Red River Valley Water Supply Project

Supplemental Analysis of Missouri River Effects

Missouri River Basin Water Management Division
Northwestern Division
Corps of Engineers

March 2008

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EXECUTIVE SUMMARY

Future depletions of water from the Missouri River are going to affect the amount of water that moves through the Missouri River Mainstem Reservoir System (Mainstem Reservoir System). One such potential depletion of water could be through a trans-basin diversion to the Red River Valley in North Dakota and Minnesota. The U.S. Department of Interior, Bureau of Reclamation (Reclamation) issued a Final Environmental Impact Statement (FEIS) on the Red River Valley Water Supply Project (RRVWSP) in December 2007 with the assistance of several cooperating agencies, including the U.S. Army Corps of Engineers (Corps).

The Corps provided reports on Missouri River impacts for Reclamation's three EISs (Draft EIS, Supplemental Draft EIS, and FEIS). Changes to the hydrologic modeling process and information contained in the Corps' reports were modified to respond to comments received on the Draft and Supplemental Draft EISs. The hydrologic modeling completed for the Missouri River from which the impacts were computed included historic Missouri River basin inflow/flow depletion data developed by Reclamation for the RRVWSP EISs. As comments provided by the Missouri Department of Natural Resources on the FEIS were being reviewed during preparation of the Record of Decision (ROD) by Reclamation, Corps modeling staff noted that the transfer of the Reclamation depletion data to the Corps' hydrologic model, the Daily Routing Model (DRM) had not been completed properly. The present level of streamflow depletion input file, which is used to make adjustments to the historic inflows to the Missouri River, was appropriately modified and the Current conditions, No Action, and the preferred alternative identified in the FEIS (Garrison Diversion Unit Import to the Sheyenne River, or GDUISR, alternative) and their impacts modeling runs were redone.

This report presents the results of the post-FEIS modeling analysis of the Current conditions and the No Action and GDUISR alternatives. The full period of analysis continues to be the 1930-2002 period; however, emphasis continued to be placed on analyzing the effects of a drought like that of the 1930s (1930-1941). This focus was selected because the modeling conducted by the Corps was originally set up such that the forecasted volume of water was used in each year of the modeling period, which is not very likely. A repeat of the 1930s drought is the most likely situation where this forecasted volume of water would be used each year. Historically, the Red River Valley experienced a coincidental drought during the same period that the Missouri River Basin experienced this drought.

This post-FEIS RRVWSP analysis continued to incorporate the sediment accumulation in the Mainstem Reservoir System reservoirs in future years that was added to DRM for the FEIS analysis following the Supplemental Draft EIS. As with the previous modeling, the DRM output data were used in the economic and environmental impacts models developed for the previous Corps Missouri River Master Water Control and Update Study (Master Manual Study). Several additional analyses using various modeling techniques used for the previous Draft and Supplemental Draft EIS's were also completed to address what the Corps considered to be special concerns by interests in the Missouri River Basin.

The Corps elected to analyze just three simulations. The first simulation was for Current conditions under the water control plan in the 2004 Revision of the Corps' Missouri River Master Water Control Manual. It included the 2002 level of depletions with sedimentation continuing at the last measured rate for each reservoir projected up to 2010. The second simulation was for 2050 conditions in the Missouri River Basin under the 2004 Revision and projected sediment accumulation in the reservoirs and increased depletions within the Missouri River Basin of 557,500 acre-feet over those for the Current conditions. This 2050-conditions simulation represented the No Action alternative in the FEIS and for the analysis for this report. The third simulation included in this report is for the preferred alternative (GDUISR) identified in the FEIS, which includes withdrawing water from the Missouri River. It includes the same amount of sedimentation as the No Action alternative and an additional 80,239 acre-feet of depletions above those of the No Action alternative from the Missouri River Basin.

In general, the effects of the water withdrawal from the Missouri River for import to the Red River Valley by the RRVWSP preferred alternative (GDUISR) range from no change to about 3 percent change. Only the change in tern and plover habitat value is greater than that due to a dramatic difference in one year's value. The percent changes are relatively small because the volume of water to be withdrawn is small. The Current conditions model simulation determined that there would be 5 non-navigation years (1935, 1936, 1938, 1941, and 1942). Addition of 557,500 acre-feet of forecasted Missouri River Basin depletions between 2002 and 2050 that would occur under No Action also resulted in 5 non-navigation years; however, the years are different years (1935-1938 and 1941). Adding an additional 80,239 acre-feet annually of Missouri River withdrawal for the Red River Valley under the preferred alternative resulted in the same non-navigation years during the 1930s drought as the No Action alternative.

Even though the full period of analysis (1930-2002) changes have been presented throughout this report, these have limited value because the Corps' modeling of the full period assumed diversion of the full amount (80,239 acre-feet) of water to the Red River Valley by the preferred alternative in all years of the modeling period. In reality, relatively smaller amounts of this water would be diverted during non-drought periods in the Red River Valley.

INTRODUCTION

The U.S. Department of Interior, Bureau of Reclamation (Reclamation) and the State of North Dakota were tasked to "jointly prepare and complete environmental impact statements (EIS's) concerning all feasible options to meet the comprehensive water quality and quantity needs of the Red River Valley and the options for meeting those needs including delivery of water from the Missouri River to the Red River Valley…" (Section 8(C)(2)(A) of the Dakota Water Resources Act of 2000). Reclamation requested the assistance of the U.S. Army Corps of Engineers (Corps) to analyze the effects of some of the options for delivery of water from the Missouri River on Missouri River uses and resources. A report was submitted by the Corps to Reclamation in August 2005 that evaluated the average annual effects for a repeat of the period 1930-2002 for two alternatives with two forecasted water use scenarios under current (2002) Missouri River depletion levels and 2050 depletion levels. The data in the report were used for Reclamation's Draft EIS (DEIS) that was released for public review in December 2005.

In response to comments following the DEIS, Reclamation asked the Corps again for assistance as it initiated efforts to prepare a Supplemental DEIS (SDEIS) for the Red River Valley Water Supply Project (RRVWSP). For this second effort, Reclamation requested an analysis of three action alternatives that would withdraw water from the Missouri River for transfer to the Red River Valley. It also requested that the analysis of effects focus on a repeat of the drought of the 1930s (1930-1941) with some analysis provided for the full period of analysis of 1930-2002. To provide a basis for comparison, two additional model simulations of alternatives were again completed. These two simulations included Current conditions (2002) for the Corps' Missouri River Master Water Control Manual (Master Manual) Water Control Plan and No Action (includes an additional 557,500 acre-feet of Missouri River Basin depletions between 2002 and 2050 under the same Water Control Plan).

In response to comments on the SDEIS and the availability of new information, Corps assistance was asked for a third time as Reclamation initiated preparation of a Final EIS (FEIS). This request was for a reanalysis of the same five alternatives included in the SDEIS (Current conditions, No Action and three Missouri River import alternatives); however, an additional modeling component was requested. Following the Corps' analysis for the SDEIS, Corps modeling for the Western Area Power Administration (Western) was conducted that included modification of the Daily Routing Model (DRM) sedimentation files to accommodate continuing sediment deposition into the Missouri River Mainstem Reservoir System. The primary objective of this study (report entitled, "Future Depletions and Sedimentation Effects on the Missouri River Mainstem System", completed in February 2007), was to evaluate the combined effects of future Missouri River Basin depletions and sedimentation in the reservoirs on Mainstem Reservoir System power generation over the next 100 years. Two modeling simulations conducted for the Western analysis were equivalent to the Current conditions and the GDUISR alternative in the FEIS with the addition of future sediment deposition in the Mainstem Reservoir System reservoirs.

The analysis of the withdrawals on Missouri River uses and resources relied on the models developed for the Missouri River Master Manual Review and Update Environmental Impact Statement (Master Manual EIS) completed by the Corps in March 2004. These models included the Daily Routing Model (hydrologic, hydropower, and navigation outputs) and the many economic use and environmental resource models developed for the Master Manual EIS. This report and the previous three of the Corps' reports summarize many of these models.

Reclamation completed the FEIS in December 2007 and exercised a 30-day waiting period before its Record of Decision (ROD) would be prepared. According to Section 1056.10 of the National Environmental Policy Act, no decision on the proposed action shall be made by a Federal agency until at least 30 days after the publication of the *Federal Register* notice that a final environmental impact statement has been filed with the U.S. Environmental Protection Agency. During this waiting period, the Missouri Department of Natural Resources provided comments in which it continued to challenge the DRM and subsequent impacts modeling based on what it felt were understated impacts using information gleaned from the Corps' Master Manual EIS's. In response to this comment, the Corps again reexamined its modeling results for each level of analysis, which led to the comparison of depletion files from the Master Manual EIS and RRVWSP EIS modeling efforts. This detailed examination determined that the present level streamflow depletion data provided by Reclamation had been incorrectly interpreted and entered into a revised depletion file for DRM simulations for the RRVWSP. The Corps readily notified Reclamation of the situation and agreed to provide this supplemental report outlining revised data for three simulations, Current conditions and the No Action and GDUISR alternatives.

MISSOURI RIVER AFFECTED ENVIRONMENT

Chapter 3 of the Master Manual EISs is entitled "Description of Existing Environment". This chapter provides all of the necessary information on the Missouri River affected environment for the RRVWSP FEIS.

SUMMARY OF ALTERNATIVES ANALYZED FOR THIS REPORT

A base simulation of the 2004 Master Manual's Water Control Plan for the Missouri River was completed for the RRVWSP to provide the basis for Current conditions (Current) on the Missouri River. This simulation was completed using the revised Missouri River Basin depletions computed by Reclamation based on the 2002 level of water development within the Missouri River Basin and 2010 sedimentation conditions. The depletions, covering the period from 1929 to 2002, were revised by Reclamation, and the results of the DRM output files for the 1930s drought appeared to be the result of historical depletions being down slightly from those used in the Daily Routing Model for the Master Manual EIS.

A second simulation was run with an additional 557,500 acre-feet of Missouri River depletions forecasted between 2002 and 2050. This alternative is referred to as No Action in the RRVWSP FEIS, and this alternative remains the same for this report. This alternative will be used to provide a basis for presenting the relative effects of the preferred alternative identified in the FEIS that uses Missouri River water to partially meet the forecasted 2050 water needs in the Red River Valley. For the FEIS, the continuation of the sedimentation rates based on the most recent sediment surveys for each Mainstem Reservoir System reservoir was incorporated into the simulation of the No Action alternative.

The third alternative modeled for this report, the preferred alternative, or GDUISR, is the one that would withdraw additional water from the Missouri River. Because this alternative's effects would be compared to the No Action alternative that represents 2050 conditions, it was modeled with its respective depletion amount of 80,239 acre-feet plus the 557,500 acre-feet of forecasted (2050) Missouri River in-basin depletions and the same amount of sediment accumulation in the six Mainstem Reservoir System reservoirs as the No Action alternative. The information on this preferred alternative is also summarized in Table 1.

Table 1. Missouri River import alternative identified as the Preferred Alternative in the RRVWSP FEIS.

Alternative	Report Acronym	Withdrawal Location	Volume of Water Diverted Annually*
Garrison Diversion Unit Import to Sheyenne River	GDUISR	Garrison reservoir	80,239 acre-feet

* The alternative was modeled under 2050 conditions, which included an additional 557,500 acre-feet of depleted water due to actions within the Missouri River Basin from current conditions (2002) plus the listed amount for this alternative. Depletion numbers with a monthly breakdown were provided to the Corps, by Reclamation.

COMPARATIVE ANALYSIS OF THE EFFECTS OF THE RRVWSP ALTERNATIVES

The results of the comparative analysis of RRVWSP alternatives on Missouri River uses and resources are initially presented on an individual use or resource basis. Summary tables will be provided at the end of the report to provide some perspective on the overall impacts among the alternatives for all of the uses and resources. Results from two periods of analysis are discussed, the total 1930-2002 simulation period and the 12-year period from 1930 to 1941 (repeat of a drought similar to that of the 1930s). Also, emphasis of the comparisons in this report will be between the No Action and the GDUISR alternatives.

HYDROLOGIC EFFECTS

Before addressing the uses and resources that were evaluated, some data on the hydrologic outputs from the DRM are appropriate to provide some perspective on how the Current conditions modeling results completed for the RRVWSP compare to that conducted for the Corps' Master Manual EIS selected plan. This section also discusses how the hydrologic modeling results for Current conditions modeling compare to the No Action and GDUISR alternatives and how the No Action alternative's hydrology compares to the GDUISR alternative.

Figure 1 presents the total Missouri River Mainstem Reservoir System (Mainstem Reservoir System) storage levels during the drought of the 1930s and the subsequent 2 years of the recovery period. This figure shows that the amount of water in storage for a repeat of the 1930s drought is both more and less for the Corps' Master Manual EIS selected plan, depending on the year. This storage difference results because of the number of non-navigation years and which years have no navigation service. The Master Manual EIS selected plan has 4 non-navigation years; whereas, the RRVWSP Current conditions has 5 non-navigation years. The inclusion of the 31-MAF navigation preclude provides some indication of the years of non-navigation. The only year that is different is 1936, which is a navigation year for the Master Manual EIS selected plan and a non-navigation year for the RRVWSP Current conditions. The Missouri River Master Manual EIS modeling used inflow depletion data that were updated to 1987 by Reclamation. These data were revised by Reclamation for the RRVWSP Missouri River analyses based on 2002 agricultural census data. The DRM adjusts the amount of inflow coming into the Mainstem Reservoir System based on the adjusted depletion values. For example, to model 1930, the runoff into the Mainstem Reservoir System must be adjusted to reflect the volume of runoff that would have occurred if the current depletion factors had been the same in 1930 as they are today. An increase in the depletions between 1987 and 2002 of about 200,000 acre-feet accounts for the difference, although the depletions varied from year to year, and they also had an effect on the years that did not have Missouri River non-navigation service.

Table 2 presents the navigation season length data for the three simulations for this study and similar data for the Master Manual EIS selected plan for the period 1930-1943. The 2 additional years from the normal data set are included in the table to allow the display of 1942 as a non-navigation year for the RRVWSP Current Conditions and to show that navigation service was restored to season lengths longer than any experienced between1932 and 1942 for the three RRVWSP simulations. The non-navigation years all have a zero in the non-navigation year, and those years are highlighted to assist with that identification.

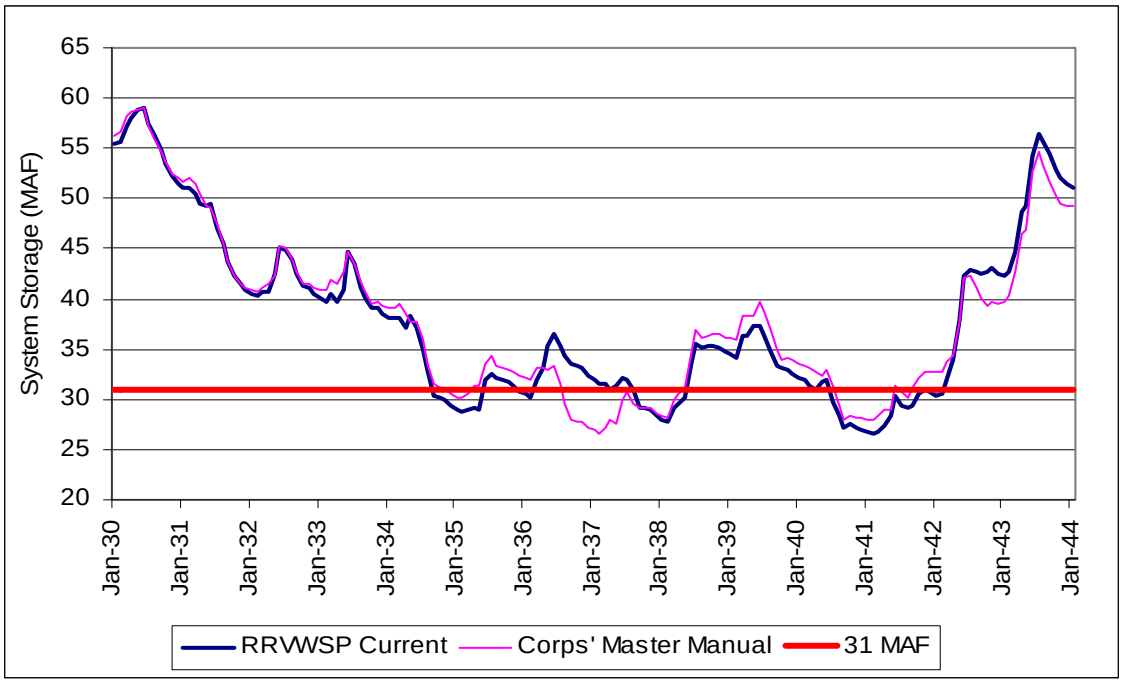

Figure 1. Comparison of the RRVWSP Current conditions storage levels for a repeat of the drought of the 1930s and subsequent recovery period with the Corps' Master Manual EIS selected plan storage levels during the same period.

Table 2. Comparison of non-navigation years for the three RRVWSP simulations for this report and for the Master Manual EIS selected plan.

	Current	No Action	GDUISR	MM EIS
1930	8	8	8	8
1931	7.57	7.17	7.14	7.48
1932	7	7	7	7
1933	7	7.00	7.00	7
1934	6.19	6	6	6.3
1935	0	0	0	0
1936	0	0	0	6
1937	6	0	0	0
1938	0	0	0	0
1939	6.23	6.76	6.63	6.73
1940	6	6	6	6
1941	0	0	0	0
1942	0	6.74	6.61	7
1943	8	7.31	7.21	8

Figure 2 shows the total Mainstem Reservoir System storage levels for the RRVWSP Current conditions and the No Action and GDUISR alternatives over the same 15-year period as shown in Figure 1. This second storage plot shows that the differences between

the No Action and GDUISR alternatives are considerably less than the differences between the Current conditions and the No Action alternative. This smaller difference occurs because the depletion amounts between those used for the No Action and GDUISR alternatives and the Current conditions differ by a factor of seven (557,500/80,239).

Figure 3 shows the differences in the amount of water in Mainstem Reservoir System storage for the GDUISR alternative and the No Action alternative (zero line on the plot). It shows that the difference ranges from an initial value of zero to about 600,000 acre feet by the end of 1941. The DRM incorporates the increased annual depletion values into the regulation decisions following the Master Manual criteria, but the change in storage is less than the accumulated depletion amounts. For example, the GDUISR alternative uses just over 80,000 acre-feet per year more than the No Action alternative, which equates to about 1,000,000 acre-feet over 12 years, but the storage difference is 600,000 acre-feet by the end of 1941, the twelfth year of the 1930s drought. The drought conservation criteria of the Corps' Master Manual Water Control Plan save the difference, about 40 percent of the use during that 12-year period. This is reflected primarily in navigation season lengths between the No Action and GDUISR alternatives. To provide some perspective on reservoir-related impacts, the maximum identified during the 1930s drought approximated a 600,000 acre-feet difference from the No Action alternative. This equates to a stage difference of around 1 foot in the upper three reservoirs on March 1, when Mainstem Reservoir System storage is balanced among these reservoirs during a drought.

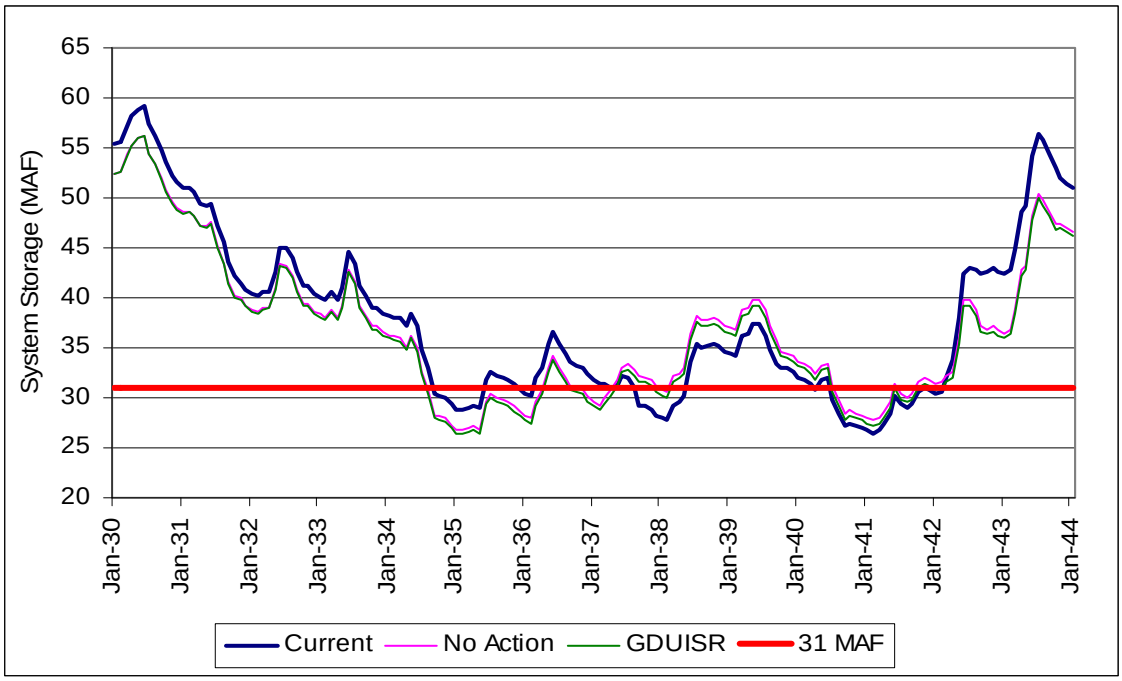

Figure 2. Comparison of the Current conditions storage levels for a repeat of the drought of the 1930s and subsequent recovery period with those of the No Action and GDUISR alternatives storage levels during the same period.

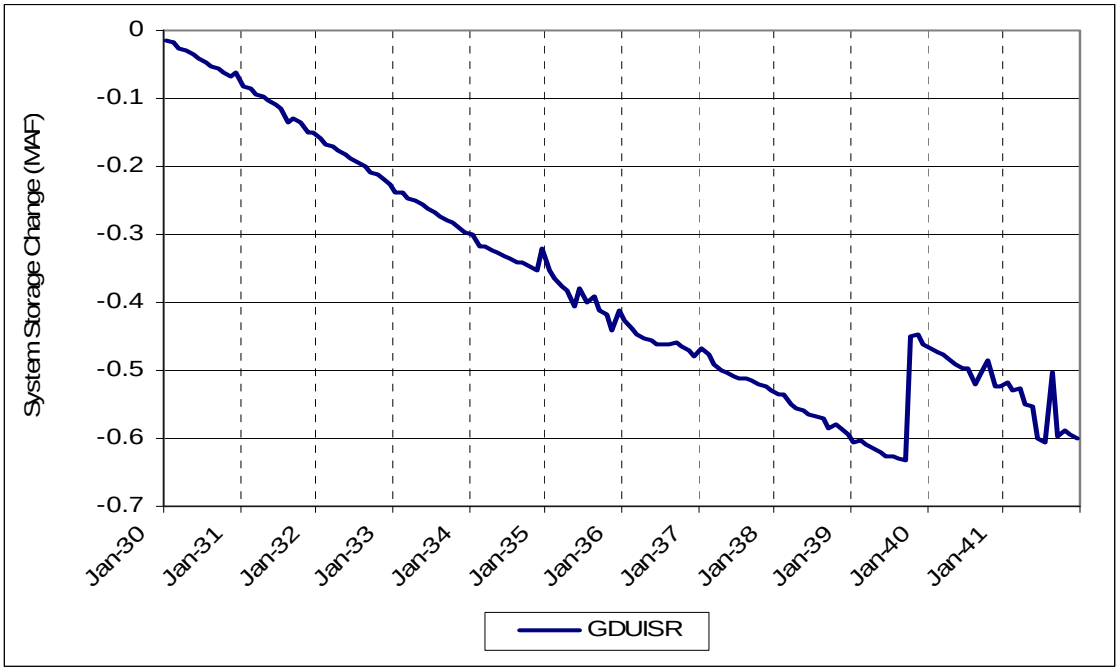

Figure 3. Missouri River Mainstem Reservoir System storage differences between the No Action alternative and the GDUISR alternative.

One final factor needs to be discussed before going into the Missouri River use and resource impacts. The Current conditions have 5 non-navigation years, which is the same as the No Action and GDUISR alternatives. The years in which there would be no navigation service differ slightly from the Current conditions to the No Action and GDUISR alternatives, which both have the same non-navigation years. This would lead one to believe up front before any of the analyses are even completed that the differences between the No Action alternative and the GDUISR alternative will, therefore, be relatively small. The differences among the three simulation's impacts are related to small differences in the navigation season lengths (and service levels in 1931 and 1939) for the Lower Missouri River downstream from the Missouri River Mainstem Reservoir System and to the relatively small differences in the amount of water stored in and released from the Mainstem Reservoir System reservoirs.

FLOOD CONTROL

Flood control benefits were computed for the riverine reaches from Fort Peck Dam to the mouth of the Missouri River and the four largest reservoirs on the Mainstem Reservoir System. Average annual benefits are presented in Table 3 for both the 1930-1941 and 1930-2002 periods of analysis for the Current conditions and the No Action and GDUISR alternatives. Table 3 includes some aggregation of the reach data. Figure 4 includes the average annual total flood control benefits for the Current Conditions and the No Action

and GDUISR alternatives. Annual values for the three simulations for the 1930-1941 period of analysis are presented in Figure 5.

Table 3. Average annual flood control benefits ($ million).

	Total	Reservoirs	Upper River	Lower River
		1930-1941		
Current	169.30	-0.01	64.54	104.77
No Action	169.33	0.00	64.54	104.80
GDUISR	169.33	0.00	64.54	104.80
		1930-2002		
Current	438.83	-0.56	91.76	347.62
No Action	437.29	-0.63	91.82	346.10
GDUISR	437.42	-0.62	91.83	346.20

Three conclusions can be drawn from the data presented in Table 3 for the 1930s drought. First, the average annual flood damages that would have happened had the Mainstem Reservoir System not been in place in the river reaches were lower for the 1930s drought period of 1930-1941 than for the full period of analysis of 1930-2002. Second, the differences for the total column between the Current conditions and the No Action and GDUISR alternatives are only $0.03 million for the 1930's drought, which is equivalent to a percentage change of less than 0.02 percent. Third, the change between the No Action and GDUISR alternatives in the 1930s drought is zero.

Table 3 and Figure 4 show that the future depletions will have essentially no effect on the flood control benefits for a repeat of the 1930s drought. The table shows that there would be both very minor positive and negative changes for the full period of analysis from 1930 to 2002. That difference is due to the effects of sedimentation reducing the size of the non-flood control storage zones, which results in some higher releases in some higher inflow years to ensure that adequate flood control storage remains available. Figure 5 shows that the flood control benefits range annually from no benefits to about $650 million a year; however, there is essentially no difference among the three simulations in all years.

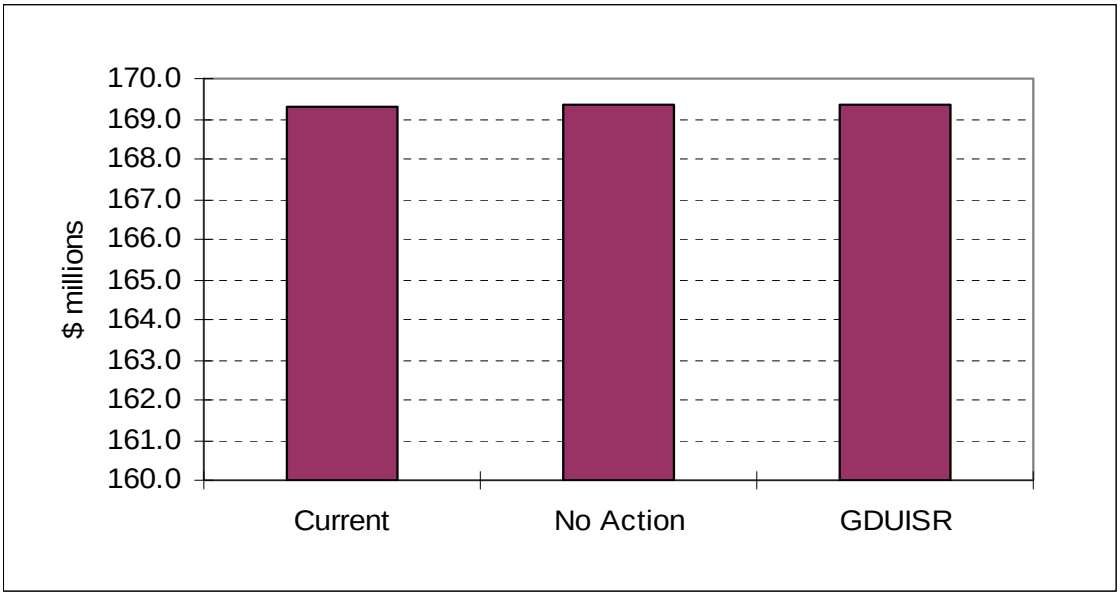

Figure 4. Average annual total flood control benefits, 1930-1941.

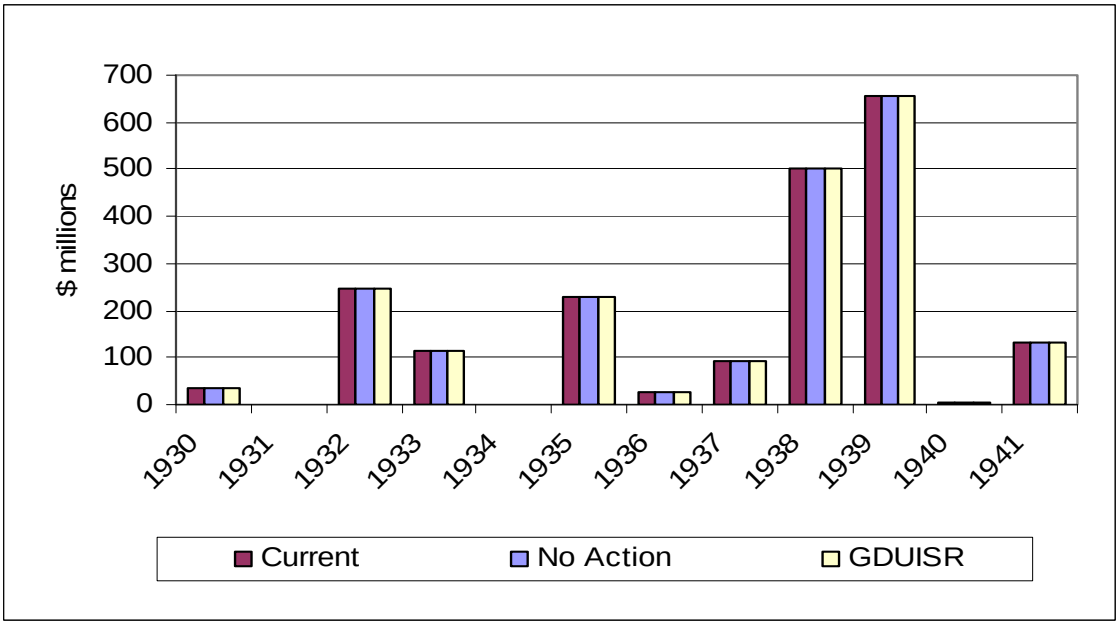

Figure 5. Annual total flood control benefits, 1930-1941.

MISSOURI RIVER NAVIGATION

Navigation occurs on the Missouri River from Sioux City, Iowa to the mouth near St. Louis, Missouri. The average annual total navigation benefits for the 1930-1941, 1930-1942, and 1930-2002 periods of analysis are presented in Table 4. The extra period of analysis (1930-1942) for the navigation economics is in table to include the effect of the non-navigation year for Current conditions in 1942, as shown previously in Table 2.

Figure 6 includes the total average annual values for the Current Conditions and the No Action and GDUISR alternatives for the 1930-1941 and 1930-1942 periods. Annual values for the Current conditions and the No Action and GDUISR alternatives for the 1930-1942 period of analysis are presented in Figure 7.

Table 4. Average annual total Missouri River navigation benefits ($millions).

	1930-1941	1930-1942	1930-2002
Current	2.01	2.12	7.51
No Action	2.08	1.68	5.67
GDUISR	2.08	1.68	5.52

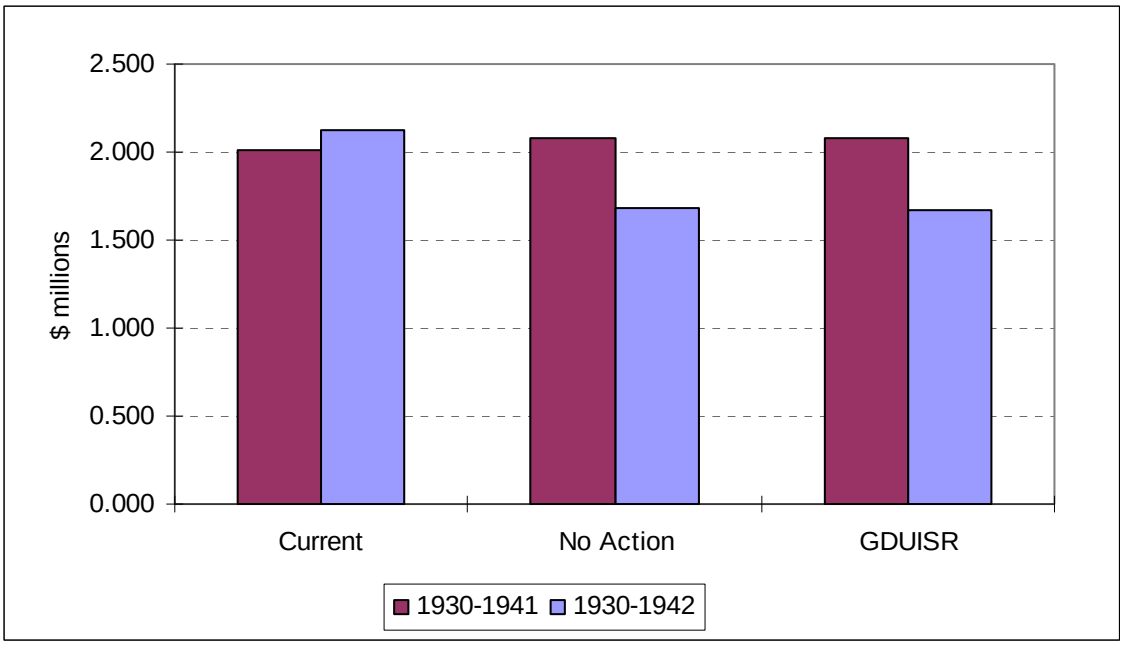

Figure 6. Average annual total Missouri River navigation benefits, 1930-1941 and 1930-1942.

Table 4 and Figure 6 show that the average navigation benefits for the 1930-1941 period go up from the lower value for the Current conditions to the slightly higher value for the No Action and GDUISR alternatives. This increase is due to the additional non-navigation year (for a total of 5 non-navigation years in the No Action and GDUISR alternatives compared to 4 for the Current conditions for 1930-1941 period) that occurs in the 1930-1941 period for these two alternatives, based on the Daily Routing Modeling assumptions used in the RRVWSP analysis of Missouri River effects. This increase in benefits for the 12-year period offset the higher benefits for the Current conditions in years that have higher service levels (1930 and 1931) and longer season lengths. The major portion of the increasing portion of the annual benefits for the No Action and GDUISR alternatives occurs in 1937, as shown in Figure 7. This is due to the assumption

that there would be no navigation operations and maintenance costs on the Missouri River navigation channel in a non-navigation year. These costs are usually to repair any damage to the ends of structures that may have occurred during and after the previous year's navigation season, and they would not occur if no navigation is anticipated in a given year. The total benefits drop below zero in some of the minimum navigation service years, also as shown in Figure 7, due to the fact that the operations and maintenance costs assumed in the economic computations equal or exceed the direct navigation benefits in minimum service years. The shorter the navigation season is, the greater the likelihood that these costs will exceed the direct benefits. The annual Missouri River navigation benefits in a full service year, whether 8 or 8.33 months long, are over $15 million, as shown in Figure 7 in 1930.

Inclusion of 1942 data into the average annual navigation benefits analysis reverses the general trends discussed above for the average annual navigation benefits during the drought period. The additional year adds benefits to the Current conditions analysis because of its fifth non-navigation year and its positive net benefits for the year due to the elimination of the operation and maintenance costs while the No Action and GDUISR alternatives have a navigation season without much traffic and benefits as this industry begins its long climb to recover the navigation tonnage movements it lost due to no navigation service in so many years.

Navigation benefits for the No Action and GDUISR alternatives are essentially the same, as shown in both Table 4 and Figure 6. A small difference occurs during the full period of analysis of 1930-2002. This likely results from having less storage available in the multiple purpose pools of the Mainstem Reservoir System due to continuing sedimentation. Reduced service and season lengths occur earlier in extended droughts and may also occur in the second year of a 2-year drought.

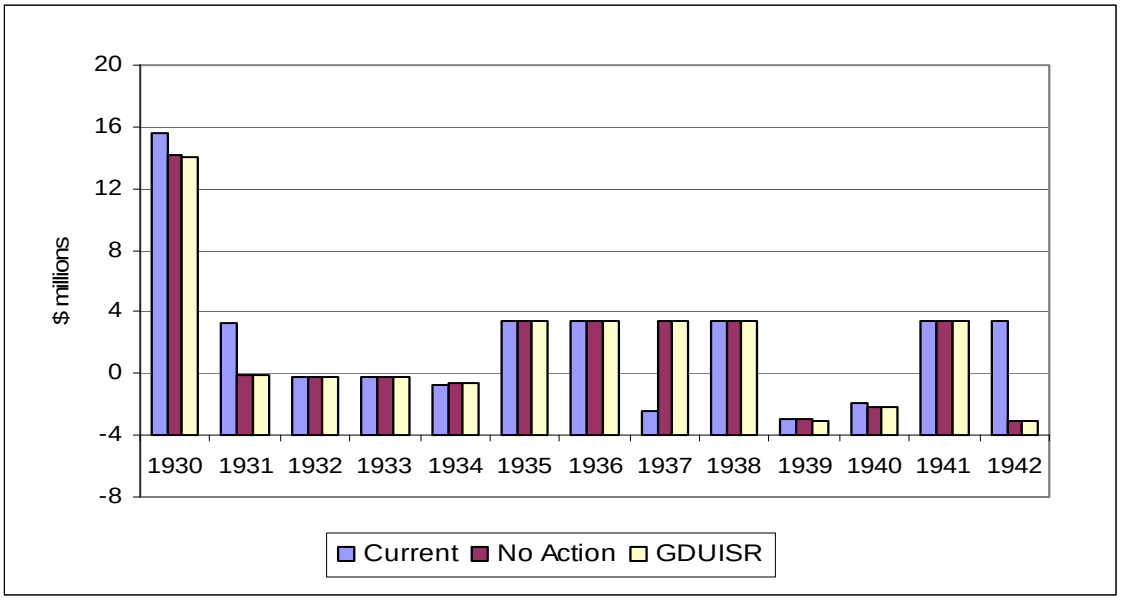

Figure 7. Annual total Missouri River navigation benefits, 1930-1942.

Table 5 presents the Missouri River navigation season lengths for the 12 years of the 1930s drought plus 1942 for just the three RRVWSP simulations. Annual water use increases for the No Action and GDUISR alternatives result in a relatively small reduction of navigation season lengths. To better understand what the effect is on season length, Figure 8 was prepared. If more that two alternative depletion alternatives had been used to prepare this figure, the slope of the linear regression line through the data points could have been used to determine the effect of depletions on average annual days of navigation that would be lost per million acre-feet of depletions. In this case, however, only two points were used to generate the line. The two points represent the No Action and GDUISR alternatives, and the difference between those two alternatives is 5 days. The annual average loss of days is, therefore, 5/12, or 0.4 days. Real-time regulation season-length decisions by the Corps are made in 1-day increments. Figure 9 presents the additional number of days that the season length would be shortened for the GDUISR alternative relying on Missouri River water relative to the No Action alternative. The figure verifies that the net effect of the additional depletions due to the GDUISR alternatives is 5 days of navigation over the 12-year period, with 4 of these days occurring in 1939. The releases from Gavins Point Dam for the No Action and GDUISR alternatives over the 12-year period from 1930 to 1942 would have identical releases every day except for the days affected at the end of the 1930 and 1939 navigation seasons.

Table 5. Missouri River Navigation Season Lengths (months).

	Current	No Action	GDUISR
1930	8	8	8
1931	7.57	7.17	7.14
1932	7	7	7
1933	7	7	7
1934	6.19	6	6
1935	0	0	0
1936	0	0	0
1937	6	0	0
1938	0	0	0
1939	6.23	6.76	6.63
1940	6	6	6
1941	0	0	0
1942	0	6.74	6.61

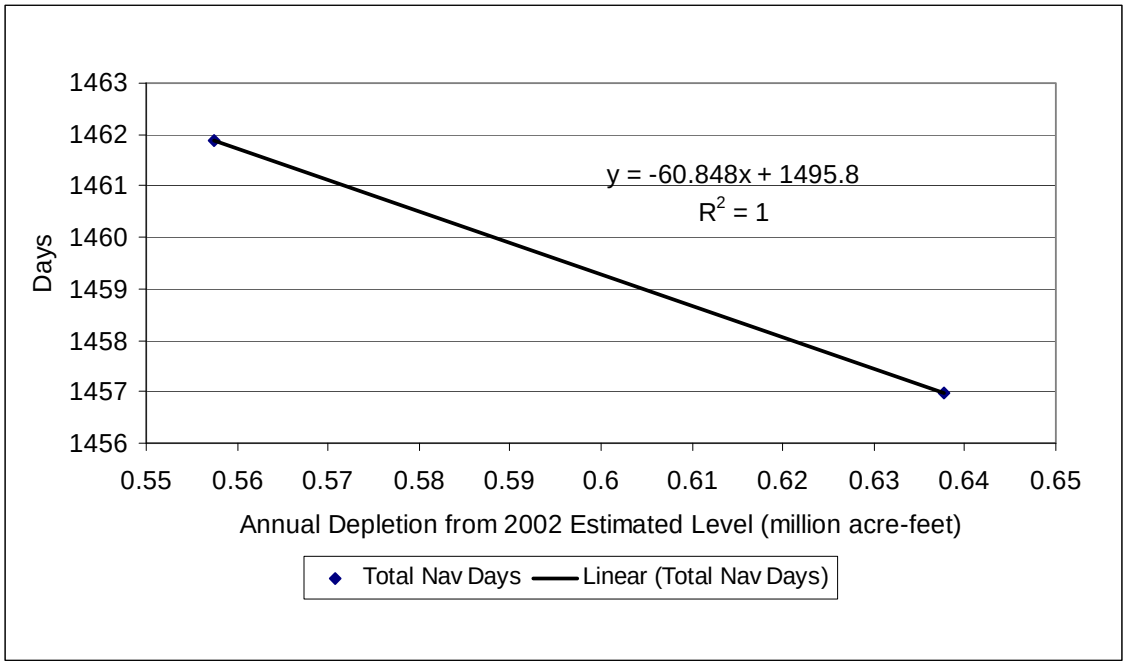

Figure 8. Number of navigation days in the 12-year period from 1930 to 1941 versus the amount of depletions for the No Action and GDUISR alternatives.

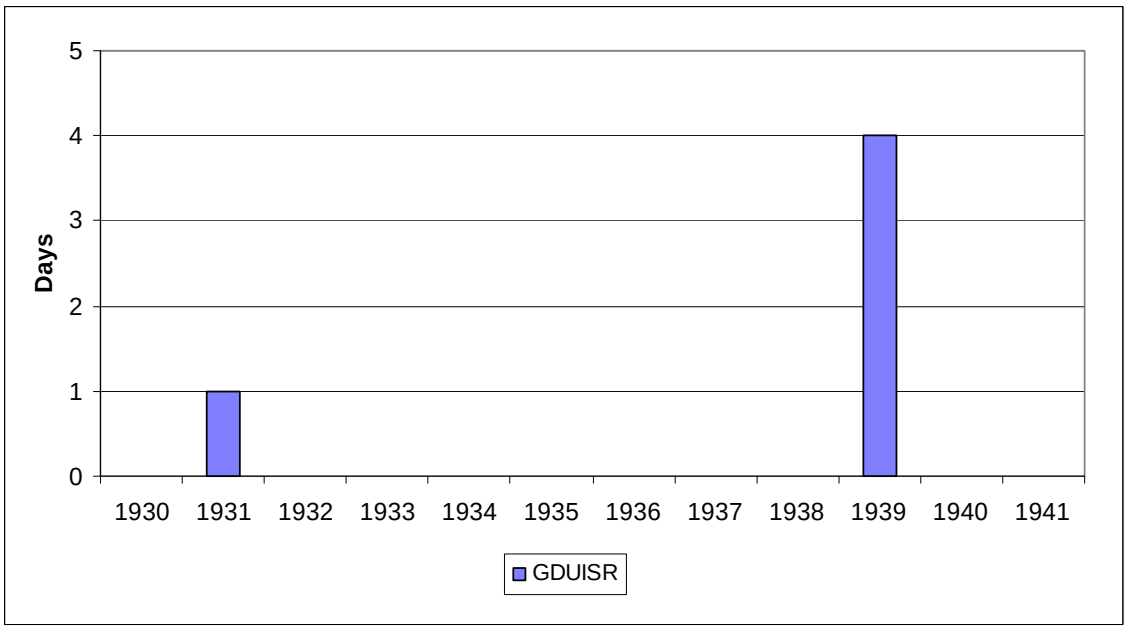

Figure 9. Number of days the navigation season would be shortened in the 12-year period from 1930 to 1941 for the GDUISR alternative, as compared to the No Action alternative.

MISSISSIPPI RIVER NAVIGATION

Discussion on Mississippi River impacts is included in this report because interest by some agencies and individuals in this use relying on Missouri River flows even though Mississippi River navigation is not an authorized purpose for the operation of the Missouri River Mainstem Reservoir System. A reduction of Missouri River navigation by 5 days during the 1930s drought between the No Action and GDUISR alternatives would affect Mississippi River flows for more than 5 days during the 1930s drought.

Initiating the reduction of water from the Missouri River to the Mississippi River by the 1 day in 1931 translates to a reduction of 3,000 cfs over the next 6 days. However, navigation on the Mississippi River would be more severely affected by the 9 days of lower flows from the Missouri River in 1939. This year was selected for Mississippi River navigation impacts analysis because it was the most severe year for increased Mississippi River navigation efficiency costs during a 1930s drought. For a repeat of 1939 flows at St. Louis, Missouri, the reduction of the navigation flows on the Mississippi River of from 3,000 cfs the first day to 15,000 cfs the fifth day in 3,000 cfs increments back to zero difference on the tenth day (flows are reduced by 3,000 cfs per day at the end of the navigation season) would occur when the stages at St. Louis are approximately -2 feet (approximately 60,000 cfs). The changes between the No Action and GDUISR alternatives would occur just prior to an extended period when flows on the Mississippi River would not be adequate to allow any service to navigation. The difference in Missouri River flows would mean that navigation would likely have to be suspended 4 days earlier for the GDUISR alternative. At a cost of $5 million a day, the total increased inefficiency costs for shallow and deep draft navigation on the Mississippi River would be an estimated $20 million. This increased inefficiency cost is relatively small when one considers that the annual Mississippi River shallow draft navigation benefits alone are about $2 billion ($20M/$2000M*100=1%).

Using another potential response by those relying on Mississippi River navigation, there may be no difference in cost for the 4-day earlier suspension of navigation in a year like 1939. Depending on the accuracies of forecasts, it is likely that a complete shutdown for the late fall and winter period could have been forecast. The navigation industry could have been prepared to accelerate all planned movements. Any commodities to be moved on the Mississippi River would have had to be moved out by the sometime during the third or fourth week of October 1939. For the GDUISR alternative, the rush to complete the movement of the commodities from St. Louis would have been slightly greater, and if completely successful, the difference in cost could have been as low as zero.

HYDROPOWER

Economic Modeling Benefits

Hydropower is generated at all of the six dams forming the Mainstem Reservoir System on the Missouri River. During drought, generation at all six dams is reduced by either

lower releases from the dams only, as is the case for the three smaller, downstream dams (Big Bend, Fort Randall, and Gavins Point), or by reduced releases and lower reservoir levels, as is the case at the three larger, upstream dams (Fort Peck, Garrison, and Oahe). Reductions in the amount of water in Mainstem Reservoir System storage by actions that increase depletions, such as transport of water to the Red River Valley during an extended drought, could have an impact on hydropower. Table 6 presents the average annual hydropower economic benefits in terms of National Economic Development (NED) dollars for both periods of analysis. Figure 10 shows the total 1930s drought values graphically. This figure includes the total average annual values for the Current conditions and the No Action and GDUISR alternatives. Annual values for all three simulations for the 1930-1941 period of analysis are presented in Figure 11.

Both Table 6 and Figure 10 show that the forecasted Missouri River Basin depletions through 2050 of the No Action alternative combined with the out-of-basin transfer of water of the GDUISR alternative have a minor adverse impact on hydropower NED benefits. When compared to the hydropower benefits for the No Action alternative, the losses for the increased depletions of the GDUISR alternative during the 1930s drought are estimated to be $2.3 million per year. This loss equates to 0.42 percent change from the benefits of the No Action alternative. For the full, 73-year period of analysis, the difference is somewhat smaller (-0.26 percent).

Future sedimentation into the Mainstem Reservoir System will have a positive effect on the hydropower benefits. This is evident when the benefits increase from the Current conditions to the No Action alternative for both periods of analysis. Even though the depletions increased by 557,500 acre-feet, the benefits went up. An additional increase in depletions reduced the benefits for the GDUISR alternative, which is what one would expect for increasing depletions. Even with the decreased benefits for the GDUISR alternative, the hydropower benefits for both periods of analysis for this alternative under 2050 depletion and sedimentation conditions are higher than for the Current conditions.

Table 6. Average annual hydropower benefits ($ millions).

	Total	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
				1930-1941			
Current	537.5	47.6	94.4	151.9	108.3	100.3	34.9
No Action	542.1	47.6	98.8	154.9	107.0	99.4	34.4
GDUISR	539.8	47.5	97.4	154.1	107.0	99.4	34.4
				1930-2002			
Current	649.1	62.9	133.7	190.8	112.6	110.0	39.1
No Action	649.2	62.6	135.3	191.5	112.2	108.9	38.7
GDUISR	647.5	62.6	134.6	191.0	112.1	108.6	38.6

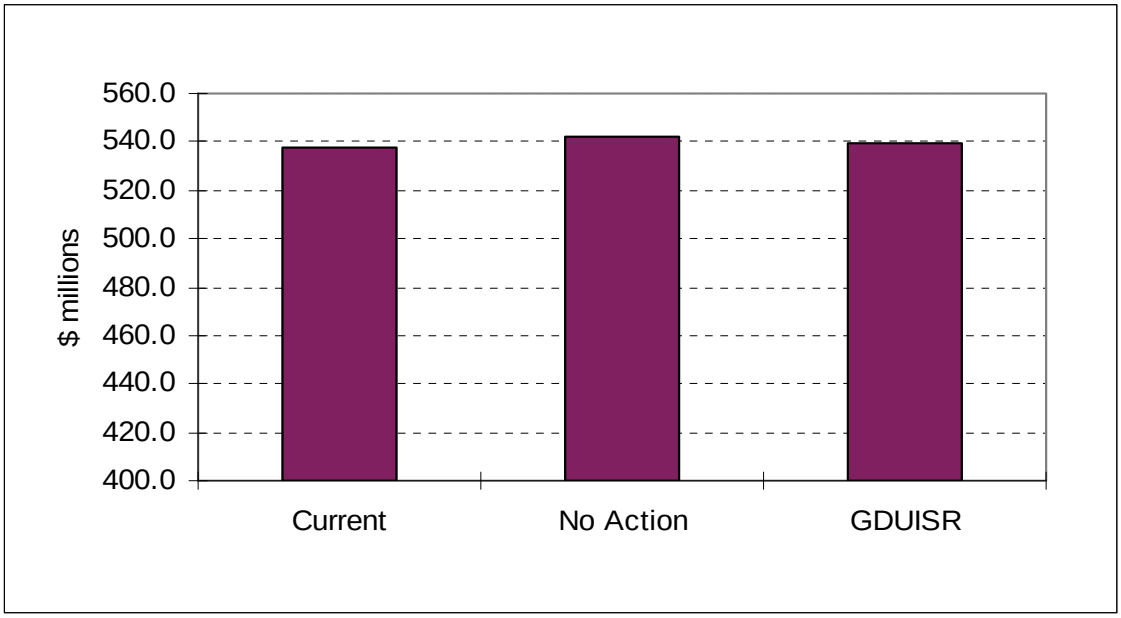

Figure 10. Average annual total hydropower benefits, 1930-1941.

Figure 11 shows the annual values and that the hydropower benefits generally decline through 1935 as Mainstem Reservoir System storage declines but increase in 1939 and 1940 before decreasing again through 1941. These changes tend to follow the total Mainstem Reservoir System storage plot with the exception of the adverse effects of the non-navigation seasons in terms of the volume of water released and its impacts on hydropower generation at all of the dams.

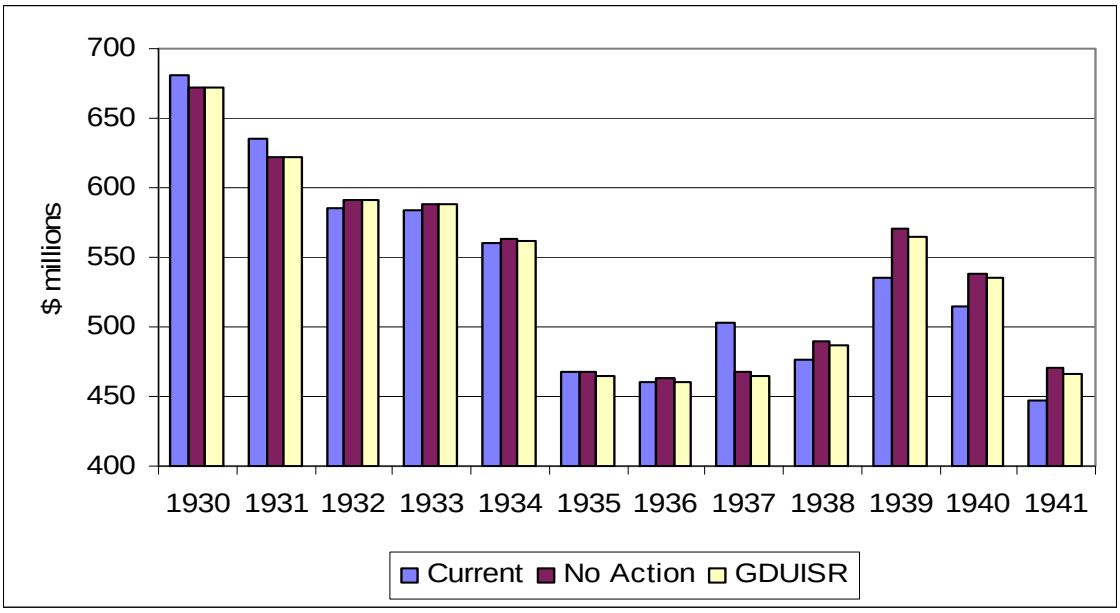

Figure 11. Annual total hydropower benefits, 1930-1941.

Hydropower Marketing Revenues

Reduced annual generation or a redistribution of the annual generation has an impact on the revenues received by the Western Area Power Administration (Western) when it markets the electricity generated at the Corps' Mainstem Reservoir System. To determine the extent of the effects of the water used from the Missouri River for the No Action and GDUISR alternatives, a spreadsheet model developed by Western for the Master Manual EIS was used to compute the net annual energy revenues that Western would accumulate through a drought like that of the 1930s and over the full period of analysis. This spreadsheet model subtracts the amount of firm energy committed each month to Western's customers from that generated according to the DRM hydropower output files on an average annual basis for each month for the period being analyzed. This difference is then multiplied times a rate structure that is based on a marketing forecast. The spreadsheet then sums the pluses (excess energy above the firm amount) and the minuses (energy that needs to be purchased to meet the firm commitment) to arrive at an average annual revenue value for the sales and purchases as Western markets the energy for the period being analyzed. Table 7 presents the results of an analysis using a rate structure used for the Master Manual EIS that relied on the monthly Cinergy Rates of January 30, 2001. Cinergy provided monthly rate values for the upcoming year at the end of each month. The analysis was conducted for both the 1930s drought period and the full period of analysis of 1930-2002.

Table 7. Average annual hydropower revenues Westerns' sales and purchases outside its firm energy commitments ($ millions).

	1930-1941	1930-2002
Current	-65.58	75.15
No Action	-76.08	71.68
GDUISR	-77.67	68.90

Table 7 shows first that the revenues during the 1930s drought period are negative meaning that considerable power would have to be purchased during such a drought. Second, the table shows that the No Action alternative increased depletions over Current conditions would have an average annual impact of $10.5 million during a drought like that of the 1930s. The magnitude of the increased average annual losses of revenue from Current conditions to the 2050 conditions indicates that the additional non-navigation year during the 12-year period of analysis of the No Action and GDUISR alternatives is an important factor. This is shown on Figure 12 where the 5 non-navigation years of 1935-1938 and 1941 (all non-navigation years for the No Action and the GDUISR alternatives) have the largest losses of revenue. When compared to the No Action alternative, a net revenue loss of about $1.6 million occurs in the 1930s drought period for the addition of the depletions resulting from the implementation of the GDUISR alternative, which relies on the diversion of Missouri River water to the Red River Valley.

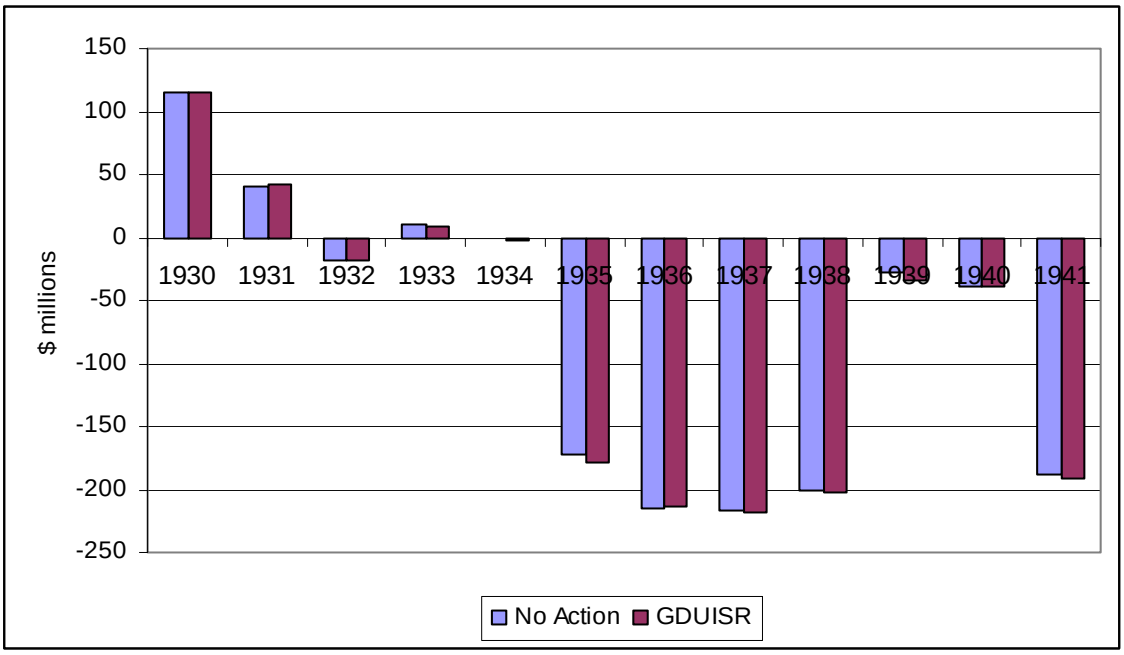

Figure 12. Annual net energy revenues from purchases and sales below and above, respectively, of Western's firm energy commitment to its customers for the No Action and GDUISR alternatives.

Hydropower and Thermal Generation Capacity at Risk

The above discussion has identified that hydropower benefits and revenues decrease during extended droughts such as the 1930s drought. Thermal generation along the mainstem of the Missouri River is also adversely affected when flows are diminished below levels that can fully accept the waste heat in the water discharged to the river after it is used for cooling the generators. If the flow is diminished too much, the primary solution is to reduce generation to limit the amount of waste heat. The average annual amount of hydropower generation capacity that falls below the summer marketing capacity by Western of 2070 megawatts (MW) is listed in Table 8. This table also lists the amount of thermal generation that is at risk on average in the summers during the 1930 drought. The thermal generation maximum-day values were computed by pulling data from the water supply model on lost generation instead of the net economic cost of the lost generation. Also, the model had to be run on a daily time step to accomplish this task of computing capacity at risk. The value used from this more intense water supply modeling is the highest daily value during the period being modeled, in this case, mid-June through mid-September. Using the two capacity values, a sum is computed to arrive at the total generation capacity that may be at risk during a drought like the 1930s drought, should both the thermal and hydropower maximum reductions occur on the same day. Because non-navigation years are a large factor in the computation of the average annual values, Table 8 also includes the data for 1930-1942 so that the fifth non-navigation year for Current conditions can be included in the analysis of capacity at risk.

All three simulations will, therefore, include 5 non-navigation years in the period of analysis that includes 1942. The discussion below focuses on the 1930-1942 data.

One can generally see that the No Action and GDUISR alternatives with the fifth non-navigation year during the 1930-1941 period of analysis would have greater amounts of thermal generation capacity at risk than under Current conditions with only 4 non-navigation years during the 12-year period. When the 1930-1942 period of analysis data are examined, the differences between the Current conditions and the No Action and GDUISR alternatives is reduced. The No Action and GDUISR alternatives have slightly over 1.5 percent more capacity at risk than would occur under Current conditions. This value would be over 19 percent if 1942 were not included in the comparison, verifying that the non-navigation years are a significant factor in the computation of the average annual values.

The average annual values, however, do not provide a representative picture of what Western, the thermal generating utilities, and the consumers of electricity (those delivering the electricity to the ultimate users) will be dealing with on an annual basis. Figures 13, 14, and 15 provide this perspective. These three figures show the annual hydropower, thermal, and total capacity at risk, respectively. The thermal generation has the highest amount of capacity at risk in the non-navigation years when river flows would be the lowest in the summer. Because the thermal numbers are greater, the total numbers are greatest in the non-navigation years, and these totals range from 2000 to about 4500 MW. Because 1937 was not a non-navigation year under Current conditions but was one in 1942, noticeable differences occur in those two years between Current conditions and the No Action and GDUISR alternatives.

Table 8. Missouri River mainstem capacity at risk from mid-June through mid-September (MW)

	Hydropower	Thermal	Total
	1930-1941		
Current	54.2	1123.4	1177.5
No Action	68.1	1335.9	1404.0
GDUISR	78.2	1326.7	1404.9
	1930-1942		
Current	54.2	1259.4	1313.6
No Action	65.1	1268.7	1333.8
GDUISR	75.5	1260.2	1335.8

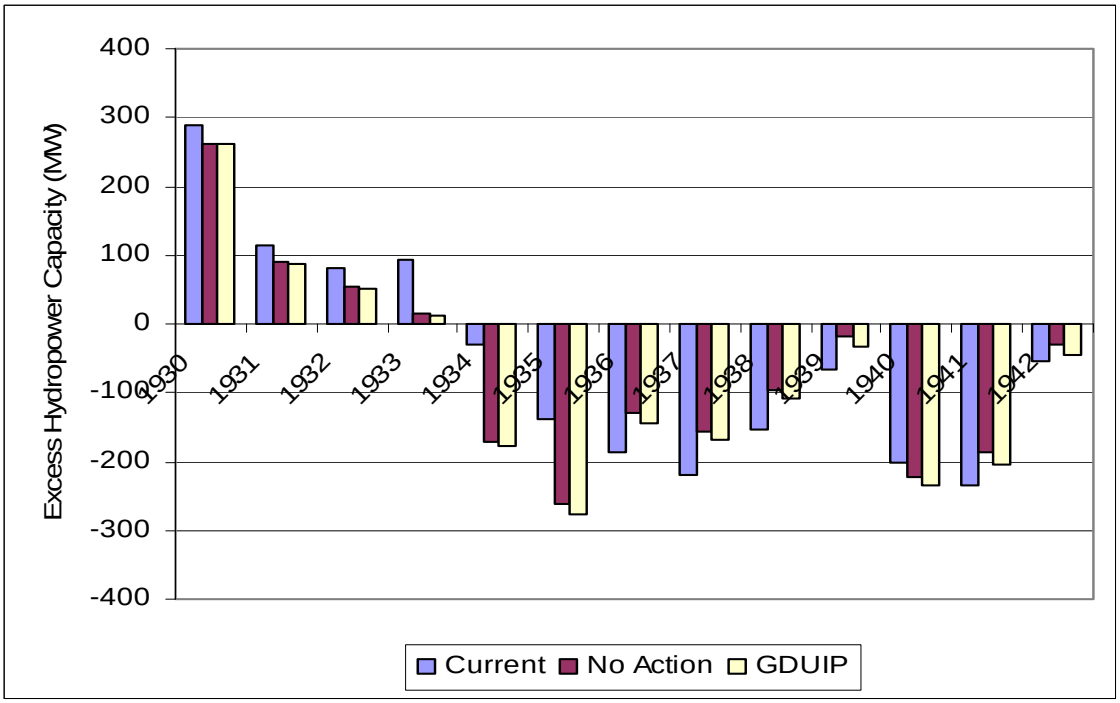

Figure 13. Annual hydropower capacity in excess of Western's summer marketable capacity from mid-June through mid-September, 1930-1942.

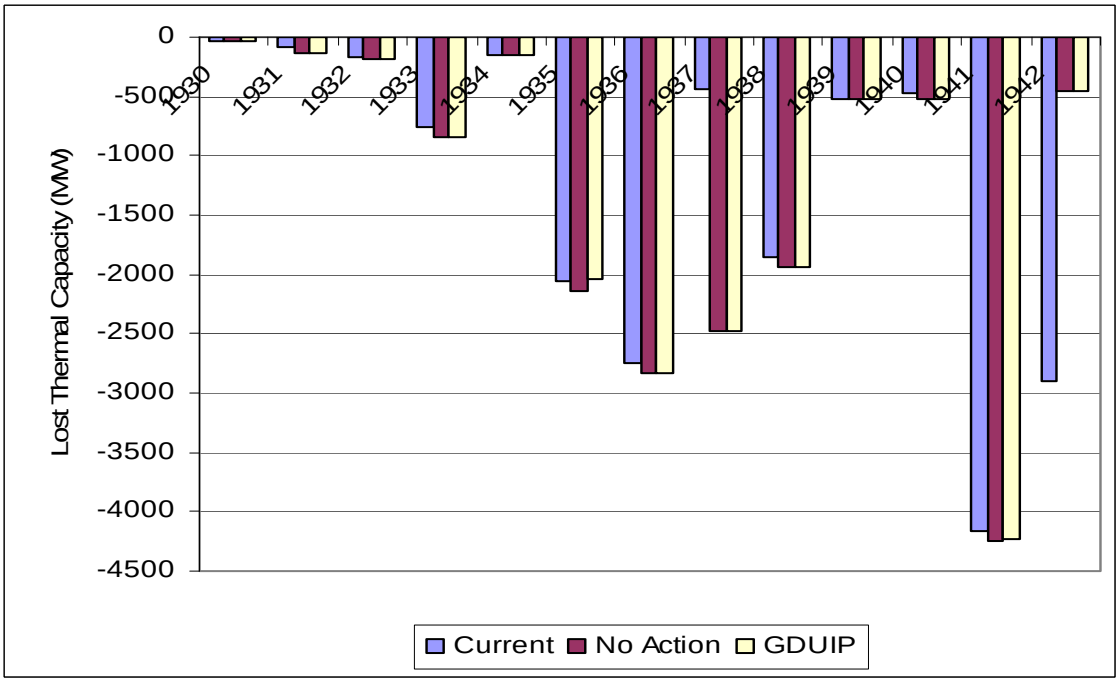

Figure 14. Annual thermal generating capacity at risk from mid-June through mid-September, 1930-1942.

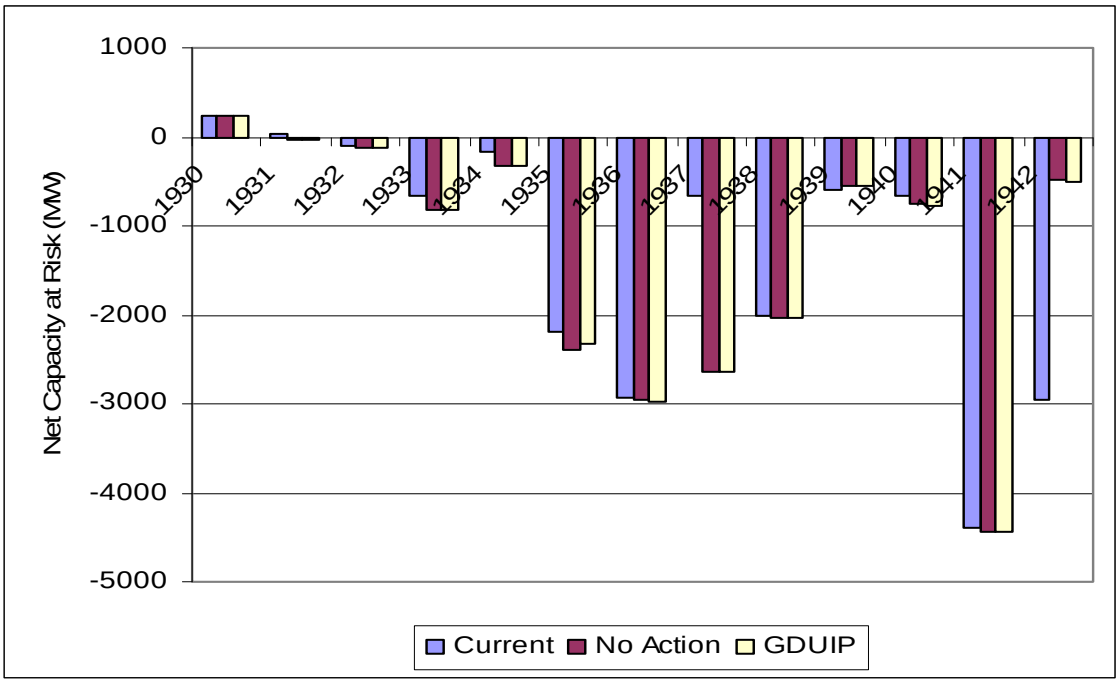

Figure 15. Annual combined hydropower and thermal generating capacity at risk from mid-May through mid-September, 1930-1942.

Hydropower and Thermal Generation Energy at Risk

Generation of electricity is reduced from the Mainstem Reservoir System as capacity is diminished when the reservoir levels drop and releases from the reservoirs are lowered during extended droughts. Reduced releases within and from the Mainstem Reservoir System result in lower flows in the river reach below Garrison Dam and downstream from the Mainstem Reservoir System on the Lower River in which to dissipate heat from the thermal generators in those two reaches. Normally a maximum increase of 5 degrees Fahrenheit is allowed. In extremely warm summer periods, the temperature of the receiving stream may exceed 85 degrees Fahrenheit, and the amount of water temperature increase allowed is reduced as all heat sources must not raise the temperature above 90 degrees.

The effect of the drought of the 1930s on energy generation limitations, or energy at risk, was evaluated for the No Action and GDUISR alternatives because water use from these alternatives would reduce the amount of water moving through and downstream from the Mainstem Reservoir System during an extended drought like that of the 1930s. For comparative purposes, the energy at risk was also computed for Current conditions. The average annual energy at risk for the three simulations is presented in Table 9. Values for two time periods are listed in this table; however, the following discussion will focus on the 1930-1942 (instead of the normal 1930-1941) time period because of the major effect that non-navigation years has on the average annual values. All three simulations have 5 non-navigation years when 1942 is included in the evaluation. Table 9 shows that the No Action and GDUISR alternatives have greater amounts of energy at risk relative to the

Current conditions. The hydropower values are the energy generation marketed by Western minus the firm commitment made to Western's customers for the months of mid-June (1/2 of the June monthly value) through mid-September (1/2 of the September monthly value). A positive number in Table 9 means that, on average, enough energy is generated to meet the firm commitments. The thermal values are the cutbacks in generation required to comply with the thermal discharge permits for the hottest time of the year, mid-June through mid-September. One gigawatt-hour of energy is not generated on average annual during the 1930-1942 period of analysis for the energy at risk analysis when the total value for the GDUISR alternative is compared to the No Action alternative. When the thermal and hydropower values are combined, the No Action and GDUISR alternatives have less than 1 percent more energy at risk than under Current conditions. If 1942 had not been included in the analysis, this less than 1 percent difference would have been about 35 percent, showing the significance of not including 1942 in the evaluation.

Table 9. Missouri River mainstem energy at risk from mid-June through mid-September (GWh)

	Hydropower	Thermal	Total
	1930-1941		
Current	55	-559	-504
No Action	18	-697	-679
GDUISR	14	-691	-678
	1930-1942		
Current	0	-618	-618
No Action	25	-647	-622
GDUISR	19	-642	-623

This average annual analysis does not give a total picture for the variability and the worst year that could occur in a drought like that of the 1930s. Figures 16, 17, and 18 show the amount of energy that would need to be purchased (negative numbers on the figures) to either meet Western's firm energy commitments to its customers or by the utilities purchasing power from the Missouri River mainstem thermal powerplants when the Mainstem Reservoir System powerplants cannot operate at full capacity for the 1930-1942 period. Hydropower energy at risk is greatest in the non-navigation years (1935-1938 and 1941) for the No Action and GDUISR alternatives. Similarly, the thermal energy at risk is greatest in the non-navigation years; therefore, the combined energy-at-risk values occur in the non-navigation years. Inclusion of the 1942 data shows the non-navigation years for the Current conditions (1935, 1936, 1938, 1941, and 1942) have major negative values. The loss of energy availability could exceed 1,300 to 2,500 GWh in the summer months of the non-navigation years. Variability among the non-navigation years is likely due to the differences in tributary inflows in the Garrison downstream reach and the Lower River.

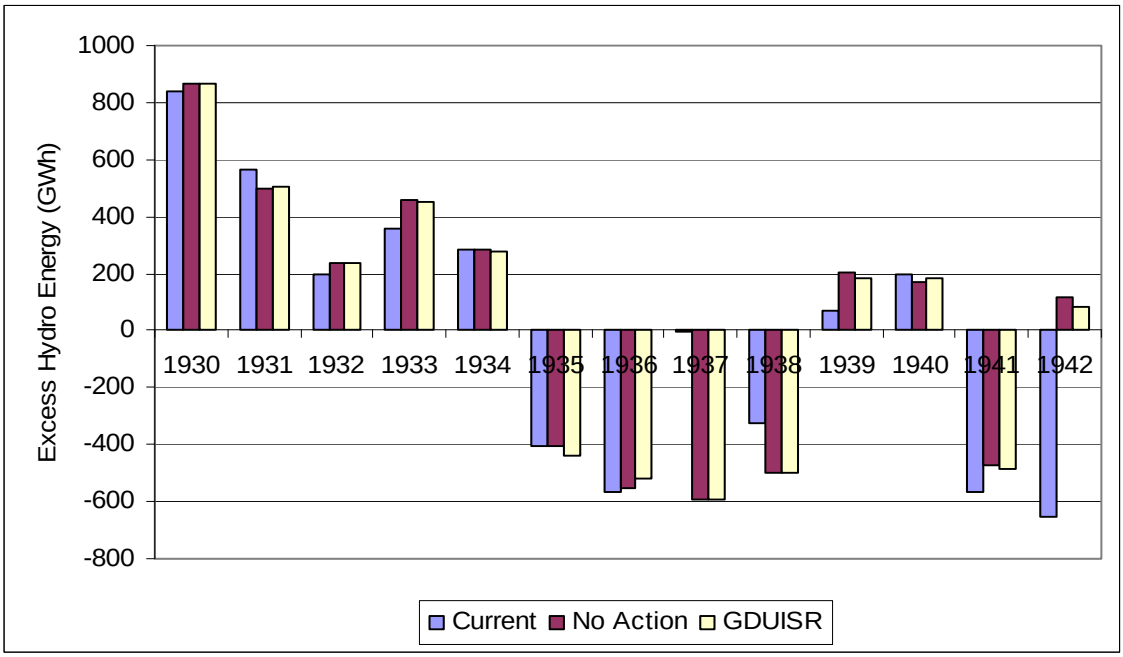

Figure 16. Annual hydropower mid-June through mid-September energy in excess of Western's firm energy commitments for those months, 1930-1942.

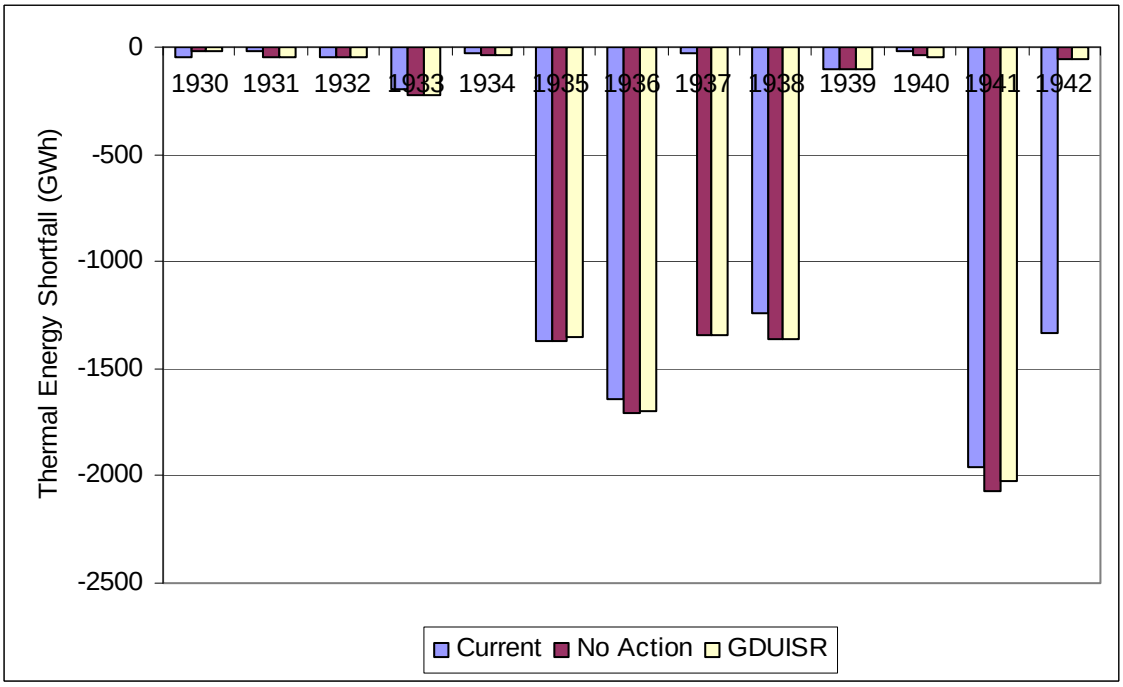

Figure 17. Annual thermal energy at risk from mid-June through mid-September energy, 1930-1942.

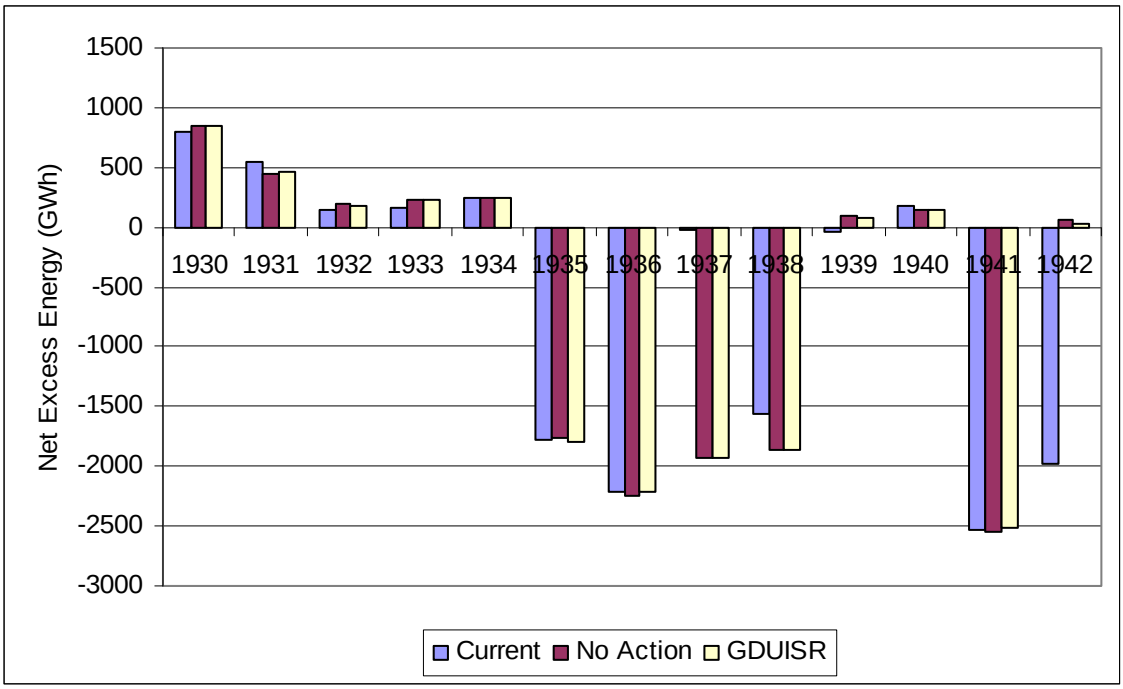

Figure 18. Annual combined energy at risk from mid-June through mid September, 1930-1942.

WATER SUPPLY

An important benefit of the Mainstem Reservoir System is the availability of water at more than 1,600 intake facilities along lake and river reaches from Fort Peck reservoir to St. Louis. Economic benefits accrue to the use of water for thermal powerplants, agriculture, public and private drinking water, and other industrial uses of water not served by public systems.

Table 10 presents the average annual water supply benefits for both the 1930s drought and the 1930-2002 periods of analysis. To provide a more visual perspective of the changes in the total 1930-1941 water supply benefits, Figure 19 was prepared. This figure shows the average annual benefits for 1930-1941 period of analysis. Both the No Action and GDUISR alternatives have essentially the same average annual water supply benefits, with those of the 73-year period of analysis being the larger of the two sets. Figure 20 shows that the annual benefits for the No Action and GDUISR alternatives vary slightly among themselves in some of the 1930s drought years. The primary factor affecting the water supply economics is most likely the water supply/water quality effects of lower flows in the non-navigation years on the thermal powerplants, as demonstrated in the power-at-risk discussion above. In fact, had the 1942 data been included in the average annual computations, the Current conditions and the No Action and GDUISR alternatives Lower River and Total values would likely be about the same.

Table 10. Average annual water supply benefits ($ millions).

	Total	Lakes	Upper River	Lower River
		1930-1941		
Current	535.7	16.2	92.8	426.7
No Action	528.2	16.4	92.7	419.1
GDUISR	528.1	16.2	92.8	419.1
		1930-2002		
Current	605.7	20.2	95.4	490.1
No Action	604.5	20.4	95.4	488.7
GDUISR	604.4	20.3	95.4	488.6

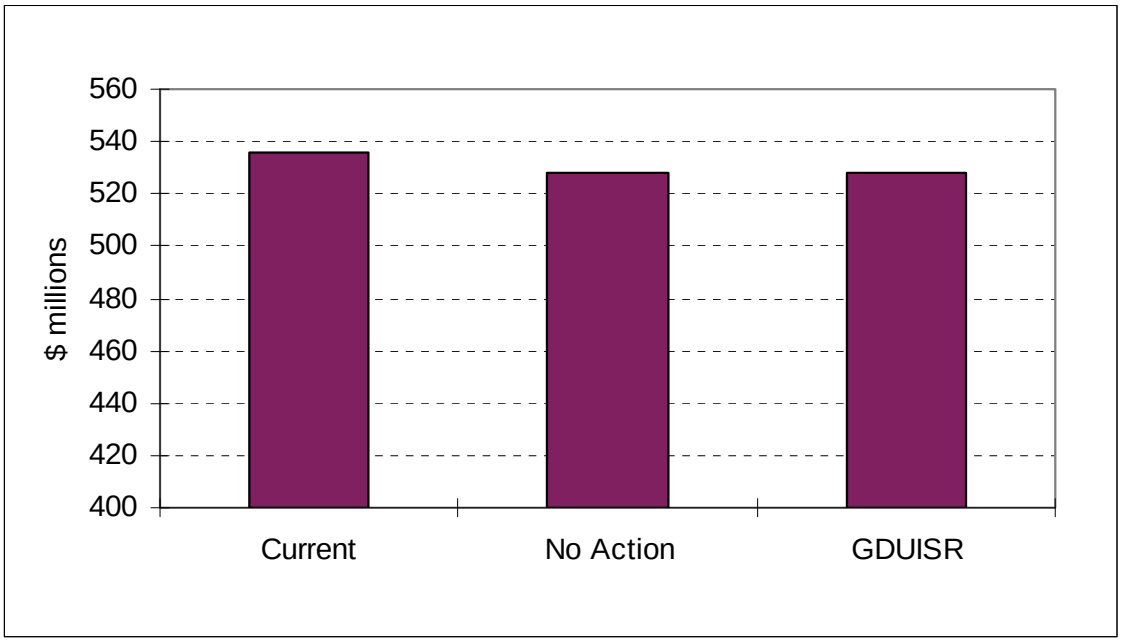

Figure 19. Average annual total water supply benefits, 1930-1941.

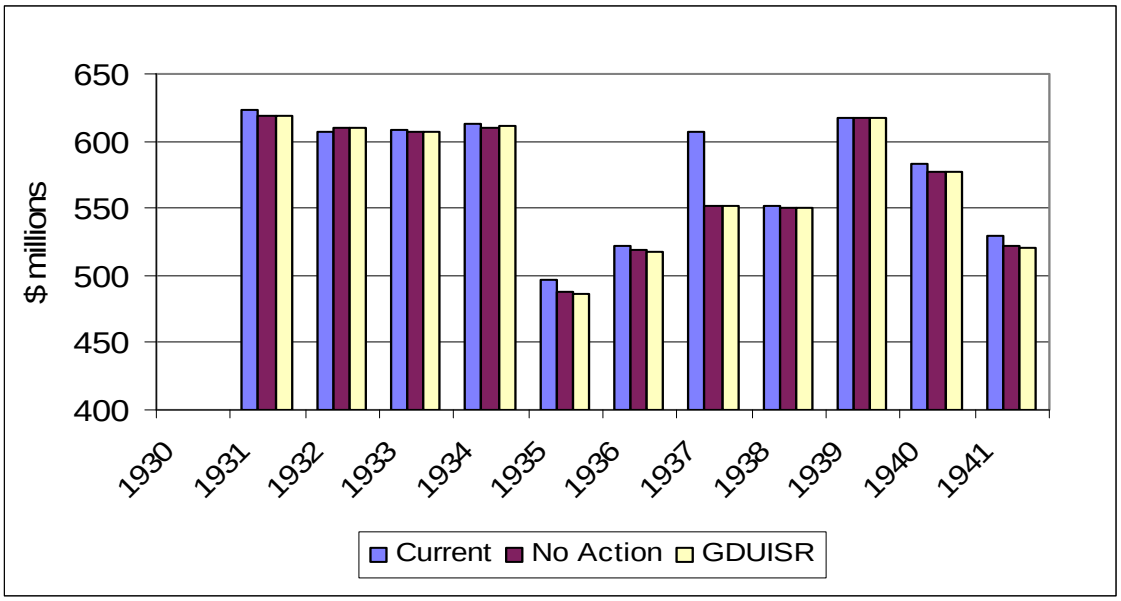

Figure 20. Annual total water supply benefits, 1930-1941. (Note that the benefits for 1930 do not appear on the figure because the water supply economics modeling assumes replacement of facilities occurs in year 1 and every 30 years subsequently.)

As the reservoir levels drop, some municipal intakes are more likely to lose their access to water from the lake. A special analysis identified the municipal intakes at greatest risk of losing water access and if there was a difference among the alternatives regarding the loss of access on Garrison and Oahe reservoirs. Table 11 identifies the shutdown water surface elevations for the two intakes at greatest risk of losing access to water on each of the two reservoirs, minimum reservoir elevations during the 1930s drought, and required intake level changes. A negative change indicates that the intake needs to be lowered.

The intake evaluated on Garrison reservoir, the intake for Parshall, North Dakota, would need to be lowered under Current conditions and the No Action and GDUISR alternatives. The amount of lowering required would be the most for the Current conditions and the least for the No Action alternative. The difference between No Action and the GDUISR alternative is 0.22 feet.

The Wakpala, South Dakota intake on Oahe reservoir would need to be lowered the most under Current conditions, a total of 7.44 feet. The No Action alternative would require no lowering, and the GDUISR would require that the Wakpala intake be lowered 0.55 feet. The ice-period elevations for Oahe reservoir were checked for the No Action and GDUISR alternatives to ensure that the lower, open-water conditions controlled, which they did for both alternatives.

Figures 21 and 22 provide some perspective on the relative water level changes in Garrison and Oahe reservoirs, respectively. These figures also provide some perspective on how these levels change relative to the water levels required for the Parshall and Wakpala intakes to function under both the ice and open-water conditions.

Table 11. Minimum reservoir elevations during the 1930s drought and required intake level changes (feet msl).

	Parshall, ND		Wakpala, SD	
Ice Requirement	1801.5		1566.8	
Open Water Requirement	1797.5		1563.8	
	Elevation	Date	Elevation	Date
Current	1792.44	3/1/41	1559.36	2/25/41
No Action	1793.77	3/14/36	1563.96	6/24/35
GDUISR	1793.55	2/7/35	1563.25	5/31/35
	Required Intake Level Change	Controlling Requirement	Required Intake Level Change	Controlling Requirement
Current	-9.06	Ice	-7.44	Ice
No Action	-7.73	Ice	0.16	Open Water
GDUISR	-7.95	Ice	-0.55	Open Water

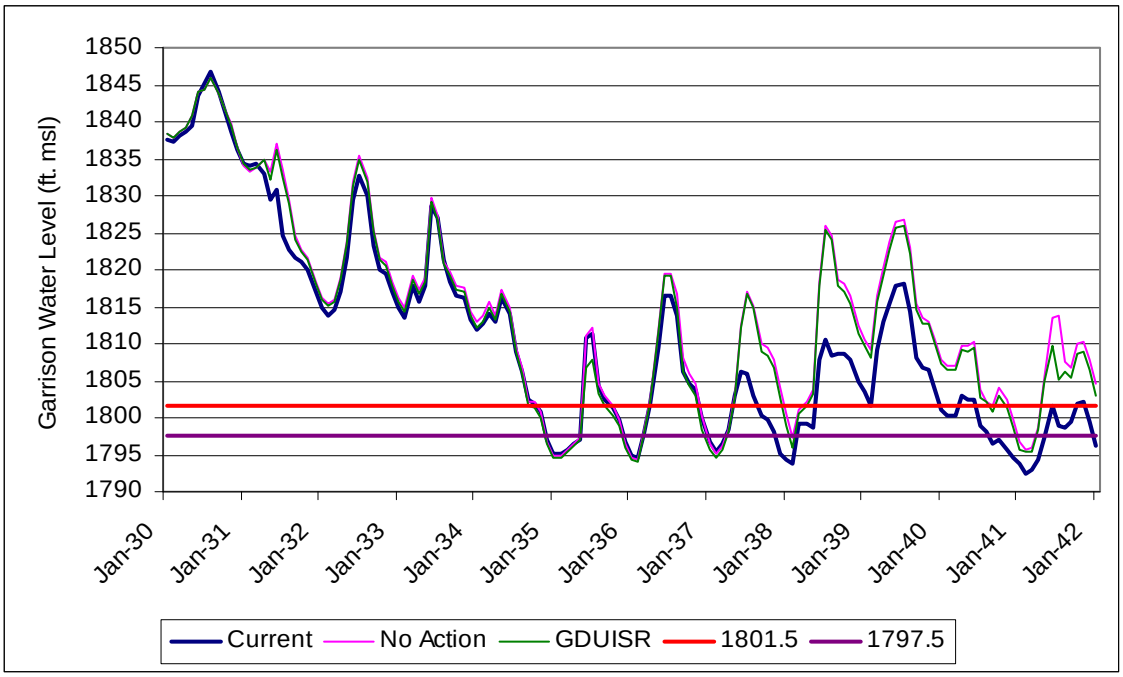

Figure 21. End-of-month Garrison reservoir elevation for each month of the 1930s drought with the minimum required ice and open-water elevations for the Parshall, North Dakota intake.

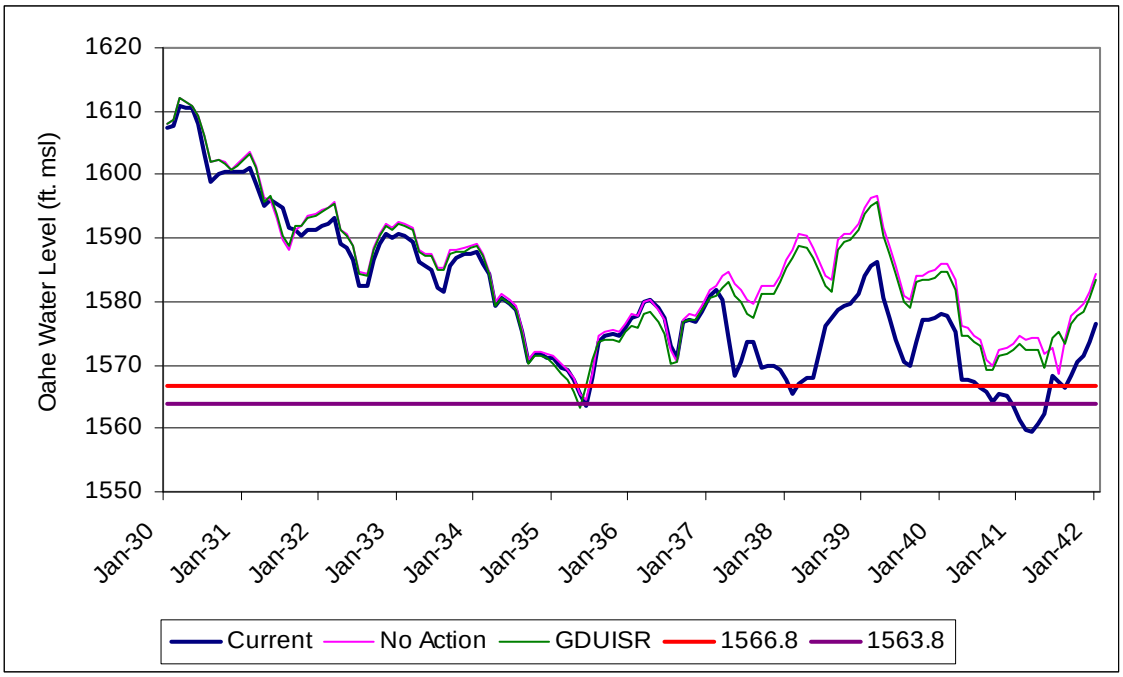

Figure 22. End-of-month Oahe reservoir elevation for each month of the 1930s drought with the minimum required ice and open-water elevations for the Wakpala, South Dakota intake.

RECREATION

Recreation benefits were computed for all reaches of the Missouri River from Fort Peck reservoir to the mouth. These benefits are summarized in Table 12 and Figure 23. Changes in total recreation benefits during a drought like that of the 1930s decrease $0.8 million (-1.14 percent) from the No Action alternative to the GDUISR alternative, indicating that increasing depletions decreases recreation benefits. The increased benefits for the No Action and GDUISR alternatives relative to Current conditions are an indication that continuing sedimentation will have a positive effect on recreation at the upper three reservoirs. The positive effects of the sedimentation on reservoir recreation more than offset the negative effects of the depletions included in the 2050 alternatives as the total benefits for the No Action and GDUISR alternatives are higher than those under Current conditions.

The annual total recreation benefits are shown in Figure 24. There are relatively small differences between the No Action and GDUISR alternatives on an annual basis. Figures 25 through 27 show the annual values for each of the upper three reservoirs, and the decreased benefits occur in similar patterns to those seen for the total recreation benefits discussed above. The severity of the drought and the associated operation and maintenance costs, including boat ramp extensions, result in benefits dropping to zero and below during the 1934-1935 period at Garrison reservoir and in 1935 at Oahe Reservoir.

Table 12. Average annual recreation benefits ($ millions).

	Total	Upper 3 Res.	Lower. 3 Res.	Upper River	Lower River
			1930-1941		
Current	66.6	15.5	28.2	4.5	18.3
No Action	69.9	18.9	28.5	4.4	18.0
GDUISR	69.1	18.1	28.5	4.4	18.0
			1930-2002		
Current	86.1	33.1	28.9	4.5	19.5
No Action	86.8	34.0	28.9	4.5	19.4
GDUISR	86.6	33.8	28.9	4.5	19.4

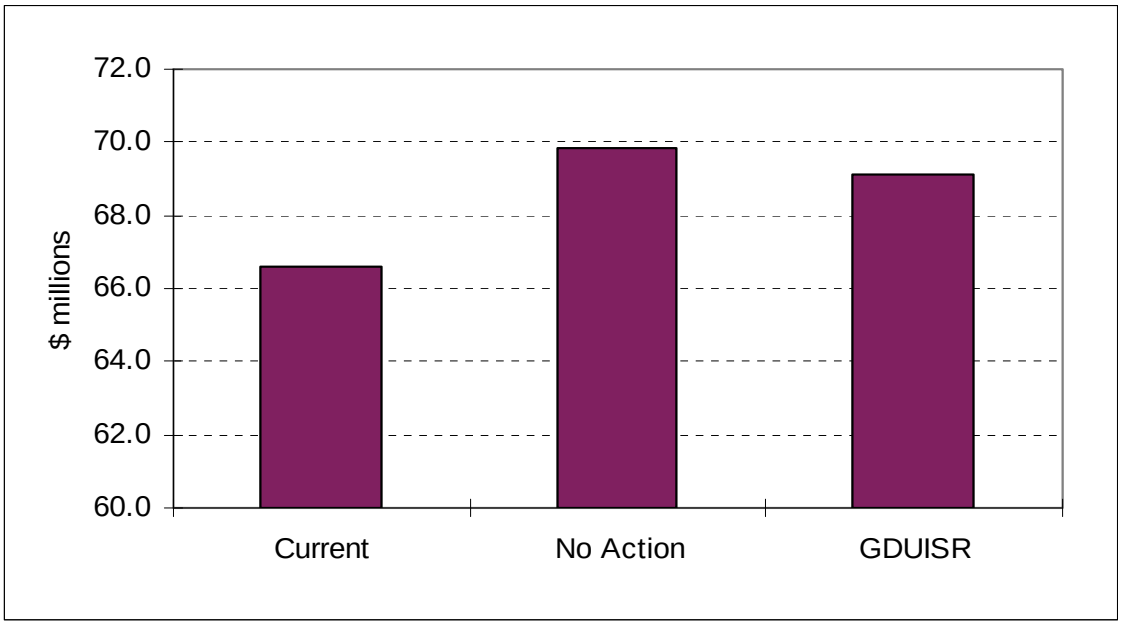

Figure 23. Average annual total recreation benefits, 1930-1941.

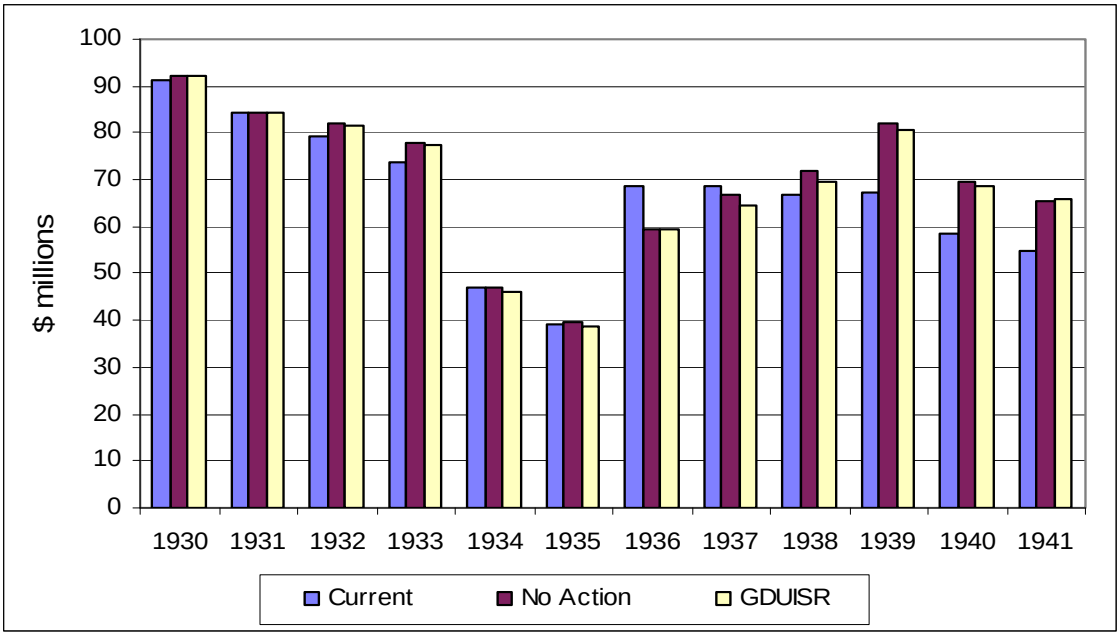

Figure 24. Annual total recreation benefits, 1930-1941.

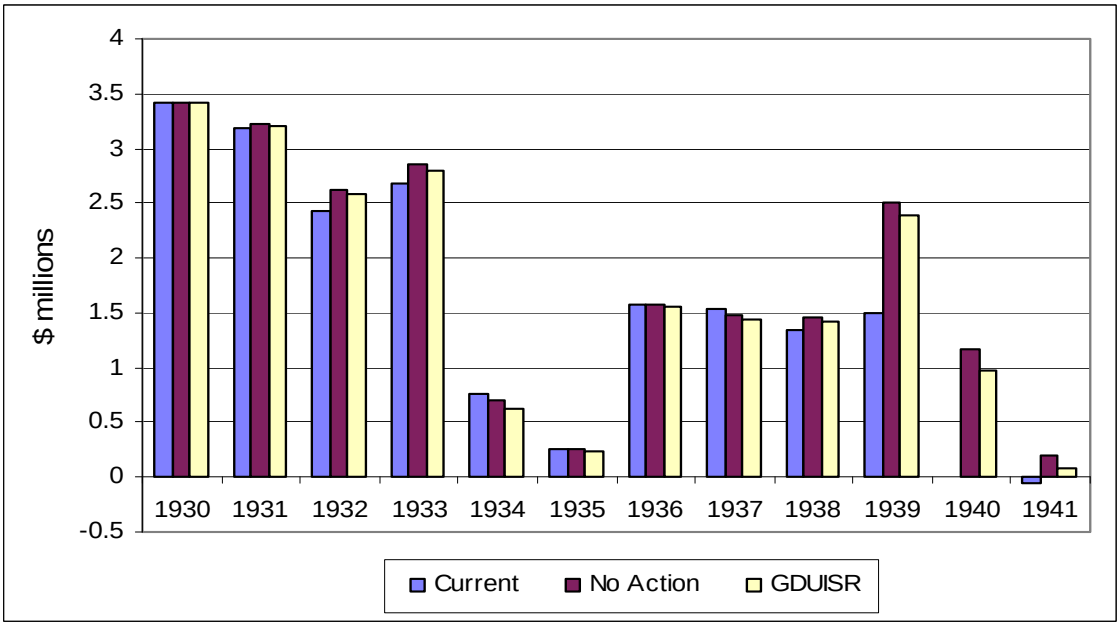

Figure 25. Annual Fort Peck reservoir recreation benefits, 1930-1941.

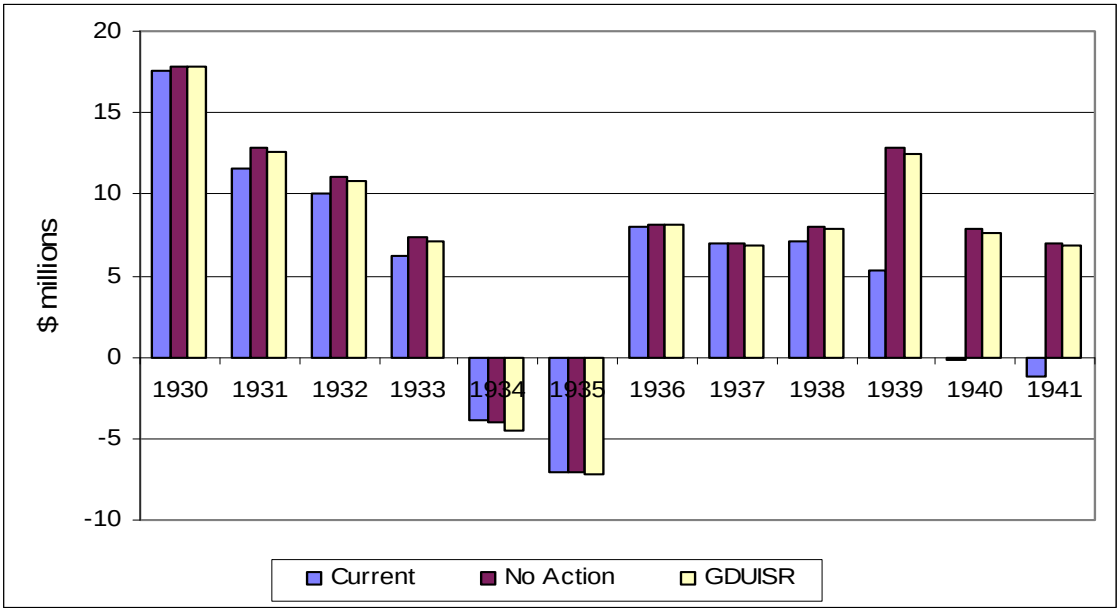

Figure 26. Annual Garrison reservoir recreation benefits, 1930-1941.

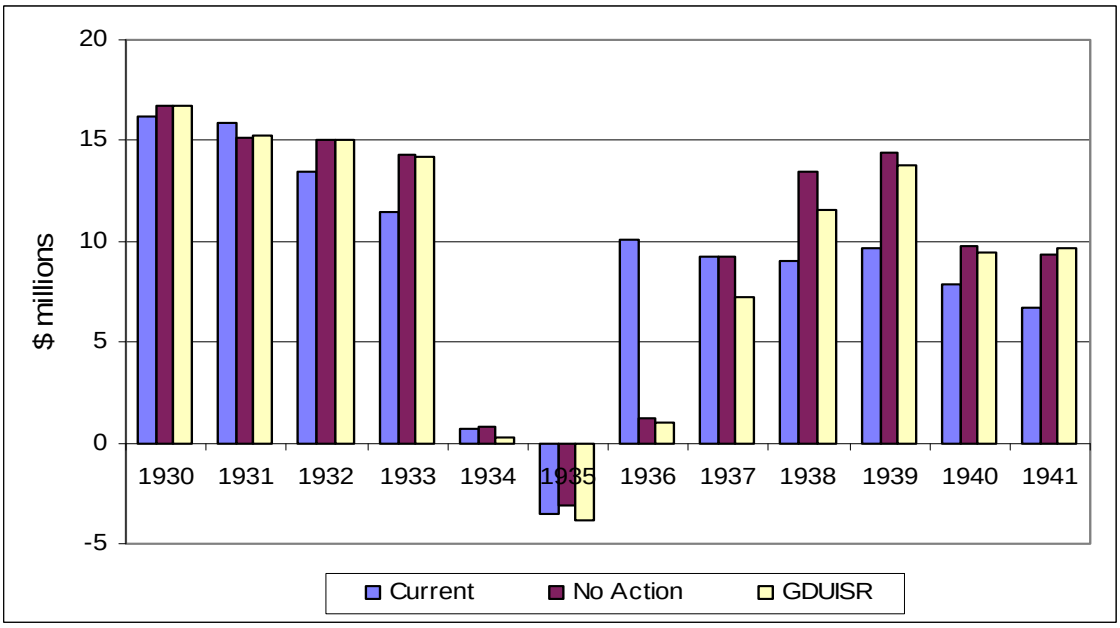

Figure 27. Annual Oahe reservoir recreation benefits, 1930-1941.

RESERVOIR COLDWATER FISH HABITAT

Various coldwater fish species in the three larger reservoirs of the Mainstem Reservoir System require lower temperature and higher dissolved oxygen criteria to meet their habitat needs. Table 13 and Figure 28 show the average annual reservoir coldwater fish habitat values for the 1930s drought. The table also includes the values for the 73-year

period of analysis from 1930 to 2002. Annual values for this habitat are the minimum volume of this habitat in the July through October timeframe of each year.

Both Table 13 and Figure 28 show that the reservoir coldwater fish habitat will increase in the future for both periods of analysis. The increase between the Current conditions and the No Action alternative with 2050 depletion and sedimentation conditions is the result of the increasing sedimentation, with the effect of the sedimentation masking the negative effect of the increased depletions. The average annual coldwater fish habitat value during the 1930s drought is 0.13 MAF lower for the GDUISR alternative when compared to the No Action alternative, which represents average annual habitat changes of -3.07 percent. This affirms that increasing depletions decrease reservoir coldwater fish habitat. The loss of habitat over the full period of analysis for the change from No Action is -0.51 percent.

The reach data in Table 13 also show variability as the depletions increase for the GDUISR alternative above those of the No Action alternative. Coldwater fish habitat in all three reservoirs generally decreases in both periods of analysis. The main concern with reservoir coldwater habitat is complete loss of this habitat during an extended drought because that could lead to a loss of one or more fish species, including the critical forage fish species in one or more of the reservoirs. The annual total values shown in Figure 29 do not show a complete loss of the coldwater habitat in the reservoirs. Figures 30, 31, and 32 present the annual reservoir coldwater habitat values for Garrison, Fort Peck, and Oahe reservoirs, respectively. This order was chosen because this is the order in which these reservoirs are likely to lose the coldwater habitat.

Table 13. Average annual reservoir coldwater fish habitat (MAF)

	Total	Fort Peck Lake	Lake Sakakawea	Lake Oahe
		1930-1941		
Current	3.80	1.30	0.65	1.85
No Action	4.24	1.44	0.67	2.13
GDUISR	4.11	1.40	0.63	2.08
		1930-2002		
Current	9.29	3.42	2.52	3.35
No Action	9.67	3.56	2.64	3.47
GDUISR	9.62	3.53	2.64	3.45

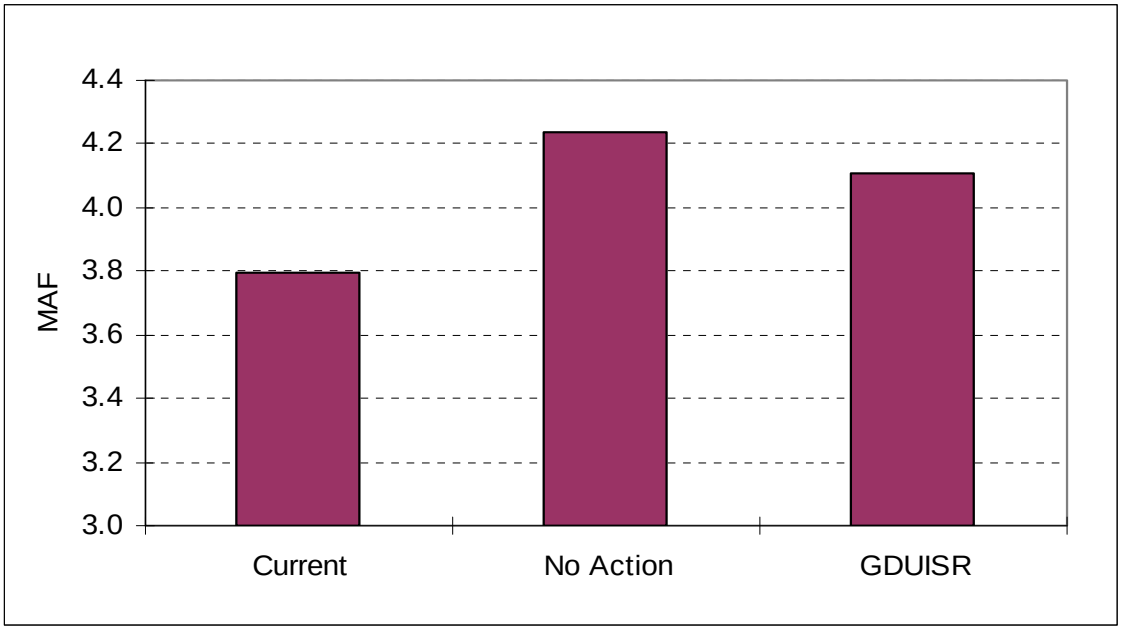

Figure 28. Average annual total reservoir coldwater fish habitat, 1930-1941.

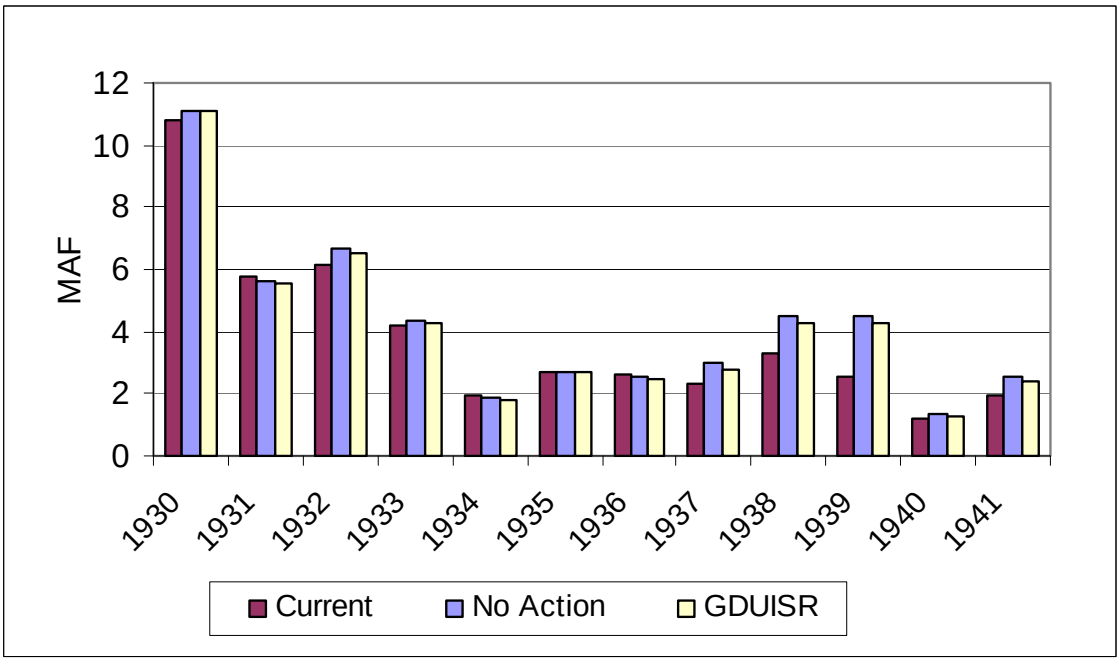

Figure 29. Annual total reservoir coldwater fish habitat, 1930-1941.

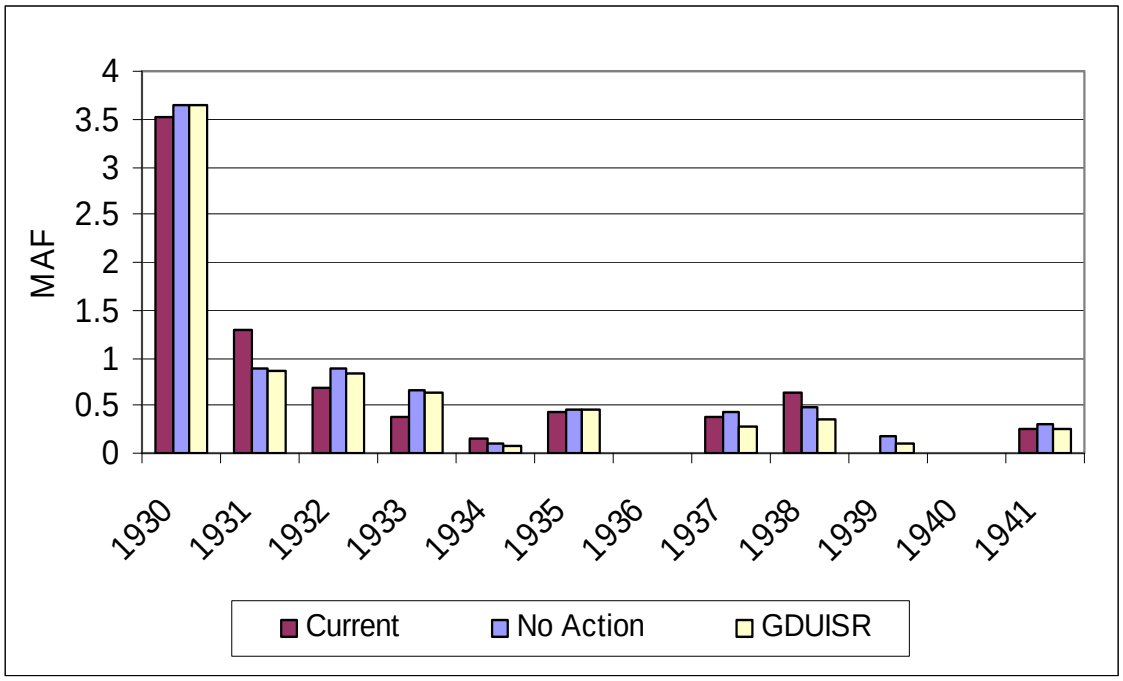

Figure 30. Annual Garrison reservoir coldwater fish habitat, 1930-1941.

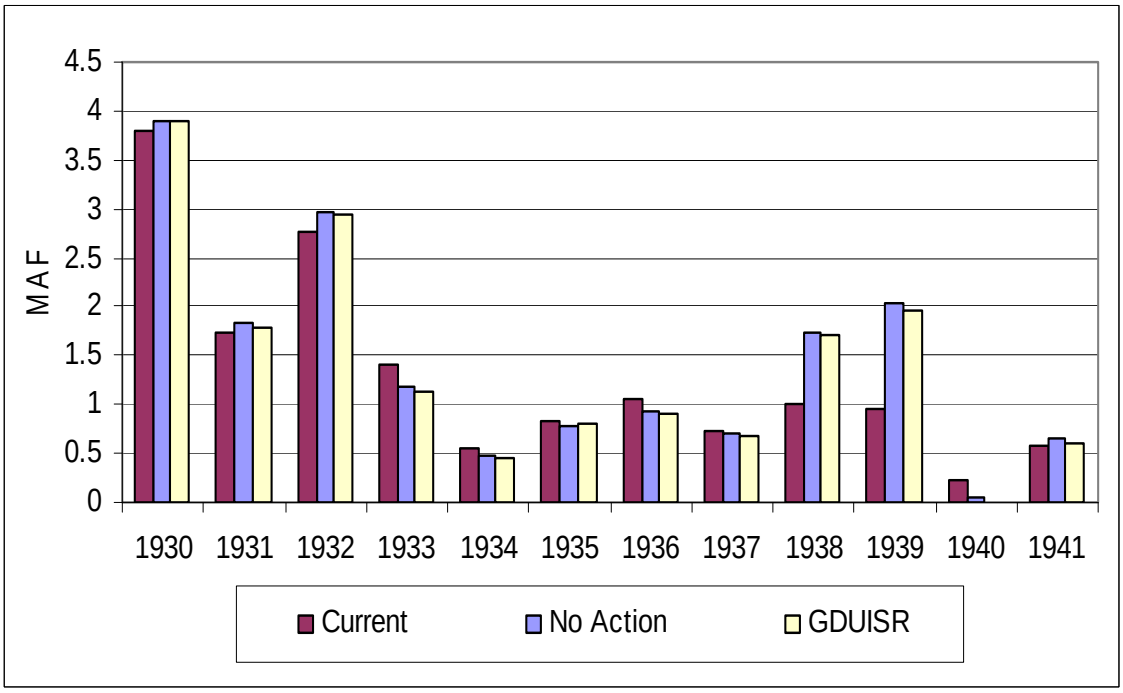

Figure 31. Annual Fort Peck reservoir coldwater fish habitat, 1930-1941.

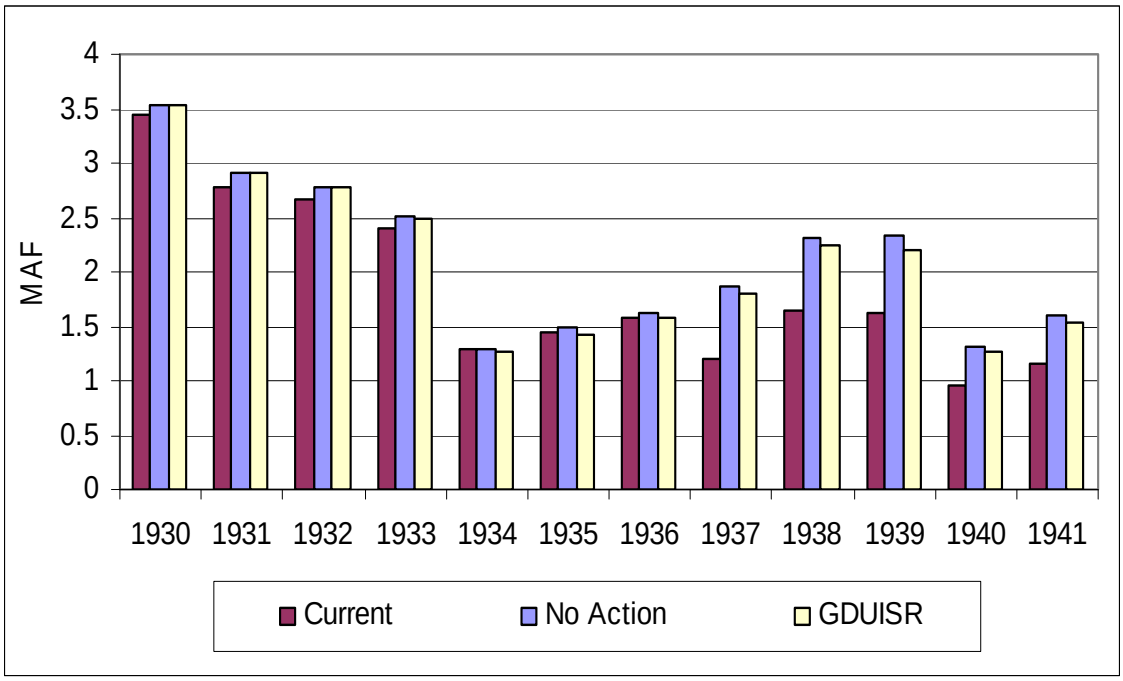

Figure 32. Annual Oahe reservoir coldwater fish habitat, 1930-1941.

The coldwater habitat is essentially completely lost in 4 years in Garrison reservoir sometime during the drought under all three of the simulations, including Current conditions. The habitat is at or near zero in Fort Peck reservoir in 1940. Lake Oahe is able to maintain a minimum of about 1 MAF of this habitat through the entire drought for all three of the simulations. The Corps is currently involved with detailed modeling of the three reservoirs, and one hypothesis is that the depth of water withdrawal is an important factor in affecting the order of losing this critical habitat in all three reservoirs, with Oahe reservoir being the one to retain some habitat longest in an extended drought (based on the Master Manual modeling and the untested hypothesis for the uncompleted, more detailed modeling).

RIVERINE COLDWATER FISH HABITAT

Coldwater habitat for river fish occurs downstream from Fort Peck and Garrison Dams. The average annual values for this habitat for the three simulations are shown in Table 14 and Figure 33. Values for the 1930s drought and the 73-year modeling period are shown in the table, and only the drought values are plotted on the figure. Also, the values are the average miles of river that meet the criteria in the April through September timeframe.

Values in the table and figure for the 1930-1941 drought period show that the average annual miles of coldwater habitat will increase in an extended drought as the depletions increase above the Current conditions and sedimentation occurs between the current time and 2050. It is readily apparent that the increase is caused by the sedimentation that

results in more cold water being released from the two upstream reservoirs. As the depletions increase for the same level of sedimentation, the miles of riverine coldwater habitat diminishes by 0.01 mile (0.06 percent reduction) on average during the 1930s drought for the GDUISR alternative. Overall, the future amount of riverine coldwater fish habitat will be greater than it would be under Current conditions for the 2050 alternatives because of the effect of future sedimentation and regulation of the Mainstem Reservoir System under the current Master Manual criteria. Similar results occur for the full period of analysis from 1930 through 2002, with the No Action alternative having the highest amount of riverine coldwater fish habitat.

Table 14. Average annual riverine coldwater fish habitat (miles).

	Total	Fort Peck	Garrison
	1930-1941		
Current	146.84	114.60	32.24
No Action	149.08	113.31	35.77
GDUISR	149.07	113.76	35.31
	1930-2002		
Current	179.85	137.33	42.51
No Action	181.84	137.81	44.03
GDUISR	181.57	137.73	43.84

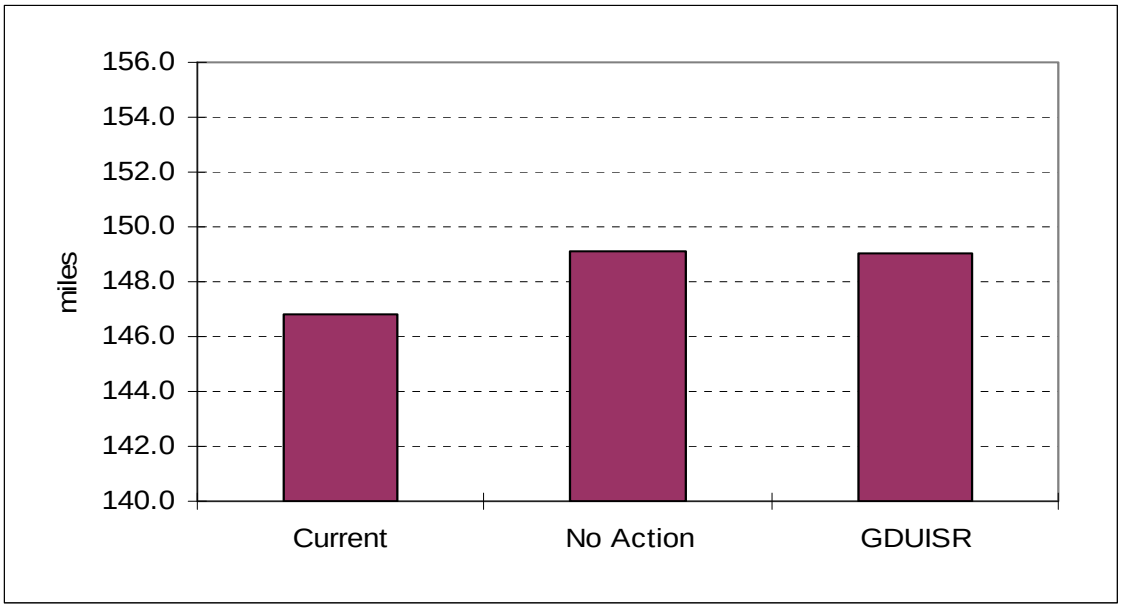

Figure 33. Average annual total riverine coldwater fish habitat, 1930-1941.

Annual values for riverine coldwater fish habitat for the 1930s drought period are shown on Figure 34. This figure shows that the number of miles of riverine coldwater fish habitat diminishes from about 195 miles quickly in a drought, and stays in the range of 120 to 160 miles in the last 11 years of the 12-year drought. There is little variation

between the No Action and GDUISR alternatives in any year, with the greatest difference being less than 5 miles. These small differences, however, account for the differences in the average annual values.

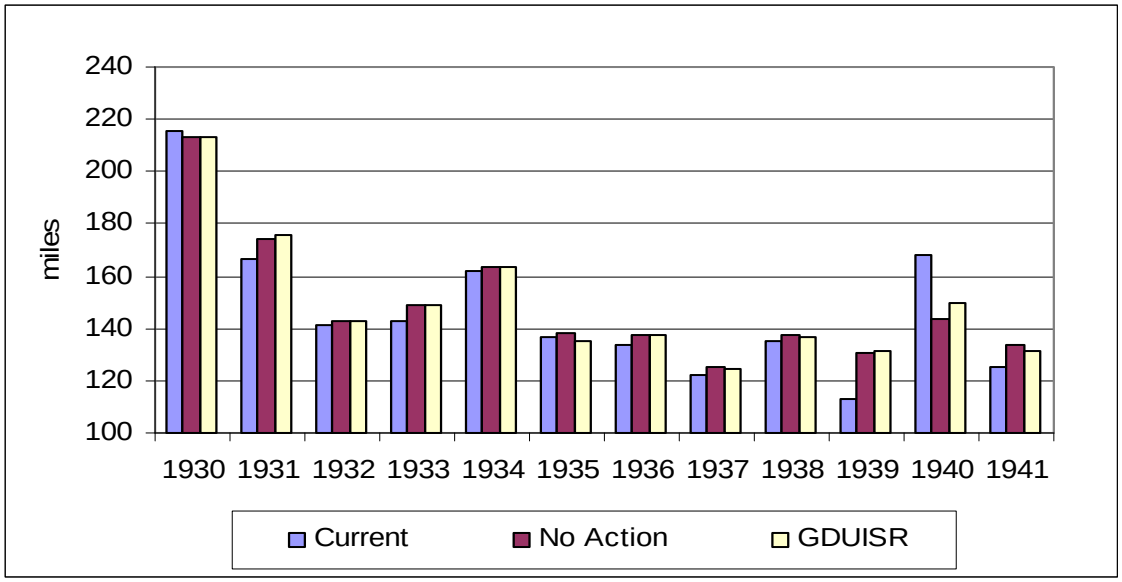

Figure 34. Annual total riverine coldwater fish habitat, 1930-1941.

RIVERINE WARMWATER FISH HABITAT

Warmwater habitat for river fish occurs downstream from Fort Peck, Garrison, and Fort Randall Dams. The average annual values for this habitat for the three simulations are shown in Table 15 and Figure 35. Values for the 1930s drought and the 73-year modeling period are shown in the table, and only the drought values are plotted on the figure. Also, the values are the average miles of river that meet the criteria in the April through August timeframe.

As expected with lower reservoir levels and lower releases during a drought like the 1930s drought, the amount of riverine warmwater fish habitat is higher during the 1930s drought than it averages over a combination of normal, wet, and drought periods, as would occur over the full 73-year period of analysis. For both periods of analysis, the change for the GDUISR alternative from the No Action alternative is negative for the diversion of water to the Red River Valley. This decrease is 0.31 miles for the 1930s drought period. In terms of percent changes from the No Action alternative, this change is a decrease of 0.40 percent. Over the full period of analysis, the average annual warmwater riverine fish habitat values increase slightly for the change from the No Action alternative to the GDUISR alternative. For both periods of analysis, Current conditions provides more warmwater fish habitat in the river reaches than the No Action and GDUISR alternatives. This is likely the result of the continuing sedimentation resulting in more coldwater in the reservoirs that is then released to river reaches, diminishing warmwater habitat.

Table 15. Average annual riverine warmwater fish habitat (miles)

	Total	Fort Peck	Garrison	Fort Randall
		1930-1941		
Current	80.59	57.16	6.94	16.50
No Action	77.52	56.60	6.72	14.21
GDUISR	77.21	56.24	6.56	14.42
		1930-2002		
Current	54.06	34.83	5.86	13.37
No Action	53.31	33.40	6.31	13.59
GDUISR	53.58	33.53	6.42	13.63

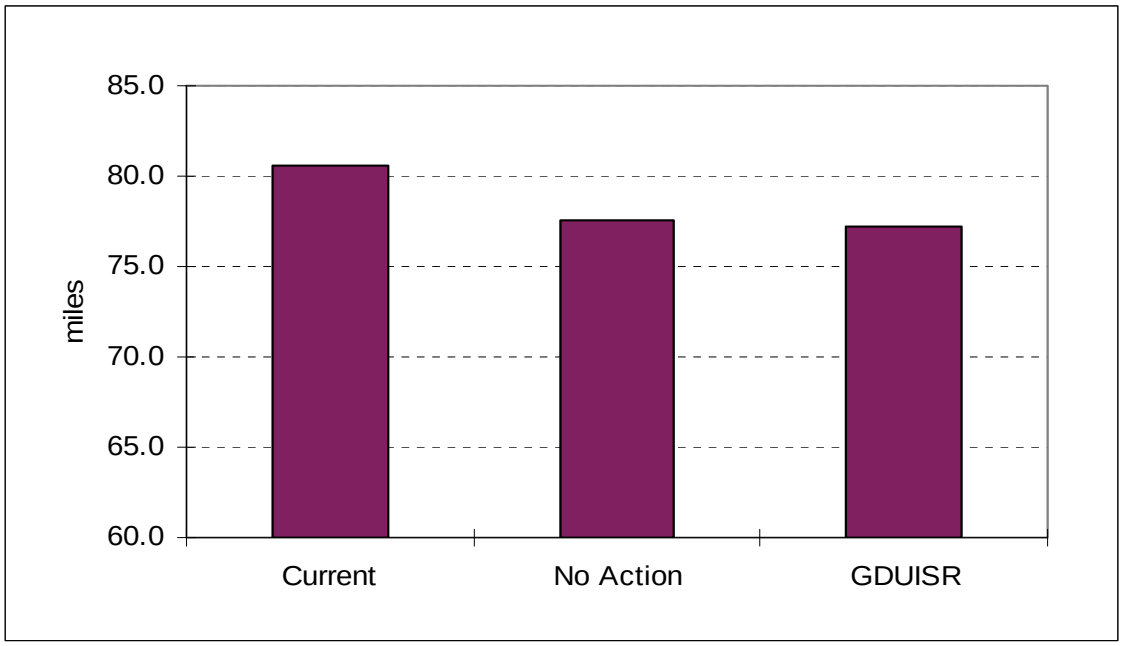

Figure 35. Average annual total riverine warmwater fish habitat, 1930-1941.

Figure 36 presents the annual average total values for riverine warmwater fish habitat. The figure shows that, as the drought progresses and the reservoir levels drop and releases are reduced, the amount of warmwater habitat generally increases to a peak amount in 1939. The greatest differences between the No Action and the GDUISR alternatives in a single year occurred in 1935. This difference was a negative difference, which led to the decrease in the average annual values for the warmwater habitat.

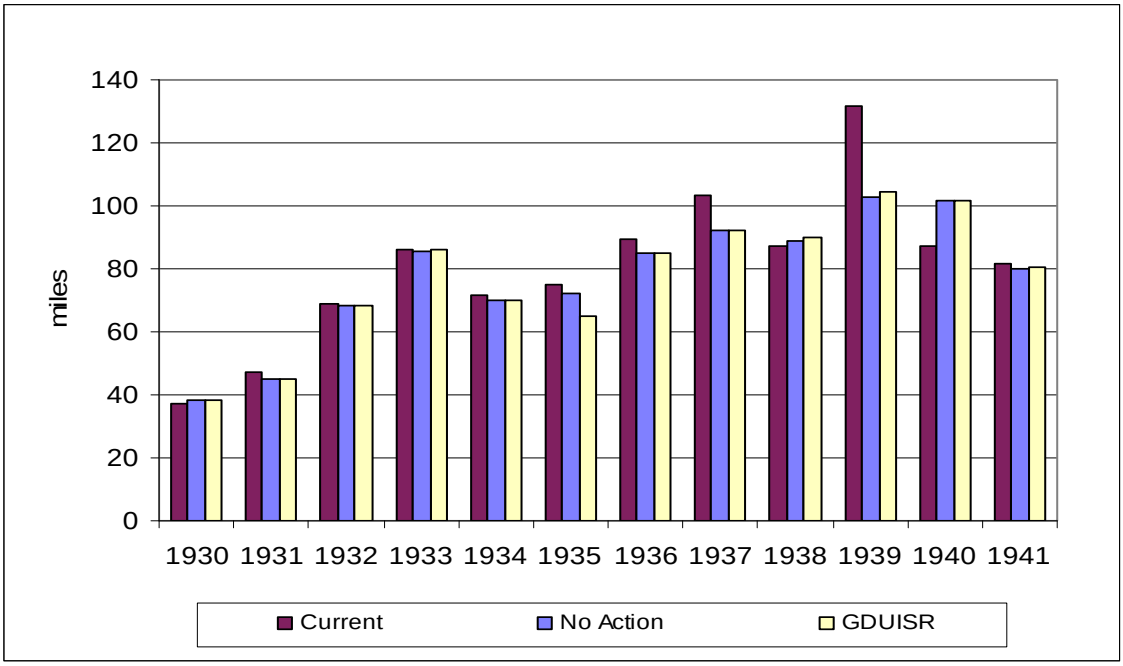

Figure 36. Annual total riverine warmwater fish habitat, 1930-1941.

RESERVOIR YOUNG FISH PRODUCTION

The reservoir young fish production index values are based on regressions of hydrologic factors versus actual young fish production in the six Mainstem Reservoir System reservoirs in the 1980s and early 1990s. Higher index values mean higher young fish production. Average annual total fish production values computed for three periods of analysis are presented in Table 16, and the 1930-1941 values are shown in Figure 37.

The table and figure show that there is essentially no difference for the total young fish production index values from the No Action alternative to the GDUISR alternative for both periods of analysis. The values for these two alternatives are higher than the Current conditions average annual values by from 0.04 to 0.21 units. The net increases for both periods of analysis are the result of continuing sedimentation in the Mainstem Reservoir System and not the increased depletions. This net increase is most notable for Gavins Point reservoir for the 1930s drought period, which is the reservoir most affected by the sedimentation.

Based on the following discussion on the annual total young fish production values, the period 1030-1942 was added to Table 16. Inclusion of the fifth non-navigation year so that the Current conditions and the No Action and GDUISR alternatives had the same number of non-navigation years brought the total index values closer together. There is still a net increase due to the dominant sedimentation factor for the No Action alternative, and the negative effects of increased depletions are noticeable for the GDUISR alternative.

Table 16. Average annual reservoir young fish production (index).

	Total	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
			1930-1941				
Current	2.28	0.22	0.37	0.25	0.24	0.16	1.03
No Action	2.49	0.23	0.44	0.25	0.26	0.19	1.13
GDUISR	2.48	0.22	0.42	0.25	0.26	0.19	1.13
			1930-1942				
Current	2.42	0.21	0.41	0.29	0.31	0.20	1.00
No Action	2.49	0.22	0.45	0.27	0.26	0.21	1.08
GDUISR	2.47	0.22	0.44	0.27	0.26	0.21	1.08
			1930-2002				
Current	2.28	0.51	0.49	0.39	0.26	0.25	0.38
No Action	2.33	0.53	0.51	0.39	0.25	0.25	0.40
GDUISR	2.32	0.53	0.50	0.39	0.25	0.25	0.40

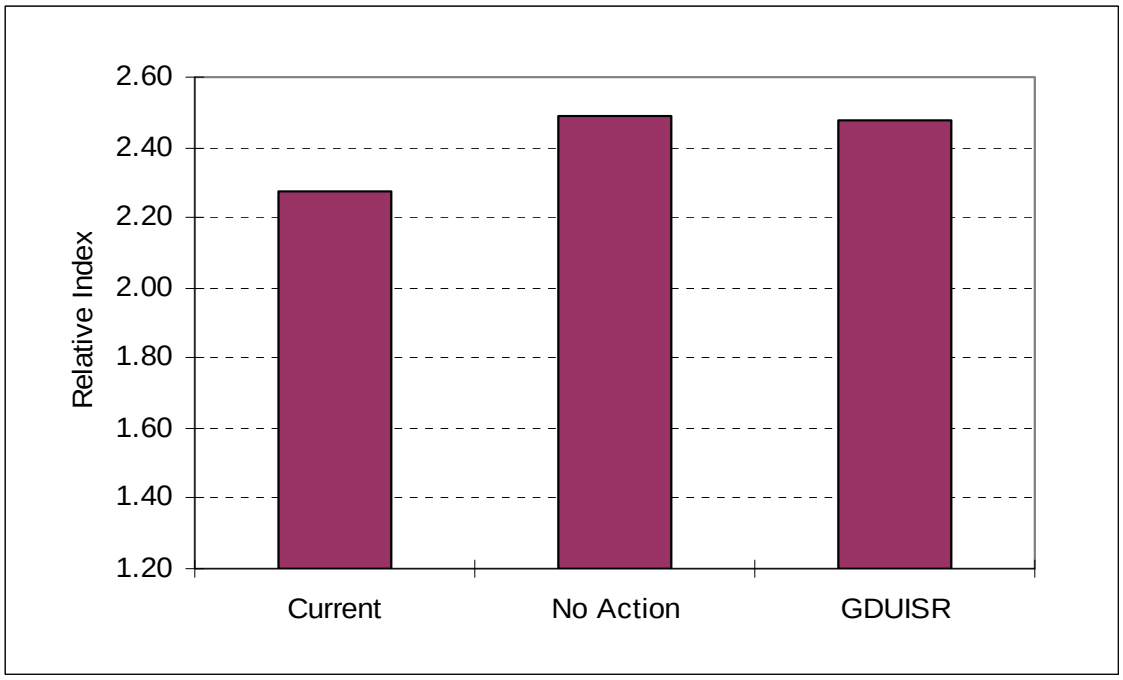

Figure 37. Average annual total young fish production index, 1930-1941.

Figure 38 presents the annual total young fish production index values. The values through the drought drop, increase dramatically, and then drop dramatically until 1941, which has increased values again. The increases occur in the non-navigation years. There is some variation between the No Action and GDUISR alternatives; however, this difference is very small in the years it occurs.

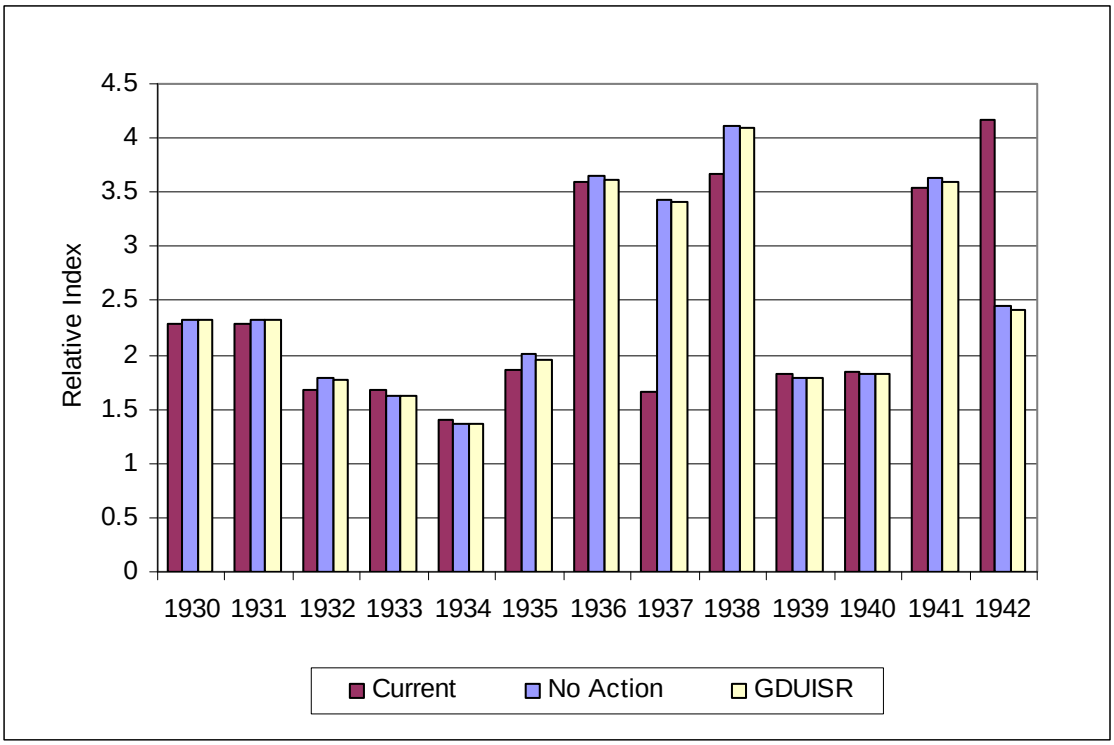

Figure 38. Annual total young fish production index, 1931-1941.

NATIVE RIVER FISH PHYSICAL HABITAT

Construction of the Mainstem Reservoir System has altered the historical flow patterns moving through the various reaches of the Missouri River. Also, the reduction in peak annual flows and other factors have resulted in channel shape and capacity changes. These changes have altered the velocity and depth patterns that occurred throughout the year in the various river reaches. The native river fish physical habitat model computes monthly indices indicating how close channel velocities and/or depths under a water control plan compare to the historic values for each river reach in the Upper (within the Mainstem Reservoir System) and Lower Missouri River. A perfect match would be an index value of 1.0 for that month. Table 17 and Figure 39 show the average annual index values for the 12 years of the 1930s drought. The table also presents the data for the full 73-year period of analysis.

As the depletions and sedimentation increase above Current conditions, the physical habitat index values decreases for the 1930s drought period of analysis and increases for the full period of analysis, although those differences are relatively small. Compared to the No Action alternative, the GDUISR alternative would have a slightly higher value (+0.09 percent) for the 1930s drought, indicating that depletions have relatively little effect on the physical habitat for native river fish. Because non-navigation flows tend to decrease the total index value (discussed below), a data set with 1942 added to the 1930-1941 data was included in Table 17. This affirms that the non-navigation years have an influence on the average annual values. Instead of increasing for the combined total

value, the value stays the same between Current conditions and the No Action alternative but increases slightly (-0.10 percent) with the increased depletions of the GDUISR alternative. This affirms that increasing depletions has an extremely small positive effect. The combined increasing depletions and sedimentation between the Current conditions and the No Action alternative have opposite effects on the two reaches, with the value decreasing very slightly for the Upper River and increasing very slightly for the Lower River. Overall, the effects of the two factors, sedimentation and depletions are extremely small on native river fish physical habitat index values.

Figure 40 presents the annual total physical habitat values for the 1930s drought period. Except for 1936, 1938, and 1941, all of the values generally remain relatively close together, ranging from 80 to about 84 on an annual basis. Relatively small differences occur from the No Action alternative to the GDUISR alternative in many years, with largest difference occurring between Current conditions and the No Action and GDUISR alternatives in 1937 due to the differences in the non-navigation years between the Current conditions simulation and the other two simulations. This figure illustrates the adverse effect the non-navigation years have on the total native river fish physical habitat values.

Table 17. Average annual native river fish physical habitat (index)

	Total	Upper River	Lower River
		1930-1941	
Current	81.11	25.45	55.66
No Action	80.68	25.14	55.53
GDUISR	80.75	25.20	55.55
		1930-1942	
Current	81.01	25.34	55.67
No Action	81.00	25.17	55.83
GDUISR	81.08	25.23	55.86
		1930-2002	
Current	80.88	25.24	55.64
No Action	81.08	25.23	55.85
GDUISR	81.08	25.23	55.84

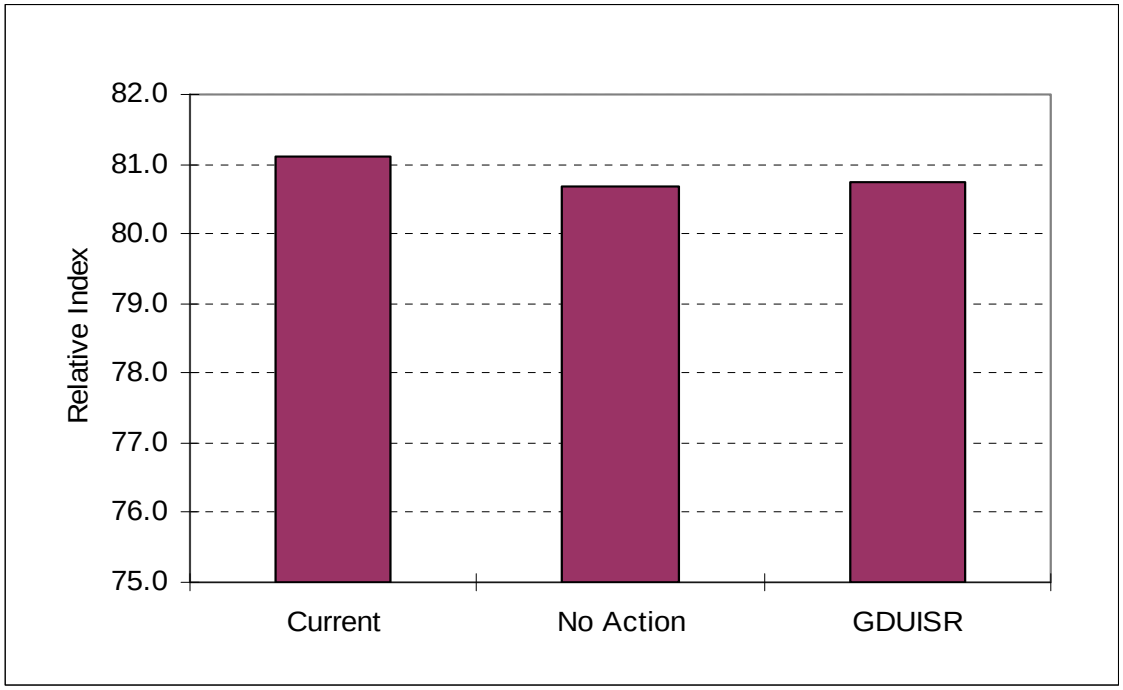

Figure 39. Average annual total native river fish physical habitat index, 1930-1941.

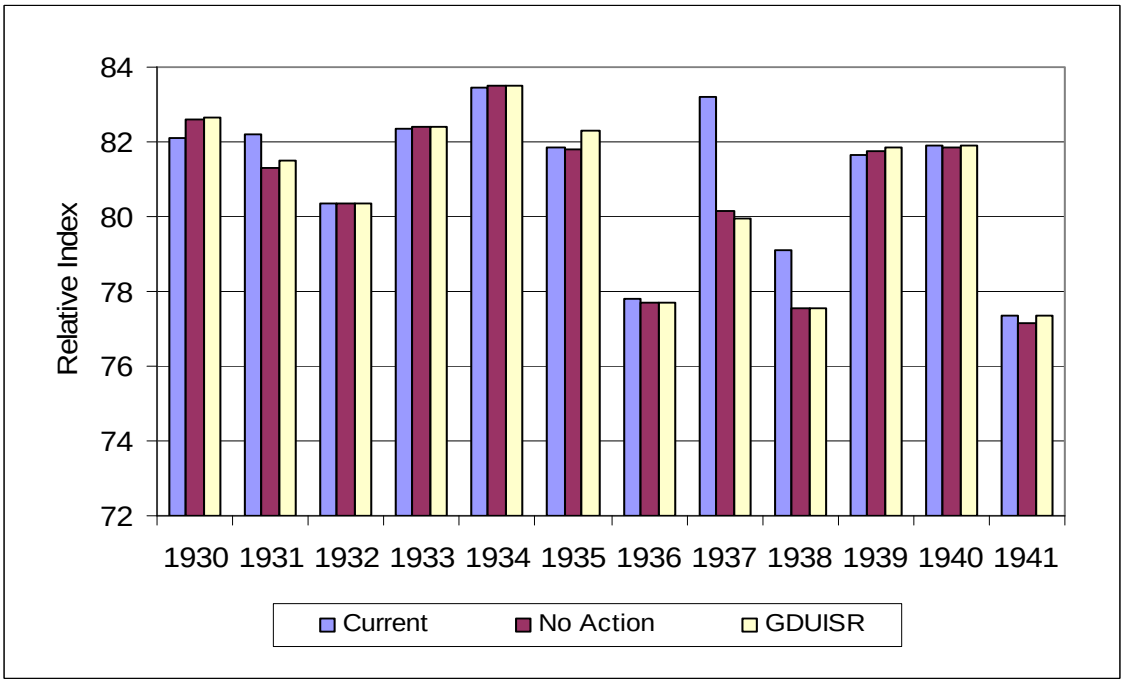

Figure 40. Annual total native river fish physical habitat index, 1930-1941.

RIVERINE TERN AND PLOVER HABITAT

Riverine tern and plover habitat occurs on four reaches of the Missouri River, downstream from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams. Changes to habitat that existed in about the 1991 timeframe were modeled to determine annual values for the number of acres that remained in these reaches as vegetation encroached on bare sand habitat during the summer months and then scoured away by high flows. The modeling did not account for the geomorphic processes that build and erode sandbars and islands or the Corps' habitat construction and vegetation removal efforts that have gone on in recent years. Average annual total habitat values in acres of habitat for the two periods of analysis are presented in Table 18, and the values for the 1930s drought period only are shown on Figure 41.

Tern and plover habitat values increase as a result of Missouri River continuing depletions and sedimentation resulting between the Current conditions levels and those under the No Action and GDUISR alternatives. The habitat gains are in the reach downstream from Garrison, Fort Randall, and Gavins Point Dams. The acres of tern and plover habitat for the No Action and GDUISR alternatives are very similar, with the differences occurring in the reach downstream from Garrison Dam for both periods of analysis. It appears that the increased sedimentation in the reservoirs is the primary beneficial factor in most reaches in both periods of analysis. Only the habitat in the Garrison downstream reach is lower, and this reduction occurs in both periods of analysis. This reach still has a net gain of habitat between Current conditions and the GDUISR alternative.

Table 18. Average annual riverine tern and plover habitat (acres)

	Total	Fort Peck	Garrison	Fort Randall	Gavins Point
			1930-1941		
Current	312.4	46.3	140.6	16.0	109.4
No Action	449.6	46.3	266.1	16.5	120.7
GDUISR	393.4	46.3	209.9	16.5	120.7
			1930-2002		
Current	306.3	35.2	177.4	32.4	61.3
No Action	342.5	35.7	185.2	41.9	79.6
GDUISR	341.2	48.8	166.8	43.5	82.1

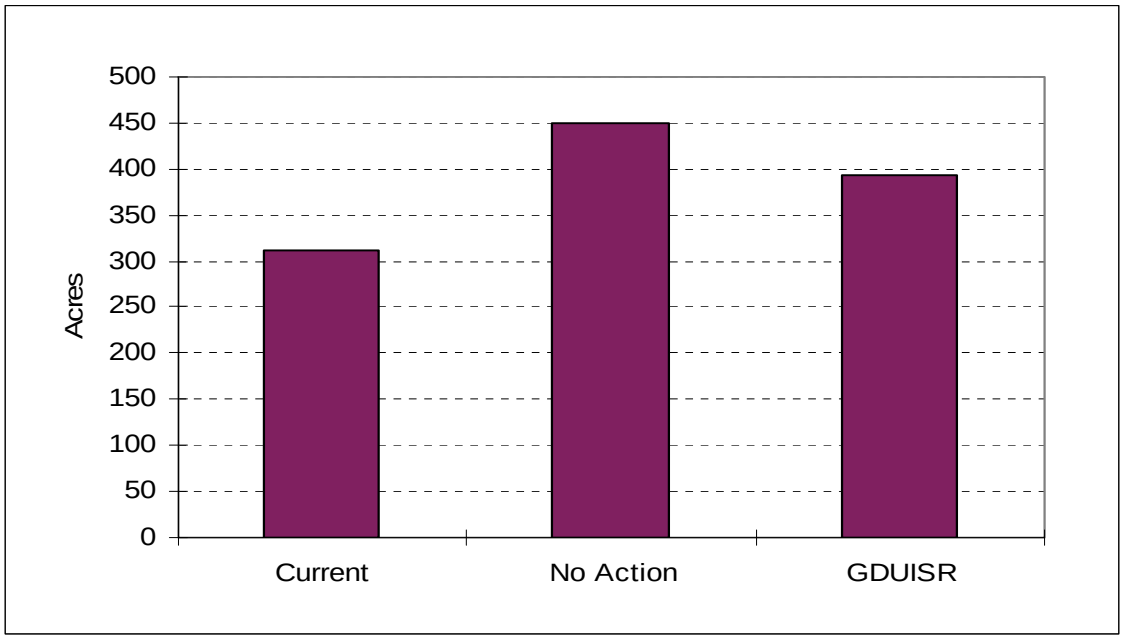

Figure 41. Average annual total riverine tern and plover habitat, 1930-1941.

Figure 42 presents the annual values through the 1930s drought for the total riverine tern and plover habitat. Habitat for the terns and plovers is generally in the 150- to 400-acre range in the 1930-1941 period except in the non-navigation years when the habitat increases to over 800 acres. The return to minimum service flows in results in the reduced acres as vegetation would have encroached to lower elevations on the sandbars and islands in the non-navigation years. The dramatic increase in the habitat for the No Action alternative in 1941 occurs in the reach downstream from Garrison Dam. This is a result of 2 consecutive months of the minimum allowable release in that reach for the No Action alternative but not the other two alternatives. This appears to be an anomaly, and would most likely not occur differently among the alternatives in real-time operation. This difference in only 1 year has an impact on the lower average annual values in both periods of analysis for the No Action and GDUISR alternatives. Without the 1941 data included for the Garrison reach, the total No Action alternative value is 409.4 acres and the GDUISR alternative value is 404.4 acres. This is a reduction of only 1.22 percent, with the difference resulting from a reduction for the GDUISR alternative in 1932.

Ongoing requirements and efforts to create additional tern and plover habitat are factors that reduce the negative aspect of this loss of habitat due to Missouri River regulation and flow impacts, including the effects of actions resulting in additional depletions. The amount of tern and plover habitat is extremely variable as vegetation encroachment and island or sandbar erosion affect the amount of clear sand habitat, the preferred habitat of these two bird species. In the case of the modeling results discussed above, vegetation encroachment is part of the model computations, and the island clearing (vegetation removal) currently being conducted will ensure that the variability the model computes will be diminished for the Garrison and other river reaches showing considerable tern and plover habitat variability.

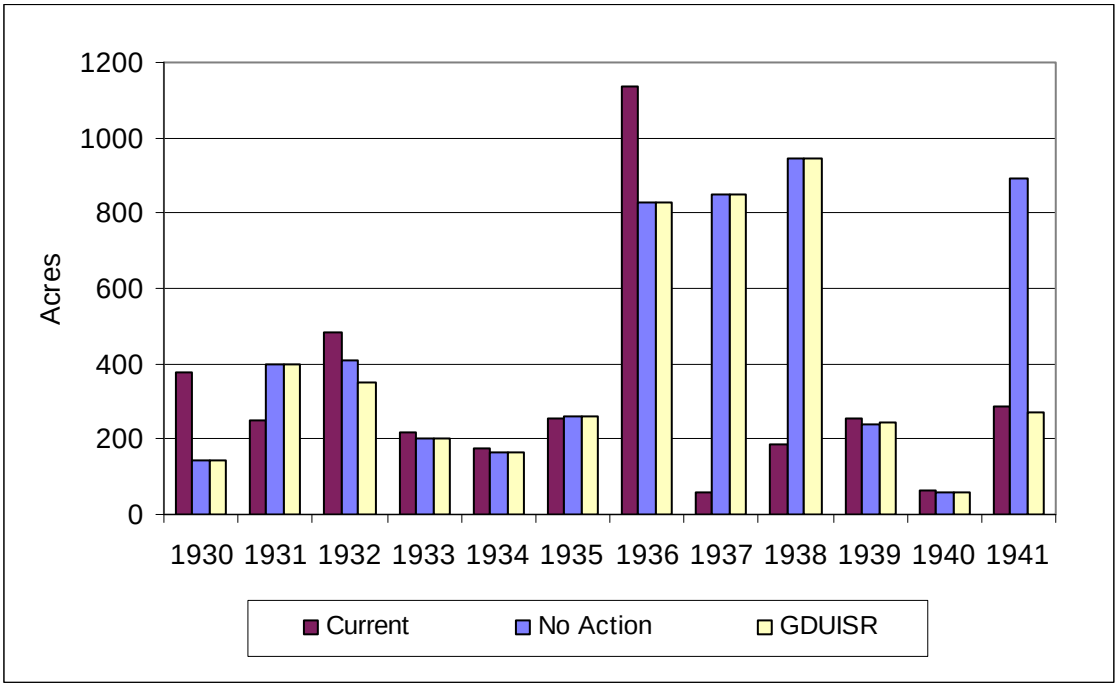

Figure 42. Annual total riverine tern and plover habitat, 1930-1941.

WETLAND HABITAT

Wetland habitat at approximately 40 sites from Fort Peck Lake to the mouth of the Missouri River were surveyed to determine the mix of wetland, riparian, bare sand, and open water habitat within a specific area comprising essentially all of each site surveyed. The effects of rising and falling water levels in the reservoirs and river reaches were modeled to determine potential effects on the mix of these four habitat types. The results of the modeling of the Current conditions and the No Action and GDUISR alternatives are presented in Table 19 for both periods of analysis for the total and sub-reach data. The total average annual values for the 1930s drought analysis are shown on Figure 43.

Table 19 and Figure 43 show that the total wetland habitat values for the 1930-1941 period decrease between the No Action and GDUISR alternatives. The change of -650 acres represents a change of -0.58 percent from the average annual value for the No Action alternative. The reductions are on the reservoir deltas and Upper River reaches. A similar change occurs for the average annual values for the full period of analysis.

Table 19. Average annual wetland habitat (1000 acres)

	Total	Reservoir Deltas	Upper River	Lower River
		1930-1941		
Current	115.55	42.45	41.01	32.09
No Action	111.61	38.91	42.17	30.53
GDUISR	110.96	38.54	41.89	30.53
		1930-2002		
Current	150.74	35.27	46.51	68.96
No Action	147.64	34.61	46.02	67.01
GDUISR	146.78	33.54	46.24	67.00

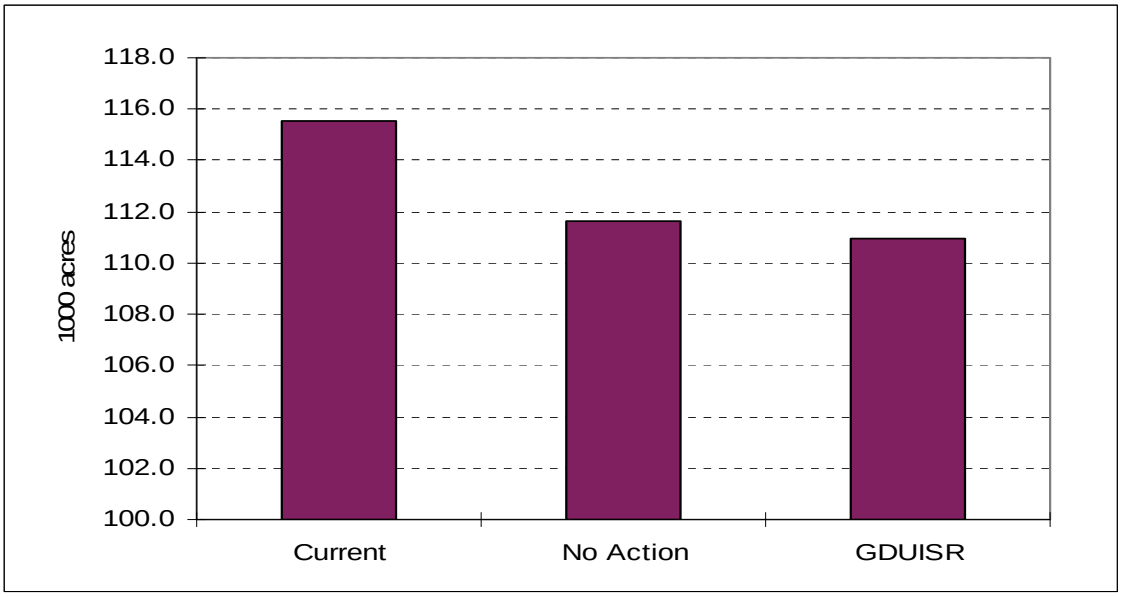

Figure 43. Average annual wetland habitat, 1930-1941.

Figure 44 presents the annual values for the 1930s drought period. This figure shows variability in every year among Current conditions and the alternatives as there appears to be no set trend among them. Further examination of the delta and river reach breakdowns shows the variability on an annual basis also occurs in the delta and Upper River reaches.

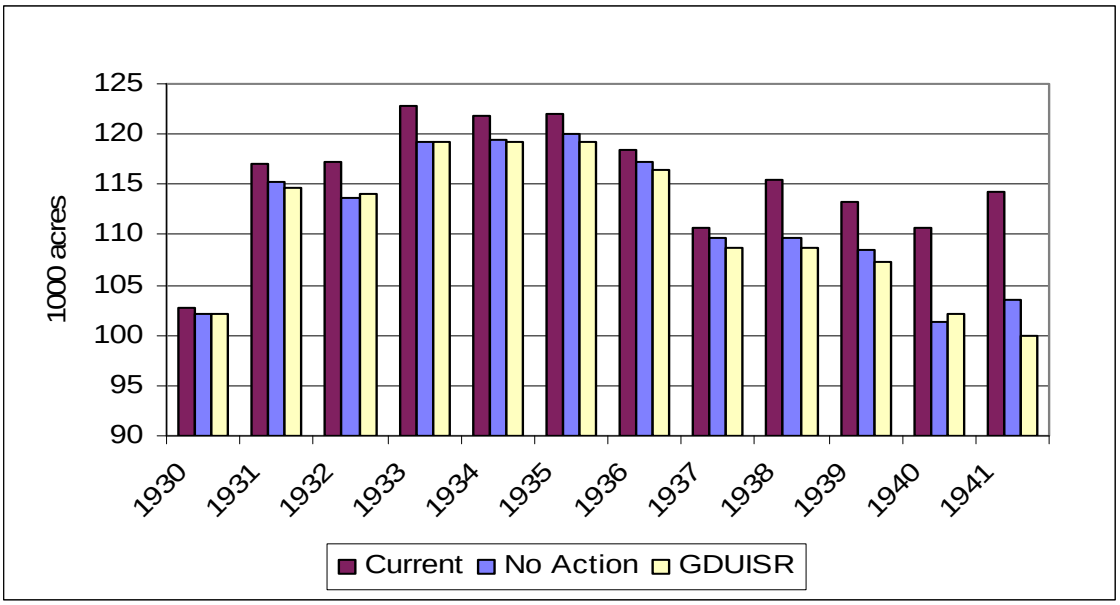

Figure 44. Annual total wetland habitat, 1930-1941.

RIPARIAN HABITAT

Riparian habitat is one of the four habitat types that were measured at the approximately 40 representative sites between the Fort Peck delta and the mouth of the Missouri River. It is the vegetative habitat type that needs the driest conditions. Table 20 and Figure 45 present the data on the riparian habitat values for the Current conditions and the No Action and GDUISR alternatives.

Both the table and the figure show that, for the 1930s drought period of analysis, the No Action and GDUISR alternatives have a total riparian habitat value that is slightly higher than the Current conditions value. The increase in the total habitat value is primarily due to the increase on the Lower River reach for these two alternatives. The values for the 1930s drought period are about 70 percent higher than those for the full period of analysis.

Comparison of the 1930s drought figures shows that the No Action alternative would provide an additional 710 acres out of 147,890 acres of habitat for the Current conditions. The GDUISR alternative would provide an average annual additional 450 acres over that for the No Action alternative, or 1,160 acres more than Current conditions. The additional 450 acres equates to an increase of 0.30 percent.

Table 20. Average annual riparian habitat (1000 acres)

	Total	Reservoir Deltas	Upper River	Lower River
		1930-1941		
Current	147.89	14.40	38.88	94.61
No Action	148.60	14.09	38.57	95.94
GDUISR	149.05	14.51	38.60	95.94
		1930-2002		
Current	88.19	9.43	33.49	34.16
No Action	88.16	10.04	33.47	34.61
GDUISR	87.43	10.04	33.47	34.61

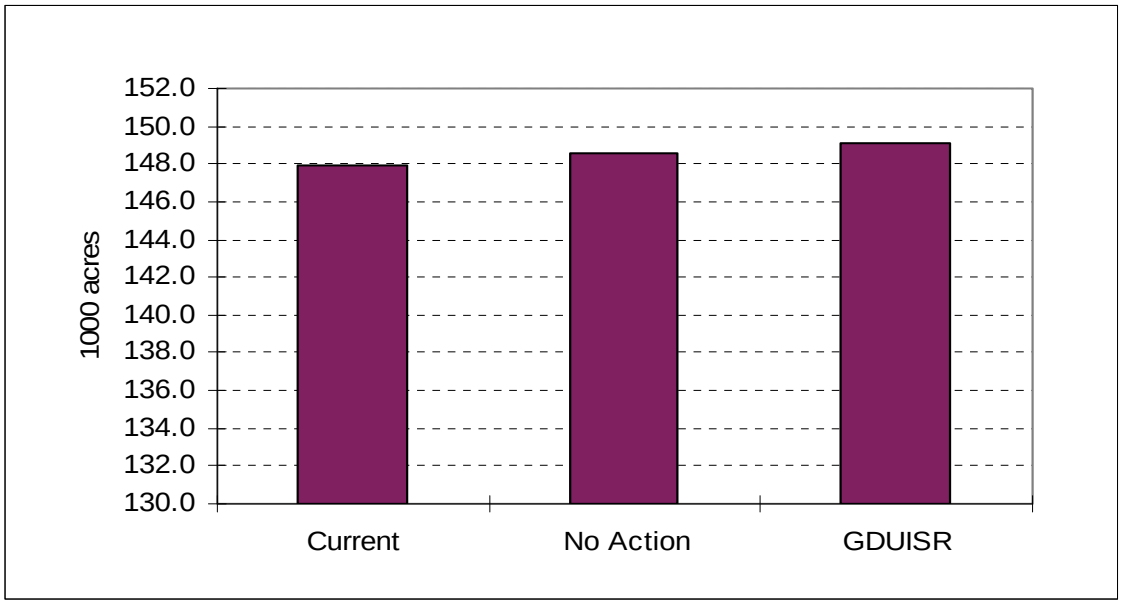

Figure 45. Average annual total riparian habitat, 1930-1941.

Figure 46 presents the annual values for riparian habitat. It shows that the riparian habitat increases gradually through the 1930s drought, which would be expected with the drier conditions in the reservoirs and river reaches. The values in all years for Current conditions and the No Action and GDUISR alternatives are essentially the same, with slightly greater differences occurring in the latter years of the drought.

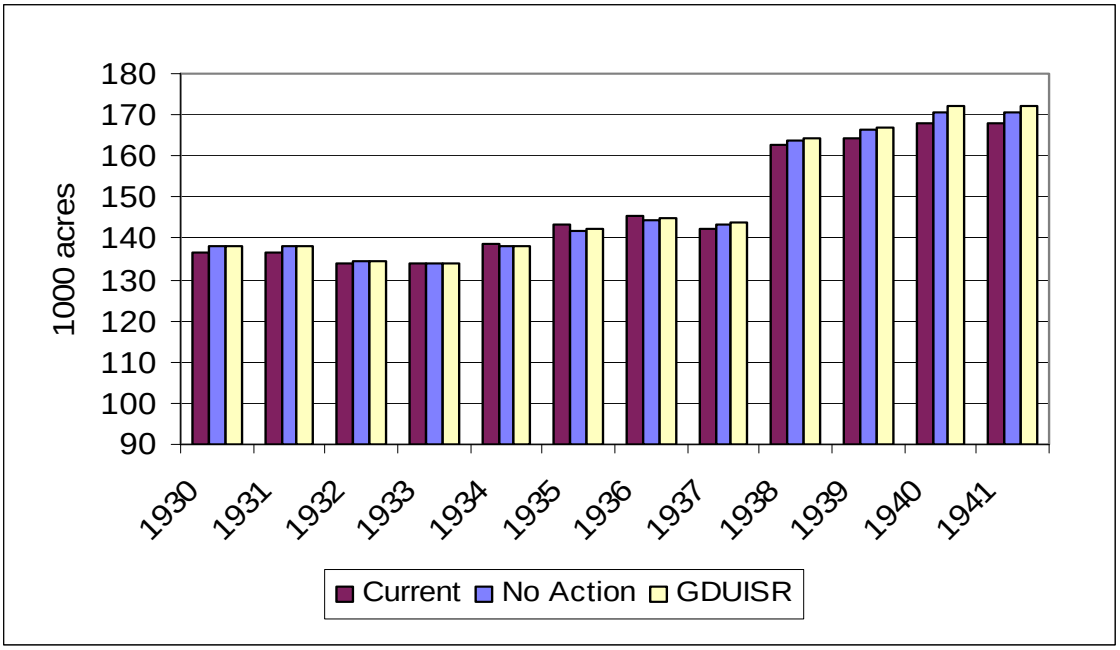

Figure 46. Annual total riparian habitat, 1930-1941.

HISTORIC PROPERTIES

The historic properties analysis focused on the potential erosion of known cultural, prehistoric, and historic sites located along the upper four reservoirs. To turn the number of "hits" by wave action into a value that an increase reflects a positive change between alternatives, the summation of months the known sites were susceptible to erosion was converted to an index value. Average annual effects of Current conditions and the No Action and GDUISR alternatives on these sites are listed in Table 21 for both periods of analysis and on Figure 47 for the 1930s drought period of analysis.

The table and figure show that the historic properties index values diminish as depletions increase to 2050 for the No Action alternative. This, however, is not likely the cause as continuing sedimentation is more likely the factor causing the decrease. The value increases for increasing depletion at the same amount of sedimentation, as evidenced by the increase in value for the GDUISR alternative. The difference of 21 units for the 1930s drought period is equivalent to 0.30 percent.

Figure 48 presents the annual index values during the 1930s drought. The values are generally the same in 1930 at about 4200 units, and they increase over the next 5 years of the drought to about 7500 units. The values remain at about 7500 for the remainder of the 1930 to 1941 period because the water levels in the upper three reservoirs have dropped such that the wave action does not affect the known sites in these reservoirs and the index value is maximized. The only exception to this occurs for the No Action and GDUISR alternatives in 1938 and 1939 as a likely result of some storage recovery due to the previous non-navigation years.

Table 21. Average annual historic properties values (index).

	Total	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Lake Sharpe
			1930-1941		
Current	7134	196	3719	3015	204
No Action	7029	195	3703	2926	204
GDUISR	7050	195	3702	2949	204
			1930-2002		
Current	5327	153	2877	2093	204
No Action	5207	150	2792	2061	204
GDUISR	5227	150	2804	2068	204

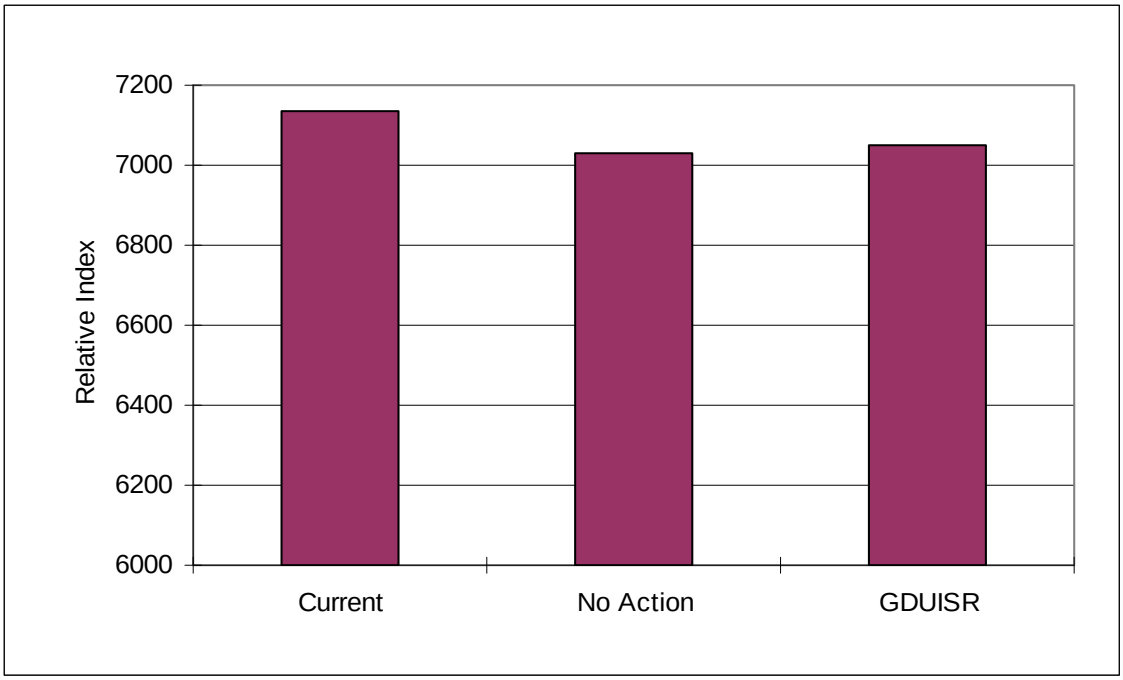

Figure 47. Average annual total historic properties index, 1930-1941.

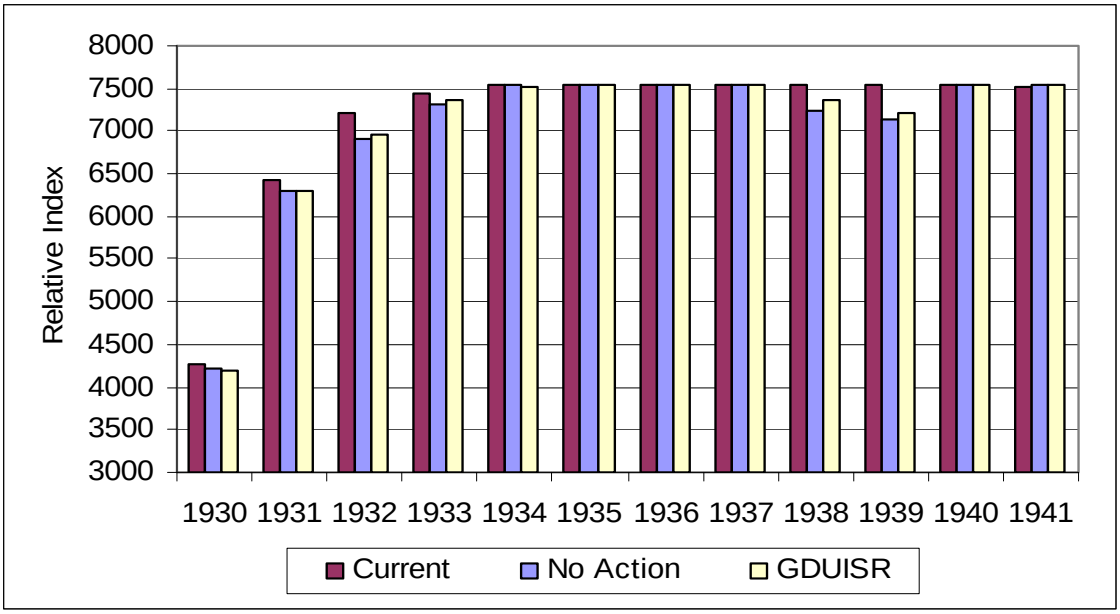

Figure 48. Annual total historic properties index, 1930-1941.

SUMMARY OF THE COMPARATIVE IMPACTS DURING THE 1930s DROUGHT

The individual sections of the comparative analysis of the Current conditions and the No Action and GDUISR alternatives have focused on the effects of the simulations on an economic use or an environmental resource one by one for the 1930s drought period. This section will first provide a comparative analysis of the GDUISR (preferred RRVWSP) alternative and the No Action alternative among all of the economic uses and environmental resources in one table for the 1930s drought period. Second, it will provide a similar comparative analysis for the full 1930s drought period with the comparison of the No Action and GDUISR alternatives to Current conditions to provide another perspective of the changes. Tables 22 and 23 present these comparisons. The changes in the various categories are due to continuing sedimentation, increased depletions, the change in the sequence of the 5 non-navigation years, or a mixture of these three factors, depending on the category.

Table 22 presents the positive average annual impacts during a repeat of the 1930s drought highlighted in green and the negative impacts highlighted in red, with the raw values without units for the No Action alternative provided in that column. Those values that are not highlighted (round off to zero) are changes between -0.5 and +0.5 percent, meaning those impacts are very small compared to those highlighted. Even though an impact may not be highlighted, the effects of an alternative in that category, no matter how small, may be significant to someone.

Table 22 shows that the GDUISR alternative would cause some negative impacts from those that would occur under No Action. Moving just over 80,000 acre-feet of water

annually to the Red River Valley would have negative effects greater than -0.5 percent in six categories – hydropower energy revenues, recreation, reservoir coldwater fish habitat, young fish production, riverine tern and plover habitat, and wetland habitat. There were no positive changes greater than 0.5 percent. By making an adjustment from the 1930-1941 period of analysis, affects only tern and plover habitat, and eliminating 1941 from the analysis results in impacts no greater than - 3.1 percent.

Table 22. Comparison of the GDUISR alternative to the No Action alternative, 1930-1941.

	No Action Ave. Ann. Value 1/	GDUISR Percent Change from No Action Value
Flood Control	169.3	0.00
Navigation	2.08	-0.38
Hydropower NED	542.1	-0.43
Hydropower Energy Revenues	-76.1	-2.10
Hydropower + Thermal Capacity at Risk	1404.0	-0.06
Hydropower + Thermal Energy at Risk	679.1	0.22
Water Supply	528.2	-0.03
Recreation	69.9	-1.08
Reservoir Coldwater Fish Habitat	4.24	-3.06
Riverine Coldwater Fish Habitat	149.1	0.00
Riverine Warmwater Fish Habitat	77.5	-0.40
Young Fish Production	2.49	-0.61
Phy. Hab. for Native River Fish	80.7	0.09
Riverine Tern and Plover Habitat	449.6	-12.49 2/
Wetland Habitat	111.6	-0.58
Riparian Habitat	148.6	0.30
Historic Properties	7029	0.30

1/ Units vary among the various economic use and environmental resource categories.
2/ Exclusion of 1941 data results in a tern and plover change to -1.22 percent.

Table 23 presents the percent changes from Current conditions during the 1930s drought period for the No Action and GDUISR alternatives. It shows positive and negative changes greater than 0.5 percent in either green or red, respectively, in most of the categories. This table indicates that one would not expect essentially no change to flood control for both alternatives for the forecasted depletions and the continuing sedimentation in the reservoirs. Positive changes would be anticipated to navigation, hydropower, recreation, reservoir coldwater fish habitat, riverine coldwater fish habitat, young fish production, riverine tern and plover habitat, and riparian habitat. Negative changes would be anticipated to hydropower revenues, hydropower plus thermal capacity

at risk, hydropower plus thermal energy at risk, water supply, riverine warmwater fish habitat, native river fish physical habitat, wetland habitat, and historic properties. Navigation benefit gains would be the result of reduced operations and maintenance costs due to a second non-navigation year during the 1930s drought. The changes in the various categories are due to continuing sedimentation, increased depletions, the change in the sequence of the 5 non-navigation years, or a mixture of these three factors, depending on the category. In the case of navigation, inclusion of an additional year, 1942, into the analysis of impacts to have 5 non-navigation years in the comparative analysis for Current conditions results in a change from a positive effect to a negative effect, as noted in footnote 2 in the table. Although the additional year was added to some other categories in which changes would occur, the changes did not result in any different indications of impacts as noted by the colors in the table.

Table 23. Comparison of the No Action and GDUISR alternatives to Current conditions, 1930-1941.

	Current	No Action	GDUISR
	Ave. Ann. Value 1/	Percent Change from Current Conditions Value	
Flood Control	169.3	0.02	0.02
Navigation 2/	2.01	3.47	3.08
Hydropower NED	537.5	0.86	0.42
Hydropower Energy Revenues	-65.6	-16.00	-18.43
Hydropower + Thermal Capacity at Risk 3/	1177.5	-19.23	-19.31
Hydropower + Thermal Energy at Risk 4/	504.1	-34.73	-34.43
Water Supply	535.7	-1.40	-1.43
Recreation	66.6	4.92	3.79
Reservoir Coldwater Fish Habitat	3.80	11.60	8.18
Riverine Coldwater Fish Habitat	146.8	1.52	1.52
Riverine Warmwater Fish Habitat	80.6	-3.81	-4.20
Young Fish Production 5/	2.28	9.49	8.82
Phy. Hab. for Native River Fish 6/	81.1	-0.54	-0.45
Riverine Tern and Plover Habitat 7/	312.4	43.93	25.96
Wetland Habitat	115.6	-3.41	-3.97
Riparian Habitat	147.9	0.48	0.79
Historic Properties	7134	-1.48	-1.18

1/ Units vary among the various economic use and environmental resource categories.
2/ Adding 1942 to the navigation analysis results in net losses of 20.8 percent for the No Action and GDUISR alternatives.
3/ Adding 1942 to the capacity at risk analysis reduces the impacts to -1.54 and -1.69 percent for the No Action and GDUISR alternatives, respectively.
4/ Adding 1942 to the energy at risk analysis reduces the impacts to -8.38 and -8.25 percent for the No Action and GDUISR alternatives, respectively.
5/ Adding 1942 to the young fish production analysis reduces the impacts to 2.75 and 2.05 percent to the No Action and GDUISR alternatives, respectively.
6/ Adding 1942 to the physical habitat for native river fish analysis reduces the impacts to -0.01 and +0.10 percent to the No Action and GDUISR alternatives, respectively.
7/ Taking 1941 out of the tern and plover analysis changes the impacts to 30.09 and 28.52 percent to the No Action and GDUISR alternatives, respectively

SUMMARY OF THE COMPARATIVE IMPACTS DURING THE FULL PERIOD OF ANALYSIS

Even though full period of analysis changes have been presented throughout this report, they have limited value because the Corps' modeling of the full period assumed diversion of the full amount of water to the Red River Valley in all years of the modeling period. In reality, a relatively small amount, if any, of this water would be diverted in the non-drought periods in the Red River Valley. A decision was made by the Corps, however, to present the summary tables and some discussion on the full period of analysis results. This provides some perspective on long-term changes with a variety of Missouri River basin conditions, not just drought conditions. These results may also provide some validity of the modeling results to those who questioned the 1930s drought modeling results in the RDEIS and this document. Tables 24 and 25 present the results for the comparison between the No Action and GDUISR alternatives and between Current conditions and the No Action and GDUISR alternatives, respectively.

Table 24 shows that very little impact is anticipated over the full period of analysis even if the full amount of water were diverted to the Red River Valley in all years. Positive impacts would be anticipated for the GDUISR alternative to riverine warmwater fish habitat. Negative impacts would be anticipated for the GDUISR alternative for navigation, hydropower revenues, reservoir coldwater fish habitat, wetland habitat, and riparian habitat. All of these changes are in the 1 to 4 percent range.

Table 24. Comparison of GDUISR alternative to the No Action alternative, 1930-2002.

	No Action Ave. Ann. Value 1/	GDUISR Percent Change from No Action Value
Flood Control	437.3	0.03
Navigation	5.67	-2.62
Hydropower NED	649.2	-0.26
Hydropower Energy Revenues	71.7	-3.88
Water Supply	604.5	-0.01
Recreation	86.8	-0.23
Reservoir Coldwater Fish Habitat	9.7	-0.54
Riverine Coldwater Fish Habitat	181.8	-0.15
Riverine Warmwater Fish Habitat	53.3	0.51
Young Fish Production	2.33	-0.13
Phy. Hab. for Native River Fish	81.1	-0.01
Riverine Tern and Plover Habitat	342.5	-0.38
Wetland Habitat	147.6	-0.58
Riparian Habitat	88.2	-0.83
Historic Properties	5207	0.39

1/ Units vary among the various economic use and environmental resource categories.

Table 25 shows the changes for the No Action and GDUISR alternatives compared to Current conditions, assuming the full diversion of water for each alternative to the Red River Valley in all years. Negative changes would also be anticipated for navigation, hydropower energy revenues, riverine warmwater fish habitat, wetland habitat, riparian habitat, and historic properties. Positive changes would be anticipated for recreation, riverine coldwater fish habitat, riverine coldwater habitat, young fish production, and tern and plover habitat.

Table 25. Comparison of No Action and GDUISR alternatives to Current conditions, 1930-2002.

		No Action	GDUISR
	Ave. Ann. Value 1/	Percent Change from Current Conditions Value	
Flood Control	438.8	-0.35	-0.32
Navigation	7.51	-24.43	-26.41
Hydropower NED	649.1	0.01	-0.26
Hydropower Energy Revenues	75.2	-4.62	-8.32
Water Supply	605.7	-0.21	-0.22
Recreation	86.1	0.81	0.58
Reservoir Coldwater Fish Habitat	9.3	4.06	3.50
Riverine Coldwater Fish Habitat	179.8	1.11	0.96
Riverine Warmwater Fish Habitat	54.1	-1.39	-0.88
Young Fish Production	2.28	2.07	1.93
Phy. Hab. for Native River Fish	80.9	0.25	0.24
Riverine Tern and Plover Habitat	306.3	11.81	11.38
Wetland Habitat	150.7	-2.05	-2.63
Riparian Habitat	88.2	-0.03	-0.86
Historic Properties	5327	-2.25	-1.87

1/ Units vary among the various economic use and environmental resource categories.