

Economic Impact Analysis  
Reoperation of Green River Lake, KY

Pilot Project for the Sustainable Rivers Project

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## 1. Background

Green River Lake is located in the Eastern Pennyroyal region of south central Kentucky. It is approximately ninety air miles south-southeast of Louisville, KY, about eight miles south of Campbellsville, KY, and 11 miles north of Columbia, KY. The dam site is at mile 305.7 on Green River. The lake area lies in Taylor and Adair counties with a very small easement in Casey County. At spillway crest level, it extends from the dam site up Green River a distance of thirty-five miles, and up Robinson Creek tributary a distance of about seventeen miles. Construction of the project began in April 1964 and was completed in June 1969. The project was placed in operation in February 1969 and has served as a multipurpose lake with flood risk management as the primary function. The dam is an earth and rock fill structure 141 feet in height by 2,350 feet in length by 960 feet base width. The control tower has 3 slide gates and 2 bypasses with intakes to control downstream water temperatures for aquatic species. To the right abutment an uncontrolled open cut serves as the spillway. A dike closes a saddle beyond the spillway. Counting both land (over 24,000 acres) and water (over 8,200 acres), Green River Lake's total acreage of over 32,000 acres marks it as being by far the largest project in the United States Army Corps of Engineer's Louisville District.

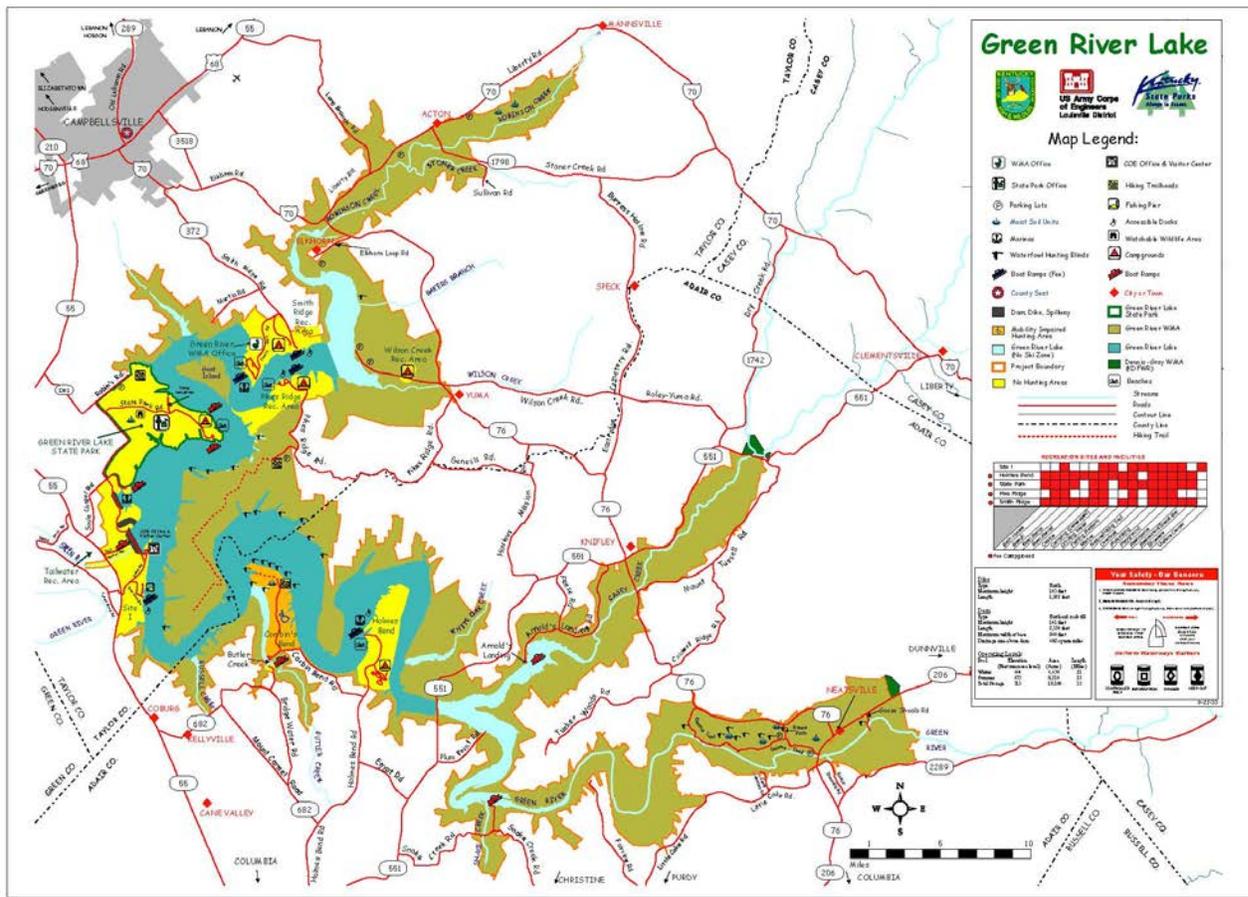
The Corps, in cooperation with the Commonwealth of Kentucky manages the land and water for wildlife, fisheries, and recreation purposes. The Corps administers the lands and water of Green River Lake in cooperation with several federal and state agencies and local governments. The Corps also owns the Green River Wildlife Management Area (WMA) and licenses it to the Kentucky Department of Fish and Wildlife Resources for wildlife management purposes. The WMA contains approximately 20,500 acres of relatively steep slopes with oak-hickory forests, flat bottomlands and ridge-tops with mixed hardwood forests. There are cleared areas with agricultural crops, warm, and cool season grass fields and "old-field succession" habitats. Beyond the surrounding terrain, Green River Lake hosts exceptional biological diversity. With more than 60 species of mussels, 152 species of fish, a host of endemic species and multiple cave systems that are connected to the river, Green River Lake has one of the richest aquatic collections in the nation. In fact, Green River is actually the 4<sup>th</sup> most biologically diverse river in the United States and is exceptional in the number of and variety of species of freshwater mussels that are found in its waters. Many of these species have been adversely impacted by human influences in the basin, including 12 globally rare fish species and 7 endangered, and 21 imperiled mussel species.

The 8,210 acre Green River Lake and surrounding area offers a wide variety of outdoor recreation opportunities. Situated amongst a rolling terrain, steep bluffs, and flowing streams, Green River Lake lies in the section of Kentucky known as the Highland Rim. Within this dynamic landscape, the project site offers a diverse variety of outdoor recreation opportunities. Green River Lake affords opportunities for camping (or related overnight lodging/visitation), fishing, boating, hunting, hiking, swimming, and sightseeing, amongst other various activities.

The Corps operates four campgrounds at Green River Lake. These campgrounds offer a variety of sites and facilities, including waterfront, woodland, primitive, and developed sites. The aforementioned campgrounds are: 1) Holmes Bend – Class A, the largest campground at Green River Lake with 125 sites (water and electric available), 2) Smith Ridge – Class A, second largest campground with 80 sites (water and electric available), Pikes Ridge – Class B, smallest campground with 60 sites (water and electric available), and 4) Wilson Creek – Non-fee, primitive camping area with 5 designated sites. The Kentucky Department of Parks also operates and manages Green River State Park on land leased from the Corps. The park maintains a 156 site lakeside campground (water and electric available). In addition to campgrounds, Green River Lake also features 3 privately operated, full service marinas. Those marinas are Green River Marina (Green River State Park), Holmes Bend Marina Resort, and Emerald Isle Resort and Marina. Amenities, services, and goods offered at each marina include, but are not limited to, boat rental (ranging from paddle canoes to houseboats), gas, bait, fishing gear and supplies, picnicking and grocery supplies, in addition to overnight lodging. The Corps and other local government organizations operate several day-use recreational facilities on Green River Lake beyond the campgrounds and marinas previously discussed. The recreation areas of Butler Creek and Arnold’s Landing, for instance, are maintained and operated by the Adair County, KY government body.

In addition to campgrounds, fishing, boating, and swimming are amongst the most popular recreation activities that take place on Green River Lake, although sightseeing, hunting, and picnicking outings are quite frequent as well. In fact, in 2010, readers of Kentucky Living magazine recognized Green River Lake as the second place winner for the category “Best Boating – Lake or River.” Green River Lake was also recognized as the third place winner for the category “Best Fishing Spot.” It is quite routine for single visits to the project site to yield participation in multiple activities. There are 10 boat ramps available for public use at Green River Lake, four of which are managed and maintained by the Corps. These include the ramps located at the Holmes Bend, Smith Ridge, Pikes Ridge, and Dam Area recreation sites. A launching permit (which can be purchased either annually or daily) is required to launch a boat at these Corps operated ramps. Another boat ramp is located at the Green River Lake State Park and is managed by the Kentucky Department of Parks. The other ramps include Green River Marina, Snake Creek, Butler Creek, Arnold’s Landing, and also Emerald Isle Marina. Snake

Creek ramp is operated by the Kentucky Department of Fish and Wildlife Resources while Arnold's Landing and Butler Creek are managed by the local Adair County, KY government. In terms of fishing opportunities, anglers can pursue a wide variety of species including, but certainly not limited to, walleye, crappie, smallmouth bass, largemouth bass, channel catfish, bluegill, and also one of the premiere muskie fisheries in Kentucky. The Corps and the Kentucky Division of Fish and Wildlife Resources work together on various projects to improve all fish habitats. The results of these joint efforts increase angler success whereby serving to provide a dynamic, enjoyable fishing experience. In addition to aquatic endeavors, many habitat improvement and proven wildlife practices (from native grass plantings to moist soil management efforts) are constantly underway at Green River Lake. As a result, a variety of wildlife and a number of game and nongame species inhabit the lands surrounding Green River Lake. Various habitats support deer, turkey, rabbit, quail, squirrel, dove, and waterfowl populations at the project site. Do to its distinct terrain and wide-ranging wildlife population, hiking, hunting, and general sightseeing generate significant visitation to Green River Lake.



## 2. Purpose

In the Fall of 1998, representatives of The Nature Conservancy (TNC), including the Green River Bioreserve Director, Richie Kessler, the Director of the Kentucky Chapter, Jim Aldrich, and the TNC Staff Hydrologist, Brian Richter, met with representatives of the Planning and Water Management elements of the Louisville District, U. S. Army Corps of Engineers (Corps). Corps representatives were Rob Fuller, Chief, Planning Division, Bob Beil, Chief, Hydrology Section, Bill Byron, Reservoir Management, Jeff Kleckner, Chief, Plan Formulation Branch, and Mike Turner, Senior Ecologist, Environmental Analysis Branch. Discussion centered on the opportunities for the two organizations to develop a beneficial working relationship in the TNC Green River Bioreserve Area, but particular emphasis was extended to the possibility of modifying the operation of Green River Lake. At the aforementioned meeting the Corps conceded that during certain times of the year high/low level/cold water releases are necessary to maintain the current operational objectives of the project. The Corps agreed that some flexibility may exist in these objectives which would allow for a more natural regimen of reservoir release. The Corps offered to consider a modified plan of operation on a three-year trial basis, provided the proposal maintained acceptable levels of current benefits (especially flood risk management and recreation) and provided that TNC collect data downstream to qualify/quantify the benefits served by the modification.

The conservation goals and strategies proposed by TNC centered on restoring natural hydrologic (flow quantity, timing, and variability) and temperature regimes to Green River, KY. Restoration of natural hydrologic and temperature regimes was considered to be imperative to maintaining and improving the aquatic biota and riparian ecosystem of the Green River Bioreserve. This strategy was also considered to be perhaps the most challenging goal because restoration of historic pre-dam flow conditions runs counter to the primary reason for construction of the Green River Dam and Lake, which is flood risk management. An analysis of discharge records for Green River Dam revealed the extent to which recent water temperatures had differed from historic conditions. It was determined that natural or near-natural conditions could be restored by changing the operation of the dam or by modifying discharge structures for temperature control. The degree of hydrologic alteration was determined to provide management options to restore the natural hydrologic regime without compromising Green River Dam and Lake operating goals. Even though TNC's conservation goals and strategies of restoration of natural flow conditions appeared to function counter to reservoir flood risk management objectives, it was concluded that this was not necessarily the case. The most efficient reservoir operation is one which accomplishes all design objectives while minimizing

the deviations from normal. In this respect the goals of TNC and the Corps were found to be compatible.

The intent of the reoperation modification was to produce an operating plan which met existing Corps objectives (especially flood risk management) and concurrently produced a more natural regime of reservoir release and outflow temperatures. Green River Lake, like most Louisville District projects, is operated with a winter and summer pool. When the project is at pool, either winter or summer, and in a normal operating mode (i.e. passing inflow) releases are comparable to that experienced in the natural flow regime. However, during the filling period (15 March – 15 April, or until summer pool is attained) and during the drawdown period (15 September – 30 November) releases can and do vary significantly from what would be expected naturally. Flows on an annual or yearly basis compare quite favorably; however, flows during the filling and emptying periods, especially in the ranges of multilevel release capability (300 – 350 cfs) diverge by about 30 percent. Spring releases occur about 30 percent less often and Fall releases occur about 30 percent more often. Any increase in duration of release above the capacity of the multilevel release system, especially after lake stratification (typically June), increases the potential for atypical cold water releases. The greater the difference between winter and summer pool, the greater the potential for deviation from a natural flow regime. During both periods of pool stability, winter and summer, releases from the project are quite similar in duration to those experienced in the natural regime.

Since recreational facilities at this project were designed for a summer pool level of 675 and modification of this would have incurred significant cost and create social unrest, no consideration was given to a change in summer pool level. A higher winter pool level at Green River Lake was limited by established flood risk management capabilities and not by the total environmental benefit that could be achieved.

Displayed in Table 1 below is the original Green River Lake operation plan, which was in effect from 1969 to 2001.

**Table 1**

<b>Original Green River Lake Operation Plan (1969 - 2001)</b>	
<b>Pools</b>	
Winter Pool	664
Summer Pool	675
<b>Non-Crop Season Release Rates</b>	
Maximum	7200 cfs
Minimum	300 cfs
<b>Spring Filling Schedule</b>	
15 March - 15 April (or until 675 is attained)	
Minimum release 50 cfs	
<b>Fall Drawdown Schedule</b>	
15 September - 15 October	675 - 674
16 October - 30 November	674 - 664

Table 2, below, displays the proposed, accepted, and new reoperation plan for Green River Lake, which has been in effect from 2002 to present.

**Table 2**

<b>Green River Lake Reoperation Plan (2002 - 2010)</b>	
<b>Pools</b>	
Winter Pool	668
Summer Pool	675
<b>Non-Crop Season Release Rates</b>	
Maximum	8200 cfs
Minimum	300/1000 cfs
<b>Spring Filling Schedule</b>	
March 15 - April 15	668 - 673
April 16 - May 1	673 - 674
May 2 - May 15*	674 - 675
*or until summer pool is reached	
<b>Fall Drawdown Schedule</b>	
September 15 - October 31	675 - 674.5
November 1 - November 30*	674.5 - 668
*or until winter pool is reached	

General comparison between the former and current operating plans for Green River Lake yields the following conclusions: 1) winter pool has been permanently raised four feet from 664 to 668, 2) non-crop season release rates have been increased (both maximum and minimum amounts), 3) the spring filling schedule has been extended by, generally, thirty days (from April 15 to May 15 – or until summer pool is reached), and 4) the fall drawdown schedule has been altered by only reducing pool elevation one foot through October 31 as opposed to October 15 and drawdown measures halt at the modified winter pool level of 668 as opposed to 664. The remainder of the fall drawdown is accomplished after temperatures equalize from top to bottom in the lake, usually in mid to late November.

Based on a comparison of key variables and environment analysis conducted in a joint effort between TNC and the Corps, it was determined that the reoperation plan of Green River Lake become permanent after a three year trial period that began in 2002 and concluded in 2005. This determination was made as the reoperation manifested multiple positive environmental and ecological benefits while not adversely impacting the project's primary objective of flood risk management. This plan produced an improved flood risk management capability for events of high magnitude and only slightly worse utilization for routine annual events. Therefore, no loss of flood risk management benefit is attributed to the increased winter pool. Use of this plan resulted in a reduction of May cold water releases by 8 percent and October cold water releases by over 46 percent. Environmental analysis indicated that it provided the best overall reproduction of a natural flow regime. In addition, the use of a 668 winter pool provided for greater capability/capacity in utilization of the upper opening of the multilevel release system. This capability/capacity provided for better opportunity to release higher temperature waters during the spring when the overall temperature of the reservoir water column is less than the natural temperature regime. Preliminary analyses indicated that a delayed filling and higher winter pool provides an improvement in overall lake water quality. The reoperation plan was also found to generate a more dependable source of water supply.

In light of the proven improvements and benefits to environmental quality, flood risk management, water quality, and dependability as a source of water supply of Green River Lake as a result of the reoperation efforts, the true impact on recreation at the project site was mostly unknown. What is known is that the reoperation plan delayed or modified filling shows some adverse impact on attainment of summer pool level. Though the former operation plan defines the filling curve as mid-March through mid-April, in reality, no adverse impacts are associated with non-attainment of summer pool until Memorial Day. This, in effect, provides the former plan more than an additional month to reach the desired level. A shift in filling of as little as 15 days has a measurable impact on dependability of attaining summer pool. Though

the delay, in combination with higher releases, reduces the number of days that the project is above the desired recreation level, this is not enough in itself to offset the filling deficiencies. Table 3 shows the monthly duration for pool levels in the desired recreational zone (summer pool  $\pm 1$  foot) for the original operation and reoperation. Reoperation is shown to reduce the percent of time in the ideal recreation zone during June, July, August and September by 2.8, 0.99, 1.38, and 1.89 percent but increases the period for ideal recreation during October by 52.36 percent.

**Table 3**

Percentage Time Between 674 and 676 (Summer Pool +/- 1 foot) (WY 1940 - 1999)			
	Original Operation	Reoperation	% change
June	80.9	78.7	-2.80%
July	91.6	90.7	-0.99%
August	95.4	94.1	-1.38%
September	86.1	84.5	-1.89%
October	38.4	80.6	52.36%

The purpose of this study is to investigate the Green River Lake reoperation plan to determine, within the scope of the reoperation procedures, the impact it has had on recreation at the project site based on the regional economic impacts that have taken place as a result of its application.

### 3. Methodology

The Recreation Economic Assessment System (REAS) model was utilized to determine the economic impacts of the reoperation of Green River Lake, KY. REAS is the Corps' latest model for conducting economic impact analysis. REAS was designed to provide a strategic, accurate way of applying appropriate multipliers to spending and visitation data. This model was developed by Dr. Wen-Huei Chang and Scott Jackson, Engineer Research and Development Center (ERDC), USACE, in cooperation with Daniel Stynes and Dennis Propst, Department of Park, Recreation, and Tourism Resources, Michigan State University. The research team at ERDC has modified the model specifically to accommodate Corps applications.

The REAS model is most simply put, at its core, an input-output (I/O) model that utilizes inputs (visitation data) to produce estimated economic outputs (total sales, jobs supported, and labor income) which can assist an analyst in conducting an economic impact analysis. An impact analysis estimates the importance or significance of an industry or activity to a region and usually includes spending by both local residents and visitors from outside the region. An input-output model is a representation of the flows of economic activity between sectors within a region. The model captures what each business or sector must purchase from every other sector in order to produce a dollar's worth of goods and services. Using such a model, flows of economic activity associated with any change in spending may be traced either forward (e.g., spending generates employee wages, which induces further spending) or backward (e.g., visitor purchases of meals leads restaurants to purchase additional inputs, such as groceries, utilities, etc.). Multipliers for a region may be derived from an I/O model of the region's economy. Multipliers capture the size of the secondary effects in a given region, generally as a ratio of the total change in economic activity in the region relative to the direct change. Multipliers may be expressed as ratios of sales, income or employment, or as ratios of total income or employment changes relative to direct sales. Multipliers express the degree of interdependency between sectors in a region's economy and therefore vary considerably across regions and sectors. Custom and unique multipliers based on historically supported economic and recreational activity within a 30 mile radius of the Green River Lake, KY area were utilized for this effort.

Input-output models essentially explore the linkages that exist between industries. An input of one industry is the output of a second industry. Any change in the output of an industry will have an indirect impact on the industries that are linked to this producer. Furthermore, changes in production that require a change in labor will induce an impact on consumer spending. These three impacts— direct, indirect, and induced – make up the multipliers that were used in this analysis. Final demand is the term for sales to final customers (household or government). Sales between industries are termed intermediate sales. Economic impact analysis generally estimates the regional economic impacts of final demand changes with consideration to the capture rate of the region itself, relative to the activity studied. Capture rate is the percentage of spending that accrues to the region's economy as direct sales or final demand. Similar to the multipliers mentioned previously, the capture rate utilized for this effort was custom and unique to the Green River Lake, KY area based on historically supported activity and nature of the surrounding economic landscape within a 30 mile radius. All tourists spending on services within the region are captured; however, tourist purchases of goods are generally not all treated as final demand to the region. For imported goods bought at retail establishments, typically only the retail (and possibly the wholesale) margins will accrue to the local economy. Visitor spending is one type of final demand. The REAS model accounts for all economic activity generated by visitation to Corps and non-Corps owned and operated recreation locations alike within a 30 mile radius of the project site.

For this effort, annual visitation data were acquired for the fiscal years of 1994 through 2010 and applied to the REAS model to determine visitor spending. The analysis consisted of two distinct data sets, both with equal eight year durations – FY94 through FY01 and FY03 through FY10 (FY02 was considered independent of the aforementioned data sets as it represented the fiscal year in which the reoperation of Green River Lake took place. For the purposes of comparison and analysis, it was considered as an independent year of activity as the proposed reoperation methods were initiated and instituted). Determining final demand allows for the estimation of direct effects to the economy. Direct effects are the changes in economic activity during the first, initial round of spending. For tourism, this involves the impacts on the tourism industries (businesses selling directly to tourists) themselves. Beyond direct effects, secondary effects are the changes in economic activity from subsequent rounds of re-spending or tourism dollars. There are two types of secondary effects, indirect and induced. Indirect effects are the changes in sales, income, or employment within the region in backward-linked industries supplying goods and services to tourism businesses. For example, the increased sales in linen supply firms resulting from more motels sales, is an indirect effect of visitor spending. Induced effects are the increased sales within the region from household spending of the income earned in tourism and supporting industries. Employees in tourism and supporting industries spend the income they earn from tourism on housing, utilities, groceries, and other consumer goods and services. This resulting activity generates sales, income, and employment throughout the region's economy. The overarching goal of this particular analysis is to provide the total effects of the reoperation of Green River Lake (via total sales dollars, jobs supported, and labor income) to the region, based on visitation and activity participation data. Total effects, quite simply, are the sum of direct, indirect, and induced effects.

#### **4. Results**

Activity and visitation figures associated with Green River Lake for the use of this analysis were provided by Lori Brewster and Jim Goode of the Green River Lake Corps Project Office and by Keith Chasteen of the Operations Division of the Louisville District. As mentioned in the Methodology section, for this effort, annual visitation data were acquired for the fiscal years of 1994 through 2010 and applied to the REAS model to determine economic impacts. The analysis consisted of two distinct data sets, both with equal eight year durations – FY94 through FY01 and FY03 through FY10 (FY02 was considered independent of the aforementioned data sets as it represented the fiscal year in which the reoperation of Green River Lake took place. For the purposes of comparison and analysis, it was considered as an independent year of activity as the proposed reoperation methods were initiated and instituted at the project site).

The following Table 4 presents the total visitation data associated with Green River Lake segmented into Original Operation Schedule (FY94 through FY01) and Reoperation Schedule (FY03 through FY10). The table delineates the particular fiscal year, number of total annual visits to the project site, and the percentage change in visitation from the previous fiscal year to the following fiscal year. Also captured in this table is the total percentage change in visitation from the beginning of each data set to the end, along with an average annual percentage change in visitation.

**Table 4**

**Green River Lake, KY  
Total Annual Visits**

	<b>Fiscal Year</b>	<b>Total Visits</b>	<b>% change</b>	
<b>Original Operation Schedule</b>	1994	767,800		
	1995	862,200	12.29%	
	1996	841,700	-2.38%	
	1997	943,700	12.12%	
	1998	984,410	4.31%	
	1999	1,269,405	28.95%	
	2000	1,048,748	-17.38%	
	2001	1,028,561	-1.92%	
	Total % Change (1994-2001)			35.99%
	Average Annual % Change			5.14%
	2002	1,037,516	N/A	
<b>Reoperation Schedule</b>	<b>Fiscal Year</b>	<b>Total Visits</b>	<b>% change</b>	
	2003	977,857		
	2004	1,063,574	8.77%	
	2005	1,118,113	5.13%	
	2006	1,151,522	2.99%	
	2007	1,244,338	8.06%	
	2008	1,204,584	-3.19%	
	2009	1,348,391	11.94%	
	2010	1,464,218	8.59%	
		Total % Change (2003 - 2010)		
	Average Annual % Change			6.04%

Examination of the Original Operation Schedule (FY94-FY01) reveals that annual percentage changes in visitation varied widely across the eight year duration, ranging from a -17.38% decrease in FY00 to a 28.95% increase in FY99. Explanation for the visitation spike in FY99 and subsequent drop in FY00 were sought after via use of literature research and informal

interviews conducted with Louisville District personnel, Green River Lake Project Office personnel, and local marina and business owners, but no concrete conclusions were determined. At the time of this writing it can only be assumed that the 28.95% spike in FY99 served as an anomaly and the -17.38% drop in FY00 stands as the likely return to normalcy from said anomaly. However, this vast fluctuation in visitation is also represented with four years of increased visitation compared with three years of decreased visitation. The total percentage change of total visits during the Original Operation Schedule was found to be 35.99% with an average annual percentage change to be 5.14%. As far as Reoperation Schedule (FY03-FY10) data, on the other hand, total percentage change of total visits (42.28%) and average annual percentage change (6.04%) across the data set are only marginally higher than that of the Original Operation Schedule, but a closer inspection reveals a much different trend in visitation activity. For instance, the fluctuation in annual visitation in the Reoperation Schedule is limited to a -3.19% decrease in FY08 to an 11.94% increase in FY09. The 3.19% decrease in visitation in FY08 also serves as the only FY in which visitation decreased within the data set. The remaining six years all boasted positive trends in visitation to Green River Lake. In an effort to possibly better understand this lone FY of visitation downturn, it is important to note the national climate of economic activity of FY08 as the National Bureau of Economic Research (NBER) declared on December 1, 2008 that the United States had been in a recession since December 2007. It is quite reasonable to presuppose that this overarching dynamic of national economic recession contributed as a major factor in the lone FY of visitation downturn at Green River Lake during the Reoperation Schedule. Although the difference between total percentage change (6.29%) and average annual percentage change (0.9%) for total visitation for each data set is marginal in nature, it is of great importance to note that not only did visitation and recreational activity not decline as a result of the Reoperation Schedule, but it actually increased. The very nature of this visitation increase, albeit marginal, suggests that the hypothesis put forth by TNC and the Corps team with regard to reoperation of Green River Lake not adversely impacting recreation at the project site as being correct. In fact, trend analysis suggests that the steadier, more reliable growth rates in visitation over the last seven years advocates a declaration of a minor improvement to the recreation benefit category as a whole. From this point in the analysis it is of equal, if not more, importance to determine the resulting regional economic impacts that have occurred as a result of this more stable, healthy upward trend in visitation to Green River Lake, KY.

Table 5 below displays the actual activities and visitation figures for each activity enjoyed at Green River Lake during both the Original Operation Schedule and the Reoperation Schedule.

**Table 5**  
**Green River Lake, KY**  
**Visitation/Participation, by Activity**

		Activity data										
Original Operation Schedule	Fiscal Year	Camping	Picnic	Boat	Fish	Hunt	Ski	Swim	Other	Sgtsee	Activity Total	VISITATION TOTAL
		1994	102578	26233	77906	240270	7473	23520	96845	50393	247590	872,809
	1995	115190	29459	87485	269811	8392	26412	108752	56589	278031	980,120	862,200
	1996	112451	28758	85404	263396	8193	25784	106166	55244	271420	956,817	841,700
	1997	126078	32243	95754	295315	9185	28909	119032	61938	304312	1,072,767	943,700
	1998	131517	33634	99885	308055	9582	30156	124167	64610	317439	1,119,044	984,410
	1999	169593	43371	128802	397239	12356	38886	160114	83315	409341	1,443,017	1,269,405
	2000	140113	35832	106413	328188	10208	32127	132282	68833	338186	1,192,182	1,048,748
	2001	137416	35143	104365	321871	10011	31508	129736	67508	331677	1,169,234	1,028,561
	2002	138612	35448	105273	324673	10098	31783	130865	68096	334564	1,179,414	1,037,516
Reoperation Schedule	2003	130642	33410	99220	306004	9518	29955	123340	64180	315326	1,111,595	977,857
	2004	142093	36339	107917	332828	10352	32581	134152	69806	342967	1,209,035	1,063,574
	2005	149380	38202	113451	349895	10883	34252	141031	73385	360554	1,271,034	1,118,113
	2006	153843	39344	116841	360350	11208	35275	145245	75578	371327	1,309,012	1,151,522
	2007	166244	42515	126259	389395	12112	38118	156952	81670	401258	1,414,522	1,244,338
	2008	152580	41069	120621	377599	11032	35965	145856	81070	396341	1,362,133	1,204,584
	2009	180466	47504	137626	417022	13293	41787	172568	85709	437372	1,533,347	1,348,391
	2010	205391	48657	149681	462744	14727	45331	189307	96599	459703	1,672,140	1,464,218

This table delineates the participation of all the activities which are available at Green River Lake, KY. Individual activities include camping, picnicking, boating, hunting, skiing, swimming, other, and sightseeing. It should be noted that the sum total of all activities produces a visitation figure greater than the total visitation figure, as carried over from Table 4, which is also displayed. This difference is caused by the fact that many visitors to the project site take part in multiple activities during their one visit. For example, one visitor may come to Green River Lake and choose to boat, fish, and sightsee while on the project site. The REAS model utilizes custom multipliers designed around historically supported activity rates (according to VERS, date of last Recreation Use Survey for Green River Lake was October 27, 1992) and applies those multipliers to total visit figures. For this reason, for the remainder of the analysis total visitation figures were input into the REAS model to provide regional economic impacts.

Below, Table 6 shows the first results provided by the REAS model upon input of total visitation data. Table 6 displays total visitation and total visitor spending for each fiscal year analyzed in both the Original Operation and Reoperation schedules.

**Table 6**

**Green River Lake, KY**

**REAS – Total Visitor Spending, by year**

Original Operation Schedule	Fiscal Year	Total Visitation	Total Visitor Spending		
	1994	767,800	\$15,656		
1995	862,200	\$17,581			
1996	841,700	\$17,163			
1997	943,700	\$19,243			
1998	984,410	\$20,073			
1999	1,269,405	\$25,884			
2000	1,048,748	\$21,385	Total % change (94-01)	33.96%	
2001	1,028,561	\$20,973	Avg. Annual % change	4.85%	
2002		1,037,516	\$21,155		
Reoperation Schedule	2003	977,857	\$19,939		
	2004	1,063,574	\$21,687		
2005	1,118,113	\$22,799			
2006	1,151,522	\$23,480			
2007	1,244,338	\$25,373			
2008	1,204,584	\$24,562			
2009	1,348,391	\$27,494	Total % change (03-10)	49.74%	
2010	1,464,218	\$29,856	Avg. Annual % change	7.11%	

Table 6 presents a pattern very similar to that shown in Table 4 with respect to total visitor spending trends in each data set analyzed. During the Original Operation Schedule, the total percentage change in total visitor spending within a 30 mile radius of the Green River Lake area increased by 33.96% which produced an average annual percentage change of 4.85%. As with total annual visitation, however, an increase in total visitor spending is realized during the Reoperation Schedule as compared to the Original Operation Schedule. During the Reoperation Schedule, the total percentage change in total visitor spending within a 30 mile radius of the Green River Lake area is increased by 49.74% which generated an average annual percentage change of 7.11%. Under these conditions, the increase in total visitor spending figures is even

greater than the increase in total visitation figures. Total percentage change in visitor spending increased under the Reoperation Schedule by 15.78% and the average annual percentage change increased by 2.26% whereas respective total visitation comparisons only yielded increases of 6.29% and 0.9%. Consideration of single visitations generating multiple activity participation provides the explanation for the greater increases realized in total visitor spending versus total visitation. Also, as with total visitation, the trend analysis of total visitor spending under the Reoperation Schedule suggests a much steadier, more reliable growth pattern than what was experienced during the Original Operation Schedule. Reliable growth patterns in trend analysis support more probability for sustainable growth patterns for future segments, or years, in the case of Green River Lake total visitor spending under the Reoperation Schedule. An improvement in annual visitor spending of nearly 16% (from 33.96% to 49.74%) over an equal seven year time frame (2.26% average annual increase – from 4.85% to 7.11%) suggests an improvement in recreation activity and a positive regional economic impact under the Green River Lake Reoperation Schedule which may be even more than simply marginal.

The following Tables 7, 8, and 9, respectively, present additional increments built onto Table 6. Table 7 displays the total visitation, total visitor spending, and total sales for each fiscal year analyzed in both the Original Operation and Reoperation schedules. Total sales include the direct effects combined with secondary effects, indirect and induced, to produce the total effect as shown below. Similar to total visitor spending, under the Reoperation Schedule total sales increased by 15.78% (average annual percentage increase of 2.26%) over total sales in the Original Operation Schedule.

**Table 7**

**Green River Lake, KY**

**REAS – Total Sales, by year**

	Fiscal Year	Total Visitation	Total Visitor Spending	Total Sales		
				Direct Effects	Secondary Effects	Total Effects
<b>Original Operation Schedule</b>	1994	767,800	\$15,656	\$8,103.31	\$2,734.55	\$10,838
	1995	862,200	\$17,581	\$9,099.60	\$3,070.76	\$12,170
	1996	841,700	\$17,163	\$8,883.25	\$2,997.75	\$11,881
	1997	943,700	\$19,243	\$9,959.75	\$3,361.03	\$13,321
	1998	984,410	\$20,073	\$10,389.40	\$3,506.02	\$13,895
	1999	1,269,405	\$25,884	\$13,397.22	\$4,521.04	\$17,918
	2000	1,048,748	\$21,385	\$11,068.42	\$3,735.16	\$14,804
	2001	1,028,561	\$20,973	\$10,855.37	\$3,663.27	\$14,519
	2002	1,037,516	\$21,155	\$10,949.88	\$3,695.16	\$14,645
<b>Reoperation Schedule</b>	2003	977,857	\$19,939	\$10,320.24	\$3,482.68	\$13,803
	2004	1,063,574	\$21,687	\$11,224.89	\$3,787.97	\$15,013
	2005	1,118,113	\$22,799	\$11,800.49	\$3,982.21	\$15,783
	2006	1,151,522	\$23,480	\$12,153.09	\$4,101.20	\$16,254
	2007	1,244,338	\$25,373	\$13,132.66	\$4,431.76	\$17,564
	2008	1,204,584	\$24,562	\$12,713.10	\$4,290.18	\$17,003
	2009	1,348,391	\$27,494	\$14,230.83	\$4,802.35	\$19,033
	2010	1,464,218	\$29,856	\$15,453.26	\$5,214.88	\$20,668

Table 8 displays the total visitation, total visitor spending, total sales, and jobs supported for each fiscal year analyzed in both the Original Operation and Reoperation schedules. Jobs supported include the direct effects combined with secondary effects, indirect and induced, to produce the total effect as shown below. Similar to total visitor spending and total sales, under the Reoperation Schedule jobs supported increased by 15.78% (average annual percentage increase of 2.26%) over jobs supported in the Original Operation Schedule.

**Table 8**

**Green River Lake, KY**

**REAS – Jobs Supported, by year**

	Fiscal Year	Total Visitation	Total Visitor Spending	Total Sales			Jobs Supported		
				Direct Effects	Secondary Effects	Total Effects	Direct Effects	Secondary Effects	Total Effects
Original Operation Schedule	1994	767,800	\$15,656	\$8,103.31	\$2,734.55	\$10,838	145	37	182
	1995	862,200	\$17,581	\$9,099.60	\$3,070.76	\$12,170	163	41	204
	1996	841,700	\$17,163	\$8,883.25	\$2,997.75	\$11,881	159	40	199
	1997	943,700	\$19,243	\$9,959.75	\$3,361.03	\$13,321	179	45	224
	1998	984,410	\$20,073	\$10,389.40	\$3,506.02	\$13,895	186	47	233
	1999	1,269,405	\$25,884	\$13,397.22	\$4,521.04	\$17,918	240	61	301
	2000	1,048,748	\$21,385	\$11,068.42	\$3,735.16	\$14,804	198	50	248
	2001	1,028,561	\$20,973	\$10,855.37	\$3,663.27	\$14,519	195	49	244
		2002	1,037,516	\$21,155	\$10,949.88	\$3,695.16	\$14,645	196	50
Reoperation Schedule	2003	977,857	\$19,939	\$10,320.24	\$3,482.68	\$13,803	185	47	232
	2004	1,063,574	\$21,687	\$11,224.89	\$3,787.97	\$15,013	201	51	252
	2005	1,118,113	\$22,799	\$11,800.49	\$3,982.21	\$15,783	212	53	265
	2006	1,151,522	\$23,480	\$12,153.09	\$4,101.20	\$16,254	218	55	273
	2007	1,244,338	\$25,373	\$13,132.66	\$4,431.76	\$17,564	239	59	298
	2008	1,204,584	\$24,562	\$12,713.10	\$4,290.18	\$17,003	228	57	285
	2009	1,348,391	\$27,494	\$14,230.83	\$4,802.35	\$19,033	255	64	319
	2010	1,464,218	\$29,856	\$15,453.26	\$5,214.88	\$20,668	277	70	347

Table 9 displays all REAS outputs as determined by total visitation to Green River Lake, KY. Table 9 presents total visitation, total visitor spending, total sales, jobs supported, and labor income for each fiscal year analyzed in both the Original Operation and Reoperation schedules. Labor income includes the direct effects combined with secondary effects, indirect and induced, to produce the total effect as shown below. Similar to total visitor spending, total sales, and jobs supported, under the Reoperation Schedule labor income increased by 15.78% (average annual percentage increase of 2.26%) over labor income in the Original Operation Schedule.

**Table 9**

**Green River Lake, KY**

**REAS – Labor Income, by year**

	Fiscal Year	Total Visitation	Total Visitor Spending	Total Sales			Jobs Supported			Labor Income		
				Direct Effects	Secondary Effects	Total Effects	Direct Effects	Secondary Effects	Total Effects	Direct Effects	Secondary Effects	Total Effects
<b>Original Operation Schedule</b>	1994	767,800	\$15,656	\$8,103.31	\$2,734.55	\$10,838	145	37	182	\$3,035.66	\$805.33	\$3,841
	1995	862,200	\$17,581	\$9,099.60	\$3,070.76	\$12,170	163	41	204	\$3,408.89	\$904.35	\$4,313
	1996	841,700	\$17,163	\$8,883.25	\$2,997.75	\$11,881	159	40	199	\$3,327.84	\$882.85	\$4,211
	1997	943,700	\$19,243	\$9,959.75	\$3,361.03	\$13,321	179	45	224	\$3,731.12	\$989.83	\$4,721
	1998	984,410	\$20,073	\$10,389.40	\$3,506.02	\$13,895	186	47	233	\$3,892.08	\$1,032.53	\$4,925
	1999	1,269,405	\$25,884	\$13,397.22	\$4,521.04	\$17,918	240	61	301	\$5,018.86	\$1,331.46	\$6,350
	2000	1,048,748	\$21,385	\$11,068.42	\$3,735.16	\$14,804	198	50	248	\$4,146.45	\$1,100.02	\$5,246
	2001	1,028,561	\$20,973	\$10,855.37	\$3,663.27	\$14,519	195	49	244	\$4,066.64	\$1,078.84	\$5,145
	2002	1,037,516	\$21,155	\$10,949.88	\$3,695.16	\$14,645	196	50	246	\$4,102.04	\$1,088.24	\$5,190
<b>Reoperation Schedule</b>	2003	977,857	\$19,939	\$10,320.24	\$3,482.68	\$13,803	185	47	232	\$3,866.17	\$1,025.66	\$4,892
	2004	1,063,574	\$21,687	\$11,224.89	\$3,787.97	\$15,013	201	51	252	\$4,205.07	\$1,115.57	\$5,321
	2005	1,118,113	\$22,799	\$11,800.49	\$3,982.21	\$15,783	212	53	265	\$4,420.70	\$1,172.77	\$5,593
	2006	1,151,522	\$23,480	\$12,153.09	\$4,101.20	\$16,254	218	55	273	\$4,552.79	\$1,207.81	\$5,761
	2007	1,244,338	\$25,373	\$13,132.66	\$4,431.76	\$17,564	239	59	298	\$4,919.76	\$1,305.17	\$6,225
	2008	1,204,584	\$24,562	\$12,713.10	\$4,290.18	\$17,003	228	57	285	\$4,762.58	\$1,263.47	\$6,026
	2009	1,348,391	\$27,494	\$14,230.83	\$4,802.35	\$19,033	255	64	319	\$5,331.15	\$1,414.31	\$6,745
	2010	1,464,218	\$29,856	\$15,453.26	\$5,214.88	\$20,668	277	70	347	\$5,789.10	\$1,535.80	\$7,325

**5. Analysis**

It was assumed from the outset of the Green River Lake reoperation initiation that though the original operation schedule provided for slightly higher ideal summer pool utilization in June, July, August, and September, the reoperation plan was able to reasonably approach the original levels. This assumption was supported by minimal percentage decreases in each respective month of -2.80% (June), -0.99% (July), -1.38% (August), and -1.89% (September). Additionally, the reoperation schedule was found be able to produce a 52.36% increase in ideal recreation levels in the month of October. Since reoperation was initiated at Green River Lake, KY in 2002, total visitation to the project site has increased by 6.29% over an eight year time frame (35.99% from 1994 through 2001 versus 42.28% from 2003 through 2010). Average annual visitation to the project site has increased by 0.9% during that same time frame (5.14% from 1994 through 2001 versus 6.04% from 2003 through 2010). Additionally, from a regional economic impact standpoint, total visitor spending, total sales, jobs supported, and labor income generated from

Green River Lake have all increased by 15.78% over an eight year time frame (33.96% from 1994 through 2001 versus 49.74% from 2003 through 2010). Average annual increases in total visitor spending, total sales, jobs supported, and labor income generated from the project site has increased by 2.26% during that same time frame (4.85% from 1994 through 2001 versus 7.11% from 2003 through 2010). This documented increase in annual visitation to the project site and the consequential increase in regional economic activity generated by that visitation growth trend conclude that the reoperation of Green River Lake, KY had no adverse impacts on recreation and its associated regional economic activity. In fact, it can also be concluded that rather than being adverse or neutral, the true impact of the reoperation has actually been marginally beneficial to recreation and regional economic activity. This marginally beneficial impact likely stems from the 52.36% increase in ideal recreation pool levels in the month of October as a result of the reoperation, whereas the slightly lower than ideal recreation pool levels in the months of June, July, August, and September had little to no adverse impact.

Furthermore, trend analysis was applied to the data of both the original operation schedule and the reoperation schedule. Trend lines are essentially graphical representations of trends in data which can be utilized to analyze problems of prediction. Such analysis is also known as regression analysis. By using regression analysis, trend lines can be extended beyond the actual data plots (total visitor spending per each fiscal year) to predict future values. Reliability of trend lines is based on the R-squared value of the trend line. The R-squared value is a number between 0 and 1 which essentially quantifies the goodness of fit of an existing trend line in determining future values. A trend line is most reliable when its R-squared value is at or near 1. The more closely a trend line fits existing data, the more accurate a forecast that utilizes this trend line is likely to be. Polynomial trend lines are curved lines that are used mostly when data fluctuates. Polynomial trend lines of total visitor spending were applied to each data set with a forecast for three future periods, or fiscal years in this case, and the results can be seen below in Figures 1 (Original Operation) and 2 (Reoperation), respectively.

Figure 1

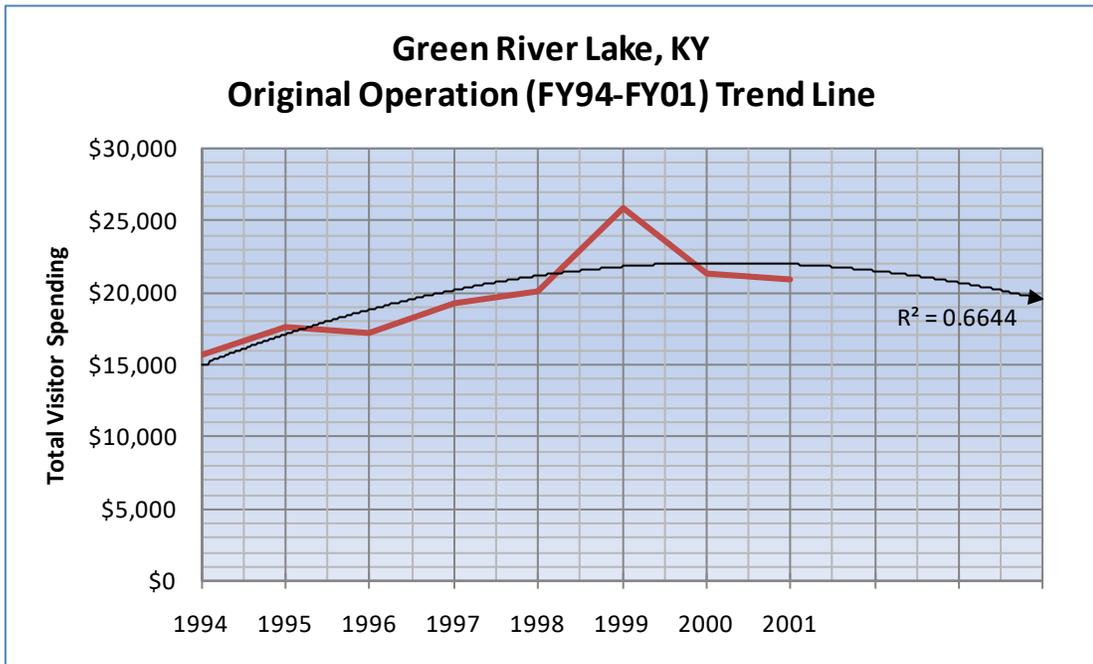


Figure 1 displays the trend line of total visitor spending under original operation at Green River Lake from the years 1994 through 2001 and a forecasted trend line for years 2002 through 2004. Analysis of this trend line yields two major conclusions. First, with an R-squared value of 0.6644, the reliability of this trend line and forecast is largely uncertain. Second, although admittedly uncertain, the projected forecast is negative, as seen with the downward slope in future periods. It is impossible to declare that total visitor spending would have continued to decline in future periods under the original operation schedule of Green River Lake with any measure of confidence, but it can be concluded that the forecast for future visitor spending was definitively vague and quite possibly negative.

Figure 2

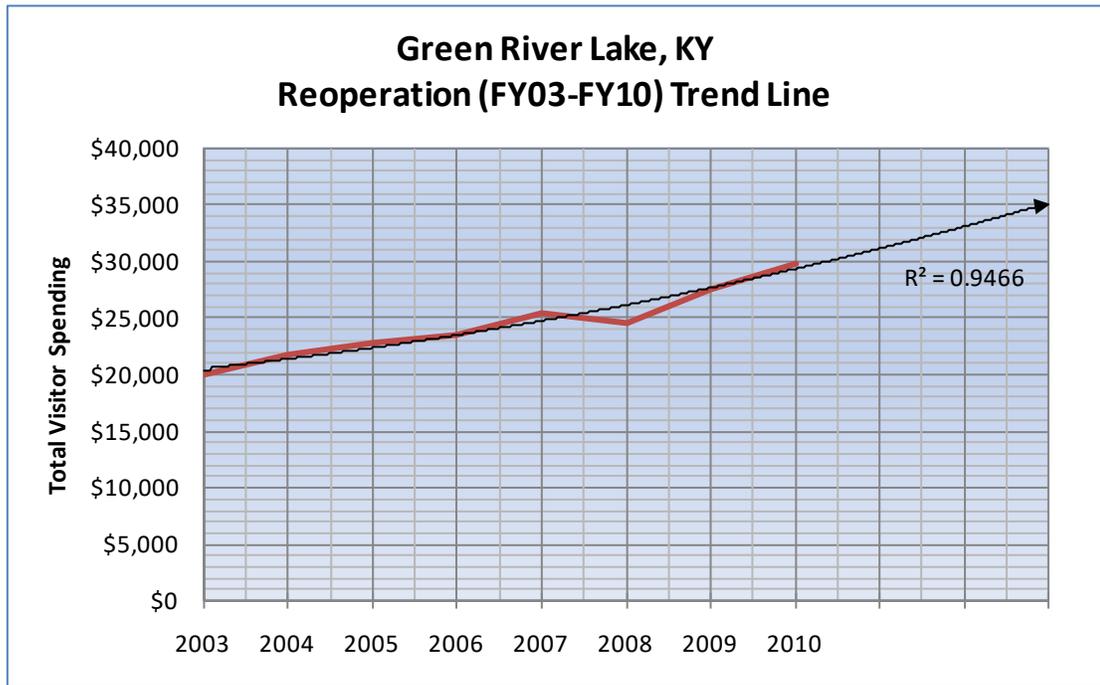


Figure 2 displays the trend line of total visitor spending under reoperation at Green River Lake from the years 2003 through 2010 and a forecasted trend line for years 2011 through 2013. Analysis of this trend line also yields two major conclusions. First, with an R-squared value of 0.9466, the reliability of this trend line and forecast is mostly dependable. Second, the projected forecast is positive, as seen with the upward slope in future periods. While it is impossible to declare that total visitor spending will continue to grow definitively in future periods under the reoperation schedule of Green River Lake, it can be concluded as a result of trend analysis that the forecast for future visitor spending is both positive and reliable.

It also bears mentioning again that the growth in regional economic activity at Green River Lake, KY during the years of reoperation has taken place in the midst of a much more economically pessimistic and volatile time frame as compared to the original operation time frame studied. Total visitation and visitor spending fluctuated greatly during the original operation time frame despite consistent GDP growth rates (5.6% average according to the Bureau of Economic Analysis) and relatively steady inflation rates (2.58% average according to the Department of Labor Statistics). However, during the reoperation time frame, the National Bureau of Economic Research (NEBR) declared that the United States had been in a recession beginning in December 2007. The NEBR stated that the deterioration in the labor market, real

personal income, industrial production, wholesale and retail sales, and gross domestic product through fiscal year 2008 were the key factors as to why it decided to state that the recession began the previous year. It is widely accepted that the fall of the housing market, which actually began in 2006, was the primary cause of the broader economic malaise. With this background in mind, it is encouraging to note that total visitation and regional economic activity at Green River under the reoperation time frame actually increased at a greater rate than either had during the studied original operation time frame.

In addition to the measured, quantitative impacts analyzed and discussed heretofore, this study would be remiss to disregard other qualitative economic impacts that the reoperation of Green River Lake has had, either directly or indirectly, on the downstream portion of Green River. One such impact is the reduced cost of water treatment realized by the City of Greensburg, KY as a result of the reoperation of Green River Lake. This reduced cost stems primarily from the increased water quality of the Green River due to reoperation efforts. The delayed fall drawdown allows for “turnover” between the upper (epilimnion – best quality water) and lower (hypolimnion – poorest quality water) stratified regions of the Green River Lake pool. This “turnover” effect yields higher quality water for the downstream release, which in turn reduces the amount of treatment required to produce potable water supply. Another qualitative impact manifested downstream the Green River is the proliferation of canoe liveries which have opened business operations since the reoperation effort was undertaken. While multiple conversations with individual livery owners were conducted, specific data (rental figures, sales totals, etc) was not available. Even without quantitative analysis, however, the increases in canoe livery operations around the Green River suggest an improved market for the activity. Since reoperation efforts have attempted to mimic natural precipitation events to the Green River, reliable flow and much lower levels of turbidity have generated conditions much more conducive to canoeing, kayaking, and floating the Green River. In addition, the reoperation efforts have produced an extended recreation season for the downstream region. The longer recreation season provides more time and opportunity for potential visitation and increased demand for services and equipment required to utilize the Green River.

It is the conclusion of this study that the reoperation efforts undertaken at Green River Lake, KY, as a result of the collaborative efforts of The Nature Conservancy and the United States Army Corps of Engineers, beginning in 2002 and made permanent after a three year trial period in 2005, have had no adverse impacts on recreation or regional economic activity within a 30 mile radius of the project site. Furthermore, regression analysis of the continued increase in total visitation and economic activity at the project site during reoperation, despite a national economic recession, suggests that the forecasted trend line for future regional economic activity is both positive and reliable. For these reasons the reoperation plan is considered to

have produced a marginally beneficial impact on recreation and regional economic activity at Green River Lake, KY.