feet into the ground to reach groundwater, while lateral roots fill the capillary zone above the water table. Reported water losses from individual mature trees have ranged from 7.9 to 19.8 gallons per day (USACE 2005). Mesquite currently dominates 4,710 acres in the project area.

Willow Baccharis

Willow baccharis is a native perennial that grows to a height of about 13 feet. Historically, it was confined to river banks and creek channels. Today, the species has expanded into the uplands as well. It's an aggressive invader that can quickly dominate disturbed sites. It produces many seeds and also spreads through adventitious buds along lateral roots. It frequently forms a dense, closed canopy that reduces the amount of sunlight reaching the ground. This results in nearly bare ground that is subject to erosion. Willow baccharis probably uses more water than mesquite (Gatewood 1950) and is considered a noxious plant in many parts of the American southwest. It covers about 1,544 acres in the project area.

Saltcedar, mesquite, and willow baccharis are able to out-compete more ecologically appropriate, native species for three primary reasons: (1) they reproduce more efficiently; (2) they are better adapted to exploit groundwater resources; and (3) they are highly aggressive. Saltcedar, for example, exudes salt from its leaves that inhibits the sprouting and growth of native species. Mesquite spreads an extensive root system that leaves little room for other root systems and that very efficiently removes moisture from both the soil and groundwater. Dense willow baccharis communities shade ground cover and prevent competing growth. These three species have encroached upon healthy riparian communities and crowded out higher quality habitat. In addition, they significantly reduce the amount of water available for groundwater recharge and in-stream base flows, causing degradation to the aquatic ecosystem.

Studies have demonstrated that removal of phreatophytic brush has the potential to increase both surface water flow and groundwater recharge. This occurs because of reductions in the capture and evapotranspiration of water by phreatophytic species (Griffin 1989). A four-year study of the impacts of

[4] A facultative phreatophyte uses lots of water when it is available, but also thrives in dry conditions.

mesquite control on the North Concho River near San Angelo showed that the untreated site had a potential net consumption of about 71 mm (2.8 inches) more water per year than the treated site (Saleh 2009).

Results from Saleh (2009) indicate there is great potential to increase water yield in the watershed by eliminating mesquite trees. Rates of evapotranspiration at the mesquite-treated sites dropped up to 25% during the growing season over the untreated sites. Mesquite treatment enhanced surface water supplies, recharge of groundwater aquifers, and spring flows. Mesquite density on the sites averaged 1,830 trees per acre, or slightly more than half of the 3,000 trees per acre at Twin Buttes. Despite record drought in Tom Green County, groundwater levels in the North Concho basin continued to climb during the study and numerous previously dry springs and seeps became active again. Base flows in previously dry or intermittent tributaries became perennial and base flows on the North Concho River steadily increased. Comparative analysis of flood flow hydrographs indicated a shift in the river's hydrologic behavior toward pre-brush conditions (UCRA and TIAER 2006). Treated watersheds re-established significant water yield on an annual basis, while untreated watersheds produced virtually no water yield during the same period.

Topography

Terrain in the area ranges from alluvial plains with gentle slopes to high hills and steep bluffs. Much of the area is used for rangeland or agriculture. The nearly level, alluvial plains were subject to periodic, extensive flooding prior to the construction of Twin Buttes Dam.

Impacts of Preferred Alternative

Brush removal would temporarily expose local terrain to increased erosion due to loss of vegetative cover. Natural re-vegetation should steadily reduce potential erosion once the aggressive phreatophytic species have been reduced or eliminated. There should be no other impacts to topography.

Impacts of No Action Alternative

The no action (no project) alternative would not impact topography in the project area.

Soils

Twin Buttes Reservoir is located mostly in flat lands consisting of limestone soils surrounded by high ground made of sandy loam. There is an isolated area of red clay between Twin Buttes and Nasworthy Lake. Primary soil types are of the Angelo, Kimbrough, and Tulia series. Angelo soils are nearly level to gently sloping soils found on smooth outwash plains. They are well-drained, have slow surface runoff, are moderately permeable, and are well suited for crop or

rangeland. Kimbrough soils are gently-sloping to sloping and undulating soils on outwash plains. They are well-drained, have medium surface run-off, are moderately permeable, and are mostly used as range and wildlife habitat. Tulia soils are nearly level to gently sloping soils found on outward plains. They are well-drained, have medium surface run-off, and are moderate permeable. They are suitable for crops, rangeland, and wildlife habitat.

Impacts of Preferred Alternative

Brush removal would temporarily expose local soils to increased erosion. Natural re-vegetation should reduce potential erosion once the aggressive phreatophytic species have been reduced or eliminated.

Impacts of No Action Alternative

The no action (no project) alternative would not limit or reduce the infestation of saltcedar, which would result in increasing salinity of the soil.

Land Use

Much of the property around the reservoir is used either as rangeland or cropland. Common crops include beef cattle, sheep/goats, cotton, dairy, wheat, grain sorghum, hay, and pecans. San Angelo, a city of approximately 99,178 people (Podunk 2005) and the San Angelo International Airport lie immediately north of the reservoir.

Impacts of Preferred Alternative

Phreatophytic plant reduction or removal would re-open a large area surrounding the reservoir for native plant re-establishment. This would greatly improve the area for livestock, wildlife, and human use. Land uses such as hunting, fishing, nature-watching, camping, hiking, picnicking, and others would improve. The value of land as wildlife habitat would greatly improve.

Impacts of No Action Alternative

The no action (no project) alternative would allow continuing growth and expansion of phreatophytic plant populations, resulting in continuing negative impacts to land use.

Air Quality

The USEPA does not maintain any air quality monitoring stations in Tom Green County. The nearest site is located in Odessa, approximately132 miles north-northwest. Air quality at Odessa meets or exceeds the primary EPA standard for air quality, with very few exceptions, and the area is therefore classified as an attainment area.

Impacts of Preferred Alternative

Airborne levels of herbicides and/or soil particulates would increase for brief periods in areas where spraying or plowing occur. Both activities are common in this primarily agricultural area, so there would be only small, short-term changes in air quality resulting from the proposed project.

Impacts of No Action Alternative

The no action (no project) alternative would result in decreasing levels of understory cover (grasses and forbs), due to continuing spread of saltcedar, mesquite, willow baccharis, and prickly pear cactus. More soils would be exposed to wind and water erosion, resulting in increased levels of dust and particulates carried by severe, seasonally frequent winds and storms. Air quality would gradually be reduced.

Socioeconomic Conditions

Except for San Angelo, Tom Green County is sparsely populated. It encompasses 1,522 square miles and has an approximate population of 99,178 (Podunk 2005). Twin Buttes Reservoir is located on the southern outskirts of the city, so impacts of the project would be primarily to urban and nearby agricultural and livestock areas, especially irrigated acreage. San Angelo is sometimes referred to as "The agribusiness capital of Texas" (City of San Angelo 2009). The most important economic sectors outside of agriculture include retail trade, light industry, and education. San Angelo serves as the regional center for communications, Federal programs, health care, recreation, retirement, and tourism (USACE 2005). Estimated median household income in San Angelo during 2008 was $40,867 compared to $50,043 state-wide (City of San Angelo 2009). Since there are so few residents outside the city, county population figures are provided on ethnicity. The following ethnic groups are present (percentages in parentheses) (Podunk 2005):

- White non-Hispanic (60.1%)
- Hispanic (25.5%)
- Black (2.9%)
- American Indian (0.3%)
- Asian (0.8%)
- 2 or more races (1.7%)*
- Other (8.7%)

Surface water resources are important to the San Angelo community. Twin Buttes reservoir is the largest of three reservoirs in this semi-arid area that provide municipal and industrial (M&I) water. The lake also serves for recreation and flood control. Flooding has periodically devastated the area in the past. Much of the stored water is used to irrigate 10,000 acres of crop and rangeland (Reclamation 1994).

Impacts of Preferred Alternative

Purchases of fuel, pesticides, equipment services and repairs, and other incidentals should provide minor, temporary economic benefits to the local community. In the long-term, agriculture, recreation and sports retailers, M&I water users, industrial water users, and irrigators should all benefit economically.

Impacts of No Action Alternative

The no action (no project) alternative would not replace noxious, phreatophytic plant species with more economically beneficial native species. The local economy would continue to suffer because of negative impacts to surface and groundwater levels. This would result in negative economic impacts to agriculture, recreation and sport retailers, M&I users, industrial water users, and irrigators.

Recreational, Scenic, and Esthetic Resources

Except for areas overgrown with nuisance vegetation, much of the Twin Buttes shoreline is available for primitive camping, picnicking, fishing, and hunting. Camping is also available at nearby San Angelo State Park, located near O.C. Fisher Lake. Native American petroglyphs, prehistoric Permian vertebrate animal tracks, a small bison herd, a large herd of Texas longhorn cattle, a black-tailed prairie dog town, and a grave site dating to 1847 are found within the park.

Impacts of Preferred Alternative

Long-term benefits should result to local wildlife, agriculture, and increased water storage, resulting in improvements to recreational, scenic, and esthetic resources.

Impacts of No Action Alternative

The no action (no project) alternative would result in long-term negative damage to native wildlife and water storage, resulting in further damage to recreational, scenic, and esthetic resources.

Cultural Resources

The Twin Buttes area was originally occupied by the Kiowa, Comanche, and Apache Tribes, among others. These tribes relinquished occupation in the Medicine Lodge treaties of 1865 and 1867. The Kiowa and Comanche were given rights to "…hunt on any lands south of the Arkansas River so long as the buffalo may range thereon in such numbers to justify the chase…" This right was lost with the disappearance of free-roaming buffalo. No other rights were granted in these treaties (Reclamation 1994). Based on the absence of identified Indian properties in the area, Reclamation has determined that the project would have no effect upon Indian trust assets.

The project area contains cultural resources ranging from Paleo-Indian through historic times. All historical and archeological sites are protected by the Antiquities Act of 1906, Historic Sites Preservation Act of 1966, and other applicable Federal and State laws and orders.

Impacts of Preferred Alternative

Under the preferred alternative, helicopter herbicide spraying would have no effect on historic properties. Once helicopter spraying is completed, some smaller areas would likely be treated by plowing. Plowing could impact archeological sites located in the area of concern. All Federal land at the reservoir has been surveyed for cultural resources, and Reclamation maintains a list of cultural sites that need to be protected. Should there be any potential to disturb known areas of concern, all possible efforts would be taken to avoid damaging the cultural sites. Once all proposed plowing areas are identified and mapped, a separate consultation with the Texas State Historic Preservation Officer (SHPO) would be required to determine potential adverse effects and, if necessary, plan mitigation. Mitigation must be completed before any ground disturbing activity would be allowed.

Impacts of No Action Alternative

The no action (no project) alternative would not impact any cultural resources.

Surface Water

In 1964 (prior to extensive siltation above the dam,) Twin Buttes Reservoir stored about 186,203 acre-feet of water at an elevation of 1,940 feet (top of the conservation pool.) Water covered about 9,079 acres at this elevation (Reclamation 2010). The highest reservoir elevation reached was 1942.2 feet, about 2.2 feet up into the flood pool, in May 1975 (Reclamation 2010a). An estimated 184,600 acre-feet of water were in storage at the time, covering about 9,414 acres. In recent years, long-term drought and impacts from the invasion of phreatophytic vegetation have kept storage levels below normal. During the first 10 months of 2009 (the most recent data available), surface elevations ranged from 1925.39 feet to 1926.12 feet, or from 13.88 to 14.61 feet below maximum conservation pool level. Recorded local precipitation levels during this 10-month period totaled 17.02 inches, which was near normal (Reclamation 2010a).

Most surface water in the drainage basin comes from local run-off and springs. Three streams feed Twin Buttes Reservoir – the Middle and South Concho rivers and Spring Creek. Flows in the Middle and South Concho rivers are erratic, with frequent periods of low or no flow (Reclamation 1994). The South Concho River at Christoval (the nearest USGS flow gauge to the reservoir, about 10 miles upstream) averaged 27,030 cubic feet per second (ft^3/sec) from 1930 through 2009. Flow in the Middle Concho near Tankersley (about a mile upstream from the reservoir) averaged 11,354 ft^3/sec from 1930 through 1961 when sampling apparently stopped at this site (USGS 2010). Spring Creek flows averaged about

11,172 ft^3/sec at Tankersley from 2002 through 2009. Generally impervious soils result in rapid run-off and high flood peaks in all three streams. For example, the South Concho peaked at 111,000 cfs in 1936 (Reclamation 1994), causing widespread flooding.

Impacts of Preferred Alternative

Based on previous studies in the area, brush removal may result in higher groundwater levels, and some formerly dry springs and seeps surrounding Twin Buttes Reservoir may become active again. Base flows in previously dry or intermittent tributaries may become perennial, and base flows in Spring Creek and the South and Middle Concho Rivers could steadily increase. Hydrologic conditions in all three streams could improve to near pre-brush conditions, as they did on the North Concho River between 2000 and 2004 when phreatophytic vegetation was removed (UCRA and TIAER 2006). Based on these results, water yield from Twin Buttes Reservoir may improve on an annual basis.

Impacts of No Action Alternative

The no action (no project) alternative would result in continued degradation of surface water quantity in the reservoir, contributing streams, and springs.

Groundwater

Local groundwater tables are typically within a few feet of the ground surface (USACE 2005). Groundwater normally discharges to the reservoir and local streams by seepage or springs where the water table is near the land surface (Ashworth 1995). Texas Park and Wildlife (TPWD) staff working in the area surrounding O.C. Fisher Lake reported that many of the springs had either stopped flowing or progressively reduced their flow prior to 2005, even though local aquifers are described as under partial artesian pressure (USACE 2005).

Impacts of Preferred Alternative

Some previously dry springs and seeps surrounding Twin Buttes Reservoir and local streams may again become active as groundwater levels rise. More groundwater may become available for irrigation, M&I water, and lake recharge. This may benefit water quality and would benefit local native species, aquatic, riparian, and terrestrial ecosystems, and human communities.

Impacts of No Action Alternative

The no action (no project) alternative may result in continued degradation of ground water quantity in the area. Groundwater recharge of local streams and Twin Buttes Reservoir may continue to decrease.

Water Quality

Since there are no major pollution sources to the South or Middle Concho rivers upstream, water quality in Twin Buttes Reservoir is generally good. Water

quality in Spring Creek tends to be only fair due to high turbidity (a measure of total suspended solids or TSS), total dissolved solids (TDS), and hardness levels. The Texas Commission on Environmental Quality (TCEQ) stated that all water quality parameters met required standards (TCEQ 2008). The reservoir is not on the Texas 303(d) list of waterbodies that fail to meet standards, but invasive plant monocultures[5] have resulted in bare, open spaces between plants that increase run-off and erosion. Sediments carried into the lake remain suspended for a time before dropping to the bottom, impacting native species first in the water column and then in the sediment. Twin Buttes is a shallow reservoir (maximum depth of 42 feet at full conservation pool level.) Thus, sediments can easily be re-suspended during storm events. High turbidity/TSS can cause gill abrasion or fin rot and blanket fish spawning and feeding areas. It can also eliminate sensitive food organisms and reduce sunlight penetration to aquatic plants, thereby impeding photosynthesis. Suspended particles also provide increased surface area for transport of pesticides, heavy metals, and other toxic compounds.

Impacts of Preferred Alternative

Care would be taken to prevent runoff or herbicide overspray impacts to the reservoir during the project. Completion of the proposed project could help protect reservoir water quality in the long-term by recharging streams and the lake with high quality groundwater and returning runoff characteristics to pre-brush conditions.

Impacts of No Action Alternative

The no action (no project) alternative could result in continued degradation of water quality in the area caused by lowering water tables and increasing turbidity caused by watershed runoff.

[5] Monocultures are populations of a single plant or animal species. They are often composed of aggressive invasive species, which out-compete and replace typically diverse native communities.

Figure 5: Former wetland below Twin Buttes Dam (in background) now dry and overgrown with mesquite, saltcedar, and willow baccharis

Wetland Resources

Wetland areas were mapped between Twin Buttes Dam and Lake Nasworthy in 1994 (Reclamation 1994). Wetlands were identified based on similar species and function. They included Forested, Emergent, and Open Water wetlands according to accepted classification guidelines (Cowardin 1979). Forested wetlands include those area with woody plant species at least 20-feet tall that can survive in saturated soil during the growing season. Emergent wetlands include those with erect, root hydrophytes (excluding moss and lichen) present during most of the growing season. They are usually dominated by perennials like cattail (*Typha* spp.), bulrush (*Scirpus* spp.), rushes (*Juncus* spp.) and spike rushes (*Eleocharis* spp.) Vegetation in open water wetlands is not emergent.

Based on a survey in 1994, about 35.2 acres of wetlands once existed below Twin Buttes Dam along the South Concho River. This included 2.4 acres of forested wetlands, 7.0 acres of emergent wetlands, and 25.8 acres of open water wetlands. Another 26.1 acres of wetlands existed along Spring Creek, including 12.1 acres of forested wetlands, 11.7 acres of emergent wetlands, and 2.3 acres of open water wetlands. Since 1994, reductions in flow from the Twin Buttes spillway, installation of seepage controls, and prolonged drought have eliminated all wetlands below the dam (see Figure 4.) As a result, all known, former wetlands have disappeared.

Impacts of Preferred Alternative

The preferred alternative would not impact existing wetlands, as there are none in the project area.

Impacts of No Action Alternative

The no action (no project) alternative would not result in any changes to wetland conditions.

Fish and Wildlife

Fish species found in Twin Buttes Reservoir include largemouth and smallmouth bass (*Micropterus* spp.), walleye (*Stizostedion vitreum*), crappie (*Pomoxis* spp.), several species of sunfish (*Lepomis* spp.), blue, bullhead, and channel catfish (*Ictalurus* spp.), carp (*Cyprinus carpio*), and freshwater drum (*Aplodinotus grunniens*.) Several of these species are stocked for recreational fishing.

The area surrounding the reservoir supports populations of white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), opossum (*Didelphis*

marsupialis), armadillo (*Dasypus novemcinctus*) rats and mice (Family Heteromyidae), rabbits (*Sylvilagus* spp.), nutria (*Myocastor coypus*), squirrel (*Sciurus* spp.), and fox (*Vulpes* spp.). The nutria is a non-native, invasive species. Birds include wild turkey (*Meleagris gallopavo*), mourning dove (*Zenaidura macroura*), and great blue heron (*Ardea herodias*), as well as various woodpeckers, hawks, owls, vultures, waterfowl, and songbirds. Snakes, lizards, and frogs are also abundant.

The reservoir and surrounding areas originally provided excellent habitat for birds, including waterfowl, shorebirds, neo-tropical passerines, and other migratory birds. The significance of conserving, improving, and restoring habitat for migratory birds has been well established by Federal policy and legislature including the Fish and Wildlife Conservation Act, Migratory Bird Treaty Act, and Executive Order 13186 (to name a few).

Impacts of Preferred Alternative

Removing invasive brush monocultures from within and around Twin Buttes Reservoir could result in temporary displacement of some wildlife species; however, it would allow re-vegetation by native species and create more complex, heterogeneous habitat. This would result in beneficial long-term impacts on aquatic and terrestrial fish and wildlife, including migratory birds.

Impacts of No Action Alternative

The no action (no project) alternative would result in increasing degradation of both aquatic and terrestrial fish and wildlife habitat.

Vegetation

Semi-arid central Tom Green County is located in an ecological transition zone between the Rolling Plains and Edwards Plateau physiographic regions. Regional soils are typically calcareous, silty loams that support upland vegetative species including mesquite (*Prosopis* spp.), needlegrass (*Stipa* spp.), buffalograss (*Buchloe dactyloides*), grama grass (*Bouteloua* spp.), etc. (Reclamation 1994). Land surrounding the reservoir is dominated by a mesquite-grassland association, with scattered oak (*Quercus* spp.), cedar (*Juniperus* spp.), acacia (*Acacia* spp.), and other brush. Bulrushes (*Scirpus* spp.) dot the fluctuating reservoir shoreline; but recently, saltcedar (*Tamarix* spp.), mesquite, willow baccharis (*Baccharis salicina*) and other invading species have replaced native vegetation in many areas surrounding local streams and the reservoir.

Impacts of Preferred Alternative

The proposed project would reduce or eliminate dense populations of invasive phreatophytic vegetation, making room for re-vegetation by native species. This would result in improved aquatic and terrestrial habitat.

Impacts of No Action Alternative

The no action (no project) alternative would result in increasing degradation of native vegetation and greater destructive impacts from rapidly-spreading nuisance, invasive species.

Transitional Habitat

Transitional habitat extends from the riparian zones (or shoreline where there is no riparian zone,) outward to the edge of the project area. Historically, these lands were either submerged within the reservoir or covered predominantly by prairie grasses with interspersed mesquite and oak in uplands and along ridges. Fire suppression, overgrazing, and prolonged drought contributed to proliferation of mesquite woodlands, willow baccharis, and saltcedar (USACE 2005). Much of the area has been invaded to the point where community composition can be referred to as primarily brushy. Prickly pear cactus (*Opuntia* spp.) is a common understory plant, especially in areas dominated by mesquite. Prickly pear, when present in dense patches, provides poor wildlife habitat. Many forbs and legumes as well as over 140 species of wildflowers exist in the area, but continue to decrease in abundance as invasive plants take over.

Impacts of Preferred Alternative

The proposed project would reduce or eliminate dense populations of invasive phreatophytic vegetation in the transition zone, making room for re-vegetation by more beneficial and less-destructive native species.

Impacts of No Action Alternative

The no action (no project) alternative would result in increasing degradation of native vegetation and greater destructive impacts from rapidly-spreading nuisance, invasive species.

Threatened and Endangered Species (T&E)

The U.S. Fish and Wildlife Service (USFWS) lists three (3) threatened and three (3) endangered species known to occur in Tom Green County (USFWS 2010).

<u>Threatened</u>

- Bald eagle (Sonoran desert population of *Haliaeetus leucocephalus*),
- American black bear (*Ursus americanus*)
- Concho Water snake (*Nerodia paucimaculata*.)

<u>Endangered</u>

- Black-capped vireo (*Vireo atricapilla*)
- Interior least tern (*Sterna antillarum*)
- Northern aplomado falcon (*Falco femoralis septentrionalis*.)

The USFWS also lists the Mexican gray wolf (*Canus lupus baileyi*) as an experimental, non-essential population. It was re-introduced in Arizona and may be found in Arizona, New Mexico, and west Texas.

TPWD reports nine (9) State-listed threatened and five (5) endangered species found or possibly found in Tom Green County (TPWD 2010), including:

Threatened

- Common black-hawk, *Buteogallus anthracinus*
- Peregrine falcon, *Falco peregrinus*
- American peregrine falcon, *Falco peregrinus anatum*
- Bald eagle, *Haliaeetus leucocephalus*
- Texas fatmucket mussel, *Lampsilis bracte*ata
- False spike mussel, *Quadrula mitchelli*
- Texas pimpleback mussel, *Quadrula petrina*
- Texas fawnsfoot mussel, *Truncilla macrodon*
- Texas horned lizard, *Phrynosoma comutum*

Endangered

- Whooping crane, *Grus americana*
- Interior least tern, *Sterna antillarum athalassos*
- Black-capped vireo, *Vireo atricapilla*,
- Gray wolf, *Canis lupus*
- Red wolf, *Canis rufus*

A brief summary of life cycle information for all Federal and State-listed species follows.

Bald eagle – This large raptor is found primarily near rivers and large lakes. It nests in tall trees or on cliffs near water. It roosts communally, especially in winter and hunts live prey, scavenges, and pirates foot from other birds, including eagles.

American black bear – This bear is highly adaptable, living in habitats ranging from arid scrub to southern swamps and dense forests. Its diet is mostly vegetarian, but is augmented with insects, small mammals and fish. Young are born in the mid-winter. Only the isolated Louisiana, Texas, and Mississippi populations are listed as threatened by the USFWS.

Concho water snake – The Concho water snake is found in the Concho and Colorado rivers in only 10 west-central Texas counties. It grows to less than 3 feet in length. They are active from March through October, but hibernate during the winter. The diet consists primarily of small fish. Baby snakes hatch from July through September. Concho water snakes prefer free-flowing streams over rocks and shallow riffles, but can survive in lakes with suitable shoreline habitat. Habitat loss has been the principle reason for the snakes' decline.

Black-capped vireo – This migrant inhabits mid-successional areas where the dominant species are oaks, sumacs, persimmon, and other broad-leafed shrubs. oak-juniper woodlands with a distinctive patchy, two-layered aspect (a shrub and tree layer with open, grassy spaces); requires foliage reaching to ground-level for nesting cover; returns to same territory or nearby each year; feeds on insects in deciduous and broad-leaved shrubs and trees (primarily oaks.) It is unlikely that this species would utilize the project area (USFWS 2004).

Interior least tern – This bird breeds in the interior United States along large rivers during the summer. It prefers unvegetated sand or gravel bars within wide river channels, along salt flats, or on artificial habitats such as sand pits. The interior least tern feeds primarily on small fish, but also eats crustaceans, insects, mollusks, and worms. They are considered transients and occasional summer breeders in Texas.

Northern aplomado falcon – Aplomado falcons require open grasslands or savannah with scattered trees or shrubs. It is at its northern limits in Texas. They are fast fliers and work in pairs, often chasing prey as they flee into dense grass. They do not make their own nests, but use those of other birds. They eat mostly birds and insects. Severe overgrazing and brush encroachment have sometimes been blamed for the species' decline, but recent studies suggest other possible reasons. One theory suggests that the decline of black-tailed prairie dogs, which are one of the bird's favorite prey, partially led to the decline of aplomado falcons.

Common black hawk – This hawk prefers cottonwood-lined rivers and streams. It often perches over water and feeds mostly on frogs, small fish, and crayfish. The species is vulnerable to disturbance near its nesting sites in the spring.

Peregrine falcon – Native to both North and South America, the peregrine falcon is an uncommon transient and occasional resident in Texas. They live in a variety of habitats and nest in cliffs, trees or tall buildings. They prey on birds, small mammals, lizards, fishes, and insects. Peregrine falcons nest in May or June.

American peregrine falcon – This subspecies of peregrine falcon is a resident of the Trans-Pecos region, including the Chisos, Davis, and Guadalupe mountain ranges.

Texas Fatmucket – This mussel historically occurred throughout the Colorado and Guadalupe basins of central Texas. Only four (4) isolated populations remain and they are at risk from scouring floods, dewatering, and poor land management practices.

False spike – The only live false spikes found in Texas were in the San Marcos River. All other specimens collected were either sub-fossil or fossil.

Texas pimpleback – The Texas pimpleback mussel is confined to the Colorado and Guadalupe drainages. The only confirmed remaining population is in the Concho River (well downstream from Twin Buttes Reservoir), where the population has been badly reduced by dewatering.

Texas fawnsfoot – This species of mussel historically inhabited the Colorado and Brazos drainages of central Texas. A recently discovered population in the Navasota River is the only known surviving population.

Texas horned lizard – Also known as the horny toad, this species can be found in arid and semi-arid habitats in open areas with sparse plant cover. The species digs for nesting, hibernation, and insulation purposes. The species is commonly found in loose sand or loamy soils.

Whooping crane – The whooping crane is North America's tallest bird. A small, self-sustaining population breeds and nests at Wood Buffalo National Park in Canada and over-winters at Aransas National Wildlife Refuge on the Texas gulf coast. They migrate through the Great Plains in spring and fall using rivers, lakes, and other water bodies for feeding and resting. The species' diet consists of insects, frogs, rodents, small birds, berries, plant tubers, crayfish, and waste grains from harvested cropland. They typically roost in riverine habitat on isolated sandbars and in large, palustrine wetlands (dominated by trees, shrubs, and emergent plants.)

Gray wolf – Mexican gray wolves prefer to eat large, hoofed animals like deer and elk. They also occasionally consume javelinas, rabbits, ground squirrels, mice, and other smaller mammals. The species once ranged from central Mexico to southwestern Texas, southern New Mexico and southeastern Arizona. It was re-introduced to Arizona in 1998 by the USFWS, but may wander as far east as Texas. Mexican wolves are social animals, hunting in packs. They prefer mountain forests, grasslands, and shrub lands. Mating season ranges from mid-February through mid-March.

Red wolf – Red wolves are slightly smaller than gray wolves and eat rabbits, deer, raccoons, and rodents. They also live and hunt in packs. Most of the species was wiped out by predator programs by the 1930s, leaving only two isolated populations, one in the Ozarks and the other in Texas.

Impacts of Preferred Alternative

The proposed project would not affect any Federally threatened or endangered species. The bald eagle sometimes migrates through the area, foraging in Twin Buttes Reservoir and roosting in taller riparian trees along local streams, but its presence is intermittent and would not be impacted by the proposed project. The black-capped vireo is very habitat-selective, preferring shrub and tree layers with scattered oak and open, grassy spaces. The peregrine falcon may occasionally migrate through the area, feeding on waterfowl that utilize the reservoir, but again, it is unlikely that this species would be found in the project area. The only

State-listed species listed as a probable area resident is the Texas horned lizard, but it prefers arid uplands for habitat, rather than the low areas immediately surrounding the reservoir. Overall, the proposed project should have long-term beneficial impacts on endangered and threatened species by replacing low-quality invasive vegetative monocultures with more complex, heterogenous habitat which is more suitable for use by wildlife. .

Impacts of No Action Alternative
The no action (no project) alternative would not benefit threatened or endangered species. The continued spread of nuisance invasive species would ensure that these species could not use the local habitat.

Critical Habitat

The USFWS has not designated any critical habitat in the proposed project area.

Impacts of Preferred Alternative
The preferred alternative would not impact any critical habitat.

Impacts of No Action Alternative
The no action (no project) alternative would not impact any critical habitat.

Climate Change

The climate in Tom Green County is semi-arid, with an annual average temperature of 64.9^0 F. Temperatures can range from below freezing in the winter to over 100^0 F in the summer. Lowest temperatures occur in January, when the average low is 30.6^0 and the average high is 56.8^0. Highest temperatures occur in July with an average high of 92.7^0. The area averages 271 days of sunshine and 21.2 inches of rain per year. Recent rainfall totals are significantly less, as Tom Green County is currently experiencing a long period of drought (City of San Angelo 2009).

Climate change must be considered when U.S. Department of Interior (USDOI) agencies or bureaus engage in actions affecting potential utilization of resources that require environmental review (USDOI Secretarial Order 3226). Council on Environmental Quality (CEQ) draft guidance requires Federal agencies to determine whether and to what extent their actions affect the climate, and the extent to which changing climate affects their actions.

Impacts of Preferred Alternative
Extended drought is contributing to lower or less frequent flows in tributaries feeding Twin Buttes Reservoir. Lower rainfall leads to lower water levels in the streams, reservoir and groundwater. Phreatophytic vegetation exasperates these conditions. Climate scientists generally agree that climate change will result in

longer periods of drought, more variable and sporadic precipitation, fewer but more damaging floods, and increasingly violent weather conditions. Projected conditions would ultimately result in even lower average flows in surface streams, reduced water storage in reservoirs, and reduced groundwater recharge. Reducing or eliminating (killing) phreatophytic species like saltcedar, mesquite, and willow baccharis would temporarily contribute minor amounts of additional carbon dioxide (CO_2) and other greenhouse gases to the atmosphere as dead plants oxidize (rot). Living plants already contribute CO_2 to the atmosphere during daily photosynthesis and metabolism (formation of sugar using CO_2, water and sunlight.) As native species replace the dead invasives, additional CO_2 would be generated that would replace amounts lost to destruction of the phreatophytes. Any resulting change in the amount of CO_2 generated would be insignificant.

Impacts of No Action Alternative

The no action (no project) alternative would not impact potential climate change.

Cumulative Impacts

NEPA and the Endangered Species Act (ESA) both require the consideration of cumulative effects. NEPA requires that cumulative effects analysis consider the incremental impact of the proposed action, when added to other past, present, and reasonably foreseeable future actions. The ESA considers Federal actions to have already been accounted for and requires the analysis of non-Federal actions only.

Impacts of Preferred Alternative

There are no known cumulative impacts associated with the preferred alternative. No mitigation would be necessary.

Impacts of No Action Alternative

The no action (no project) alternative would not impact potential climate change.

Environmental Justice

Evaluating environmental justice requires an understanding of where project impacts occur and where potentially affected groups are located. Race and ethnicity in Tom Green County (Podunk 2005) is predominantly white, non-Hispanic (approximately 60%). The remaining approximate populations include black or African American (3%); American Indian or Alaska native (2.9%); Asian (0.8%); Hispanic or Latino (26.0%); two or more races (1.6%); and others. Impacts of the proposed project would not affect any one population over any other. No Indian Trust Assets would be affected.

Impacts of Preferred Alternative

There are no known Environmental Justice impacts associated with the preferred alternative.

Impacts of No Action Alternative
The no action (no project) alternative would not impact Environmental Justice.

Human Health, Safety, and Security

The mixing and handling of all herbicides would be monitored to ensure that chemical label safety recommendations and restrictions are followed. All Federal and State crop-dusting regulations would also be followed. No aerial dusting would occur when wind speeds exceed 10 mile per hour or when wind direction is toward any proximally located persons or non-target species. These protective measures serve as quality control for treatment effectiveness determinations. Care would be taken to spray near areas used by the public only when visitation is not expected. Signs would be used to warn the public away from any newly sprayed areas. Only experienced helicopter and ground equipment operators would be allowed to operate herbicide application or mechanical removal equipment and all recommended safety gear would be worn.

Impacts of Preferred Alternative
There only minor safety and security impacts expected with the preferred alternative.

Impacts of No Action Alternative
The no action (no project) alternative would not impact human health, safety, and security.

List of Environmental Commitments

- Only herbicides approved by the USEPA would be used.
- All chemicals would be applied only by licensed or State-certified applicators and in compliance with all chemical labels and instructions.
- Helicopters, on the other hand, deliver smaller droplets over compact areas, resulting in little drift and better coverage of target species
- To minimize drift, no herbicides would be applied from the air if winds exceed 10 mph or where possible drift could result in contamination to nearby residences, persons, or threatened or endangered species.
- Plowing would be used only in areas where plant size and density allow it, especially in areas where cotton fields are located adjacent to the treatment area or where human exposure to herbicides, if applied, cannot be prevented.
- Best Management Practices (BMPs) would be used to prevent offsite contamination by herbicides.
- Any required permit(s) would be obtained before the project begins.

- All possible efforts would be taken to avoid damaging cultural sites. Once all proposed plowing areas are identified and mapped, a separate consultation with the Texas State Historic Preservation Officer (SHPO) would be required to determine potential adverse effects and, if necessary, plan mitigation. Mitigation must be completed before any ground disturbing activity would be allowed.
- Care would be taken to prevent runoff or herbicide overspray impacts to the reservoir.
- Care would be taken to spray near areas used by the public only when visitation is not expected. Signs would be used to warn the public away from any newly sprayed areas.

Compliance with Environmental Statutes

Clean Water Act (CWA, Section 404)

Section 404 of the CWA is administered by the USACE, with oversight from the USEPA. Section 404 regulates the placement of dredged or fill materials into water bodies, including wetlands. A permit would be required for any action that caused more than minimal adverse impact to regulated waters. The proposed action would not impact waters of the U.S., including wetlands.

Endangered Species Act (ESA)

ESA requires consultation with the USFWS for actions that may affect Federally-listed threatened or endangered plant, fish, or wildlife species. Reclamation has determined that the proposed project would not affect any threatened or endangered species.

Farmland Protection Policy Act (FPPA)

The U.S. Natural Resources Conservation Service (NRCS) enforces this Act. The lead Federal agency (Reclamation) is required to consult with NRCS, if prime or unique farmlands are going to be impacted. No farmlands would be negatively impacted by the project.

Fish and Wildlife Coordination Act (FWCA)

FWCA, as amended, requires Federal agencies to consider the effects on fish and wildlife of any project that involves modification of a water body and to consult with the USFWS on those activities in order to mitigate potential impacts. The proposed project would not modify a water body, so consultation with the USFWS on impacts to fish and wildlife resources is not necessary.

Migratory Bird Treaty Act (MBTA)

The MBTA makes it illegal for people or actions to "take" migratory birds, their eggs, feathers or nests. Take is defined in the MBTA to include by any means or in any manner, any attempt at hunting, pursuing, wounding, killing, possessing or transporting any migratory bird, nest, egg, or part thereof. The proposed project would restore native habitat in the project area and result in beneficial impacts to migratory birds.

National Historic Preservation Act (NHPA, Section 106)

NHPA establishes the protection of historic properties as national policy. It requires cooperation with states, tribes, local governments, and the general public. Historic properties are those buildings, structures, sites, objects, and districts, or properties of traditional religious and cultural importance to Native Americans, or determined to be eligible for inclusion in the National Register of Historic Places (NRHP). Should any cultural resources be discovered during the project, historic or cultural resources would be completed before any ground disturbing acitivites are undertaken. Proper mitigation would be negotiated with the State Historic Preservation Officer.

Consultation and Coordination

Public Involvement

NEPA requires Federal agencies to involve the public when taking actions such as construction, funding, or permitting. Public involvement provides an opportunity for interested individuals, officials, and organizations to participate in the NEPA process. The final EA/FONSI prepared by the USACE in 2005, which was adopted by Reclamation as part of this EA, included extensive agency coordination and collaboration as part of its restoration plan of O.C. Fisher Reservoir. Agencies consulted by the USACE included the UCRA, TPWD, USFWS, Environmental Protection Agency, Texas Agricultural Extension

Service, Natural Resource Conservation Service, Texas State Soil and Water Conservation Board, and Angelo State University.

Reclamation and UCRA participated in the production of this draft EA. The draft EA will be made available for public review and comment for 10 calendar days, and it will be distributed to organizations and individuals for additional review if requested. A press release to the public will be made prior to beginning the project.

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Appendix

Integrated Pest Management Plan

INTEGRATED PEST MANAGEMENT PLAN

FOR

TWIN BUTTES RESTORATION PROJECT,

SAN ANGELO PROJECT, TEXAS

DRAFT

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION, GREAT PLAINS REGION

OKLAHOMA-TEXAS AREA OFFICE,

THE CITY OF SAN ANGELO, TEXAS,

TEXAS STATE SOIL AND WATER CONSERVATION BOARD,

AND THE UPPER COLORADO RIVER AUTHORITY

MARCH 2010

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PURPOSE AND BACKGROUND

The purpose of this document is to describe an Integrated Pest Management Plan (IPM) for the Twin Buttes Restoration Project. The project is located on lands managed by the Bureau of Reclamation Oklahoma-Texas Area Office (OTAO) designated as the San Angelo Project.

The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) estimates that over the past 200 years several thousand foreign plant and animal species have become established in the United States. About one in seven become invasive, leading to problems that cost the country more than $138 billion each year. Many harmful invasive species clearly impair biological diversity by causing population declines, species extinctions, shifts in predator-prey dynamics, shifts in species niches, changes in habitat, and reductions in ecosystem complexity (APHIS 2006).

This IPM plan was developed to provide guidance to techniques used to control brush species on Reclamation's San Angelo Project, Texas reserved lands. This plan is temporally and spatially specific to the Twin Buttes Restoration Project and will remain in effect until completion or termination of the project.

This IPM borrows significantly from studies conducted by the United States Army Corp of Engineers (USACE) for its currently on-going O.C. Fisher Lake Ecosystem Restoration Project and from the Bureau of Reclamation's Dakotas Area Office Integrated Pest Management Plan. O.C. Fisher Lake is located less than ten miles from Twin Buttes Reservoir and the two are comparable in all pertinent aspects, i.e. climate, topography, soils, land use, aquatic wildlife, terrestrial resources, plant species, threatened and endangered species, etc. This IPM deals only with the control of three species of plants, i.e. mesquite, willow baccharis, and saltcedar, which have been identified as problematic on Reclamation lands.

PROJECT LANDS

This IPM will cover Reclamation OTAO reserved and fee title lands located at Reclamation's San Angelo Project, Texas. This IPM does not cover transferred works and/or lands to other federal agencies.

The San Angelo Project is in the immediate vicinity of the City of San Angelo in west-central Texas. Bureau of Reclamation development provided for the construction of Twin Buttes Dam and Reservoir, a headworks at Nasworthy Reservoir, and an irrigation and distribution system to serve a project area of about 15,000 acres. The project provides for the integrated operation of Twin Buttes Reservoir with the existing Nasworthy Reservoir to meet the municipal water requirements of San Angelo; and permits irrigation of the project lands and provides flood protection, recreation, and fish and wildlife benefits.

Facility Descriptions

Twin Buttes Dam is a 134-foot-high zoned earthfill structure with a crest width of 30 feet and a crest length of over 8 miles. The embankment contains 21,407,330 cubic yards of material. An equalizing channel with a bottom width of 250 feet was excavated between the South Concho

River and Spring Creek drainage areas. The outlet works for the dam, located near the left abutment, include an approach channel from the Middle Concho River. The spillway structure, on the left abutment, is an uncontrolled ogee weir 200 feet in width. A concrete chute section, 320 feet long, extends from the crest to a stilling basin. Water from the stilling basins of the spillway and outlet works discharges into a common channel.

Twin Buttes Reservoir has a conservation storage of 177,500 acre-feet with a flood capacity of 640,568 acre-feet.

Headworks and Main Canal

The Main Canal headworks was constructed on the eastern edge of Lake Nasworthy. The headworks consist of a semicircular intake structure containing ten 4.5-foot by 5.5-foot intake openings with fish screens leading into a 5-foot by 6-foot concrete conduit, and an outlet transition connecting to the concrete-lined Main Canal. Flows are controlled by a 5-foot-square motor-driven slide gate mounted at the upstream end of the conduit.

The 15.9-mile-long Main Canal has an initial capacity of 165 cubic feet per second. The canal follows an easterly and northeasterly direction to the project lands east of San Angelo. A 39-mile system of concrete-lined laterals completes the distribution of irrigation water.

Construction

Construction of Twin Buttes Dam was begun in 1960 and completed in 1963. Construction on the Main Canal and laterals was done at the same time; all facilities were completed in 1963. Following completion of construction, severe drought conditions prevailed in the Twin Buttes Dam watershed until April through August 1971, when above normal rains broke the drought and brought substantial inflow to Twin Buttes Reservoir. Studies of seepage data resulted in a pilot grouting contract which was awarded in June 1976 and completed in March 1977. Subsequent to the grouting, a foundation cutoff wall was installed through a large section of the upstream toe of the dam, between 1996 and 1999.

In the decades since the construction of Twin Buttes Reservoir, the lands owned by the Bureau of Reclamation (hereafter referred to as Reclamation) have become heavily infested with the invasive brush species saltcedar, willow baccharis and mesquite. Much research exists that attests to the prolific growth and high water consumption of these brush species. Each of these species is targeted for treatment.

The following is mostly from the USACE Detailed Project Report and Integrated Environmental Assessment for the O.C. Fisher Lake Ecosystem Restoration Project. Acreage amounts have been changed to reflect the conditions at Twin Buttes Reservoir.

MANAGEMENT AREAS

The following areas of particular interest and are specific to the implementation of this pest management plan.

Aquatic Lacustrine and Riverine Habitat
These areas include waters flowing into the reservoir, the reservoir itself, and outflows released from the reservoir. Lacustrine and riverine are terms defined in Classification of Wetlands and Deepwater Habitats of the United States (Cowardin, et al.) The areas include the water covered areas of the Twin Buttes Reservoir North Pool and South Pool, the equalization channel, the South Concho River and Spring Creek. These waters provide habitat for fish and other aquatic organisms and provide a freshwater source for wildlife, livestock, irrigation, recreation, municipal water supplies and other downstream uses.

Aquatic Riverine Intermittent Habitat
Aquatic Riverine intermittent habitat contains surface water only on a seasonal or temporary basis. These project specific areas include the Middle Concho River, Burks Creek and several small, unnamed tributaries. The habitat remains dry most of the year and only holds surface water for relatively brief periods. Vegetation in this habitat consists mostly of willow baccharis and saltcedar with some mesquite.

Riparian Woodland Habitat
Riparian woodland habitat is found along the rivers and creeks within the study area where perennial surface water is historically found. It exists mainly in a corridor on either side of the channels and in some cases up the tributaries. Saltcedar, willow baccharis, and mesquite are all present in these habitat areas.

Transitional and Rangeland Habitat
These areas comprise a large portion of the project lands. They are dominated by mesquite ranging in size from a few inches in diameter and bushy to large mature trees.

Recreation Areas
These areas consist mostly of areas where boat ramps and camping facilities are located. There are also located at other shoreline access points. These areas require additional care and timing to avoid incidental herbicide exposure to the public, especially children.

TARGETED PESTS

Plants (this IPM deals only with specific phreatophytic plant species)

Impact of Phreatophytic Plant Species
The invasive nature, high evapotranspiration rate, very efficient means of reproduction, and ability to better exploit groundwater resources than other, more historically and ecologically appropriate species, allows these phreatophytic species to exploit the historical vegetative community. The proliferation of these heavy water utilizing species has resulted in encroachment within the riparian zone and led to increased competition and further decreases in

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soil moisture within the riparian community. Consequently, many endemic trees, shrubs, and grasses are no longer dominant and becoming increasingly scarce. Not only has the phreatophytic species replaced the higher quality riparian habitat, they significantly decrease the amount of water available for groundwater recharge and in-stream base flows, thereby causing further degradation to the aquatic ecosystem.

Phreatophytic Plant Species

The invasive brushy species of concern include the exotic saltcedar (*Tamarix ramosissima*), and two natives, mesquite (*Prosopis glandulosa*) and willow baccharis (*Baccharis salicina*). While mesquite and willow baccharis are considered native species, historically, they occupied only a small niche of the historical climax community. Interception, evaporation, and the ability of phreatophytic species to extract large amounts of water from the ground to meet transpiration requirements are the primary factors reducing water availability for the riparian and aquatic ecosystems.

Saltcedar

This non-native, deciduous, phreatophytic shrub or small tree grows rapidly, attaining a height of up to 30 feet, and forming dense, impenetrable thickets. Saltcedar is a native of Europe and Asia that was introduced in the United States in the early 1800's where it was sold as an ornamental, escaping cultivation in the 1870's. In the early 1900's, an attempt was made to use the trees for erosion control along waterways. Saltcedar became naturalized and spread rapidly in the 1930s and 1940s and by 1965, saltcedar had completed invasion of most suitable western riparian areas (DeLoach and Tracy 1997). An extremely invasive plant, saltcedar is now found across the western half of Texas and throughout the southwest.

Some of the undesirable traits of saltcedar include:

- consumes more water than comparable native plant communities
- crowds out native stands of riparian and wetland vegetation
- dries up springs, wetlands, riparian areas and small streams by lowering surface groundwater tables
- widens floodplains by clogging stream channels
- increases sediment deposition due to the abundance of saltcedar stems in dense stands
- increases the salinity of surfaces soil through salt exudation from its leaves rendering the soil inhospitable to native plant species
- provides generally lower wildlife habitat value than native vegetation

Reproduction of saltcedar is accomplished through several pathways. From April through October, each plant can produce 500,000 small, wind-disseminated seeds. Additionally, the plant has strong vegetative reproduction properties with the ability to establish new plants from removed stems, and resprouting from the root collar if established plants are disturbed (Merkel and Hopkins 1957). For new seedlings to survive, the soil must remain saturated for several months. The seedlings grow faster than most native plants and send down a tap root rapidly, with little branching until it reaches the groundwater table. At the groundwater table, the root develops profuse secondary branching. One study documented a saltcedar tap root to be 16 feet deep, with a diameter of 3/16 inches, and still growing toward the groundwater table 26 feet deep

(Hart 2003). At maturity, the roots exploit the groundwater table by placing the majority of the roots within the capillary zone above the groundwater table and extending some roots into the saturation zone. Saltcedar occupies an estimated 1092 acres within the study area and continues to expand as surface water levels decrease.

Of the three species of concern, saltcedar possesses the highest evapotranspiration rate, and studies have shown the evapotranspiration rate of a mature saltcedar tree to be up to 200 gallons per day (McGinty and Hart 2001). An acre of dense saltcedar on the upper portion of the Pecos River in Texas, is estimated to use 5 to 7 acre-feet of water every year (Hart 2003). Brotherson et al. (1982) conducted a study showing that the longer the saltcedar occupies an area, the drier it becomes.

Mesquite

This species is a natural component of Texas rangeland, and historically, mesquites grew as single-trunk specimens that were limited to lowland areas. Today, dense stands of mesquite are found on lowland and upland sites, and the plant is now considered a noxious brush species occurring on millions of acres of Texas rangeland.

Mesquite is a facultative phreatophyte (Sosebee and Wan 1987) capable of growing up to 60 feet and developing trunks three feet in diameter. If its canopy is damaged or killed, it resprouts from its basal bud zone (root collar) and develops a multi-trunk form that becomes very resistant to control. It is well adapted to both wet and dry conditions once established, and can easily dominate an area due to its extensive dual root system including lateral roots and taproots. The lateral roots consume water from shallow depths as available and in drought conditions, tap roots pump water from far beneath the surface (Jensen 1988). Mesquite of various densities currently dominates approximately 4,710 acres within the study area. In addition to the habitats mentioned above, mesquite is also prevalent on the dam face and the area downstream of the dam and will be treated there if conditions permit.

Mesquite possesses a dual root system including a shallow root system and a much deeper root system, which allows it to extract water directly from the groundwater table while following the resulting lowered groundwater levels to great depths. Mesquite taproots have been found extending up to 60 feet below the surface to reach groundwater (Sosebee and Wan 1987). A study conducted in Throckmorton, Texas, approximately 140 miles northeast of Twin Buttes Reservoir, found daily water loss of each mesquite tree to be between 7.9 to 19.8 gallons.

Willow Baccharis

Willow baccharis is a hardy, native perennial shrub that can grow to 13 feet tall (Hobbs and Mooney 1987). Historically, it was confined to riverbanks and creek channels within the region, but it has expanded its range to include uplands areas as well. Willow baccharis is an aggressive invader species that quickly invades and dominates disturbed sites. It is a prolific seed producer that also spreads through adventitious buds along lateral roots and exhibits strong resprouting characteristics. It frequently forms dense, closed canopy stands (Holmes 1998). Willow baccharis is a phreatophyte estimated to utilize more water than mesquite (Gatewood et al. 1950).

OBJECTIVES FOR TREATMENT

The removal of native vegetation during construction coupled with the failure of the reservoir to maintain the conservation pool and historical low lake levels have led to the proliferation of invasive phreatophytic plant species, saltcedar, willow baccharis and mesquite. These phreatophytic plant species are responsible for decreased stream-flows and a lowered groundwater table resulting in additional degradation to the quantity and quality of aquatic habitats and a cycle of ever-increasing proliferation of these invasive phreatophytic plants.

The objectives of treatment include the following:

- Protect the structural integrity of the dam embankment from damage caused by root systems of trees and woody vegetation, primarily mesquite.
- Control the proliferation of phreatophytic vegetation to conserve groundwater resources and prevent additional degradation of aquatic habitat.
- Prevent the establishment of phreatophytic vegetation in areas not now affected.
- Lessen and/or eliminate competition of undesirable woody plants with native plants and grasses for valuable groundwater resources.
- Restore mesquite dominated rangelands to grasslands.

DOCUMENTATION AND MONITORING

Documentation of the existing size and extent of phreatophytic plant communities (prior to treatment) coupled with documentation of treated areas and plant mortality and regrowth monitoring (after treatment), will be used to measure the effectiveness of the brush control program.

- The existing extent of each species of concern will be determined using airborne GPS mapping.
- For aerial applications, documentation records including date, time, application rates, and weather conditions will be generated.
- Areas treated by aerial application will be mapped using an airborne GPS mapping program to facilitate comparative analysis with pre-treatment maps.
- The mixing and handling of all herbicides will be monitored to ensure chemical label safety recommendations and restrictions are adhered to. This will also serve as quality control for treatment effectiveness determinations.
- Areas treated by mechanical means will be mapped using a GPS recorder to document areal locations and extents.
- Treated areas will be monitored in successive growing seasons to determine treatment method(s) effectiveness and need for follow-up treatments
- Photographs will be taken of treatment and monitoring activities to be used for documentation purposes.

THREATENED AND ENDANGERED SPECIES

USFWS reports that two endangered species, two threatened species, and one candidate species are federally listed and known to occur within Tom Green County, as summarized in Table 1. In addition, the American peregrine falcon (*Falco peregrinus* var. *anatum*) and Texas horned lizard (*Phrynosoma cornutum*) are listed as State endangered species for Tom Green County. Most of these species are not known to occur within the study area. Species of particular interest identified by the USFWS within the proposed project area are the black-capped vireo and the Concho water Snake.

TABLE 1. Threatened and Endangered Species That May Occur Within Study Area

Common Name	Scientific Name	Federal or State	Status
Black capped vireo	*Vireo atricapillus*	Federal and State	Endangered
Interior least tern	*Sterna antillarum*	Federal and State	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Federal (de-list pending) and State	Threatened
Concho water snake	*Nerodia paucimaculata*	Federal	Threatened with critical habitat
Whooping crane	*Grus americana*	Federal and State	Endangered
Texas horned lizard	*Phrynosoma cornutum*	State	Threatened
American peregrine falcon	*Falco peregrinus* var. *anatum*	State	Endangered

Black-capped Vireo (*Vireo atricapillus*)

This strikingly beautiful endangered songbird is known to occur in Tom Green County and is considered a habitat specialist, nesting in mid-successional brushy areas (before areas develop into mature woodlands) where the dominant species are oaks, sumacs, persimmon, and other broad-leafed shrubs. Juniper may be common in vireo habitat, but juniper prominence is not essential or even preferred by the birds. Typical nesting habitat is composed of a shrub layer extending from the ground to about six feet covering about 35-55% of the total area, combined with a tree layer that may reach 30 feet or more. Open, sometimes grassy spaces separate clumps of trees and shrubs. The vireo depends upon broad-leafed shrubs and trees, especially oaks, which provide insects upon which it feeds. Due to the lack of suitable habitat and its relatively disturbed nature, it is unlikely that this species would utilize the study area.

Concho Water Snake (*Nerodia paucimaculata*)

The Concho water snake was listed as threatened on September 3, 1986, with critical habitat designated on June 29, 1989. Critical habitat includes a stretch of the Concho River extending from Mullin's Crossing located 5 miles northeast of the town of Veribest, downstream to the confluence of the Concho and Colorado Rivers in Tom Green and Concho Counties (USFWS 1993). In addition, critical habitat includes a stretch of the Colorado River extending from FM 3115 bridge near the town of Maverick downstream to the confluence of the Colorado River and Salt Creek, northeast of the town of Doole, Runnels, Concho, Coleman, and McCulloch Counties; and the entire O.H. Ivie Reservoir basin. Although historically the Concho water snake occurred over about 276 miles of the Colorado and Concho Rivers, it is presently distributed

discontinuously over about 199 river miles of the Colorado and Concho Rivers in 20 Texas counties (USFWS 1993).

Habitat for the Concho water snake consists of shallow riffles, rock debris, and crevices for shelter, and free-flowing streams over rocky substrates. Adults can live in either shallow or deep flowing water over various substrates but riffles are critically important to the survival of juveniles. Diet consists mostly of fish; juveniles feed almost entirely on minnows (Rose 1989). Decline of the species is due to loss of habitat and degradation due to large, mainstream reservoirs on the Colorado and Concho Rivers, plus several smaller impoundments on tributary streams. Other threats include pollution and water quality degradation due to refining, petroleum production, treated sewage disposal, pesticide use and feedlot activities. There is critical habitat designated for the Concho water snake in Tom Green County; however, it is downstream of Twin Buttes Reservoir on the North Concho River. Due to the lack of suitable habitat and location, it is unlikely that this species would utilize the project lands.

SPECIES SPECIFIC PEST MANAGEMENT

Saltcedar Treatment

Saltcedar within the study area grows extremely thick, estimated up to 3,000 stems per acre, and limits the methods available for consideration. Several removal methods were considered, including mechanical, chemical and biological means. The preferred method must kill or remove the root crown located approximately 18 inches beneath the ground surface.

Mechanical removal means considered to remove saltcedar included powergrubbing, excavation, cabling, chaining, root plowing, and hydraulic shearing with herbicide application. The thick growth of some saltcedar stands makes mechanical removal ineffective and inefficient. Mechanical methods would require more than one treatment to ensure the removal of all root crowns, root fragments, and other remnants capable of sprouting, and can be non-selective disturbing roots of desirable herbaceous and woody species. Further, heavy equipment cannot access most of the saltcedar areas because saltcedar is located in lower areas capable of holding water at or near the surface periodically. Therefore, mechanical removal was not considered further as a viable means of saltcedar treatment.

Hydraulic shearing with herbicide application is also not considered a viable alternative for saltcedar within the study area. Hydraulic shearing is not designed for dense growths of saltcedar or smaller plants and proper herbicide application is not possible, rendering this removal method ineffective.

Conducting a prescribed burn across stands of saltcedar is highly effective at removing the top growth, but it would sprout vigorously from its roots. Additional treatment would then be required and prescribed burning saltcedar is therefore not a viable consideration.

Biological control of saltcedar was also explored. The saltcedar leaf beetle, *Diorhabda elongata*, introduced from northern China and Kazakhstan in central Asia is approved for release by the United States Department of Agriculture-Animal and Plant Health Inspection Service (APHIS).

The beetle was rigorously studied to ensure that beetles would not threaten other non-target species. Both adults and larvae feed on the saltcedar leaves and repeated feeding by subsequent generations of beetle larvae is expected to cause dieback and suppress growth. The number of beetles required to make an impact in a timely manner upon such large acreage of saltcedar are unavailable and therefore it cannot be considered a viable alternative for initial control.

The most cost effective method is herbicide application of *Habitat* applied in August or September. To obtain optimum kill rate, saltcedar should remain undisturbed for two years. Due to the dense growth of the saltcedar and difficulty accessing saltcedar stands, ground spraying is not possible and aerial spraying is required.

Herbicide application by rotary-wing aircraft (helicopter) is more effective than herbicide application by fixed-wing aircraft for several reasons. Helicopters fly at a much slower air speed enabling accurate application to non-linear populations of saltcedar, especially beneficial along tributaries. Helicopters have much less spray pattern distortion during turns than fixed-wing aircraft, and are equipped with special booms that deliver the herbicide in larger droplet sizes, preventing the danger of spray drift that fixed-wing aircraft possess.

Approximately 1,092 acres will require saltcedar removal. A possible secondary treatment, biological control by releasing of the saltcedar leaf beetle, would occur three years after initial treatment to control any then-existing stands and prevent future saltcedar expansion.

Willow Baccharis Treatment

Willow baccharis is very similar to saltcedar in its growth habit within the study area, growing dense stands up to 3,000 stems per acre, although it does not grow as tall. The same comparison results are drawn. Alternatives considered for removal of willow baccharis included mechanical removal, prescribed burn and herbicide application. For the same reasons as saltcedar, removal of willow baccharis through mechanical means and prescribed burning is ineffective and requires additional treatments. Therefore, mechanical means and prescribed burning were not considered viable alternatives.

Like saltcedar, the most cost efficient means is herbicide application, and it must be done from the air due to dense growth and the difficulty accessing the willow baccharis stands. Again, due to the non-linear growth of the willow baccharis stands, rotary-wing aircraft (helicopter) more effectively applies herbicide. Herbicide application of the recommended mixture of *Weedmaster* and *Spider* herbicides in the spring, with one year non-disturbance, is over 90% successful. Approximately 1,544 acres will require treatment. An additional individual plant spray treatment may be required two years after initial treatment.

Mesquite Treatment

Mesquite possess a root crown approximately 12-18 inches underground that must be killed or removed in order to successfully kill the mesquite. Several alternatives available for removal of mesquite were investigated. Alternatives considered for mesquite removal included several mechanical methods, herbicide application, and prescribed burning.

Prescribed burning is not effective upon mature mesquite plants, those greater in age than a few

years. Only the top growth is destroyed and the root system remains viable. Fire is not considered a viable alternative for initial removal of mesquite.

Herbicide application with the recommended mixture of *Reclaim* and *Remedy* herbicides is an effective means of removing mesquite. Due to the areal extent, density, height of the mesquite and the terrain, herbicide application through individual plant treatment is not feasible for consideration. The only feasible alternative for herbicide application within the study area is aerial application. Aerial herbicide (fixed wing) application can result in significant vapor drift during application and the herbicide has been documented to kill agricultural crops, especially cotton, and other desirable vegetation within vapor drift areas. Helicopter aerial herbicide application will reduce vapor drift, but due to the nature of the herbicide and application requirements it cannot be used for all mesquite areas. There are residential areas and agri-business operations adjacent to mesquite areas and vapor drift is a major concern. Due to the serious consequences of vapor drift, it has been determined that aerial herbicide application can possibly be used for approximately 2,471 acres, but only if conditions warrant.

Repeated aerial herbicide applications over a several year period with *Weedmaster* herbicide may be an effective means of removing mesquite. *Weedmaster* herbicide would defoliate the mesquite and prevent photosynthesis from occuring. The kill rate with this type of treatment regimen would only be around 15% the first year and subsequent applications would achieve higher kill rates. However, due to uncertainty about the number of years between applications, the number of applications necessary to achieve a sufficient kill percentage, and the lack of available research data to support this method, it was discarded as an option.

Mechanical removal methods considered were powergrubbing, excavation, chaining/cabling, root plowing, and hydraulic shearing with herbicide application. Effectiveness of all mechanical removal methods were comparable, 85% and above when performed properly. Chaining/cabling is only effective for removing trees 4 to 18 inches in diameter. It is also very non-selective and impacts desirable woody vegetation. Due to its limited use on specific sizes of mesquite and its non-selectivity, chaining/cabling was not considered a viable alternative.

Powergrubbing is probably the next least effective means of mesquite removal, but it can be fairly effective with a good operator and good ground conditions. It is very selective, but not as selective as excavation. As compared to excavation, powergrubbing disturbs a much greater area because the dozer must push the mesquite out of the ground creating an entrance and an exit trench, totaling approximately 8 feet in length and at least 2 feet wide, and the dozer must also travel to each mesquite in order to remove it, creating further ground and desirable vegetation disturbance. Follow-up treatments to remove the mesquites not initially removed is also required. Powergrubbing was removed as an alternative because it was not one of the most cost effective alternatives.

Hydraulic shearing with herbicide application is highly selective and can be highly effective, up to 98%, but its effectiveness is dependent upon the care exercised when applying the herbicide. The ground immediately adjacent to the trunk of the mesquite is left undisturbed. Hydraulic shearing with herbicide application is considered a viable alternative. However, based on visual observation, most of the mesquite areas on project lands were previously mechanically treated,

which has resulted in dense monocultures of multi-stemmed mesquite. Apparently either the ground was bladed or chained at the time of dam construction, which left root systems intact. Hydraulic shearing with herbicide application in stands of multi-stemmed, dense mesquite with oversized root systems would be ineffective and therefore was removed as an alternative.

Excavation offers the highest effectiveness and is highly selective. Only plants growing immediately adjacent to the mesquite, up to 3 feet from the trunk, are detrimentally affected. It can be about 95% effective if the machine operator is skilled. Excavation also generates desirable ancillary environmental benefit. The method creates small holes after mesquite is removed. Holes left are approximately three to four feet wide, sloping from the edge to about 18 inches deep in the middle. These holes would serve to retain water during rain events and hold moisture for longer periods of time than is possible on flat, undisturbed areas. This is vital component to maintaining desirable grass and forb species under the dry and hot summer conditions the study area experiences. This method is considered feasible and will be used in less dense mesquite stands with larger trees.

Root plowing creates the most ground disturbance of all the mechanical removal means. However, given the uniform tree size, oversized root systems, density and the monoculture nature of most of the stands of mesquite in the study area, it has been deemed to be not only the most cost effective method, but also the only mechanical method that will achieve high kill rates on the majority of acreage chosen for mechanical treatment. Approximately 2,238 acres of mesquite has been targeted for root plowing and/or excavation.

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APPENDIX B

LINKS TO

HERBICIDE LABELS
AND
HERBICIDE MSDS SHEETS

LINKS TO HERBICIDE LABELS AND MSDS SHEETS

Habitat Herbicide Link
http://www.cdms.net/LabelsMsds/LMDefault.aspx?manuf=82&t=2

Reclaim Herbicide Link
http://www.cdms.net/LabelsMsds/LMDefault.aspx?manuf=11&t=

Remedy Herbicide Link
http://www.dowagro.com/ca/prod/remedy.htm

Spyder Herbicide Link
ttp://www.cdms.net/LabelsMsds/LMDefault.aspx?manuf=171&t=