Title

Bayview Avenue extension, Richmond Hill, Ontario, Canada habitat creation and wildlife crossings in a contentious environmental setting: a case study (September 2005)

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Bayview Avenue Extension, Richmond Hill, Ontario, Canada Habitat Creation and Wildlife Crossings in a Contentious Environmental Setting: A Case Study (September 2005)

Proponent and Project Funder: York Region Transportation and Works, Regional Municipality of York, Newmarket, Ontario, Canada

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Abstract: Bayview Avenue is an important north-south arterial road link in the road network of the York Region, Ontario, Canada. The roadway passes through a portion of the Oak Ridges Moraine (ORM), one of Ontario's most significant landforms as recognized through the Oak Ridges Moraine Conservation Act (2001) and Plan (2002).

McCormick Rankin Corporation (MRC) and its subsidiary, Ecoplans Limited, were retained by the proponent, York Region, to plan and design the 4.5-km missing-link Bayview Avenue extension from Stouffville Road north to Bloomington Road. This two-lane rural roadway was planned and designed to support the Region's growth (within the Greater Toronto area) while being sensitive to topography and natural-environmental features. Forest, wetland, and kettle features; Lake St. George Conservation Field Center uses; and wildlife habitat/movements were key resource issues and challenges recognized by the project team throughout the planning, design, and construction work.

Accordingly, an innovative environmental-management and enhancement program was developed and implemented during the project. The objectives were to reduce and mitigate effects on the natural environment, provide habitat creation and wildlife passage, advance the body of environmental research and education, and secure agency approvals.

The wetland-habitat creation project was developed in consultation with Education Centre field staff, and incorporated the following: a) creation of a three-cell experimental wetland complex outdoor "laboratory" located in a cultural meadow and connecting existing natural areas well removed from Bayview Avenue; b) protection of archaeological finds that were integrated in the wetland creation project; c) provision of trail and lookout zones; and d) provision of added habitat diversity in what was a cultural meadow.

The planning and design of the roadway also integrated an amphibian-migration study and detailed literature review on wildlife crossings. In response to this work, recognition of the reported presence of the rare Jefferson Salamander in the area, and the desire to maximize roadway permeability for wildlife, dedicated amphibian tunnels were located and installed under the roadway. In addition, a three-span 81-meter bridge was installed across an open dry ravine to maintain the ORM landscape character and provide a 14-meter vertical clearance for wildlife movement.

The Individual EA for the road project was successfully delivered in 1998 and the design was completed in 2001. The road was opened to traffic in 2002.

Post-construction monitoring at the amphibian tunnels (spring 2003, 2004) and recent observations (2005) have confirmed use by a variety of species including small mammals, Wood Frog, American Toad, Leopard Frog, and Spring Peeper. Use by target salamanders has not yet been confirmed. Challenges encountered include water ponding in some tunnels and some landscape changes from residential development. Outdoor education uses of the created wetland area have been very positive and will likely expand in the future.

In conclusion, the environmental-management program for the roadway was instrumental in securing agency approvals for the project. These efforts were also acknowledged by the naturalist community. The science of wildlife-crossing mitigation has been advanced and some challenges associated with tunnel design and landscape changes have been noted. Further tunnel monitoring has been recommended. Tangible environmental and educational benefits have been realized with the wetland-habitat creation project. The undertaking received the Canadian Consulting Engineers Award of Excellence in 2003.

Introduction

Bayview Avenue is an important north-south arterial road link in the road network of the York Region, Ontario, Canada. The roadway passes through a portion of the Oak Ridges Moraine (ORM), one of Ontario's most significant landforms as recognized through the Oak Ridges Moraine Conservation Act (2001) and Plan (2002). The moraine is a glacial-deposition feature about 100 miles in length with rolling topography and characterized by a mix of agricultural lands, forest, wetland, thicket, and rural residential areas. Total forest cover on the moraine is about 30 percent. The general site location is shown in Figure 1.

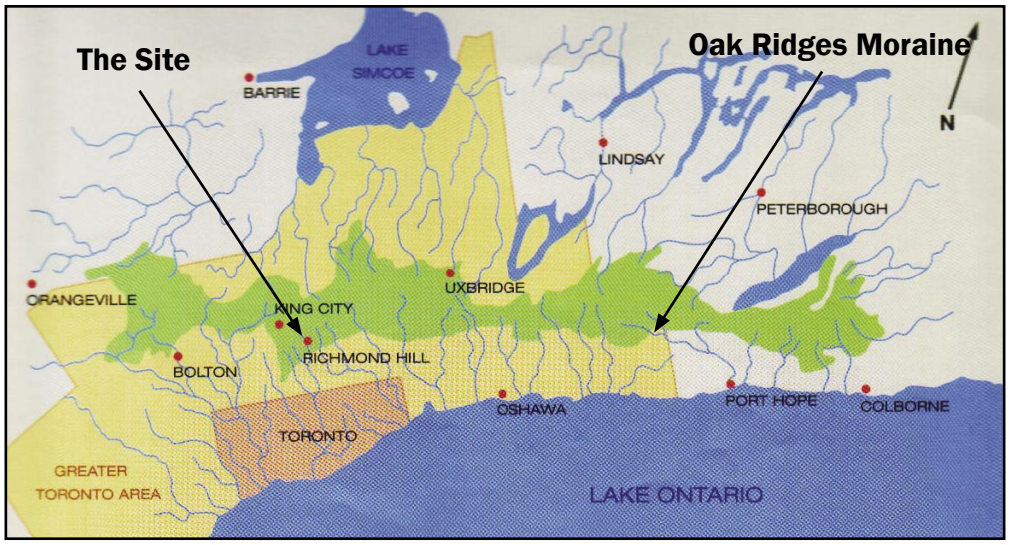


Figure 1. Site Location–Oak Ridges Moraine
(Graphic Courtesy of Ontario Nature–Federation of Ontario Naturalists)

McCormick Rankin Corporation (MRC) and its subsidiary, Ecoplans Limited, were retained by the proponent, York Region Transportation and Works, to plan and design the 4.5-km missing-link Bayview Avenue extension from Stouffville Road north to Bloomington Road.

The ORM landscape in this area consists of agricultural lands, forest and wetland blocks, kettle lakes, Toronto Region Conservation Authority (TRCA) lands, and areas of existing and approved development. This two-lane rural roadway was planned and designed to support the Region's growth (within the Greater Toronto area) while being sensitive to topography and natural environmental features. Figure 2 shows the moraine features and topography during road construction.

Given the high environmental profile of the undertaking, the project went through both the Class Environmental Assessment (EA) and Individual EA study processes. The Jefferson Forest, Wilcox-St. George provincially significant wetland (PSW), kettle lakes, the Lake St. George TRCA Outdoor Education Center uses, and wildlife habitat/movements were key resource issues and challenges recognized by the project team throughout the planning, design, and construction work.

Construction Photographs

Figure 2. Local Moraine setting and Bayview Avenue construction (2002)

Accordingly, an innovative environmental-management and enhancement program was developed and implemented during the project. The objectives were to reduce and mitigate effects on the natural environment, provide habitat creation and wildlife passage, advance the body of environmental research and education, and secure agency approvals.

The Individual EA for the road project was successfully delivered in 1998 (Ecoplans Limited and McCormick Rankin Corporation, 1997a) and the design was completed in 2001. The road was opened to traffic in 2002.

This case-study paper focuses on the design and delivery of two key facets of the environmental-management program for the roadway: 1) the wetland-habitat creation project and 2) wildlife-crossing mitigation. An overview panel of this environmental-management program is shown in Figure 3.

Figure 3. Bayview Avenue Extension–Environmental-Management Program Summary

Environmental-Management Program

Wetland creation pilot project

There is an existing section of Bayview Avenue bordering the Lake St. George TRCA Conservation Field Centre lands. However, widening of this road section was not feasible because of existing road geometry and the condition, traffic safety and sightlines, and impacts that would be incurred on numerous existing homes. Consequently, the road extension had to "thread the needle" between two key constraint areas: 1) the existing residential area to the west and 2) the Lake St. George Conservation Field Centre lands to the east (mosaic of agricultural fields, cultural meadow, thicket, forest, wetland, and the Lake St. George kettle lake).

The adopted environmental-management approach was careful roadway routing through this area, buffer measures through contour grading and planting, invasive-species removal (buckthorn management), wetland-substrate salvage, and wetland-habitat creation (Ecoplans Limited and McCormick Rankin Corporation, 1997b). Figure 4 shows the roadway routing through this area, along with the various environmental-management measures.

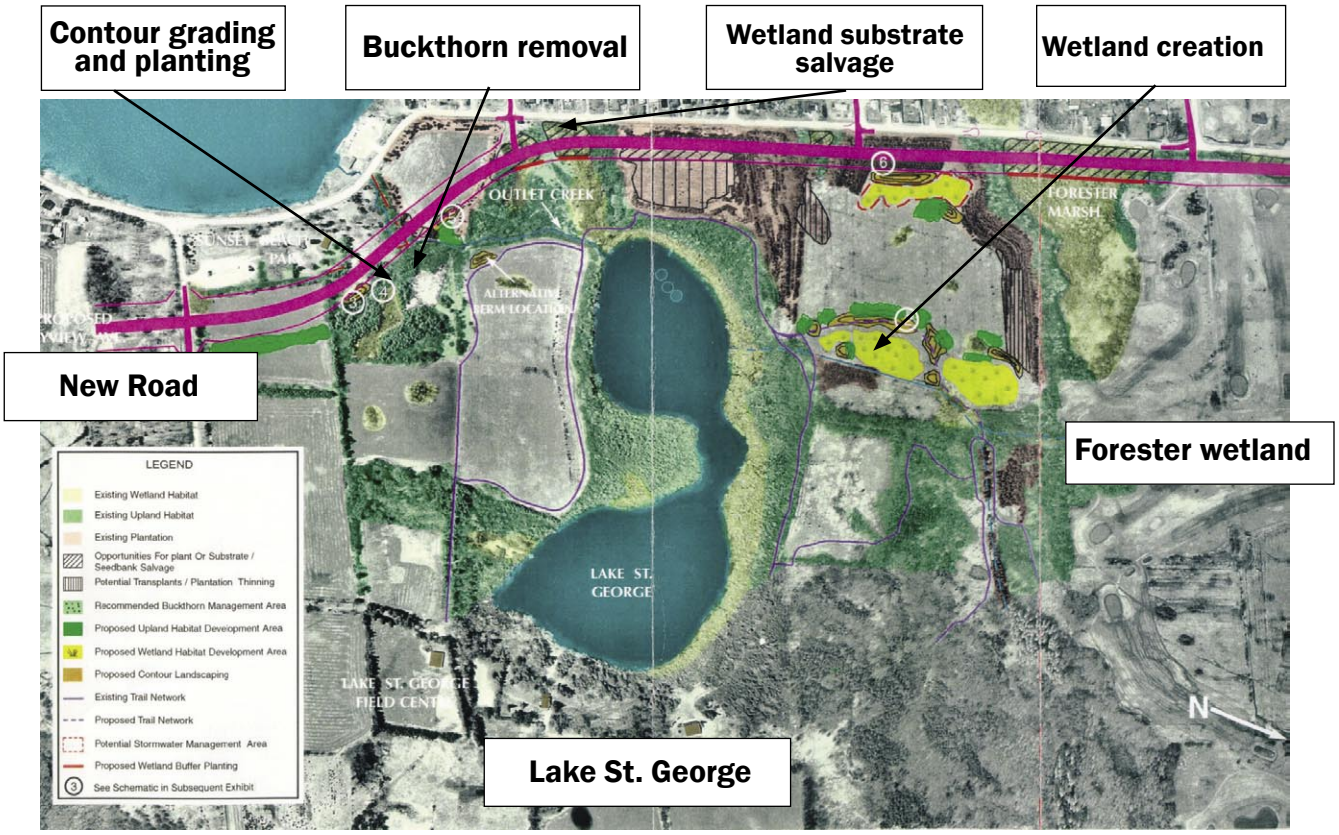
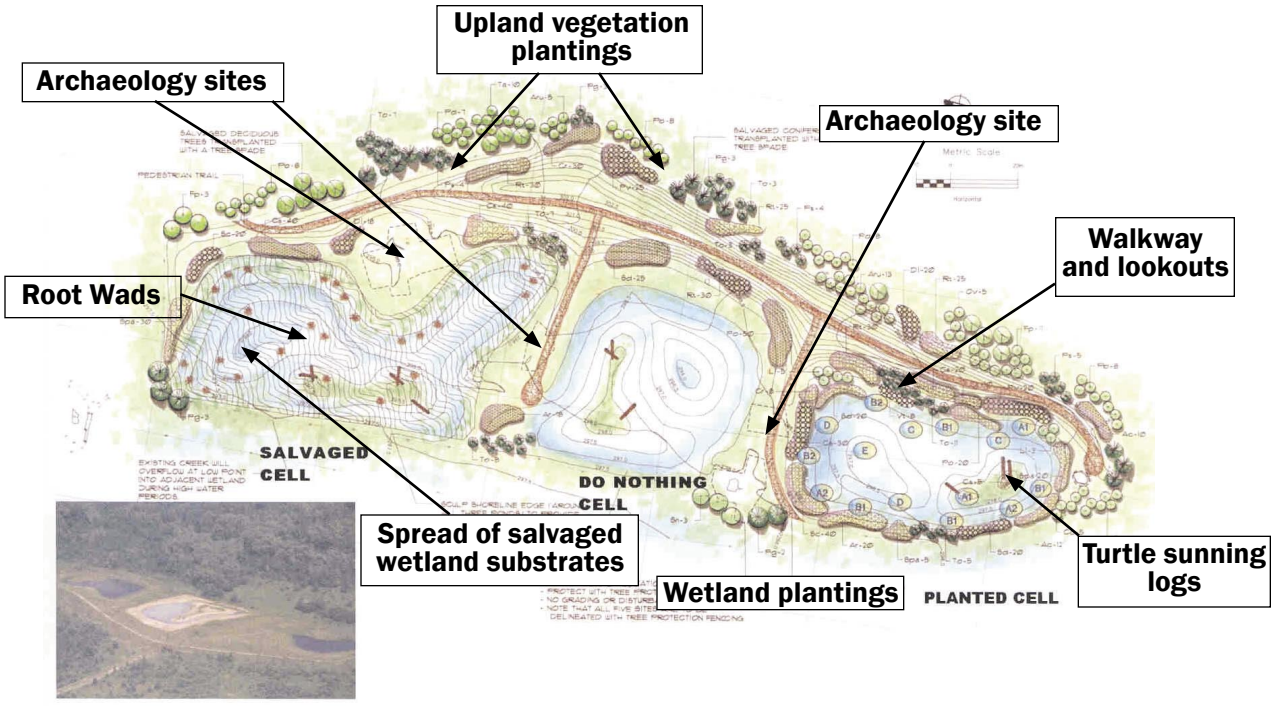


Figure 4. Lake St. George Conservation Field Centre lands–Environmental Management and Enhancement

Considerable effort was made to avoid all wetlands, not just the PSW, during the roadway routing, while also conserving ORM topography and buffering the TRCA Lake St. George Conservation Field Centre lands. However, some wetland removal was unavoidable (about 1.5 ha) and the roadway had to cross a portion of the Conservation Field Centre land close to a small wetland pond and forest used for outdoor education (Frog Pond for calling amphibians and outdoor survival skills program in adjacent forest).

In recognition of these effects, a wetland-habitat creation project was developed in consultation with TRCA Conservation Field Centre staff, incorporating the following (See Figure 5):

- Creation of a three-cell wetland habitat complex (a “do-nothing cell,” a planted cell, and a cell with salvaged wetland substrates) located between a natural wetland (Forester Marsh/Swamp) and Lake St. George on the TRCA property and buffered (300 m) from Bayview Avenue
- Protection of archaeological finds that were integrated in the wetland-creation project
- Provision of trail and lookout zones for outdoor education and cultural heritage experiences
- Provision of an “outdoor laboratory” where wetland and upland vegetation development and wildlife colonization can be tracked by Conservation Field Centre staff and students
- Provision of more diverse wildlife habitat in what was a cultural meadow and improved habitat connections between Forester Wetland and Lake St. George



Pilot Wetland Habitat Creation Area

Figure 5. Pilot Wetland Habitat Creation Landscape Plan–Bayview Avenue Project

The wetland creation site was a cultural meadow with the groundwater table located relatively close to the surface. A small drainage channel follows the east side of the site, with seasonal flow eventually reaching Lake St. George. The excavations for the wetland pools created adjacent upland mounds. The wetland depressions were graded to provide a range of water depths, a variety of sculpted edges, and therefore a diversity of microhabitats. The upland areas accommodate trails and lookouts. Wetland construction was undertaken and completed in 2000.

North planted cell

Figure 6 is a series of photographs showing construction and planting of the north wetland cell in September 2000 and wetland conditions in July 2002 and August 2005.

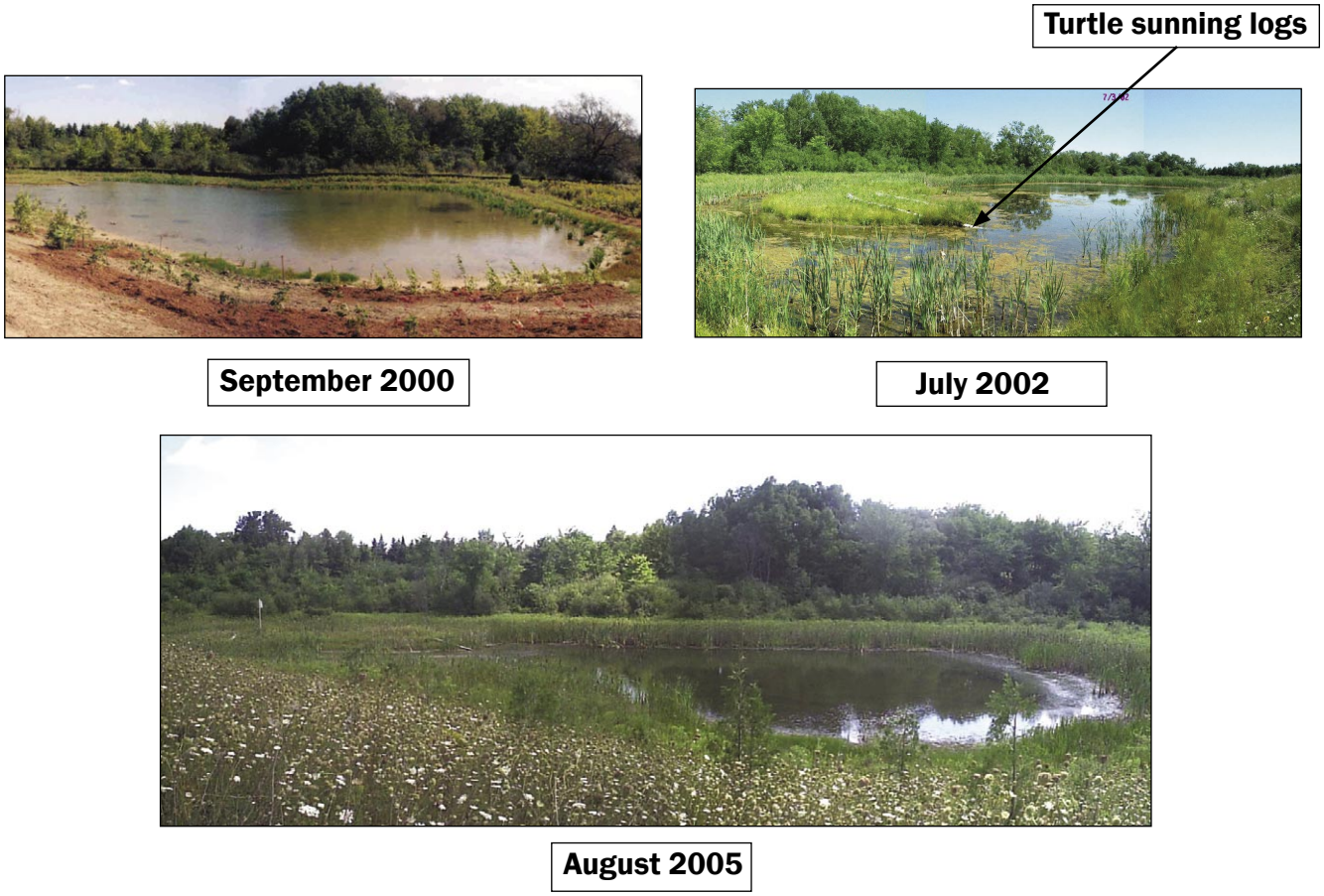


Figure 6. North Wetland Cell (Planted)–Stages of Development

An overview of the planted wetland cell development is as follows:

- The wetland cell was developed following a traditional design approach. Topsoil from the area was salvaged, stockpiled, and then spread over the graded depression and upland areas.
- Turtle sunning logs were obtained from woody material cut during roadway construction. The logs were strategically placed extending from the shoreline into the pond.
- Upland zones were seeded using a standard MTO (Ministry of Transportation Ontario) Type 1 seed mix. Nodal plantings of a variety of tree and shrub species were installed throughout the upland zone.
- The wetland portion of the cell was planted with the following associations: shoreline wet meadow plants, grassy wet meadow plants, shallow emergents (up to 15-cm high sun-tolerant and shade-tolerant species), emergent plants (up to 30-cm high), deep-water emergent plants (up to 60-cm high), and floating/submerged plants. A complete list of all vegetation installed in the planted cell is provided in Appendix A.

General observations stemming from this work were as follows:

- A good growth of cultural-meadow vegetation developed in the surrounding upland zone (see Figure 6, August 2005 photo). This developed in part from the Type 1 MTO seed mix that included native and non-native cover species. Use of a native seed mix would have been preferable.
- Wildlife browse of planted vegetation material was an ongoing challenge (Canada Goose, ducks, Cottontail Rabbit, Raccoon, Porcupine, White-tailed Deer). Planted upland nodes still persist to varying degrees.
- Although not planted, Cattail (*both Typha latifolia and T. angustifolia*) quickly colonized portions of the wetland. Occasional overflow from the adjacent drainage channel provided the source of cattail material (dispersing seed).

- Nevertheless, observations in August 2005 revealed a good quality wetland system with the following conditions:
    - A good mix of shoreline wet meadow and grassy wet meadow species, including *Eupatorium maculatum*, *Eupatorium perfoliatum*, *Scirpus cyperinus*, *Glyceria striata*, *Juncus effusus*, *Scirpus acutus*, *Scirpus atrovirens*, *Carex hystericina*, and *Carex vulpinioidea*.
    - The presence of emergent wetland plants including *Sparganium eurycarpum*, *Alisma plantago aquatica*, and *Sagittaria latifolia*, as well as *Eleocharis palustris* (thriving colony in the southwest portion of the wetland).
    - The presence of submerged Canada Waterweed (*Elodea canadensis*) and floating pondweed (*Potamogeton pectinatus*) along the west and southwest wetland margins.
    - Numerous tracks of White-tailed Deer, Raccoon, Muskrat, numerous Leopard Frogs observed, Great-blue Heron and Green-back Heron observed, and reports of periodic waterfowl use.Numerous water striders were observed.
    - A Wood Duck nest box has been erected by Field Center staff at the north end of the wetland. No confirmed nesting at present.

Central "do-nothing cell"
Figure 7 is a series of photographs showing initial construction of the "Do-Nothing" wetland cell in September 2000 and wetland conditions in July 2002 and August 2005.

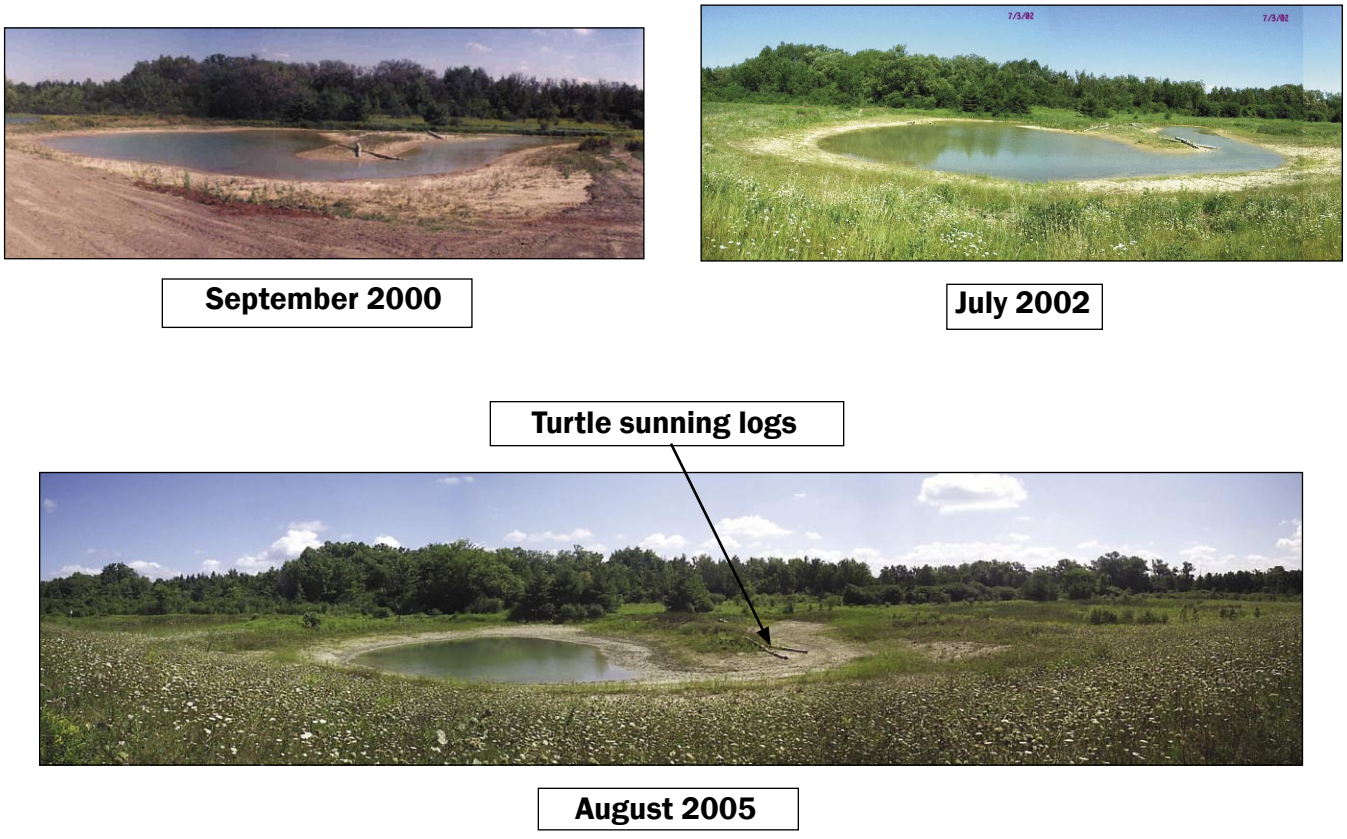


Figure 7. "Do-Nothing" Wetland Cell–Stages of Development

An overview of the "Do-Nothing" wetland cell development is as follows:

- The wetland cell was excavated down to the clay substrates below the water table. No additions of topsoil, planted vegetation, or any organic material were made in the wetland depression.
- An upland promontory was provided to increase the shoreline extent and provide a location for turtle sunning logs.

General observations stemming from this work were as follows:

- Other than a small cluster of shrub willow in the upper south margin of the wetland, riparian vegetation growth, and colonization has been negligible in this cell.
- The summer of 2005 has been very dry in southern Ontario and probably accounts for the limited amount of standing water present in the August 2005 photo (compared with the September 2000 and July 2002 photos).
- Cultural meadow vegetation has developed around the dry upper margins of the facility.
- Submerged and floating aquatic plant growth has been negligible.
- There are a few isolated clusters of spike rush (*Eleocharis sp.*), rush (*Juncus sp.*), and bulrush (*Scirpus validus*) present in the upper damp margin of the southwest corner.
- A few Water Striders were observed, but in limited numbers. Waterfowl have been occasionally observed loafing on the pond and a single Spotted Sandpiper was observed during the August 2005 site visit. A few tracks of White-tailed Deer and Raccoon were evident in the 2005 site check. A few Leopard Frogs were observed during the August 2005 site check, but overall habitat quality for amphibians in this cell is very limited.
- This wetland cell was nicknamed “The Beach” by Field Centre staff since its development. Sterile, barren, beach-like conditions persist today as evident in the August 2005 photo.
- The very limited habitat, wetland vegetation, and wildlife diversity in this cell are attributed to the sterile conditions provided by the clay substrates, with an absence of inoculation materials (such as topsoil or organic material) that would contribute plant-seed sources and a suitable rooting medium for colonizing species. Even cattail, an aggressive colonizing wetland plant, is absent from this wetland cell;

These observations confirm the importance of providing a suitable rooting medium environment in wetland-cell development to ensure some level of wetland plant colonization and growth. Without these conditions, even proximity to more-productive wetland cells (such as the Planted Cell and the Wetland Salvage Cell) as well as other natural seed sources (surrounding landscape) is no guarantee of successful wetland development.

Wetland salvage cell–south

Figure 8 is a series of photographs showing initial construction of the wetland substrate salvage cell in May 2000, and subsequent wetland conditions in July 2002 and August 2005.

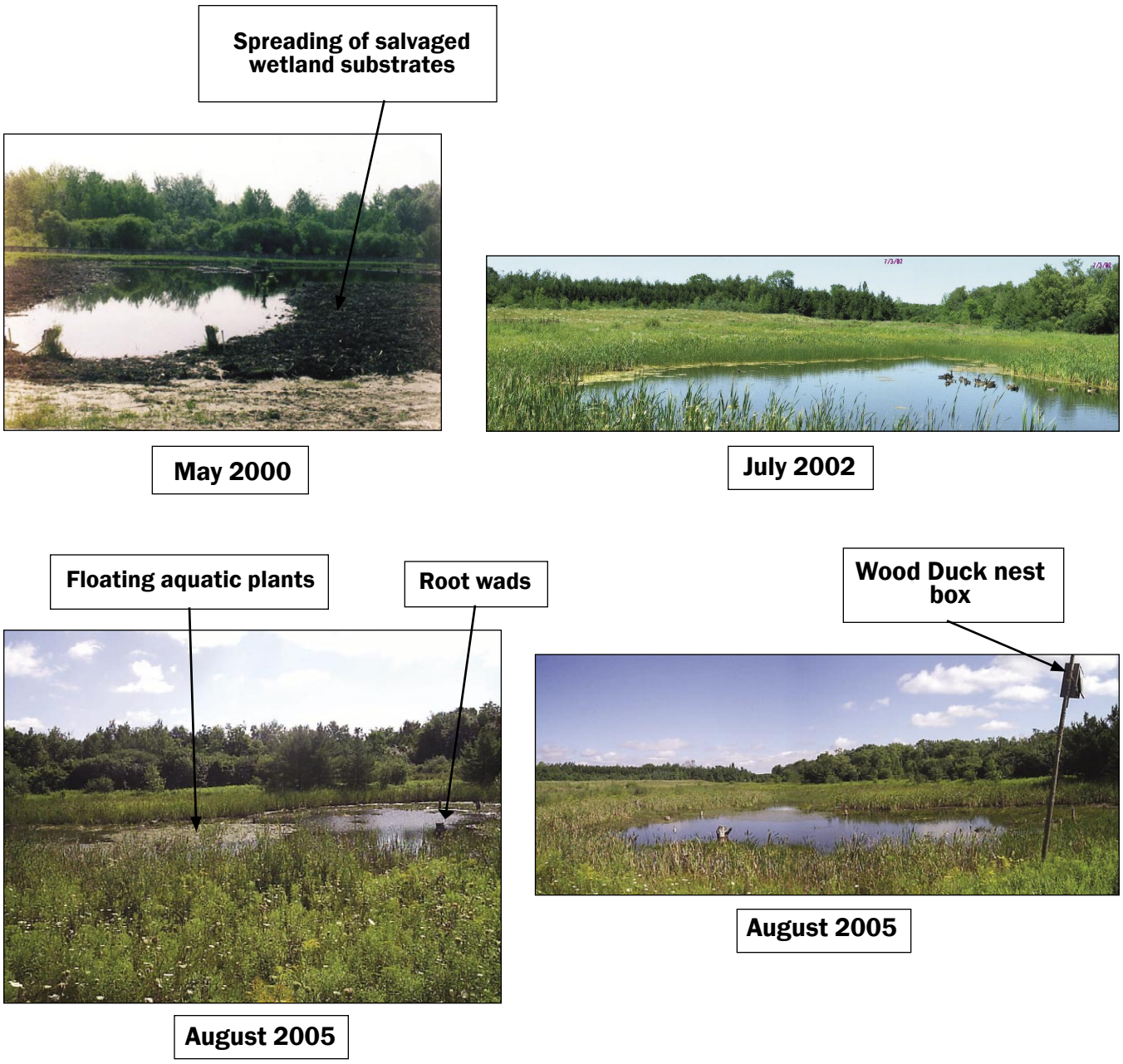


Figure 8. Wetland Substrate Salvage Cell–Stages of Development

An overview of the wetland salvage cell development is as follows:

- The wetland cell was excavated below the water table and raised upland mound zones were developed during the grading.
- Wetland substrates and organic material were salvaged from wetland pockets removed by the roadway and subsequently spread throughout the graded wetland depression. Willow root wads were also salvaged from the construction area and placed throughout the wetland cell. Turtle sunning logs were strategically placed extending from the shoreline into the wetland.

General observations stemming from this work were as follows:

- This was the fastest-developing wetland cell. It exhibited natural wetland characteristics within 3 months of construction.

- Wetland plants such as various sedges (*Carex sp.*), Nodding Bur-marigold (*Bidens cernua*), and Water Plantain (*Alisma plantago-aquatica*) developed first. Cattail (*Typha latifolia and T. angustifolia*) colonized parts of the wetland subsequently via seasonal overflow contributions from the adjacent drainage swale.
- The willow root wads initially exhibited leaf-out and then eventually died. However, the root wads continue to provide aquatic habitat, perches, and habitat for colonizing plants.
- The seed bank salvage placement was thicker than anticipated. Consequently, wetland pond depths were shallower than planned. Nevertheless, wetland water levels persisted throughout the summer, with minimum water depths of 25 to 30 cm present during the August 2005 site visit (following a very dry summer in southern Ontario, as noted previously).
- The wetland has developed with a variety of habitats–open water, meadow marsh, tall grass meadow marsh, cattail marsh, shrub thicket, and floating and submerged wetland. There is remarkably little invasive plant colonization (a few Purple Loosestrife stems noted) and a good diversity of wetland types and plant species has developed. A variety of rushes, sedges, bulrushes, spike rushes, broad-leaved herbaceous plants, and shrubs are present. Examples include *Scirpus atrovirens*, *Bidens cernua*, *Glyceria striata*, *Scirpus cyperinus*, *Eupatorium maculatum*, *E. perfoliatum*, *Asclepias incarnata*, *Carex hystericina*, *Carex stricta*, *Juncus effusus*, *Scirpus acutus*, *Eleocharis palustris*, *Carex vulpinoidea*, *Alisma plantago-aquatica*, *Sparganium eurycarpum*, *Sagittaria latifolia*, *Elodea canadensis*, *Potamogeton pectinatus*, *Scirpus validus*, and *Euthamia graminifolia*.
- Game trails (Muskrat, Raccoon, and White-tailed Deer) frequent the wetland. Leopard Frogs are abundant. Numerous Water Striders were observed during the August 2005 site visit as well as numerous baitfish. In addition, Great Blue Heron, Green-backed Heron, Mallard, Red-winged Blackbird, American Goldfinch, 12-spotted Skimmer (Dragonfly), and White-tailed Skimmer (Dragonfly) were observed.
- A Wood Duck nest box has been erected by Field Center staff at the south end of the wetland. To date, no nesting has been confirmed.
- Discussions with Lake St. George Conservation Field Centre staff (August 17, 2005) confirmed that this wetland cell has been the fastest to develop of the three cells and supports a good diversity of both plant and animal life.

Wetland Pilot Project–Field Centre Perspective

An interview with a Lake St. George Conservation Field Centre staff member (Mr. Jake Elkert) on August 17, 2005 yielded the following perspectives on the integration of the wetland-creation project with the outdoor-education program:

- Field Centre pond studies and the watershed program now involve about eight visits to the wetlands each year (four visits in the summer/fall period and four visits in the spring period). Observation activities include water sampling, assessing pond life (aquatic invertebrates), noting differences between the wetland cells, and wildlife presence.
- An Oak Ridges Moraine group has an annual visit to the wetlands. In addition to checking the various wetland cells, the ORM group has a particular interest in the archaeology sites that were integrated in the wetland creation project.
- Night hikes are held to listen to calling frogs (particularly Spring Peepers). While the existing Frog Pond site nearest Bayview Avenue is still used for this purpose (with vigorous frog calling), there is also good Spring Peeper calling at the constructed wetlands. The wetland creation area provides an alternative amphibian calling area for Outdoor Education uses because it is further removed from the traffic noise on Bayview Avenue (about 300 meters away).
- Weekend visits are made by groups such as the Girl Guides and Brownies, who have done some supplementary planting (cedar and dogwood) in the upland areas bordering the wetlands.
- The Field Centre has in the past provided a high-school environmental-science credit program. The addition of the created wetland complex on site provides an opportunity to re-initiate the science credit program if desired.

Wildlife-Crossing Mitigation

Overview of issues

The wildlife-crossing mitigation for the roadway developed in recognition of the following features and issues:

- The presence of kettle ponds and lakes, wetlands, forest blocks, and ravine topography in the area all provide wildlife habitat and wildlife movement opportunities.
- Frog movements were identified as an issue during the EA study process.
- Confirmation of Jefferson Salamander in the area (a provincially rare and nationally threatened species) by the Richmond Hill Field Naturalists. This occurred late in the design phase of the project.
- A desire to increase roadway permeability for wildlife.

Accordingly, a detailed amphibian-migration study was undertaken with the following objectives:

1. Assess Jefferson Salamander presence and movements in the area.
2. Assess movements by other amphibian species in the area.
3. Determine appropriate mitigation measures for incorporation in roadway design and construction.
4. Identify a post-construction monitoring strategy.

Amphibian migration study

Mole salamanders (such as the Jefferson Salamander and Spotted Salamander) emerge from overwintering sites and migrate in the spring during rainy or very humid nights to breeding ponds. After eggs have hatched, salamander larvae develop for three to four months in the breeding pond. Thereafter, the larvae move from the pond to surrounding forest areas to feed through the summer and fall, prior to the fall dispersal to overwintering sites (Rye and Weller 2002).

Anticipated amphibian movement areas were determined in the field in consultation with Ministry of Natural Resources staff and Dr. Jim Bogart. This determination guided the location and extent of drift fencing (paige wire fence with sediment fence attached and heeled into the ground) that was to be installed for amphibian capture and release. A study protocol was subsequently developed (Ecoplans Limited, 2002) and approved. Finally, a detailed literature review of wildlife-crossing mitigation was undertaken.

Drift fencing 2.2-km long was installed bordering both sides of the road right-of-way (ROW) in the selected movement areas. Pitfall traps were installed at 10-to-30-meter intervals along both sides of the drift fencing. Each pitfall trap consisted of a new four-liter paint can buried in the ground adjacent to the drift fence. A drainage hole was drilled in the bottom of each can. In each pail, a damp sponge was placed within an open plastic bag to provide a moist area for captured amphibians. In addition, a 3/8-inch diameter wooden dowel was placed in each pail to provide an escape route for small mammals. Pail lids were secured between sampling events and then offset with a brick on top to provide a capture entrance for moving amphibians. Figure 9 shows an example of the drift fencing and pitfall pail.

Figure 9. Amphibian Migration Study–Drift Fencing and Pitfall Pail Setup

The migration study and amphibian-processing protocol were completed under a Wildlife Scientific Collector's Authorization provided by MNR. Captured Jefferson Complex Salamanders were measured, sexed, toe-clipped (for genetic DNA analysis), and released in the original direction of movement following protocol procedures. Figure 10 shows an example of salamander capture (pitfall pail) and processing.

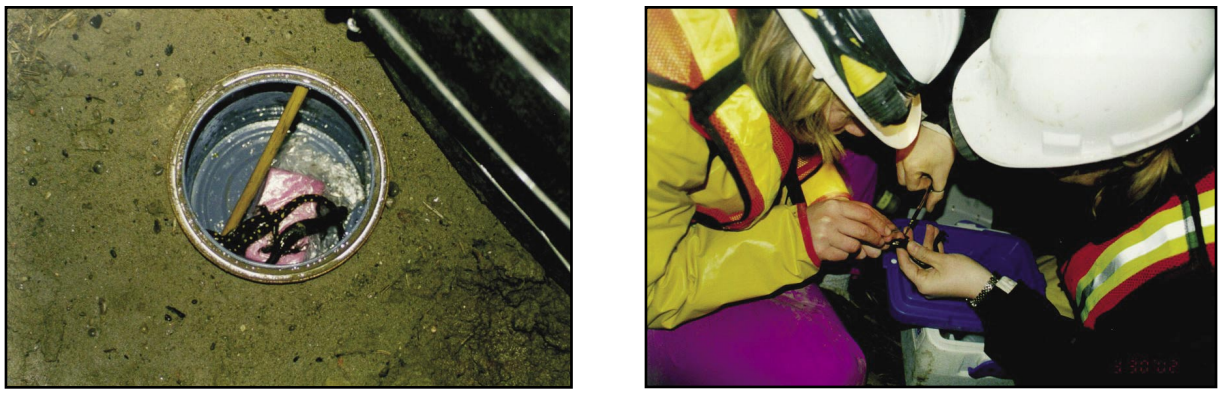


Figure 10. Amphibian Migration Study–Salamander Capture and Processing

Figure 11 summarizes the capture locations of Jefferson Complex Salamander and Spotted Salamander relative to Stouffville Road and the new Bayview Avenue Extension.

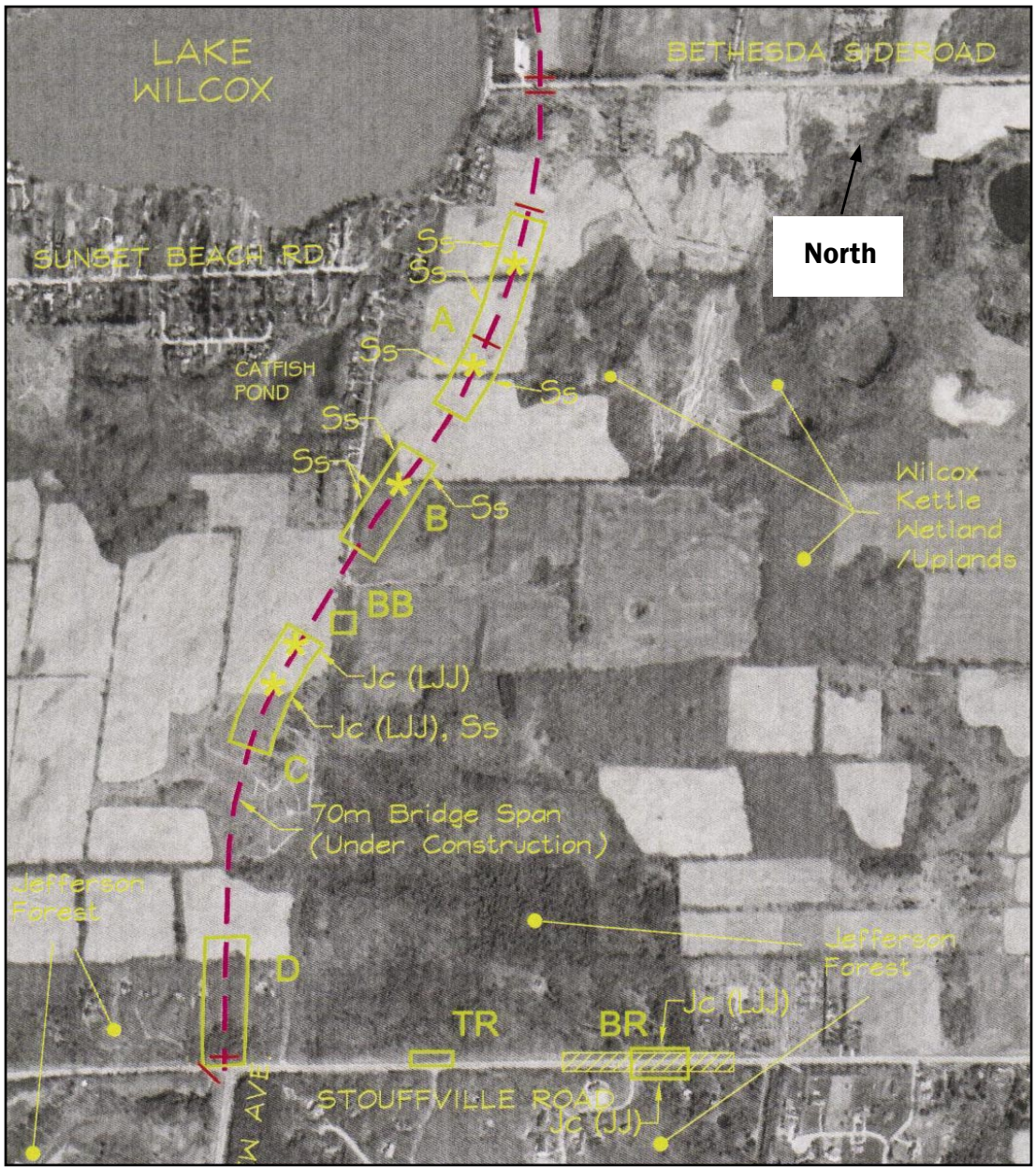


Figure 11. Amphibian Migration Study–Salamander Captures (2002). Jefferson Complex Salamander = Jc; Spotted Salamander = Ss; A to D, TR, and BR are Survey Zones where drift fencing was installed.

Key study activities and findings are highlighted below:

- 220 working pitfall traps were checked through the night by a two- or three-person field crew during 11 sampling events between March and May 2002. With this sampling approach, about 22,000 trap night hours were available for capture during the survey events.
- There were 147 captures/observations of the following eight species: Jefferson Complex Salamander (15), Spotted Salamander (30), Leopard Frog (63), Wood Frog (19), Spring Peeper (14), American Toad (four), Redback Salamander (one), and Northern Redbelly Snake (one).
- Of the 15 Jefferson Complex Salamanders recorded, one was the True Jefferson species (JJ) and the remainders were the Silvery Salamander (LJJ), a strong indicator of the presence of True Jefferson Salamander populations in this area. However, the number of captured/observed individuals is small relative to the survey effort. This may reflect a combination of a small population size and other dispersed breeding ponds in the landscape that do not require salamander movements across Bayview Avenue.
- Inferred movements by Jefferson Complex Salamanders were north and south across Stouffville Road and west (small numbers) towards Bayview Avenue.

- Inferred movements by Spotted Salamanders (in greater numbers) were predominantly west to east across the ROW from the Lake Wilcox area following agricultural fields to breeding sites in the Wilcox kettle wetlands to the east of Bayview Avenue.
- Moderate numbers of Wood Frog, Leopard Frog, and Spring Peeper were observed/captured in similar activity zones (Figure 11, Zones A, B, and C) as recorded for the salamanders.
- There never were mass migration movements of hundreds of amphibians at a time in very focused areas during this study. Movements involved smaller numbers of animals (about 150) in a more dispersed pattern. This number is (of course) conservative and does not include amphibians lost due to road mortality and not detected during road mortality surveys. In addition, the presence of Jefferson Complex Salamanders, as well as moderate numbers of several other amphibian species, led to a decision to provide some dedicated amphibian tunnels. The movement observations and capture information summarized in Figure 11, coupled with the detailed capture information (10-to-30-meter pitfall trap spacing) provided good guidance for tunnel placement.

Based on the capture data from the amphibian migration study, five dedicated amphibian tunnels were added to the design and located as shown in Figure 12. Tunnel-design characteristics were developed through the findings of the detailed literature review, knowledge of site-specific conditions, and discussions with knowledgeable professionals, including Dr. Bogart.

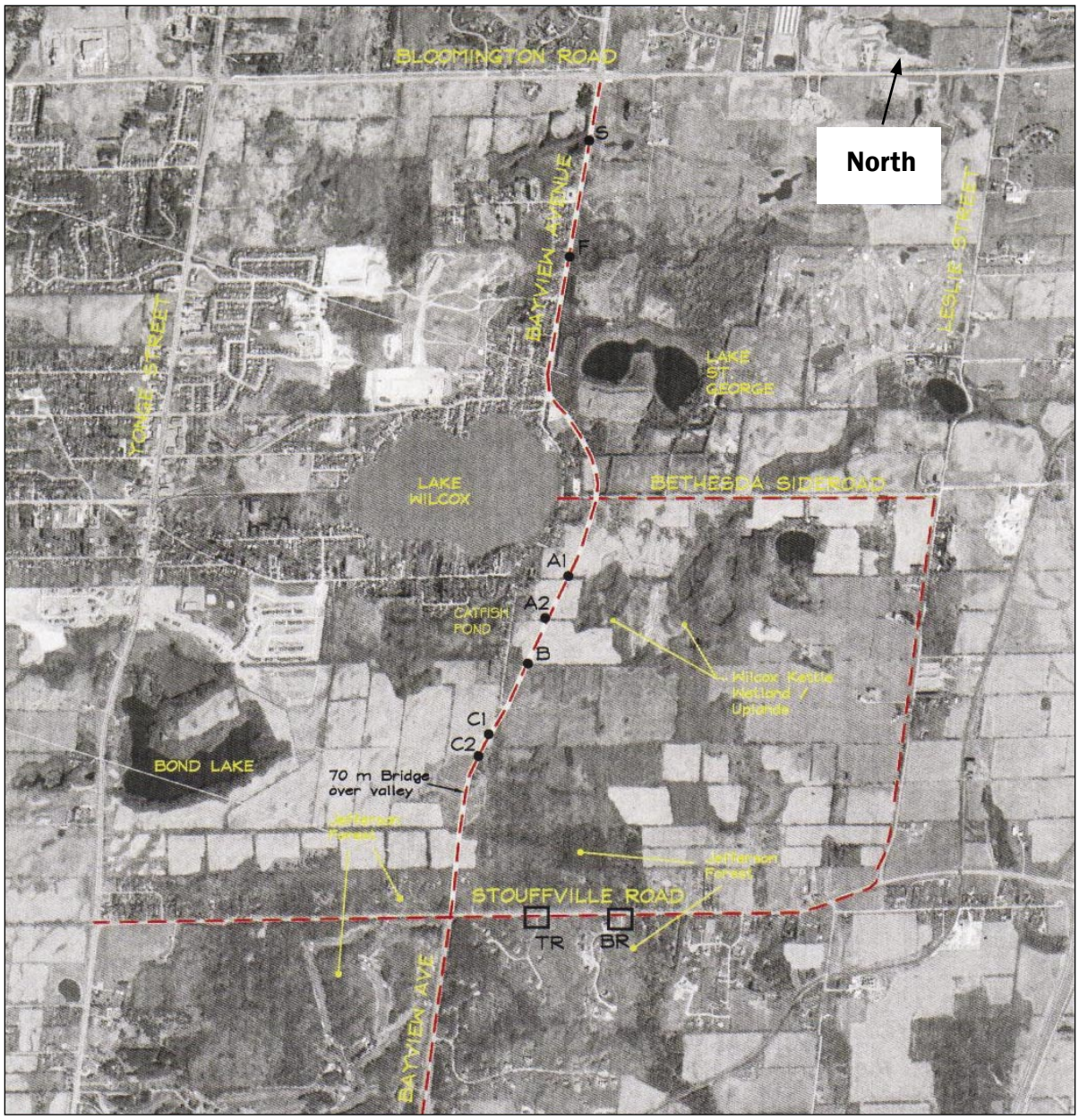


Figure 12. Bayview Avenue Extension Amphibian Tunnel Locations. (Tunnels A1, A2, B, C1, and C2)

The five dedicated amphibian culverts/tunnels were installed under the Bayview Avenue extension between Bethesda Side Road and Stouffville Road within zones A, B, and C (2002 study). The tunnel locations, dimensions, materials, and other characteristics were based on the findings and recommendations of the 2002 salamander study and are highlighted in Table 1 below (north to south from Bethesda Side Road). A sample tunnel cross section is provided in Appendix B.

Table 1. Characteristics of Amphibian Tunnels Installed under the Bayview Avenue Extension

Location	Tunnel Characteristics	Rationale
Tunnel A1	• 1.2-meter concrete pipe with two manhole tees and grates • About 25 meters in length • 50 meters of funnel fencing on each side of tunnel • On-site sandy substrates placed in tunnel	• Capture area for Wood Frogs, Spotted Salamanders, and Leopard Frogs moving towards Wilcox Kettle wetland/uplands • Meets basic size and multi-species use guidelines • Inlet grates for comparison with A2
Tunnel A2	• 1.2-meter circular CSP (corrugated steel pipe tunnel) • About 25 meters in length • 50 meters of funnel fencing on each side of tunnel • On-site sandy substrates placed in tunnel	• Capture area for Wood Frogs, Spotted Salamanders, and Leopard Frogs moving towards Wilcox Kettle wetland/uplands • Meets basic size and multi-species use guidelines
Tunnel B	• 1.2-meter circular CSP (corrugated steel pipe tunnel) • About 31 meters in length • 50 meters of funnel fencing on each side of tunnel • On-site sandy substrates placed in tunnel	• Capture area for Wood Frogs and Spotted Salamanders moving to/from adjacent wet area • Tunnel size supports suite of small to mid-size wildlife-species movements
Tunnel C1	• 1.0 x 1.7 meter elliptical concrete culvert • About 25 meters in length • 30 meters of funnel fencing on each side of tunnel • On-site sandy substrates placed in tunnel	• Located where LJJ Jefferson polyploid and Spotted Salamander crossing • Provides larger opening for tunnel exit brightening, no grates, for comparison with nearby Tunnel C2
Tunnel C2	• 1.2-meter concrete culvert with two manhole tees and grates (each end) • About 25 meters in length • 30 meters of funnel fencing on each side of tunnel • On-site sandy substrates placed in tunnel	• Located where LJJ Jefferson polyploid and Spotted Salamanders crossing • Addresses reasonable diameter guide-line for “see-throughness” • Supports multi-species movements • Grates to provide supplementary light and drainage

The photos in Figure 13 show examples of tunnel construction, tunnel interior (with natural substrates), and one of the finished tunnels (road under operation).

Figure 13. Bayview Avenue Extension–Examples of Amphibian Tunnel Construction, Interior, and Finished Look

Tunnel monitoring (2003/2004)
Tunnel monitoring was undertaken during the spring amphibian migration period in 2003 and 2004 as follows:

- A desire to increase roadway permeability for wildlife.
- Monitoring conducted by a two- or three-person survey crew with radios.
- Six to eight monitoring visits were undertaken each spring (March and April, 2003 and 2004).
- Solar-powered Moon Ray lights were installed at some tunnels to collect anecdotal information on possible attractiveness for amphibians moving through tunnels;
- A tunnel pitfall trap system was installed at each tunnel. The system consisted of a v-shaped plastic fence held in place by wooden stakes (See photo in Figure 14). Amphibians migrating through the tunnel from the opposite end would be directed by the plastic fence (which was still transparent) at the tunnel exist to a pitfall trap. In addition, pitfall traps were installed at each junction of the tunnel end and the funnel fence wall. Amphibians moving along the funnel wall toward the tunnel would be directed to these pitfall traps. In this manner, amphibian movements toward or through the tunnel could be observed/inferred. In addition, the survey crew slowly walked the funnel walls leading to all tunnels, and recorded/observed any amphibians noted. The survey crew also slowly drove the road through the study area looking for amphibian activity.
- Repeat checks following the above survey procedure were made along the road, at each tunnel, and along the funnel walls throughout each survey night.

Figure 14. Bayview Avenue Extension–Tunnel Monitoring

Summary findings and conclusions of the monitoring work were as follows:

- Spring weather conditions in 2003 were very poor for amphibian movements because of very cool temperatures, rapid cooling during evenings, and bouts of snow/freezing rain. As a result, amphibian activity in 2003 in this study area was very limited. Limited tunnel passage by Spring Peeper and American Toad was confirmed. Observational data for amphibians were too limited to draw any conclusions about the role of additional artificial light (Moon Ray lights) or variations in tunnel characteristics on amphibian use of tunnels.
- Spring weather conditions in 2004 were better for amphibian activity. There was good calling frog activity in the area during the surveys and road mortality surveys showed moderate levels of amphibian activity.
- There was subdivision and sewer work in the area during the spring of 2004. This may have influenced some animal movements during the construction phase. However, migrating amphibians, particularly mole salamanders, are fairly persistent when moving to breeding ponds, as attested by periodic observations of salamanders (and frogs) in residential pools, basement window sills, and backyards.
- In 2004, 22 amphibians and three mammals were recorded in the vicinity of the tunnels (captures, movement along funnel walls, or movement through tunnels). There was confirmed tunnel use by Raccoons, American Toads, Wood Frogs, Spring Peepers, Leopard Frogs, and Meadow Voles. Observations were generally evenly spread across tunnels A1, A2, B, and C1. Raccoon tracks were noted in all tunnels. Both Meadow Vole use (visual sighting) and other small mammal tracks (possibly *Microtus* or *Peromyscus*) were observed in Tunnel C1.
- There was no recorded tunnel use by Jefferson Salamander or Spotted Salamander in either 2003 or 2004. In 2003, one Jefferson Complex Salamander was observed walking past the entrance to tunnel C1 to the end of the funnel wall, where it then attempted to cross the road. This animal was subsequently carried to the west side of the road and then released. Salamanders may need to "learn" to find and use the tunnels. We are hopeful this may occur over time.
- Most tunnels maintained damp sandy substrate conditions as desired (free draining with roadside stormwater bypassing the tunnels as designed). The exception was tunnel C2, which had persistent ponded water throughout the tunnel during the surveys and may have impeded or restricted animal use. The reason for the poor drainage of this tunnel is under review.

During a recent check of the tunnels in August 2005, two observations were made:

- Dispersing and foraging Leopard Frogs were active in the area. A few adults and one juvenile were observed using tunnels A1, A2, and B.
- In tunnel C2 (manhole tees and grates), silt material had fallen through the grates, resulting in silt piles under each manhole, with water ponding evident in between. Grates in this instance may therefore introduce some management challenges in the future.

Environmental Management Overview

Project summary/costs

- The Individual Bayview Avenue EA was successfully delivered in 1998.
- The road design was completed in 2001 and the road was opened to traffic in 2002.
- Total cost of the project (road works, wetland creation, and other mitigation, engineering, amphibian migration study and tunnels, and approvals) was about $10 million (US).
- The environmental management and wetland creation (pre-stressing of forest zones, protection fencing, clearing and grubbing, transplanting, berm construction (two berms + wetland berm), seed bank salvage, and landscaping costs totaled about $820,000 (US). Of this total, the wetland construction costs were about $330,000 (US).
- The cost of the 81-meter three-span bridge was about $1.2 million (US).
- The amphibian migration study cost (2002) was $71,000 (US).
- The cost of the five amphibian tunnels totaled $360,000 (US).
- Amphibian tunnel monitoring costs for 2003/2004 were $14,500/year (US).
- The project was awarded the Award of Excellence by the Consulting Engineers of Canada in 2003.

Landform Conservation–Oak Ridges Moraine

Conservation of landform topography has been identified as an important objective in the Oak Ridges Moraine Conservation Plan. One of the relevant transportation policies in the Plan deals with minimizing construction disturbance in natural linkage areas and allowing for wildlife movement. In addition to the provision of the dedicated amphibian tunnels, the project also installed a major three-span 81-meter bridge across ravine topography near the south end of the road extension (see Figure 15). This bridge maintains a good valley openness and clearance above the ravine bottom. Numerous White-tailed Deer tracks were observed in the sandy soils during the August 2005 site check.

Figure 15. Landform Conservation–Three-span 81-meter Bridge

Conclusions

- The environmental-management program was instrumental in securing agency approvals for a contentious project.
- The Project Team efforts were acknowledged by the naturalist community. At the completion of the amphibian migration study and design, a positive letter was received from the Richmond Hill Field Naturalists.
- The science of wildlife-crossing mitigation was advanced. Some challenges were noted with tunnel drainage (one tunnel) and subdivision/sewer work. There are answers and questions. Further tunnel monitoring has been recommended.
- The pilot wetland-habitat creation project provided tangible environmental and educational benefits and holds much promise for future Field Centre uses, as well as an example for other habitat-creation projects.

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Biographical Sketches: Geoff Gartshore (B.Sc., M.Sc.) is a senior Ecologist and Partner with Ecoplans Limited, the independent environmental division of McCormick Rankin Corporation. Mr. Gartshore has been a key participant in a wide range of environmental projects encompassing terrestrial and aquatic-resource assessments for many public and private-sector clients throughout Ontario. He also helped prepare the Environmental-Management Plan for a major highway in New Brunswick. His expertise has been applied to highway and utility corridor studies, resource-management studies and plans, urban-development impact studies, and rehabilitation and restoration projects. Mr. Gartshore's special interest is in wildlife and transportation mitigation strategies for highways and urban developments. He has been working as an Ecologist since 1981 and has been with Ecoplans Limited since 1984. He has presented various research and case-study papers before bodies such as the International Road Federation, Environment Canada, Ontario Good Roads Association, Municipal Engineers Association, the University of Windsor, and the International Conference on Ecology and Transportation. He has participated in projects that received awards from the Consulting Engineers of Canada and the Transportation Association of Canada.

Michelle Purchase, B.E.S., M.L.A., Landscape Architect, has over five years experience working on environmental projects and is a Full Member of the Ontario Association of Landscape Architects. Ms. Purchase assists with the completion of environmental inventories and impact assessments, as well as the preparation of landscape designs and site-supervision services for numerous projects. She has recently been managing landscape design, environmental impact, and tree-management projects. Ms. Purchase conducts detailed botanical inventories (she is formally trained in the Ecological Land Classification System for Southern Ontario), prepares conceptual plans, research, graphic presentations, detailed designs, reports, construction drawings and specifications, cost estimates, and post-construction rehabilitation and monitoring. She has addressed arboricultural and ecological design challenges as they relate to a wide variety of projects including stream restoration, forest management, transportation, trail design, public park design, natural-heritage planning, and residential-estate design.

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Appendices

Appendix A. Bayview Avenue Extension, York Region, Ontario Canada. Wetland Creation Project–List of Planted Vegetation.

Seed Mix
MTO Type 1

Species planted in Planted Cell:
Speckled Alder, *Alnus rugosa*
Serviceberry, *Amelanchier sp.*
Gray Dogwood, *Cornus racemosa*
Red Osier Dogwood, *Cornus sericea*
Bush Honeysuckle, *Diervilla lonicera*
Ninebark, *Physocarpus opulifolius*
Chokecherry, *Prunus viginiana*
Staghorn Sumac, *Rhus typhina*
Pussy Willow, *Salix discolor*
Black Elderberry, *Sambucus canadensis*
Meadowsweet, *Spirea alba*
American Cranberry, *Viburnum trilobum*
Tamarack, *Larix laricina*
White Spruce, *Picea glauca*
White Pine, *Pinus strobus*
White Cedar, *Thuja occidentalis*
Red Maple, *Acer rubrum*
Musclewood, *Carpinus caroliniana*
Green Ash, *Fraxinus pennsylvani*
Ironwood, *Ostrya virginiana*
Balsam Poplar, *Populus balsamifera*
Eastern Cottonwoo, *Populus deltoides*
Black Willow, *Salix nigra*
Basswood, *Tilia Americana*

wet meadow mix (Shoreline) (28 plants per zone covering 5 sq. meters)
Swamp Milkweed, *Asclepias incarnata*
Spotted Joe Pye Weed, *Eupatorium maculatum*
Wool Grass, *Scirpus cyperinus*

grassy wet meadow (Shoreline)
Redtop, *Agrostis alba (stolonifera)*
Canada Blue-joint, *Calamagrostis canadensis*
Fowl Mannagrass, *Glyceria Striata*
Rice Cutgrass, *Leersia oryzoides*

shallow emergents - up to 15 cm
Nodding Bur-marigold, *Bidens cernua*
Porcupine Sedge, *Carex hystericina*
Wooly Sedge, *Carex Lanuginosa*
Tussock Sedge, *Carex stricta*
Soft Rush, *Juncus effusus*
Hardstem Bulrush, *Scirpus acutus*

shallow emergents - up to 15 cm (shade tolerant)
Marsh Spike Rush, *Eleocharis palustris*
Retrorse Sedge, *Carex retrorsa*
Fox Sedge, *Carex vulpinoidea*

emergents - up to 30 cm
Water Plantain, *Alisima plantago-aquatica*
Giant Bur-reed, *Sparganium eurycarpum*

deep water emergents - up to 60 cm
Lake Sedge, *Carex lacustris*
Water Smartweed, *Polygonum amphibium*
Arrowhead, *Sagittaria latifolia*

submerged and floating,
Waterweed, *Elodea canadensis*
Sago Pondweed, *Potamogeton pectinatus*

Appendix B. Bayview Avenue Extension, York Region, Ontario Canada. Amphibian Tunnel–Sample Cross Section.