Dowagiac River - Pucker Street Dam Draw Down Experience

Berrien County, T07S, R17W, Secs 12, 13, 14, 22, and 23
Surveyed May 1999 through September 2002

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Environment

The Dowagiac River is located in the southwestern corner of Michigan's Lower Peninsula. Originating in the lower tier of townships in Van Buren County, the Dowagiac River flows in a southwesterly direction across Cass County and enters Berrien County before joining the St. Joseph River in Niles, Michigan. The Dowagiac River watershed encompasses an area of 302 square miles (Berry 1992) and has an average annual discharge of 301 cubic feet per second (255 square mile drainage area) at the town of Sumnerville (Blumer et al. 1997). The watershed drains glacial deposits consisting of outwash sand and gravel, ice-contact sand and gravel with end moraines of coarse-textured till and glacial lake deposits (Kirby and Hampton 1998). These coarse textured materials allow substantial groundwater contributions to the Dowagiac River system. The Dowagiac River and most tributaries provide a popular coldwater fishery (Wesley and Duffy 2003).

The Pucker Street Dam (Appendix 1, Pg 1) is the only mainstem barrier and is located approximately three miles upstream of the Dowagiac River's confluence with the St. Joseph River (Figure 1). The dam is in Niles Township, Berrien County and is owned by the City of Niles. The impoundment at full head of 20 ft creates a narrow 60 acre impoundment that has an average depth of three feet.

The Dowagiac River below the dam meanders within a narrow valley until it reaches the St. Joseph River floodplain near M-31. Cobble, gravel, and sand are the major substrate types with some boulders found in riffle areas. Coarse woody material and boulders provide cover for fish with some deep holes. Staff from Michigan Department of Environmental Quality conducted macroinvertebrate and habitat assessments at several locations throughout the watershed and on the Dowagiac River just below the dam. The macroinvertebrate community and habitat were rated "excellent" below the dam. The Dowagiac River was meeting its use as a coldwater fishery (Heaton 1997).

Public access is available just below the dam from the Niles Township Losensky Park. Access is available on both sides of the river. Anglers can shore fish or wade from this site. Drift boats and canoes can be carried to the river from the parking lot. The only other access below the dam is at M-31. Michigan Department of Natural Resources recently purchased two acres of the former Niles Canoe Livery for public access.

History

The Dowagiac River has been managed as a coldwater fishery for more than a century. Crystal Springs State Fish Hatchery operated in the late 1800's and was located about one mile north of Sumnerville. This hatchery raised various species of trout and salmon. The primary management of the Dowagiac River in recent history has been brown trout stocking. An average of 1,200 yearling brown trout were stocked below the dam on an annual basis for more than 30 years consisting of Harrietta, Plymouth

Rock, Saint Croix, Wild Rose, and Seeforellen strains. In 2000, the annual stocking rate was raised to 6,800 yearling brown trout after a stream measurement indicated significantly more acreage below the dam than originally estimated. The strain changed to Gilchrist Creek in 2004. The three miles of river below the dam also naturally produces an unknown number of brown trout, steelhead, coho, and Chinook salmon. Great lakes salmonids have had access to the lower Dowagiac River since the St. Joseph River Ladder Project was completed in 1992.

Creel surveys have been conducted on the Dowagiac River continuously from 1992 to 2004 to evaluate the salmonid fishery. Angler hours for the fall (September and November) fishery range from 5,000 to 17,500. The fall steelhead and Chinook salmon catches range from 50 to 1,200 and 150 to 2,750, respectively. This popular fishery has drawn people from 15 different states and anglers from Canada based on observed license plates from vehicles parked at the dam.

Pucker Street Dam's history goes back to 1897 when a wooden dam was constructed to power a mill. The existing concrete dam was built about 100 feet downstream of the wooden dam in 1928. It was used to produce hydro-electricity. The dam was originally owned by Indiana and Michigan Power and was later sold to the City of Niles. Sedimentation behind the dam soon became an issue. In 1940, enough sediment had settled behind the dam that it had to be dredged out. Much of this sediment settled into the impoundment after the Dowagiac River was channelized from Decatur to the Berrien and Cass county line. In the 1970's, the dam had an annual power output of 3.0 million Kwh.

Angler activity below the dam was low until the late 1980's. Brown trout provided a modest fishery but access was difficult. The river popularity with anglers began to grow in the 1990s and peaked once salmon and steelhead had access up to the dam. With this new activity on the lower river, anglers began to complain about the dam's operations. This hydro-electric dam operated in a peaking mode. The impoundment was lowered twice a day. During refill, virtually no water was released below the dam causing riffles to become exposed for more than three hours at a time. This operation style and the complaints from anglers prompted a meeting between the City of Niles and Michigan Department of Natural Resources (MDNR) in 1991. The purpose of this meeting was to discuss the potential of creating minimum flows below the dam. Another meeting convened in 1992 after continued angler complaints regarding resource damages during low water and concern for safety with wildly fluctuating water depths.

From 1993 to 1995, the City of Niles attempted to maintain minimum flows of 75 cfs below the dam. However, improper dam operations continued to occur. Tainter gates, which open from the bottom, were accidently left open on several occasions allowing the entire impoundment to drain and allowing tons of sediment to be released. Staff would open the gates some during the weekend when rain was expected causing the impoundment water elevation to decrease if the rain event was less than expected. This was done after property owners on the impoundment complained of flooding after rain events. If the rain event missed the area, the impoundment would completely drain. The capacity of the impoundment was very low due to years of sediment build up and could not effectively be managed to control flooding.

The City of Niles announced in 1996 that the generators were no longer operational after silt and sand had caused major damage to the turbines. Both the City and MDNR met again to discuss the future of the dam. It was decided that the best option was to open the gates and create run of river flow. This would eliminate the fluctuating water levels and the periodic silt releases. There would be one large episode of sediment release after the gates are opened permanently rather than several small releases indefinitely. This decision was supported by a dam inspection report that found several cracks in the spillway structure and recommended raising the gates to relieve pressure on the dam.

A public meeting was held by the City of Niles to discuss a permit application to draw down the impoundment. The public was against this option. Most of the opposition was from impoundment property owners that feared the effects of the draw down, stating that they did not want to live on "mud flats". It was agreed that Niles Township would be given the opportunity to come up with an alternative. One alternative discussed was to remove the gates and pour a concrete wall across the top that would maintain impoundment levels and run of river flow. However, the City of Niles voted April 27, 1998 via a resolution to move forward with permanently lifting the gates before Niles Township presented their alternative plan.

Permit 97-12-0116 was issued on February 16, 1999 to permanently draw down the existing impoundment by five feet to an elevation of 680 feet. This was to occur by lifting two gates on the dam with a third to be lifted once the draw down was completed. The draw down was to be controlled at one foot per day, and all exposed banks and mud flats were to be seeded immediately.

Current Status

Methods and Results

The draw down of Pucker Street Dam began on May 10th, 1999. Various measurements taken prior to the permit application indicated that there was two to 8 feet of organic sediment in the impoundment. The intent was to draw down the impoundment one foot per day and allow the spring flows to move sediments quickly through the system.

Monitoring stations were established above and below the dam (Figure 2). Kenzie Bridge was used as a control site and was located two miles above the dam and out of the visible influence of the impoundment, which is approximately 1.2 miles above the dam. Losensky Park station was located immediately below the dam, and M-31 station was 2.8 miles downstream of the dam. Photos, dissolved oxygen, temperature, and turbidity were measured daily during the draw down using a YSI 55 oxygen/temperature probe and a Hanna Instruments 93703 turbidity meter. Temperature was also measured for the month of July in 2000 with Onset Temperature loggers at Kenzie Bridge and M-31 stations using methods described by Wehrly et al. (1998).

Turbidity remained at or below 15 FTU at all monitoring stations for the first week after the draw down started (Figure 3). Losensky Park consistently had higher turbidity than the control site at Kenzie Bridge and M-31 downstream. Turbidity increased in the second week and remained high for about three weeks while the river cut a new channel through the impoundment. Bottom sediments from the impoundment were exposed to air after the first week of the draw down. Turbidity peaked around May 24th at 90 FTU. By August 1999, the turbidity at all three sampling stations was the same and appeared to be back to normal levels for the river.

Temperature ranged from 13 to 23 °C with Kenzie Bridge consistently lower than the two sites below the impoundment (Figure 4). In late June and August, recorded temperatures were as much as two °C cooler above the impoundment. This difference was more evident post drawdown than before the drawdown. The July 2000 mean temperatures were 18.6 °C for Kenzie Bridge and 18.8 °C for M-31.

Dissolved oxygen remained high throughout the drawdown (Figure 5). Oxygen was highest when river temperatures were lower. Losensky Park and M-31 monitoring sites had higher dissolved oxygen concentrations than the Kenzie Road site, which was probably due to atmospheric mixing of air and water going over the dam and riffles in the lower river.

Two weeks into the drawdown, the exposed sediment in the impoundment was aerially seeded with annual rye grass. This seed mix was inexpensive and germinated quickly to help stabilize the sediments. It was also observed that several native plants had already germinated including grasses, willows, and maples. The entire impoundment area was vegetated a month and a half after the draw down started (Appendix 1, Pgs 2-4).

Twenty five days into the draw down a significant amount of sand on the river bottom was observed below the dam. Most of the Dowagiac River substrate consisted of gravel, cobble, and rock in this area, so any sand substrate was the result of the draw down. Transects were set up on June 8th, 1999 at seven locations below the dam (Figure 2). A mix of pools (T4 and T5), riffles (T2, T3, and T6) and runs (T1 and T7) were selected to determine sand depth changes over time in different habitat types. Sand depth, which was defined as the measurement from the surface of the sand down to hard substrate, was measured at five to ten foot intervals across the river using a metal ruler. Transect measurements were made on June 8th and July 21, 1999 and on July 27, 2000.

There was a significant amount of sand ranging from 0 to 18 inches at various intervals within these transects. T1 through T5 had the most sand on June 8th (Figure 6). T6 and T7 had the lowest amount of sand at this time. By July 21, 1999, the riffles showed a decrease in sand indicating that the high velocity areas were starting to clear out. The runs and pools continued to show high amounts of sand. By this time, the sand began to show in the lower transects such as T7 at the Niles Canoe livery. A year after the drawdown, the upper transects (T1-T5) had a decrease in sand with several samples with no sand. However, the lower transects continued to see increases in sand depth a year after draw down (Appendix 2).

The deposition of sand observed on June 8, 1999 was of great concern, so the Fisheries Division Heavy Equipment Crew moved in and constructed a sediment trap immediately above the dam on June 10th. An excavator was used to remove organic sediments along the river and replaced them with sand and gravel to create a stable pad for trap cleaning. An extended 60 ft boom excavator was used to reach as far across the river as possible to create a deep hole to collect the sand bedload. The original trap was 95 ft long, 50 ft wide, and 8 ft deep (Appendix 1, Pg 7).

The spoils from the initial excavation were mostly organic material, silt, and clay. This material required a heavy metal contaminant analysis to determine the proper use and disposal of the spoils as part of the Michigan Department of Environment Quality permit. The contaminant samples found arsenic levels ranging from 6.1 mg to 25 mg per kg of soil. This was above the screening level for arsenic in soil (6.6 mg), so the spoils required proper disposal. Disposal options were to haul the spoils to a landfill or contain the spoils on site. Subsequent trap cleanings consisted of 95% or more of sand based on a sieve analyses and were considered contaminant free. Therefore, the contaminated spoils were buried on site with clean sand, and a deed restriction was placed on the land limiting the use for development.

The sand bedload was so high that the sediment trap filled on a monthly basis. Costs to dredge the trap ranged from $3,000 to $4,500 depending on the equipment used and contractor. The Fisheries Division Heavy Equipment Crew cleaned the trap with a rented long reach excavator for $3,000. A contractor was hired with a drag line that cost $4,500. The dragline method was preferred because it could dig the trap wider and deeper. The final trap size was 110 ft long, 70 ft wide and 12 ft deep. The trap was maintained until September 2002 when bedload estimates at the dam were equivalent to background estimates. The sediment trap was cleaned 14 times (two times by Fisheries Division and 12 times by contractors) at a total cost of approximately $50,000, which was shared between Fisheries Division and City of Niles. Approximately, 48,000 cubic yards of sand were removed from the river (Appendix 1, Pg 7).

The City of Niles and Fisheries Division agreed to maintain the trap until the sand bedload stabilized in the impoundment. Sampling sites were established at Glenford Lane above the impoundment and just above Pucker Street bridge (Figure 2). Bedload was collected at 1 to 2 ft intervals along a transect with a 153 µm mesh plankton net mounted to a 5.25 inch square metal frame on a pole. This allowed water to flow through while collecting most bedload sediment and debris. The debris was discarded, and the sediment was weighed on site as a wet weight. These data were used to calculate the bedload estimate per day.

Bedload estimates were 35 tons per day when the trap was first installed while estimates at Glenford Lane ranged from five to less than one ton per day depending on river discharge (Figure 7). The bedload above Pucker Street Bridge remained high through the fall of 1999. From spring of 2000 through spring of 2001, the bedload above the dam remained at about five tons per day. In the fall of 2001, the bedload estimates above the Pucker Street bridge and Glenford Lane were approximately the same at 3 tons per day. At this time, trap cleaning frequency was down to about once every 6 months. The bedload estimates were again the same in September 2002 at less than one ton per day. At this time, the City of Niles and Fisheries Division officially abandoned the trap. The mountain of sand that was created with the sand spoils was leveled, top soiled, and seeded (Appendix 1, Pg 7).

Three years after the draw down the river channel stabilized considerably in the former impoundment. There was still erosion of some banks during high flows, which periodically added sediment to the system. The river below the dam recovered to almost pre-draw down conditions. Riffle and run substrates returned to gravel and cobble, and the holes deepened. There was still sand along the edges of the river that was not there prior to draw down.

Analysis and Discussion

The major goals of this project were to create run of river flow and eliminate frequent sediment pulses as flow gates at the dam were manipulated. The permanent raising of the gates and draw down accomplished both goals but at a high initial and short-term cost of increased sand bedload. After three years, the impoundment reverted to an 80 ft wide river channel with riffles, runs, and pools and substrates consisting of clay, sand, gravel, and cobble (Appendix 1, Pg 6). The long-term change was the introduction of a natural sand bedload below the dam. The dam was an effective sand trap for over 80 years. The run of river flow and natural sediment transport will be healthier for river morphology and biology.

The Pucker Street Dam draw down was a learning experience. With the rapid draw down, sediments moved and the lower river sand loads increased quickly. This was a great concern to property owners, anglers, and fisheries biologists. A slower draw down rate, similar to the Stronach Dam on Pine River, may have produced more subtle changes (Burroughs et al. 2009). However, the overall changes to the river system with headcutting through impoundment and deposition of sediment downstream would have been the same. A slower draw down, if practical, would have been less of an immediate impact to the river system and biological community.

The incorrect assumption that mostly silt would move downstream created a situation that required urgent response. The probing samples of the impoundment sediments implied that the material was soft like silt and organic matter and would flush down river with high spring flows. The three week pulse of turbidity below the dam was expected and returned to normal once the draw down was complete. The amount of sand movement was not expected and required management with a sediment trap. After the banks where exposed, it was apparent that sand layers existed in between the silt and organic layers (Appendix 1, Pg 5). These layers of sand were probably deposited in the impoundment during high flow events. Core samples prior to the draw down may have discovered these layers and allowed for a better plan to mitigate the sand.

Stream temperatures warmed through the impoundment by at least two degrees after draw down due to increased sun exposure and presence of dark sediments. After two years of vegetation growth and narrowing of the river channel, the temperatures upstream and downstream of the dam were similar. M-31 July mean temperature decreased two ºC in 2000 compared to measurements in 1993 (Wesley and Duffy 2003). This was a positive result of the project and will assist future management of trout and salmon in the lower river. Anglers have observed more Chinook salmon and steelhead smolts than in the past, a likely result of colder summer temperatures.

Turbidity measurements were elevated for about a month. Even with the highest turbidity of 90 FTU, it did not appear that turbidity was high enough to cause noticeable mortalities of fish and invertebrates. Only one dead white sucker was observed at the M-31 station. Rowe et al. (2002) showed mortality in smelt and some invertebrates with turbidity over 1,000 FTU. It is not clear what effect long-term exposure to turbidity had on feeding behavior and survival of fish and invertebrates. Most studies are conducted for 24 hrs or simulate pulses of sediment similar to rain events. Dam draw downs increase turbidity for longer periods of time. Dissolved oxygen remained above 8 mg/l in the lower river throughout the high turbidity exposure and may have increased survival of fish and invertebrates.

The mud flats were a concern of the public before and during the project. The perception of land owners was that this condition would be permanent. Aerial seeding of grass germinated within a week and improved the appearance. This expense may not have been necessary since native plants and trees took over the area in a month or two. The impoundment area remained very soft to walk on for 6 months. However, land owners were mowing and maintaining lawns in this area one year later.

Stream transects established downstream to monitor sand depths were useful for documenting changes over time. Ideally, these transects should have been established and monitored prior to the draw down for background data. These data would have been important to show the public what conditions were like before, during, and after the high sand bedload. It was observed with these data that the river adjusted to the increased sand and returned to gravel and cobble substrates in high velocity areas once the sand source was decreased or eliminated.

The use of a sand trap to mitigate sand movement downstream was a good decision. The anglers and property owners wanted something done, and it prevented another 48,000 cubic yards of sand from going over the dam. This probably assisted the lower river in its recovery. The presence of arsenic originally was a concern and would have increased the costs of disposal if an onsite facility was not created. Arsenic occurs naturally in soils and groundwater in Michigan and was also used in agricultural pesticides. Based on Hansen (1973), the trap size was only 40 to 80% effective on sand sized particles and larger depending on flow rates. Therefore, sand continued to move downstream even with the trap in place. To be 100% effective, the trap required a length of 400 ft. This was not practical given the location of the dam and Pucker Street bridge.

Sediment trap maintenance was expensive. It was greatly appreciated that the City of Niles shared the expense. A slow draw down over a few years would be a less expensive option. The tainter style gates of the dam made this impossible. A temporary sheet pile dam with stop logs would need to be constructed to accomplish a controlled draw down at this dam. The cost of this procedure may have been similar to the sand trap maintenance. Dam owners with tainter gates should consider a temporary dam option rather than relying on a sand trap.

Bedload estimates to monitor sediment movement through the impoundment were useful. It would have been difficult otherwise to determine when sand bedloads where back to natural levels. The method used was only appropriate to determine the difference in bedload between sites and may not have accurately estimated the actual bedload of the Dowagiac River. A Helley-Smith sampler and methods described by Beschta (1996) would provide better estimates for comparison with other river systems.

While measuring bedload at the Glenford Lane station, it was observed that the velocity and substrate size increased and that the channel was narrowing. Observations also revealed that the effect of the draw down reached farther upstream than the impoundment visible boundary. This was similar to observations of Burroughs (2007) for the Pine River, a tributary to the Manistee River in the Michigan's northern Lower Peninsula.

The methods employed and data collected where mostly reactive to problems experienced during the draw down. The power of these data would improve with pre-draw down estimates. Future draw downs and dam removals should have a well thought out sampling and monitoring strategy if that is important to making management decisions during the process. Job changes and reduced budgets also affected sampling frequency. Monitoring should continue for at least three years or longer post draw down or removal to help understand long-term changes to the system.

Management Direction

The Dowagiac River should continue to be managed as a coldwater fishery through habitat protection and rehabilitation and through brown trout stocking as necessary. The run of river flow and colder temperatures as a result of the draw down will benefit the coldwater fishery. The following management actions should also be considered:

1. Visually monitor the river above and below the dam every two years and note significant changes and address habitat problems associated with the draw down as necessary.

2. Conduct a stream survey using Status and Trends protocol above and below the dam to evaluate the fish community and natural reproduction of trout and salmon.

3. Work with the City of Niles to open a third gate and more if feasible to allow increased flood conveyance.

4. Develop a long-term strategy to address Pucker Street Dam removal as stated in the Management Options of the St. Joseph River Assessment (Wesley and Duffy 1999). The strategy should use a public process to consider the benefits and costs of full fish passage into the upper Dowagiac River and should consider the best option for sediment management. There is still 15 ft of head on the dam that is preventing fish passage and containing sediment.

5. Work with the City of Niles to secure funding for dam removal.

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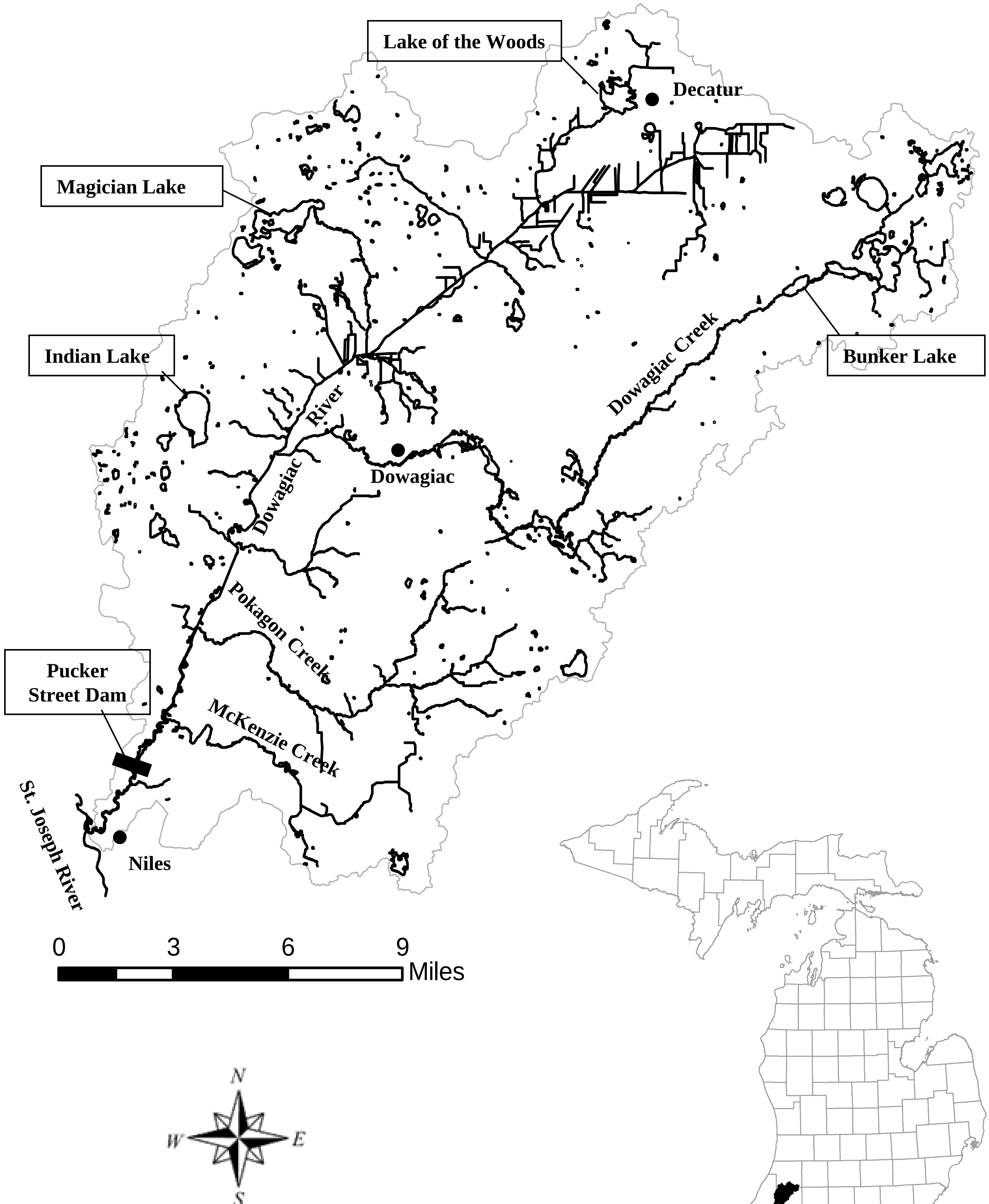


Figure 1. The Dowagiac River and major tributaries

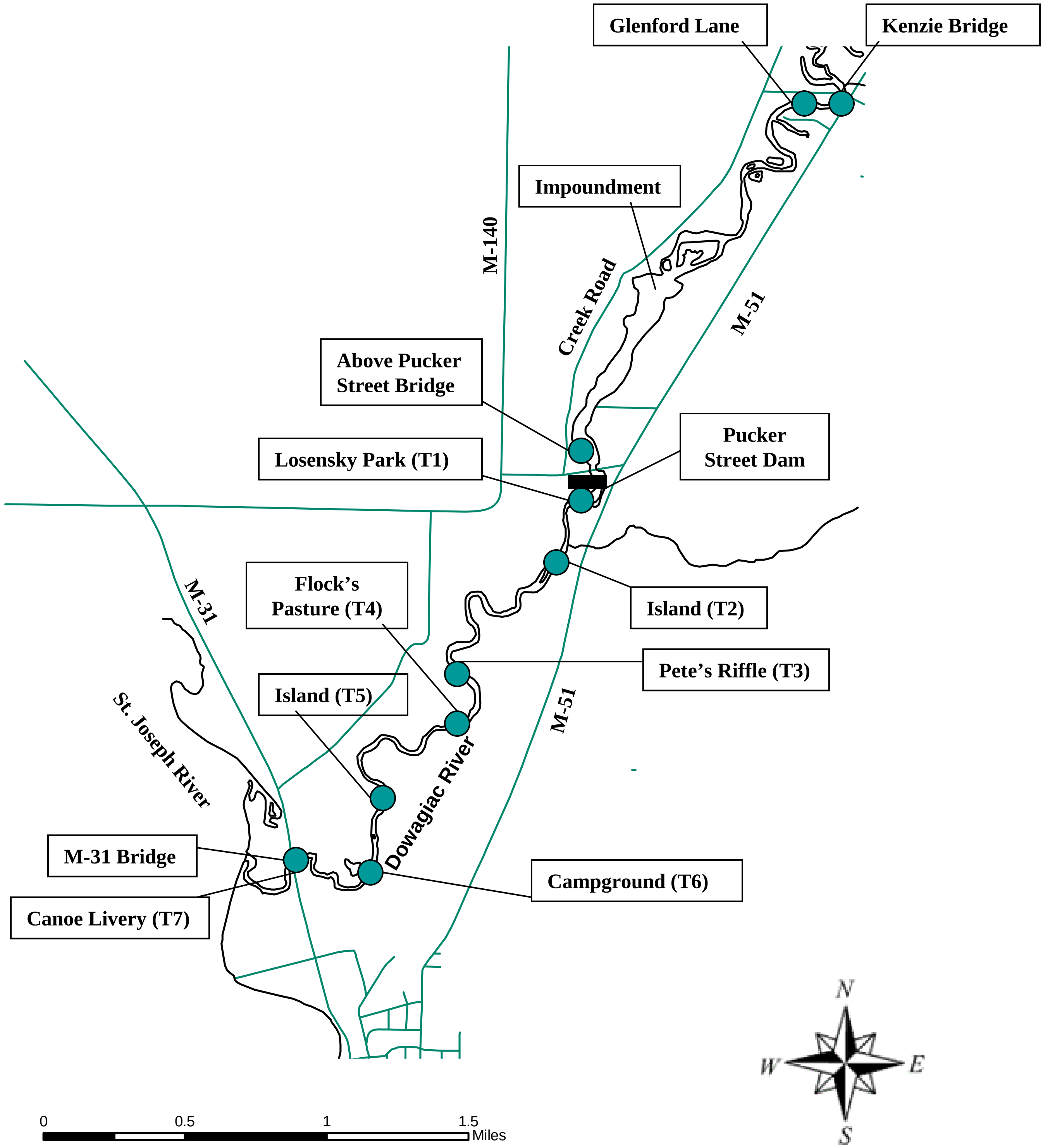


Figure 2. Location of sampling stations along the Dowagiac River.

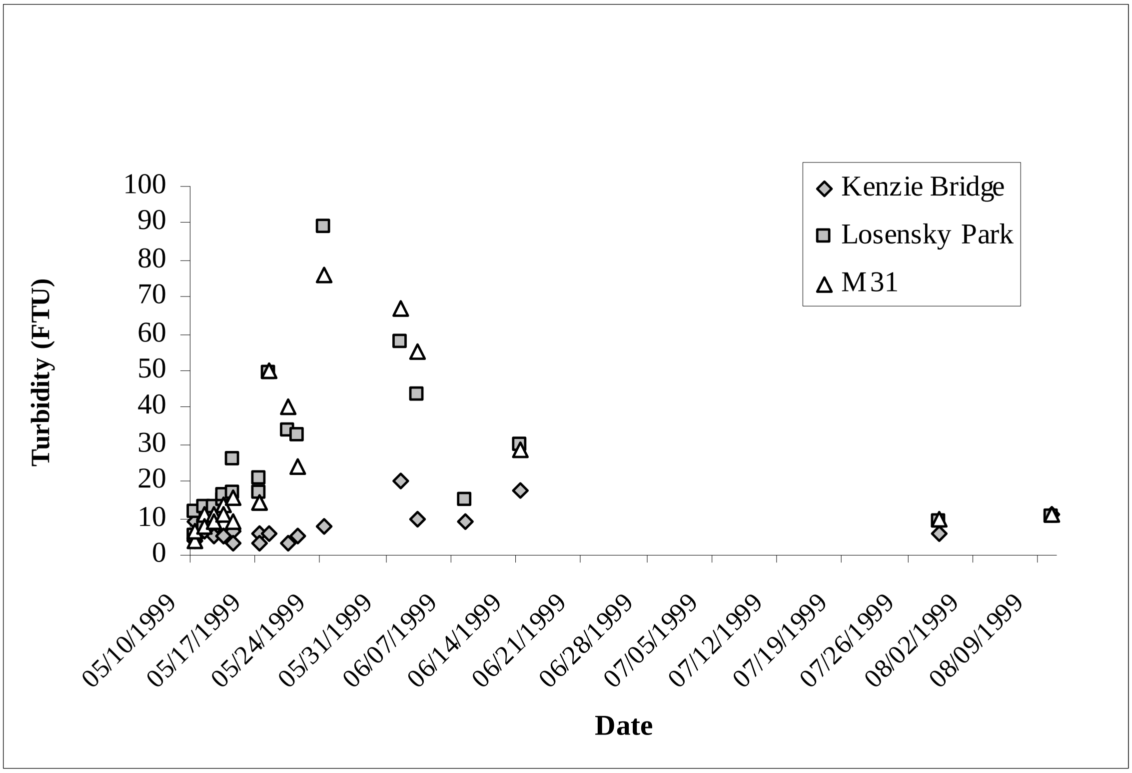


Figure 3. Turbidity of the Dowagiac River during the Pucker Street Dam draw down.

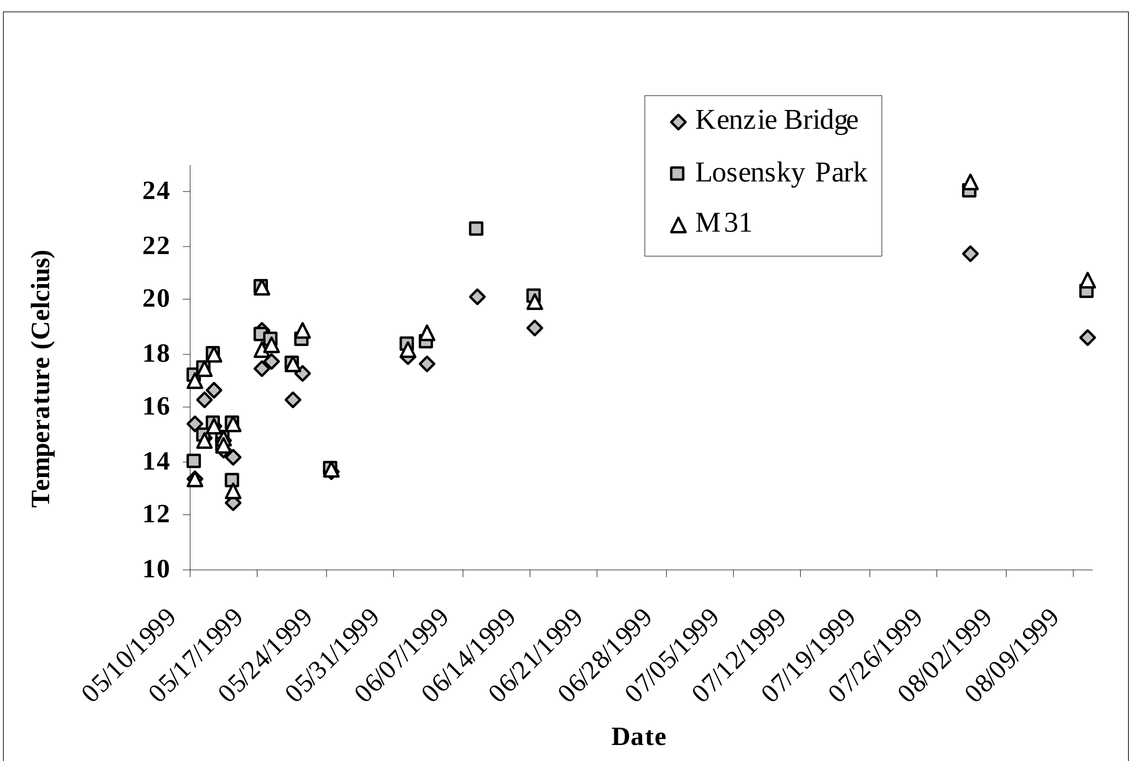


Figure 4. Temperature of the Dowagiac River during the Pucker Street Dam drawdown.

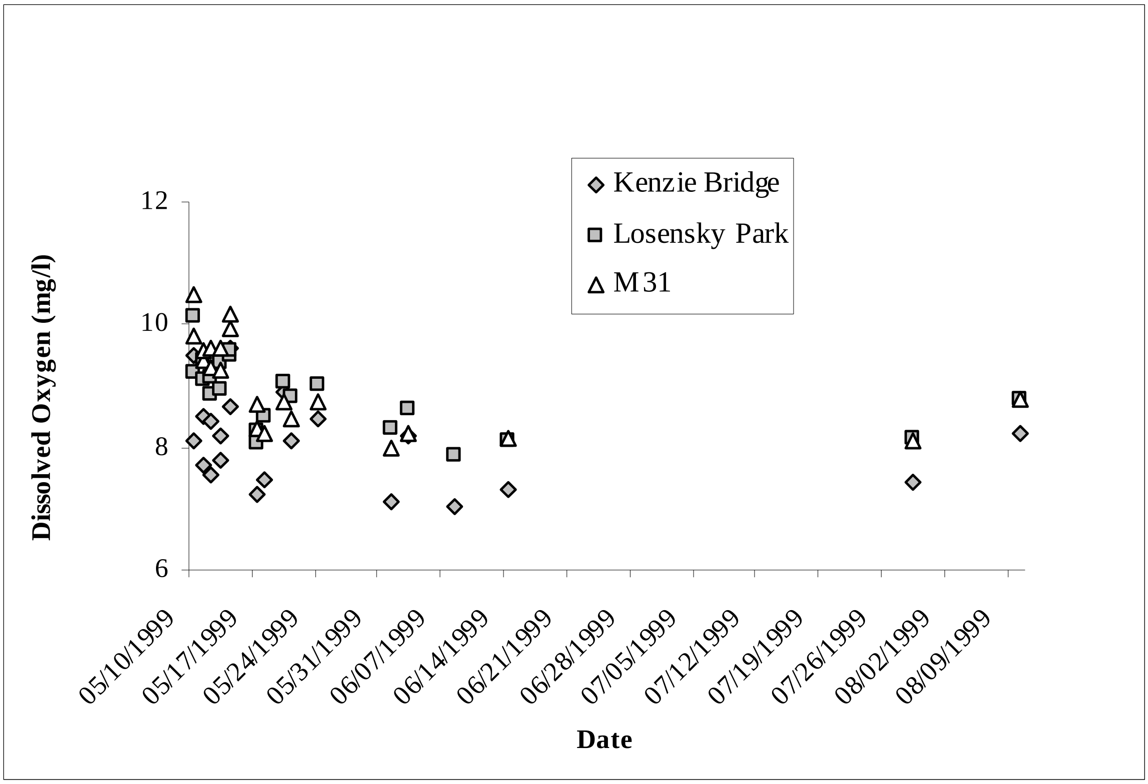


Figure 5. Dissolved oxygen of the Dowagiac River during the Pucker Street Dam drawdown.

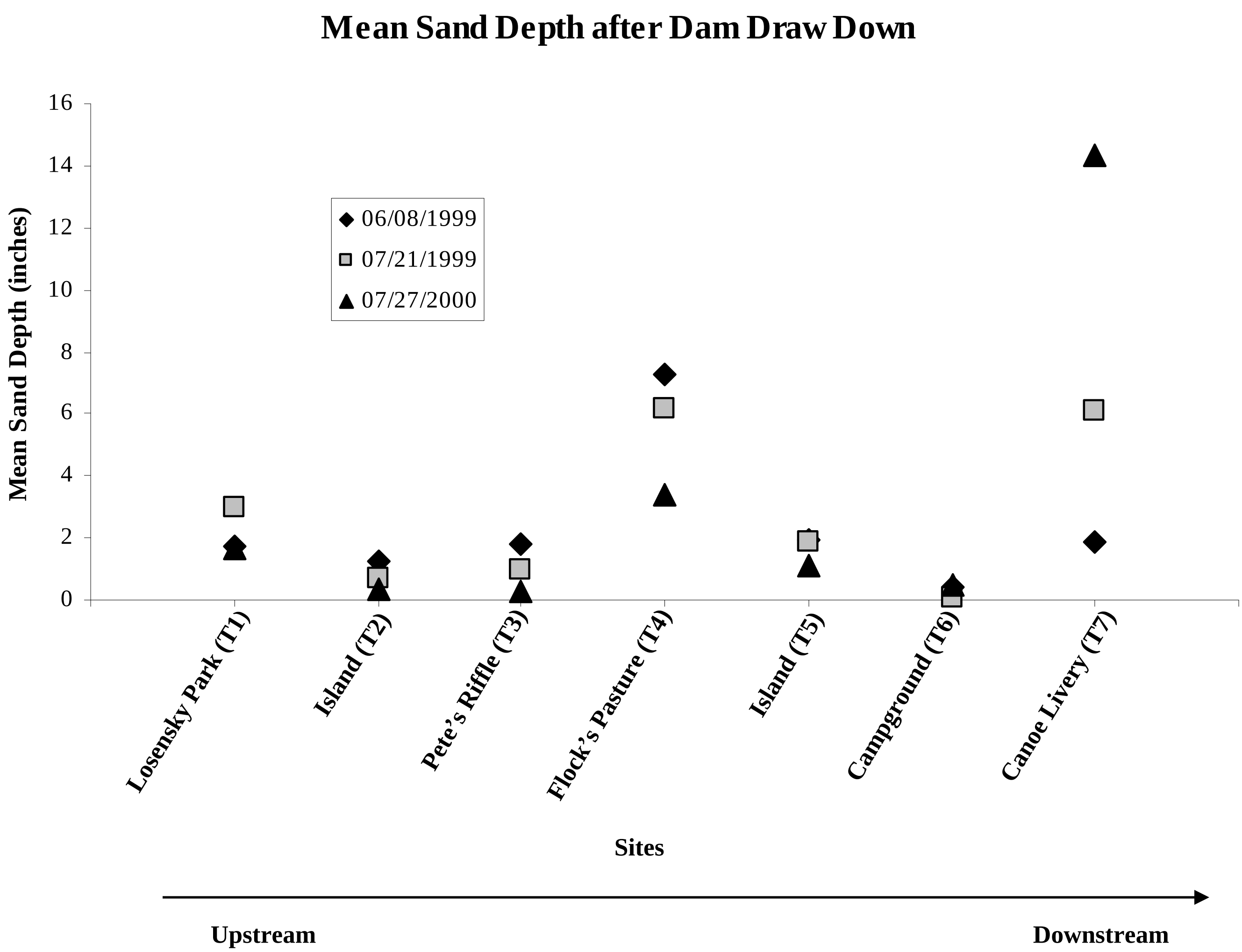


Figure 6. Mean sand depth along seven transects of the Dowagiac River after the Pucker Street Dam draw down.

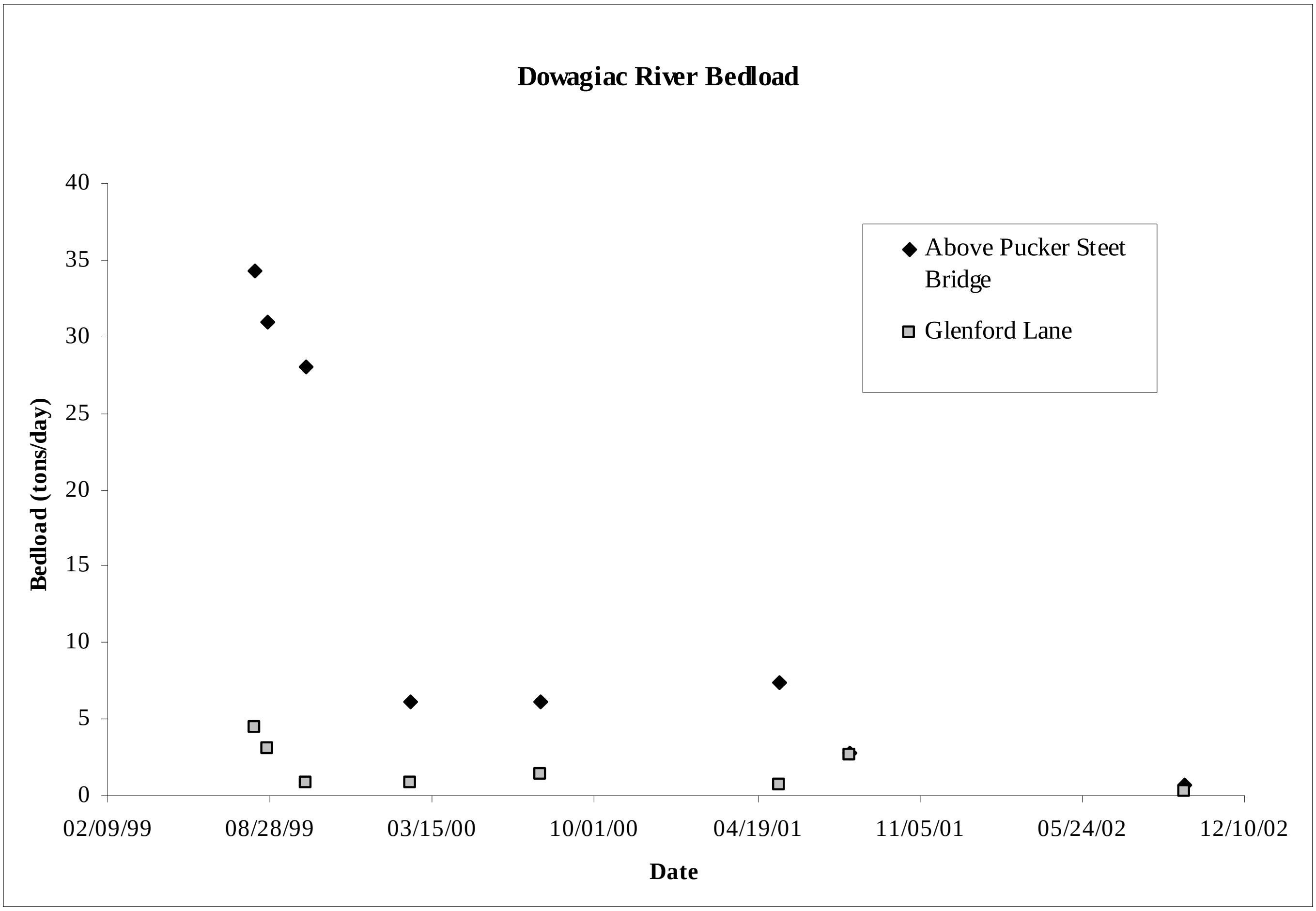


Figure 7. Dowagiac River bedload above Pucker Street Bridge and Glenford Lane.

Appendix 1.

Photo Series of the Pucker Street Draw Down Experience on the Dowagiac River

Pucker Street Dam in Niles, Michigan.


June 1999 before draw down


June 1999 during draw down


June 1999


July 2002

View looking upstream from Pucker Street Bridge.

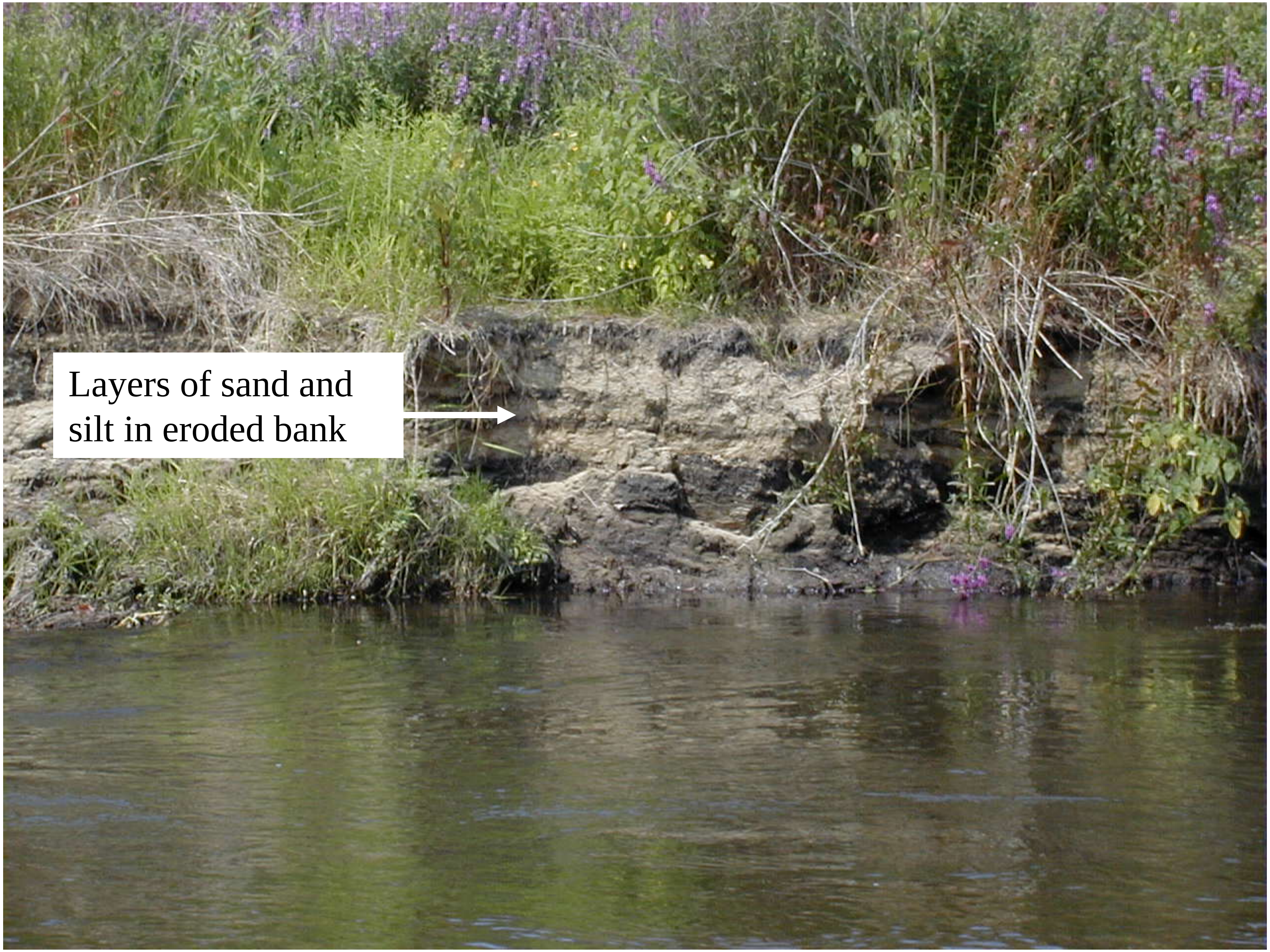
View across the impoundment at the pipleline approximately 0.5 miles above dam.


June 1999


June 1999

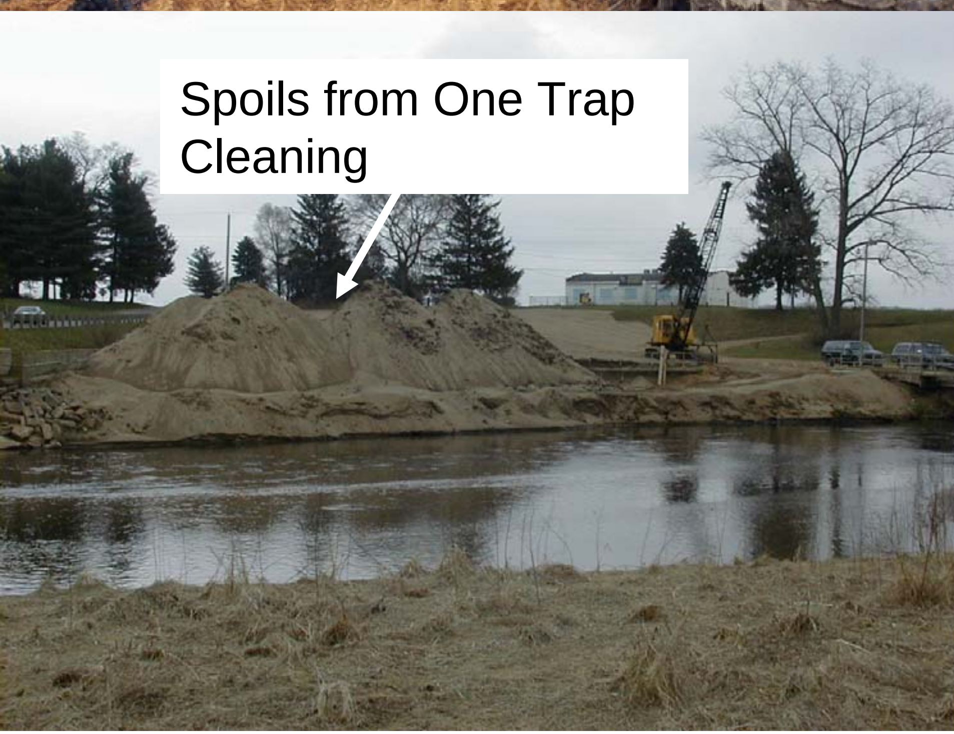

August 1999


July 2000



View of cross-section of eroded bank in former impoundment showing multiple layers of silt and sand. This material was soft and easy to probe through before draw down.

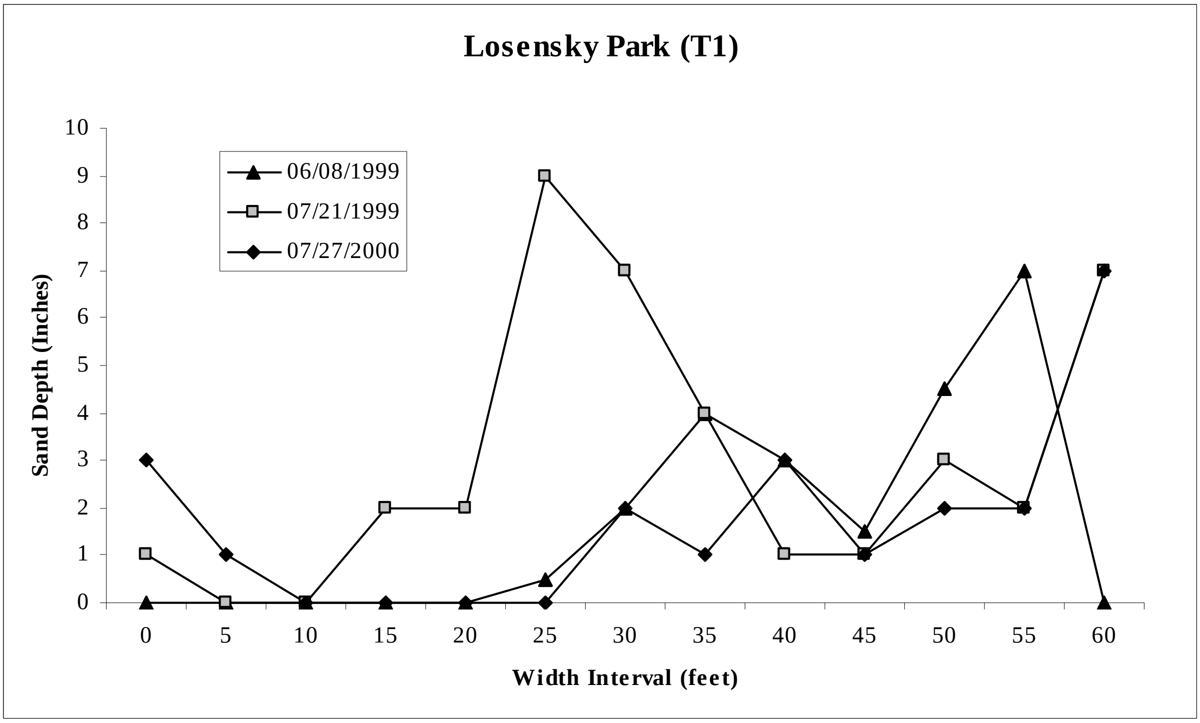
Aerial view of Pucker Street Impoundment post draw down.



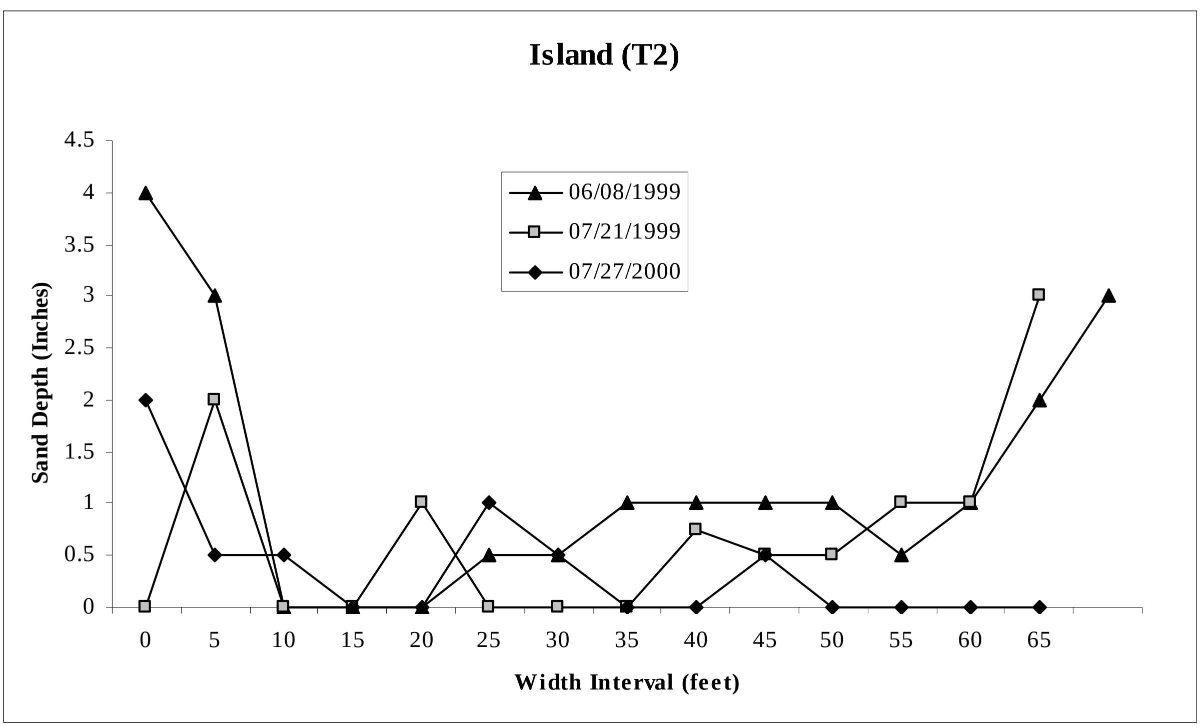
Sediment trap between the bridge and dam.

Appendix 2

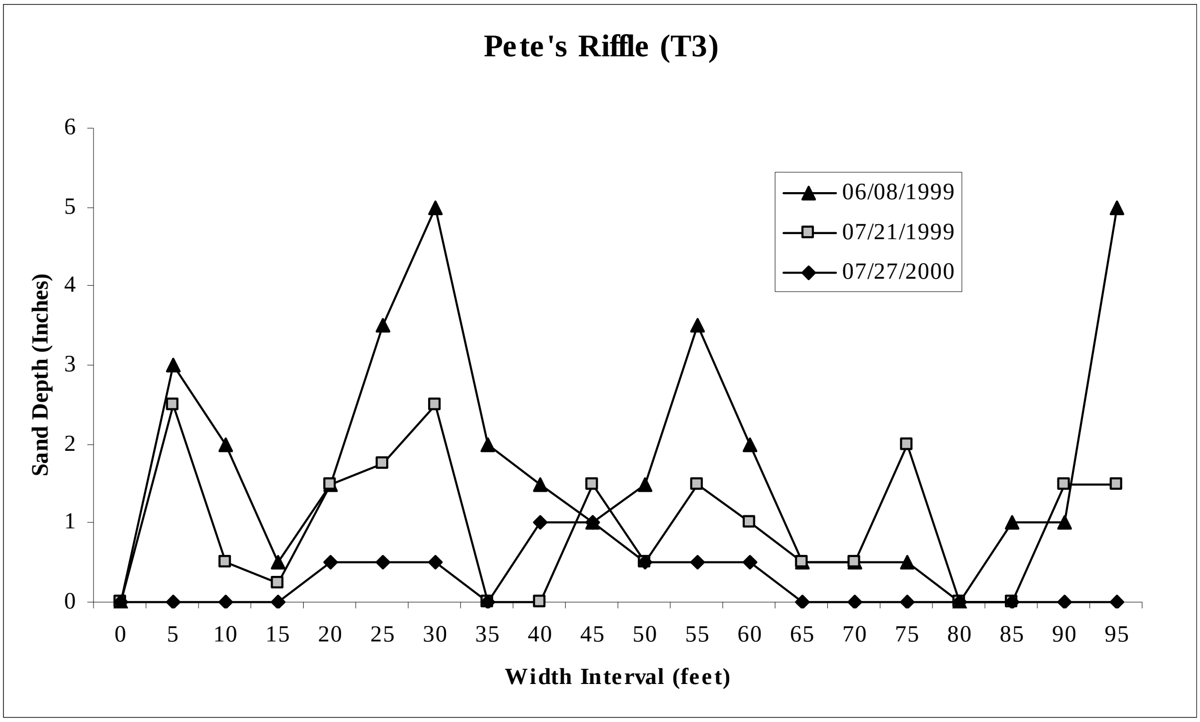
Sand depth cross-section results for transects 1 through 7 on the Dowagiac River from June 8th, 1999; July 21, 1999; and July 27, 2000.



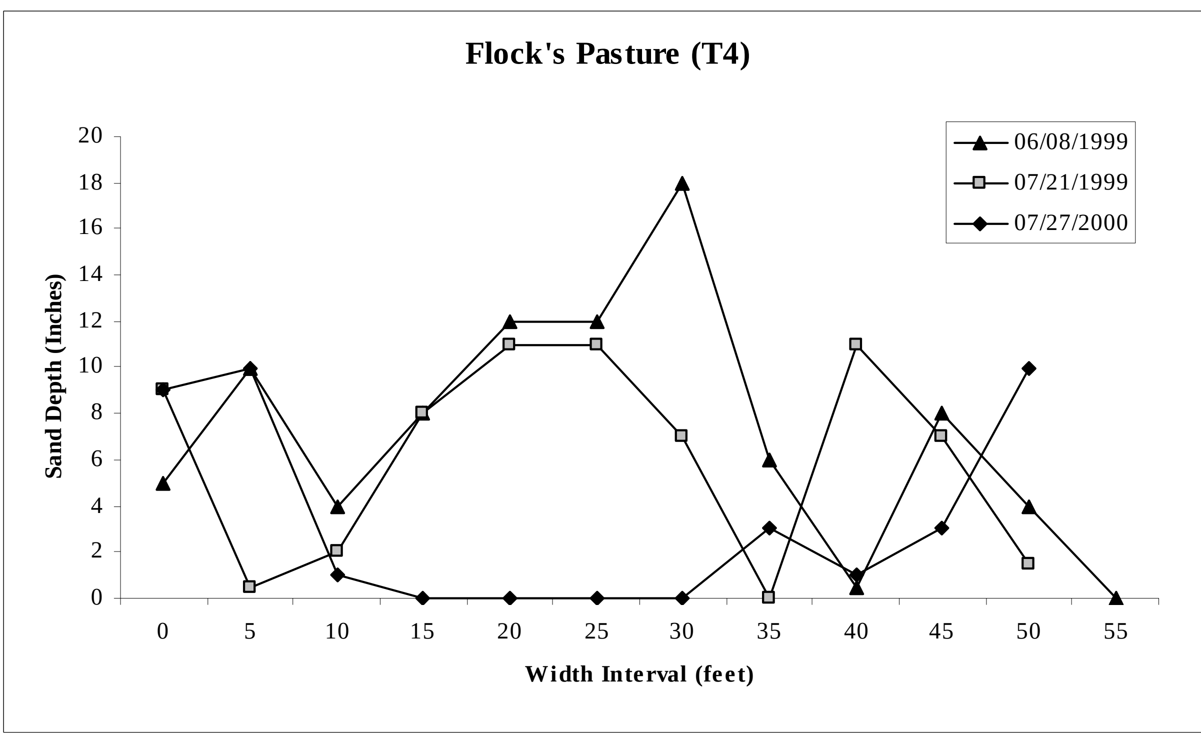
Sand depth cross-section of the Dowagiac River at Losensky Park (T1).



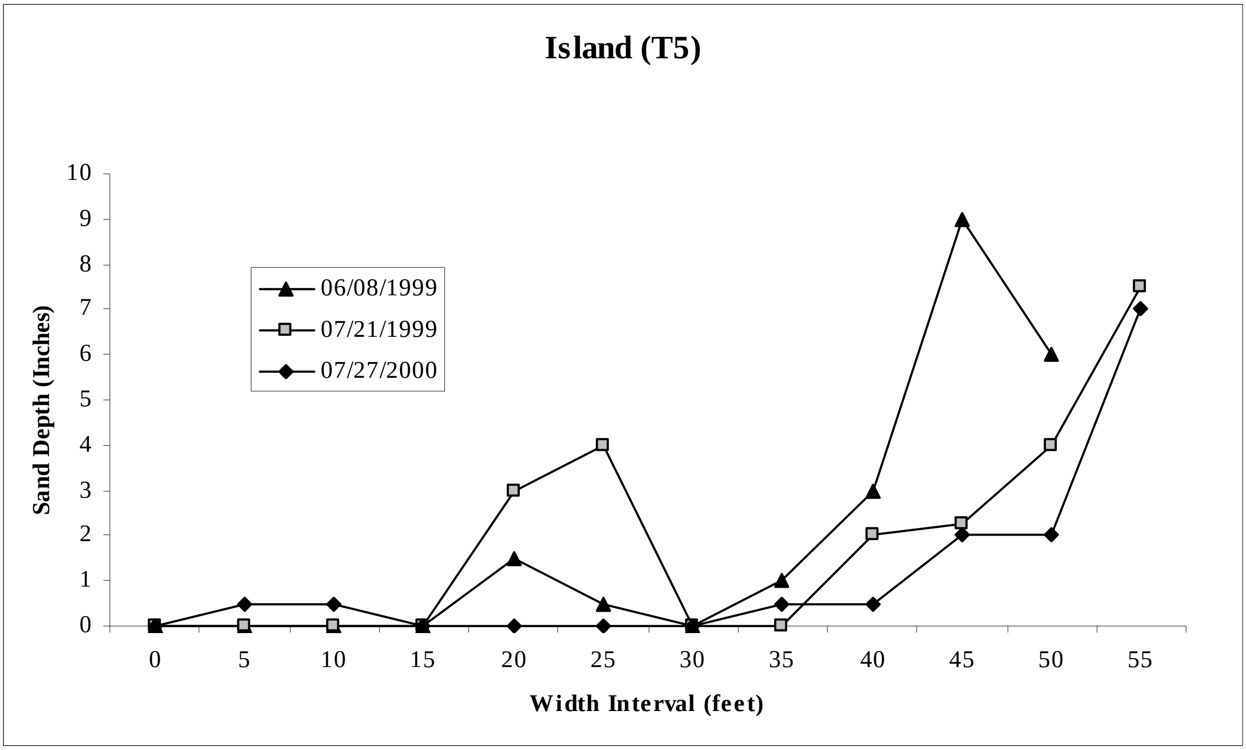
Sand depth cross-section of the Dowagiac River at the first island (T2).



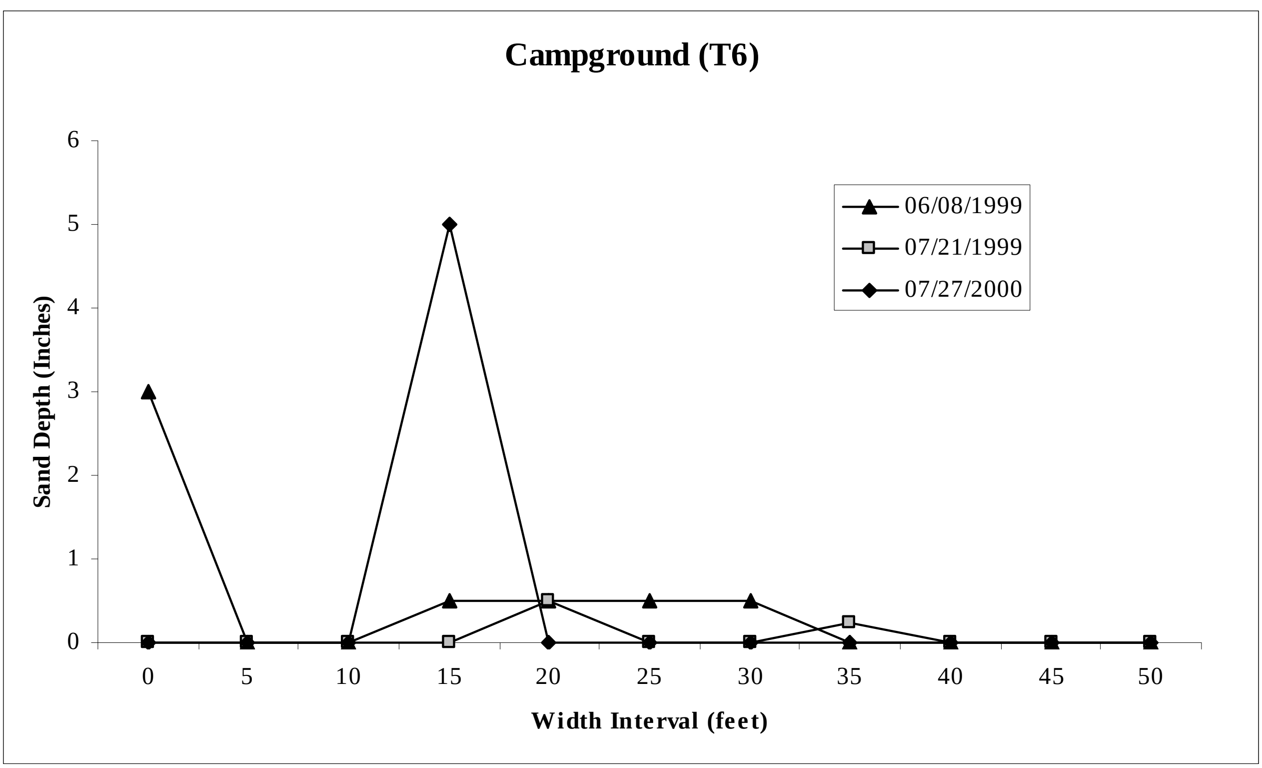
Sand depth cross-section of the Dowagiac River at Pete's riffle (T3).



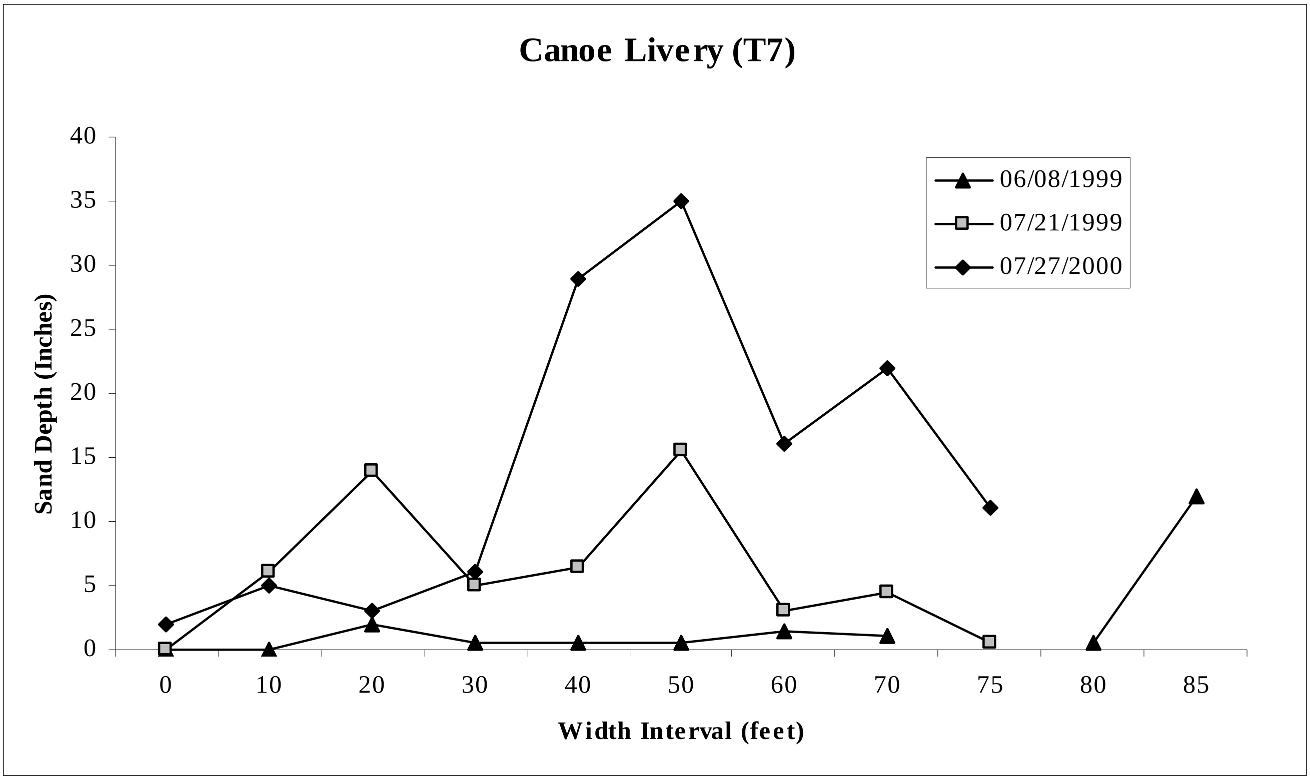
Sand depth cross-section of the Dowagiac River at Flock's pasture (T4).



Sand depth cross-section of the Dowagiac River at the second island (T5).



Sand depth cross-section of the Dowagiac River at the campground (T6).



Sand depth cross-section of the Dowagiac River at the canoe livery (T7).