2007 Project Abstract
For the Period Ending June 30, 2009

PROJECT TITLE: Land Retirement Effects on Minnesota River Basin Streams
PROJECT MANAGER: Victoria Christensen
AFFILIATION: U.S. Geological Survey
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WEBSITE: http://mn.water.usgs.gov/projects/description/8607C0Z.html
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: ML 2007, [Chap. HF 293], Sec.[2], Subd. 5(c).

APPROPRIATION AMOUNT: $275,000

Overall Project Outcome and Results

The Minnesota River Basin lies within one of the most productive and intensively managed agricultural regions in the world. Current agricultural practices use large quantities of chemical fertilizer to maintain productivity—as much as 7.4 and 2.9 tons/mi^2 for nitrogen and phosphorus, respectively. The excess of these nutrients have the potential for deleterious effects on stream quality through runoff. To address concerns about degradation of agricultural streams, the state of Minnesota was requested to provide funding to retire an additional 100,000 acres of agricultural lands to improve water quality and aquatic biology. This study was designed to provide a comprehensive evaluation of agricultural set-aside programs on a basin scale and their effect on water quality.

This study was divided into two phases. The primary Phase 1 objective was to compare water quality and aquatic biological conditions across three basins similar with respect to physical setting and hydrology, but differing in the degree of agricultural land retirement. The Phase 2 objective was to assess the relation between biotic integrity and land retirement across the Minnesota River Basin.

Fully-instrumented sampling sites with automated samplers, water-quality monitors, and streamflow gages were installed from 2005-2008. Findings include:

- Nitrogen concentrations were highest, with a mean of 15.0 mg/L, in South Branch Rush River, the subbasin with little land retirement; nitrogen concentrations were lower in Chetomba Creek (mean of 10.6 mg/L) and West Fork Beaver Creek (mean of 7.9 mg/L), subbasins with more land retirement at the basin scale.
- Total phosphorus concentrations were not directly related to land retirement percentages with average concentrations of 0.259 mg/L at West Fork Beaver Creek, 0.164 mg/L at Chetomba Creek, and 0.180 mg/L at South Branch Rush River.
- Index of biotic integrity (IBI) scores increased as local land retirement percentages (within 50 and 100 meters of the streams) increased.
- Comparisons made within the basins showed that nutrient, suspended-sediment, and chlorophyll-*a* concentrations decreased with increasing land retirement.

Data from this study can be used to evaluate the success of land retirement programs for improving stream quality. Two reports will be published in September 2009, describing Phase 1 and Phase 2 of the study.

Project Results Use and Dissemination

The results from this study were disseminated through USGS and BWSR websites, two abstracts, a conference proceeding paper, and several presentations and posters. The water-quality and streamflow information was provided in real-time through the USGS website. USGS and BWSR personnel have participated in basin activities highlighting the selected subbasins and emphasizing the effects of land retirement. A USGS Scientific Investigations Report entitled, "Water-Quality and Biological Characteristics and Responses to Agricultural Land Retirement in Streams of the Minnesota River Basin, Water Years 2006–08" is scheduled to be published by September 30, 2009. A manuscript has been completed covering Phase 2 of the study and will be submitted to a peer reviewed journal in September 2009.

Trust Fund 2007 Work Program Final Report

Date of Report: August 10, 2009
Trust Fund 2007 Work Program Final Report
Date of Work program Approval:
Project Completion Date: June 30, 2009

I. PROJECT TITLE: Land Retirement Effects on Minnesota River Basin Streams

Project Manager: Victoria Christensen
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Location: Minnesota River Basin

Total Trust Fund Project Budget:	**Trust Fund Appropriation:**	**$ 275,000**
	Minus Amount Spent:	**$ 275,000**
	Equal Balance:	**$ 0**

Legal Citation: ML 2007, [Chap. HF 293], Sec.[2], Subd. 5(c).

Appropriation Language:
$275,000 is from the trust fund for the second biennium to the board of water and soil resources for a cooperative agreement with the United States Geological Survey to define the relation between land retirement and water quality and biological integrity in Minnesota River sub-basins and determine if nutrient transport reductions improve habitat and bio-diversity in order to enhance prioritization of future land retirements. This appropriation must be matched by an equal amount of nonstate money.

II. And III. FINAL PROJECT SUMMARY

The Minnesota River Basin lies within one of the most productive and intensively managed agricultural regions in the world. Current agricultural practices use large quantities of chemical fertilizer to maintain productivity—as much as 7.4 and 2.9 tons/mi^2 for nitrogen and phosphorus, respectively. The excess of these nutrients have the potential for deleterious effects on stream quality through runoff. To address concerns about degradation of agricultural streams, the state of Minnesota was requested to provide funding to retire an additional 100,000 acres of agricultural lands to improve water quality and aquatic biology. This study was designed to provide a comprehensive evaluation of agricultural set-aside programs on a basin scale and their effect on water quality.

This study was divided into two phases. The primary Phase 1 objective was to compare water

quality and aquatic biological conditions across three basins similar with respect to physical setting and hydrology, but differing in the degree of agricultural land retirement. The Phase 2 objective was to assess the relation between biotic integrity and land retirement across the Minnesota River Basin.

Fully-instrumented sampling sites with automated samplers, water-quality monitors, and streamflow gages were installed from 2005-2008. Findings include:

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- Total phosphorus concentrations were not directly related to land retirement percentages with average concentrations of 0.259 mg/L at West Fork Beaver Creek, 0.164 mg/L at Chetomba Creek, and 0.180 mg/L at South Branch Rush River.
- Index of biotic integrity (IBI) scores increased as local land retirement percentages (within 50 and 100 meters of the streams) increased.
- Comparisons made within the basins showed that nutrient, suspended-sediment, and chlorophyll-*a* concentrations decreased with increasing land retirement.

Data from this study can be used to evaluate the success of land retirement programs for improving stream quality. Two reports will be published in September 2009, describing Phase 1 and Phase 2 of the study.

IV. OUTLINE OF PROJECT RESULTS*:*

Result 1: Stream gaging

Description:

Streamflow was collected at 3 USGS sites (one in each basin) through the 2008 water year (ending September 2008). In addition, streamflow and water-quality samples were collected at an additional site (South Branch Rush River, these water samples are discussed under Result 2). The Hawk Creek Watershed Project collects stream flow data at 2 additional sites (one on Chetomba Creek and one on West Fork Beaver Creek), so that between the agencies there are 2 sites in each basin, for a total of six sites. The USGS provided continuous (30-minute interval) real-time stream flow from the 4 USGS sites on the USGS National Water Information System website (http://waterdata.usgs.gov/nwis/rt). The selected water-quality parameters included on the website were temperature, pH, dissolved oxygen, specific conductance, and turbidity.

Summary Budget Information for Result 1:	**Trust Fund Budget:**	**$ 43,200**
	Amount Spent:	**$ 43,200**
	Balance:	**$ 0**
	Match Funds Spent	**$ 37,515**

Deliverable	**Completion Date**
1. Streamflow and water-quality data available on the web.	Sept. 1, 2007

Completion Date: September 30, 2008

Final Report Summary: Streamflow data was collected at 4 USGS sites and 1 Hawk Creek Watershed site. The streamflow records for South Branch Rush River near Bernadotte, South Branch Rush River near Norseland, West Fork Beaver Creek near Bechyn, and Chetomba Creek near Renville were reviewed and published in the annual data reports (http://wdr.water.usgs.gov/). Streamflow data from the three basins was disseminated through the web until September 2008. Water-quality records for specific conductance, pH, temperature, dissolved oxygen, and turbidity were disseminated in real-time to the web through the growing season. The water-quality meters were removed from the streams in September 2008.

Streamflow at Chetomba Creek near Renville ranged from 0–38.5 cubic meters per second (m^3/s; or 1,360 cubic feet per second (ft^3/s)) during 2005–08. Streamflow at West Fork Beaver Creek ranged from 0–12.5 m^3/s (442 ft^3/s) during 2005–08. Streamflow at South Branch Rush River near Norseland ranged from 0–16.5 m^3/s (584 ft^3/s) during 2006–08. Mean annual streamflow was greater in water year 2006 than in water year 2007 for Chetomba Creek, West Fork Beaver Creek, and South Branch Rush River. The maximum instantaneous peak flow for Chetomba Creek near Renville and South Branch Rush River near Norseland occurred in water year 2006, and the maximum peak flow for West Fork Beaver Creek occurred in water year 2007. Streamflow in water year 2008 was lower than water years 2006 and 2007 for Chetomba Creek and West Fork Beaver Creek. However, temporal streamflow patterns for South Branch Rush were different than other study sites, having higher flow in water year 2008 than in water years 2006 and 2007.

Water years 2007 and 2008 were historically dry years regionally. Zero flow occurred during many days in water years 2007 and 2008 for Chetomba Creek and South Branch Rush River. For the 10-year period of record at Chetomba Creek near Maynard (site 05314518), the annual mean streamflow was 2.59 m^3/s (91.3 ft^3/s), which is greater than the mean annual flows at this site during water years 2007 and 2008. Although the period of record is shorter at the other sites compared to site 05314518, water years 2007 and 2008 likely were low-flow years compared to historical flows at those sites as well (Chetomba Creek, West Fork Beaver Creek, and South Branch Rush River). Because of the effect of streamflow on water quality, concentrations of nutrients and sediment collected during this study may not be representative of historical conditions.

Result 2: Water-Quality and Biological Sampling

Description:

This enhancement to the Retired Lands project added water-quality sampling at a second South Branch Rush site during 2007. The sampling schedules described in previous work plans provided to the LCCMR (funded under ML 2005, First Special Session, [Chap.1], Art. 2, Sec.[10], Subd. 7(c)) was continued through 2008. This sampling includes 4 routine (low-flow) samples at each USGS site and at the Hawk Creek Watershed site on Chetomba

Creek and 3 event samples (high-flow). The samples collected by the USGS were analyzed for turbidity, sediment, and nutrients. The Hawk Creek Watershed Project continues to collect biweekly and event samples at their Chetomba Creek and West Fork Beaver Creek sites and this data was evaluated by the USGS to assess the paired sites in those basins. Additional sediment samples were collected during storm events, in order to compare the change in sediment delivery with the hydrograph. This enhancement to the project included up to 12 samples per site collected at USGS sites with automated samplers. Biological sampling was focused at several sites in the Chetomba basin in 2008, in order to characterize the difference in biology between the two sites with substantial land retirement between them.

Summary Budget Information for Result 2:	**Trust Fund Budget:**	**$ 144,800**
	Amount Spent:	**$ 139,600**
	Balance:	**$ 5,200**
	Match Funds Spent	**$ 73,038**

Deliverable	**Completion Date**
1. Real time water-quality data will be posted on the web.	September 30, 2007

Completion Date: September 30, 2008

Final Report Summary: About 200 water-quality samples were collected from the three basins during 2008. This number is larger than collections in past years due to the storm samples that we were able to capture and process for sediment analysis. In-stream water quality monitors also were installed at South Branch Rush River near Bernadotte, South Branch Rush River near Norseland, and Chetomba Creek near Renville for the 2008 season and data was available in real-time from the USGS website: http://waterdata.usgs.gov/nwis/rt. The website provided continuous and real-time measures of specific conductance, pH, temperature, dissolved oxygen, and turbidity in the streams during the summer sampling season. A water-quality monitor was installed at Judicial Ditch No. 1. Data from this site was not available in real-time—it was downloaded every two weeks to the USGS data base. Autosamplers were installed at 3 of the sites (on the South Branch Rush and Chetomba Creek).

Although dissimilarities existed among the three subbasins, considerable effort was made to select subbasins that were similar with respect to some of the most important factors for water quality and biology. Concentrations of nitrite plus nitrate and total nitrogen decreased with increasing retired land percentage in the Minnesota River Basin. Nitrate plus nitrate concentrations were highest in South Branch Rush River, the subbasin with little or no land retirement, and lower in Chetomba Creek and West Fork Beaver Creek, subbasins with more total land retirement. Total phosphorus concentrations did not decrease with an increase in total (basin) land retirement. Total phosphorus concentrations were greatest at the site with the greatest retired land percentages within the subbasin, and increased with increases in the retired land percentage in the 50-m influence zone (defined as a 50-m zone on both sides of the stream). Chlorophyll *a* also did not follow a consistent trend with

retired land characteristics except that concentrations were greatest at the site with the least amount of retired land in the 50-m influence zone.

The relation of benthic algal, benthic invertebrate, and fish metrics with retired land characteristics also was evaluated. Biological responses to retired land varied among the different taxa (algae, invertebrates, and fish) and varied with the proximity of retired land considered (total subbasin compared to influence zone). More clear relations were apparent for retired land within the 50-m influence zone than for retired land in the subbasin. The small sample size precludes a statistical analysis; however, an analysis of the trends observed can provide insight into the influence of retired land characteristics on biological resource quality. Although the algal measures analyzed showed no clear relations, the total algal biovolume (indicator of stream productivity) and the percentage of algal biovolume composed of blue-green algae were greatest at the site with the least retired land in the 50-m influence zone (Chetomba Creek near Renville).

Very few of the invertebrate measures were related directly with the percentage of land retirement in the subbasin, possibly due to differences in physical habitat among the streams. However, more clear relations were apparent between the invertebrate measures and retired land within the 50-m influence zone than for the percentage of land retirement in the subbasin. The number of fish species collected at each site was not related to the percentage of land retirement. However, the percentage of tolerant species decreased with increasing land retirement percentage, indicating better resource quality at sites with higher percentages of land retirement. In this study, IBI scores increased as the local land retirement percentages (50- and 100-m influence zones) increased. The relation was not as clear with retired land percentages in wider zones of influence.

Wilcox signed rank tests were performed on the paired samples from the upstream and downstream sites in Chetomba Creek and South Branch Rush River in order to test the significance of the differences. When concentrations at the upstream Chetomba Creek near Renville site are compared to concentrations at the downstream Chetomba Creek near Maynard site (Judicial Ditch No. 1), nitrite plus nitrate ($p=0.03$), total nitrogen ($p=0.01$), total phosphorus (p.0.03), and chlorophyll-*a* ($p=0.02$) concentrations decrease between the sites and the retired land percentage in the 50-m influence zone increases from 5.01 to 8.18 percent. Although orthophosphorus concentrations and SSCs decreased as well, these differences were not statistically significant using the Wilcox signed rank test. The decrease in concentrations between the upstream and downstream sites may indicate that the retired land between the two sites leads to improved water quality.

Biological and habitat data were collected from Chetomba Creek in August 2008 by Dr. Richard Kiesling and two USGS student employees. Two abstracts and a proceedings paper on the water-quality and biology in these basins were completed in spring 2008. (Christensen, V.G. and Lee, K.E., 2008, Effects of agricultural land retirement in the Minnesota River basin [abstract and paper], proceedings of the American Water Resources Specialty Conference, June 30-July 2, 2008: Virginia Beach, Virginia, 6p.; Christensen, 2008, Estimation of nutrient loads in streams affected by agricultural land retirement using continuous monitoring and laboratory concentrations [abstract], Minnesota Water Resources Conference, October 27-28, 2008, St. Paul, Minnesota.).

Result 3: Biological Data and GIS Analysis and Reporting

Description:
Existing biological data, compiled by the MPCA at about 100 randomly selected sites in the Minnesota River basin, was compared to biological data collected from this study and GIS coverages of land retirement. This comparison allowed the results from this study to be extended to other sites in the Minnesota River basin. This work was done by the USGS with the help of a graduate student to address the relation of retired land characteristics and biological integrity.

Summary Budget Information for Result 3:	**Trust Fund Budget:**	**$87,000**
	Amount Spent:	**$92,200**
	Balance:	**$- 5,200**
	Match Funds Spent	**$66,671**

Deliverable	**Completion Date**
1. USGS Scientific Investigations Report	September 30, 2009

Completion Date: September 30, 2009; extra time is required for the report to go through USGS review and for printing.

Final Report Summary: A student was hired to assist with the GIS data analysis for this project. Biological data was compiled into a GIS database. Watersheds were delineated, percent land retirement was recalculated for each watershed, a model was created that can calculate percent of other GIS layers in the watersheds. The data base was combined with an MPCA discharger data set, in order to adjust or eliminate sites that are affected by wastewater discharges. For each basin, land retirement percent within 50, 100, 200, 300, and 400 meter zones of influence was calculated, in order to compare with the results in Chetomba Creek, West Fork Beaver Creek, and South Branch Rush River. MPCA sites and data were queried and some initial adjustments were made to the database in order to exclude data that doesn't meet certain criteria (for example, data older than 10 years were removed).

81 sites were selected between 4.3 and 2200 km^2 to examine biological indicators, such as fish IBI response to environmental and instream factors, such as basin size and degrees of agricultural land retirement. Spearman's rho results indicate IBI was marginally correlated to retired land percentage in the basin ($rho=.2014, p=.0698$); however, IBI was significantly correlated to retired land percentage in the 50- to 400-m zones of influence surrounding the streams ($p<0.05$), indicating the local or riparian land retirement may have more influence on stream quality than land retirement in upland areas. These results suggest that retired land is significant to IBI and that a combination of instream factors act together to influence IBI scores. MANCOVA and ANCOVA models indicated that other environmental factors (such as drainage basin size and water storage) often were correlated to biological response, as were in-stream factors (standard deviation of water depth and substrate type). Metabolism was calculated from diurnal variations in dissolved oxygen for 2006 and 2007 data. Dissolved oxygen and metabolism calculations will be

published in a separate journal article at a later date (scheduled to be submitted by December 2009).

Results of the Land Retirement study were disseminated through USGS and BWSR websites, two abstracts, a conference proceeding paper, and several presentations and posters. The water-quality and streamflow information was provided in real-time through the USGS website. USGS and BWSR personnel have participated in basin activities highlighting the selected subbasins and emphasizing the effects of land retirement. Results also were presented to the Minnesota Board of Water and Soil Resources in August 2008 and at the Minnesota Water Resources conference in October 2008. A USGS Scientific Investigations Report entitled, "Water-Quality and Biological Characteristics and Responses to Agricultural Land Retirement in Streams of the Minnesota River Basin, Water Years 2006–08" is scheduled to be published by September 30, 2009. A manuscript has been completed covering Phase 2, tentatively titled, **"**Retired Land Characteristics Affect Aquatic Community Responses in Small Streams", will be submitted to a peer reviewed journal in September 2009.

V. TOTAL TRUST FUND PROJECT BUDGET:

Staff or Contract Services: Streamgaging $43,200 (technician; stage sensor, data collection platform (DCP) rental; travel) Water-quality and biological sampling $144,800 (technician, biologist, hydrologist, students; water-quality equipment rental; travel; Lab analysis; supplies) Biological data and GIS analysis $87,000 (hydrologist, aquatic biologist, GIS specialist, GIS specialist, student; Travel; Printing)
Equipment: no equipment purchases; total equipment rentals=$37,200
Development: $ none
Restoration: $ none
Acquisition, including easements: $ none

TOTAL TRUST FUND PROJECT BUDGET: $ 275,000

Explanation of Capital Expenditures Greater Than $3,500: no capital expenditures greater than $3,500; however, total equipment rentals do exceed $3,500. No one piece of equipment exceeds $300/month.

VI. OTHER FUNDS & PARTNERS:

A. Project Partners: The USGS and the BWSR will be partners in the effort. The USGS will provide project design, management and evaluation, equipment, personnel, and half of the costs, in cash, for this project, through a joint funding agreement with the BWSR. The MPCA and Minnesota River Board have been consulted and are in support of the project. The BWSR and other agencies will provide in-kind support and may provide supplemental funding. A graduate student from Minnesota State University, Mankato or University of Minnesota will assist with the biological data and GIS analysis under the supervision of the USGS. The Hawk Creek Watershed Project will continue to assist with data acquisition.

B. Other Funds Proposed to be Spent during the Project Period: Because this project is a good fit with local and national science priorities of the USGS, federal matching funds (1:1) are available for this effort. The remainder of the USGS matching funds will be spent completing the Scientific Investigations report and 2 journal articles.
C. Past Spending: $ 260,000 in LCMR funds and $260,000 in USGS funds were spent prior to July 1, 2007.

D. Time: The project will include sampling from July 2007 through August 2008. Data analysis and report preparation will be complete by September 2009.

VII. DISSEMINATION:

VIII. REPORTING REQUIREMENTS:

Periodic work program progress reports were submitted not later than December 31, 2007, June 30, 2008, and December 31, 2008. A final work program report and associated products was submitted August 10, 2009 as requested by the LCCMR.

IX. RESEARCH PROJECTS:

Attachment A: Budget Detail for 2007 Projects - Summary and a Budget page for each partner (if applicable)

Project Title: Land Retirement Effects on Minnesota River Basin Streams 5(c)

Project Manager Name: Victoria Christensen

Trust Fund Appropriation: $

1) See list of non-eligible expenses, do not include any of these items in your budget sheet

2) Remove any budget item lines not applicable

2007 Trust Fund Budget	**Result 1 Budget:**	**Amount Spent** *(06/30/09)*	**Balance** *(06/30/09)*	**Result 2 Budget:**	**Amount Spent** *(06/30/09)*	**Balance** *(06/30/09)*	**Result 3 Budget:**	**Amount Spent** *(06/30/09)*	**Balance** *(06/30/09)*	**TOTAL BUDGET**	**TOTAL BALANCE**
	Streamgaging			*Water-quality and biological monitoring*			*Biological Data and GIS Analysis and Reporting*				
BUDGET ITEM			0			0			0	0	0
PERSONNEL: wages and benefits for Hydrologist, Hydrologic Technicians (3), Biologist, Geographer (GIS), students	34,000	34,000	0	57,000	57,974	-974	81,000	88,439	-7,439	172,000	-8,413
Contracts			0			0			0	0	0
Professional/technical *(with whom?, for what?)*			0			0			0	0	0
Other contracts National Water-Quality Laboratory and Iowa Sediment Lab			0	33,000	25,513	7,487			0	33,000	7,487
Biological sampling				12,600	12,847	-247				12,600	-247
Other direct operating costs *(for what? – be specific)*			0			0			0	0	0
Equipment / Tools *(what equipment? Give a general description and cost)*			0			0			0	0	0
Stage sensor rental	2,000	2,000	0			0				2,000	0
Data collection platform rental	1,200	1,200	0			0				1,200	0
Water Quality equipment rental (water-quality monitors, autosamplers)			0	34,000	34,000	0				34,000	0
Office equipment & computers - NOT ALLOWED unless unique to the project			0			0			0	0	0
Repairs to water-quality equipment			0		211	-211			0	0	-211
Printing			0			0	2,000		2,000	2,000	2,000
Other Supplies *(list specific categories)*			0			0	0		0	0	0
Lab supplies			0	3,400	3,974	-574	0		0	3,400	-574
Postage and Freight			0		241	-241	0		0	0	-241
Travel expenses in Minnesota	6,000	6,000	0	4,800	4,800	0	4,000	3,761	239	14,800	239
Travel outside Minnesota *(where?)*			0			0			0	0	0
Construction *(for what?)*			0			0			0	0	0
Other land improvement *(for what?)*			0			0			0	0	0
Other (AWRA conference registration fee)			0		40	-40			0	0	-40
COLUMN TOTAL	**$43,200**	**$43,200**	**$0**	**$144,800**	**$139,600**	**$5,200**	**$87,000**	**$92,200**	**-$5,200**	**$275,000**	**$0**
Other project costs to be covered by the USGS:											
Personnel: Support Staff (Distributed Direct)	**$19,000**	**$5,515**	**$13,485**	**$43,000**	**$15,772**	**$27,228**	**$38,000**	**$25,729**	**$12,271**	**$100,000**	52,984
Facilities	**$5,000**	**$5,000**	**$0**	**$10,000**	**$6,540**	**$3,460**	**$9,000**	**$2,823**	**$6,177**	**$24,000**	9,637
Cost Center Assessment	**$17,000**	**$17,000**	**$0**	**$39,000**	**$41,051**	**-$2,051**	**$34,000**	**$34,000**	**$0**	**$90,000**	-2,051
Project specific laptop upgrade							**$1,000**	**$0**	**$1,000**	**$1,000**	1,000
Bureau Assessment	**$10,000**	**$10,000**	**$0**	**$29,000**	**$9,675**	**$19,325**	**$21,000**	**$4,119**	**$16,881**	**$60,000**	36,206
TOTAL USGS COSTS	$51,000	$37,515	**$13,485**	$121,000	$73,038	**$47,962**	$103,000	$66,671	**$36,329**	$275,000	97,776
TOTAL PROJECT COST	**$94,200**	**$80,715**	**$13,485**	**$265,800**	**$212,638**	**$53,162**	**$190,000**	**$158,871**	**$31,129**	**$550,000**	97,776