USE OF NATIVE SPECIES IN THE RESTORATION OF A TRAIN DERAILMENT SITE

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ABSTRACT

An estimated 150 m^3 of styrene and 30 m^3 of ethylene glycol were released to a wetland area following a train derailment at a road level crossing in northern Ontario. The wetland area was bounded by railway tracks and a roadway to the south and west, respectively. A deciduous forest was to the north of the wetland, and a lake to the east. A culvert below the road level crossing conveyed flow from small creek into the wetland. Water flowed from the wetland into a nearby lake via a small channel at the easterly end of the excavated area and diffusely through an alder thicket swamp. While a detailed survey of the plant species in the wetland prior to the derailment was not available, anecdotal accounts of local residents indicated that the wetland consisted of a cattail marsh, grass sedge meadows and an alder thicket prior to the derailment.

Following the derailment, emergency response and remediation activities resulted in the disturbance of approximately 2 hectares of wetland. In addition to the remediation of the impacted soil and groundwater, a key objective of the remedial program was the restoration of the affected wetland area. Specifically, a restoration plan was developed with the following goals:

- to provide a variety of healthy self-sustaining habitats for fish and wildlife;
- to minimize the potential for the introduction of invasive species; and
- to be aesthetically pleasing.

In addition to the available scientific literature, the restoration plan was formulated around site-specific conditions that existed before the derailment and the use of plant species that are common in the Parry Sound region of Ontario. The plant selection was designed to take advantage of natural succession processes. To ensure genotype suitability, local plants were propagated, rather than importing plants from outside the Parry Sound region. Plant material collected at the site was propagated at Royal Botanical Gardens' wetland nursery in Burlington, Ontario. This innovative approach minimized the potential for the introduction of invasive species.

Initial post-planting data collection and evaluation of findings indicated that most of the plant stock has established successfully. In addition, both terrestrial and aquatic wildlife appeared to be using the site extensively within months of planting the experimental wetland. In particular, fish habitat appeared to be stable and productive, with a greater fish density and diversity in the wetland than in the neighboring lake. It is already known that several species, including pumpkinseed, yellow perch and brown bullhead utilize the wetland for spawning and nursery habitat.

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INTRODUCTION

On February 13, 2003, twenty-one cars of a southbound Canadian Pacific Railway Co. (CPR) freight train derailed at a level crossing in a rural area of northern Ontario. The derailment resulted in the release of approximately 150 m^3 of styrene and 30 m^3 of ethylene glycol into a wetland area located to the east of the railway tracks, approximately 500 metres upstream of a lake. The setting of the derailment site (referred to herein as "the Site") is shown on Figure 1. Urea and grain were also spilled but, being dry materials, they were more easily contained and removed compared to the styrene and ethylene glycol.

Emergency response and remediation of soil and water resulted in the disturbance of approximately 2 hectares of the wetland. CPR retained Stantec to plan and undertake restoration activities for the wetland and associated disturbed areas. The goal of the wetland restoration was to establish a viable, self-sustaining wetland ecosystem that would resemble the ecosystem present before the derailment.

Given that the majority of Canada's transcontinental railways pass through remote, undeveloped lands, there is a need to develop restoration approaches that are both ecologically sound and economically feasible. The project offered the opportunity to conduct research into a methodology for the restoration of wetlands at remote sites using native species. In doing so, the research investigated two key areas of uncertainty:

1) Would it be possible to establish a wetland using native species that will regenerate into a natural state within approximately 5 years?
2) Will native species enhance the natural attenuation of residual styrene at the Site?

This paper represents a progress report on the experimental wetland restoration, and focuses on addressing Item 1), above. Item 2) will be the subject of future analysis.

SITE DESCRIPTION

The Site is situated on the Canadian Shield, approximately 250 kilometres to the north of Toronto. The wetland area was bounded by railway tracks and a roadway to the south and west, respectively. A deciduous forest was to the north of the wetland, and a lake to the east. A culvert below the road level crossing conveyed flow from small creek into the wetland. Water flowed from the wetland into a nearby lake via a small channel at the easterly end of the excavated area and diffusely through an alder thicket swamp. The lake supported a warm water fishery, and a number of residential and vacation properties were situated on its shores.

The styrene and ethylene glycol were released into the wetland to the northeast of a level crossing. The overall objective of the initial remediation program was to prevent the released chemicals from reaching the nearby lake. This was accomplished through the following actions:

- Pumping of styrene free-phase liquid from sumps excavated at various locations in the wetland. The liquid was transported to licensed treatment facilities;
- Removal of the remaining liquid cargo from the derailed tank cars, followed by the removal of the tank cars themselves; and
- Excavation, to the extent practicable, of wetland sediment (peat and soil) that were impacted by styrene and ethylene glycol. The excavated soils were transported to licensed landfill facilities.

The excavation was not backfilled, and following the spring freshet, the Site was inundated with water, forming an open body of water.

Photograph 1 shows a panoramic view of the site at the completion of the initial remediation program.

BASELINE DATA COLLECTION

A systematic investigation was undertaken to establish baseline conditions at the Site against which to evaluate the success of the experimental wetland restoration. This included the collection of key baseline data, including:

- Assessment of the ecological communities (vegetation and aquatic) in the area of the Site;
- The distribution of remaining chemicals of concern in various environmental media (e.g., soil/sediment, surface water, groundwater) at the completion of the initial remedial activities; and
- Evaluation of the assimilative capacity of the watershed through pilot and field verification studies. A number of attenuation processes were investigated, including hydraulic dilution, volatilization and metabolic breakdown. Laboratory studies were completed to investigate the fate of styrene in various media (e.g., water, silt, peat).

As the focus of this paper is on the methodology used to establish the wetland, the discussion of the distribution of remaining chemicals at the end of the initial remedial activities, as well as the predictions for future changes in styrene concentrations that were presented in the assimilative capacity report are not discussed herein. As noted in the introduction, these matters will be the subject of future analysis.

Ecological Communities

<u>Vegetation Communities</u>

Since the derailment occurred when there was a significant snow cover on the wetland, it was not possible to definitively ascertain pre-remediation conditions. However, the affected wetland area was part of a larger wetland that was dissected by a road, and it is likely that the Site was similar to the unaffected wetland on the opposite side of the road. The wetland on the opposite side of the road contained large mats of emergent vegetation dissected by narrow water channels.

Vegetation communities in the area of the derailment were initially delineated on an aerial photograph (1:20,000, May 2003) and ground-truthed with a field survey. At a representative location in each community, habitat was described (i.e., location, topography, moisture, drainage, soil type, and indication of disturbance), and vegetation was sampled (i.e., community structure, composition, species abundance). A survey of the vegetation communities around parts of the lake was also conducted in July 2003 by boat to determine the natural rooted aquatic communities in the vicinity.

Fish Habitat

According to area residents, the impacted wetland did not provide fish habitat prior to the derailment. However, assuming that there was some open water at the Site and hydraulic connections the lake there could have been 0.25 ha of fish habitat along the channel connecting the lake to the wetland west of the road.

RESTORATION ACTIVITIES

Planning

A restoration plan was developed in 2003 with the following goals:

- to provide a variety of healthy self-sustaining habitats for fish and wildlife;
- to minimize the potential for the introduction of invasive species; and
- to be aesthetically pleasing.

The restoration plan is shown on Figure 2.

There is considerable literature on the construction of wetlands for various purposes and the criteria that should be used in undertaking such activities (Hagen, 1996; Taylor, 1992). The restoration plan was based on the literature, and the Site conditions before and after the derailment and subsequent remedial activities. The plan was based on the use of plant species that are common in the Parry Sound region of Ontario (Soper and Heimburger, 1982; Newmaster et al., 1997), and was designed to take advantage of natural succession processes. To ensure genotype suitability, local plants were propagated, rather than importing plants from outside the Parry Sound region.

Grading and Site Preparation

Grading and site preparation activities were completed in the summer and fall of 2003. Soil material present on the Site was used in the restoration so that only a limited amount of new material (sand) was imported. Sand imported from a local aggregate pit was used on the southern side of both islands to create turtle nesting beaches. It was also mixed with the exposed mineral clay subsoil on the northwestern and southwestern sides of the wetland. Peaty soil from disturbed areas around the Site was used in grading new slopes in the riparian/littoral zone and as topsoil on the islands. Wood chips were obtained from chipping downed woody material around the site and used as mulch.

The southwestern shore of the excavated area was modified in the fall/winter (November-February) and spring (April) of 2004 with the addition of sand and grading of the shoreline to facilitate planting and growth of new vegetation.

Planting

Native plant species propagules in the form of seeds, soil and root plugs, rhizomes, cuttings, etc. were collected at the site or in the vicinity of the site in 2003. Some propagules of aquatic plants were placed directly into the standing water of the site in the fall of 2003.

An attempt was made to import floating mats of vegetative material from surrounding wetlands. Plugs of floating mat were cut with the intent to carry them to the newly created open water habitat. However, the plugs proved to be very difficult to transport as they tended to break apart. In addition, it was impossible to anchor the plugs as, again, they tended to break apart when not supported by extensive surrounding mats of vegetation. This experimental approach was abandoned in favor of the use of individual propagules.

The majority of the materials were taken to the Royal Botanical Gardens, Burlington Wetland Nursery, in Burlington, Ontario for propagation over the winter of 2003-2004 in order to provide large quantities of ecologically appropriate plants for use in 2004. The plant stock was ready for return to the research Site in the spring of 2004. Royal Botanical Gardens staff planted the entire stock in three stages - first mostly herbaceous species (May), second aquatics and shrubs species (June), and third the remaining shrub and tree species (July). Generally, the areas located at the highest elevation above expected water levels were planted with meadow species, such as sedges, grasses and shrubs. Intermediate areas just above or just below the expected water line were planted with emergents, while the deeper water areas were planted with rooted aquatics.

Vegetation monitoring commenced in mid-August 2004 to establish baseline data for reference in subsequent years.

POST-RESTORATION DATA COLLECTION AND EVALUATION METHODS

A systematic approach was used to collect data relating to several aspects of the wetland restoration.

Vegetation and Flora

Collection of data on wetland vegetation was initiated in August 2004, and repeated in August 2005. A running list of all vascular plant species observed within the experimental wetland area was generated. Separate subsets of species found on each of the two artificial islands were also made.

For quantitative sampling, two main approaches were used: (1) plot sampling, and (2) transect sampling. Locations of the plots and transects are shown on Figure 3.

Plot Sampling

Nine plots were established in representative locations throughout the areas being replanted. The plots varied in size from 20 to 25 m^2 and were generally square to rectangular in shape. The corners were permanently staked with steel rods inserted in the ground and flagged with tape. Coordinates of the plots' northwestern corners were recorded using a Global Positioning System (GPS).

In each plot, the following data were collected: location and general description of the plot, total percent cover of vegetation, percent cover of bare ground, percent cover of woody debris, and over of all the species. Photographs of each plot, as well as panoramic photographs of the entire site from various vantage points, were taken.

Transect Sampling

Two transects running in a generally north-south direction were established. The first transect started on the northern shore, ran over open water and across the big island, and again over open water toward the southern shore. The second transect was located at the eastern end of the experimental wetland, and ran in a straight line from the northern to southern shore across the channel.

The end points of the transects were marked with metal rods, flagged and GPS coordinates and photographs were taken. Along each transect, within a 10 cm wide strip on both sides of the transect line (combined width 20 cm), all vascular species were recorded and their presence marked as lines on a diagram as they appeared and disappeared with the changing location, elevation and moisture.

Wildlife

Fish

Fish collections were undertaken using an electrofishing surveys completed at four locations (E1, E2, E3 and E4). Two small-mesh gillnets were set, one in each basin (G1 and G2). Seining was undertaken within the near shore area along the south shore of the wetland (S1). All fish captured by electrofishing and seining were identified, enumerated and released. Age classes present were noted for all species at each location. Fish sampling locations are shown on Figure 4.

Other Wildlife

Other wildlife (birds, amphibians and reptiles) were observed during site visits in May, July, August and November of 2004. Given the relatively small size of the area and the lack of baseline information to compare formal survey results, formal surveys were not deemed necessary in 2004 or 2005.

RESULTS THROUGH TO 2005

In the short period between planting and the end of the 2004 monitoring period, the experimental wetland had shown significant progress. By mid-August 2004 the species planted earlier in the season had time to establish in the new environment. Compared with the pre-planting condition of spring 2004, there was a remarkable increase of the overall cover of vegetation. In the open water, submerged and floating-leaves aquatics took root and developed leaves and new stems. On the wet sandy shores the previously bare ground became covered by several sedges, grasses, forbs and young shrubs. Notwithstanding the fact that a small number of plants appeared dead or were impacted by drought, the vast majority appeared to be thriving.

Monitoring in 2005 indicated that, compared with the situation in 2004, there had been a general increase in plant and vegetation cover throughout the experiment wetland restoration site. This progress in re-vegetation can be attributed, to a large degree, to the drop in wetland water levels in 2005. This has resulted in wide areas being exposed and subsequently invaded by numerous wetland species and some upland plants. For example, bur-reed, cattail, blue-joint grass and needle spike-rush spread out over the newly-available ground, as well as species typically associated with mudflats, such as false pimpernel and marsh purslane. Photographs 3 and 4 show typical views of the wetland in 2005.

Aquatic species have also slightly gained in cover, but due to the water level drop many water-lilies were stranded on the mudflats, which could cause survival problems for these individuals. Still, the water-lily was dominant in the floating plants group, but pond-lily has been reduced to only a few plants on the southwestern shore.

In terms of floristic analysis, the following conclusions were made:

- Native species composed the majority of the flora;
- The majority of native species are in the low to moderate sensitivity classes, being representative of general habitats and not of highly specific, natural or undisturbed situations;
- The majority of non-native species are non-invasive; and
- The Site is dominated by obligate and facultative wetland species.

Overall, seven fish species were collected during the 2005 survey, including golden shiner (*Notemigonus crysoleucas*), northern redbelly dace (*Phoxinus eos*), brown bullhead (*Ameiurus nebulosus*), central mudminnow (*Umbra limi*), brook stickleback (*Culaea inconstans*), pumpkinseed (*Lepomis gibbosus*) and yellow perch (*Perca flavescens*). All species except golden shiner were observed during the November 2003 survey (pre-restoration) as well. Age classes of most species included juveniles and adults. Pumpkinseed were found at all electrofishing locations. The highest diversity and catch-per-unit effort (CPUE) were recorded within the newly created wetland (locations E3 and E2, respectively). The fish surveys indicated that the experimental wetland is well on its way to becoming a much more productive fish habitat than the area was prior

to the derailment. Compared with the unaffected wetland on the opposite side of the road, fish density and diversity was much higher

Common bird, and mammal species, typical of the Parry Sound Region were encountered during 2005. Representative examples of bird species encountered included Common Merganser, Great Blue Heron, Mallard, White-throated Sparrow, Belted Kingfisher, Red-breasted Nuthatch, Red-winged Blackbird, Song Sparrow, and Hairy Woodpecker. Mammals encountered included Raccoon, Striped Skunk, Red Fox, Muskrat, and Red Squirrel.

CLOSURE

The data collection and evaluation to date suggests that the experimental wetland restoration program is progressing favorably, and that it is feasible to construct wetlands using typical vegetation found in Canadian Shield landscapes. The landscape disturbed by the train derailment and initial remediation activities had taken on a significantly natural appearance by the end of monitoring in 2005. Future analysis will be undertaken to assess whether the experimental wetland has enhanced the natural attenuation of residual styrene.

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Figure 1: Site Layout

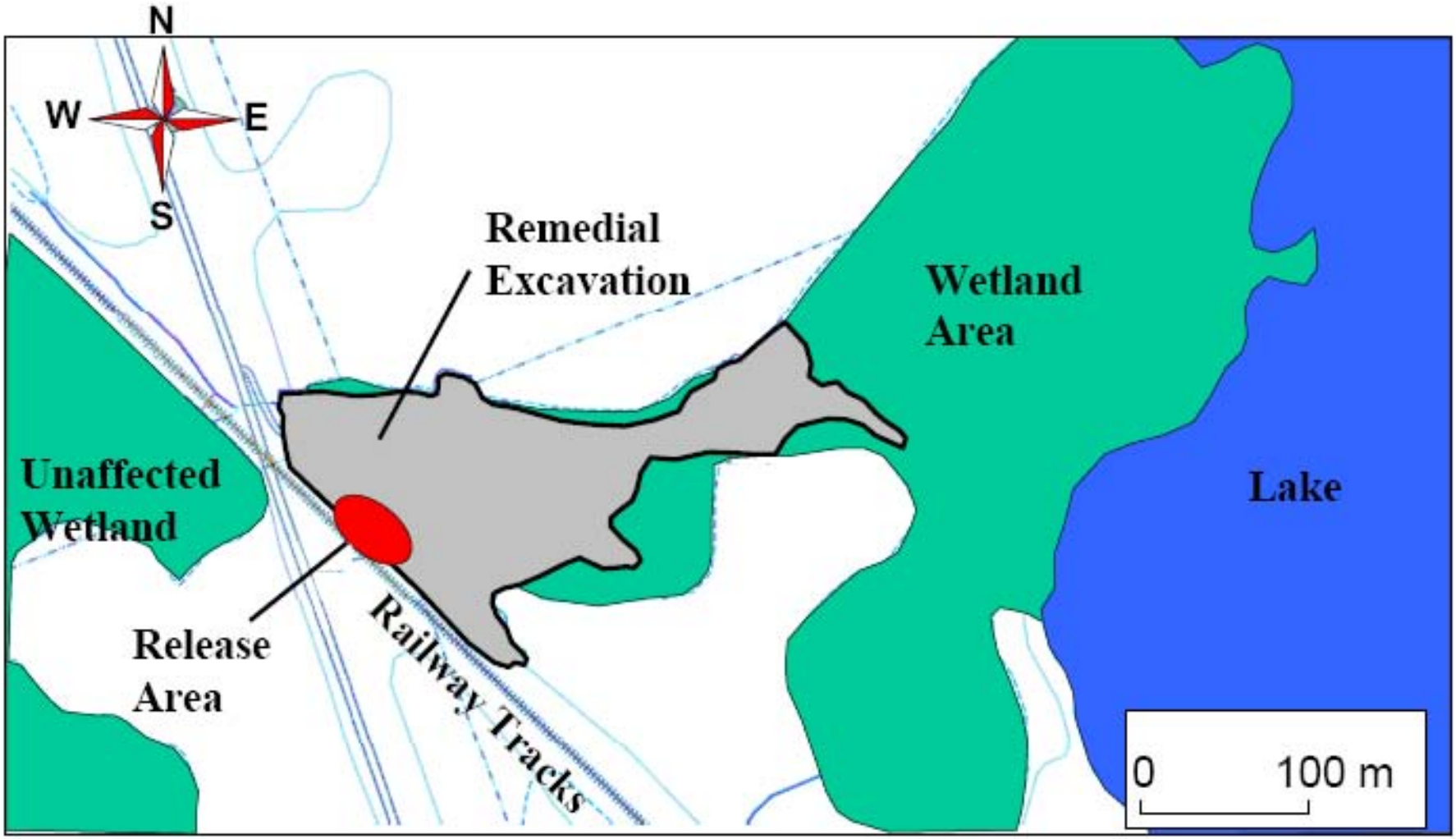


Figure 2: Restoration Plan

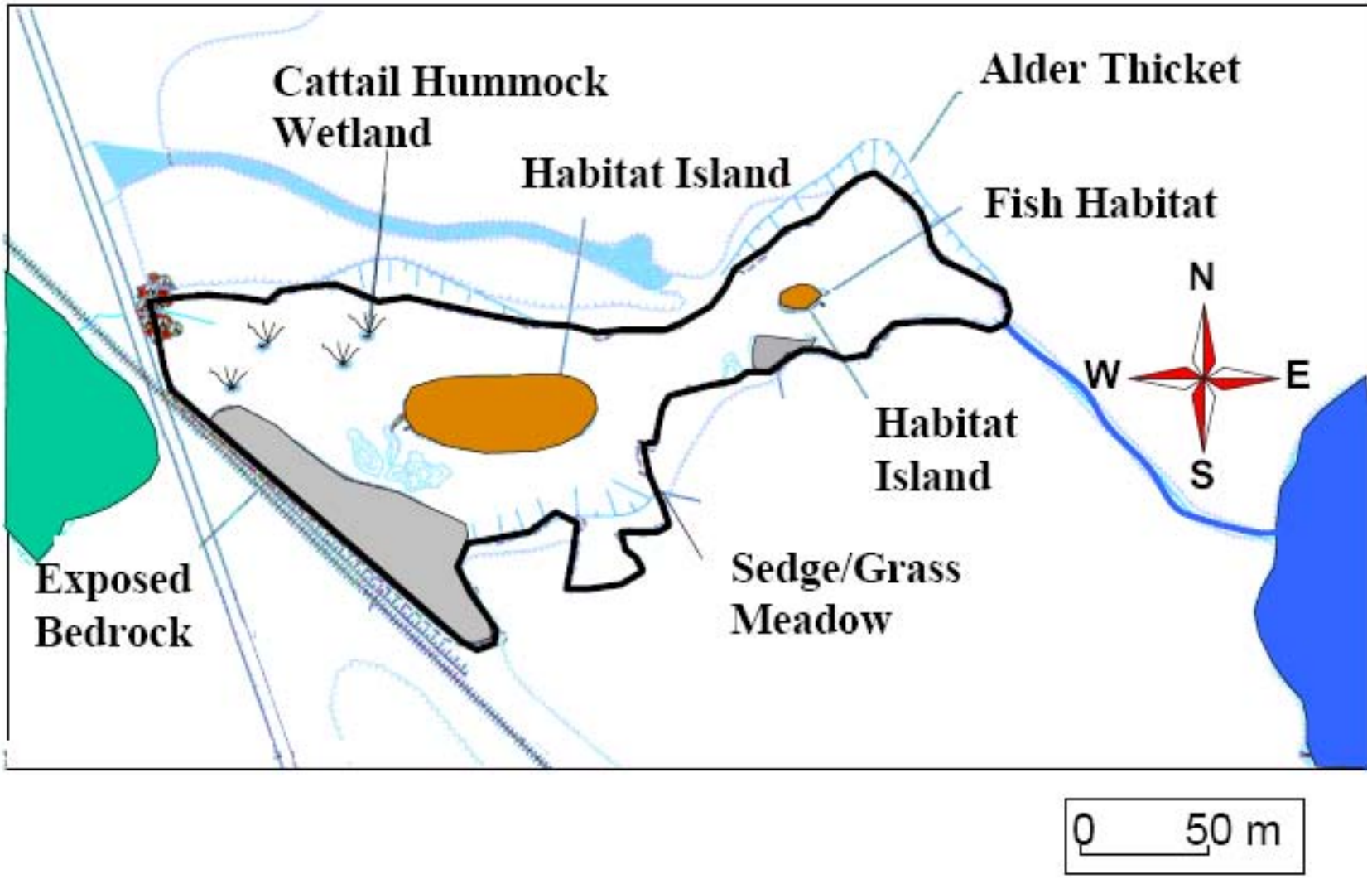


Figure 3: Locations of Plots and Transects Used for Vegetation Monitoring

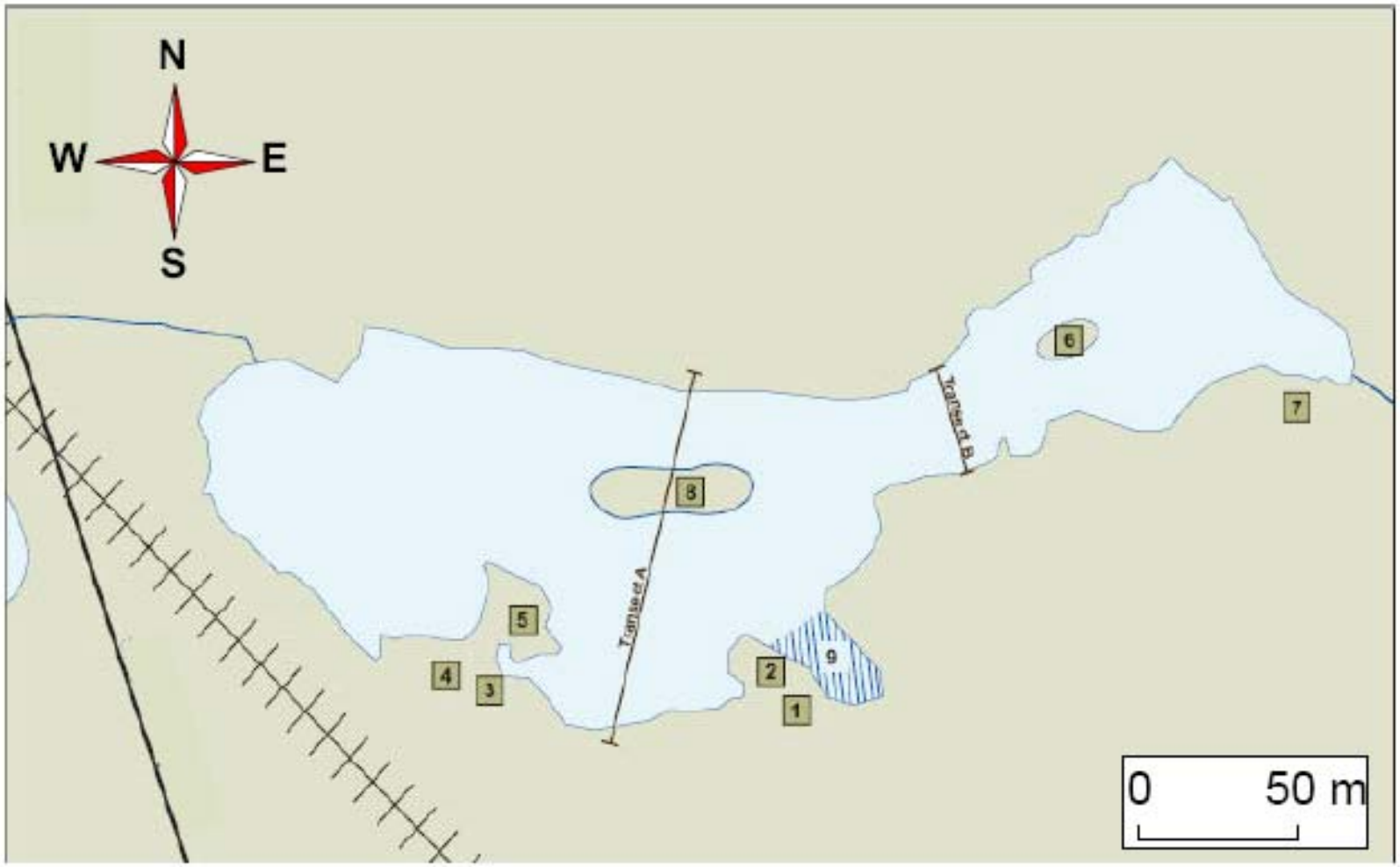
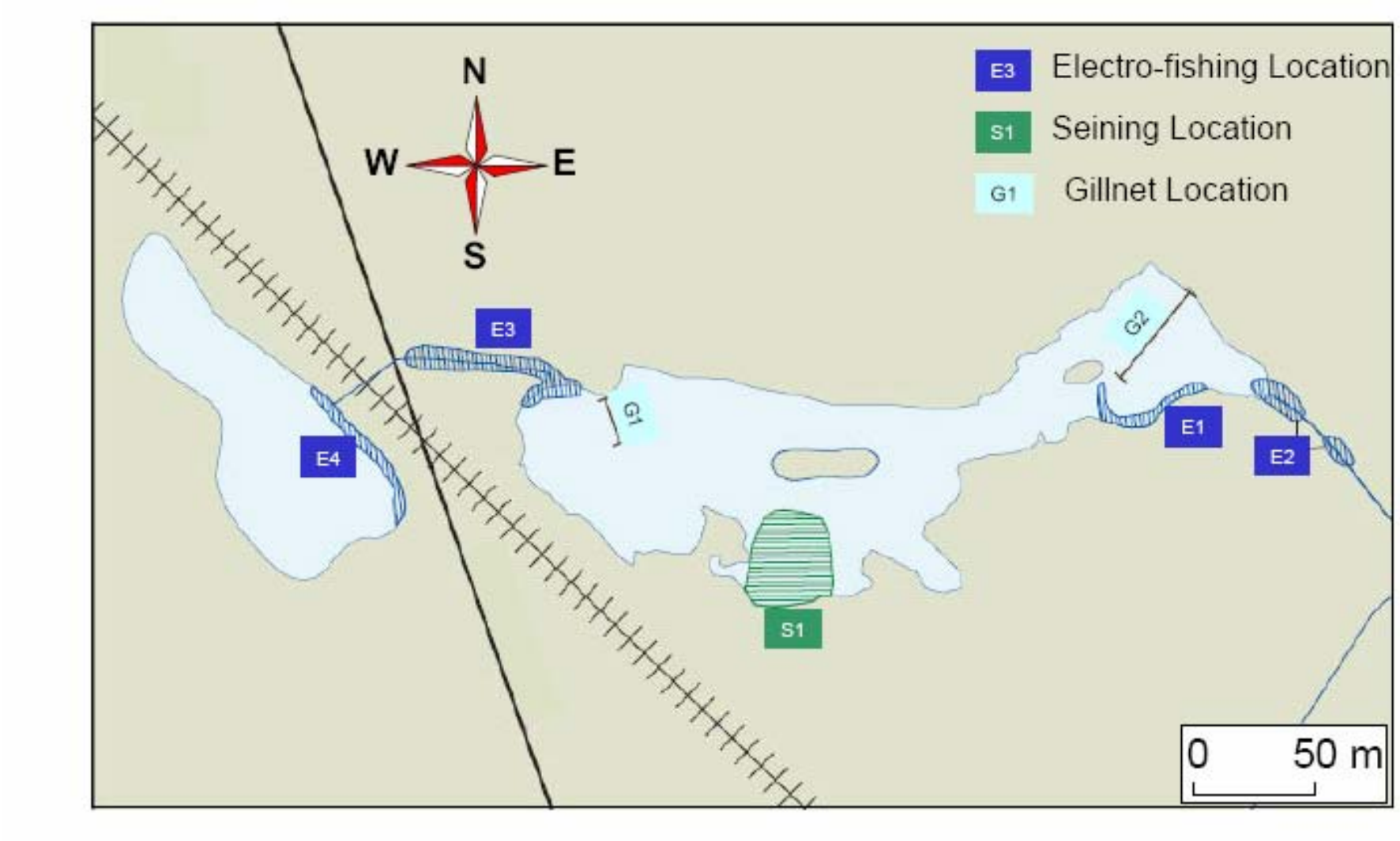


Figure 4: Fish Sampling Locations



Photograph 1: View of Site at Completion of Initial Remediation Activities

Photograph 2: View of Typical Marsh Vegetation on Opposite Side of the Road

Photograph 3: View of the Restored Wetland from Railway Tracks

Photograph 4: View of Marsh Vegetation