## Dallas Floodway Extension

# Lower Chain of Wetlands and Grasslands Ecological Management and Monitoring

***Status Report to U.S. Army Corps of Engineers***
***Fort Worth District***
***March 2013***


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## Background

The Dallas Floodway Extension (DFE) includes a chain of wetlands designed to permit unimpeded overflow of floodwaters along the west side of the Trinity River from the Dallas Floodway to Loop 12, while at the same time provide quality wetland and grassland habitat during periods of normal water flow. The project is fully authorized for flood control by Section 301 of the River and Harbor Act of 1965 (79 Stat. 1091) and modified by Section 351 of the Water Resources Development Act of 1996 (110 Stat. 3724), which authorized inclusion of non-Federal levees. The authorization was further modified to add environmental restoration and recreation as project purposes by Section 356 of the Water Resources Development Act of 1999 (Public Law 106-53). In initial planning, ecosystem restoration following construction would result in 271 acres of habitat improvement, including 123 acres of emergent wetlands, 45 acres of open water, and 102 acres of grasslands.

The USACE Fort Worth District (SWF) requested assistance from the Corps' Engineer Research and Development Center's (ERDC) Lewisville Aquatic Ecosystem Research Facility (LAERF) in planning and implementation of native aquatic plant establishment in the project. ERDC provided general guidelines for wetland cell construction to maximize vegetation establishment and ecosystem function while maintaining the system's hydraulic capacity. ERDC also provided (and continues to provide) wetland plants, their installation, long-term monitoring, and development of long-term management strategies for the project. The overall goal from ERDC's perspective is to produce wetland and grassland habitat for waterfowl and other wildlife during normal flow periods by way of development of significant native vegetation communities.

The first phase of the project called for construction of four wetland cells, designated as D, E, F, and G, known collectively as the Lower Chain of Wetlands (LCOW); construction on Cell D was completed in 2004, and plant establishment and ecosystem management was begun thereafter. Construction of Cells E, F, and G was completed in late fall 2008; establishment of native wetland plants and ecosystem management was initiated soon after the wetland cells were filled to test pumping/filling systems and levee integrities. Three additional wetland areas have been included in the project since Cell D was constructed: Rochester Park Lake (planted 2005-2007) and Cells E-West and F-North (construction completed in winter 2008 as part of the LCOW). Additional cells, A, B, and C (Upper Chain of Wetlands, UCOW) have recently entered construction phase and will be included in ERDC ecosystem management as they are completed.

In addition to establishing and monitoring wetland vegetation, SWF has engaged ERDC to monitor several components of wetland function, including sedimentation (filling in of cells), macro-invertebrate community development, fishery development, and use by aquatic and semi-aquatic wildlife, primarily shorebirds and waterfowl. SWF also requested that ERDC conduct efforts to establish vegetation in rip-rapped and other hard-armored areas, most notably the river channel below Interstate 45 and the outfalls of Cell F and Cell G. In 2010, ERDC initiated assessment of previous seeding and planting efforts in grasslands adjacent to the wetland cells. Following results of this evaluation, which showed poor native grassland community development, ERDC proposed in its FY2011 Scope of Work to employ methodologies including deviations of basic methods used to successfully establish wetland vegetation for repairing and improving the grassland community. This report focuses on vegetation establishment and ecosystem monitoring and management efforts undertaken in the LCOW and adjacent grasslands up to and during 2012. A summary of specific tasks undertaken in 2012 are provided in Appendix A.

## Wetland Vegetation Community Establishment Approaches

ERDC began transplanting native wetland plants in Cell D during late 2004 using techniques developed by ERDC researchers for establishing aquatic vegetation in lakes and reservoirs, and has continued efforts there and in the rest of the LCOW since that time. In addition to planting, management strategies have been employed to improve conditions for native plant establishment and spread, many of which proved successful in Cell D. ERDC then applied successful strategies to other cells as their construction was completed, with cell-specific modifications made to general methodologies as needed to maximize plant establishment and diversity in each.

Plants used in this project were primarily containerized specimens grown from locally collected stock in cultures at LAERF in Lewisville, Texas. Typically, a variety of species and growth forms (emergent, floating-leaved, and submersed) were planted in each cell following construction, with results from initial plantings used to identify the most suitable approaches for establishment and expansion of plants on a cell-by-cell basis. Longer-term results (e.g., vegetation response to intentional water level manipulations, overbanking events, etc.) were used to further refine plant establishment strategies. ERDC used ongoing results to identify needs for further action or changes in current action (adaptive management), and was thus better able to apply available management tools to the system. By manipulating certain environmental conditions (e.g., accounting for herbivory, changing water levels, controlling nuisance species, etc.) at the proper times, ERDC was able to steer the development of the plant community in the LCOW to one that was favorable to project goals.

It was expected that feeding activities of aquatic or terrestrial animals would impede establishment of plants in the cells, as in the case in many waterbodies in North Texas. Therefore, initial planting designs in each cell included evaluations of protected versus unprotected areas in order to ascertain which, if any, plants species would require protection for successful establishment. Initial plantings of emergent wetland species in all cells readily established and spread with and without protection from herbivores. Subsequent plantings of those species were, for the most part, made without protection, which enabled a shift in resources to focus on installing more plants, rather than fewer plants with protection. This hastened the process of full vegetative coverage in areas suitable for emergent plants in the cells. On the other hand, initial plantings indicated that herbivory, primarily by turtles and crayfish, could prevent establishment of submersed and floating-leaved vegetation, and that their establishment would require protection. Subsequent plantings of those species were made using exclosures to prevent herbivores from feeding on transplants. Despite additional efforts needed to establish herbivory-prone species, their importance as components of the aquatic portion of the wetland ecosystem merited their continued inclusion in the project. Once established in protected areas, plants were able to grow and spread to unprotected areas in most cells. In addition to protecting transplants, trapping/removal and water level manipulations were used to modify herbivore populations, both of which improved establishment and spread of some submersed and floating-leaved species.

In addition to installing and protecting plants, water levels in the LCOW cells were manipulated to encourage growth of desirable volunteer wetland species such as smartweeds and sedges, as well as grasses and forbs in riparian areas. This strategy has resulted in development of plant communities comprised of a combination of species that provide high quality habitat for waterfowl and other aquatic wildlife. In general, water levels were lowered during the spring through fall growing period to expose large areas of moist soil, which encourages growth of both wetland and grassland plants. At the same time, obligate wetland and aquatic species are able to grow in permanently flooded shallows. Following plant community development and seed production, water levels were raised to maximum pool during late fall and winter, inundating vegetated areas and providing access to food and cover for invertebrates, fish, waterfowl and other aquatic wildlife. To further diversify LCOW habitats, variations in timing and water level fluctuations were made between cells.

Managing nuisance species has been a critical component of establishing native vegetation in the LCOW. In addition to changing water levels seasonally to prevent or reduce establishment of some nuisance plants when properly timed, combinations of mechanical, chemical, and biological control methods have been applied when deemed necessary. In general, weed management has followed an early detection/rapid response approach, and techniques have focused on management of targeted species, as opposed to non-selective, broad-spectrum control. By placing pressures specifically on nuisance plants, desirable plants have been able to better compete for available resources and resist reinfestations once control has been achieved.

Monitoring has been critical for ongoing evaluation of vegetation community dynamics, and has included assessments of plant community development in and around the wetland cells. Additionally, basic water quality (pH, dissolved oxygen, conductivity, and temperature) and sedimentation in the cells have been monitored at prescribed stations. Moreover, further biological monitoring (fish and macro-invertebrates) was initiated in 2009 to help define project success, and includes not only the wetland chain but a stretch of the Trinity River just beneath IH-45. Monitoring of the adjacent grasslands and planting efforts to establish vegetation in rip-rap areas were initiated in 2010. Grassland monitoring was initiated in 2009, and in 2010 ERDC conducted pilot studies to ascertain the most successful methodologies for establishing grassland vegetation adjacent to the LCOW cells. Larger-scale grassland plantings and monitoring were then initiated in late 2011 and continued through late 2012.

## Wetland Plantings

Plant establishment was initiated in Cell D in 2004, in Rochester Park Lake in 2005, in Cells E, F, and G in 2008. Planting began in E-West, F-North, the Wood Duck Pond (and several small water features associated with Cell G) in 2009 and continued with supplemental plantings throughout 2012. Table 1 provides the thirty-one species of aquatic plants that have been transplanted into the cells to date. These include nine submersed species, three floating-leaved species, and nineteen emergent species. Most of these species are perennial and capable of year-to-year recovery following periods of dormancy due to cold temperatures, dry periods, or periods of excessive inundation; all additionally spread from seed.

**Table 1. Thirty-one species of native aquatic plants representing three growth forms have been transplanted in the LCOW since October 2004.**

| Scientific name | Common name | Growth form |
|---|---|---|
| *Acmella oppositifolia* | Opposite leaved spot flower | emergent |
| *Bacopa monnieri* | Water hyssop | emergent |
| *Carex cherokeensis* | Cherokee sedge | emergent |
| *Ceratophyllum demersum* | Coontail | submersed |
| *Chara vulgaris* | Muskgrass | submersed |
| *Echinodorus berteroi* | Tall burhead | emergent |
| *Echinodorus cordifolius* | Creeping burhead | emergent |
| *Eleocharis acicularis* | Slender spikerush | emergent |
| *Eleocharis macrostachya* | Flatstem spikerush | emergent |
| *Eleocharis quadrangulata* | Squarestem spikerush | emergent |
| *Heteranthera dubia* | Water stargrass | submersed |
| *Juncus effusus* | Soft rush | emergent |
| *Justicia americana* | Waterwillow | emergent |
| *Najas guadalupensis* | Southern naiad | submersed |
| *Nelumbo lutea* | American lotus | floating-leaved |
| *Nymphaea mexicana* | Yellow water lily | floating-leaved |
| *Nymphaea odorata* | American water lily | floating-leaved |
| *Peltandra virginica* | Arrow arum | emergent |
| *Phyla lanceolata* | Lance-leaf frog-fruit | emergent |
| *Polygonum aquaticum* | Water smartweed | emergent |
| *Pontederia cordata* | Pickerelweed | emergent |
| *Potamogeton illinoensis* | Illinois pondweed | submersed |
| *Potamogeton nodosus* | American pondweed | submersed |
| *Potamogeton pusillus* | Slender pondweed | submersed |
| *Sagittaria platyphylla* | Delta arrowhead | emergent |
| *Sagittaria latifolia* | Broadleaf arrowhead | emergent |
| *Schoenoplectus americanus* | American bulrush | emergent |
| *Schoenoplectus californicus* | Giant bulrush | emergent |
| *Schoenoplectus tabernaemontani* | Softstem bulrush | emergent |
| *Vallisneria americana* | Wild celery | submersed |
| *Zannichellia palustris* | Horned pondweed | submersed |

## Wetland Plantings, Monitoring, and Management Results To Date

### Moist soil management and plant establishment

Design and construction of Cell D (and later, most other cells) resulted in three general depths at full pool (392-ft ASL): a shallow shelf (approximately one-foot deep; 391-ft ASL), a deep shelf (approximately three-feet deep; 389-ft ASL), and a flood conveyance channel (approximately seven feet deep; 385-ft ASL). Our original planting strategy called for moist soil management in which water levels were to be held at two elevations dependent upon time of year: Full pool (winter pool, 392-ft ASL) would be held between late fall and late winter to provide habitat access to waterfowl and other aquatic wildlife on the shallow shelf; low pool (summer pool; 391-ft ASL) was planned for between late winter and late fall to encourage establishment, growth, and spread of both emergent aquatic and terrestrial plants on the shallow shelf. Submersed, floating-leaved, and deepwater emergent species would be established from the grade between shallow and deep shelf, and on the deep shelf itself (389-ft ASL); no plants would be established in the channel or grade between deep shelf and channel. Some species were expected to grow as deep as four or five feet along the slopes leading to the channel.

The original planting strategy was not followed in late 2004 in order to reduce possible erosion of the newly excavated wetland slopes during Trinity River overbank events. Water levels were held at winter pool rather than summer pool, with test plantings of emergent species conducted at the winter pool shoreline and floating-leaved and selected submersed plants installed at the drop-off to the three-foot deep shelf. Because plants grew (albeit slowly) throughout the 2004-2005 winter, we continued planting at winter pool through late spring, 2005. Some submersed plant species were also planted on the deep shelf during that time.

In 2006 and 2007, we lowered Cell D to summer pool according to our prescribed schedule and planted the majority of emergent plants at the water's edge (391-ft ASL) and submersed and floating-leaved plants on the deep shelf (389-ft ASL), which was 2-ft deep at the time of plantings. These plantings, combined with volunteer colonization by desirable vegetation, resulted in full coverage over the shallow shelf and partial coverage on the deep shelf, meeting the goals of aquatic plant establishment set for Cell D by the end of the 2008 growing season (Figure 1). Many of the species planted combined with desirable volunteer wetland species including sedges (*Carex spp.*), water primrose (*Ludwigia repens*), annual smartweeds (*Polygonum spp*.), flatsedge (*Cyperus acuminatus*), duckweed (*Lemna* sp.), rushes (*Juncus spp*.), buttercup (*Ranunculus* sp.), and rattlebox (*Sesbania* sp.) were well established by 2008 and have continued to thrive between 2009 and 2012.

**Figure 1. Vegetation is widespread along the shoreline and in the shallows of Cell D, meeting the overall goals of aquatic plant establishment in that wetland.**

In addition to scheduled water level manipulations, we periodically attempted to inundate exposed areas during hot and dry periods when emergent species showed signs of stress to ensure that adequate moisture was available to sustain survival and growth of wetland species. Water is supplied to Cell D via a moderately small electric submersed pump (3 H.P.) managed by the City of Dallas Central Waste Water Treatment Plant (CWWTP), and during the heat of summer, this pump proved inadequate to inundate the shallow shelf (raising elevation from 391-ft ASL to 392-ft ASL) in a timely manner, taking as long as three weeks when pumping 24-hours per day. Despite this limitation, plants were able to recover following periods of desiccation on exposed areas of the shallow shelf. The worst periods of exposure occurred during the summers of 2008 and 2010. In 2008, unknown persons lowered the weir gate to lowest managed pool setting (389-ft ASL, or 3-ft below full pool) on two occasions, exposing all plants to desiccation. In 2010, an extended period under which the water supply pump was not working resulted in water levels dropping below 389-ft ASL, with all plant colonies exposed to summer heat and desiccation for a significant portion of the growing season. This resulted in a major setback to the wetland plant community in Cell D. However, plants showed signs of recovery in late summer/early fall following pump repair and refilling to summer pool. The plant community showed few signs of long-term damage from these events except for increases in invasive species (specifically alligatorweed, *Alternanthera philoxeroides*) following these events, indicating that the community was well established and capable of withstanding harsh environmental conditions.

Although initially viewed as inhibitory to our goals, uncontrolled/unauthorized lowering of water levels resulted in expansion of many desirable species. Combined with good recovery of other plant species when the cell was refilled showed that manipulating water levels during the growing season could be used to increase growth and spread of the wetland plant community to lower elevations, resulting in more of the cell occupied by beneficial plants. We used this information to alter the moist soil management schedule by adding a water level change event: following the dry heat of summer (September 2008), we lowered the cell to 390.5-ft ASL (one foot below summer pool), where it remained until the schedule called for winter pool (392-ft ASL) in late October/early November. This timing (after summer heat) manipulation resulted in additional growth of emergent species onto lower elevations, increasing colony sizes and overall vegetative coverage in the cell, without causing damage to other more water-obligate species. Just as importantly, the timing of this drawdown did not appear to benefit invasive species. As this project emphasizes adaptive management, we decided to incorporate a late summer to fall drawdown below summer pool in an effort to increase habitat value. This manipulation exposes mudflats for a short period, providing habitat for migratory shorebirds, and is compatible with management strategies for certain invasive species such as alligatorweed.

In 2011 and 2012, we investigated additional season manipulation of water levels to provide better habitat for overwintering waterfowl and shorebirds. Eight or so weeks after cells have been raised to full pool in late fall to inundate wetland and grassland areas, water levels are lowered by six inches to expose mudflats where terrestrial vegetation has declined. This action also makes deeper vegetated areas available to dabbling ducks and wading birds. A revised moist soil management schedule for Cell D is therefore:

- **Winter pool (392-ft ASL, full pool): November to March**
- **Mid-winter pool (391.5-ft ASL, 0.5-ft below full pool): February**
- **Late winter pool (392-ft ASL, full pool): March**
- **Spring pool (390.5-ft ASL, 1.5-ft below full pool): April and May**
- **Summer pool (391-ft ASL, 1-ft below full pool): June to September**
- **Summer saturation pool (392-ft ASL, full pool): As needed June to September**
- **Fall pool (390-ft ASL, 2-ft below full pool): October**

Deviation from this schedule has been applied when environmental conditions are not conducive to intended results of water level manipulations, or when additional benefits might be realized. For instance, sustained drought or hot weather in October may circumvent lowering the cell to fall pool. Results of vegetation community development in Cell D following moist soil strategies are given in Figure 2. Plant communities were well-established substantially by 2008 and persisted through 2012.


**Figure 2. Native wetland plants persisted around Cell D in 2012.**

In general, ERDC began applying a similar moist soil management schedule to other cells as planting was initiated in each, with slight variations made to produce more diverse habitats within the LCOW. The following section outlines moist soil management differences and plant community responses between 2009 and 2012.

- Cell E-West was initially managed with two water levels in 2009, including a winter pool (full; 384.5-ft ASL) and summer pool (1-ft lower; 383.5-ft ASL). However, between 2010 and 2012 the cell has been managed without water level changes (no moist soil management) at a permanent pool of 383.5-ft ASL. Cell E-West was built with steeper slopes than most other cells, and lacks planting shelves, which has resulted in a thin band of mixed wetland/grassland plants along its perimeter. However, an island located in the western half of the cell increases overall wetland plant coverage. Plants installed between 2009 and 2012 are now well established around the perimeter of the cell and island (Figure 3). Arrowheads, burheads, bulrushes, and smartweeds are most widespread in this cell.

- Cell E has been managed to produce a mixed wetland vegetation/mudflat habitat similar to that in Cell D since late 2008. Late winter pool (full pool; 389-ft ASL) is lowered by 1-ft (388-ft ASL) to achieve summer pool, and then lowered another 0.5-ft to fall pool (387-ft ASL) to provide habitat for migrating shorebirds and mudflat-loving waterfowl such as shovelers (*Anas clypeata*) and teal (*Anas* spp.). Plants installed between 2010 and 2012 are well established and have spread throughout most of the cell (Figure 3). Moist soil management in this cell has resulted in establishment of large stands of delta arrowhead, bigpod sesbania, and water lilies.

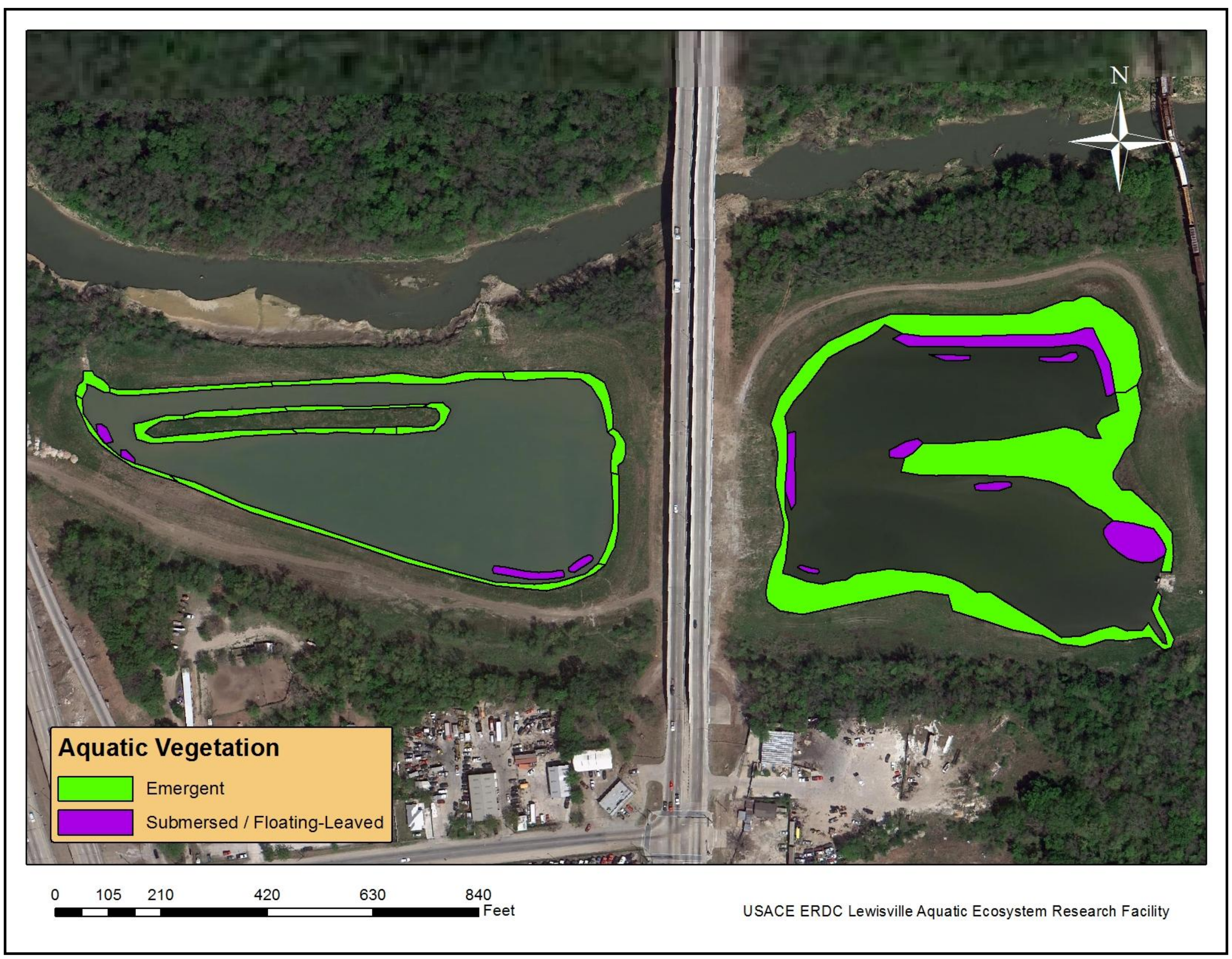



**Figure 3. Native wetland plants continued spreading and were well established around Cell E-West (left) and Cell E (right) by the end of the 2012 growing season.**

- Cell F-North has been managed as an ephemeral wetland since 2009. Wetland species appropriate for those conditions were planted between 2009 and 2012, with water levels not managed other than to prevent elevation from dropping below 381.5-ft ASL (to preserve fish and other aquatic wildlife). We have set full pool at 384.5-ft ASL using the dam board box to permit overflow from runoff, thereby preventing complete inundation of the islands other than during overbanking events. Emergent plants, especially water smartweed and water primrose, and water lilies are now well-established and spreading along the perimeter of this cell (Figure 4).

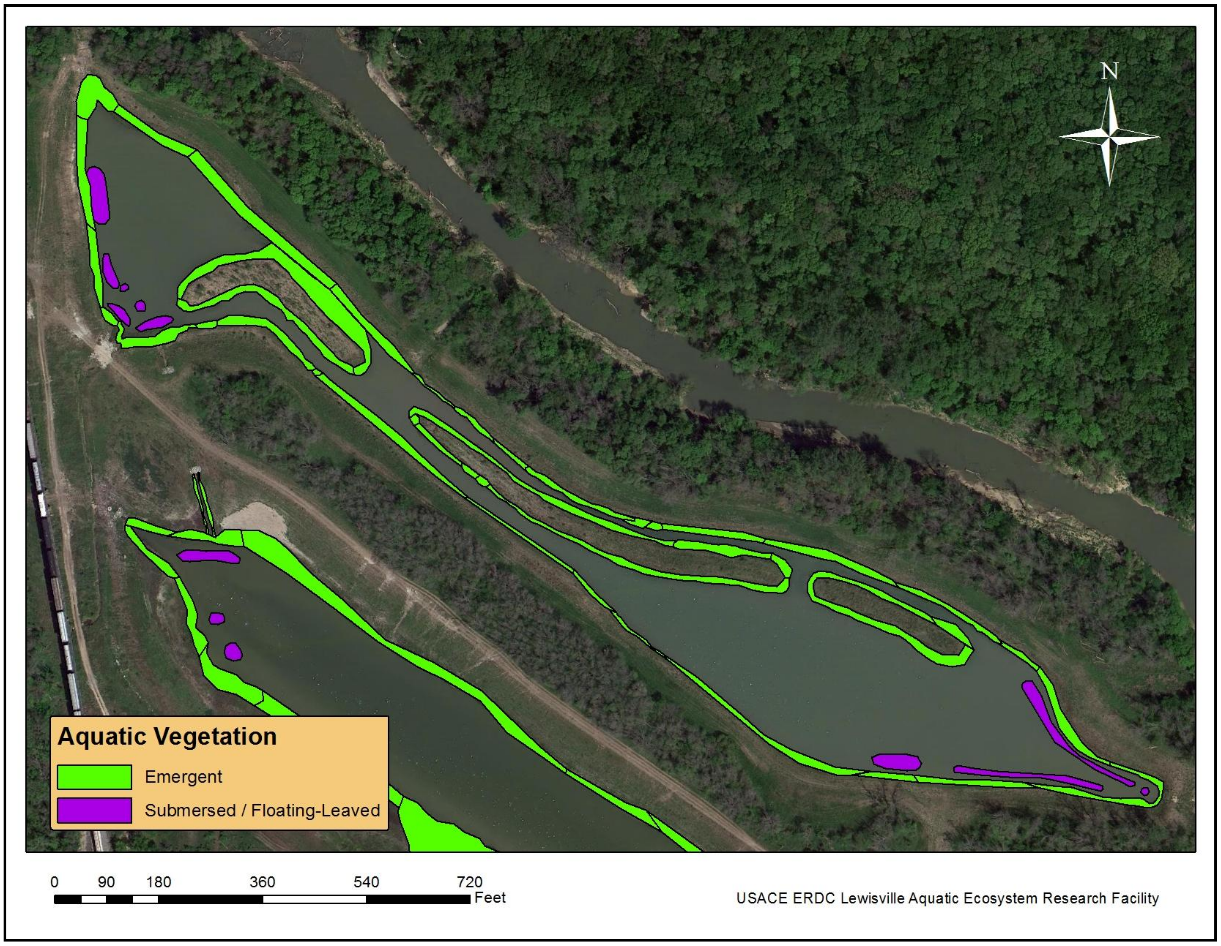
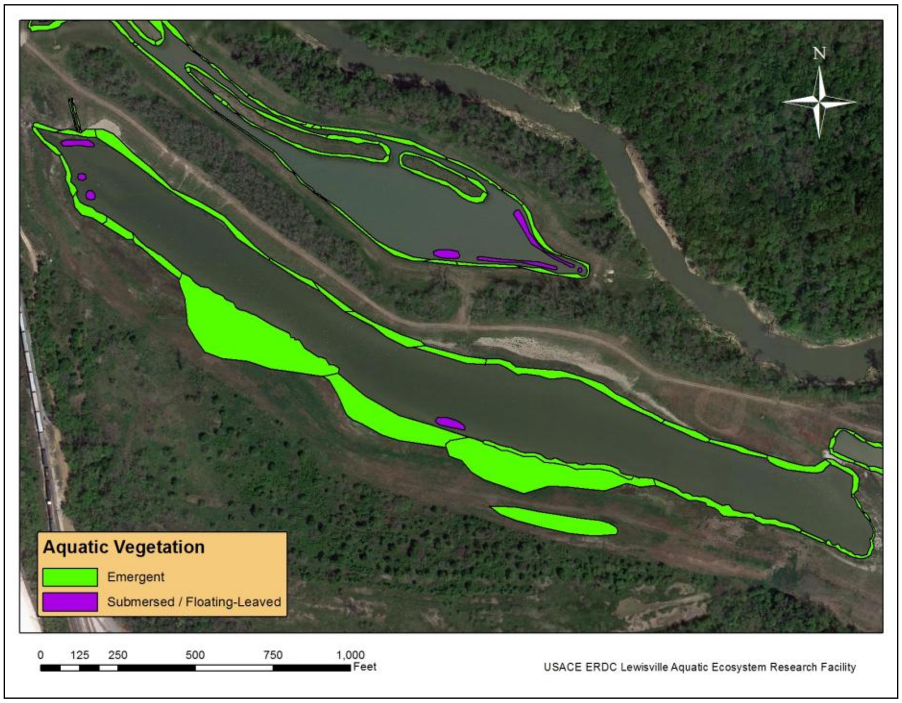



**Figure 4. Native wetland plants continued spreading and were well established around perimeters of Cell F-North and its islands by the end of the 2012 growing season.**

- Beginning in late 2008, Cell F was managed similarly to Cell D, with water level changes including an early winter pool (full; 388-ft ASL), mid-winter pool (387.5-ft ASL), late winter pool (388-ft ASL), spring pool (386.5-ft ASL), summer pool (387-ft ASL), and fall pool (another ½-ft to 1-ft lower; 386.5-ft to 386-ft ASL) to encourage establishment of mixed wetland and grasslands to provide better winter habitat for species that use flooded terrestrial areas, such as mallards (*Anas platyrhynchos*). ERDC planted the westernmost portion of this cell, designated F (West), with wetland plants in FY2009 and FY2010 (Figure 5). Planting in easternmost half, designated Cell F (East), was delayed in order to manage a significant cattail infestation occurring in that cell; planting was initiated in FY2010 and completed in FY2012. Additional plantings have been made in large expanses of full pool inundated areas associated with F (West) and F (East) in order to hasten plant community establishment in mixed wetland/grassland zones. As of 2012, emergent species such as bulrushes, sesbania, arrowheads, spikerushes, arrowheads, and sedges are abundant around this cell.



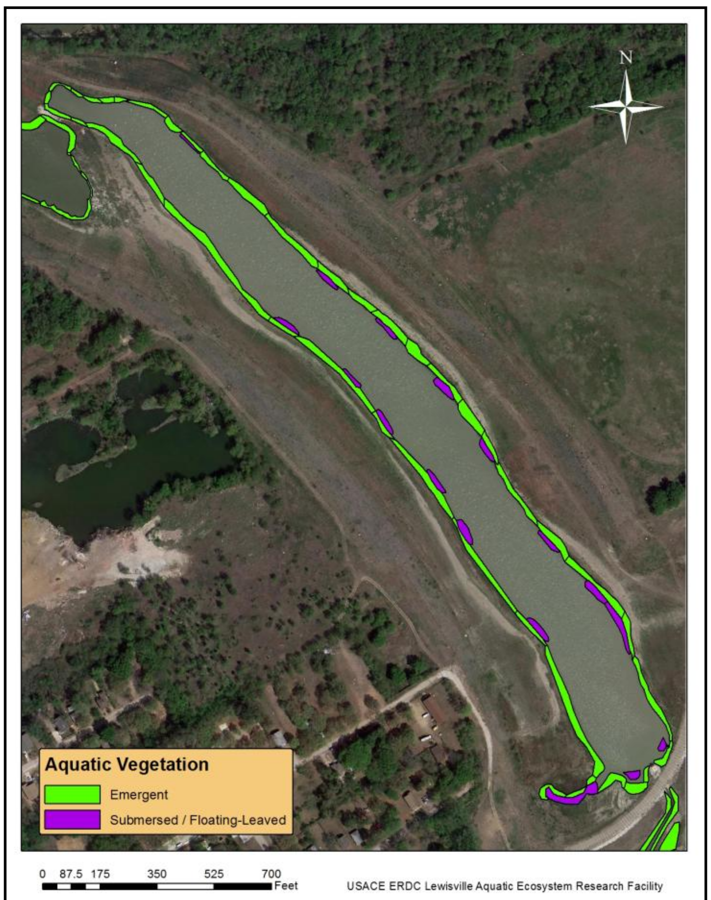




**Figure 5. Native aquatic plants continued spreading and were well established around the perimeters of Cell F (West), top, and Cell F (East), bottom by the end of the 2012 growing season.**

- Cell G has been managed similarly to Cell D, but with a wider fluctuation in water levels. Winter pool is set at (387-ft ASL) and summer pool (384.5-ft ASL), 1 ½-ft lower. This has given similar results as in other cells, but appears to have benefitted submersed species, particularly pondweeds and water stargrass. Greater water level fluctuations results in inundation of more expansive areas supporting grassland species, providing additional food and cover for dabbling duck species such as mallards, gadwalls (*Anas strepera*), American wigeons (*Anas americana*), northern pintails (*Anas acuta*), and teal (*Anas* spp.). Plants installed between 2009 and 2012 have responded well to this plan (Figure 6). In addition to submersed species, Cell G supports large stands of bulrushes, pickerelweed, arrowheads, spikerushes, sedges, sesbania, and others.

- Planting was initiated in 2009 and continued in 2012 in the Wood Duck Pond, an approximately 4-acre sump area adjacent to Cell G. This pond is connected to Cell G via a culvert and water levels fluctuate according to the prescribed management in the cell. The sump area was planted primarily with floating-leaved species, including American lotus (*Nelumbo luteum*) to produce habitat for wood ducks (*Aix sponsa*) and other waterfowl (Figure 6). Additional species established include spikerushes, arrowheads, and bulrushes.

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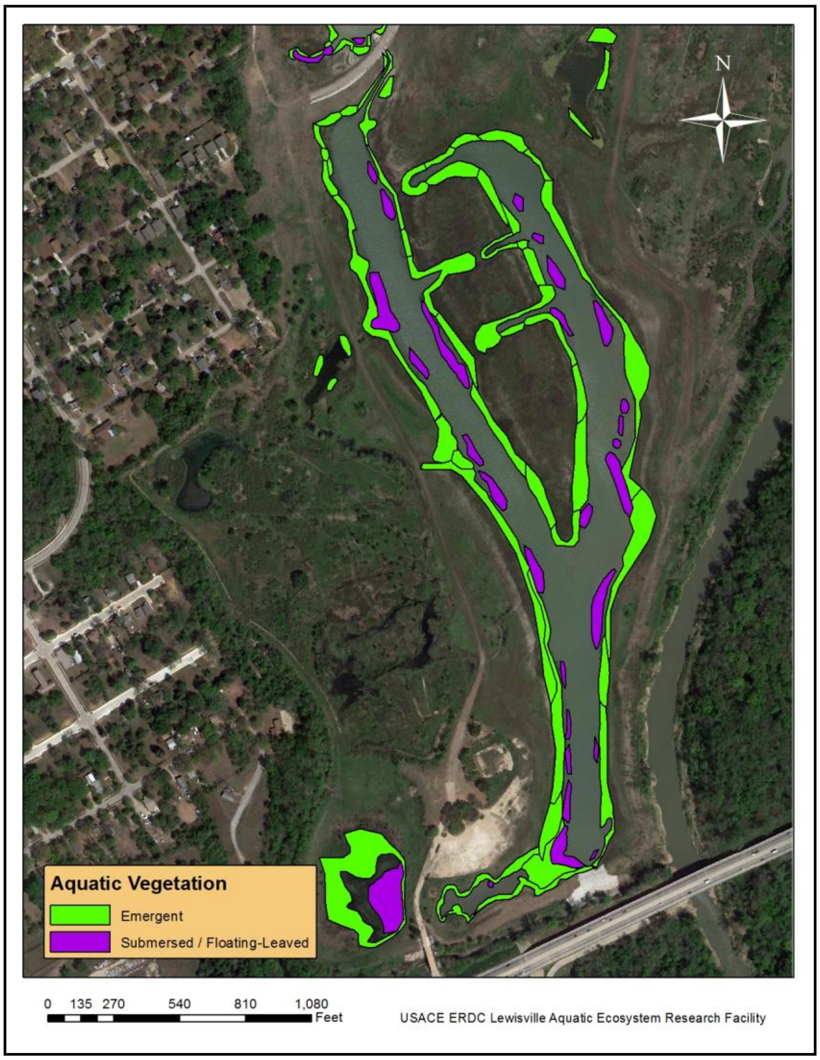


**Figure 6. Native aquatic plants continued spreading and were well established around Cell G, the Wood Duck Pond (southwest side of Cell G), and several smaller water features by the end of the 2012 growing season.**

Table 2 provides a list of species observed in the wetlands (on the 1-ft deep shelf or below) since 2005. Most are desirable native plants that had been transplanted by ERDC or had naturally established from seed banks. In addition to these plants, many grassland species were growing intermingled with wetland species in the moist soil areas. Aquatic vegetation surveys conducted in 2012 indicated that most planted species and many desirable volunteer species were well established- and spreading in the wetland cells throughout the LCOW.

**Table 2. Forty-nine plant species have been observed in the wetlands between 2005 and 2012. Species highlighted in bold are considered invasive and are being managed by ERDC.**

| **Scientific name** | **Common name** | **Transplant (T) or Volunteer (V)** | **Wetland cell** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **D** | **E-W** | **E** | **F-N** | **FW** | **FE** | **G** |
| *Acmella oppositifolia* | Spot flower | V | X | | X | | X | | X |
| ***Alternanthera philoxeroides*** | **Alligatorweed** | **V** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| *Azolla caroliniana* | Mosquito fern | V | | X | | | | | X |
| *Bacopa monnieri* | Water hyssop | T | X | X | X | X | X | X | X |
| *Carex* cherokeensis | Cherokee sedge | T & V | X | X | X | X | X | X | X |
| *Carex crus-corvi* | Ravenfoot sedge | T & V | X | X | X | X | X | X | X |
| *Ceratophyllum demersum* | Coontail | T | X | | X | | X | X | |
| *Chara vulgaris* | Muskgrass | T | X | | X | | | | X |
| *Cyperus* sp. | Flatsedge | V | X | X | X | X | X | X | X |
| *Echinodorus berteroi* | Tall burhead | T | X | X | X | | X | | |
| *Echinodorus cordifolius* | Creeping burhead | T | X | X | X | | X | | X |
| *Eleocharis acicularis* | Slender spikerush | T | X | X | X | X | X | X | X |
| *Eleocharis macrostachya* | Flatstem spikerush | T | X | X | X | X | X | X | X |
| *Eleocharis quadrangulata* | Squarestem spikerush | T | X | X | | | X | | X |
| ***Fraxinus caroliniana*** | **Green ash** | **V** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| *Heteranthera dubia* | Water stargrass | T | X | X | X | | | X | X |
| *Hibiscus* sp. | Hibiscus | V | | | | X | | | X |
| *Hydrocotyle* sp. | Pennywort | V | X | X | X | X | X | X | X |
| *Juncus effusus* | Soft rush | T | X | | X | X | X | X | X |
| *Juncus* sp. | Rush | V | X | X | | | X | X | X |
| *Justicia americana* | American waterwillow | T | | X | | X | | | X |
| *Lemna* sp. | Duckweed | V | X | X | X | X | X | X | X |
| *Ludwigia repens* | Water primrose | V | X | X | X | X | X | X | X |
| *Najas guadalupensis* | Southern naiad | T | X | X | X | X | X | | X |
| *Nelumbo lutea* | American lotus | T & V | | | | | | | X |
| *Nymphaea mexicana* | Yellow water lily | T | X | X | X | X | X | X | X |
| *Nymphaea odorata* | American water lily | T | X | X | X | X | X | X | X |
| *Paspalum distichum* | Jointgrass | V | X | X | X | X | X | X | X |
| *Peltandra virginica* | Arrow arum | T | X | X | | X | | | |
| *Phyla lanceolata* | Lance-leaf frog's fruit | T & V | X | | X | X | X | X | X |
| *Phyla nodiflora* | Texas frog's fruit | T & V | X | X | X | X | X | X | X |
| *Polygonum aquaticum* | Water smartweed | T | X | X | X | X | X | X | X |
| *Polygonum spp.* | Smartweeds | V | X | X | X | X | X | X | X |
| *Pontederia cordata* | Pickerelweed | T | X | X | X | X | X | X | X |
| ***Populus deltoides*** | **Cottonwood** | **V** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| *Potamogeton illinoensis* | Illinois pondweed | T | X | X | X | X | X | X | X |
| *Potamogeton nodosus* | American pondweed | T | X | X | X | X | X | X | X |
| *Potamogeton pusillus* | Slender pondweed | T | X | X | X | X | X | X | X |
| *Ranunculus sp.* | Buttercup | V | X | X | X | X | X | X | X |
| *Sagittaria latifolia* | Broadleaf arrowhead | T | X | X | X | X | X | X | X |
| *Sagittaria platyphylla* | Delta arrowhead | T | X | X | X | X | X | X | X |
| ***Salix nigra*** | **Black willow** | **V** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| *Sesbania herbacea* | Bigpod sesbania | V | X | X | X | X | X | X | X |
| *Schoenoplectus americanus* | American bulrush | T | X | X | X | X | X | | X |
| *Schoenoplectus californicus* | Giant bulrush | T | X | X | X | X | X | | X |
| *Schoenoplectus tabernaemontani* | Softstem bulrush | T | X | X | X | X | X | X | X |
| ***Typha* sp.** | **Cattails** | **V** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| *Vallisneria americana* | Wild celery | T | X | X | X | | | | X |
| *Zannichellia palustris* | Horned pondweed | T | X | | X | | | | X |

## Herbivory

Plantings at the LCOW consisted primarily of emergent species, and few of those, if any, have been affected by herbivores at any point during vegetation establishment in the LCOW. Because protection for emergent plants was largely not needed, ERDC was able to shift resources from construction of protective exclosures to production and transplanting of more plants, which hastened the process of establishing native desirable vegetation in the wetlands.

Emergent plants are not the only growth form needed to provide high quality habitat (and benefits) in the LCOW. Floating-leaved and submersed species are important components of most aquatic ecosystems, providing significant benefits such as structural habitat for fish and their prey, water column nutrient-load reduction, and food for waterfowl and other aquatic wildlife. Survival and growth of floating-leaved and submersed species, however, required protection in the LCOW, primarily from turtles. Whenever planting these species, ERDC used protection, such as ring cages, to ensure their establishment (Figure 7). Once established, many species of floating-leaved and submersed species are capable of spreading beyond protected areas, thereby providing larger-scale benefits to a given system. In addition to using ring cages for protection, ERDC installed several larger pens (approximately 10-ft x 20-ft) for protection of submersed species in some of the cells in order to increase overall plant biomass and seed production, and thereby speed the process of spread to unprotected areas.

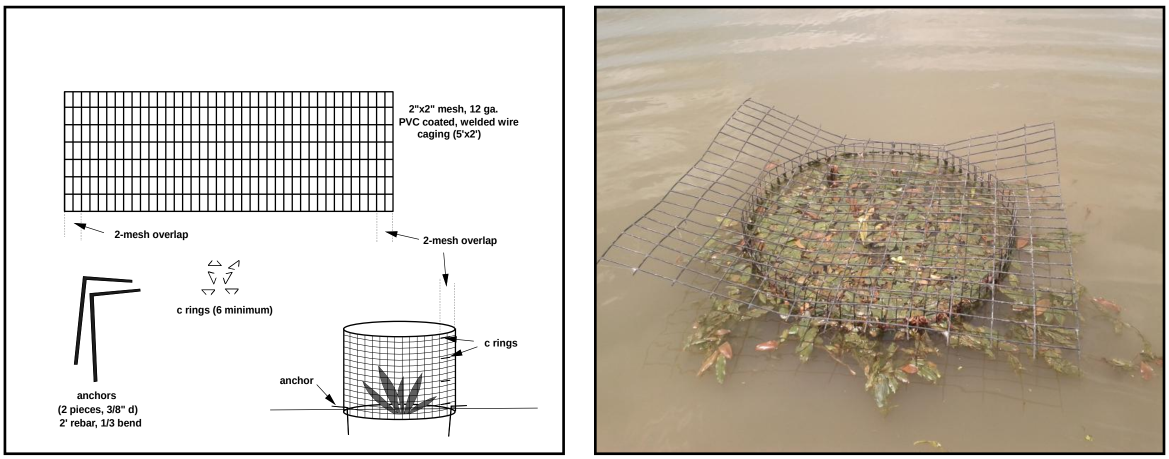


**Figure 7. Ring cages were installed to serve as protection for newly establishing vegetation from grazing by turtles, common carp, and other herbivores. In cases where cages were regularly overtopped by rising water, covers were installed to prevent herbivores from swimming inside. The photo at the right shows that once plants, in this case American pondweed (*Potamogeton nodosus*), grow to fill cages, they begin to spread to unprotected areas.**

**Turtles:** The principal herbivore encountered in the LCOW has been semi-aquatic turtles, mostly red-eared sliders (*Trachemys scripta elegans*), but includes river cooters (*Pseudemys* sp.) and map turtles (*Graptemys* sp.). While emergent species have only been moderately affected by turtles, submersed and floating-leaved species have been hard-hit on occasions. Beginning in 2006, ERDC began deploying fall-in traps in Cell D to capture and relocate turtles to the Trinity River or LAERF (located upstream on the Trinity River) (Figure 8). ERDC reasoned that a reduction in turtle population density would in turn reduce grazing pressure on newly establishing vegetation, thereby enabling spread of plants from protective exclosures. Between 2006 and 2012, over 750 turtles were captured from Cell D and relocated, and following initiation of this practice several species, including American pondweed, water stargrass, American water lily, and yellow water lily, exhibited greater spread outside of protected areas. Additionally, volunteer species such as water primrose spread significantly throughout the cell in conjunction with turtle management. Inexplicably, we have only encountered moderate problems with turtles in other cells following initial planting and protection: once plants are established inside exclosures in those cells, they are able to grow beyond protection (unlike in Cell D, where turtles prevented spread from cages). Turtle trapping has not been required in other cells.

**Figure 8. Fall-in turtle traps have proven successful for capture and relocation of grazing turtle species in Cell D. Red-eared sliders (*Trachemys scripta elegans*) dominate the turtle population in the LCOW.**

**Common carp:** In late 2006, we observed that adult common carp (*Cyprinus carpio*) were present in Cell D and in subsequent years that common carp were in all cells (Figure 9). While successful reproduction in any cell has not been verified as of this report, we did observe spawning behavior in Cell E in spring 2010 and in other cells in 2011 and 2012. Because common carp can have devastating impacts on aquatic vegetation and aquatic ecosystems in general, we installed eight pens (10-ft x 10-ft x 4-ft tall) designed to trap and contain carp (and turtles) until they can be removed in Cell D (Figure 10). Traps are planted with submersed species to act as attractants, and several carp and numerous turtles have been caught using this methodology since their installation. Overall herbivory damage has lessened in Cell D since turtle and carp traps have been installed, but low numbers of carp removed indicate that turtles are the primary problem. Portable carp funnel traps were tested near inflows of other cells in 2012, but were not successful in capture or removal of carp, although some turtles were captured. Additional tests will be conducted in spring 2013.

**Figure 9. Common carp (*Cyprinus carpio*) have been observed in all cells except for Cell F-North.**

**Figure 10. Carp traps have been constructed in Cell D to help reduce numbers of large carp.**

**Invertebrates:** Grazing by other herbivores has periodically caused problems during the project. While evident in all cells since their filling, crayfish (*Procambarus clarkii* and others) did not appear to cause significant problems for plants until spring 2010, when submersed plants in Cell E, Cell G, and the Wood Duck Pond were heavily damaged and required replantings on two occasions (Figure 11). ERDC lowered water levels in both cells by six inches to simulate drying conditions, which may have triggered burrowing activity by the crayfish and lessened their impacts on new plantings. Additionally, lower water levels may have left the crayfish more susceptible to predators such as herons and egrets. Although crayfish and their chimneys are frequently observed, no problems with plants have occurred since 2010.

Other invertebrates have been observed feeding on desirable plants, but these typically do only limited damage and should be considered important ecosystem components, helping to prevent any one plant species from taking over the plant community. Examples include waterlily leafcutter moths (*Synclita* sp.) feeding on floating-leaved and some emergent species, and seasonal populations of native flea beetles (*Lysathia ludoviciana*) that damage water primrose (Figure 12). A number of these species are generalist feeders, and may help keep nuisance plants such as alligatorweed in check.

**Figure 11. Crayfish (*Procambarus* sp.) have been observed in all LCOW cells. In some cases, populations become dense enough to impact establishing submersed vegetation.**

**Figure 12. Waterlily leafcutter moth (*Synclita* sp.) damage on American pondweed (*Potamogeton nodosus*).**

**Waterfowl:** Although a highly desirable component of the ecosystem, dabbling ducks have contributed to plant loss during winters in all cells, primarily in the form of uprooted arrowheads and rushes, but overall damage to plant populations appears to be minimal. Because native plants and overwintering waterfowl have co-evolved, waterfowl feeding typically does not significantly damage plant populations, and in fact may benefit regrowth of some species the following spring by enabling higher germination and sprouting rates of seeds and tubers. However, if resident populations of waterfowl (e.g., Canada geese, mallards, etc.) establish in DFE wetlands, their effects on the plant community may become problematic (Figure 13). Fortunately, other than occasional reproduction by small numbers of resident mallards, we have seen no evidence as of early 2013 that a significant resident waterfowl population is developing at the LCOW. In the event that resident populations do begin to develop, a plan for their management will have to be formulated.

**Figure 13. Migrating dabbling ducks feed heavily on aquatic plants during cooler seasons in the LCOW, but have not excessively damaged plant colonies to date. Development of large populations of resident ducks or geese, such as these mallards (*Anas platyrhynchos*), could inflict significant damage on vegetation communities in the LCOW.**

**Mammals:** Beavers (*Castor canadensis*) have been observed in several cells and beginning in 2010 have caused some damage to American and yellow water lilies and possibly bulrush colonies. While some recovery of damaged plants had occurred by late 2011, supplemental plantings were made in 2012 to ensure those species are present in the cells in which damage occurred, most notably Cell D and Cell E.

To date, beaver activity in other cells has not included noticeable damage to plants, although issues have occasionally occurred at the outfall of Cell E and Cell G, where beavers have brought materials (mostly willow twigs, alligatorweed, and mud) to dam the weir gate boxes (Figure 14). Efforts to discourage dam-building have included hand removal of materials, short-term stoppage of pumping to prevent water from flowing over weir gates (which triggers beaver dam-building behavior), and restricting water flow to morning daylight hours when beaver are less likely to be active. These efforts have provided reasonably good results and beaver activity has been manageable through 2012.

Beavers have also burrowed in and around several weir structures, with most burrowing occurring at the dam board weir box in Cell E-West, the weir gate box in Cell E, and the flow trough from the Cell E weir gate box into Cell F (West). Burrows did not appear to be extensive (or active) as of 2012, but they should be monitored periodically to ensure the earthen areas around these structures are not overly damaged.

If beavers continue to be problematic or their activity increases to the point of preventing weir gate operation or causing levee integrity failure, trapping and relocation may be required. Alternatively, because recolonization will likely become an ongoing issue, consideration of modifications to the outlet weirs and other structures prone to beaver activity may be necessary. For instance, fencing off areas to prevent beaver from constructing dams has proven successful in some situations, although maintenance of fencing may be high in the LCOW, where periodic significant water flow may result in excess debris (trash, logs, mats of vegetation, etc.) preventing flow to the weirs and/or damaging fencing. Alternative beaver discouragement methods might include installation of sound producing devices (predator calls or unpleasant sonic pulses) or electrical barriers to keep beaver away from sensitive areas.

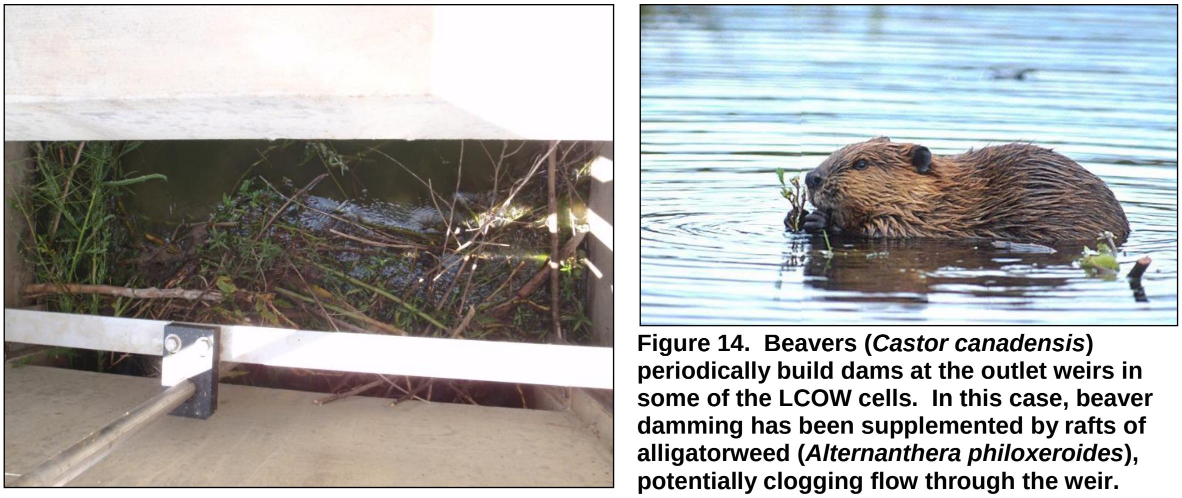

**Figure 14. Beavers (*Castor canadensis*) periodically build dams at the outlet weirs in some of the LCOW cells. In this case, beaver damming has been supplemented by rafts of alligatorweed (*Alternanthera philoxeroides*), potentially clogging flow through the weir.**

Nutria (*Myocastor coypus*) were observed in one cell (E-West) in 2010, but feeding on plants has not yet been seen, and nutria have not apparently established in the LCOW. Because nutria have the potential to significantly damage belowground portions of bulrushes and other rhizatomous species, as well as damage levees when burrowing, monitoring their occurrence is highly important at the LCOW, and if observed, control measures will have to be devised. Nutria have not been observed since the initial sighting in 2010.

Feral pigs (*Sus scrofa*) tracks have been observed along the shoreline of Cells F-East and G, with some damage to shoreline plants such as bulltongue and flatstem spikerush occurring in FY2011 and grassland plants in 2012. If feral hog damage intensifies during scheduled low water periods (e.g., summer pool), water levels may have to be raised to inundate wetland plantings and prevent access to the pigs. If excessive activity is noted in grassland areas, animal control may have to be applied to remove the animals, or at least reduce their densities in the area.

## Effects of overbanking on wetland plants

Numerous overbanking events have occurred since completion of Cell D, with the most severe occurring during summer 2007, when continuous overbanking occurred for about six weeks in June and July (during the active growing season). Complete submersion of plants combined with high turbidities damaged both planted and volunteer plant species, but recovery was noted for nearly all species within four weeks of overbanking cessation. Plants that were most severely impacted due to this event included the submersed species wild celery and Illinois pondweed. Shorter-term overbanking events, usually lasting only several days to a few weeks, have occurred during all years of the project, but have had only minimal direct impacts on wetland plants in any of the cells. In some cases, protective exclosures have been washed away or damaged by floating debris and have required replacement or repair. The three overbanking events occurring in 2012 had minimal impacts on vegetation communities and exclosures in the LCOW.

Indirectly, flushing of nutrients (and planktonic algae) that build up when adding effluent has sometimes improved water quality and benefitted growth of some plants in the cells. Typically, if the system appears to be on the brink of an algal bloom (e.g., water starting to green up), an overbanking event will effectively replace that water with river water. While not of pristine quality, river water is generally lower in nutrients than CWWTP effluent.

Overbanking has also served as a natural stocking mechanism for fish, other aquatic wildlife, and volunteer plant species. No fish or other aquatic animals were intentionally stocked in any of the cells after their construction, but populations and communities of these organisms developed rapidly in each cell following initial overbanking events.

## Effects of water supply disruption on wetland plants

ERDC regularly manipulates water levels to encourage growth of desirable plants. However, these fluctuations are moderate and are carefully monitored to ensure that potential negative effects are avoided. Drying emergent plants too quickly or at the wrong time of year, for instance, could damage existing stands, just as lowering of the water at any time could expose submersed species and lead to their mortality. Several events have occurred since Cell D was constructed in which water levels dropped unexpectedly. In the first case, unauthorized lowering of the weir gate to its lowest setting resulted in water levels falling to 3-ft below full pool during mid-summer, exposing many plants to desiccation. We were able to refill the cell using the CWWTP pumps within a few weeks, but many plants exhibited signs of damage before water levels returned to summer pool. A few weeks after refilling, the water level was lowered again by the same amount and in the same manner (unauthorized), and again refilled. Fortunately, plant colonies suffering from this double-drawdown proved highly resilient and most had recovered before the end of that growing season. Part of ERDC's management of the entire LCOW since that time has been to monitor water levels and weir gate elevations to make sure prescribed conditions are met to prevent unnecessary damage to wetland plant communities.

CWWTP pump failures have occasionally interfered with ERDC's ability to maintain water levels, resulting in sometimes profound negative effects on the wetland plant community. The most notable occurred in 2010, when pump failures in the winter resulted in cells holding significantly less water than normal during the spring (most had fallen 3 to 4 feet below full pool by June, when pumps were repaired) (Figure 15). Ecologically, this event represented a major disturbance, with the resultant exposed mud banks providing an ideal situation for rapid expansion of an undesirable species, alligatorweed (*Alternanthera philoxeroides*), and increased germination and seedling growth success of black willows (*Salix nigra*) and cattails (*Typha* sp.). Up to that time, these species were being held in check using several management strategies (see Weed management section, below), including water level manipulations. Since the prolonged pump failure, more intensive management has been required to keep the invasive plants under control. Short term pump failures in the winter of 2011-2012 and spring 2012 resulted in slight interruption of moist soil management, but repairs were timely enough to prevent excessive water losses, damage to existing plant communities, or a repeat of rapid expansion of nuisance plants.

**Figure 15. Periods of low water have occurred on several occasions due to unauthorized lowering of weir gates and CWWTP pump failure. Although many wetland plants suffered during these times, recovery following inundation has been good. Unfortunately, these events have given alligatorweed (*Alternanthera philoxeroides*) a strong foothold and competitive advantage over native plants in many of the LCOW wetland cells.**

## Weed management

A critical but often overlooked (until it is too late) component of vegetation establishment projects is management of nuisance species, which is especially important in new construction projects such as the LCOW. Beginning as early as 2005, several undesirable species began growing as volunteers in Cell D, and began establishing in other cells as their construction was completed. Problematic species included cattails, black willows, and cottonwoods (*Populus deltoides*), present in area seedbanks, and alligatorweed, its source the CWWTP channel that is used to supply water to the LCOW (Figure 16). Although cattails are native to north Texas and are good contributors to wetland function via nutrient abatement and structural habitat, the species is aggressive and tends to crowd out other wetland species that provide a wider range of benefits to wetland-dependent wildlife. Likewise, black willows and cottonwoods are native species that provide certain benefits to wetlands, but are woody and can impede water flow, which is not compatible with the flood conveyance requirements of the project. Alligatorweed is a nuisance species introduced to the U.S. from South America capable of expansive growth that degrades wetland function and can impede water flow, especially through structures such as the weir gate boxes. Because these (and other) nuisance species were capable of significant disruption of project goals, ERDC began efforts to manage them to minimize their impacts on establishing desirable vegetation and flood conveyance, and to avoid larger-scale and expensive efforts to control them if left unconstrained.

**Figure 16. Black willows, *Salix nigra* (top left), Eastern cottonwoods, *Populus deltoides* (top right), cattails, *Typha* spp. (bottom left), and alligatorweed, *Alternanthera philoxeroides* (bottom right) are the primary undesirable wetland species being managed in the LCOW.**

When encountering cattails and tree saplings, ERDC staff initially hand-pulled them in order to prevent their growth and spread. While these efforts met with moderate success, they did not provide the level of control desired due to extensive seed banks of the two species in the areas. Spot-treatments with nonselective glyphosate (cattails and trees) and later with selective triclopyr (trees) were therefore implemented. Spot-treatments were used to minimize damage to non-target species, and included wicking and foliar application with a small tank sprayer. An additional benefit of using triclopyr over glyphosate for trees was its ineffectiveness on monocots (grasses and most herbaceous wetland species planted around the LCOW). Treatment in this manner has been highly successful on cattails, black willows, and cottonwoods, with only limited impacts on desirable vegetation. ERDC continued management of cattails and tree saplings as needed in all cells through 2012. At the time of this report, cattails are either absent or uncommon in all cells, with the exception of a few stands left untreated to provide food for beavers (as an alternative to them feeding on bulrushes). Tree saplings are near-absent or uncommon in most cells, with the exception of small stands of black willows adjacent to Cell F (East), Cell G, and the Wood Duck pond. These trees are not of concern for flow impediment and are therefore being retained to provide additional habitat in the LCOW. ERDC will continue managing cattails and tree saplings in all cells during 2013. Table 3 provides an overview of the current nuisance plant management strategy in the LCOW; herbicide applications are made as needed, generally twice yearly.

**Table 3. Overview of nuisance plant management efforts being undertaken at the LCOW.**

| Cell | Cattails | Willows & cottonwoods | Alligatorweed** |
|---|---|---|---|
| **D** | Glyphosate as needed; currently no infestation | Triclopyr as needed; currently no infestation | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **E** | Glyphosate as needed; small infestation remains | Triclopyr as needed; small infestation remains | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **E-West** | Glyphosate as needed; currently no infestation | Triclopyr as needed; currently no infestation | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **F (West)** | Glyphosate as needed; currently no infestation | Triclopyr as needed; currently no infestation | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **F (East)** | Glyphosate as needed; currently no infestation | Triclopyr as needed; currently no infestation | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **F-North** | Glyphosate as needed; currently no infestation | Triclopyr as needed; small infestation remains | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **G** | Glyphosate as needed small infestation remains* | Triclopyr as needed; small infestations await decision-making | Triclopyr as needed; alligatorweed insects four times in spring and summer; infestation declining |
| **Wood Duck pond** | Glyphosate as needed small infestation remains* | Triclopyr as needed; some are left purposefully as habitat | No alligatorweed infestation |
| **CWWTP channel** | N/A | N/A | Alligatorweed insects four times in spring and summer; infestation declining |

*small stands of cattails have been left purposefully to bait beavers away from establishing bulrushes
**infestations have been reduced, but persist in all cells. More rigorous control strategies are discussed below and were included in the FY2012 SOW

Alligatorweed remains established in all cells, but declined significantly during 2012. Alligatorweed easily spreads by fragments and is believed to have first been introduced into Cell D in FY2005, by both overbanking events and pumping from the infested CWWTP channels. Initial treatments included hand-pulling and glyphosate application, and the population was well under control in FY2006 and FY2007. However, unintentional low-water events beginning in FY2008 provided opportunities for explosive spread. In FY2009 and FY2010, pumps supplying Cell D and the remaining LCOW failed during spring and summer. Delayed repairs prevented maintaining water at levels that can stymie the spread of alligatorweed, with most wetland cells dropping by 3 feet or more before pumps were repaired. Large mud flats exposed at those times provided suitable conditions for alligatorweed to aggressively spread into available niches, with no means to slow the spread by inundating the mud flats. In addition to treating infestations with glyphosate, ERDC began introducing biocontrol agents, alligatorweed flea beetles (*Agasicles hygrophila*) and stem-boring moths (*Arcola malloi*), in Cell D during FY2008, in an effort to manage the infestation before other LCOW cells were completed (Figure 17). Thus far, flea beetle populations have not successfully overwintered, but stem-boring moths have established and populations recover annually. While the combination of the two can devastate alligatorweed populations, each alone provides only limited control and does not reduce the problem. By 2010, despite yearly introductions when the beetles were available from the COE Jacksonville District, flea beetle populations had yet to become established and alligatorweed continued to thrive. In FY2011, ERDC began using triclopyr in conjunction with biological control, which provided the best control results since the infestation began. However, the four native species that occupy similar niches as alligatorweed (water primrose, water smartweed, opposite leaved spot flower, and lance-leaf frog-fruit) are also susceptible to triclopyr, and alligatorweed remained dominant following recovery because control was not selective. ERDC and SWF recognized that managing alligatorweed would require more effective (but selective) control and in 2012 began making multiple releases of alligatorweed flea beetles acquired from multiple sources: Jacksonville District and a population started in cultures at the LAERF. Earlier-in-the-year releases combined with four (or more) release dates resulted in substantial declines in alligatorweed in the LCOW and increases in native plants growing in the same general areas. ERDC also released beetles in the CWWTP channels to reduce the likelihood of reinfestations. In addition to releasing insects, areas without populations of plants capable of competing with alligatorweed were planted with water smartweed, frog-fruit, and spot flower.

It remains uncertain if alligatorweed flea beetles will survive winters in the north Texas area. ERDC will monitor recovery of populations during 2013, and in the event the beetles are not found, additional releases will be made. It is possible that reintroduction of beetles will be required periodically as a part of the long-term management strategy.

**Figure 17. Alligatorweed flea beetles acquired from USACE Jacksonville District and those reared at LAERF cultures were released multiple times in 2012 in a successful effort to control alligatorweed infestations at the LCOW. Establishment of these biocontrol agents can provide sustained management of alligatorweed in the wetland cells, but whether or not the beetles are established remains unknown.**

ERDC will continue to manage nuisance species in the wetland chain during FY2013, as well as additional undesirable species located in the LCOW. For example, a patch of giant cane, *Arundo donax*, which was documented between the Trinity River and Cell F, was spot-treated with glyphosate during the 2010 growing season; regrowth of this colony did not occur during 2011 or 2012.

## Water quality

Other than precipitation and overbanking events, wetland cell water levels are maintained by diverting effluent from the CWWTP. Initially, water levels in Cell D were maintained (to counter evaporation and wicking by grassland areas) by pumping effluent 6 hours or more per day. This resulted in substantial input of nutrients, with total nitrogen sometimes exceeding 8 mg/L and total phosphorus exceeding 5 mg/L. These nutrient loads were responsible for significant algal blooms that occurred during spring 2006, and were first dominated by filamentous species. We were able to reduce filamentous algal blooms by dropping the water level by six inches below summer pool (to 390.5 ft-asl), exposing the shallow shelf where the majority of the algae occurred, eliminating it through desiccation. After bringing water levels back to summer pool, however, a planktonic algae bloom occurred, resulting in water quality problems due to high rates of photosynthesis. On several occasions, we recorded pH in excess of 10 units (hand-held meter, spot checks), a level that is harmful to fish and possibly to some aquatic vegetation. While an established community of aquatic vegetation can serve to reduce algal blooms, the vegetation community was not mature enough for that to occur. Therefore, we opted to implement measures in an effort to limit algal growth. First, we reduced pumping to 1 or 2 hours per day to lower input of new nutrients. We also raised the water level by six inches above summer pool (to 391.5-ft ASL) to inundate some of the emergent and terrestrial species that had established on the shallow shelf. We reasoned that these plants, which were better established than submersed species, had better potential to compete with algae for nutrients and would help reduce the overall nutrient loading in the water column. Subsequent to these actions, planktonic algae became less and less problematic, and plant growth increased. While pH remained moderately high, it fell to acceptable levels for fish and other aquatic wildlife (9.5 and below). An overbanking event near the end of the 2006 growing season additionally benefited the system by flushing nutrients (and moderate algal bloom) out of the water column. The system has since matured further due to plant growth, adding organic materials to substrates and binding nutrients, with decomposition contributing to water quality (ecosystem nutrient recycling). Algae blooms have not been a problem in Cell D since 2006.

The water source for Cells E-West, E, F-North, F, and G is the same as for Cell D, although treatment plant water is pumped directly into only two of those cells. A second, larger pump supplies water to Cell E-West and Cell E. Valves associated with the water supply lines enable diversion of water to either or both cells. The outflow for water in Cell E-West leads directly into the Trinity River, but water pumped into Cell E flows into Cell F, which has two outflows, one that supplies water to F-North and one to Cell G. Cell F-North outflow empties directly into the Trinity River, while Cell G outflow empties into Honey Branch Creek, a small tributary to the river. Weir boxes permit management of water flow through the wetland chain. For instance, water can be set to flow through Cells E, F, and G, bypassing flow to F-North by raising dam boards in the outflow from Cell F. The ability to manage water flow through the wetland chain provides an additional tool for modifying water quality.

As learned from Cell D, monitoring water quality in the wetland chain is critical for optimal adaptive management strategy development needed to establish and manage submersed species. Because water from the treatment plant first enters Cell E (and separately Cell E-West) and then flows into other cells, we initially planted these cells more densely to hasten plant community establishment. This approach facilitated removal of some nutrients, thereby reducing algal blooms in downstream cells. We have additionally reduced pumping to a minimum (thereby reducing nutrient inputs during the establishment phase) for maintaining water levels, even permitting drops of several inches below target elevations at times. This combined effort has thus far resulted in only short-lived and mostly insignificant algal blooms in any of the cells.

We take field readings of temperature, pH, dissolved oxygen, and conductivity using a Hydrolab Quanta, (Loveland, CO) in all cells to provide guidance for when algae management or other water quality actions are necessary. Water quality has remained in the range conducive to growing aquatic plants and supporting fish and other aquatic wildlife between FY2009 and FY2012 (Appendix B and Table 4). Occasional periods of high pH (usually in summer or fall) have occurred in Cell E-West and E, where water enters the cells directly from the wastewater treatment plant, reflecting increased algal photosynthesis responding to nutrient loading. However, as water flows through the system, nutrients are sequestered by plants, reducing algal photosynthesis (expressed as lower pH). Interestingly, this also occurred in Cell D during the first few years, but as that wetland community matured, algal blooms and high pH have declined, indicating that the wetland is now absorbing nutrients as they enter the system.

| Table 4. Water quality (temperature, pH, dissolved oxygen, and conductivity) remained suitable for plants and aquatic wildlife during 2012. | | | | | |
|---|---|---|---|---|---|
| **Sample site** | **Season** | **Temp (C)** | **pH units** | **DO mg/L** | **Conductivity mS/cm** |
| D inlet | Spring | 30.7 | 8.3 | 7.9 | 0.579 |
| | Summer | 24.0 | 7.9 | 8.4 | 0.669 |
| | Fall | 9.7 | 6.8 | 15.1 | 0.732 |
| D outlet | Spring | 30.2 | 9.3 | 10.2 | 0.507 |
| | Summer | 25.1 | 8.4 | 10.3 | 0.664 |
| | Fall | 8.3 | 7.8 | 16.4 | 0.714 |
| E-West inlet | Spring | 30.7 | 8.9 | 8.2 | 0.390 |
| | Summer | 24.5 | 8.8 | 9.9 | 0.619 |
| | Fall | 8.3 | 7.9 | 9.2 | 0.706 |
| E-West outlet | Spring | 31.8 | 8.9 | 8.6 | 0.391 |
| | Summer | 24.3 | 9.1 | 11.3 | 0.591 |
| | Fall | 8.6 | 7.9 | 9.2 | 0.702 |
| E inlet | Spring | 32.2 | 8.9 | 8.9 | 0.549 |
| | Summer | 23.9 | 7.3 | 6.1 | 0.665 |
| | Fall | 9.8 | 7.9 | 15.5 | 0.736 |
| E outlet | Spring | 29.6 | 8.9 | 8.0 | 0.547 |
| | Summer | 23.7 | 7.6 | 8.4 | 0.663 |
| | Fall | 9.4 | 7.9 | 12.5 | 0.741 |
| F-North inlet | Spring | 30.4 | 7.7 | 7.4 | 0.307 |
| | Summer | 24.8 | 7.9 | 6.4 | 0.161 |
| | Fall | 8.1 | 8.0 | 10.2 | 0.255 |
| F-North outlet | Spring | 31.4 | 8.0 | 5.4 | 0.344 |
| | Summer | 24.1 | 7. 9 | 7.9 | 0.374 |
| | Fall | 7.8 | 7.9 | 7.9 | 0.374 |
| F (West) inlet | Spring | 30.5 | 8.9 | 8.7 | 0.454 |
| | Summer | 23.1 | 8.5 | 6.8 | 0.685 |
| | Fall | 8.1 | 7.9 | 10.3 | 0.751 |
| F (West) outlet | Spring | 29.5 | 8.7 | 8.0 | 0.482 |
| | Summer | 23.8 | 8.8 | 8.8 | 0.687 |
| | Fall | 7.7 | 7.9 | 10.9 | 0.757 |
| F (East) inlet | Spring | 28.7 | 8.7 | 7.9 | 0.526 |
| | Summer | 23.8 | 8.8 | 9.7 | 0.69 |
| | Fall | 7.8 | 7.9 | 10.4 | 0.747 |
| F (East) outlet | Spring | 28.1 | 8.6 | 7.6 | 0.527 |
| | Summer | 23.1 | 8.1 | 10.0 | 0.647 |
| | Fall | 7.5 | 7.9 | 8.6 | 0.748 |
| G inlet | Spring | 28.4 | 8.7 | 8.8 | 0.417 |
| | Summer | 22.6 | 8.6 | 7.7 | 0.65 |
| | Fall | 7.8 | 7.9 | 10.1 | 0.745 |
| G outlet | Spring | 29.7 | 8.4 | 6.4 | 0.420 |
| | Summer | 22.4 | 8.1 | 8.1 | 0.660 |
| | Fall | 7.5 | 7.9 | 12.3 | 0.745 |
| ***Mean*** | | **20.7** | **8.3** | **9.3** | **0.580** |

Water quality in the LCOW has stabilized somewhat as the system has matured between 2009 and 2012 (Table 5). While temperature and DO fluctuations are often associated with weather patterns as much as other factors, pH and conductivity more accurately reflect biological activity occurring in the water. Both pH and conductivity have leveled out during the past several years, and algal blooms frequency and intensity have declined. Although data is limited by quantity and temporally, it appears that equilibrium is being reached reflecting the stable state of the wetland cells. It is of particular interest that drought conditions occurred during both 2011 and 2012, requiring that pumping time be increased to maintain water levels in the cells. However, only slight changes in pH or conductivity accompanied the additional nutrient input, indicating the system's ability to absorb additional nutrients without detriment.

**Table 5. Average LCOW-wide water quality (temperature, pH, dissolved oxygen, and conductivity) measured in spring, summer, and fall, appear to have stabilized and fall within acceptable parameters for aquatic wildlife.**

| Year | Temp (*C) | pH units | DO mg/L | Conductivity mS/cm |
|---|---|---|---|---|
| **2009** | 20.8 | 8.8 | 11.2 | 0.451 |
| **2010** | 23.8 | 8.1 | 8.5 | 0.530 |
| **2011** | 22.9 | **8.3** | 10.0 | 0.641 |
| **2012** | 20.7 | 8.4 | 9.3 | 0.580 |
| | | | | |
| **Mean of means** | **22.1** | **8.3** | **9.8** | **.550** |

## Overbanking and sedimentation

The Trinity River overbanks an average of three to four times per year at the LCOW, with the most notable events occurring in June 2007 (6 weeks) and September 2010 (Table 6). During those events, silt is deposited in the wetland cells and surrounding areas, particularly when overbanking lasts for an extended period of time. In addition to overbanking that occurs during Major (40-ft crest), Moderate (38-ft crest), and Minor (30-ft crest) Flood Stages of the Trinity River (overbanking begins when the river crests at about 33-ft), periods of high flow before and after flood stages causes backflows into the outlet at Cell D, the outlet and cut at Cell F-West, and the outlet and cut at Cell F-North. Our observations suggest that this begins as soon as the river crests at near 30-ft (Minor Flood Stage), several feet lower than crests needed for full overbanking to occur. While all flood stages have the potential to deposit sediments in the LCOW, Cell D, E-West, and F-North are perhaps the most vulnerable due to longer periods of time at which the river exceeds Minor Flood Stage. For instance, during the September 2010 overbanking event, full overbanking occurred over an approximate three-day period, but Cells D, E-West, and F-North received river water over almost four days (Figure 18).

**Table 6. Historical crests for Trinity River, Dallas, TX since January 2007.**

| Date | Historical crests (ft) | Flood stage | Effect on LCOW |
|---|---|---|---|
| Jan-07 | 34.29 | Minor | Full overbank |
| Apr-07 | 35.71 | Minor | Full overbank |
| Jun-07 | 40.25 | Major | Full overbank |
| Jul-07 | 32.06 | Minor | Flow into D, E-West, and F-North |
| Sep-07 | 34.21 | Minor | Full overbank |
| Oct-07 | 31.63 | Minor | Flow into D, E-West, and F-North |
| Mar-08 | 37.52 | Moderate | Full overbank |
| Apr-08 | 33.02 | Minor | Partial overbank |
| Nov-08 | 31.96 | Minor | Flow into D, E-West, and F-North |
| Mar-09 | 31.87 | Minor | Flow into D, E-West, and F-North |
| May-09 | 33.29 | Minor | Partial overbank |
| Jun-09 | 38.19 | Moderate | Full overbank |
| Sep-09 | 38.55 | Moderate | Full overbank |
| Oct-09 | 37.14 | Minor | Full overbank |
| Jan-10 | 35.92 | Minor | Full overbank |
| Feb-10 | 34.28 | Minor | Full overbank |
| Mar-10 | 30.41 | Minor | Flow into D, E-West, and F-North |
| Sep-10 | 41.39 | Major | Full overbank |
| May-11 | 31.99 | Minor | Flow into D, E-West, and F-North |
| Jan-12 | 38.30 | Moderate | Full overbank |
| Feb-12 | 31.34 | Minor | Flow into D, E-West, and F-North |
| Mar-12 | 38.25 | Moderate | Full overbank |
| Jan-13 | 33.35 | Minor | Partial overbank |

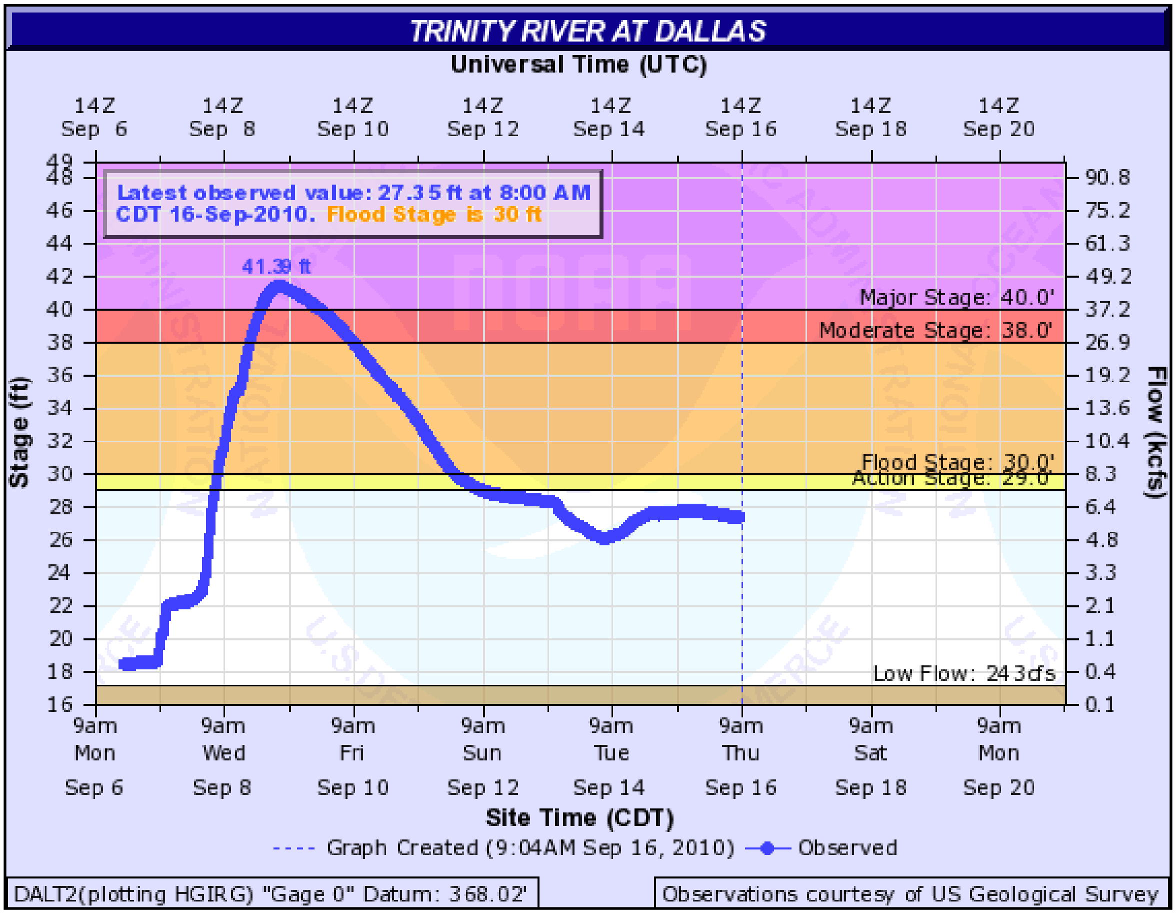


**Figure 18. USGS Trinity River gage data for the mid-September, 2010 overbanking event at the LCOW.**

SWF requested that ERDC periodically measure sedimentation rates in the LCOW cells beginning in 2008. Since that time, water depth measurements have since been recorded along permanent, GPS-marked transects (three to seven per cell evenly distributed along each cell's length). Water surface elevation is recorded for each cell using weir box elevation data, with depths subtracted to calculate cell bottom elevations at each measured point. Depth measurements are made twice-yearly, in spring and fall, unless conditions (e.g., overbanking) preclude safe access to the cells (Figure 19).

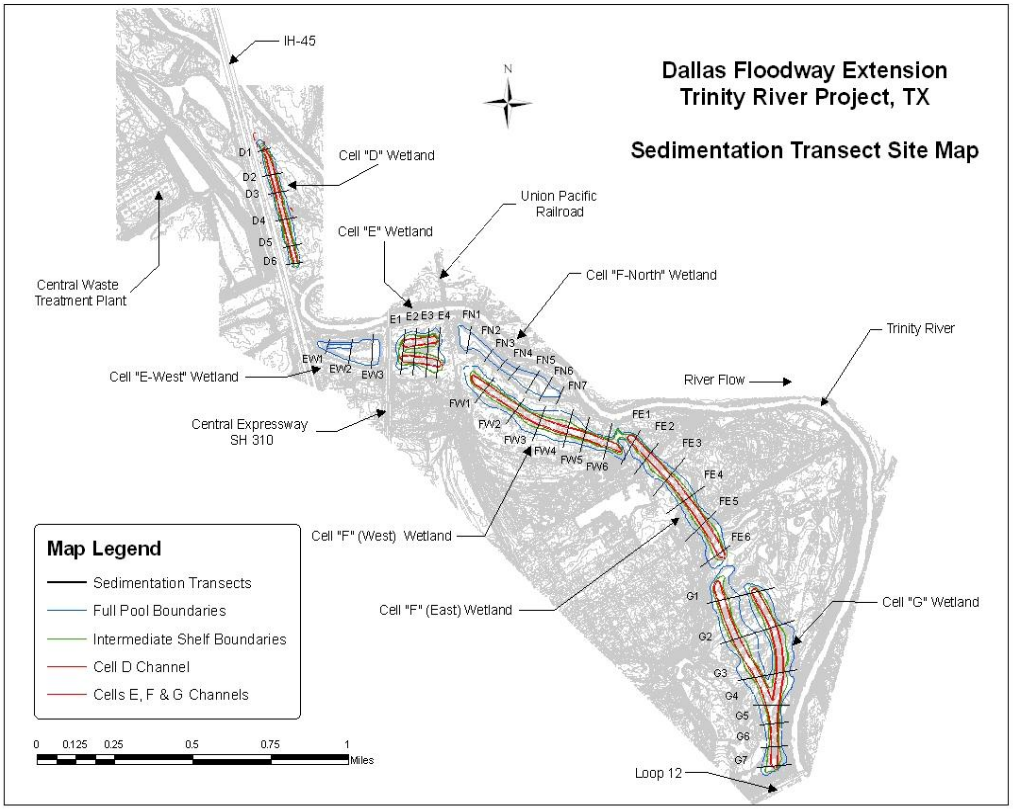


**Figure 19. LCOW sedimentation transect site map. Transects are symbolized by the wetland cell letter and transect number north-to-south or west-to-east (i.e., the northernmost transect in Cell D is designated as D1).**

Depth readings were taken beginning in 2008 (Cell D) or 2009 (remaining LCOW cells) and were continued through FY2012. Data presented here reflect initial measurements taken in 2008 (Cell D) and 2009 (all other cells) and in summer 2012 (Tables 7 through 13). Other measurements made during the project are given in Appendix C.

**Table 7. Elevation (ASL in feet) calculated from depths taken along six transects in Cell D in 2008 (baseline) and 2012.**

| Transect D1 | | Transect D2 | | Transect D3 | |
|---|---|---|---|---|---|
| **2008** | **2012** | **2008** | **2012** | **2008** | **2012** |
| 388.05 | 389.61 | 387.89 | 389.61 | 388.05 | 389.61 |
| 385.36 | 389.01 | 384.77 | 389.28 | 384.61 | 385.34 |
| 384.77 | 386.00 | 384.11 | 386.65 | 384.11 | 386.00 |
| 385.59 | 386.98 | 384.77 | 385.01 | 384.77 | 388.95 |
| 387.79 | 389.28 | 387.89 | 389.61 | 387.79 | 389.61 |
| **Transect D4** | | **Transect D5** | | **Transect D6** | |
| **2008** | **2012** | **2008** | **2012** | **2008** | **2012** |
| 387.89 | 389.93 | 388.05 | 389.77 | 388.05 | 389.61 |
| 384.61 | 388.29 | 384.77 | 385.01 | 386.25 | 387.64 |
| 384.11 | 385.34 | 384.11 | 385.01 | 385.92 | 386.33 |
| 384.77 | 385.01 | 384.41 | 385.67 | 386.41 | 388.29 |
| 387.79 | 389.28 | 387.72 | 389.61 | 388.22 | 389.61 |

**Table 8. Elevation (ASL in feet) calculated from depths taken along three transects in Cell E-West in 2009 (baseline) and 2012.**

| Transect EW1 | | Transect EW2 | | Transect EW3 | |
|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 383.75 | 383.024 | 382.43 | 382.86 | 383.35 | 383.68 |
| 380.96 | 381.22 | 382.83 | 378.10 | 380.43 | 379.18 |
| 381.22 | 381.38 | 377.15 | 376.79 | 376.3 | 376.79 |
| 382.14 | 381.48 | 377.94 | 377.25 | 375.71 | 376.46 |
| 383.35 | 383.35 | 383.35 | 383.51 | 375.81 | 376.95 |
| | | | | 376.37 | 376.79 |
| | | | | 379.12 | 376.95 |
| | | | | 382.17 | 383.18 |

**Table 9. Elevation (ASL in feet) was calculated from depths taken along four transects in Cell E in 2009 (baseline) and 2012.**

| Transect E1 | | Transect E2 | | Transect E3 | | Transect E4 | |
|---|---|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 387.54 | 385.86 | 387.67 | 386.12 | 387.57 | 386.25 | 387.54 | 386.12 |
| 386.03 | 385.26 | 386.23 | 383.07 | 385.93 | 383.20 | 382.82 | 382.71 |
| 382.36 | 381.92 | 382.65 | 382.61 | 382.59 | 382.61 | 381.96 | 382.74 |
| 382.33 | 382.08 | 382.59 | 382.74 | 382.49 | 382.41 | 386.36 | 386.25 |
| 382.29 | 381.92 | 382.49 | 382.58 | 382.42 | 382.90 | 386.59 | 386.18 |
| 386.10 | 382.41 | 386.23 | 386.02 | 382.75 | 381.98 | 381.77 | 383.30 |
| 387.57 | 385.89 | 387.67 | 386.25 | 387.54 | 386.45 | 382.71 | 383.40 |
| 387.21 | 386.02 | 387.51 | 386.08 | 387.57 | 385.92 | 387.34 | 386.51 |
| 386.43 | 386.02 | 386.29 | 384.81 | 386.20 | 385.86 | | |
| 382.03 | 382.90 | 382.42 | 381.59 | 382.16 | 382.18 | | |
| 381.44 | 382.64 | 382.26 | 381.59 | 381.77 | 382.08 | | |
| 382.00 | 381.30 | 382.16 | 381.59 | 381.77 | 381.98 | | |
| 382.42 | 383.40 | 382.42 | 381.92 | 382.10 | 381.53 | | |
| 387.67 | 386.02 | 382.03 | 381.59 | 387.54 | 386.25 | | |
| | | 387.67 | 386.25 | | | | |

**Table 10. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (West) in 2009 (baseline) and 2012.**

| Transect FW1 | | Transect FW2 | | Transect FW3 | | Transect FW4 | | Transect FW5 | | Transect FW6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 386.34 | 385.12 | 386.67 | 385.45 | 386.41 | 385.18 | 386.31 | 385.35 | 386.51 | 384.86 | 386.61 | 385.74 |
| 384.97 | 384.43 | 384.90 | 384.53 | 385.52 | 385.22 | 385.23 | 384.63 | 385.36 | 383.41 | 385.43 | 383.48 |
| 381.1 | 381.21 | 380.28 | 382.89 | 380.67 | 380.92 | 384.70 | 384.46 | 380.51 | 380.69 | 380.47 | 381.21 |
| 381.03 | 380.89 | 380.60 | 380.59 | 380.87 | 380.85 | 381.33 | 381.02 | 380.77 | 380.66 | 381.36 | 380.98 |
| 381.03 | 380.95 | 380.93 | 380.59 | 380.83 | 380.85 | 380.64 | 380.89 | 380.93 | 380.33 | 380.87 | 380.66 |
| 381.85 | 381.08 | 380.55 | 380.66 | 385.36 | 384.86 | 380.64 | 380.76 | 382.57 | 380.23 | 380.90 | 381.25 |
| 385.56 | 383.87 | 386.08 | 383.54 | 385.2 | 385.08 | 385.10 | 384.82 | 385.03 | 383.97 | 384.74 | 382.82 |
| 386.7 | 385.22 | 386.51 | 385.18 | 386.34 | 385.45 | 386.57 | 385.51 | 386.51 | 385.64 | 386.57 | 385.51 |

**Table 11. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (East) in 2009 (baseline) and 2012.**

| Transect FE1 | | Transect FE2 | | Transect FE3 | | Transect FE4 | | Transect FE5 | | Transect FE6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 386.02 | 385.77 | 386.21 | 385.12 | 386.02 | 385.12 | 386.51 | 384.76 | 386.05 | 384.43 | 386.34 | 385.18 |
| 385.26 | 384.99 | 384.74 | 383.22 | 385.26 | 384.86 | 384.70 | 382.40 | 385.16 | 382.89 | 384.77 | 384.53 |
| 385.29 | 384.99 | 380.47 | 380.82 | 380.50 | 382.56 | 380.93 | 380.92 | 381.36 | 380.89 | 381.10 | 382.00 |
| 385.13 | 384.76 | 380.93 | 380.59 | 380.77 | 380.26 | 380.18 | 380.79 | 382.74 | 381.77 | 380.34 | 381.90 |
| 385.13 | 384.86 | 381.1 | 380.98 | 380.77 | 380.62 | 382.67 | 381.25 | 380.77 | 380.59 | 379.46 | 380.92 |
| 384.44 | 384.79 | 382.74 | 381.90 | 381.10 | 380.92 | 380.22 | 382.89 | 381.10 | 380.26 | 379.50 | 380.95 |
| 384.97 | 384.86 | 384.02 | 382.56 | 385.52 | 383.87 | 385.10 | 384.56 | 384.97 | 381.25 | 385.03 | 383.22 |
| 386.34 | 385.22 | 386.21 | 384.53 | 386.31 | 384.53 | 386.18 | 384.72 | 386.51 | 385.12 | 385.26 | 384.99 |

**Table 12. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell F-North in 2009 (baseline) and 2012.**

| Transect FN1 | | Transect FN2 | | Transect FN3 | | Transect FN4 | | Transect FN5 | | Transect FN6 | | Transect FN7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 382.51 | 382.79 | 382.51 | 382.59 | 382.74 | 383.18 | 382.31 | 383.02 | 382.61 | 382.86 | 382.48 | 383.18 | 382.34 | 382.89 |
| 380.61 | 377.54 | 382.18 | 381.54 | 382.15 | 382.69 | 381.46 | 381.54 | 381.29 | 381.71 | 381.52 | 381.87 | 379.06 | 380.83 |
| 378.05 | 377.34 | 382.18 | 381.87 | 382.48 | 383.35 | 382.57 | 383.18 | 382.41 | 383.18 | 382.61 | 383.51 | 376.28 | 377.94 |
| 377.00 | 378.56 | 381.95 | 381.28 | 382.54 | 383.38 | 382.61 | 383.35 | 382.67 | 382.86 | 382.48 | 383.25 | 376.28 | 377.12 |
| 377.88 | 378.43 | 381.59 | 381.15 | 380.77 | 380.59 | 381.43 | 379.90 | 380.70 | 380.56 | 379.85 | 378.26 | 376.60 | 377.02 |
| 378.74 | 377.87 | 382.54 | 382.59 | 382.57 | 382.20 | 378.74 | 376.30 | 376.18 | 376.62 | 376.77 | 376.62 | 381.20 | 380.07 |
| 379.72 | 377.874 | | | | | 377.88 | 376.69 | 376.11 | 376.30 | 376.44 | 376.30 | 382.51 | 382.50 |
| 381.36 | 381.15 | | | | | 379.82 | 380.17 | 375.85 | 377.67 | 376.44 | 376.62 | | |
| 382.67 | 382.36 | | | | | 381.66 | 381.05 | 378.08 | 377.90 | 379.85 | 379.51 | | |
| | | | | | | 382.74 | 381.87 | 377.91 | 377.61 | 382.67 | 382.794 | | |
| | | | | | | 383.29 | 383.18 | 380.61 | 379.05 | | | | |
| | | | | | | | | 383.59 | 383.35 | | | | |

**Table 13. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell G in 2009 (baseline) and 2012.**

| Transect G1 | | Transect G2 | | Transect G3 | | Transect G4 | | Transect G5 | | Transect G6 | | Transect G7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 | 2009 | 2012 |
| 382.69 | 382.61 | 382.62 | 383.01 | 382.62 | 384.15 | 382.75 | 384.09 | 382.03 | 383.86 | 382.03 | 384.09 | 383.70 | 384.06 |
| 380.20 | 379.83 | 380.20 | 379.79 | 380.33 | 380.48 | 380.06 | 380.28 | 380.06 | 380.25 | 379.97 | 380.97 | 379.67 | 381.14 |
| 380.06 | 380.19 | 380.16 | 378.28 | 380.10 | 380.35 | 380.13 | 379.86 | 378.10 | 379.33 | 379.80 | 379.83 | 379.60 | 380.48 |
| 382.52 | 379.99 | 382.69 | 382.94 | 382.56 | 383.11 | 379.77 | 380.42 | 379.93 | 379.83 | 380.10 | 379.76 | 377.77 | 380.15 |
| 382.03 | 383.11 | 382.56 | 383.11 | 382.52 | 383.79 | 382.82 | 383.50 | 382.82 | 384.22 | 382.69 | 383.76 | 379.41 | 384.06 |
| 381.05 | 379.66 | 380.06 | 380.02 | 380.03 | 379.96 | | | | | | | | |
| 380.42 | 379.20 | 378.88 | 379.50 | 380.25 | 379.83 | | | | | | | | |
| 380.89 | 380.32 | 382.52 | 382.91 | 383.38 | 382.42 | | | | | | | | |
| 381.89 | 383.76 | | | | | | | | | | | | |

Despite several overbanking events per year, and notably the long-term overbanking that occurred during the summer of 2007 and extensive overbanking in 2010, few of the LCOW cells appear to be filling with sediments at significant rates (Table 14). On the contrary, some cells (E-West, E, F (West), and F (East)) appear to have deepened slightly on average, likely the result of scouring occurring during overbanking events. Cell D, the oldest cell at 9 years since construction was completed, has shown the greatest sediment build up, averaging about 1/5$^{th}$ foot sedimentation per year, with buildup occurring throughout the cell. One explanation for greater sedimentation rates in Cell D is its position relative to flow: when the Trinity River overbanks, water flow is perpendicular to the length of this cell, whereas flow over other cells is generally parallel to their lengths. While portions of all cells can serve as sediment traps, especially where elevations change significantly, flow rates of water is altered, provide opportunity for sediment deposition. Cell D's orientation results in a larger portion of the cell (its entire length) subject to this occurrence compared with other cells (upstream and downstream widths, or "ends"). Build up of sediments that has occurred in other cells is most notable in these areas, and particularly near the Cell F (West) to Cell F (East) dividing rip-par and culvert, the Cell F (East) outlet, and Cell G outlet.

**Table 14. Mean changes in elevation (in feet) between baseline observations and 2012 observations in the LCOW.**

| Wetland cell | Transects | | | | | | | Total cell | Annual sedimentation rate |
|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **Mean (ft)** | **Mean (ft)** |
| D | 1.87 | 2.15 | 2.04 | 1.74 | 1.21 | 1.33 | | 1.72 | +0.19 |
| E- West | -0.19 | -2.08 | 0.09 | | | | | -0.59 | -0.15 |
| E | -1.00 | -1.18 | -1.47 | 0.23 | | | | -0.99 | -0.20 |
| F -North | -0.51 | -0.31 | 0.22 | -0.38 | 0.14 | 0.09 | 0.59 | 0.03 | +0.01 |
| F (West) | -1.14 | -0.07 | -0.34 | -0.38 | -1.59 | -1.09 | | -0.87 | -0.17 |
| F (East) | -0.29 | -0.83 | -0.98 | -1.07 | -1.87 | -0.29 | | -0.89 | -0.18 |
| G | -0.34 | -0.01 | 0.29 | 0.53 | 0.91 | 0.77 | 1.95 | 0.44 | +0.09 |

While the primary source of sediment deposition in the cells is most likely from overbanking events, movement of soil during erosion of grassland areas may play a role in areas where sediment deposits have been observed. Washing out of unvegetated shorelines has occurred during windy days, and grassland soils are carried into the cells during most heavy rain events and in some areas during overbanking events. In 2005, this was highly evident along portions of Cell D prior to establishment of grassland cover crops (winter rye) and wetland vegetation along the shoreline, and was similarly evident in the remaining LCOW in 2009 following construction. However, once grassland plants were established, this type of erosion became less significant, with cover crops holding topsoils in place. Additionally, soil that did wash towards the cell was caught by plants established along the shoreline; at the same time, shoreline plants have minimized shoreline erosion due to wave action.

Cells that are filling in with sediments at highest rates include Cell D and Cell G. Based upon sedimentation rates calculated over 9 years (Cell D) and 5 years (Cell G), preliminary predictions can be made when sedimentation will fill the channels in each of these cells. At that time, the greatest depths in the cells will be 3-ft, the maximum depth to which the each of the cells can be drained using their weir gate boxes. At current rates of sedimentation, the Cell D channel will be filled in approximately 12 years, and the Cell G channel in approximately 40 years, at which times decisions will have to be made regarding any need to dredge materials to recover some functions of each cell. While flood conveyance will not be affected, ecosystem function will change in response to sedimentation. It remains to be seen whether or not those changes will be positive or negative, and whether or not they can be incorporated into the overall LCOW ecosystem management strategies.

## Armored areas plantings

Several areas prone to erosion were identified by SWF and ERDC in 2009: the outfall from Cell F to Cell G and the outfall from Cell G into Honey Springs Branch (Figures 20 and 21); additionally, water flowing into Cells E-West and F-North just prior to and during overbanking by the Trinity River had caused some erosion problems (Figures 22 and 23). And, finally, areas adjacent to hard-armored slopes of the Trinity River just below the IH-45 Bridge were deemed of concern (Figure 24). SWF contracted repairs of hard armored areas at the Cell F to G outfall (2009), the Cell G outfall (2010) and the riverbank (2009). Following repairs, SWF took additional measures by engaging ERDC to plant an array of plants, both terrestrial and wetland (Table 15), to improve performance of armoring at these sites as well as at cuts associated with Cell E-West and Cell F-North. Large-scale plantings at these sites were conducted in 2010 and 2011, with supplemental plantings made as-needed in 2012.

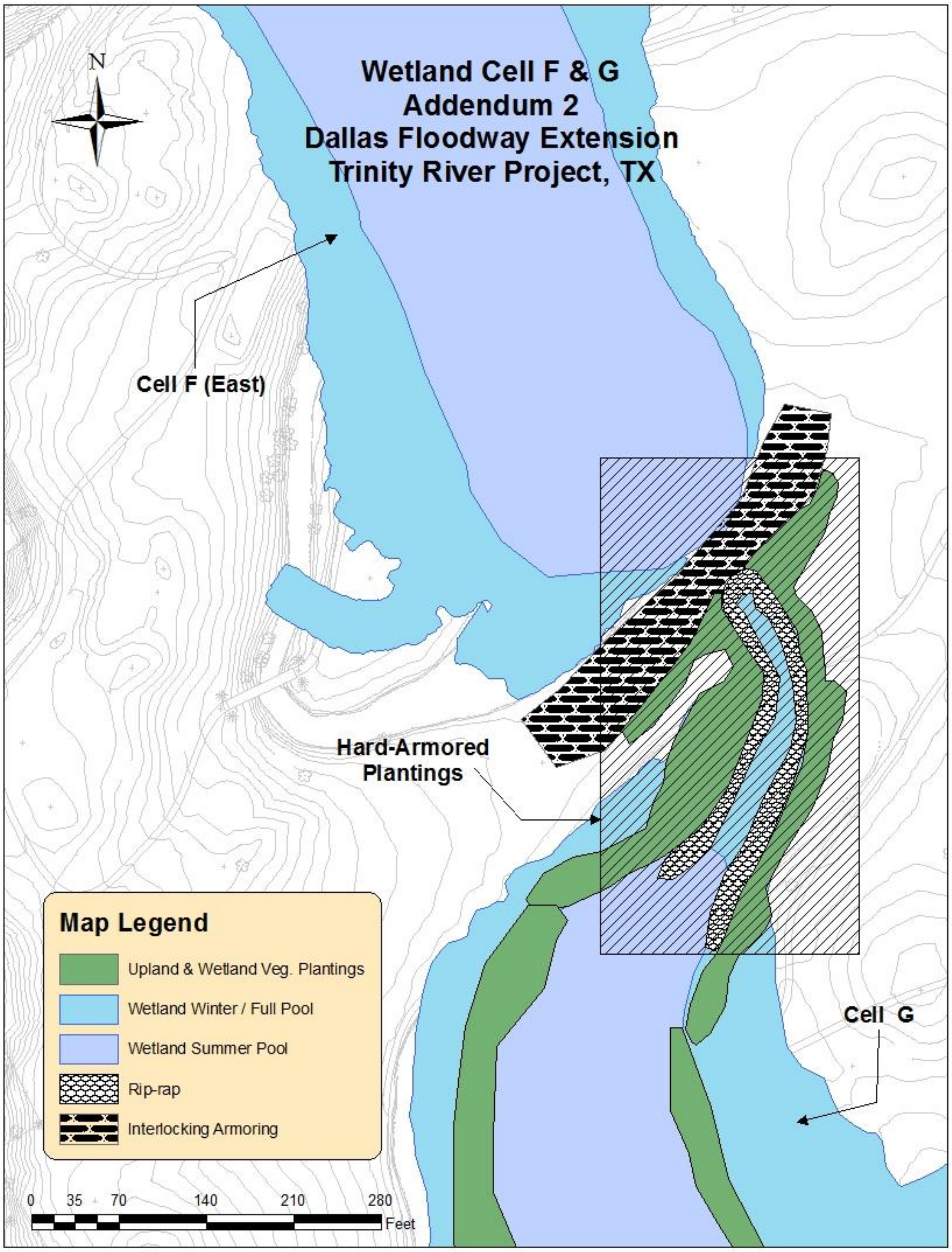


**Figure 20. Hard armored areas at the outfall of Cell F into Cell G have been planted to improve performance of armoring. Plantings were initiated in 2010 and completed in 2012.**

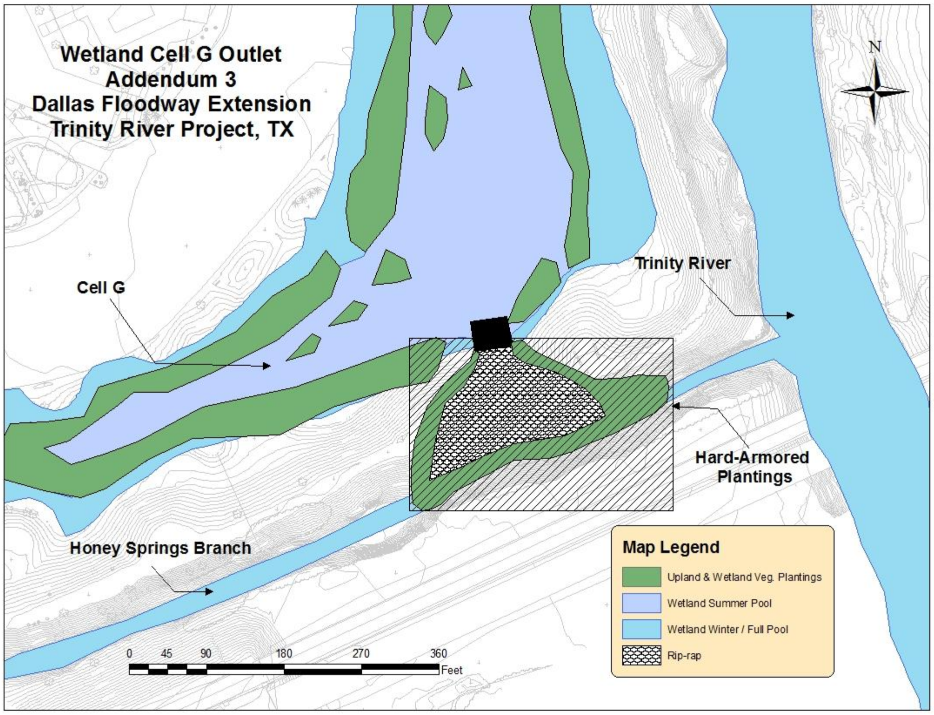


**Figure 21. Hard armored areas at the outfall of Cell G were planted to improve performance of armoring. Plantings were initiated in 2011 following completion of repairs and completed in 2012.**

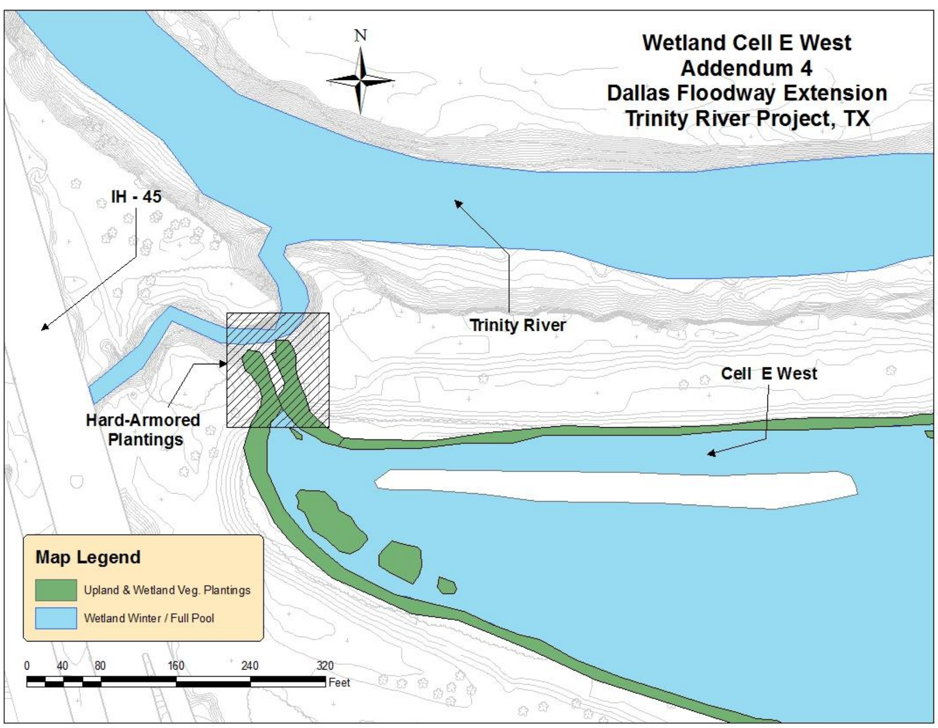


**Figure 22. A moderately hard armored cut at the northwest corner of Cell E-West was planted to improve performance of armoring and reduce overall erosion. Plantings were initiated in 2010 and completed in 2012.**

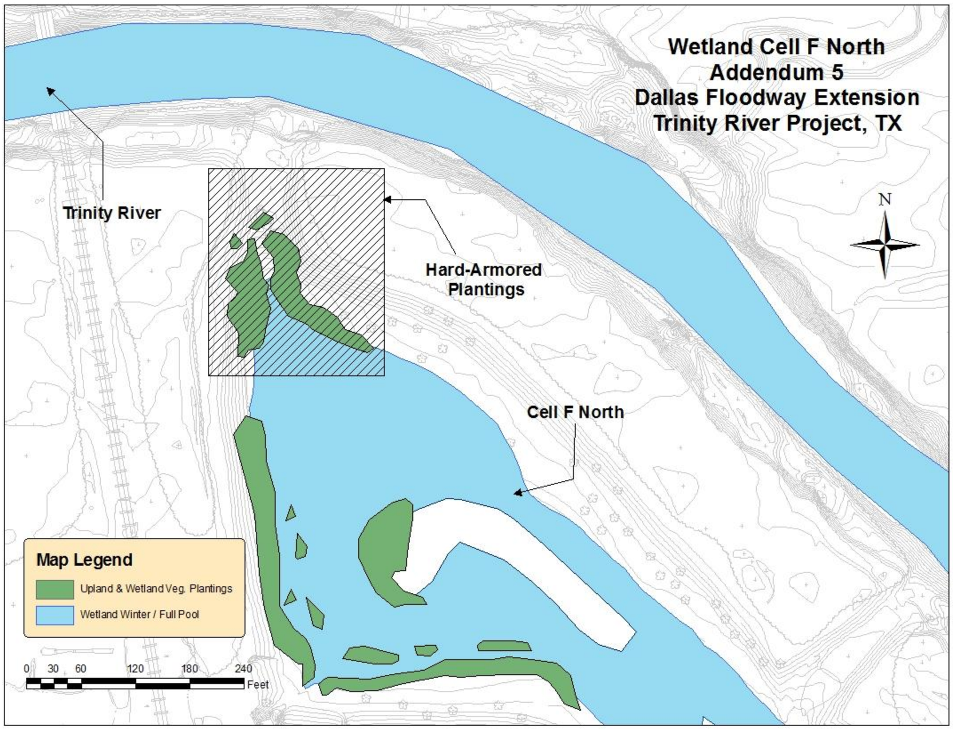


**Figure 23. A moderately hard armored cut at the northwest side of Cell F-North was planted to improve performance of armoring and reduce overall erosion. Plantings were initiated in 2010 and completed in 2012.**

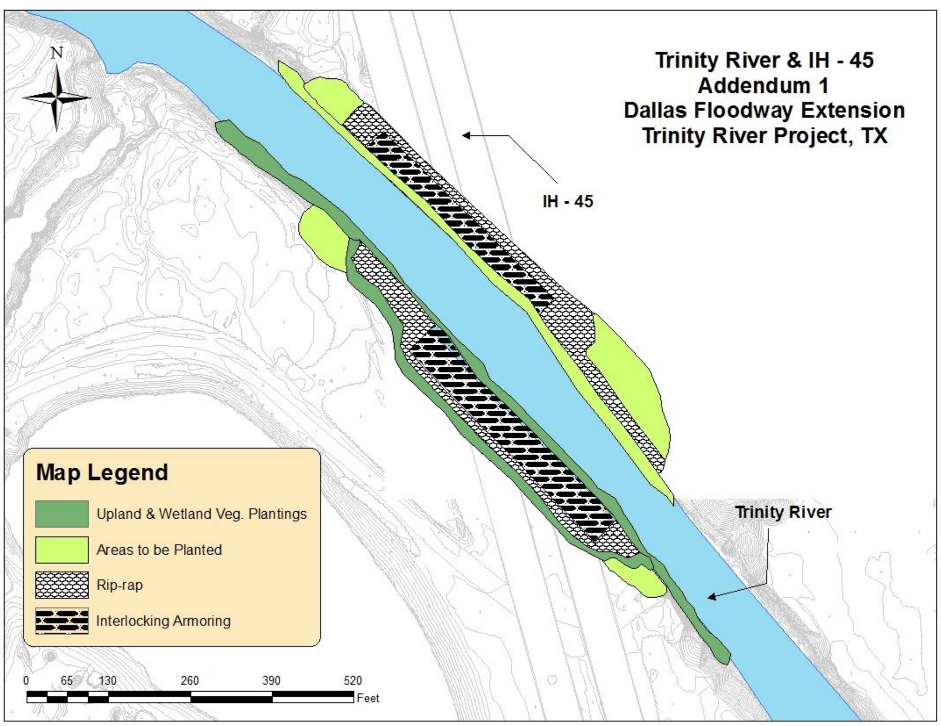


**Figure 24. Hard armored areas along the river channel below the IH-45 bridge have been planted to improve performance of armoring. Plantings were initiated in 2010 and will continue through 2013. Additional planting is required to compensate for damage to plantings made by repeated erroneous mowing.**

**Table 15. Native plants were installed around several hard-armored areas at the LCOW to improve performance of erosion control.**

| Species | Common name | Growth form | Established |
|---|---|---|---|
| *Ampelopsis arborea* | Peppervine | Woody vine | Yes |
| *Ampelopsis cordata* | Heart-leaf peppervine | Woody vine | No |
| *Bacopa monnieri* | Water hyssop | Perennial herb | Yes |
| *Callirhoe involucrata* | Winecup | Perennial herb | Yes |
| *Campsis radicans* | Trumpet creeper | Woody vine | Yes |
| *Carex cherokeensis* | Cherokee sedge | Perennial sedge | Yes |
| *Eleocharis* (3+ spp.) | Spikerushes | Perennial rush | Yes |
| *Glandularia bipinnatifida* | Prairie vervain | Perennial herb | Yes |
| *Hibiscus* (2+ spp.) | Mallows | Shrub | No |
| *Juncus effusus* | Needle-rush | Perennial rush | Yes |
| *Justicia americana* | Waterwillow | Perennial herb | Yes |
| *Malvaviscus drummondii* | Turk's cap | Shrub | Yes |
| *Panicum obtusum* | Vine mesquite | Perennial grass | Yes |
| *Passiflora incarnata* | Passion flower | Woody vine | No |
| *Phyla nodiflora* | Frog-fruit | Perennial herb | Yes |
| *Schoenoplectus* (3+ spp.) | Bulrushes | Perennial rush | Yes |
| *Smilax (*2+ spp.) | Green briar | Woody vine | Yes |
| *Vitis mustangensis* | Mustang grape | Woody vine | Unknown |

**Results to date:** Plant production began at LAERF in FY2010, with test plantings conducted at all sites later in the year except for the Cell G outfall, which was under construction. Planting was intiated at the Cell G outfall and continued at other areas during FY2011 and FY201. Plantings were made in summer, fall, winter, and spring to evaluate species selection and timing of establishment. Fall and winter plantings were the most successful, with peppervine (*Ampelopsis arborea*), trumpet creeper (*Campsis radicans*), winecup (*Callirhoe involucrata*), prairie vervain (*Glandularia bipinnatifida*), vine mesquite (*Panicum obtusum*), and frog-fruit (*Phyla nodiflora*) establishing well along higher elevation rip-rap areas at all sites. Likewise, waterwillow, spikerushes, and frog-fruit established well near the water's edge, particularly in the rip-rap along the river's shoreline. However, repeated mowing (4 times observed) of plants along the river, including weed whacking of plants in the rip-rap at the river's edge, resulted in poor establishment performance of some individual plants in that area. Despite this damage, a large portion of the plants did survive (estimated at 70%), but growth was limited. ERDC has worked with the City of Dallas and provided no-mow area instructions, and began replanting areas damaged by mowing in FY2012. While the intense heat and drought of both 2011 and 2012 may have contributed to setting plants back at all sites, recovery of most had occurred by mid-fall (except under the I-45 overpass, where recovery was low). It is anticipated that growth and spread will resume in spring 2013, with minimal supplemental planting required to ensure vegetation establishment is complete along the river and the outfalls of Cell F and Cell G. At the time of this report, additional planting does not appear to be required at the cuts at Cell E-west and F-north.

## Biological monitoring

ERDC began monitoring fish and macro-invertebrate populations in 2008 along the stretch of modified Trinity River just north of Cell D at IH-45, Cell D, and the other LCOW cells following their filling in 2009. Collection sites were selected and marked (GPS) as permanent monitoring stations for development of a baseline for existing populations. In the river, one station was within an area in which erosion control rip-rap and additional bank armoring has since been installed (under IH–45), one station was 200-ft upstream, and one station was 200-ft downstream of the rip-rap area. Two sampling stations were established in each of the wetland cells, one near the inflow (Site 1) and one near the outflow (Site 2). Cell F was treated as two separate cells for fish and macro-invertebrate sampling: F (West) and F (East). Fish were collected with backpack electrofishing equipment, identified to the species level and counted in the field, and then released. Species richness (the number of different species identified) was calculated for fish surveys. All fishery sample data collected from the LCOW are given in Appendix D.

Macro-invertebrates were collected with a sweep net (three samples per site), preserved in the field, and returned to the lab for identification (to Family or Genus) and enumerated. After addition of rip-rap to the river, macro-invertebrates were sampled by brushing them off rocks into a downstream collection net. In addition, three rip-rap samples were taken back to the lab and macro-invertebrates were rinsed off, collected and sorted. Simpson Diversity Indices (SDI) were calculated for macro-invertebrates, where lower numbers tend to indicate fewer species and individuals, and higher numbers indicate greater numbers of species and/or greater equitability between numbers of species present. Species evenness was calculated to evaluate relative abundance of species, which can be used as an indicator of ecosystem stability. Sampling was initiated in fall 2008, with only the river, Cell D, and Cell E sampled---other cells were still under construction at that time and not sampled. Twelve additional samplings have been conducted since that time (spring, summer, and fall 2009-2012) and results for all but fall 2012 macro-invertebrate samples are given in this report. All macro-invertebrate sample data collected from the LCOW are given in Appendices E, F, and G.

***Riverine Fish:*** Five species of fish were collected from the river prior to installation of bank armoring in fall 2008, including mosquitofish (*Gambusia affinis*), bluegills (*Lepomis macrochirus*), brook silversides (*Labidesthes sicculus*), blacktail shiners (*Cyprinella venusta*), and a single tadpole madtom (*Noturus gyrinus*) (Table 16). Mosquitofish were the dominant species collected, representing over 90% of individuals collected from all three sites. The upstream sample site (1) included riffles from a remnant bridge/culvert and supported the greatest species richness, including blacktail shiners, which represented 24% of the fish collected at that site. Sites under the bridge (2, now armored) and downstream from the bridge (3) had hardpan substrates with little structure and supported fewer fish species and numbers of individuals.

**Table 16. Five fish species were collected from the Trinity River near and under the IH-45 overpass during fall 2008 sampling, prior to river bottom and bank armoring. Site 1 is upstream from the bridge; Site 2 is the rip-rap area under the bridge; Site 3 is downstream from the bridge.**

| Sample site | Mosquitofish | Bluegill | Brook silverside | Blacktail shiner | Tadpole madtom | Species richness |
|---|---|---|---|---|---|---|
| **1** | 400 | 2 | 0 | 125 | 1 | 3 |
| **2** | 100 | 0 | 0 | 0 | 0 | 1 |
| **3** | 200 | 0 | 2 | 0 | 0 | 2 |

Fish sampling in the river was conducted again in spring 2009, with summer and fall sampling not conducted due to hazards using the backpack electrofisher in the rip-rap areas during moderately high flow conditions. While the same areas were sampled when flow permitted, actual sampling technique was altered due to addition of rip-rap at the base of the interlocking armoring along the bank of sampled areas. Instead of wading through shallows adjacent to the shoreline, observations of fish were made by walking along the armored shoreline and holding sampler electrodes out into the water. Fish collected in 2009 using these methods are given in Table 17. The fish assemblage had shifted from one dominated by mosquitofish, which prior to armoring had occupied quieter waters along the shorelines, to blacktail shiners, which occupied turbulent areas generated by flow over and between rip-rap below the bridge. Prior to armoring, highest species richness was observed at the upstream sample site, which was adjacent to riffles and a large, fallen tree. However, following armoring below the bridge, highest species richness shifted to Site 2, indicating that riffles and other habitat (e.g., gaps between rip-rap) created by the armoring benefitted more species in this section of the Trinity River.

**Table 17. Four fish species were collected from the Trinity River near and under the IH-45 overpass during spring 2009 sampling. Site 1 is upstream from the bridge; Site 2 is the rip-rap area under the bridge; Site 3 is downstream from the bridge.**

| Sample site | Mosquitofish | Bluegill | Redfin shiner | Blacktail shiner | Species richness |
|---|---|---|---|---|---|
| **1** | 0 | 0 | 1 | 23 | 2 |
| **2** | 2 | 1 | 3 | 53 | 4 |
| **3** | 1 | 0 | 0 | 57 | 2 |

Fish were sampled along the river during fall 2010; spring and summer samplings were not conducted during that year due to high flow conditions (Table 18). No fish were collected upstream (Site 1) or downstream (Site 3) from the bridge along the river's edge. Five species were collected from Site 2 below the bridge. Riffles, interstitial spaces between rip-rap, and overall structure provided by this area appeared to continue supporting fish relative to the bare upstream and downstream channel. While total numbers of fish collected during this sampling period were low, attributable to cool water temperatures (10° C) occurring at that time, species richness had increased from the previous year.

**Table 18. Five fish species were collected from the Trinity River near and under the IH-45 overpass during a fall 2010 sampling. Site 1 is upstream from the bridge; Site 2 is the rip-rap area under the bridge; Site 3 is downstream from the bridge.**

| Sample site | Largemouth bass | Bluegill | Warmouth | Blacktail shiner | Tadpole madtom | Species richness |
|---|---|---|---|---|---|---|
| **1** | 0 | 0 | 0 | 0 | 0 | 0 |
| **2** | 1 | 2 | 1 | 2 | 1 | 5 |
| **3** | 0 | 0 | 0 | 0 | 0 | 0 |

Because conditions during spring, summer, and fall sampling periods in 2011 were deemed unsuitable, a fish sampling was performed in winter 2011 (Table 19). While not directly comparable to other samplings, we conducted this sampling to verify earlier findings. This sampling resulted in the highest species richness collected during the project in the rip-rap areas below the bridge and included two species not previously collected from the river, log perch (*Percina caprodes*) and green sunfish (*Lepomis cyanellus*). Only a single species, the blacktail shiner, was collected from the other sites. This appears to confirm that the rip-rap area below the bridge is serving as suitable habitat for riffle-dependent and structure-dependent fisheries.

**Table 19. Six fish species were collected from the Trinity River near and under the IH-45 overpass during a winter 2011 sampling. Site 1 is upstream from the bridge; Site 2 is the rip-rap area under the bridge; Site 3 is downstream from the bridge.**

| Sample site | Log perch | Bluegill | Green sunfish | Mosquito-fish | Blacktail shiner | Redfin shiner | Species richness |
|---|---|---|---|---|---|---|---|
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2** | 2 | 4 | 1 | 1 | 29 | 1 | 6 |
| **3** | 0 | 0 | 0 | 0 | 4 | 0 | 1 |

No fish sampling was conducted in 2012 due to flow conditions. Late winter sampling will be made in 2013 if conditions permit. Additional sampling will be conducted in spring, summer and fall contingent upon safety.

***Riverine Macro-invertebrates:*** Two families of macro-invertebrates, both insects, were collected from the Trinity River and IH-45 in fall 2008, including water striders (Hemiptera: Gerridae) and whirligig beetles (Coleoptera: Gyrinidae). Both families primarily use the water surface for habitat. No benthic macro-invertebrates were collected from any site. Only water striders were collected from all sample sites. Macro-invertebrate numbers and diversity were low (richness of R = 2, evenness E = 0.772, and Simpson's diversity or D = 0.353) at all river sample sites, likely due to hard, relatively smooth substrates associated with each site. The upstream sample site that is adjacent to the riffles showed the highest diversity of fish, but that "close by" effect was not noted for macro-invertebrates. Overall, habitats (hard, smooth substrates in varying water flow velocities) in areas sampled were not suitable for colonization by many macro-invertebrates otherwise likely to be found in the river in the fall of 2008.

Six families of macro-invertebrates, all insects, were collected from the river in spring 2009 after the addition of rip-rap below the IH-45 bridge (R = 6, E = 0.296, D = 0.436). All macro-invertebrates collected were from rip-rap samples taken under the bridge (Site 2) while no macro-invertebrates were collected from upstream and downstream sites (1 and 3 respectively). Common netspinner caddisflies (Trichoptera: Hydropsychidae) (71.5%) and common midges (Diptera: Chironomidae) (22.3%) dominated the rip-rap samples, while three mayfly families (Ephemeroptera: Baetidae, Caenidae, Heptageniidae) (5.3%) as well as narrow-winged damselflies (Odonata: Coenagrionidae) (0.8%) were collected. Species collected in fall 2008 were not present at any of the sample sites in spring of 2009 after the rip-rap addition. This was attributed to seasonal changes or a transformation in stream ecology due to addition of rip-rap making a more lotic system with a lack of depositional environments more complimentary to species such as water striders and whirligig beetles. Both taxa richness and diversity improved from 2008 to 2009, while evenness declined due to the dominance of highly productive taxa such as Chironomidae and Hydropsychidae.

2010 macro-invertebrate sampling illustrated the continuance of this colonization dynamic due to hard-armoring and rip-rap additions. Taxa richness, evenness, and diversity increased from 2009 (R = 12, E = 0.384, D = 0.783). New taxa, including riffle beetles (Coleoptera: Elmidae), burrower mayflies, brushlegged mayflies (Ephemeroptera: Ephemeridae, Isonychiidae), dobsonflies (Megaloptera: Corydalidae), and longhorned caddisflies (Tricoptera: Leptoceridae) were all sampled for the first time. Sample site 2 remained similar to that of 2009, although increased in diversity and evenness as well as the riffle beetle population. Interestingly, Site 3, in which no individuals were detected in 2009, had the highest richness (R = 9) in 2010. This could be due to how the additions under IH-45 have changed the flow regime as well as added habitat structure, which is in turn developing suitable lotic and lentic macro-invertebrate habitat for colonization downstream.

Similar trends were observed in 2011 as in previous sampling periods, in that the primary location of taxa richness is from Site 2 or under the IH-45 overpass. This, as previously stated, is most likely because this sample site contains added rip-rap and has increased the macro-invertebrate refuge due to the enormity of interstitial spaces. New taxa collected during this sampling period included bladder snails (Physidae), leaf beetles (Chrysomelidae), and black flies (Simulidae). Diversity improved throughout each sample set and ranged from 0.754-0.849 compared to the 0.353-0.783 previously observed. Raw collection data and taxa richness, evenness, and diversity from Trinity River IH-45 samples from 2008-2011 are given in Appendix E.

2012 macro-invertebrate sampling of the Trinity River is given in Table 20. Site 2 (IH-45 rip-rap) remained the richest sampling site in terms of taxa. New taxa collected during this sampling period include longhorned caddisflies (Trichoptera: Leptoceridae), freshwater snails (Gastropoda: Pomatiopsidae), broad-shouldered water striders (Hemiptera: Veliidae), and basket clams (Bivalvia: *Corbicula sp.*). Hard-armoring still appears to have improved colonization for a greater number of macro-invertebrates with the increased diversity of habitat types it created.

**Table 20. Macro-invertebrates collected from 3 sites under the IH-45 Trinity River Bridge in 2012. 1 = upstream site, 2 = IH-45 bridge site, 3 = downstream site, M = mean, M*f* = frequency.**

| Trinity River & IH - 45 | | Spring 2012 | | | | | Summer 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **1** | **2** | **3** | **M** | **Mf** | **1** | **2** | **3** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | |
| Baetidae | Small minnow mayflies | | | | | | | 2 | | 0.67 | 0.024 |
| Caenidae | Small squaregill mayflies | | | | | | | 1 | | 0.33 | 0.012 |
| Chironomidae | Common midges | 37 | 62 | 40 | 46.3 | 0.908 | 24 | 21 | 10 | 18.3 | 0.671 |
| Corixidae | Water boatmen | | | 1 | 0.33 | 0.007 | | | | | |
| Corydalidae | Dobsonflies | | | | | | | 2 | | 0.67 | 0.024 |
| Gerridae | Water striders | | | 2 | 0.67 | 0.013 | | | 2 | 0.67 | 0.024 |
| Gyrinidae | Whirligig beetles | | | 1 | 0.33 | 0.007 | | | | | |
| Heptageniidae | Flatheaded mayflies | | | | | | | 8 | | 2.67 | 0.098 |
| Hydropsychidae | Common netspinners | | | | | | | 10 | | 3.33 | 0.122 |
| Leptoceridae | Longhorned caddisflies | | 5 | | 1.67 | 0.033 | | | | | |
| Veliidae | Broad-shouldered water striders | | 1 | | 0.33 | 0.007 | | | | | |
| ***Mollusca*** | | | | | | | | | | | |
| Bivalvia | Freshwater bivalves | | | | | | | | | | |
| Corbicula | Basket clams | | 2 | 1 | 1 | 0.020 | | 2 | | 0.67 | 0.024 |
| Pomatiopsidae | Freshwater snails | | 1 | | 0.33 | 0.007 | | | | | |
| ***Totals*** | | **37** | **71** | **45** | **51** | **1.000** | **24** | **46** | **12** | **27.3** | **1.000** |
| ***Taxa Richness*** | | | | | | **8.000** | | | | | **8.000** |
| ***Evenness*** | | | | | | **0.151** | | | | | **0.262** |
| ***Simpson's Diversity*** | | | | | | **0.173** | | | | | **0.523** |

***Wetland Cells Fish:*** Electrofishing sampling has been conducted thirteen times in Cell D (2008-2012) and twelve times in all other wetland cells (2009-2012). For the purposes of fish sampling, Cell F is treated as two cells: F (West) and F (East). The first sampling in Cell D occurred several years after fish had been introduced through overbanking events and fishery development had already occurred. Sampling in other cells commenced soon after they filled, enabling us to better track development of those fisheries from their onset. This is reflected by low numbers collected in spring 2009 but higher numbers collected later that year, when many of the fish in the latter samplings were young-of-the-year. Numbers collected have also been influenced by environmental conditions: for instance, low numbers and species collected in fall 2009 and 2011 in most cells reflect cold temperatures (below 8°C) that occurred during those sample periods---fish had moved to deeper waters and were not harvestable using shallow water electrofishing equipment. Long-term sampling should continue to provide information on whether or not the LCOW is supporting substantial, quality fisheries and to evaluate whether or not those fisheries are sustainable under LCOW conditions.

Twenty-one fish species have been collected from LCOW cells between 2008 and 2012 (Table 21). Sunfishes, shad, and minnows have made up the majority of fish collected during most sampling periods, with bluegill and shad appearing to dominate the forage-predator base, and large-mouth bass serving as major predators. Other forage species include redear sunfish, orange-spotted sunfish, blacktail shiners, and redfin shiners. Predators include warmouth, white crappie, several catfish species, and spotted gar.

| **Table 21. Twenty-one fish species have been collected in the LCOW between 2008 and 2012.** | | | | |
|---|---|---|---|---|
| **Common name** | **Scientific name** | **Cell(s)** | **Reproductive recruitment** | **Comments** |
| Warmouth | *Lepomis gulosus* | All except F-north | Yes | Common centrarchid in the LCOW; desirable predator |
| Bluegill | *Lepomis macrochirus* | All | Yes | Abundant centrarchid in the LCOW; desirable forage/predator |
| Redear sunfish | *Lepomis microlophus* | D | No | Uncommon centrarchid in the LCOW; desirable forage/predator |
| Orange-spotted sunfish | *Lepomis humilis* | All except E and F-north | Yes | Common to abundant centrarchid in the LCOW; desirable forage/predator |
| Longear sunfish | *Lepomis megalotis* | All except F (West) | Yes | Uncommon to common centrarchid in the LCOW; desirable forage/predator |
| Green sunfish | *Lepomis cyanellus* | All except D and F-north | Yes | Uncommon to common centrarchid in the LCOW; desirable forage/predator, but can become problematic |
| Largemouth bass | *Micropterus salmoides* | All | | Common centrarchid in the LCOW; desirable predator |
| White crappie | *Poxomis annularis* | All except F-north | Yes | Common centrarchid in the LCOW; desirable predator |
| Blacktail shiner | *Cyprinella venusta* | All | Yes | Common cyprinid in the LCOW; desirable forage |
| Redfin shiner | *Lythrurus umbratilis* | E-west, F(East), and G | No | Uncommon cyprinid in the LCOW; desirable forage |
| Common carp | *Cyprinus carpio* | All except F-north | No | Uncommon to common cyprinid in the LCOW; undesirable benthic feeder |
| Blackspotted topminnow | *Fundulus notatus* | F-north and G | Yes | Uncommon cyprinodontid in the LCOW; desirable forage |
| Brook silverside | *Labidesthes sicculus* | D, F-north, and G | Yes | Uncommon to common atherinid in the LCOW |
| River redhorse | *Moxostoma carinatum* | E-west and E | No | Rare stream cyprinid in the LCOW; desirable benthic feeder |
| Channel catfish | *Ictalurus punctatus* | E | No | Uncommon ictalurid in the LCOW; desirable predator; numbers likely higher |
| Bullhead | *Ictalurus sp.* | F (East) | | Uncommon ictalurid in the LCOW desirable predator; numbers likely higher |
| Flathead catfish | *Pylodictis olivaris* | G | | Uncommon ictalurid in the LCOW; desirable predator; numbers likely higher |
| Mosquitofish | *Gambusia affinis* | All | Yes | Common to abundant poeciliid in the LCOW; desirable forage/mosquito larvae predator |
| Spotted gar | *Lepisosteus oculatus* | All except E and F (West) | No | Uncommon to common lepisosteid in the LCOW; somewhat desirable predator |
| Log perch | *Percina caprodes* | D, E, F-north, and G | Yes | Uncommon to common percid in the LCOW; desirable |
| Gizzard shad | *Dorosoma cepedianum* | All | Yes | Abundant clupeid in the LCOW; desirable filter feeding forage |

The greatest numbers of species have been collected from Cell G (18), followed by Cell F (East) (16), Cells D and E-west (14), Cell E (13), and Cells F-north and F (West) (11). Table 22 provides a summary of species richness yearly averages (spring, summer, and fall) for each cell.

**Table 22. Mean fish species richness (spring, summer, and fall) for each of the LCOW cells.**

| Cell | Species richness *mean* 2009 | Species richness *mean* 2010 | Species richness *mean* 2011 | Species richness *mean* 2012 | 4-year *mean* |
|---|---|---|---|---|---|
| **D** | 6.0 | 5.3 | 6.7 | 5.3 | **5.8** |
| **E-west** | 6.3 | 5.3 | 4.0 | 4.3 | **5.0** |
| **E** | 5.3 | 5.3 | 5.3 | 5.3 | **5.3** |
| **F-north** | 3.7 | 4.3 | 3.0 | 4.0 | **3.8** |
| **F (West)** | 4.0 | 4.3 | 5.3 | 5.7 | **4.8** |
| **F (East)** | 3.7 | 5.3 | 6.3 | 6.0 | **5.3** |
| **G** | 3.3 | 6.3 | 7.3 | 7.3 | **6.1** |
| **LCOW *mean*** | **4.6** | **5.2** | **5.0** | **5.4** | **5.1** |

Fourteen species of fish have been collected from Cell D since 2008 (Appendix D). Introduction of fish into the cell probably began in late 2004 during overbank events or possibly through the inflow pump. Species richness has been moderately stable since sampling began, with average annual richness of 5.8 (range: 5.3-6.7, Table 22). This stability appears to reflect the maturity of the wetland cell. Since sampling began, the fishery has typically been dominated by several forage species (bluegill, shad, and mosquitofish, mostly), but includes significant numbers of predators such as largemouth bass (*Micropterus salmoides*) and warmouth (*Lepomis gulosus*). The cell also supports small numbers of undesirable fish, most notably common carp. Mixed size classes of many species, particularly the sunfishes, indicates reproduction of those species is occurring in the cell. Overall, it appears a moderately stable largemouth bass-bluegill fishery had developed in Cell D as of 2008 and was persisting in 2012, with overall increases in open-water forage species over time. No previously uncollected species were found in Cell D during 2012.

Fourteen species have been collected during nine samplings conducted in Cell E-West from 2009 to 2012 (Appendix D). Overall, species occurring in the cell were similar to those seen in Cell D, not surprising considering the two cells share their source of introduction (Trinity River overbanking). Richness has been variable since sampling began, with the fewest numbers of species collected in 2011, on average. Bluegill and mosquitofish commonly dominate samples, with largemouth bass, warmouth, and green sunfish (*Lepomis cyanellus*) comprising the predator species. The presence of shad indicates that in addition to the developing centrarchid fishery, a sustained open-water fishery is developing in the cell. The fishery appears to be stabilizing, but may be influenced by the limited littoral zone (no shallow water planting shelves). Sunfish and shad reproduced readily in this cell and white crappie were collected from the cell for the first time in 2012.

Thirteen species have been collected from Cell E since spring 2009, with species richness remaining stable since sampling began (Appendix D, Table 22). Bluegill and mosquitofish regularly dominate the samples, although shad are periodically caught in greater numbers. Predators include largemouth bass, warmouth, and green sunfish. Reproductive recruitment is occurring by many of the species inhabiting the cell. No previously uncollected species were found in Cell D during 2012.

Eleven species have been collected from Cell F-North between 2009 and 2012 (Appendix D). Species richness has been consistently lower in this cell than others in the LCOW (Table 22). This cell is the shallowest of the LCOW, and vegetation had only just begun to establish significantly in 2011, likely contributing to fewer species of fish established. Bluegill and mosquitofish have been the dominant forage species; largemouth bass are the dominant predators. Relatively low numbers of open-water species (shad) are also present in the cell. This cell appears to be the only one supporting a breeding population of blackspotted topminnows (*Fundulus notatus*). No previously uncollected species were found in Cell D during 2012.

Eleven species were collected from Cell F (West) between 2009 and 2012 (Appendix D). Species richness has increased gradually over time in this cell, indicating that the fishery is continuing to develop (Table 22). Bluegill and mosquitofish have dominated the forage population, with largemouth bass comprising most of the predator population since 2009. Shad were collected for the first time in 2011, indicating that an open-water fishery has begun to develop. No new fish species were collected from this cell in 2012.

Sixteen species were been collected from Cell F (East) between 2009 and 2011 (Appendix D), and species richness has stabilized over time (Table 22). Bluegill and mosquitofish typically dominate collections; largemouth bass, warmouth, and green sunfish are the predators. Shad have been collected in a number of samples, indicating open-water fishery development. No new species were collected in 2012.

Eighteen species were collected from Cell G between 2009 and 2012 (Appendix D). Only mosquitofish were initially collected, indicating that fishery development was in its early stages in the cell. Since that time, species richness has increased and represents the highest of all cells (Table 22), with bluegill and mosquitofish dominating; predators have been dominated by largemouth bass. Shad have been collected periodically, indicating that the cell supports an open-water fishery. Heavy usage of Cell G by cormorants and white pelicans in 2009 and 2010 were indicative of shad serving as a significant food source for migratory birds in those years. Two new species, green sunfish and spotted gar, were collected in 2012.

Samples conducted over four years have provided some insight into trends that may be occurring in the fishery populations in the LCOW wetland cells. Overall, cells that support more vegetation support greater numbers of fish species. Additionally, as vegetation communities have developed over time, so have fish communities. In Cell E-West and F-North, where littoral zones (and thus vegetation) and water levels are limited, fish communities are represented by fewer species, but some of those may be suited only to conditions provided by those cells. Four years, however, may not be adequate to draw conclusions about sustainability of fish populations in the cells. For instance, early data suggested that the fisheries in each cell were being reset following each overbanking event. Under those conditions, and considering the unpredictability of overbanking, it was possible that stable fisheries could not establish in the cells, lowering the overall value of the habitat. However, longer-term monitoring is showing that fish are likely taking refuge in vegetation or other structures, or in the deeper channels, during overbanking, and significant numbers of individuals remain (combined with new individuals from the river) in the cells to sustain their populations. Longer-term monitoring will provide enough information to confirm this supposition.

***Wetland Cells Macro-invertebrates:*** Macro-invertebrate sampling has been conducted thirteen times in Cell D and twelve times in all other wetland cells. This report details the most recent samplings from fall 2011 to summer 2012; previous samples and data are given in Appendices F and G of this report. Similarly to electrofishing, sampling in Cell D began in late 2008, several years after its construction, with vegetation establishment well under way. Sampling in other cells started soon after they were filled, enabling ERDC to track colonization from their onset. In addition to macro-invertebrates collected during sampling (see below), large benthic mollusks common to the Trinity River drainage were occasionally encountered, including the paper pondshell mussel (*Utterbackia imbecillis*), giant floater (*Pyganodon grandis*), and introduced Asiatic clam (*Corbicula* sp.), all of which are considered biological indicators of fair to good water quality.

Taxa richness or R, evenness (E), and Simpson's diversity index (SDI, scale from 0 to 1 with 1 being the best diversity) are given in Table 23 for all wetland cells during the FY2012 sampling period. Mean R across the LCOW ranged from 22.00 to 13.00 with three distinct groupings from highest to lowest (D>G>E, E-W, F-N, F (W), F (E)). Cells D and G (*mean* R = 22.00 and R = 16.33 respectively) are among the highest in taxa richness. This may be due the significant successes of establishing submersed aquatic vegetation in these cells, in some cases in close proximity to the macro-invertebrate sampling sites (Figure 25). For example, taxa have been collected and identified in these cells that correlate with the establishment of the submersed aquatic vegetation American pondweed and water stargrass, such as microcaddisflies (Tricoptera: Hydroptilidae), whom create their final instar purse-shape cases from submersed leaves, as well as waterlily leafcutter moths (Lepidoptera: *Synclita),* which larvae cut leaf matter for casing and eventual pupation. In contrast, lower in taxa richness, cells E,EW,FN,FW, and FE are statistically similar and range from R = 13.67 to 13.00. This illustrates that, although with lower taxa richness, these wetland cells have ecologically progressed in taxonomically similar ways in terms of the macro-invertebrate communities. Flora dwelling or utilizing macro-invertebrates remained entrenched in all cells.

Mean Simpson's diversity indices (SDI) ranged from 0.75 to 0.57 in the LCOW during 2012 sampling indicating that the macro-invertebrate community colonization across all wetlands continues to improve with wetland development and establishment. It also suggests that the faunal community dynamics appear to be sustainable regardless of overbanking events or other significant hydrological issues. Mean taxa richness and diversity across all wetlands and sampling dates is R = 14.90 and SDI = 0.67 suggesting a healthy macro-invertebrate community across the entirety of the LCOW. SDI's from earlier samples are given in Appendix F.

**Table 23. Population characteristics of macro-invertebrates collected from the LCOW from fall 2011 to summer 2012.**

| Wetland | Season | D | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|---|
| ***Taxa Richness*** | Fall 2011 | 25 | 15 | 14 | 8 | 11 | 10 | 10 | 13.3 |
| | Spring 2012 | 18 | 14 | 8 | 8 | 12 | 16 | 14 | 12.9 |
| | Summer 2012 | 23 | 10 | 17 | 23 | 18 | 14 | 25.00 | 18.6 |
| ***Evenness*** | Fall 2011 | 0.12 | 0.10 | 0.31 | 0.34 | 0.21 | 0.26 | 0.18 | 0.22 |
| | Spring 2012 | 0.20 | 0.41 | 0.38 | 0.30 | 0.33 | 0.29 | 0.50 | 0.34 |
| | Summer 2012 | 0.17 | 0.28 | 0.34 | 0.23 | 0.24 | 0.26 | 0.21 | 0.25 |
| ***Diversity*** | Fall 2011 | 0.67 | 0.36 | 0.77 | 0.64 | 0.56 | 0.62 | 0.45 | 0.58 |
| | Spring 2012 | 0.72 | 0.83 | 0.67 | 0.59 | 0.74 | 0.78 | 0.45 | 0.68 |
| | Summer 2012 | 0.74 | 0.65 | 0.83 | 0.81 | 0.77 | 0.73 | 0.81 | 0.76 |
| | ***Mean Taxa Richness*** | 22.0 | 13.0 | 13.0 | 13.0 | 13.7 | 13.3 | 16.3 | **14.9** |
| | ***Mean Evenness*** | 0.16 | 0.27 | 0.34 | 0.29 | 0.26 | 0.27 | 0.30 | **0.27** |
| | ***Mean Diversity*** | 0.71 | 0.61 | 0.75 | 0.68 | 0.69 | 0.71 | 0.57 | **0.67** |

**Figure 25. American pondweed (*Potamogeton nodosus*) establishment in Cell G has contributed to high numbers and diversity of macro-invertebrates.**

At this point in the macro-invertebrate sampling regime at the LCOW, ERDC has identified 52 total taxa of aquatic springtails, insects, worms, spiders, crustaceans, and mollusks. All freshwater functional feeding groups are represented by the fauna collected in each wetland cell including filtering collectors (Brachycentridae), scrapers (Gastropoda), engulfing (Coenagrionidae) and piercing predators (Belostomatidae), piercing herbivores (Corixidae), collector gatherers (Chironomidae), shredders (Amphipoda), and scavenger/omnivores (Physidae). Total taxa richness for each cell over the duration of macro-invertebrate sampling in 2012 is given in Table 24 along with the individual taxa observed in each wetland cell. All cells increased in taxa richness from previous years. Cell D continues to support the highest richness at 39 total taxa, while the remaining LCOW cells range from 26 to 31 taxa. This verifies the ecological maturity of Cell D versus the remaining cells, but also indicates a positive trend with the remaining LCOW. Raw data for fall 2011, spring 2012, and summer 2012 are provided in Appendix G. Fall 2012 samples were collected and are currently being sorted and counted.

Taxa of interest (first time collected or collected at an increased rate throughout the LCOW) collected in 2012 included sminthurid springtails (Enthognatha: Sminthuridae), semi-aquatic grasshoppers (Orthoptera: Acrididae), giant water bugs (Hemiptera: Belostomatidae), humpless case makers (Trichoptera: Brachycentridae), shore flies, (Diptera: Ephydridae), marsh treaders (Hemiptera: Hydrometridae), soldier flies (Diptera: Stratiomyidae), aquatic worms (Annelida: Oligochaeta), freshwater mussels (Unionidae).

**Table 24. Macro-invertebrates collected from the LCOW from 2008–2012.**

| Taxa | Common name | D | E | EW | FN | FW | FE | G |
|---|---|---|---|---|---|---|---|---|
| ***Entognatha*** | | | | | | | | |
| Isotomidae | Springtails | | | | X | | | |
| Sminthuridae | Springtails | X | | | | | | |
| ***Insecta*** | | | | | | | | |
| Acrididae | Semi-aquatic grasshoppers | | | | | | X | X |
| Aeshnidae | Hawker dragonflies | | | | | | | X |
| Baetidae | Small minnow mayflies | X | X | X | X | X | X | X |
| Belostomatidae | Giant water bugs | X | X | X | X | X | X | X |
| Brachycentridae | Humpless case makers | | | X | | X | X | X |
| Caenidae | Small squaregill mayflies | X | X | X | X | X | X | X |
| Ceratopogonidae | Biting midges | X | X | X | X | X | X | X |
| Chaoboridae | Phantom midges | | | X | X | | | |
| Chironomidae | Midges | X | X | X | X | X | X | X |
| Chrysomelidae | Leaf beetles | X | | | | | | |
| Coenagrionidae | Narrow-winged damselflies | X | X | X | X | X | X | X |
| Corixidae | Water boatmen | X | X | X | X | X | X | X |
| Culicidae | Mosquitoes | X | | X | | | | |
| Curculionidae | Weevils | X | X | | | | | |
| Dytiscidae | Predaceous diving beetles | X | | X | X | X | X | X |
| Elmidae | Riffle beetles | | | | | X | | |
| Ephydridae | Shore flies | X | | | X | | X | X |
| Gerridae | Water striders | X | | X | X | X | | X |
| Gomphidae | Clubtail dragonflies | X | | X | X | | | |
| Gyrinidae | Whirligig beetles | | | | | | X | |
| Haliplidae | Crawling water beetles | X | X | X | X | X | X | X |
| Hebridae | Velvet water bugs | X | | | | X | X | |
| Hydrometridae | Marsh treaders | | | | | | | X |
| Hydrophilidae | Water scavenger beetles | X | X | X | X | X | X | X |
| Hydropsychidae | Net-spinning caddisflies | | | | | | | |
| Hydroptilidae | Microcaddisflies | X | X | | | X | | X |
| Libelullidae | Skimmers (dragonflies) | X | X | X | X | X | X | X |
| Limnephilidae | Northern case makers | | | X | X | X | X | |
| Mesoveliidae | Water treaders | | | X | | | | X |
| Noteridae | Burrowing water beetles | X | | | | | | |
| Pleidae | Pygmy backswimmers | X | | | | | | X |
| Pyralidae | Grass moths | X | | | | | | |
| Sciomyzidae | Marsh flies | X | X | | | | | |
| Stratiomyidae | Soldier flies | X | X | X | X | | X | X |
| Synclita | Waterlily leafcutter moth | X | X | X | X | X | | X |
| Veliidae | Broad-shouldered water striders | X | X | X | X | X | | |
| ***Annelida*** | | | | | | | | |
| Hirudinea | Freshwater leeches | X | | X | | X | | |
| Oligochaeta | Aquatic worm | X | X | X | | X | X | X |
| ***Arachnida*** | | | | | | | | |
| Hydracarina | Water mites | X | X | X | X | | X | X |
| ***Crustacea*** | | | | | | | | |
| Cambaridae | Freshwater crayfish | X | | | | | | |
| Hyalellidae | Amphipods | X | X | X | X | X | X | X |
| Palaemonidae | Grass shrimp | X | X | X | X | | X | X |
| ***Mollusca*** | | | | | | | | |
| Ancylidae | Freshwater limpets | X | X | X | | | X | X |
| Corbicula | Basket clams | X | | | | | X | X |
| Lymnacidae | Pond snails | | X | X | X | X | X | X |
| Physidae | Bladder snails | X | X | X | X | X | X | X |
| Planorbidae | Ram's horn snails | X | X | | X | X | X | |
| Pomatiopsidae | Freshwater snails | X | | X | X | X | | |
| Unionidae | Freshwater mussels | | X | | | | | X |
| Valvatidae | Valve snails | X | X | X | X | | | |
| ***Totals*** | | **39** | **26** | **31** | **28** | **26** | **27** | **31** |

From the first thirteen samples from the LCOW, ERDC has identified certain dynamics about the development of the macro-invertebrate community structure as a whole in a floodway passage. First, macro-invertebrate taxa richness, evenness, and diversity improved with time and appear to coincide with development of native aquatic vegetation communities. Second, macro-invertebrate colonies may be “reset” by overbanking events to some extent, but not detrimentally. Third, as wetland development and aquatic vegetation community establishment continues to progress in the LCOW, the wetlands are becoming more taxonomically similar to each other and specifically to the more mature Cell D with increased taxa richness and diversity. This suggests that the remaining LCOW continues to be on the proper path ecologically.

***Observations of vertebrates*****:** In addition to fish and macro-invertebrates, ERDC has kept informal records of higher vertebrates encountered in the wetland chain. Previously, reported observations were limited to only those species observed in direct association with the wetland cells or other nearby water features in previous reports (Figure 26). However, this report includes all species that ERDC researchers have observed in the wetlands, grasslands, and woodland areas along the LCOW from Cell D to Cell G.

**Figure 26. Waterbirds observed at the LCOW since 2005 include the black-necked stilt (*Himantopus mexicanus*) and American bittern (*Botaurus lentiginosus*).**

ERDC has observed numerous mammals (14 species), birds (108 species), reptiles (13 species), and amphibians (6 species) to date. Identifications have been made with and without the aid of binoculars and pertinent field guides. In some cases, identifications have been made from tracks or other signs such as hog rooting or beaver cuttings, etc. Surveys and general observations were initiated in fall 2005 on Cell D, and in other cells beginning in late 2008. Soon after filling in late 2008, mammals, waterbirds, reptiles, and amphibians began utilizing cells E-West, E, F-North, F, and G, sometimes in large numbers (especially waterfowl and gulls). Table 25 provides a list of species and the general areas of the LCOW in which they have been observed. For the most part, wetlands include the wetland cells, other water features (such as the Wood Duck pond), and adjacent moist soil areas associated with each; grasslands include those areas mostly cleared of trees and seeded or planted with native grasses and forbs, and woodlands include areas in which trees have been left standing, particularly between the LCOW and the river. Typically, several species not previously recorded at the LCOW are observed every year. For instance, a common goldeneye (*Bucephala clangula*) was observed for the first time in 2012. Several factors influence the occurrence of new species, including yearly changes in migratory patterns, but it is likely that management of the LCOW wetlands and grasslands is resulting in better habitat and therefore is attracting more wildlife.

Although comparative data is not available, we suspect that the vertebrate diversity and species richness is vastly different between the LCOW and the more common grassy swales with the boundaries of the

Trinity River flood conveyance.   As an example, water level manipulations appear to be benefitting waterfowl.  During most years, migratory waterfowl begin utilizing the cells in early to mid November, with submersed, floating-leaved, and emergent vegetation serving as a food source or habitat for their food source (e.g., macro-invertebrates) adequate to hold their numbers.  In late November to early December, cells are raised to winter pool, inundating mixed wetland and grassland vegetation and providing additional food sources for many waterfowl species.  An added benefit was observed in Cell D in the winters of 2011 and 2012.  Inundation of grasses and forbs when the cell was raised to winter pool led to a significant copepod bloom, which in turn drew in hundreds of northern shovelers and undoubtedly provided significant forage for the fishery (Figure 27).

**Figure 27.  Northern shovelers (*Spatula clypeata*) flock to and filter-forage copepod blooms associated with decomposing vegetation in winter-inundated wetlands in Cell D.**

**Table 25. Vertebrate species (excluding fish) observed in the wetland chain since September 2005. Those listed in bold font were observed for the first time during FY2012. Wetland cells include mudflats and moist soil areas surrounding each wetland.**

| Common name | Scientific name | Area |
|---|---|---|
| ***Mammals*** | | |
| Beaver | *Castor canadensis* | Wetlands |
| Coyote (tracks & roadkill) | *Canas latrans* | Grasslands |
| **Bobcat (tracks)** | ***Lynx rufus*** | **Grasslands** |
| Mink | *Neovison vison* | Wetlands |
| Feral pig (tracks & rooting) | *Sus scrofa* | Wetlands/grasslands |
| Fox squirrel | *Sciuris nigra* | Woodlands |
| Harvest mouse | *Reithrodontomys sp.* | Grasslands |
| **Hispid cotton rat** | ***Sigmodon hispidus*** | **Grasslands** |
| Nine-banded armadillo | *Dasypus novemcinctus* | Wetlands/grasslands |
| Nutria | *Myocastor coypus* | Wetlands |
| Raccoon | *Procyon lotor* | Wetlands |
| River otter | *Lontra canadensis* | Wetlands |
| Striped skunk | *Mephitis mephitis* | Wetlands/grasslands |
| Virginia opossum | *Didelphis virginiana* | Wetlands |
| ***Birds*** | | |
| **American bittern** | ***Botaurus lentiginosus*** | **Wetlands** |
| American coot | *Fulica americana* | Wetlands |
| American crow | *Corvus brachyrhynchos* | Wetlands/grasslands/woodlands |
| **American goldfinch** | ***Carduelis tristis*** | **Woodlands** |
| American kestrel | *Falco sparverius* | Grasslands |
| American pipit | *Anthus rubescens* | Wetlands/grasslands |
| American robin | *Turdus migratorius* | Grasslands/woodlands |
| American white pelican | *Pelecanus erythrorhynchos* | Wetlands |
| American wigeon | *Mareca americana* | Wetlands |
| Anhinga | *Anhinga anhinga* | Wetlands |
| Bald eagle | *Haliaeetus leucocephalus* | Wetlands/grasslands |
| Barn swallow | *Hirundo rustica* | Wetlands/grasslands/woodlands |
| **Barred owl** | ***Strix varia*** | **Woodlands** |
| Belted kingfisher | *Megaceryle alcyon* | Wetlands |
| Black vulture | *Coragyps atratus* | Grasslands |
| Black-necked stilt | *Himantopus mexicanus* | Wetlands |
| Blue jay | *Cyanicutta cristata* | Woodlands |
| Blue-winged teal | *Anas discors* | Wetlands |
| Bonaparte’s gull | *Larus philadelphia* | Wetlands |
| **Brewer’s blackbird** | ***Euphagus cyanocephalus*** | **Grasslands/woodlands** |
| Brown-headed cowbird | *Molothrus ater* | Grasslands |
| **Brown thrasher** | ***Toxostoma rufum*** | **Woodlands** |
| **Budgerigar** | ***Melopsittacus undulatus*** | **Grasslands** |
| Bufflehead | *Bucephala albeola* | Wetlands |
| Canada goose | *Branta canadensis* | Wetlands |
| Canvasback | *Aythya valisneria* | Wetlands |
| Carolina chickadee | *Parus carolinensis* | Woodlands |
| Cattle egret | *Bubulcus ibis* | Wetlands/grasslands |
| Cedar waxwing | *Bombycilla cedrorum* | Woodlands |
| Chimney swift | *Chaetura pelagica* | Wetlands/grasslands |
| **Common barn owl** | ***Tyto alba*** | **Woodlands** |
| **Common goldeneye** | ***Bucephala clangula*** | **Wetlands** |
| Common grackle | *Quiscalus quiscula* | Grasslands/woodlands |
| **Common nighthawk** | ***Chordeiles minor*** | **Grasslands** |
| Cooper’s hawk | *Accipiter cooperii* | Woodlands |
| Crested caracara | *Polyborus plancus* | Grasslands |
| Dark-eyed junco | *Junco hyemalis* | Woodlands |
| Dickcissel | *Spiza americana* | Grasslands |
| Double-crested cormorant | *Phalacrocorax auritus* | Wetlands |
| Eastern bluebird | *Sialia sialis* | Grasslands/woodlands |
| **Eastern kingbird** | ***Tyrannus tyrannus*** | **Grasslands** |
| Eastern meadowlark | *Sturnella magna* | Grasslands |
| Eastern phoebe | *Sayornis phoebe* | Wetlands/grasslands/woodlands |
| European starling | *Sturnus vulgaris* | Grasslands |
| Franklin’s gull | *Larus pipixcan* | Wetlands |
| Gadwall | *Anas strepera* | Wetlands |

| **Common name** | **Scientific name** | **Area** |
|---|---|---|
| Great blue heron | *Ardea herodius* | Wetlands |
| Great egret | *Ardea alba* | Wetlands |
| Great-tailed grackle | *Quiscalus mexicanus* | Grasslands |
| Green heron | *Butorides virescens* | Wetlands |
| Green-winged teal | *Anas carolinensis* | Wetlands |
| Hooded merganser | *Lophodytes cucullatus* | Wetlands |
| Inca dove | *Columbia inca* | Grasslands |
| Indigo bunting | *Passerina cyanea* | Grasslands |
| Killdeer | *Charadrius vociferus* | Wetlands/grasslands |
| Least sandpiper | *Erolia minutilla* | Wetlands |
| Least tern | *Sternula antillarum* | Wetlands |
| Lesser scaup | *Aythya affinis* | Wetlands |
| Lesser yellowlegs | *Totanus flavipes* | Wetlands |
| Little blue heron | *Florida caerulea* | Wetlands |
| Loggerhead shrike | *Lanius ludovicianus* | Grasslands |
| Mallard | *Anas platyrhynchos* | Wetlands |
| Marsh wren | *Cistothorus palustris* | Wetlands |
| **Mississippi kite** | ***Ictinia mississippiensis*** | **Grasslands/woodlands** |
| Mourning dove | *Zenaida macroura* | Grasslands |
| Northern cardinal | *Cardinalis cardinalis* | Woodlands |
| Northern flicker | *Colaptes auratus* | Grasslands/woodlands |
| Northern harrier | *Circus cyaneus* | Wetlands/grasslands |
| Northern mockingbird | *Mimus polyglottos* | Grasslands/woodlands |
| Northern pintail | *Anas acuta* | Wetlands |
| Northern rough-winged swallow | *Stelgidopteryx serripennis* | Wetlands/grasslands |
| Northern shoveler | *Spatula clypeata* | Wetlands |
| **Painted bunting** | ***Passerina ciris*** | **Grasslands/woodlands** |
| Pied-billed grebe | *Podilymbus podiceps* | Wetlands |
| **Purple martin** | ***Progne subis*** | **Wetlands/grasslands** |
| Redhead | *Aythya americana* | Wetlands |
| **Red-bellied woodpecker** | ***Melanerpes carolinus*** | **Woodlands** |
| Red-shouldered hawk | *Buteo lineatus* | Grasslands/woodlands |
| Red-tailed hawk | *Buteo jamaicensis* | Grasslands/woodlands |
| Red-winged blackbird | *Agelaius phoeniceus* | Wetlands/grasslands |
| Ring-billed gull | *Larus delawarensis* | Wetlands |
| Ring-necked duck | *Aythya collaris* | Wetlands |
| Rock pigeon | *Columbia livia* | Grasslands |
| Ruby-crowned kinglet | *Regulus calendula* | Woodlands |
| **Ruby-throated hummingbird** | ***Archilochus colubris*** | **Grasslands** |
| **Ruddy duck** | ***Oxyura jamaicensis*** | **Wetlands** |
| Savannah sparrow | *Passerculus sandwichensis* | Grasslands |
| Snowy egret | *Leucophoyx thula* | Wetlands |
| Sora | *Porzana carolina* | Wetlands |
| Spotted sandpiper | *Actitis macularia* | Wetlands |
| Scissor-tailed flycatcher | *Tyrannus forficatus* | Grasslands |
| Tree swallow | *Tachycineta bicolor* | Wetlands/grasslands |
| Tricolored heron | *Egretta tricolor* | Wetlands |
| Tufted titmouse | *Baeolophus bicolor* | Woodlands |
| Turkey vulture | *Cathartes aura* | Grasslands |
| Upland sandpiper | *Bartramia longicauda* | Wetlands/grasslands |
| Vesper sparrow | *Pooecetes gramineus* | Grasslands |
| Western kingbird | *Tyrannus verticalis* | Grasslands |
| White ibis | *Eudocimus albus* | Wetlands |
| **White-crowned sparrow** | ***Zonotrichia leucophyrs*** | **Woodlands** |
| White-faced ibis | *Plegadis chihi* | Wetlands |
| White-throated sparrow | *Zonotrichia albicollis* | Woodlands |
| White-winged dove | *Zenaida asiatica* | Grasslands |
| Willet | *Catoptrophorus semipalmatus* | Wetlands |
| Wilson's phalarope | *Phalaropus tricolor* | Wetlands |
| Wilson's snipe | *Gallinago gallinago* | Wetlands |
| Wood duck | *Aix sponsa* | Wetlands |

| Common name | Scientific name | Area |
|---|---|---|
| **Yellow-bellied sapsucker** | ***Sphyrapicus varius*** | **Woodlands** |
| Yellow-rumped warbler | *Dendroica coronata* | Grasslands/woodlands |
| ***Reptiles*** | | |
| Blotched water snake | *Nerodia erythrogaster* | Wetlands |
| Broad-banded water snake | *Nerodia fasciata* | Wetlands |
| Common snapping turtle | *Chelydra serpentina* | Wetlands |
| Diamondback water snake | *Nerodia rhombifer* | Wetlands |
| Green anole | *Anolis carolenisis* | Grasslands |
| Mississippi map turtle | *Graptemys kohnii* | Wetlands |
| Mud turtle | *Kinosternum subrubrum* | Wetlands |
| Red-eared slider | *Trachemys scripta* | Wetlands |
| **Red-striped ribbon snake** | ***Thamnophis proximus*** | **Wetlands** |
| River cooter | *Pseudemys concinna* | Wetlands |
| **Southern painted turtle** | ***Chrysemys dorsalis*** | **Wetlands** |
| **Texas rat snake** | ***Elaphe obsoleta*** | **Grasslands** |
| Western ribbon snake | *Thamnophis proximus* | Wetlands |
| ***Amphibians*** | | |
| American bullfrog | *Rana catesbeiana* | Wetlands |
| Blanchard's cricket frog | *Acris crepitans* | Wetlands |
| **Bronze frog** | ***Rana clamitans*** | **Wetlands** |
| Gulf coast toad | *Bufo valliceps* | Wetlands |
| Southern leopard frog | *Rana utricularia* | Wetlands |
| Upland chorus frog | *Pseudacris triseriata* | Wetlands |

Use by waterbirds since LCOW construction was completed was high during fall and winter 2008/2009, with hundreds and sometimes thousands of mostly ducks observed on each cell during each site visit between November and February. Counts were lower during fall and winter 2009/2010 and 2010/2011 (usually around 500 or so birds per visit in all the LCOW cells), which corresponded with lower counts in North Texas in general those years, including counts on research ponds at the LAERF, north of Dallas. Unusually cold temperatures during those years may have pushed waterfowl further south to find more suitable wintering grounds. However, high numbers were again observed during fall and winter 2011 and 2012, with Cell G alone holding on average over 1,700 birds per visit in 2011. The entire LCOW held nearly four thousand birds per visit during that same period (Table 33).

**Table 33. Number of waterfowl observed in the LCOW on four occasions in late fall and early winter 2011.**

| Species | Cell D | Cell E-West | Cell E | Cell F-North | Cell F (West) | Cell F (East) | Cell G | Wood duck pond |
|---|---|---|---|---|---|---|---|---|
| Mallard | 8 | 0 | 5 | 0 | 18 | 17 | 47 | 23 |
| Northern shoveler | 5 | 39 | 13 | 10 | 13 | 50 | 196 | 2 |
| Northern pintail | 14 | 2 | 45 | 13 | 25 | 10 | 473 | 25 |
| Gadwall | 28 | 24 | 52 | 53 | 163 | 113 | 785 | 26 |
| American wigeon | 8 | 3 | 50 | 0 | 75 | 38 | 25 | 0 |
| Bufflehead | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| Ring-billed duck | 21 | 12 | 51 | 5 | 40 | 25 | 80 | 8 |
| Canvasback | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 0 |
| Blue-winged teal | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| Pied-billed grebe | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 |
| Double-crested cormorant | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| American coot | 1 | 0 | 17 | 0 | 1 | 0 | 106 | 1 |
| **Mean total waterbirds** | **85** | **83** | **235** | **83** | **336** | **253** | **1714** | **100** |

On one occasion in 2012 (late December, following an overbanking event), over 6,500 waterfowl were observed, primarily in Cells F and G, consisting mostly of pintails, Northern shovelers, gadwalls, and ring-billed ducks. Large differences in numbers of birds between cells may be related to vegetation community establishment, but are just as likely influenced by other factors. For instance, relatively few birds were observed on Cell D despite the substantial vegetation community there, whereas heavy usage of a similar vegetation community in Cell G has been observed. The proximity of Cell D to IH-45 and its high traffic flow may be playing a role in wetland cell selection by many of the birds. Some species, however, appeared less concerned about traffic in 2012:  large flocks of Northern shovelers utilized Cell D regularly during that year.

## Wetlands Summary

Wetland vegetation has become well-established in the LCOW and currently covers most of the perimeters of all cells and significant portions of the shallow planting shelves found in some cells.  A dynamic planting schedule, water level manipulation, herbivore trapping and relocation, and management of nuisance plant species have continued to facilitate development of a desirable native plant community that includes obligate and facultative wetland species, rather than stands of willows and cattails typical in disturbed wet areas in north Texas.  Concurrently, fish and macro-invertebrate communities have developed and begun to show evidence of stabilization, leading to usage by a variety of waterbirds, including ducks, sandpipers, egrets, and herons.  In order to ensure that the wetlands are in their best possible ecological condition when the Corps hands the LCOW over to the City of Dallas (anticipated to begin in 2014, continued management, particularly of nuisance species, and supplemental plantings of desirable species will be made as needed in 2013.

## Operations and Maintenance Manual

An O&M manual is critical to ensure that the City of Dallas is capable of engaging interactive management of the wetlands cells to provide sustainable aquatic and migratory bird species diversity and stability once the Corps completes its project obligations.  ERDC developed a draft O&M manual for Cell D during 2009, with iterations since that time incorporating the remaining cells in the LCOW as their proper management has been developed.  Additional modifications to the O&M were incorporated in 2012 for SWF and the City of Dallas review, and it is anticipated that the manual will be completed during 2013.  Following grassland community establishment (see section below), an O&M manual for grasslands management will be developed and provided to the City of Dallas (anticipated 2014).

## LCOW Adjacent Grasslands

ERDC conducted assessments of seeding and planting efforts in grasslands adjacent to the wetland cells in 2009. Following results of this evaluation, which showed poor native grassland community development, ERDC proposed to test modifications of basic methods used to successfully establish wetland vegetation for repairing and improving the grassland community, focusing primarily on species selection (perennials vs. annuals, grasses vs. forbs), propagules (seeds versus containerized), and post-planting management (mowing vs. no mowing). Following initial evaluations, ERDC proposed to begin large-scale establishment of grassland vegetation using results from tests. This section describes grassland plant community improvements conducted between 2009 and 2012.

### Grassland evaluations

Vegetation surveys were conducted in 2009 and 2010 to identify, categorize and enumerate the plant communities in seeded grassland areas surrounding the LCOW. These areas had been drill-seeded over a period of time between 2007 (Cell D) and 2009 (remaining LCOW). Plugging of several grass species was also conducted at Cell D in 2009. Informal surveys conducted in late 2009 and early 2010 focused on locating species that had been seeded at the site, and suggested that most of the seeds and some of the species did not germinate or that germinated seedlings did not survive; instead, the grasslands appeared to be dominated by nuisance species such as giant ragweed (*Ambrosia trifida*). Of 44 species identified, 10 were nonnative and considered undesirable (e.g., Johnsongrass, *Sorghum halepense*). Of the 32 native species identified, seven were undesirable in grasslands, and included aggressive forbs (e.g., giant ragweed and marsh-elder, *Iva annua*) and woody species (e.g., cedar elm, *Ulmus crassifolia*). Fifteen of the native species observed were included in drill-seeding, but none of these appeared to occur in significant numbers. A list of plant species observed during informal surveys is given in Table 34.

**Table 34. Plant species observed during informal surveys made in 2010. Status: N = native; NS = native, seeded (highlighted in bold); I = introduced. Category: U = undesirable grassland plant; D = desirable grassland plant.**

| Scientific Name | Common name | Status | Category |
|---|---|---|---|
| *Ambrosia trifida* | Giant ragweed | N | U |
| ***Andropogon gerardii*** | **Big bluestem** | **NS** | **D** |
| *Arundo donax* | Arundo | I | U |
| *Baccharis halimifolia* | Eastern baccharis | N | U |
| *Bothriochloa ischaemum* | King Ranch bluestem | I | U |
| ***Centaurea americana*** | **American basketflower** | **NS** | **D** |
| ***Chamaecrista fasciculata*** | **Partridge pea** | **NS** | **D** |
| *Convolvulus equitans* | Bindweed | N | D |
| ***Coreopsis basilis*** | **Golden-wave** | **NS** | **D** |
| ***Coreopsis lanceolata*** | **Lanceleaf coreopsis** | **NS** | **D** |
| *Cucurbita foetidissima* | Wild gourd | N | D |
| *Cuscuta sp.* | Dodder | N | D |
| *Cynodon dactylon* | Bermuda grass | I | U |
| ***Dalea purpurea*** | **Purple prairie clover** | **NS** | **D** |
| *Erodium cicutarium* | Redstem stork's bill | I | U |
| *Eustoma exaltatum* | Texas bluebells | N | D |
| *Fraxinus pennsylvanica* | Green ash | N | U |
| ***Helianthus maximiliani*** | **Maximilian sunflower** | **NS** | **D** |
| *Heliotropium indicum* | Indian heliotrope | I | U |
| *Iva annua* | Marsh-elder | N | U |
| *Lamium amplexicaule* | Henbit | I | U |
| *Ludwigia alternifolia* | Seedbox | N | D |
| *Melia azederach* | Chinaberry | I | U |
| ***Oenothera speciosa*** | **Pink evening rose** | **NS** | **D** |
| ***Panicum virgatum*** | **Switchgrass** | **NS** | **D** |
| *Phalaris sp.* | Canary grass | I | U |
| ***Phlox drummondii*** | **Drummond phlox** | **NS** | **D** |
| *Pyrrhopappus pauciflorus* | Texas dandelion | N | D |
| *Ranunculus macounii* | Buttercup | N | D |
| ***Ritibida columnifera*** | **Mexican hat** | **NS** | **D** |

| | | | |
|---|---|---|---|
| ***Salvia azurea*** | **Pitcher sage** | **NS** | **D** |
| ***Salvia coccinea*** | **Scarlet sage** | **NS** | **D** |
| *Secale cereale* | Rye | I | D |
| *Sesbania drummondii* | Rattlebox | N | U |
| *Setaria macrostachya* | Large-spike bristlegrass | N | D |
| *Sida ciliaris* | Bracted fanpetals | N | D |
| *Solanum rostratum* | Buffalobur | N | U |
| ***Sorgastrum nutans*** | **Indiangrass** | **NS** | **D** |
| *Sorghum halepense* | Johnsongrass | I | U |
| *Sporobolus sp.* | Dropseed | N | D |
| *Stellaria media* | Common chickweed | I | U |
| *Tridens albescens* | White tridens | N | D |
| ***Tripsacum dactyloides*** | **Eastern gamagrass** | **NS** | **D** |
| *Ulmus crassifolia* | Cedar elm | N | U |
| *Vernonia sp.* | Ironweed | N | D |

A formal survey was conducted in late spring 2010 to confirm casual observations and determine whether or not additional efforts would be needed establish desirable vegetation in specified areas. Seventeen permanent transects (GPS-recorded) were placed around the LCOW for evaluation of the grassland communities (Figure 28). A 1-m x 1-m sampling plot was placed every 25 feet along each transect, with plant species presence and estimates of percent cover recorded. Voucher specimens were collected and returned to LAERF for final identification. Surveys used to evaluate the status of subsequent efforts to improve the grasslands used these same transects and procedures in spring 2011 and 2012; supplemental meander surveys to identify summer- and fall-blooming species were also conducted those years.

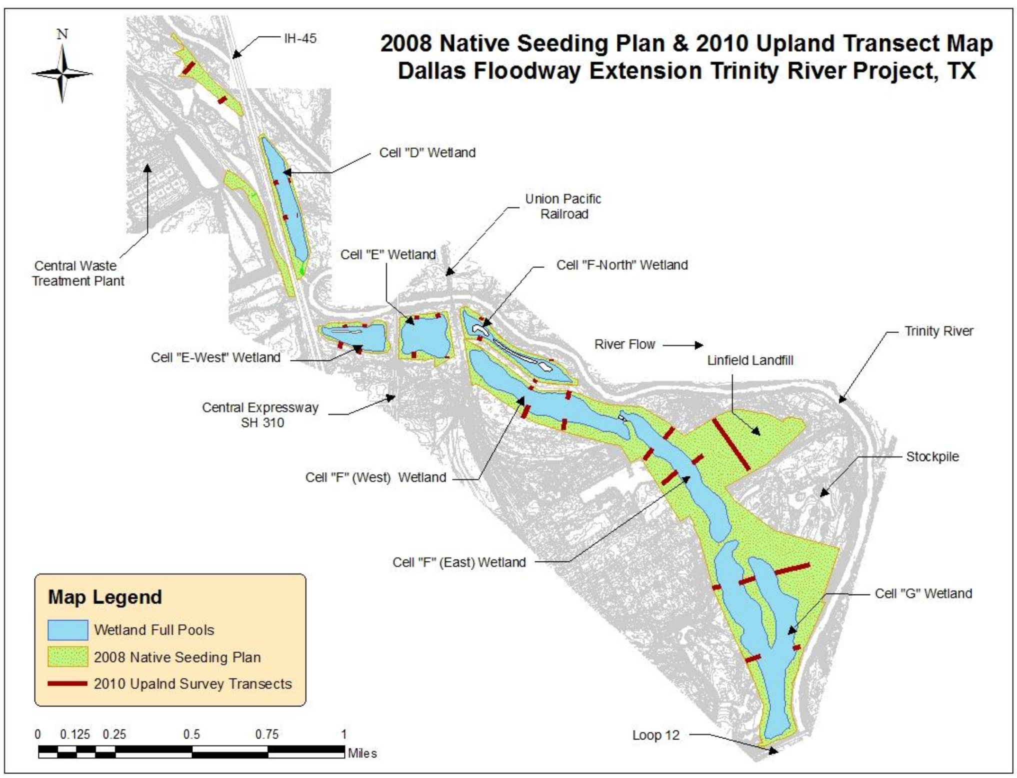


**Figure 28. Seventeen transects were placed around the LCOW for evaluating the plant communities within drill-seeded areas.**

The 2010 spring transects survey identified 73 plant species in the LCOW grassland areas, with 47 (64%) of those considered desirable; the remaining 26 (36%) species are considered undesirable and are either nonnative or aggressive (Appendix H). Only eleven drill-seeded or plugged species were identified in the transect survey, representing 15% of the total species identified and 23% of the desirable native species. Undesirable species were encountered more frequently (45.7%) than desirable species (42.8%), cover crop species (6.4%), and unknown species (5.1%).

Percent cover estimates showed that undesirable species covered 65.6% of the grasslands and desirable species 34.4%. Undesirable species were dominated by giant ragweed, with an estimated cover of over 25% of the entire surveyed area, almost half the area dominated by undesirable species. Desirable species coverage was dominated by volunteer species (73%) as opposed to seeded species (27%). Seeded species represented just over 5% of total grassland cover and most notably included 3% clasping coneflower (*Dracopis amplexicaulis*), 1% Illinois bundle flower (*Desmanthus illinoensis*) and 1% Plains coreopsis (*Coreopsis tinctoria*).

Following the spring 2010 survey, it was determined improvements could be made to the vegetation community, and that establishing better grasslands would require a change in strategy from drill seeding, which had provided low success (other than rye cover crop establishment) following two efforts. Because undesirable vegetation was well established and dominated the grasslands by 2010, grassland improvement would require inclusion of management of at least some of those species, most notably giant ragweed. ERDC requested and SWF complied with engaging a contractor for scheduled mowing in an effort to target giant ragweed and some of the other nuisance grassland plants to reduce competition with desirable plants. Properly timed mowing would further benefit by preventing production of new seeds of nuisance species, thereby reducing the weedy seedbank and provide longer-term benefits to beneficial plants. In concert with management by mowing, ERDC began the process of determining the best approach to improving the species diversity and overall grassland plant community at the LCOW.

## Grassland test plantings

A four-year effort was formulated for establishing plant communities in the grasslands surrounding the LCOW. First year efforts included conducting test plantings to evaluate differences between seeding and containerized plants, (containerized) annuals and (containerized) perennials, and (containerized) grasses and (containerized) forbs. Two test locations were selected: Cell F (West) between the lower end of the cell and the Trinity River, and Cell D (between the wetland cell and Interstate Highway 45). Twelve native grassland plants, including six perennial grasses and six perennial or annual forbs, were selected for the tests based upon their predicted suitability for establishment under conditions that occur in the LCOW (Table 35).

**Table 35. Twelve grassland species were selected for test plantings at two locations in the LCOW.**

| Scientific name | Common name | Growth form |
|---|---|---|
| *Andropogon gerardii* | Big bluestem | Perennial grass |
| *Chamaecrista fasciculata* | Partridge pea | Annual forb |
| *Dracopis amplexicaulis* | Clasping coneflower | Annual forb |
| *Desmanthus illinoensis* | Illinois bundleflower | Annual forb |
| *Helianthus maximiliani* | Maximilian sunflower | Perennial forb |
| *Oenothera speciosa* | Pink evening primrose | Annual forb |
| *Panicum virgatum* | Switchgrass | Perennial grass |
| *Salvia coccinea* | Scarlet sage | Annual forb |
| *Schizachyrium scoparium* | Little bluestem | Perennial grass |
| *Sorghastrum nutans* | Yellow Indiangrass | Perennial grass |
| *Tridens albescens* | White tridens | Perennial grass |
| *Tripsacum dactyloides* | Eastern gamagrass | Perennial grass |

Containerized plants were produced at LAERF culture facilities during fall and winter 2010/2011 and transplanted into the field in late winter 2011. Six individuals of each of the twelve species were transplanted on 5-ft centers within each containerized plant treatment plot (one at Cell D, two at Cell F). Seeds of the same species were broadcast in adjacent plots, which were then harrowed to improve soil contact in seeded plots. The area was cordoned off to prevent unintentional mowing or other mechanical disturbance to the plots.

Plant establishment was monitored periodically to evaluate the treatments. Few, if any, plants established from seeds at either test site by the end of the growing season. Because the seeds had proven viable (ERDC produced many of the containerized plants using the same seed stock), it appeared that they either failed to germinate or did not survive following germination. While overbanking did not occur (silt cover has been implicated in failure of seed drilling at the LCOW), 2011 spring and summer were particularly dry and may have contributed to seed failure. Considering the poor performance of seeding in this test (and previous seeding efforts) and uncertainties of environmental conditions at the LCOW grasslands, ERDC concluded that establishing vegetation from seed would have the lowest probability of success and therefore would not be included in large-scale plantings.

Containerized perennials fared much better, with survival estimates for most species in excess of 70% at both locations. Most annual forbs, however, did not appear to survive (Table 36).

**Table 36. Containerized perennial grasses are the most likely to survive conditions in the LCOW grassland areas.**

| **Common name** | **Cell F (West) % survival** | **Cell D % survival** |
|---|---|---|
| Big bluestem | 75 | 90 |
| Partridge pea | 0 | 0 |
| Clasping-leaved coneflower | 0 | 0 |
| Illinois bundleflower | 0 | 0 |
| Maximilian sunflower | 100 | 100 |
| Pink evening primrose | 0 | 0 |
| Switchgrass | 70 | 80 |
| Scarlet sage | 0 | 25 |
| Little bluestem | 40 | 100 |
| Yellow Indiangrass | 80 | 70 |
| White tridens | 60 | 90 |
| Eastern gamagrass | 98 | 70 |
| **Mean** | **44** | **52** |

Several factors likely contributed to survival between containerized plant treatments. Each species likely responded differently to growing conditions during the spring and summer of 2011, with perennial grasses exhibiting the highest survival as a group. Annuals and forbs fared poorly under those conditions, indicating that transplanting them (without subsequent irrigation) would not be successful during dry years in the LCOW grasslands. Drought conditions may have also affected accuracy of survival estimates for some perennial species, which may have gone into stress dormancy. And, the presence of other foliage (most notably giant ragweed), may have made it difficult to find some species (of any type) during assessments.

Basis for mean differences in survival rates between Cell F and Cell D are not clear at this time, although survival rates in Cell D, which were generally higher, may be attributed to soil moisture (no readings were below 10%) or possibly the shading effect of the elevated highway overlooking the plots to the west. Soil moisture measured in late summer showed that portions of the plots at Cell F held 3% or less moisture, where all plants, including volunteers, had died due to drought stress---those areas looked as though they had been treated with broad spectrum herbicides. Other areas within the plots held considerably more soil moisture (10% and greater), and plants, although appearing stunted, remained alive.

Considering that containerized, perennial species (all the grasses and one forb, Maximilian sunflower, *Helianthus maximiliani*), exhibited the highest survival, ERDC decided to focus on that group of plants for establishing a sustainable native grassland plant community in the LCOW.

## Grassland large-scale plantings

Large-scale grassland plantings were intiated during the winter of 2011/2012 using containerized plants produced at the LAERF. Ten grassland species were selected for planting, including grasses and several perennial forbs that had proven successful in 2010 plot tests; smaller numbers of untested perennial forbs were available and were included in the plantings (Table 37).

**Table 37. Numbers of ten perennial species and the areas in which they were selected for large-scale planting in the grasslands adjacent to the LCOW. IH-45 represents an area just west of Interstate Highway 45.**

| Scientific name | Common name | IH-45 | E-West | E | F-North | F (West) | F (East) | G | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| *Amsonia tabernaemontana* | Eastern bluestar | | 6 | 24 | | | | | 30 |
| *Andropogon gerardii* | Big bluestem | 50 | 25 | 24 | 12 | 24 | 24 | 48 | 207 |
| *Carex crus-corvi* | Crow foot sedge | | 10 | 24 | | | | | 34 |
| *Helianthus grosseserratus* | Sawtooth sunflower | | | | | | | 50 | 50 |
| *Helianthus maximiliani* | Maximilian sunflower | 50 | 10 | 10 | | | | | 70 |
| *Panicum virgatum* | Switchgrass | 100 | | 0 | | 12 | | 36 | 148 |
| *Schizachyrium scoparium* | Little bluestem | 50 | 25 | 24 | 12 | 24 | 24 | 48 | 207 |
| *Sorghastrum nutans* | Indiangrass | | 30 | 30 | 12 | 96 | 96 | 72 | 336 |
| *Tridens albescens* | White tridens | 50 | | 4 | | 48 | 48 | 120 | 270 |
| *Tripsacum dactyloides* | Eastern gamagrass | 100 | 50 | 50 | 100 | 200 | 200 | 450 | 1150 |
| | **TOTAL** | **400** | **156** | **190** | **136** | **404** | **392** | **824** | **2502** |

Grasslands slated for improvement in the ERDC 2010 SOW totaled 48 acres, and included areas immediately surrounding most of the wetland cells and a section of grassland just south of the Trinity River and west of Interstate Highway 45. ERDC additionally supplemented grassland plantings around Cell D, bringing the total grassland improvement area to approximately 55 acres (Figure 29). Several desirable grass species were already established in some areas, with those species that appeared sufficient for further natural colonization considered when laying out planting schematics. For instance, switchgrass was fairly well established around portions of Cell E-West, E, F-North, and F (West), and therefore no additional plantings of that species was planned for those areas. In all, four general planting areas were identified within the turfing area.

1. Seven+ acres west of IH-45. This area was dominated by Bermudagrass and Johnsongrass. Efforts focused on overplanting the existing nuisance species-dominated grassland with large, robust species, including big bluestem, eastern gamagrass, little bluestem, Maximilian sunflower, switchgrass, and white tridens. Planting began in 2011 (fall).

2. Eight+ acres surrounding Cell D. Eastern gamagrass and switchgrass had been established from plugs in some areas. Supplemental planting with other grass species and forbs was initiated in 2011/2012 (winter).

3. Fifteen acres surrounding portions of Cell E-West, E, F-North, and F (West). All species except for switchgrass (which is already moderately established in these areas) were planted, beginning 2011/2012 (winter).

4. Twenty-five acres surrounding portions of all cells (except Cell D). All species were planted in those areas, beginning in 2011/2012 (winter).


**Figure 29. Turfing map highlights areas slated for grassland vegetation community improvements beginning in 2011.**

In addition to species already established, considerations were given to elevations, and ultimately, soil moisture in each planting area. Those species thought least likely to survive drought conditions (e.g., Eastern gamagrass) were planted nearest the wetland cells, where the water table was expected to provide higher soil moisture to sustain growth even under drought conditions. Species more tolerant of drought conditions (e.g., switchgrass) were planted at higher elevations.

Plantings were made on multiple transects running parallel with wetland cell shorelines and placed 30-ft apart. This resulted in tiers of plantings at different elevations, with tiers closest to the wetland cell at lowest elevation and those farthest from the wetland cell at the highest elevation. Dependent upon the turfing area dimensions (Figure 29), one to three tiers were installed around the LCOW. An exception was the IH-45 area, where 6 tiers were installed, all at the same elevation. Plantings were made on 30-ft centers along each tier, resulting in an approximate 30-ft on center distribution of plants in the turfing area. Approximately 2500 containerized plants were transplanted into the grasslands during that time (Table 37).

Evaluations of large-scale plantings were made periodically, with a final evaluation made near the end of the first growing season (September 2012), when ERDC was able to locate approximately 21% of the plants installed. While this number appears to imply low survival, it is more a reflection being able to locate individual plants in mixed communities of vegetation. Although each transplant was marked with a survey flag, most flags were destroyed by mowing that took place twice during that year. And, because some species are slow to establish, even when planted from containers, they may remain difficult to locate for two or three years.

Several species were more easily found than others, including switchgrass, Eastern gamagrass, and white tridens. However, some of all species were located with the exception of Eastern bluestar. Documented survival under harsh growing conditions (the summer of 2012 suffered drought conditions similar to those occurring in 2011) provided ERDC with additional information for continuing to formulating plantings strategies for 2013.

ERDC altered its approach for the second year of large-scale planting (beginning in the 2012 winter). Instead of continuing to plant individuals to fill in the 30-ft on center layout already planted, plots were distributed around the turfing areas in which multiple species were planted. In total, 65 plots were set up for planting during 2012-2013 (Appendix I). This approach was taken in order to address three goals: 1) increase desirable species coverage, 2) increase number and distribution of desirable species, and 3) identify additional techniques for greater establishment success.

Plots measured approximately 25-ft x 25-ft and were placed around each wetland cell and the area west of I-45. After selection and marking with survey flags, plots were treated with 2% a.i. glyphosate to kill nuisance vegetation, primarily Bermudagrass and Johnsongrass, which might interfere with newly establishing transplants. The primary focus of the plots was to establish perennial grasses and forbs that had proven successful in previous plantings, but included species that have begun to establish naturally in the grasslands but have not yet become widespread; these species were planted in each of the 65 plots in winter 2012 (Table 38 and Figure 30). Additional species will be planted in each plot in spring 2013 (Table 38 and Figure 30), resulting in 25 species that will be installed during the second year plantings.

**Table 38. Species selected for the second year of large-scale plantings in the LCOW grasslands.**

| **Planted winter 2012** | | **To-be-planted spring 2013** | |
|---|---|---|---|
| **Scientific name** | **Common name** | **Scientific name** | **Common name** |
| *Andropogon gerardii* | Big bluestem | *Bouteloua curtipendula* | Sideoats grama |
| *Bouteloua dactyloides* | Buffalograss | *Chamaecrista fasciculata* | Partridge pea |
| *Callirhoe involucrata* | Winecup | *Coreopsis tinctoria* | Plains coreopsis |
| *Glandularia bipinnatifida* | Dakota vervain | *Dalea purpurea* | Purple prairie clover |
| *Helianthus maximiliani* | Maximilian sunflower | *Desmanthus illinoensis* | Illinois bundleflower |
| *Lippia nodiflora* | Texas frogfruit | *Dracopis amplexicaulis* | Clasping leaf coneflower |
| *Panicum virgatum* | Switchgrass | *Engelmannia pinnatifida* | Cutleaf daisy |
| *Schizachyrium scoparium* | Little bluestem | *Eriochloa sericea* | Texas cupgrass |
| *Sorghastrum nutans* | Indiangrass | *Gaillardia pulchella* | Indian blanket |
| *Tridens albescens* | White tridens | *Helianthus grosseserratus* | Sawtooth sunflower |
| *Tripsacum dactyloides* | Eastern gamagrass | *Liatris sp.* | Gayfeather |
| | | *Monarda citriodora* | Lemon mint |
| | | *Rudbeckia hirta* | Black-eyed susan |
| | | *Salvia azurea* | Pitcher sage |

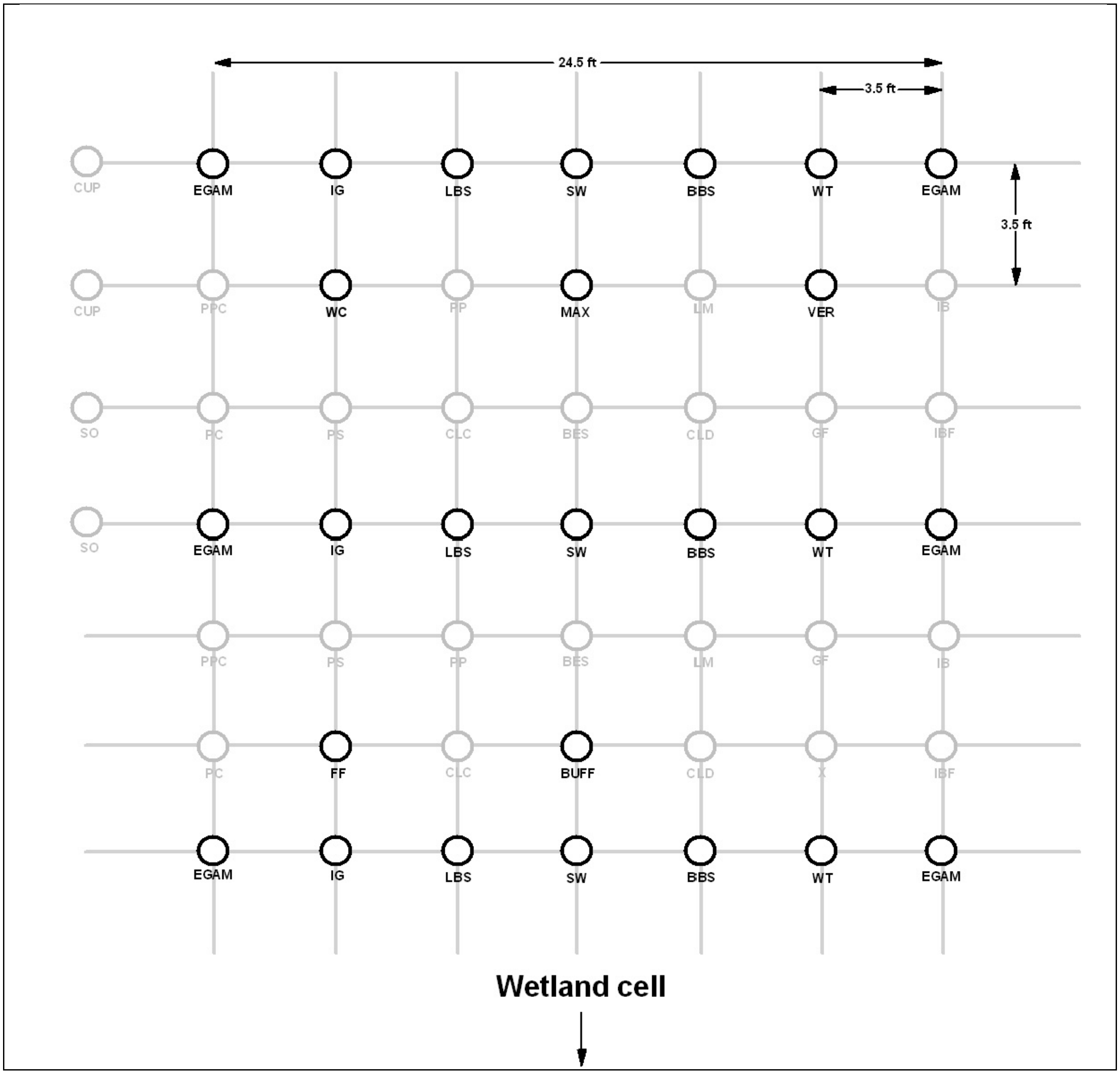


**Figure 30. Sixty-five plots were laid out around the LCOW and are being planted with 25 grassland species. Species planted in winter 2012 include: Eastern gamagrass (EGAM), Indiangrass (IG), little bluestem (LBS, switchgrass (SW), big bluestem (BBS), white tridens (WT), winecup (WC), Maximilian sunflower (MAX), Dakota vervain (VER), Texas frogfruit (FF), and buffalograss (BUFF). Species that will be planted in spring 2013, in faded gray, include purple prairie clover (PPC), plains coreopsis (PC), Indian blanket (IB), Illinois bundleflower (IBF), gayfeather (GF), lemon mint (LM), cutleaf daisy (CLD), partridge pea (PP), claspingleaf coneflower (CLC), pitcher sage (PS), black-eyed susan (BES), Texas cupgrass (CUP), and sideoats gama (SO).**

Installing large number of plots in 2012 enabled ERDC to conduct additional evaluations for establishing grassland plants in the LCOW. Several methods that should improve transplant survival establishment and growth are being evaluated. This information will be incorporated into LCOW grasslands plantings made in later 2013 and early 2014; it will additionally be valuable in developing planting strategies for the Upper Chain of Wetland's grasslands areas once they are constructed.

Methods being evaluated include combinations of irrigation and amendments with fill dirt, Terra-Sorb™, and mycorrhizal fungi:

- A portion of the plots will be irrigated on an as-needed basis, when soil moisture content drops below 10%
- Planting pits in some of the plots will be amended with fill dirt to help reduce voids common in backfilling
- Planting pits in some of the plots will be amended with Terra-Sorb™ to provide a longer-term water source between rain events
- Root balls in some of the plots will be inoculated with commercial mycorrhizal fungi to improve transplant performance
- Some plots will receive varying combinations of the above treatments, with most receiving all of them

## Additional grassland plantings

In late 2012, SWF expressed concern about poor grassland vegetation coverage and potential erosion during rain events in two areas outside the turfing area. These areas included the hillsides on either side of Cell F (East) that correspond with a cut through the old Linfield Landfill. ERDC conducted a precursory evaluation of the areas and submitted a SOW addressing the issue. The SOW called for additional seeding and planting containerized plants to help fill in bare areas. Although seeding the LCOW was not largely successful in previous efforts due to overbanking events and absence of irrigation in previous attempts, these hillsides are largely above the areas prone to overbanking, and the potential cost effectiveness and benefits of success suggested it should be used in this effort. That success would depend, in large part, upon unpredictable weather conditions that will occur in the area during fall, winter and spring of 2012/2013.

A seed mix comprised of cover crop and dry-condition suitable grass species was broadcast at 22 lbs per acre over the two hillsides in November 2012 (Table 39). Soils were harrowed as seeds were broadcast to increase seed contact with soil. In addition to seeding, the hillsides will be planted with containerized plants in winter 2011-2013.

**Table 39. Grass seeds were broadcast over two hillsides just outside the LCOW turfing area in an effort to fill in bare spots.**

| Species | Pounds per acre | X10 acres (in lbs) |
|---|---|---|
| Cereal rye | 12 | 120 |
| Buffalograss | 3 | 30 |
| Sideoats grama | 3 | 30 |
| Switchgrass | 4 | 40 |
| White tridens | <1 (4 packs) | 40 packs |

## Effects of management on the grasslands

Following drill-seeding at Cell D, intermittent mowing was conducted in association with mowing under and along the right-of-way of I-45. However, establishment of native grasslands was not considered when mowing schedules were set, resulting in several undesirable species, primarily Johnsongrass and giant ragweed, dominating the area. No mowing was conducted in the remaining LCOW grasslands after drill-seeding in 2008 and 2009, resulting in giant ragweed rapidly becoming the dominant species there.

In addition to supplementing the native grassland plant community with containerized plantings as described above, ERDC recommended that SWF initiate a scheduled, and as-needed, mowing program to help control nuisance plants while at the same time permit growth and spread (primarily by seed) of desirable species. A general schedule was followed to target the two dominant problem plants, typically calling for one or two mows per year, depending upon conditions. Two mows were made in 2010 and 2011, but only a single mow was required in 2012:

1) Mid-summer mow---targets giant ragweed and marsh-elder, which are mowed before setting seeds. Because these are annual species, preventing seed production can significantly reduce the seedbank, resulting in fewer plants the following year. Waiting until mid-summer also permits most spring annuals a chance to set seed, and provides long enough remaining growing season for seed production by many fall annuals.

2) Late summer to early fall mow---targets Johnsongrass to further reduce seed production and weaken rootstock, especially during dry periods. Many native grasses (e.g., switchgrass) can tolerate this mow and have already set seeds, minimizing damage to them.

Plant community response to this mowing schedule is evident in transect data recorded during the spring of each year (Table 40, Appendix H). In all, 73 species were identified along transects in 2012, 95 in 2011, and 64 in 2012. Variations in numbers observed include year-to-year seasonal differences (e.g., spring 2012 was very dry, possibly reducing or delaying annual species sprouting) and the amount of cover crop in an area (e.g., dense stands of cool season grasses, such as ryegrass, can reduce or “mask” early stage annuals) at the time transects surveys are conducted.

Although not enough data is available to draw reliable conclusions, comparing the three years using transect data collected each spring provides interesting results. For instance, frequencies of the two major categories of grassland plants (undesirable and desirable) making up the vegetation community have remained stable, with each representing about half the species identified at the LCOW in all three years. Undesirable species will always occur in the grasslands, but their presence does not necessarily indicate an ecosystem problem unless they become the dominant plants in the community. At the same time, changes in frequencies of desirable plants may not indicate ecosystem improvement (increases) or degradation (decreases) unless accompanied by changes in coverage (see below). However, the data available suggests that seeded/planted desirable plants are increasing in frequency in the grasslands, representing half of the desirable species encountered in 2012 as opposed to about a third in 2010.

**Table 40. Frequency estimates for the grassland surveys conducted in 2010, 2011 and 2012 in the LCOW, excluding Linfield Landfill.**

| **Year** | | **2010** | **2011** | **2012** |
|---|---|---|---|---|
| **Undesirable** | | 45.7 | 51.1 | 51.8 |
| **Desirable** | *Volunteers* | *31.4* | *32.2* | *24.1* |
| | *Seeded or planted* | *17.8* | *16.4* | *24.8* |
| | **Total** | 49.2 | 48.6 | 48.9 |
| **Unknown** | | 5.1 | 0.1 | 0.0 |

Percent coverage of these categories is more revealing in terms of ecological condition, and this has changed noticeably since mowing was implemented in 2010 (Table 41, Appendix H). For the purpose of this summary, cover crop species have been assigned into either desirable (cereal rye) or undesirable (ryegrass). In 2010, about 48% of the grasslands coverage was by undesirable plants, predominantly giant ragweed (25.3%), Bermudagrass (5.2%), ryegrass (3.1%) and Johnsongrass (2.9%). However, by spring 2011 (after a season of mowing), undesirable plants coverage declined to 34.2%, with that change due primarily to a major decline in giant ragweed (15.9%). By spring 2012 (after a second season of mowing), undesirable plant coverage increased slightly to 39.3%.

**Table 41. Estimated percent coverage by grassland species in the LCOW from 2010-2012.**

| Year | 2010 | 2011 | 2012 |
|---|---|---|---|
| Undesirable | 48.0 | 34.2 | 39.9 |
| Desirable | 34.3 | 50.8 | 47.9 |
| Bare | 17.6 | 14.9 | 12.2 |
| Unknown | >0.1 | >0.1 | 0.0 |

In addition to undesirable species coverage declines after two mowing seasons, changes in the species comprising that coverage also occurred: by 2012, declining undesirables included giant ragweed (from 25.3% to 3.2%) and Bermudagrass (from 5.2% to 2.1%), while increases were seen in ryegrass (3.1% to 21.4%) and Johnsongrass (2.9% to 4.7%). Ryegrass, while not generally considered beneficial to native grasslands, does serve as a cover crop to reduce erosion and, because it is a cool season grass, may serve as shade for younger stages of warmer season forbs and grasses. If ryegrass were classified as a desirable species in this project, undesirable and desirable ratios change considerably, with larger declines in undesirable plants and greater increases in desirable plants during the period (Table 42).

**Table 42. Estimated percent coverage by grassland species in the LCOW from 2010-2012. The cover crop ryegrass is assigned as a desirable species in these estimates.**

| Year | 2010 | 2011 | 2012 |
|---|---|---|---|
| Undesirable | 44.9 | 19.7 | 18.5 |
| Desirable | 37.4 | 65.3 | 69.3 |
| Bare | 17.6 | 14.9 | 12.2 |
| Unknown | >0.1 | >0.1 | 0.0 |

In both cases presented above, desirable native species have increased in response to mowing and reduction of giant ragweed. In 2010, coverage was dominated by cereal rye (9.5%), slim aster (5.2%), clasping coneflower (3.0%), frogfruit (1.7%), and Illinois bundleflower (1.0%). By 2012, cereal rye, a cover crop, had declined as expected (to 2.1%), but others had increased: slim aster (to 5.4%), clasping coneflower (to 5.4%), frogfruit (to 2.7%), and Illinois bundleflower (to 2.4%). Another desirable annual species, pink evening primrose, which was not observed in transect surveys in 2010, was recorded at 4.5% coverage in 2011 and 8.8% coverage in 2012.

Bare areas (those in which no plants are observed) are unwanted in the grasslands, mostly due to the fact that these areas tend to be prone to erosion and/or provide opportunity for establishment of nuisance plants. Transect percent coverage data indicate that bare areas have declined between 2010 and 2012 (Table 41, Appendix H). In 2010, 18% of each transect plot supported no vegetation, but by 2012, only about 12% areas within transect plots did not support vegetation. This is in part due to a change in the vegetation community and growth forms of plants dominating it: grasses and sprawling forbs commonly produce higher densities of stems and runners than tall forbs such as giant ragweed, resulting in better groundcover and reduced erosion.

Meander surveys conducted in 2012 were used to verify transect results and evaluate the overall grassland community condition at the LCOW (Appendix J). These general surveys support transect results and preliminary conclusions, with the overall status in the grasslands showing a large decline in giant ragweed accompanied by a surge in ryegrass and several desirable grassland species in the spring and early summer. Meander surveys further support transect data suggesting that several undesirable species, including Johnsongrass and Bermudagrass, are not spreading at rapid rates due to management of giant ragweed, but rather that desirable plants such as switchgrass, white tridens, pink evening primrose, and others are filling in those areas more rapidly. Meander surveys also suggest that two species of concern in 2011---common morning-glory and balloonvine, fall annuals that do not show up in significant numbers in spring surveys---were no longer as widespread in 2012, possibly the result of mowing that targeted other summer annuals (ragweed and marsh-elder). One undesirable species that was identified in late winter 2012 that may become problematic, although it currently infests only a small percentage of the LCOW grasslands: the cool season, annual bastard cabbage (*Rapistrum rugosum*), an invasive plant becoming more and more widespread in Texas that may require management in future years.

## Grasslands Summary

Overall, the grasslands appear to be on the right track to meet project goals of establishing a plant community dominated by desirable species that are tolerant of conditions that occur at the LCOW---dry periods occasionally interrupted by overbanking events. After three years of management, the grasslands have been transformed from one dominated by undesirable plants (mostly giant ragweed) to one in transition between cover crop and desirable plants (Figure 31). As management continues to target undesirable species, their occurrence should continue to decline as they are replace by beneficial grassland species.


**Figure 29. Giant ragweed dominated most of the LCOW grasslands in 2009 and 2010 (left). Mowing was initiated in late 2010, primarily targeting ragweed: by late 2012, ragweed was no longer dominant, providing the opportunity for establishment and spread of desirable grassland species such as switchgrass, Eastern gamagrass, and others (right).**

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# Appendix A

**Dallas Floodway Extension**

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

# 2012 Task Status Report Summary

**US Army Engineer Research and Development Center**
**Lewisville Aquatic Ecosystem Research Facility**

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**Planning and Materials**

Materials were purchased to complete tasks through August 2012
Additional materials were purchased to complete tasks through December 2012

**Plant Production**

All aquatic and grassland plants were produced for plantings through August 2012
Additional grassland plants were produced for plantings through December 2012
Additional plants are being produced and maintained for plantings beyond December 2012

**Plantings**

Wetland Cell D

Supplemental plantings of submersed and floating-leaved aquatic species in existing ring-cage and pen exclosures not containing vegetation were made in 2012;

Wetland Cell E-West

Multiple pen constructions were replanted with submersed and floating-leaved aquatic plants in spring and early summer 2012.

Wetland Cell E

Supplemental plantings of submersed and floating-leaved aquatic species were made in existing ring-cage and pen exclosures not containing vegetation in winter, spring and summer 2012.

Wetland Cell F

Section F (West) received supplemental plantings of floating-leaved plantings in spring 2012.

Section F (East) was planted with emergent, submersed, and floating-leaved vegetation at 15 total sites around wetland in summer 2012. High density plantings were made in near the outfall to help reduce erosion to due wave action and overbank events.

Wetland Cell F-North

Supplemental submersed floating-leaved plantings were made in summer 2012.

Wetland Cell G

Supplemental plantings of submersed and floating-leaved aquatic species in existing ring-cage and pen exclosures not containing vegetation were made early summer 2012.

Wood Duck Pond

No plantings were required for this water feature in 2012.

Riverine Armoring - Trinity River @ IH-45

Hard-armoring rip-rap area plantings of wetland and grassland perennial herbaceous species and woody vines were planted on 2-ft centers along the west side of the river (winter, spring, and summer 2011). The river edge was planted with aquatic emergent species on 4-ft centers under and adjacent (200 ft) to IH-45 (spring 2011). Several significant replantings were required due to unauthorized mowing by COD contractors.

Additional plantings on the west side, completion of planting on the east side and replacement plantings (where needed) on the west side will be made in winter 2012-2013.

Cell F / G armoring

Hard-armored/ rip-rap areas were planted with wetland and grassland perennial herbaceous species and woody vines on 4-ft centers in 2011 and 2012.

Cell G Outfall

Hard-armored/ rip-rap areas and Cell G's outflow creek did not require planting in 2012.

Additional plantings will be made in winter 2013 to increase coverage and improve performance during high flow events.

Cell E West Outfall / Cut

Erosion area plantings of wetland and grassland perennial herbaceous species and woody vines were not required in 2012.

Cell F North Outfall / Cut

Erosion area plantings of wetland and grassland perennial herbaceous species and woody vines were not required in 2012.

**Plant and Water Quality Monitoring**

Plantings were assessed monthly for establishment, spread, herbivory and overall success through December 2012.

Several wetland cell meander surveys were conducted throughout the LCOW during 2012.

Water quality was measured approximately every three months at multiple locations in each of the wetland cells (inlet and outlet) in 2012.

**Sediment Monitoring**

Wetland cell elevation measurements used for calculating sedimentation rates were made in late spring 2012 and will be completed in winter 2013.

**Biological Monitoring**

Fisheries

Fish communities were sampled at two locations in each wetland cell in spring, summer, and fall 2012.

Macroinvertebrates

Macroinvertebrate communities were sampled at two locations in each wetland cell in spring, summer, and fall 2012.

Birds, mammals, and other vertebrates

Informal surveys were conducted throughout the LCOW on a monthly basis through December 2012.

**Grassland Planting and Monitoring**

Test Plots

Grassland species establishment test plots (comparing seeding vs. containerized plants, with and without management) were evaluated to ascertain the benefits of mowing.

Large-scale grassland plantings began in winter 2011-2012 and continue in winter 2012-2013.

Plant Production

Plants needed for grassland planting in winter 2012-2013 were acquired and put under nursery production in spring and summer 2012. Those needed for cold weather planting have been produced and are currently being maintained.

Continued production of plants needed for FY2013 plantings and initiation of production of plants that will be needed for winter 2013-2014 planting will continue through December 2013.

Mowing

Test plots and other moderate-scale areas were mowed by ERDC to specifications in summer 2012; ERDC oversaw LCOW-wide contractor mowing during summer and fall 2012.

Grassland Vegetation Surveys

Grassland areas were surveyed for vegetation presence and coverage in spring (transect surveys) and fall (meander surveys) 2012.

**Site Management**

Plant Communities

Overbanking events were documented
Submersed plant exclosures were repaired, as needed, spring – summer 2012

Herbivory

Turtle removal and relocation was made seasonally through December 2012---this effort was conducted in Cells D and F (West).

Herbicidal treatments

No herbicide treatments were required in the wetland cells during 2012.

Glyphosate treatments were made in fall 2012 at sixty-five plots to-be-planted with grassland species, primarily to control Johnsongrass and Bermudagrass.

Biocontrol treatments

Introduction of alligatorweed flea beetles were made to all LCOW wetland cells and the CWWTP supply channel on four occasions during 2012:  mid-spring, late spring, early summer, and mid-summer.  Monitoring of efficacy of biocontrol agents continued until the first killing frost (generally November).

Note:  as of this report, it appears that biocontrol treatments were successful in controlling alligatorweed in the LCOW during 2012.

**Reports**

The FY11 status report was completed and submitted in February 2012.

A draft O&M manual for the LCOW was produced and submitted in winter 2013.

# Appendix B

**Dallas Floodway Extension**

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Water Quality

**Appendix B. Water quality (temperature, pH, dissolved oxygen, and conductivity) collected in the LCOW between 2009 and 2012.**

| Sample site | Season | Temp (C) | | | | pH units | | | | DO mg/L | | | | Conductivity mS/cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | **2012** | 2009 | 2010 | 2011 | **2012** | 2009 | 2010 | 2011 | **2012** | 2009 | 2010 | 2011 | **2012** |
| D inlet | Spring | 28.6 | 33.3 | 30.4 | 30.7 | 8.4 | 8.4 | 9.2 | 8.3 | 6.6 | 8.3 | 12.3 | 7.9 | 0.485 | 0.485 | 0.402 | 0.579 |
| | Summer | 24.2 | 28.4 | 26.0 | 24.0 | 8.4 | 6.7 | 8.2 | 7.9 | 8.7 | 7.0 | 6.0 | 8.4 | 0.379 | 0.467 | 0.888 | 0.669 |
| | Fall | 6.1 | 12.6 | 14.1 | 9.7 | 8.2 | 8.1 | 7.4 | 6.8 | 11.6 | 11.5 | 8.4 | 15.1 | 0.432 | 0.760 | 0.808 | 0.732 |
| D outlet | Spring | 28.6 | 32.1 | 30.1 | 30.2 | 8.7 | 8.1 | 9.3 | 9.3 | 8.9 | 6.7 | 11.9 | 10.2 | 0.52 | 0.494 | 0.707 | 0.507 |
| | Summer | 24.5 | 28.2 | 27.9 | 25.1 | 8.8 | 6.8 | 8.9 | 8.4 | 10.1 | 6.1 | 8.1 | 10.3 | 0.352 | 0.418 | 0.887 | 0.664 |
| | Fall | 6.3 | 10.5 | 12.9 | 8.3 | 7.5 | 8.4 | 7.6 | 7.8 | 10.7 | 11.4 | 9.2 | 16.4 | 0.440 | 0.759 | 0.806 | 0.714 |
| E-West inlet | Spring | 31.0 | 33.7 | 30.0 | 30.7 | 8.8 | 10.1 | 9.3 | 8.9 | 7.6 | 12.7 | 12.5 | 8.2 | 0.375 | 0.480 | 0.730 | 0.390 |
| | Summer | 24.7 | 28.4 | 28.0 | 24.5 | 9.2 | 6.8 | 8.5 | 8.8 | 12.3 | 6.4 | 10.1 | 9.9 | 0.435 | 0.350 | 0.756 | 0.619 |
| | Fall | 7.6 | 9.9 | 12.2 | 8.3 | 8.4 | 8.2 | 7.7 | 7.9 | 13.0 | 10.3 | 12.9 | 9.2 | 0.482 | 0.610 | 0.754 | 0.706 |
| E-West outlet | Spring | 29.9 | 32.8 | 29.9 | 31.8 | 8.7 | 9.9 | 8.9 | 8.9 | 7.3 | 13.5 | 10.5 | 8.6 | 0.387 | 0.499 | 0.740 | 0.391 |
| | Summer | 25.3 | 28.8 | 27.4 | 24.3 | 8.9 | 7.1 | 9.2 | 9.1 | 11.4 | 6.4 | 13.3 | 11.3 | 0.442 | 0.340 | 0.751 | 0.591 |
| | Fall | 8.3 | 10.7 | 13.0 | 8.6 | 8.8 | 8.1 | 8.0 | 7.9 | 12.8 | 9.3 | 13.1 | 9.2 | 0.478 | 0.815 | 0.748 | 0.702 |
| E inlet | Spring | 30.7 | 31.8 | 31.4 | 32.2 | 9.8 | 8.7 | 9.4 | 8.9 | 15.8 | 11.9 | 10.7 | 8.9 | 0.535 | 0.710 | 0.366 | 0.549 |
| | Summer | 25.4 | 29.3 | 28.8 | 23.9 | 7.6 | 7.8 | 9.7 | 7.3 | 10.7 | 7.9 | 10.9 | 6.1 | 0.727 | 0.541 | 0.570 | 0.665 |
| | Fall | 8.0 | 11.0 | 13.0 | 9.8 | 9.3 | 7.7 | 8.0 | 7.9 | 15.5 | 10.4 | 11.5 | 15.5 | 0.457 | 0.808 | 0.560 | 0.736 |
| E outlet | Spring | 31.0 | 32.7 | 32.1 | 29.6 | 9.6 | 8.9 | 9.6 | 8.9 | 14.2 | 11.5 | 12.0 | 8.0 | 0.516 | 0.706 | 0.316 | 0.547 |
| | Summer | 25.2 | 29.4 | 28.7 | 23.7 | 7.5 | 8.3 | 9.8 | 7.6 | 7.8 | 6.9 | 8.8 | 8.4 | 0.724 | 0.535 | 0.568 | 0.663 |
| | Fall | 5.7 | 11.2 | 13.2 | 9.4 | 9.5 | 7.6 | 7.6 | 7.9 | 16.1 | 8.0 | 9.8 | 12.5 | 0.466 | 0.812 | 0.589 | 0.741 |
| F-North inlet | Spring | 32.2 | 31.7 | 30.0 | 30.4 | 8.7 | 8.5 | 8.1 | 7.7 | 7.1 | 9.2 | 7.0 | 7.4 | 0.385 | 0.349 | 0.344 | 0.307 |
| | Summer | 24.9 | 28.4 | | 24.8 | 8.2 | 6.9 | | 7.9 | 7.4 | 6.5 | | 6.4 | 0.378 | 0.350 | | 0.161 |
| | Fall | 8.7 | 10.6 | 12.4 | 8.1 | 8.8 | 8.2 | 7.8 | 8.0 | 13.3 | 9.6 | 10.4 | 10.2 | 0.393 | 0.385 | 0.317 | 0.255 |
| F-North outlet | Spring | 31.3 | 33.8 | 31.3 | 31.4 | 8.7 | 8.7 | 8.3 | 8.0 | 7.5 | 6.9 | 7.7 | 5.4 | 0.410 | 0.340 | 0.356 | 0.344 |
| | Summer | 25.6 | 28.9 | | 24.1 | 8.7 | 7.5 | | 7. 9 | 9.4 | 7.2 | | 7.9 | 0.353 | 0.332 | | 0.374 |
| | Fall | 6.5 | 9.8 | 10.9 | 7.8 | 8.7 | 8.1 | 8.1 | 7.9 | 10.9 | 9.6 | 10.8 | 7.9 | 0.403 | 0.390 | 0.334 | 0.374 |
| F (West) inlet | Spring | 26.6 | 32.7 | 31.1 | 30.5 | 9.3 | 9.4 | 8.6 | 8.9 | 9.6 | 8.7 | 8.6 | 8.7 | 0.350 | 0.652 | 0.524 | 0.454 |
| | Summer | 26.4 | 28.4 | 26.2 | 23.1 | 9.1 | 7.7 | 8.9 | 8.5 | 10.6 | 5.9 | 8.6 | 6.8 | 0.594 | 0.346 | 0.791 | 0.685 |
| | Fall | 7.8 | 10.5 | 11.6 | 8.1 | 8.7 | 7.9 | 7.6 | 7.9 | 12.8 | 8.7 | 9.7 | 10.3 | 0.499 | 0.769 | 0.732 | 0.751 |
| F (West) outlet | Spring | 30.5 | 32.1 | 28.6 | 29.5 | 9.6 | 9.3 | 8.2 | 8.7 | 13.3 | 6.9 | 6.9 | 8.0 | 0.380 | 0.631 | 0.512 | 0.482 |
| | Summer | 27.7 | 28.3 | 26.0 | 23.8 | 9.1 | 7.7 | 8.9 | 8.8 | 12.2 | 6.2 | 10.4 | 8.8 | 0.570 | 0.357 | 0.726 | 0.687 |
| | Fall | 8.9 | 10.1 | 11.2 | 7.7 | 8.6 | 8.3 | 7.3 | 7.9 | 13.9 | 12.0 | 9.5 | 10.9 | 0.528 | 0.757 | 0.725 | 0.757 |
| F (East) inlet | Spring | 26.6 | 32.7 | 30.3 | 28.7 | 9.5 | 9.2 | 9.2 | 8.7 | 15.5 | 7.9 | 10.5 | 7.9 | 0.440 | 0.575 | 0.616 | 0.526 |
| | Summer | 26.9 | 29.0 | 25.9 | 23.8 | 9.2 | 7.7 | 8.9 | 8.8 | 12.5 | 6.5 | 9.7 | 9.7 | 0.496 | 0.337 | 0.785 | 0.69 |
| | Fall | 8.7 | 9.9 | 11.7 | 7.8 | 8.2 | 8.0 | 8.1 | 7.9 | 12.3 | 9.7 | 11.9 | 10.4 | 0.539 | 0.679 | 0.739 | 0.747 |
| F (East) outlet | Spring | 29.7 | 31.2 | 30.6 | 28.1 | 9.7 | 8.5 | 9.3 | 8.6 | 13.2 | 8.3 | 12.4 | 7.6 | 0.322 | 0.501 | 0.607 | 0.527 |
| | Summer | 24.9 | 28.2 | 27.7 | 23.1 | 9.1 | 7.8 | 9.1 | 8.1 | 13.4 | 4.9 | 11.0 | 10.0 | 0.364 | 0.33 | 0.790 | 0.647 |
| | Fall | 6.5 | 9.9 | 12.7 | 7.5 | 8.7 | 8.1 | 7.6 | 7.9 | 12.3 | 11.1 | 10.7 | 8.6 | 0.509 | 0.645 | 0.750 | 0.748 |
| G inlet | Spring | 29.4 | 31.1 | 30.2 | 28.4 | 9.6 | 8.3 | 8.6 | 8.7 | 9.5 | 7.6 | 10.5 | 8.8 | 0.324 | 0.477 | 0.520 | 0.417 |
| | Summer | 25.6 | 29.2 | 25.0 | 22.6 | 8.9 | 7.5 | 8.2 | 8.6 | 11.8 | 5.2 | 8.1 | 7.7 | 0.361 | 0.386 | 0.762 | 0.65 |
| | Fall | 5.9 | 9.4 | 9.3 | 7.8 | 8.4 | 8.4 | 6.8 | 7.9 | 11.4 | 10.7 | 8.9 | 10.1 | 0.488 | 0.642 | 0.729 | 0.745 |
| G outlet | Spring | 28.9 | 31.2 | 30.3 | 29.7 | 8.8 | 7.2 | 8.2 | 8.4 | 7.6 | 4.7 | 8.3 | 6.4 | 0.369 | 0.495 | 0.528 | 0.420 |
| | Summer | 24.4 | 28.9 | 26.0 | 22.4 | 8.5 | 7.5 | 7.0 | 8.1 | 8.8 | 3.8 | 7.0 | 8.1 | 0.361 | 0.385 | 0.787 | 0.660 |
| | Fall | 8.3 | 9.6 | 10.5 | 7.5 | 8.8 | 7.4 | 6.8 | 7.9 | 14.2 | 11.1 | 9.2 | 12.3 | 0.475 | 0.556 | 0.731 | 0.745 |
| ***Mean*** | | 20.8 | 23.8 | 22.9 | **20.7** | 8.8 | 8.1 | 8.4 | **8.3** | 11.2 | 8.5 | 10.0 | **9.3** | 0.451 | 0.530 | 0.641 | **0.580** |

# Appendix C

### Dallas Floodway Extension

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Elevation Transect Data from 2008-2011

**Table C-1. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell D in 2008, 2009, and 2010.**

| Transect D1 | | | | | Transect D2 | | | | | Transect D3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** | **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** | **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** |
| 388.05 | 387.52 | 388.20 | 389.41 | 388.87 | 387.89 | 387.33 | 387.90 | 389.08 | 388.70 | 388.05 | 387.65 | 387.90 | 389.38 | 388.70 |
| 385.36 | 385.16 | 385.80 | 387.31 | 386.74 | 384.77 | 384.37 | 384.49 | 386.13 | 385.72 | 384.61 | 384.70 | 384.19 | 385.90 | 385.36 |
| 384.77 | 384.87 | 385.83 | 386.98 | 386.24 | 384.11 | 384.04 | 384.26 | 385.97 | 385.36 | 384.11 | 383.78 | 384.03 | 385.77 | 385.10 |
| 385.59 | 385.09 | 385.97 | 387.11 | 386.51 | 384.77 | 384.11 | 384.49 | 385.93 | 385.46 | 384.77 | 384.24 | 384.29 | 385.90 | 385.65 |
| 387.79 | 387.62 | 388.23 | 389.31 | 388.54 | 387.89 | 387.39 | 388.03 | 389.08 | 388.38 | 387.79 | 387.39 | 388.10 | 389.08 | 388.93 |
| **Transect D4** | | | | | **Transect D5** | | | | | **Transect D6** | | | | |
| **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** | **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** | **Mar-08** | **Oct-08** | **May-09** | **Jun-10** | **Oct-10** |
| 387.89 | 387.65 | 387.97 | 389.08 | 388.34 | 388.05 | 387.33 | 387.80 | 388.69 | 387.69 | 388.05 | 387.82 | 387.93 | 388.03 | 388.05 |
| 384.61 | 384.27 | 384.13 | 385.80 | 385.03 | 384.77 | 384.50 | 384.72 | 385.47 | 385.03 | 386.25 | 385.98 | 385.38 | 387.21 | 387.06 |
| 384.11 | 383.95 | 384.10 | 385.67 | 384.93 | 384.11 | 383.91 | 384.42 | 385.47 | 385.00 | 385.92 | 385.52 | 385.15 | 386.88 | 386.44 |
| 384.77 | 384.34 | 384.46 | 385.57 | 385.10 | 384.41 | 384.24 | 384.69 | 385.47 | 385.06 | 386.41 | 386.01 | 385.11 | 386.85 | 386.41 |
| 387.79 | 387.49 | 388.39 | 388.95 | 389.10 | 387.72 | 387.49 | 387.87 | 388.85 | 388.61 | 388.22 | 387.65 | 388.00 | 387.70 | 388.08 |

**Table C-2. Elevation (ASL in feet) was calculated from depths taken along three transects in Cell E-West in 2009 and 2010.**

| Transect EW1 | | | Transect EW2 | | | Transect EW3 | | |
|---|---|---|---|---|---|---|---|---|
| **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** |
| 383.75 | 383.22 | 383.02 | 382.43 | 383.22 | 383.35 | 383.35 | 383.35 | 383.52 |
| 380.96 | 381.22 | 381.22 | 382.83 | 381.55 | 380.56 | 380.43 | 381.55 | 378.83 |
| 381.22 | 382.27 | 382.53 | 377.15 | 380.56 | 376.33 | 376.30 | 376.79 | 376.99 |
| 382.14 | 382.20 | 381.55 | 377.94 | 376.30 | 376.99 | 375.71 | 376.30 | 376.86 |
| 383.35 | 383.02 | 383.52 | 383.35 | 383.35 | 383.19 | 375.81 | 376.00 | 376.63 |
| | | | | | | 376.37 | 376.46 | 376.46 |
| | | | | | | 379.12 | 378.76 | 377.19 |
| | | | | | | 382.17 | 382.56 | 383.52 |

**Table C-3. Elevation (ASL in feet) was calculated from depths taken along four transects in Cell E in 2009 and 2010.**

| Transect E1 | | | Transect E2 | | | Transect E3 | | | Transect E4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 |
| 387.54 | 386.20 | 386.36 | 387.67 | 387.44 | 386.46 | 387.57 | 387.02 | 387.05 | 387.54 | 386.52 | 386.69 |
| 386.03 | 386.10 | 384.06 | 386.23 | 385.97 | 385.97 | 385.93 | 383.74 | 383.74 | 382.82 | 382.82 | 382.46 |
| 382.36 | 382.42 | 382.00 | 382.65 | 383.08 | 382.42 | 382.59 | 382.59 | 382.46 | 381.96 | 382.39 | 382.39 |
| 382.33 | 382.26 | 381.74 | 382.59 | 382.46 | 382.46 | 382.49 | 382.42 | 382.36 | 386.36 | 386.36 | 387.02 |
| 382.29 | 382.10 | 381.70 | 382.49 | 382.26 | 382.59 | 382.42 | 382.26 | 382.33 | 386.59 | 386.59 | 386.43 |
| 386.10 | 386.10 | 386.10 | 386.23 | 386.03 | 386.03 | 382.75 | 382.75 | 382.59 | 381.77 | 382.16 | 382.16 |
| 387.57 | 385.70 | 385.87 | 387.67 | 385.70 | 387.02 | 387.54 | 386.20 | 386.69 | 382.71 | 382.23 | 382.78 |
| 387.21 | 387.08 | 386.03 | 387.51 | 386.20 | 386.36 | 387.57 | 387.41 | 387.28 | 387.34 | 386.85 | 386.95 |
| 386.43 | 386.16 | 386.10 | 386.29 | 386.36 | 386.03 | 386.20 | 386.03 | 385.87 | | | |
| 382.03 | 382.36 | 384.72 | 382.42 | 381.90 | 381.90 | 382.16 | 382.26 | 381.83 | | | |
| 381.44 | 382.03 | 381.74 | 382.26 | 382.10 | 381.83 | 381.77 | 382.03 | 381.74 | | | |
| 382.00 | 381.77 | 382.10 | 382.16 | 382.10 | 381.60 | 381.77 | 381.77 | 381.60 | | | |
| 382.42 | 382.42 | 381.93 | 382.42 | 381.70 | 381.83 | 382.10 | 382.10 | 382.10 | | | |
| 387.67 | 386.69 | 386.75 | 382.03 | 382.03 | 381.83 | 387.54 | 386.36 | 386.36 | | | |
| | | | 387.67 | 386.20 | 386.36 | | | | | | |

**Table C-4. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (West) in 2009 and 2010.**

| Transect FW1 | | | Transect FW2 | | | Transect FW3 | | | Transect FW4 | | | Transect FW5 | | | Transect FW6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 |
| 386.34 | 385.69 | 385.52 | 386.67 | 385.66 | 385.75 | 386.41 | 386.05 | 385.85 | 386.31 | 386.18 | 385.79 | 386.51 | 385.69 | 385.75 | 386.61 | 386.02 | 386.08 |
| 384.97 | 383.06 | 384.77 | 384.90 | 384.11 | 384.11 | 385.52 | 385.03 | 385.20 | 385.23 | 384.54 | 384.54 | 385.36 | 382.90 | 384.05 | 385.43 | 384.05 | 384.21 |
| 381.10 | 380.11 | 380.83 | 380.28 | 380.83 | 380.70 | 380.67 | 380.44 | 380.70 | 384.70 | 384.38 | 384.38 | 380.51 | 380.51 | 380.60 | 380.47 | 380.47 | 380.37 |
| 381.03 | 380.77 | 380.44 | 380.60 | 380.83 | 380.77 | 380.87 | 380.60 | 380.60 | 381.33 | 380.08 | 380.47 | 380.77 | 380.47 | 380.51 | 381.36 | 380.44 | 380.60 |
| 381.03 | 380.70 | 380.77 | 380.93 | 380.70 | 380.90 | 380.83 | 380.60 | 380.83 | 380.64 | 380.37 | 380.51 | 380.93 | 380.60 | 380.80 | 380.87 | 380.51 | 380.60 |
| 381.85 | 381.85 | 381.13 | 380.55 | 380.77 | 380.93 | 385.36 | 384.87 | 384.87 | 380.64 | 380.44 | 380.51 | 382.57 | 380.77 | 380.57 | 380.90 | 380.64 | 380.67 |
| 385.56 | 384.97 | 384.97 | 386.08 | 383.88 | 385.20 | 385.20 | 384.74 | 385.03 | 385.10 | 384.21 | 384.93 | 385.03 | 384.31 | 384.38 | 384.74 | 383.79 | 384.41 |
| 386.70 | 386.02 | 385.88 | 386.51 | 385.52 | 385.75 | 386.34 | 385.82 | 386.34 | 386.57 | 385.88 | 386.02 | 386.51 | 386.08 | 386.05 | 386.57 | 386.08 | 386.18 |

**Table C-5. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (East) in 2009 and 2010.**

| Transect FE1 | | | Transect FE2 | | | Transect FE3 | | | Transect FE4 | | | Transect FE5 | | | Transect FE6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 | May-09 | Jun-10 | Oct-10 |
| 386.02 | 385.79 | 386.02 | 386.21 | 386.11 | 386.28 | 386.02 | 385.85 | 386.08 | 386.51 | 385.85 | 385.36 | 386.05 | 386.02 | 386.05 | 386.34 | 385.98 | 385.43 |
| 385.26 | 384.77 | 384.97 | 384.74 | 384.87 | 384.87 | 385.26 | 385.03 | 385.00 | 384.70 | 383.56 | 383.75 | 385.16 | 384.70 | 384.70 | 384.77 | 384.64 | 385.00 |
| 385.29 | 384.87 | 384.70 | 380.47 | 380.77 | 380.67 | 380.50 | 380.60 | 380.41 | 380.93 | 380.70 | 380.70 | 381.36 | 381.10 | 380.60 | 381.10 | 381.10 | 381.36 |
| 385.13 | 384.87 | 384.20 | 380.93 | 380.64 | 380.51 | 380.77 | 380.37 | 380.34 | 380.18 | 379.95 | 380.37 | 382.74 | 380.14 | 380.37 | 380.34 | 380.11 | 380.51 |
| 385.13 | 385.13 | 384.87 | 381.10 | 380.83 | 380.83 | 380.77 | 380.57 | 380.31 | 382.67 | 379.95 | 380.11 | 380.77 | 380.44 | 380.34 | 379.46 | 380.01 | 380.34 |
| 384.44 | 384.70 | 384.90 | 382.74 | 380.70 | 380.77 | 381.10 | 380.83 | 380.57 | 380.22 | 380.44 | 379.78 | 381.10 | 380.44 | 380.74 | 379.50 | 379.78 | 379.95 |
| 384.97 | 384.44 | 384.70 | 384.02 | 384.05 | 382.74 | 385.52 | 383.98 | 384.31 | 385.10 | 383.39 | 384.61 | 384.97 | 384.38 | 384.61 | 385.03 | 384.61 | 384.54 |
| 386.34 | 385.85 | 386.02 | 386.21 | 385.85 | 386.08 | 386.31 | 385.62 | 385.62 | 386.18 | 385.85 | 386.34 | 386.51 | 386.18 | 386.34 | 385.26 | 386.08 | 385.52 |

**Table C-6. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell F-North in 2009 and 2010.**

| Transect FN1 | | | Transect FN2 | | | Transect FN3 | | | Transect FN4 | | | Transect FN5 | | | Transect FN6 | | | Transect FN7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** |
| 382.51 | 383.25 | 383.52 | 382.51 | 382.96 | 383.16 | 382.74 | 383.35 | 383.52 | 382.31 | 383.19 | 383.25 | 382.61 | 383.52 | 383.22 | 382.48 | 383.68 | 383.35 | 382.34 | 383.02 | 383.06 |
| 380.61 | 380.47 | 376.96 | 382.18 | 382.53 | 381.94 | 382.15 | 382.89 | 382.34 | 381.46 | 382.04 | 381.84 | 381.29 | 382.20 | 381.88 | 381.52 | 382.04 | 381.19 | 379.06 | 380.20 | 380.53 |
| 378.05 | 377.45 | 376.96 | 382.18 | 382.86 | 381.91 | 382.48 | 383.78 | 383.52 | 382.57 | 383.52 | 383.35 | 382.41 | 383.19 | 381.58 | 382.61 | 383.68 | 382.76 | 376.28 | 378.27 | 379.15 |
| 377.00 | 377.45 | 377.55 | 381.95 | 382.60 | 381.58 | 382.54 | 383.35 | 383.02 | 382.61 | 383.35 | 383.52 | 382.67 | 383.52 | 381.74 | 382.48 | 382.89 | 381.84 | 376.28 | 376.79 | 377.94 |
| 377.88 | 377.19 | 376.96 | 381.59 | 381.71 | 381.25 | 380.77 | 381.29 | 380.73 | 381.43 | 382.86 | 381.32 | 380.70 | 380.56 | 380.60 | 379.85 | 379.81 | 376.56 | 376.60 | 377.12 | 378.53 |
| 378.74 | 377.12 | 377.22 | 382.54 | 383.02 | 383.25 | 382.57 | 383.81 | 383.52 | 378.74 | 381.58 | 379.09 | 376.18 | 376.89 | 377.25 | 376.77 | 377.22 | 376.69 | 381.20 | 380.24 | 379.48 |
| 379.72 | 377.28 | 378.89 | | | | | | | 377.88 | 379.51 | 377.28 | 376.11 | 376.79 | 376.53 | 376.44 | 376.92 | 376.76 | 382.51 | 383.45 | 383.16 |
| 381.36 | 379.74 | 381.45 | | | | | | | 379.82 | 378.50 | 378.50 | 375.85 | 376.63 | 376.14 | 376.44 | 376.96 | 378.43 | | | |
| 382.67 | 383.25 | 383.19 | | | | | | | 381.66 | 379.22 | 380.17 | 378.08 | 376.76 | 376.00 | 379.85 | 379.91 | 381.15 | | | |
| | | | | | | | | | 382.74 | 381.38 | 381.94 | 377.91 | 377.91 | 376.27 | 382.67 | 382.70 | 383.68 | | | |
| | | | | | | | | | 383.29 | 383.29 | 383.35 | 380.61 | 380.89 | 379.55 | | | | | | |
| | | | | | | | | | | | | 383.59 | 383.52 | 383.45 | | | | | | |

**Table C-7. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell G in 2009 and 2010.**

| Transect G1 | | | Transect G2 | | | Transect G3 | | | Transect G4 | | | Transect G5 | | | Transect G6 | | | Transect G7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** | **May-09** | **Jun-10** | **Oct-10** |
| 382.69 | 382.35 | 382.12 | 382.62 | 382.25 | 382.93 | 382.62 | 382.35 | 382.35 | 382.75 | 382.35 | 382.02 | 382.03 | 382.48 | 382.16 | 382.03 | 382.19 | 382.84 | 383.70 | 383.25 | 383.25 |
| 380.20 | 379.92 | 379.66 | 380.20 | 379.92 | 379.66 | 380.33 | 380.12 | 379.53 | 380.06 | 380.09 | 379.60 | 380.06 | 381.83 | 380.74 | 379.97 | 380.51 | 380.51 | 379.67 | 384.45 | 383.17 |
| 380.06 | 379.60 | 379.56 | 380.16 | 379.92 | 379.73 | 380.10 | 380.09 | 379.76 | 380.13 | 379.92 | 379.66 | 378.10 | 380.12 | 379.76 | 379.80 | 380.09 | 379.76 | 379.60 | 379.76 | 379.24 |
| 382.52 | 382.53 | 383.79 | 382.69 | 382.35 | 382.25 | 382.56 | 382.22 | 382.25 | 379.77 | 379.76 | 379.60 | 379.93 | 379.86 | 379.33 | 380.10 | 379.76 | 378.78 | 377.77 | 379.10 | 380.15 |
| 382.03 | 382.35 | 384.58 | 382.56 | 382.35 | 382.70 | 382.52 | 382.52 | 383.93 | 382.82 | 382.55 | 382.66 | 382.82 | 382.17 | 382.09 | 382.69 | 381.24 | 383.04 | 379.41 | 381.17 | 380.09 |
| 381.05 | 381.89 | 379.83 | 380.06 | 379.89 | 381.56 | 380.03 | 380.74 | 380.74 | | | | | | | | | | | | |
| 380.42 | 380.42 | 379.76 | 378.88 | 379.99 | 379.86 | 380.25 | 380.25 | 379.76 | | | | | | | | | | | | |
| 380.89 | 381.56 | 381.56 | 382.52 | 382.35 | 382.53 | 383.38 | 384.02 | 383.19 | | | | | | | | | | | | |
| 381.89 | 382.19 | 384.02 | | | | | | | | | | | | | | | | | | |

**Table C-8. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell D in 2008 (baseline) and 2011.**

| Transect D1 | | | Transect D2 | | | Transect D3 | | |
|---|---|---|---|---|---|---|---|---|
| **Mar-08** | **Jun-11** | **Nov-11** | **Mar-08** | **Jun-11** | **Nov-11** | **Mar-08** | **Jun-11** | **Nov-11** |
| 388.05 | 390.02 | 389.59 | 387.89 | 389.75 | 389.36 | 388.05 | 389.85 | 388.67 |
| 385.36 | 387.00 | 386.57 | 384.77 | 386.57 | 387.06 | 384.61 | 386.47 | 386.15 |
| 384.77 | 386.57 | 386.44 | 384.11 | 386.74 | 386.41 | 384.11 | 386.15 | 386.08 |
| 385.59 | 387.06 | 387.33 | 384.77 | 387.00 | 386.38 | 384.77 | 386.31 | 386.34 |
| 387.79 | 389.85 | 389.20 | 387.89 | 389.69 | 388.54 | 387.79 | 389.85 | 389.03 |
| **Transect D4** | | | **Transect D5** | | | **Transect D6** | | |
| **Mar-08** | **Jun-11** | **Nov-11** | **Mar-08** | **Jun-11** | **Nov-11** | **Mar-08** | **Jun-11** | **Nov-11** |
| 387.89 | 390.02 | 388.38 | 388.05 | 389.52 | 389.52 | 388.05 | 390.44 | 388.70 |
| 384.61 | 386.11 | 385.82 | 384.77 | 386.15 | 385.95 | 386.25 | 388.38 | 386.11 |
| 384.11 | 386.05 | 386.01 | 384.11 | 386.34 | 385.85 | 385.92 | 387.88 | 386.01 |
| 384.77 | 386.77 | 386.05 | 384.41 | 386.41 | 385.92 | 386.41 | 387.33 | 386.24 |
| 387.79 | 389.52 | 389.20 | 387.72 | 389.69 | 389.03 | 388.22 | 389.52 | 388.70 |

**Table C-9. Elevation (ASL in feet) was calculated from depths taken along three transects in Cell E-West in 2009 (baseline) and 2011.**

| Transect EW1 | | | Transect EW2 | | | Transect EW3 | | |
|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 383.75 | 383.29 | 382.86 | 382.43 | 382.70 | 382.53 | 383.35 | 382.20 | 383.19 |
| 380.96 | 380.89 | 380.70 | 382.83 | 380.07 | 380.24 | 380.43 | 376.79 | 379.58 |
| 381.22 | 381.22 | 380.73 | 377.15 | 378.10 | 376.46 | 376.30 | 376.63 | 377.94 |
| 382.14 | 381.55 | 381.38 | 377.94 | 376.46 | 376.79 | 375.71 | 377.19 | 377.12 |
| 383.35 | 382.53 | 382.53 | 383.35 | 383.19 | 383.19 | 375.81 | 377.78 | 377.58 |
| | | | | | | 376.37 | 378.43 | 378.60 |
| | | | | | | 379.12 | 379.91 | 379.91 |
| | | | | | | 382.17 | 384.01 | 383.02 |

**Table C-10. Elevation (ASL in feet) was calculated from depths taken along four transects in Cell E in 2009 (baseline) and 2011.**

| Transect E1 | | | Transect E2 | | | Transect E3 | | | Transect E4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 387.54 | 385.70 | 387.03 | 387.67 | 386.03 | 386.70 | 387.57 | 385.87 | 386.74 | 387.54 | 385.97 | 386.31 |
| 386.03 | 384.06 | 382.51 | 386.23 | 382.42 | 383.33 | 385.93 | 383.90 | 383.92 | 382.82 | 382.36 | 382.60 |
| 382.36 | 382.42 | 382.77 | 382.65 | 382.39 | 382.60 | 382.59 | 382.42 | 383.10 | 381.96 | 382.39 | 382.67 |
| 382.33 | 382.10 | 382.41 | 382.59 | 382.59 | 383.33 | 382.49 | 382.33 | 382.41 | 386.36 | 385.87 | 386.57 |
| 382.29 | 382.10 | 382.41 | 382.49 | 382.59 | 383.23 | 382.42 | 382.46 | 382.90 | 386.59 | 386.36 | 386.34 |
| 386.10 | 381.93 | 382.77 | 386.23 | 385.70 | 386.54 | 382.75 | 382.39 | 382.47 | 381.77 | 382.10 | 382.44 |
| 387.57 | 385.87 | 385.75 | 387.67 | 386.52 | 387.69 | 387.54 | 386.52 | 387.39 | 382.71 | 383.08 | 385.10 |
| 387.21 | 386.03 | 386.05 | 387.51 | 386.03 | 386.21 | 387.57 | 386.69 | 387.52 | 387.34 | 386.46 | 386.38 |
| 386.43 | 386.10 | 386.87 | 386.29 | 385.67 | 386.05 | 386.20 | 385.61 | 386.44 | | | |
| 382.03 | 384.72 | 383.78 | 382.42 | 381.90 | 382.44 | 382.16 | 381.87 | 382.47 | | | |
| 381.44 | 381.90 | 382.47 | 382.26 | 381.87 | 382.41 | 381.77 | 381.93 | 382.67 | | | |
| 382.00 | 382.10 | 382.18 | 382.16 | 381.44 | 382.08 | 381.77 | 382.10 | 382.96 | | | |
| 382.42 | 382.39 | 381.95 | 382.42 | 381.77 | 382.11 | 382.10 | 381.60 | 382.05 | | | |
| 387.67 | 385.38 | 387.03 | 382.03 | 381.77 | 381.75 | 387.54 | 386.20 | 386.21 | | | |
| | | | 387.67 | 385.87 | 386.21 | | | | | | |

**Table C-11. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (West) in 2009 (baseline) and 2011.**

| Transect FW1 | | | Transect FW2 | | | Transect FW3 | | | Transect FW4 | | | Transect FW5 | | | Transect FW6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 386.34 | 385.66 | 385.53 | 386.67 | 385.92 | 385.20 | 386.41 | 386.08 | 385.37 | 386.31 | 386.05 | 385.20 | 386.51 | 386.28 | 385.20 | 386.61 | 386.02 | 385.79 |
| 384.97 | 384.97 | 383.89 | 384.90 | 385.10 | 382.58 | 385.52 | 385.10 | 384.06 | 385.23 | 385.13 | 384.38 | 385.36 | 384.31 | 383.89 | 385.43 | 384.34 | 384.15 |
| 381.10 | 380.64 | 380.94 | 380.28 | 381.03 | 380.94 | 380.67 | 380.70 | 380.78 | 384.70 | 380.77 | 381.66 | 380.51 | 380.51 | 380.78 | 380.47 | 380.54 | 380.78 |
| 381.03 | 380.87 | 380.91 | 380.60 | 380.96 | 380.94 | 380.87 | 380.80 | 380.74 | 381.33 | 380.64 | 380.61 | 380.77 | 380.60 | 380.64 | 381.36 | 380.47 | 380.78 |
| 381.03 | 380.74 | 380.94 | 380.93 | 381.03 | 380.91 | 380.83 | 380.90 | 380.94 | 380.64 | 380.87 | 380.55 | 380.93 | 380.67 | 380.78 | 380.87 | 380.57 | 380.64 |
| 381.85 | 381.10 | 380.91 | 380.55 | 380.80 | 380.94 | 385.36 | 381.06 | 382.91 | 380.64 | 380.80 | 380.78 | 382.57 | 380.64 | 380.91 | 380.90 | 380.80 | 380.91 |
| 385.56 | 384.70 | 384.38 | 386.08 | 385.10 | 383.24 | 385.20 | 385.13 | 384.88 | 385.10 | 384.97 | 384.38 | 385.03 | 384.05 | 383.56 | 384.74 | 384.31 | 382.91 |
| 386.70 | 386.21 | 385.53 | 386.51 | 386.05 | 385.20 | 386.34 | 386.18 | 385.37 | 386.57 | 386.05 | 385.27 | 386.51 | 385.52 | 385.50 | 386.57 | 385.98 | 384.84 |

**Table C-12. Elevation (ASL in feet) was calculated from depths taken along six transects in Cell F (East) in 2009 (baseline) and 2011.**

| Transect FE1 | | | Transect FE2 | | | Transect FE3 | | | Transect FE4 | | | Transect FE5 | | | Transect FE6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 386.02 | 385.88 | 385.37 | 386.21 | 385.69 | 385.86 | 386.02 | 386.25 | 385.53 | 386.51 | 386.41 | 384.94 | 386.05 | 385.98 | 385.37 | 386.34 | 386.25 | 385.37 |
| 385.26 | 385.20 | 384.88 | 384.74 | 384.97 | 384.55 | 385.26 | 385.06 | 383.86 | 384.70 | 384.87 | 384.22 | 385.16 | 384.97 | 383.40 | 384.77 | 384.84 | 384.84 |
| 385.29 | 384.93 | 384.81 | 380.47 | 380.44 | 381.96 | 380.50 | 384.97 | 380.78 | 380.93 | 381.42 | 380.19 | 381.36 | 384.80 | 380.28 | 381.10 | 381.13 | 380.35 |
| 385.13 | 385.00 | 384.68 | 380.93 | 380.74 | 380.78 | 380.77 | 381.29 | 380.68 | 380.18 | 380.70 | 380.25 | 382.74 | 382.93 | 380.28 | 380.34 | 380.51 | 380.32 |
| 385.13 | 384.87 | 384.81 | 381.10 | 381.10 | 380.78 | 380.77 | 380.70 | 380.58 | 382.67 | 382.41 | 380.45 | 380.77 | 380.87 | 380.35 | 379.46 | 380.11 | 380.58 |
| 384.44 | 384.74 | 384.55 | 382.74 | 382.87 | 380.78 | 381.10 | 381.03 | 380.51 | 380.22 | 384.54 | 380.58 | 381.10 | 381.06 | 381.10 | 379.50 | 383.82 | 382.09 |
| 384.97 | 384.87 | 384.71 | 384.02 | 383.88 | 383.24 | 385.52 | 385.69 | 384.88 | 385.10 | 384.97 | 384.38 | 384.97 | 384.70 | 384.55 | 385.03 | 384.70 | 384.61 |
| 386.34 | 386.21 | 385.86 | 386.21 | 386.31 | 385.37 | 386.31 | 386.25 | 385.56 | 386.18 | 386.05 | 385.20 | 386.51 | 386.28 | 385.70 | 385.26 | 385.69 | 386.02 |

**Table C-13. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell F-North in 2009 (baseline) and 2011.**

| Transect FN1 | | | Transect FN2 | | | Transect FN3 | | | Transect FN4 | | | Transect FN5 | | | Transect FN6 | | | Transect FN7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 382.51 | 383.52 | 383.69 | 382.51 | 382.53 | 383.52 | 382.74 | 383.52 | 384.02 | 382.31 | 383.52 | 383.52 | 382.61 | 383.02 | 383.20 | 382.48 | 383.19 | 383.52 | 382.34 | 383.52 | 384.02 |
| 380.61 | 377.61 | 378.18 | 382.18 | 382.20 | 382.64 | 382.15 | 382.04 | 383.00 | 381.46 | 383.19 | 383.29 | 381.29 | 382.04 | 382.64 | 381.52 | 381.88 | 382.77 | 379.06 | 380.24 | 379.06 |
| 378.05 | 377.28 | 378.05 | 382.18 | 382.20 | 382.64 | 382.48 | 383.19 | 383.69 | 382.57 | 383.02 | 383.62 | 382.41 | 381.88 | 382.38 | 382.61 | 382.86 | 383.20 | 376.28 | 377.61 | 378.05 |
| 377.00 | 377.61 | 378.11 | 381.95 | 382.04 | 382.54 | 382.54 | 381.55 | 383.20 | 382.61 | 383.02 | 383.52 | 382.67 | 381.71 | 382.41 | 382.48 | 382.04 | 383.20 | 376.28 | 376.96 | 378.37 |
| 377.88 | 378.10 | 378.28 | 381.59 | 381.71 | 381.88 | 380.77 | 381.06 | 381.56 | 381.43 | 381.22 | 381.00 | 380.70 | 380.73 | 381.13 | 379.85 | 377.12 | 378.41 | 376.60 | 378.27 | 378.77 |
| 378.74 | 377.78 | 378.83 | 382.54 | 382.70 | 383.52 | 382.57 | 383.02 | 383.52 | 378.74 | 379.58 | 379.72 | 376.18 | 377.28 | 378.18 | 376.77 | 377.12 | 377.78 | 381.20 | 379.09 | 380.90 |
| 379.72 | 378.86 | 379.92 | | | | | | | 377.88 | 376.96 | 379.26 | 376.11 | 376.86 | 377.72 | 376.44 | 376.79 | 377.29 | 382.51 | 383.02 | 383.52 |
| 381.36 | 381.29 | 381.03 | | | | | | | 379.82 | 378.76 | 379.92 | 375.85 | 376.63 | 377.42 | 376.44 | 378.76 | 377.62 | | | |
| 382.67 | 382.70 | 383.69 | | | | | | | 381.66 | 379.74 | 381.56 | 378.08 | 376.66 | 377.46 | 379.85 | 380.40 | 377.75 | | | |
| | | | | | | | | | 382.74 | 382.14 | 382.34 | 377.91 | 376.46 | 377.42 | 382.67 | 383.52 | 384.18 | | | |
| | | | | | | | | | 383.29 | 383.19 | 383.43 | 380.61 | 379.25 | 379.26 | | | | | | |
| | | | | | | | | | | | | 383.59 | 383.19 | 383.69 | | | | | | |

**Table C-14. Elevation (ASL in feet) was calculated from depths taken along seven transects in Cell G in 2009 (baseline) and 2011.**

| Transect G1 | | | Transect G2 | | | Transect G3 | | | Transect G4 | | | Transect G5 | | | Transect G6 | | | Transect G7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 | May-09 | Jun-11 | Nov-11 |
| 382.69 | 382.42 | 382.25 | 382.62 | 383.53 | 382.19 | 382.62 | 382.76 | 382.42 | 382.75 | 382.22 | 382.88 | 382.03 | 382.09 | 382.70 | 382.03 | 382.16 | 382.55 | 383.70 | 383.86 | 384.19 |
| 380.20 | 379.76 | 380.09 | 380.20 | 379.60 | 380.22 | 380.33 | 379.92 | 380.32 | 380.06 | 379.53 | 380.09 | 380.06 | 380.71 | 379.99 | 379.97 | 382.94 | 379.96 | 379.67 | 383.17 | 380.42 |
| 380.06 | 379.83 | 379.53 | 380.16 | 379.76 | 380.09 | 380.10 | 380.06 | 380.51 | 380.13 | 379.53 | 380.09 | 378.10 | 379.73 | 381.50 | 379.80 | 380.12 | 380.15 | 379.60 | 379.17 | 380.28 |
| 382.52 | 383.53 | 383.22 | 382.69 | 382.02 | 382.52 | 382.56 | 383.79 | 383.86 | 379.77 | 379.60 | 379.99 | 379.93 | 379.40 | 380.32 | 380.10 | 378.84 | 380.15 | 377.77 | 380.55 | 379.92 |
| 382.03 | 384.68 | 383.86 | 382.56 | 383.96 | 384.19 | 382.52 | 382.75 | 383.22 | 382.82 | 382.69 | 383.01 | 382.82 | 382.88 | 382.10 | 382.69 | 382.74 | 380.19 | 379.41 | 380.58 | 380.25 |
| 381.05 | 381.02 | 380.35 | 380.06 | 380.06 | 380.58 | 380.03 | 380.09 | 380.32 | | | | | | | | | | | | |
| 380.42 | 380.58 | 380.91 | 378.88 | 379.27 | 380.51 | 380.25 | 379.60 | 380.38 | | | | | | | | | | | | |
| 380.89 | 380.09 | 380.61 | 382.52 | 382.97 | 381.40 | 383.38 | 383.22 | 384.19 | | | | | | | | | | | | |
| 381.89 | 382.79 | 382.42 | | | | | | | | | | | | | | | | | | |

# Appendix D

### Dallas Floodway Extension

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Fishery Data

**Table D-1. Number of fish collected per species per season. Fourteen species of fish were collected from two sites in Cell D from 2008-2012.**

| Common name | Scientific name | Fall 2008 | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 | Fall 2010 | Spring 2011 | Summer 2011 | Fall 2011 | **Spring 2012** | **Summer 2012** | **Fall 2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | 8 | 1 | 6 | 2 | | | | 1 | | 1 | **2** | **1** | |
| Bluegill | *Lepomis macrochirus* | 75 | 19 | 96 | 64 | 14 | 30 | 14 | 29 | 50 | 16 | **37** | **43** | **10** |
| Redear sunfish | *Lepomis microlophus* | | 1 | | | | | | | | | | | **1** |
| Common carp | *Cyprinus carpio* | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | **1** | |
| Blacktail shiner | *Cyprinella venusta* | 1 | | | | 1 | | | 1 | 3 | | | **1** | |
| Brook silverside | *Labidesthes sicculus* | 1 | | | | | | | 2 | | | | | |
| Longear sunfish | *Lepomis megalotis* | 1 | | | | | 1 | 1 | | | | | | |
| Orange-spotted sunfish | *Lepomis humilis* | | | | | | | | 1 | | 1 | | | |
| Largemouth bass | *Micropterus salmoides* | 2 | 6 | 4 | 3 | 1 | 2 | 4 | 11 | 5 | 1 | **6** | **6** | **1** |
| Mosquitofish | *Gambusia affinis* | 90 | 54 | 120 | 3 | 10 | 3 | 50 | 100 | 10 | 1 | **4** | | |
| Spotted gar | *Lepisosteus oculatus* | | | 1 | 1 | | | 1 | 1 | | | | **1** | **1** |
| Log perch | *Percina caprodes* | | | 1 | | | | | | | | | | **1** |
| White crappie | *Poxomis annularis* | | | | | | | 1 | | | | | | **4** |
| Gizzard shad | *Dorosoma cepedianum* | | | | | | | | | 8 | | **8** | | |
| **Totals** | | 179 | 81 | 221 | 76 | 26 | 37 | 72 | 147 | 77 | 20 | **57** | **53** | **18** |
| **Richness** | | 8 | 5 | 6 | 7 | 4 | 5 | 7 | 9 | 6 | 5 | **4** | **5** | **7** |
| **Mean Richness** | | **8.0** | **6.0** | | | **5.3** | | | **6.7** | | | **5.3** | | |

**Table D-2. Number of fish collected per species per season. Fourteen species of fish were collected from two sites in Cell E-West from 2009-2012.**

| Common name | Scientific name | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 | Fall 2010 | Spring 2011 | Summer 2011 | Fall 2011 | **Spring 2012** | **Summer 2012** | **Fall 2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | | 1 | | | 1 | 2 | | | | | | |
| Bluegill | *Lepomis macrochirus* | 1 | 45 | 11 | 3 | 46 | 23 | 16 | 15 | 9 | **14** | **24** | **26** |
| Green sunfish | *Lepomis cyanellus* | | 4 | | | 1 | 1 | | | 1 | | | |
| Blacktail shiner | *Cyprinella venusta* | 3 | 23 | | | 4 | | | | | | | |
| Redfin shiner | *Lythrurus umbratilis* | 1 | 1 | | | | | | | | | **5** | |
| River redhorse | *Moxostoma carinatum* | | 1 | | | | | | | | | | |
| Longear sunfish | *Lepomis megalotis* | | 1 | | | | 1 | | 10 | | | | |
| Orange-spotted sunfish | *Lepomis humilis* | | | | | | | 3 | | 1 | | **2** | **1** |
| Largemouth bass | *Micropterus salmoides* | | 2 | | | 1 | 3 | | | | **2** | **4** | **2** |
| Gizzard shad | *Dorosoma cepedianum* | 2 | 1 | 15 | | 3 | | | 3 | | | **1** | |
| Mosquitofish | *Gambusia affinis* | 3 | 174 | 49 | 58 | 21 | 124 | 151 | 146 | 250 | **31** | | |
| Spotted gar | *Lepisosteus oculatus* | | 1 | | | | | | | | | | |
| Common carp | *Cyprinus carpio* | | | | | | 6 | 2 | | | **1** | | |
| White crappie | *Poxomis annularis* | | | | | | | | | | | | **1** |
| | **Totals** | 10 | 254 | 75 | 61 | 77 | 237 | 172 | 175 | 261 | **48** | **36** | **29** |
| | **Richness** | 5 | 11 | 3 | 2 | 7 | 7 | 4 | 4 | 4 | **4** | **5** | **4** |
| | **Mean Richness** | | **6.3** | | | **5.3** | | | **4.0** | | | **4.3** | |

**Table D-3. Number of fish collected per species per season. Thirteen species of fish were collected from two sites in Cell E from 2009-2012.**

| **Common name** | **Scientific name** | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 | Fall 2010 | Spring 2011 | Summer 2011 | Fall 2011 | **Spring 2012** | **Summer 2012** | **Fall 2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | 1 | | | | 2 | 1 | | 1 | | | | **1** |
| Bluegill | *Lepomis macrochirus* | 6 | 23 | 27 | 10 | 35 | 30 | 19 | 45 | 6 | **30** | **24** | **11** |
| Green sunfish | *Lepomis cyanellus* | 1 | 2 | 1 | | 5 | 3 | | | | **4** | | **1** |
| Common carp | *Cyprinus carpio* | 1 | | | | | | 1 | | | | **1** | |
| Blacktail shiner | *Cyprinella venusta* | | 7 | | | 4 | | | 1 | | | **1** | |
| River redhorse | *Moxostoma carinatum* | | | 6 | | | | | | | | | |
| Largemouth bass | *Micropterus salmoides* | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 5 | 1 | **4** | **2** | **3** |
| Gizzard shad | *Dorosoma cepedianum* | | 76 | | | 11 | | 23 | 55 | | | **29** | **8** |
| Mosquitofish | *Gambusia affinis* | 89 | | 1 | 4 | 16 | | 500 | 93 | 250 | **64** | **35** | **22** |
| Longear sunfish | *Lepomis megalotis* | | | | | 1 | | | | | | | |
| Log perch | *Percina caprodes* | | | | | | | | 1 | | | | |
| White crappie | *Poxomis annularis* | | | | | | | | 1 | | | | **3** |
| Channel catfish | *Ictalurus punctatus* | | | | | 1 | | | | | | | |
| | **Totals** | 99 | 109 | 37 | 15 | 77 | 35 | 545 | 202 | 257 | **102** | **92** | **49** |
| | **Richness** | 6 | 5 | 5 | 3 | 9 | 4 | 5 | 8 | 3 | **4** | **6** | **6** |
| | **Mean Richness** | **5.3** | | | **5.3** | | | **5.3** | | | **5.3** | | |

**Table D-5. Number of fish collected per species per season. Eleven species of fish were collected from two sites in Cell F (West) from 2009-2012.**

| Common name | Scientific name | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 | Fall 2010 | Spring 2011 | Summer 2011 | Fall 2011 | **Spring 2011** | **Summer 2011** | **Fall 2011** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | | 3 | | | | | | 2 | | | **1** | |
| Bluegill | *Lepomis macrochirus* | 3 | 48 | 2 | 6 | 15 | 47 | 7 | 46 | 12 | **43** | **43** | **15** |
| Green sunfish | *Lepomis cyanellus* | | 3 | | | | | | | | **6** | **6** | |
| Common carp | *Cyprinus carpio* | | 1 | | | | | | 2 | | | | |
| Blacktail shiner | *Cyprinella venusta* | | 47 | | | 3 | 2 | | 2 | | **1** | | **1** |
| Orange-spotted sunfish | *Lepomis humilis* | | | | | | | 4 | | | | | |
| Largemouth bass | *Micropterus salmoides* | 1 | 1 | | 1 | 2 | 2 | 2 | 3 | 2 | **10** | **10** | **1** |
| Gizzard shad | *Dorosoma cepedianum* | | | | | | | | 3 | 1 | | | |
| Mosquitofish | *Gambusia affinis* | 59 | 226 | 3 | 80 | 150 | 45 | 12 | 1400 | 260 | **7** | **7** | **150** |
| Brook silverside | *Labidesthes sicculus* | | | | | 1 | | | | | | | |
| White crappie | *Poxomis annularis* | | | | | | 1 | | 1 | | **2** | **2** | **2** |
| | **Totals** | 63 | 326 | 5 | 87 | 171 | 97 | 25 | 1459 | 275 | **69** | **69** | **169** |
| | **Richness** | 3 | 7 | 2 | 3 | 5 | 5 | 4 | 8 | 4 | **6** | **6** | **5** |
| | **Mean Richness** | 4 | | | 4.3 | | | 5.3 | | | **5.7** | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Totals** | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | [illegible] | [illegible] |
| **Richness** | 2 | 7 | 2 | 3 | 5 | 5 | 4 | | 2 | **3** | **4** | **5** |
| **Mean Richness** | **3.7** | | | **4.3** | | | **3** | | | **4** | | |

**Table D-6. Number of fish collected per species per season. Sixteen species of fish were collected from two sites in Cell F (East) from 2009-2012.**

| **Common name** | **Scientific name** | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 | Fall 2010 | Spring 2011 | Summer 2011 | Fall 2011 | **Spring 2012** | **Summer 2012** | **Fall 2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | | 1 | | | | | | 2 | | | | |
| Bluegill | *Lepomis macrochirus* | 1 | 28 | 31 | 4 | 37 | 18 | 28 | 63 | 7 | **15** | **35** | **6** |
| Green sunfish | *Lepomis cyanellus* | | 4 | 3 | | | | | | | | **1** | |
| Common carp | *Cyprinus carpio* | | | | | | | | 1 | 1 | | **1** | |
| Blacktail shiner | *Cyprinella venusta* | | 11 | | | 25 | 3 | 31 | 26 | | **12** | **2** | **14** |
| Orange-spotted sunfish | *Lepomis humilis* | | | | | | | 1 | 1 | | | **1** | |
| Largemouth bass | *Micropterus salmoides* | | 1 | | | 1 | 1 | 6 | 3 | | **10** | **2** | **1** |
| Gizzard shad | *Dorosoma cepedianum* | | 2 | | | | | 1 | 4 | | **4** | **25** | **15** |
| Mosquitofish | *Gambusia affinis* | 4 | 30 | | 44 | 26 | 13 | 2 | 200 | | | | **1** |
| Redfin shiner | *Lythrurus umbratilis* | | | | 3 | | | | | | | | |
| Brook silverside | *Labidesthes sicculus* | | | | | 2 | | 8 | | | | | |
| Longear sunfish | *Lepomis megalotis* | | | | | 1 | | | | | | | |
| Bullhead | *Ictalurus sp.* | | | | | | 1 | | | | | | |
| White crappie | *Poxomis annularis* | | | | | | 1 | | | | | | **2** |
| Log perch | *Percina caprodes* | | | | | | 1 | 1 | 2 | | | **1** | |
| Spotted gar | *Lepisosteus oculatus* | | | | | | | | 1 | | | | |
| | **Totals** | 5 | 77 | 34 | 51 | 92 | 38 | 78 | 302 | 8 | **41** | **68** | **39** |
| | **Richness** | 2 | 7 | 2 | 3 | 6 | 7 | 8 | 9 | 2 | **4** | **8** | **6** |
| | **Mean Richness** | **3.7** | | | **5.3** | | | **6.3** | | | **6** | | |

**Table D-7. Number of fish collected per species per season. Eighteen species of fish were collected from two sites in Cell G from 2009-2012.**

| **Common name** | **Scientific name** | Spring 2009 | Summer 2009 | Fall 2009 | **Spring 2010** | **Summer 2010** | **Fall 2010** | Spring 2011 | Summe r 2011 | Fall 2011 | **Spring 2012** | **Summer 2012** | **Fall 2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | | | | | | 1 | 1 | | 11 | | **1** | |
| Bluegill | *Lepomis macrochirus* | | 28 | 2 | 22 | 41 | 25 | 25 | 29 | 4 | **18** | **27** | **16** |
| Green sunfish | *Lepomis cyanellus* | | | | | | | | | | **1** | | |
| Blacktail shiner | *Cyprinella venusta* | | 7 | | | 8 | | 101 | 1 | 2 | **13** | **7** | **8** |
| Redfin shiner | *Lythrurus umbratilis* | | | | | | | | 1 | | **1** | | |
| Brook silverside | *Labidesthes sicculus* | | 4 | | 3 | 20 | | | 1 | | | | |
| Blackspotted topminnow | *Fundulus notatus* | | | | | | | | 1 | | | **3** | |
| Orange-spotted sunfish | *Lepomis humilis* | | 1 | | | 1 | 3 | 10 | 10 | | | | |
| Largemouth bass | *Micropterus salmoides* | | 12 | | | | 1 | | 16 | | **5** | **1** | **3** |
| Gizzard shad | *Dorosoma cepedianum* | 4 | 14 | 4 | 186 | 19 | 20 | 465 | 21 | | | **8** | **13** |
| Mosquitofish | *Gambusia affinis* | | 1 | | | | | | | | **100** | **20** | **8** |
| Flathead catfish | *Pylodictis olivaris* | | | | | 1 | | 1 | | 1 | | **1** | |
| Common carp | *Cyprinus carpio* | | | | | 2 | | | | | | | |
| Longear sunfish | *Lepomis megalotis* | | | | 1 | 1 | 3 | 1 | | | | | |
| Green sunfish | *Lepomis cyanellus* | | | | | | | 1 | | | | | **1** |
| White crappie | *Poxomis annularis* | | | | | | | | 3 | 1 | **2** | | |
| Log perch | *Percina caprodes* | | | | | | 1 | | | | | | |
| Spotted gar | *Lepisosteus oculatus* | | | | | | | | | | **1** | | |
| **Totals** | | 4 | 67 | 6 | 212 | 93 | 54 | 605 | 83 | 19 | **141** | **67** | **49** |
| **Richness** | | 1 | 7 | 2 | 4 | 8 | 7 | 8 | 9 | 5 | **8** | **8** | **6** |
| **Mean Richness** | | **3.3** | | | **6.3** | | | **7.3** | | | **7.3** | | |

# Appendix E

### Dallas Floodway Extension

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Macro-invertebrate data collected from the Trinity River 2008-2011

**Table E-1. Macro-invertebrates were collected periodically from 3 sites under the IH-45 Trinity River Bridge in 2008-2010. 1 = upstream site, 2 = IH-45 bridge site, 3 = downstream site, M = mean, M*f* = frequency.**

| | | Fall 2008 | | | | | Spring 2009 | | | | | Summer 2010 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **1** | **2** | **3** | ***M*** | ***Mf*** | **1** | **2** | **3** | ***M*** | ***Mf*** | **1** | **2** | **3** | ***M*** | ***Mf*** |
| ***Insecta*** | | | | | | | | | | | | | | | | |
| Baetidae | Small minnow mayflies | | | | | | | 2 | | 0.67 | 0.01 | 1 | 10 | 4 | 5 | 0.04 |
| Caenidae | Small squaregill mayflies | | | | | | | 3 | | 1 | 0.01 | | 6 | 12 | 6 | 0.05 |
| Chironomidae | Common midges | | | | | | | 54 | | 18 | 0.22 | 22 | 36 | 68 | 42 | 0.36 |
| Coenagrionidae | Narrow-winged damselflies | | | | | | | 2 | | 0.67 | 0.01 | | | | | |
| Corydalidae | Dobsonflies | | | | | | | | | | | | 1 | | 0.33 | 0.01 |
| Elmidae | Riffle beetles | | | | | | | | | | | | 27 | 1 | 9.33 | 0.08 |
| Ephemeridae | Common burrower mayflies | | | | | | | | | | | 1 | | 3 | 1.33 | 0.01 |
| Gerridae | Water striders | 2 | 5 | 1 | 2.67 | 0.22 | | | | | | | | | | 0.01 |
| Gyrinidae | Whirligig beetles | 4 | | 23 | 9 | 0.77 | | | | | | | | | | 0.01 |
| Heptageniidae | Flatheaded mayflies | | | | | | | 8 | | 2.67 | 0.03 | | 25 | 1 | 8.67 | 0.07 |
| Hydropsychidae | Common netspinners | | | | | | | 173 | | 57.7 | 0.71 | | 35 | 7 | 14 | 0.12 |
| Isonychiidae | Brushlegged mayflies | | | | | | | | | | | | | 1 | 0.33 | 0.01 |
| Leptoceridae | Longhorned caddisflies | | | | | | | | | | | | | 1 | 0.33 | 0.01 |
| ***Mollusca*** | | | | | | | | | | | | | | | | |
| Bivalvia | Freshwater bivalves | | | | | | | | | | | | 74 | 7 | 27 | 0.23 |
| Valvatidae | Valve snails | | | | | | | | | | | | | 5 | 1.67 | 0.01 |
| *Totals* | | *6* | *5* | *24* | *11.7* | *1.0* | | *242* | | *80.7* | *1.00* | 24 | 214 | 110 | 116 | *1.00* |
| *Taxa Richness* | | | | | | 2 | | | | | 6 | | | | | 12 |
| *Evenness* | | | | | | 0.77 | | | | | 0.29 | | | | | 0.38 |
| *Simpson's Diversity* | | | | | | 0.35 | | | | | 0.43 | | | | | 0.78 |

**Table E-2. Numbers of macro-invertebrates collected from 3 sites under the IH-45 Trinity River Bridge in 2010 and 2011. 1 = upstream site, 2 = IH-45 bridge site, 3 = downstream site, M = mean, M*f* = frequency.**

| **Trinity River & IH - 45** | | **Fall 2010** | | | | | **Spring 2011** | | | | | **Summer 2011** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **1** | **2** | **3** | ***M*** | ***Mf*** | **1** | **2** | **3** | ***M*** | ***Mf*** | **1** | **2** | **3** | ***M*** | ***Mf*** |
| | | | | | | | ***Insecta*** | | | | | | | | | |
| Baetidae | Small minnow mayflies | | 28 | | 9.33 | 0.17 | | | | | | | 16 | 1 | 5.66 | 0.09 |
| Caenidae | Small squaregill mayflies | 3 | 5 | | 2.66 | 0.05 | 2 | 2 | | 1.333 | 0.05 | | 7 | 5 | 4 | 0.06 |
| Chironomidae | Common midges | 11 | 17 | 1 | 9.66 | 0.18 | 2 | 5 | 6 | 4.333 | 0.18 | 1 | 17 | | 6 | 0.10 |
| Chrysomelidae | Leaf beetles | | | | | | | | | | | | | 1 | 0.33 | 0.01 |
| Coenagrionidae | Narrow-winged damselflies | | 7 | | 2.33 | 0.04 | | 1 | | 0.333 | 0.01 | | 28 | 2 | 10 | 0.16 |
| Corixidae | Water boatmen | | | | | | 5 | | | 1.667 | 0.07 | 1 | | | 0.33 | 0.01 |
| Corydalidae | Dobsonflies | | | | | | | | | | | | 7 | | 2.333 | 0.03 |
| Elmidae | Riffle beetles | | | | | | | | | | | | | | | |
| Ephemeridae | Common burrower mayflies | 1 | | | 0.33 | 0.01 | | | | | | | | | | |
| Gerridae | Water Striders | | | | | | | | | | | | | | | |
| Gyrinidae | Whirligig Beetles | | | | | | | | 1 | 0.333 | 0.01 | | | | | |
| Heptageniidae | Flatheaded mayflies | | 31 | | 10.33 | 0.19 | | 13 | | 4.333 | 0.18 | | 5 | | 1.66 | 0.02 |
| Hydrophilidae | Water scavenger beetles | | | | | | | 2 | | 0.667 | 0.02 | | 2 | | 0.66 | 0.01 |
| Hydropsychidae | Common netspinners | | 21 | 1 | 7.33 | 0.14 | | 12 | | 4 | 0.17 | | 78 | | 26 | 0.43 |
| Isonychiidae | Brushlegged mayflies | | | | | | | | | | | | | | | |
| Leptoceridae | Longhorned caddisflies | | | | | | | | | | | | | | | |
| Simulidae | Black flies | | 11 | | 3.667 | 0.07 | | | | | | | | | | |
| | | | | | | | ***Mollusca*** | | | | | | | | | |
| Bivalvia | Freshwater bivalves | | 19 | | 6.333 | 0.12 | | 17 | | 5.667 | 0.24 | | | | | |
| Physidae | Pond snails | | | | | | | | 2 | 0.667 | 0.02 | | 6 | 2 | 2.66 | 0.045 |
| Valvatidae | Valve snails | | | | | | | | | | | | | | | |
| *Totals* | | 15 | 139 | 2 | 52 | *1.00* | 9 | 52 | 9 | 23.33 | *1.00* | 2 | 166 | 11 | 59.6 | *1.00* |
| *Taxa Richness* | | | | | | 9 | | | | | 8 | | | | | 11 |
| *Evenness* | | | | | | 0.73 | | | | | 0.74 | | | | | 0.36 |
| *Simpson's Diversity* | | | | | | 0.84 | | | | | 0.83 | | | | | 0.75 |

# Appendix F

### Dallas Floodway Extension

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Macro-invertebrate Richness, Evenness, and Diversity (2008 through 2011)

**Table F-1. Population characteristics of macro-invertebrates collected from two sample sites in Cell D from 2008 – 2010.**

| Season | Fall 2008 | Spring 2009 | Summer 2009 | Fall 2009 | Spring 2010 | Summer 2010 |
|---|---|---|---|---|---|---|
| Taxa Richness | 18 | 17 | 16 | 8 | 21 | 12 |
| Evenness | 0.224 | 0.104 | 0.180 | 0.557 | 0.274 | 0.149 |
| Simpson's Index of Diversity | 0.752 | 0.435 | 0.653 | 0.775 | 0.826 | 0.442 |

**Table F-2. Population characteristics of macro-invertebrates collected from Cells E, E-West, F-North, F (West), F (East), and G in spring 2009.**

| Season | Site | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|
| Spring 2009 | Taxa Richness | 9 | 7 | 10 | 11 | 5 | 6 | 8.000 |
| | Evenness | 0.142 | 0.197 | 0.220 | 0.125 | 0.208 | 0.361 | 0.209 |
| | Simpson's Index of Diversity | 0.215 | 0.276 | 0.546 | 0.271 | 0.038 | 0.539 | 0.314 |

**Table F-3. Population characteristics of macro-invertebrates collected from Cells E, E-West, F-North, F (West), F (East), and G in summer 2009.**

| Season | Site | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|
| Summer 2009 | Taxa Richness | 5 | 5 | 10 | 10 | 7 | 10 | 7.833 |
| | Evenness | 0.590 | 0.280 | 0.466 | 0.267 | 0.285 | 0.435 | 0.387 |
| | Simpson's Index of Diversity | 0.661 | 0.286 | 0.785 | 0.625 | 0.499 | 0.770 | 0.604 |

**Table F-4. Population characteristics of macro-invertebrates collected from Cells E, E-West, F-North, F (West), F (East), and G in fall 2009.**

| Season | Site | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|
| Fall 2009 | Taxa Richness | 9 | 9 | 13 | 8 | 6 | 6 | 8.500 |
| | Evenness | 0.189 | 0.460 | 0.308 | 0.323 | 0.459 | 0.522 | 0.377 |
| | Simpson's Index of Diversity | 0.413 | 0.759 | 0.750 | 0.613 | 0.637 | 0.681 | 0.642 |

**Table F-5. Population characteristics of macro-invertebrates collected from Cells E, E-West, F-North, F (West), F (East), and G in spring 2010.**

| Season | Site | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|
| Spring 2010 | Taxa Richness | 12 | 13 | 10 | 10 | 12 | 14 | 11.833 |
| | Evenness | 0.353 | 0.270 | 0.590 | 0.226 | 0.101 | 0.179 | 0.287 |
| | Simpson's Index of Diversity | 0.764 | 0.715 | 0.831 | 0.557 | 0.177 | 0.600 | 0.607 |

**Table F-6. Population characteristics of macro-invertebrates collected from Cells E, E-West, F-North, F (West), F (East), and G in summer 2010.**

| Season | Site | E | EW | FN | FW | FE | G | Mean |
|---|---|---|---|---|---|---|---|---|
| Summer 2010 | **Taxa Richness** | 10 | 10 | 9 | 6 | 4 | 10 | 8.167 |
| | **Evenness** | 0.119 | 0.171 | 0.181 | 0.315 | 0.535 | 0.135 | 0.243 |
| | **Simpson's Index of Diversity** | 0.162 | 0.416 | 0.387 | 0.471 | 0.533 | 0.259 | 0.371 |

**Table F-7. Population characteristics of macro-invertebrates collected from the LCOW in fall 2010.**

| Season | Site | D | E | E-West | F-North | F (West) | F (East) | G | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Fall 2010 | Taxa Richness | 11 | 15 | 7 | 7 | 8 | 10 | 15 | 10.429 |
| | Evenness | 0.412 | 0.219 | 0.335 | 0.310 | 0.382 | 0.563 | 0.494 | 0.388 |
| | Simpson's Index of Diversity | 0.779 | 0.696 | 0.573 | 0.539 | 0.673 | 0.823 | 0.865 | 0.707 |

**Table F-8. Population characteristics of macro-invertebrates collected from the LCOW in spring 2011.**

| Season | Site | D | E | E-West | F-North | F (West) | F (East) | G | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Spring 2011 | Taxa Richness | 13 | 16 | 9 | 6 | 6 | 9 | 14 | 10.429 |
| | Evenness | 0.371 | 0.262 | 0.437 | 0.768 | 0.269 | 0.164 | 0.130 | 0.343 |
| | Simpson's Index of Diversity | 0.793 | 0.761 | 0.745 | 0.783 | 0.381 | 0.322 | 0.451 | 0.605 |

**Table F-9. Population characteristics of macro-invertebrates collected from the LCOW in summer 2011.**

| Season | Site | D | E | E-West | F-North | F (West) | F (East) | G | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Summer 2011 | Taxa Richness | 12 | 13 | 6 | 11 | 4 | 11 | 10 | 9.571 |
| | Evenness | 0.327 | 0.117 | 0.421 | 0.346 | 0.327 | 0.426 | 0.156 | 0.303 |
| | Simpson's Index of Diversity | 0.745 | 0.340 | 0.605 | 0.737 | 0.236 | 0.787 | 0.359 | 0.544 |

# Appendix G

**Dallas Floodway Extension**

**Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:**

**Raw macro-invertebrate data collected from all LCOW cells in fall 2011, spring 2012, and summer 2012; and Trinity River 2008-2011**

**Table G-1. Numbers of macro-invertebrates collected from Cell D between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | ***M*** | ***Mf*** | **I** | **O** | ***M*** | ***Mf*** | **I** | **O** | ***M*** | ***Mf*** |
| ***Entognatha*** | | | | | | | | | | | | | |
| Sminthuridae | Springtails | 1 | | 0.5 | 0.001 | | | | | | | | |
| ***Insecta*** | | | | | | | | | | | | | |
| Belostomatidae | Giant water bugs | | 1 | 0.5 | 0.001 | | | | | | 1 | 0.5 | 0.006 |
| Caenidae | Small squaregill mayflies | 12 | 2 | 7 | 0.015 | 6 | 2 | 4 | 0.051 | 7 | 12 | 9.5 | 0.109 |
| Ceratopogonidae | Biting midges | 5 | 4 | 4.5 | 0.010 | | 4 | 2 | 0.026 | | | | |
| Chironomidae | Midges | 117 | 376 | 247 | 0.541 | 15 | 15 | 15 | 0.192 | 6 | 17 | 11.5 | 0.132 |
| Coenagrionidae | Narrow-winged damselflies | 64 | 12 | 38 | 0.083 | | 1 | 0.5 | 0.006 | | | | |
| Corixidae | Water boatmen | | | | | 8 | 3 | 5.5 | 0.071 | | | | |
| Ephydridae | Shore flies | 5 | 1 | 3 | 0.007 | | | | | | | | |
| Gerridae | Water striders | | | | | 75 | | 37.5 | 0.481 | | 20 | 10 | 0.115 |
| Gomphidae | Clubtail dragonflies | | | | | | | | | 1 | | 0.5 | 0.006 |
| Haliplidae | Crawling water beetles | | | | | | | | | | 3 | 1.5 | 0.017 |
| Hebridae | Velvet water bugs | 1 | 1 | 1 | 0.002 | | | | | | | | |
| Hydrophilidae | Water scavenger beetles | | | | | 1 | | 0.5 | 0.006 | 2 | 5 | 3.5 | 0.040 |
| Hydroptilidae | Microcaddisflies | 8 | 102 | 55 | 0.121 | | | | | | | | |
| Libelullidae | Skimmers (dragonflies) | | | | | | | | | 1 | | 0.5 | 0.006 |
| Pleidae | Pygmy backswimmers | | 2 | 1 | 0.002 | | | | | | | | |
| Strayiomyidae | Soldier flies | | | | | | | | | 1 | | 0.5 | 0.006 |
| *Synclita* | Waterlily leafcutter moth | 44 | 16 | 30 | 0.066 | | | | | | | | |
| Veliidae | Broad-shouldered water striders | 8 | 5 | 6.5 | 0.014 | | | | | | | | |
| ***Annelida*** | | | | | | | | | | | | | |
| Oligochaeta | Aquatic worms | 2 | | 1 | 0.002 | 5 | 2 | 3.5 | 0.045 | | 5 | 2.5 | 0.029 |
| Hirudinea | Freshwater leeches | | | | | | | | | | 1 | 0.5 | 0.006 |
| ***Arachnida*** | | | | | | | | | | | | | |
| Hydracarnia | Water mites | 16 | 20 | 18 | 0.040 | | | | | | | | |
| ***Crustacea*** | | | | | | | | | | | | | |
| Hyalellidae | Amphipods | | | | | | 2 | 1 | 0.013 | 4 | 1 | 2.5 | 0.029 |
| Palaemonidae | Grass shrimp | | | | | | 1 | 0.5 | 0.006 | | | | |
| ***Mollusca*** | | | | | | | | | | | | | |
| Ancylidae | Freshwater limpets | | | | | 3 | | 1.5 | 0.019 | | | | |
| Corbicula | Basket clams | | | | | | | | | | 2 | 1 | 0.011 |
| Lymnacidae | Pond snails | | | | | 1 | 1 | 1 | 0.013 | | | | |
| Physidae | Bladder snails | 57 | 27 | 42 | 0.092 | 10 | 1 | 5.5 | 0.071 | 31 | 49 | 40 | 0.460 |
| Planorbidae | Ram's horn snails | 2 | 1 | 1.5 | 0.003 | | | | | 1 | 3 | 2 | 0.023 |
| Pomatiopsidae | Freshwater snails | | | | | | | | | | 1 | 0.5 | 0.006 |
| *Totals* | | 341 | 570 | 456 | 1.000 | 124 | 32 | 78 | 1.000 | 54 | 120 | 87 | 1.000 |

**Table G-2. Numbers of macro-invertebrates collected from Cell E between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | | | |
| Caenidae | Small squaregill mayflies | 1 | | 0.5 | 0.004 | 2 | 22 | 12 | 0.185 | 3 | 12 | 7.5 | 0.153 |
| Ceratopogonidae | Biting midges | 1 | | 0.5 | 0.004 | | 1 | 0.5 | 0.008 | | | | |
| Chironomidae | Midges | 66 | 150 | 108 | 0.794 | 15 | 14 | 14.5 | 0.223 | 6 | 8 | 7 | 0.143 |
| Coenagrionidae | Narrow-winged damselflies | 2 | | 1 | 0.007 | | 1 | 0.5 | 0.008 | 1 | | 0.5 | 0.010 |
| Corixidae | Water boatmen | | | | | 25 | 3 | 14 | 0.215 | | | | |
| Hydrophilidae | Water scavenger beetles | | | | | | 1 | 0.5 | 0.008 | | | | |
| Hydroptilidae | Microcaddisflies | | 25 | 12.5 | 0.092 | | | | | | | | |
| Sciomyzidae | Marsh flies | | 1 | 0.5 | 0.004 | | | | | | | | |
| Stratiomyidae | Soldier flies | | | | | | | | | | 2 | 1 | 0.020 |
| *Synclita* | Waterlily leafcutter moth | | 1 | 0.5 | 0.004 | | | | | | | | |
| Veliidae | Broad-shouldered water striders | 1 | 1 | 1 | 0.007 | | | | | | | | |
| ***Annelida*** | | | | | | | | | | | | | |
| Oligochaeta | Aquatic worms | 1 | 7 | 4 | 0.029 | | | | | | 5 | 2.5 | 0.051 |
| ***Arachnida*** | | | | | | | | | | | | | |
| Hydracarnia | Water Mites | 2 | 2 | 2 | 0.015 | | | | | | | | |
| ***Crustacea*** | | | | | | | | | | | | | |
| Palaemonidae | Grass shrimp | | | | | | | | | | 2 | 1 | 0.020 |
| Hyalellidae | Amphipods | | | | | | 20 | 10 | 0.154 | | 2 | 1 | 0.020 |
| ***Mollusca*** | | | | | | | | | | | | | |
| Ancylidae | Freshwater limpets | | | | | 2 | | 1 | 0.015 | 2 | | 1 | 0.020 |
| Lymnacidae | Pond snails | 1 | | 0.5 | 0.004 | | | | | | | | |
| Physidae | Bladder snails | 2 | 5 | 3.5 | 0.026 | 7 | 10 | 8.5 | 0.131 | 25 | 29 | 27 | 0.551 |
| Planorbidae | Ram's horn snails | 1 | | 0.5 | 0.004 | 2 | | 1 | 0.015 | | | | |
| Unionidae | Freshwater mussels | | | | | | 1 | 0.5 | 0.008 | | | | |
| Valvatidae | Valve snails | 2 | | 1 | 0.007 | 4 | | 2 | 0.031 | 1 | | 0.5 | 0.010 |
| *Totals* | | 80 | 192 | 136 | 1.000 | 57 | 73 | 65 | 1.000 | 38 | 60 | 49 | 1.000 |

**Table G-3. Numbers of macro-invertebrates collected from Cell E-West between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | | | |
| Baetidae | Small minnow mayflies | | 1 | 0.5 | 0.006 | | | | | | | | |
| Belostomatidae | Giant water bugs | | | | | | | | | | 4 | 2 | 0.016 |
| Brachycentridae | Humpless case makers | | | | | 1 | | 0.5 | 0.026 | | | | |
| Caenidae | Small squaregill mayflies | | | | | | | | | | 17 | 8.5 | 0.067 |
| Chaoboridae | Phantom midges | | | | | | | | | | | | |
| Chironomidae | Midges | 15 | 17 | 16 | 0.184 | 12 | 8 | 10 | 0.513 | 12 | 41 | 26.5 | 0.208 |
| Coenagrionidae | Narrow-winged damselflies | 4 | 5 | 4.5 | 0.052 | | | | | 5 | 56 | 30.5 | 0.239 |
| Corixidae | Water boatmen | 3 | | 1.5 | 0.017 | 1 | | 0.5 | 0.026 | 3 | 2 | 2.5 | 0.020 |
| Culicidae | Mosquitoes | | | | | | | | | | 1 | 0.5 | 0.004 |
| Dytiscidae | Predaceous diving beetles | 1 | | 0.5 | 0.006 | | | | | | | | |
| Gerridae | Water striders | | | | | | | | | 7 | | 3.5 | 0.027 |
| Gomphidae | Clubtail dragonflies | | | | | | | | | | | | |
| Haliplidae | Crawling water beetles | | | | | | | | | | | | |
| Hydrophilidae | Water scavenger beetles | | 1 | 0.5 | 0.006 | | | | | | 1 | 0.5 | 0.004 |
| Hydropsychidae | Net-spinning caddisflies | 1 | | 0.5 | 0.006 | | | | | | | | |
| Libelullidae | Skimmers (dragonflies) | | | | | | 1 | 0.5 | 0.026 | | 1 | 0.5 | 0.004 |
| Limnephilidae | Northern case makers | | | | | | | | | | | | |
| Mesoveliidae | Water treaders | | | | | | | | | | 3 | 1.5 | 0.012 |
| Stratiomyidae | Soldier flies | | 1 | 0.5 | 0.006 | | | | | 1 | 2 | 1.5 | 0.012 |
| *Synclita* | Waterlily leafcutter moth | | | | | | | | | | 3 | 1.5 | 0.012 |
| ***Annelida*** | | | | | | | | | | | | | |
| Hirudinea | Freshwater leeches | | | | | 1 | | 0.5 | 0.026 | | | | |
| Oligochaeta | Aquatic worms | | | | | | | | | | 25 | 12.5 | 0.098 |
| ***Crustacea*** | | | | | | | | | | | | | |
| Hyalellidae | Amphipods | 9 | 35 | 22 | 0.253 | | | | | | | | |
| Palaemonidae | Grass shrimp | 7 | | 3.5 | 0.040 | | | | | 1 | | 0.5 | 0.004 |
| ***Mollusca*** | | | | | | | | | | | | | |
| Ancylidae | Freshwater limpets | 10 | | 5 | 0.057 | 8 | | 4 | 0.205 | | | | |
| Lymnacidae | Pond snails | | | | | | 1 | 0.5 | 0.026 | | | | |
| Physidae | Bladder snails | 22 | 40 | 31 | 0.356 | 5 | 1 | 3 | 0.154 | 21 | 40 | 30.5 | 0.239 |
| Pomatiopsidae | Freshwater snails | | 1 | 0.5 | 0.006 | | | | | | | | |
| Valvatidae | Valve snails | | 1 | 0.5 | 0.006 | | | | | | | | |
| *Totals* | | 72 | 102 | 87 | 1.000 | 28 | 11 | 19.5 | 1.000 | 50 | 205 | 128 | 1.000 |

**Table G-4. Numbers of macro-invertebrates collected from Cell F-North between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | | | |
| Baetidae | Small minnow mayflies | 1 | | 0.5 | 0.005 | | | | | | | | |
| Belostomatidae | Giant water bugs | | | | | | | | | 2 | | 1 | 0.016 |
| Caenidae | Small squaregill mayflies | | | | | | 3 | 1.5 | 0.103 | | 3 | 1.5 | 0.024 |
| Ceratopogonidae | Biting midges | | | | | | | | | 1 | 2 | 1.5 | 0.024 |
| Chironomidae | Midges | 12 | 15 | 13.5 | 0.126 | 5 | 12 | 8.5 | 0.586 | 9 | 10 | 9.5 | 0.150 |
| Coenagrionidae | Narrow-winged damselflies | | 23 | 11.5 | 0.107 | | | | | 1 | 1 | 1 | 0.016 |
| Corixidae | Water boatmen | 69 | 47 | 58 | 0.540 | | | | | | | | |
| Dytiscidae | Predaceous diving beetles | | | | | | | | | 1 | | 0.5 | 0.008 |
| Ephydridae | Shore flies | | | | | | | | | 1 | 2 | 1.5 | 0.024 |
| Gerridae | Water striders | | | | | | 1 | 0.5 | 0.034 | | | | |
| Haliplidae | Crawling water beetles | | | | | | | | | 1 | | 0.5 | 0.008 |
| Hydrophilidae | Water scavenger beetles | | | | | | | | | 2 | | 1 | 0.016 |
| Libellulidae | Skimming dragonflies | | | | | | | | | | 2 | 1 | 0.016 |
| Stratiomyidae | Soldier flies | | | | | | | | | 1 | 1 | 1 | 0.016 |
| ***Crustacea*** | | | | | | | | | | | | | |
| Hyalellidae | Amphipods | | | | | | | | | | 4 | 2 | 0.031 |
| Palaemonidae | Grass shrimp | | | | | | | | | 1 | | 0.5 | 0.008 |
| ***Mollusca*** | | | | | | | | | | | | | |
| Lymnacidae | Pond snails | | | | | | | | | 25 | 5 | 15 | 0.236 |
| Physidae | Bladder snails | 15 | 30 | 22.5 | 0.209 | 2 | 5 | 3.5 | 0.241 | 12 | 29 | 20.5 | 0.323 |
| Planorbidae | Ram's horn snails | | 3 | 1.5 | 0.014 | | 1 | 0.5 | 0.034 | 3 | | 1.5 | 0.024 |
| Valvatidae | Valve snails | | | | | | | | | 8 | | 4 | 0.063 |
| *Totals* | | 97 | 118 | 108 | 1.000 | 7 | 22 | 14.5 | 1.000 | 68 | 59 | 63.5 | 1.000 |

**Table G-5. Numbers of macro-invertebrates collected from Cell F (West) between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| | | | | | | | ***Insecta*** | | | | | | |
| Belostomatidae | Giant water bugs | | | | | | | | | | 1 | 0.5 | 0.009 |
| Brachycentridae | Humpless case makers | | | | | 1 | | 0.5 | 0.009 | 2 | 2 | 2 | 0.037 |
| Caenidae | Small squaregill mayflies | | 1 | 0.5 | 0.033 | 10 | 39 | 24.5 | 0.450 | 7 | 10 | 8.5 | 0.159 |
| Ceratopogonidae | Biting midges | | | | | 17 | | 8.5 | 0.156 | | | | |
| Chironomidae | Midges | | 3 | 1.5 | 0.100 | 11 | 3 | 7 | 0.128 | 16 | 8 | 12 | 0.224 |
| Coenagrionidae | Narrow-winged damselflies | | | | | | | | | | | | |
| Corixidae | Water boatmen | 7 | 12 | 9.5 | 0.633 | | | | | 5 | | 2.5 | 0.047 |
| Gerridae | Water striders | | | | | | | | | | 6 | 3 | 0.056 |
| Gomphidae | Clubtails | | | | | 8 | | 4 | 0.073 | | | | |
| Haliplidae | Crawling water beetles | | | | | | | | | 1 | | 0.5 | 0.009 |
| Hydroptilidae | Microcaddisflies | | | | | | | | | 1 | | 0.5 | 0.009 |
| Libellulidae | Skimming dragonflies | | | | | | | | | | 1 | 0.5 | 0.009 |
| *Synclita* | Waterlily leafcutter moth | 1 | | 0.5 | 0.033 | | | | | | | | |
| | | | | | | | ***Annelida*** | | | | | | |
| Hirudinea | Freshwater leeches | | | | | 1 | | 0.5 | 0.009 | | | | |
| Oligochaeta | Aquatic worms | | | | | 3 | | 1.5 | 0.028 | 4 | | 2 | 0.037 |
| | | | | | | | ***Crustacea*** | | | | | | |
| Hyalellidae | Amphipods | | | | | | 3 | 1.5 | 0.028 | | | | |
| | | | | | | | ***Mollusca*** | | | | | | |
| Physidae | Bladder snails | 5 | | 2.5 | 0.167 | | 5 | 2.5 | 0.046 | 19 | 22 | 20.5 | 0.383 |
| Lymnacidae | Pond snails | 1 | | 0.5 | 0.033 | | 7 | 3.5 | 0.064 | 2 | | 1 | 0.019 |
| Pomatiopsidae | Freshwater snails | | | | | | 1 | 0.5 | 0.009 | | | | |
| *Totals* | | 14 | 16 | 15 | 1.000 | 51 | 58 | 54.5 | 1.000 | 57 | 50 | 53.5 | 1.000 |

**Table G-6. Numbers of macro-invertebrates collected from Cell F (East) between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | | | |
| Acrididae | Semi-aquatic grasshoppers | | | | | | 1 | 0.5 | 0.007 | | | | |
| Baetidae | Small minnow mayflies | | | | | 1 | | 0.5 | 0.007 | | | | |
| Belostomatidae | Giant water bugs | | | | | | | | | 1 | 2 | 1.5 | 0.028 |
| Brachycentridae | Humpless case makers | | | | | 1 | | 0.5 | 0.007 | 2 | | 1 | 0.019 |
| Caenidae | Small squaregill mayflies | | | | | 25 | 5 | 15 | 0.197 | 19 | | 9.5 | 0.179 |
| Ceratapogonidae | Biting midges | | | | | 2 | | 1 | 0.013 | 2 | | 1 | 0.019 |
| Chironomidae | Midges | | 5 | 2.5 | 0.068 | 51 | 5 | 28 | 0.368 | 12 | | 6 | 0.113 |
| Coenagrionidae | Narrow-winged damselflies | | | | | 1 | | 0.5 | 0.007 | | | | |
| Corixidae | Water boatmen | 15 | 25 | 20 | 0.548 | 15 | 7 | 11 | 0.145 | | 7 | 3.5 | 0.066 |
| Ephydridae | Shore flies | | 1 | 0.5 | 0.014 | | | | | | | | |
| Haliplidae | Crawling water beetles | 1 | | 0.5 | 0.014 | | | | | | | | |
| Hebridae | Velvet water bugs | | 1 | 0.5 | 0.014 | | | | | | | | |
| Hydrophilidae | Water scavenger beetles | | 2 | 1 | 0.027 | 2 | | 1 | 0.013 | 1 | | 0.5 | 0.009 |
| Libelullidae | Skimmers (dragonflies) | | | | | | | | | 1 | | 0.5 | 0.009 |
| ***Annelida*** | | | | | | | | | | | | | |
| Oligochaeta | Aquatic worms | | | | | | 3 | 1.5 | 0.020 | | | | |
| ***Crustacea*** | | | | | | | | | | | | | |
| Hyalellidae | Amphipods | 3 | 17 | 10 | 0.274 | | | | | 3 | 7 | 5 | 0.094 |
| Palaemonidae | Grass shrimp | 3 | | 1.5 | 0.041 | | | | | | | | |
| ***Mollusca*** | | | | | | | | | | | | | |
| Ancylidae | Freshwater limpets | | | | | 2 | | 1 | 0.013 | | | | |
| Corbicula | Basket clams | | | | | 12 | | 6 | 0.079 | | | | |
| Physidae | Bladder snails | | | | | 18 | | 9 | 0.118 | 28 | 21 | 24.5 | 0.462 |
| Planorbidae | Ram's horn snails | | | | | 1 | | 0.5 | 0.007 | | | | |
| *Totals* | | 22 | 51 | 36.5 | 1.000 | 131 | 21 | 76 | 1.000 | 69 | 37 | 53 | 1.000 |

**Table G-7. Numbers of macro-invertebrates collected from Cell G between Fall 2011 and Summer 2012.**

| | | Fall 2011 | | | | Spring 2012 | | | | Summer 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **Common name** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** | **I** | **O** | **M** | **Mf** |
| ***Insecta*** | | | | | | | | | | | | | |
| Acrididae | Semi-aquatic grasshoppers | | | | | | | | | 1 | 1 | 1 | 0.007 |
| Aeshnidae | Hawker dragonflies | | 1 | 0.5 | 0.002 | | | | | | 1 | 0.5 | 0.004 |
| Baetidae | Small minnow mayflies | 1 | 1 | 1 | 0.005 | | | | | | | | |
| Belostomatidae | Giant water bugs | | | | | | | | | 15 | | 7.5 | 0.056 |
| Brachycentridae | Humpless case makers | | | | | | 1 | 0.5 | 0.007 | | | | |
| Caenidae | Small squaregill mayflies | | 3 | 1.5 | 0.007 | 4 | 21 | 12.5 | 0.163 | 2 | 12 | 7 | 0.052 |
| Ceratapogonidae | Biting midges | 2 | | 1 | 0.005 | | | | | 2 | 1 | 1.5 | 0.011 |
| Chironomidae | Midges | 204 | 95 | 150 | 0.724 | 9 | 20 | 14.5 | 0.190 | 10 | 19 | 14.5 | 0.109 |
| Coenagrionidae | Narrow-winged damselflies | 2 | 18 | 10 | 0.048 | | 7 | 3.5 | 0.046 | 7 | 1 | 4 | 0.030 |
| Corixidae | Water boatmen | | | | | | 29 | 14.5 | 0.190 | | 14 | 7 | 0.052 |
| Dytiscidae | Predaceous diving beetles | | | | | | | | | 3 | | 1.5 | 0.011 |
| Ephydridae | Shore flies | | | | | | | | | 2 | | 1 | 0.007 |
| Gomphidae | Clubtails | | | | | 1 | 1 | 1 | 0.013 | | | | |
| Haliplidae | Crawling water beetles | | | | | | | | | | 2 | 1 | 0.007 |
| Hydrometridae | Marsh treaders | | | | | | | | | 3 | 1 | 2 | 0.015 |
| Hydrophilidae | Water scavenger beetles | 1 | | 0.5 | 0.002 | | 10 | 5 | 0.065 | 6 | 2 | 4 | 0.030 |
| Hydroptilidae | Microcaddisflies | 9 | 6 | 7.5 | 0.036 | | | | | | | | |
| Libellulidae | Skimming dragonflies | | | | | | | | | 5 | | 2.5 | 0.019 |
| Mesoveliidae | Water treaders | | | | | | | | | | 1 | 0.5 | 0.004 |
| Pleidae | Pygmy backswimmer | | | | | | | | | | 1 | 0.5 | 0.004 |
| Stratiomyidae | Soldier flies | | | | | | | | | | 1 | 0.5 | 0.004 |
| *Synclita* | Waterlily leafcutter moth | 4 | 6 | 5 | 0.024 | | | | | | 1 | 0.5 | 0.004 |
| ***Annelida*** | | | | | | | | | | | | | |
| Oligochaeta | Aquatic worms | | | | | | 3 | 1.5 | 0.020 | 17 | | 8.5 | 0.064 |
| ***Crustacea*** | | | | | | | | | | | | | |
| Hyalellidae | Amphipods | | | | | | 5 | 2.5 | 0.033 | 21 | 5 | 13 | 0.097 |
| Palaemonidae | Grass shrimp | | | | | | | | | | 1 | 0.5 | 0.004 |
| ***Mollusca*** | | | | | | | | | | | | | |
| Ancylidae | Freshwater Limpets | | | | | | | | | | 1 | 0.5 | 0.004 |
| Corbicula | Basket clams | | | | | | 1 | 0.5 | 0.007 | | 3 | 1.5 | 0.011 |
| Lymnacidae | Pond snails | | | | | 3 | | 1.5 | 0.020 | | | | |
| Physidae | Bladder snails | 26 | 34 | 30 | 0.145 | 5 | 21 | 13 | 0.170 | 69 | 36 | 52.5 | 0.393 |
| Unionidae | Freshwater mussels | | | | | 6 | 6 | 6 | 0.078 | | | | |
| *Totals* | | 249 | 164 | 207 | 1.000 | 28 | 125 | 76.5 | 1.000 | 163 | 104 | 134 | 1.000 |

# Appendix H

### Dallas Floodway Extension

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Grassland species percent cover and frequencies 2010-2012

**Table H-1. Percent cover estimates of grassland plants identified at the LCOW during spring s surveys in 2010, 2011, and 2012. Key: N = native volunteer, NS = native seeded or planted; I = introduced; D = Desirable; U = Undesirable.**

| Scientific Name | Common name | Status | *Percent cover 2010* | | *Percent cover 2011* | | *Percent cover 2012* | |
|---|---|---|---|---|---|---|---|---|
| | | | D | U | D | U | D | U |
| *Acer negundo* | Box elder | N | | | | 0.04 | | |
| *Acmella decumbens* | Creeping spotflower | N | | | 0.06 | | | |
| *Agalinis* sp. | Foxglove | N | 0.35 | | | | | |
| *Allium drummondii* | Drummond’s onion | N | 0.10 | | 0.02 | | 0.04 | |
| *Alternathera philoxeroides* | Alligatorweed | I | | 0.06 | | 1.33 | | 1.36 |
| *Amaranthus sp.* | Amaranth | N | 0.85 | | 0.12 | | 0.57 | |
| *Ambrosia trifida* | Giant ragweed | N | | 25.31 | | 15.91 | | 3.19 |
| *Amphiachyris dracunculoides* | Prairie broomweed | N | | | 0.01 | | | |
| *Andropogon gerardii* | Big bluestem | NS | | | 0.01 | | | |
| *Aster* sp. | Aster | N | | | 0.32 | | | |
| *Avena fatua* | Wild oat | I | | | | 0.02 | | 0.03 |
| *Baccharis halimifolia* | Eastern baccharis | N | | | | 0.17 | | 0.00 |
| Bare | Bare | - | | 17.58 | | 14.93 | | 18.33 |
| *Bifora americana* | Prairie bishop | N | | | 0.03 | | 0.00 | |
| *Bouteloua curtipendula* | Sideoats grama | NS | 0.11 | | 0.12 | | 0.07 | |
| *Bouteloua dactyloides* | Buffalograss | N | | | 1.32 | | 0.19 | |
| *Bromus catharticus* | Rescuegrass | I | | | | 0.04 | | 0.33 |
| *Bromus japonicus* | Japanese brome | I | | | | 0.09 | | |
| *Bromus techtorum* | Cheat grass | I | | | | | | 1.20 |
| *Bromus* sp. | Brome | I | | | | 0.19 | | |
| *Cardiospermum halicacabum* | Balloonvine | I | | 0.42 | | 0.08 | | 0.07 |
| *Carduus nutans* | Nodding thistle | I | | | | | | 0.06 |
| *Carex cherokeensis* | Cherokee sedge | N | 0.59 | | 1.06 | | | |
| *Carex crus-corvi* | Crow's food sedge | N | | | 0.67 | | 0.93 | |
| *Carex festucacea* | Fescue sedge | N | 0.02 | | 0.02 | | | |
| *Carex* sp. | Sedge | N | | | 0.41 | | 1.61 | |
| *Celtis laevigata* | Sugarberry | N | | 0.10 | | 0.02 | | |
| *Chamaecrista fasciculata* | Partridge pea | NS | 0.07 | | | | | |
| *Chasmanthium latifolium* | Inland seaoats | N | | | 0.02 | | | |
| *Chenopodium album* | Lambsquarters | I | | | | 0.01 | | |
| *Cirsium texanum* | Texas thistle | N | 0.01 | | | | | |
| *Conyza canadensis* | Canadian horseweed | N | 0.54 | | 0.26 | | | |
| *Coreopsis tinctoria* | Plains coreopsis | NS | 0.68 | | 3.02 | | 1.52 | |
| *Croton texensis* | Texas croton | N | 0.19 | | | | 0.15 | |
| *Cyclachaena xanthifolia* | Giant sumpweed | N | | | | 0.02 | | |
| *Cynodon dactylon* | Bermuda grass | I | | 5.23 | | 7.59 | | 2.12 |
| *Cyperus* sp. | Cyperus | N | 1.40 | | 0.36 | | 0.05 | |
| *Daucus carota* | Queen Anne's lace | I | | | | 0.24 | | |
| *Desmanthus illinoensis* | Illinois bundle flower | NS | 0.93 | | 1.28 | | 2.36 | |
| *Digitaria ischaemum* | Smooth crabgrass | I | | 0.67 | | 0.01 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Dracopis amplexicaulis* | Clasping coneflower | NS | 3.09 | | 6.78 | | 5.40 | |
| *Echinochloa colona* | Junglerice | I | | 2.76 | | | | |
| *Echinochloa crus-galli* | Barnyardgrass | I | | 0.19 | | 0.25 | | |
| *Eleocharis acicularis* | Needle spikerush | N | 0.16 | | | | | |
| *Eleocharis palustris* | Flatstem spikerush | N | 0.08 | | 1.05 | | 0.71 | |
| *Eleusine indica* | Goosegrass | I | | | | 0.07 | | 0.33 |
| *Elymus canadensis* | Canada wild rye | NS | 0.41 | | 0.07 | | | |
| *Elymus virginicus* | Virginia wild rye | N | 1.53 | | 5.21 | | | |
| *Engelmannia pinnatifida* | Cutleaf daisy | NS | | | 0.03 | | | |
| *Erigeron* sp. | Fleabane daisy | N | | | 0.00 | | | |
| *Erodium cicutarium* | Redstem stork's bill | I | | | | 1.88 | | 0.43 |
| *Euphorbia* sp. | Spurge | N | | 0.05 | | | | 0.04 |
| *Fraxinus pennsylvanica* | Green ash | N | | | | 0.84 | | |
| *Gaillardia pulchella* | Firewheel | NS | 0.01 | | 0.10 | | 0.00 | |
| *Galium* sp. | Bedstraw | N | | | | | 0.00 | |
| *Gaura* sp. | Beeblossom | N | | | 0.41 | | | |
| *Glandularia bipinnatifida* | Dakota vervain | N | 0.02 | | | | | |
| *Grindelia papposa* | Wax goldenweed | N | 0.01 | | 0.03 | | 0.00 | |
| *Helianthus annuus* | Common sunflower | N | 0.01 | | 0.05 | | 0.07 | |
| *Helianthus maximiliani* | Maximillion Sunflower | NS | | | 0.32 | | 0.00 | |
| *Heterotheca subaxillaris* | Camphorweed | N | | | | | 0.45 | |
| *Hordeum pusillum* | Little barley | N | | | 0.31 | | 0.32 | |
| *Ipomoea purpurea* | Common morning glory | I | | 0.02 | | 0.21 | | 0.17 |
| *Ipomoea wrightii* | Wright's morning-glory | I | | | | 0.07 | | |
| *Iva annua* | Marsh-elder | N | | 1.02 | | 3.76 | | 1.13 |
| *Juncus* sp. | Rush | N | 0.15 | | 0.60 | | 0.23 | |
| *Koeleria macrantha* | Prairie Junegrass | N | | | 0.06 | | | |
| *Lactuca serriola* | Prickly lettuce | I | | 0.77 | | | | |
| *Lathyrus hirsutus* | Caley pea | I | | | | 2.34 | | 0.45 |
| *Lepidium austrinum* | Pepperwort | N | 0.00 | | 0.07 | | 0.00 | |
| *Lepidium virginicum* | Virginia pepper-grass | N | | | 1.45 | | 0.04 | |
| *Limnodea arkansana* | Ozarkgrass | N | | | | | 0.28 | |
| *Lippia nodiflora* | Frogfruit | N | 1.67 | | 1.26 | | 2.74 | |
| *Lolium perenne* | Ryegrass | I | | 3.12 | | 14.25 | | 20.20 |
| *Ludwigia peploides* | Creeping water primrose | N | 0.06 | | 7.62 | | 0.04 | |
| *Lycopus americanus* | American water-horehound | N | | | 0.29 | | | |
| *Medicago orbicularis* | Button medic | I | | 0.17 | | 1.06 | | |
| *Medicago polymorpha* | Burclover | I | | | | 3.37 | | |
| *Melilotus officinalis* | Yellow sweetclover | I | | 2.26 | | 0.26 | | 0.06 |
| *Monarda citriodora* | Lemon beebalm | NS | 0.04 | | <0.01 | | | |
| *Morus* sp. | Mulberry | N | | 0.04 | | | | |
| *Neptunia lutea* | Yellowpuff | N | | | | | 0.01 | |
| *Oenothera speciosa* | Pink evening primrose | NS | | | 4.49 | | 8.82 | |
| *Oxalis stricta* | Common yellow oxalis | N | | | | <0.01 | | |
| *Panicum coloratum* | Klein Grass | I | | 0.19 | | | | |
| *Panicum virgatum* | Switchgrass | NS | 0.06 | | 1.01 | | 0.90 | |
| *Parthenocissus quinquefolia* | Virginia creeper | N | 0.04 | | | | | |
| *Paspalum distichum* | Knotgrass | N | 1.34 | | | | 0.00 | |
| *Phalaris canariensis* | Canarygrass | I | | | | 2.60 | | 2.68 |
| *Phyllanthus polygonoides* | Knotweed leaf-flower | N | 1.05 | | 0.50 | | | |
| *Physalis angulata* | Ground cherry | N | | | | | 0.00 | |
| *Physostegia intermedia* | Obedient plant | NS | 0.07 | | | | 0.10 | |
| *Polygonum hydropiperoides* | Swamp smartweed | N | 0.12 | | | | | |
| *Polygonum lapathifolium* | Willow smartweed | N | 0.70 | | | | | |
| *Polygonum pennsylvanica* | Pink smartweed | N | 0.85 | | | | | |
| *Polygonum* sp. | Smartweed | N | 0.23 | | 1.79 | | 0.18 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Populus deltoides* | Cottonwood | N | 0.20 | | | 0.05 | | |
| *Pyrrhopappus pauciflorus* | Texas dandelion | N | | | 0.84 | | 1.23 | |
| *Ranunculus macounii* | Buttercup | N | | | 1.38 | | 0.30 | |
| *Rosa* sp. | Wild rose | I | | | | | 0.06 | |
| *Rubus* sp. | Dewberry | N | | | 0.02 | | | |
| *Rudbeckia hirta* | Black-eyed Susan | NS | 0.02 | | | | | |
| *Rumex crispus* | Curly dock | I | | 1.01 | | 1.64 | | 1.84 |
| *Salix nigra* | Black willow | N | | 0.31 | | 0.24 | | |
| *Salvia azurea* | Azure blue sage | NS | | | 0.09 | | 0.01 | |
| *Secale cereale* | Rye | I | 9.47 | | 0.02 | | 2.04 | |
| *Sesbania herbacea* | Coffee-bean sesbania | N | 0.14 | | 0.02 | | 0.30 | |
| *Setaria parviflora* | Knotroot bristlegrass | N | 0.30 | | | | | |
| *Setaria viridis* | Green bristle grass | I | | 0.21 | | | | |
| *Smilax* sp. | Green briar | N | 0.16 | | 0.27 | | | |
| *Solanum* sp. | Nightshade | N | | 0.02 | | 0.03 | | 0.00 |
| *Solidago* sp. | Goldenrod | N | | | 0.05 | | | |
| *Sonchus* sp. | Sowthistle | I | | | | 0.84 | | 1.03 |
| *Sorghum halepense* | Johnsongrass | I | | 2.09 | | 4.07 | | 4.69 |
| *Symphyotrichum subulatum* | Slim aster | N | 5.16 | | 8.68 | | 3.71 | |
| *Tetragonotheca ludoviciana* | Sawtooth | N | | 0.10 | | | | |
| *Torilis arvensis* | Hedge parsley | I | | 1.10 | | 3.66 | | 3.13 |
| *Toxicodendron radicans* | Poison Ivy | N | | 0.06 | | | | |
| *Tragia* sp. | Noseburn | N | | | 0.02 | | 0.00 | |
| *Tridens texanus* | Texas tridens | N | 0.41 | | 0.12 | | 0.09 | |
| *Triodanis* sp. | Venus' looking-glass | N | | | 0.06 | | | |
| *Tripsacum dactyloides* | Eastern gamagrass | NS | | | 0.03 | | 0.59 | |
| *Typha latifolia* | Cattail | N | | | | 0.02 | | |
| *Viola missouriensis* | Missouri violet | N | 0.04 | | | | | |
| *Xanthium strumarium* | Cocklebur | N | | 0.23 | | 0.02 | | |
| **Total** | | | **34.4** | **65.6** | **50.9** | **49.1** | **38.1** | **61.9** |
| | | | **D** | **U** | **D** | **U** | **D** | **U** |
| | | | **2010** | | **2011** | | **2012** | |

**Table H-2. Frequencies of grassland plants identified at the LCOW in 2010, 2011 and 2012, excluding Linfield Landfill. Status: I = Introduced, N = native, NS = native seeded, P = planted, D = desirable, and U = undesirable.**

| ***Species*** | **Common name** | **Status** | **2010** | | **2011** | | **2012** | |
|---|---|---|---|---|---|---|---|---|
| | | | **D** | **U** | **D** | **U** | **D** | **U** |
| *Acer negundo* | Box elder | N | | | | 0.43 | | |
| *Acmella decumbens* | Creeping spotflower | N | | | 0.29 | | | |
| *Agalinis* sp. | Foxglove | N | 0.73 | | | | | |
| *Allium drummondii* | Drummond's onion | N | 0.15 | | 0.18 | | 0.53 | |
| *Alternathera philoxeroides* | Alligatorweed | I | | 0.31 | | 0.58 | | 2.08 |
| *Amaranthus sp.* | Amaranth | N | 1.23 | | 0.48 | | 0.91 | |
| *Ambrosia artemisiifolia* | Common ragweed | N | | | | 0.13 | | |
| *Ambrosia trifida* | Giant ragweed | N | | 13.47 | | 6.52 | | 2.80 |
| *Amphiachyris dracunculoides* | Prairie broomweed | N | | | 0.18 | | | |
| ***Andropogon gerardii*** | **Big bluestem** | **NS/P** | | | **0.18** | | | |
| *Aster sp.* | Aster | N | | | | 0.32 | | |
| *Avena fatua* | Wild oat | I | | | | 0.04 | | 0.26 |
| *Baccharis halimifolia* | Eastern baccharis | N | | | | 0.42 | | |
| *Bifora americana* | Prairie bishop | N | | | 0.26 | | 0.08 | |
| ***Bouteloua curtipendula*** | **Sideoats grama** | **NS** | **0.28** | | **0.13** | | **0.34** | |
| *Bouteloua dactyloides* | Buffalograss | N | | | 0.73 | | 0.35 | |
| *Bromus catharticus* | Rescuegrass | I | | | | 0.57 | | 1.24 |
| *Bromus japonicus* | Japanese brome | I | | | | 0.23 | | |
| *Bromus techtorum* | Cheat grass | I | | | | | | 0.41 |
| *Bromus sp.* | Brome | I | | | | | 0.30 | |
| *Cardiospermum halicacabum* | Balloonvine | I | | 1.96 | | 0.60 | | 0.99 |
| *Carduus nutans* | Nodding thistle | I | | | | | | 0.34 |
| *Carex cherokeensis* | Cherokee sedge | N | 0.24 | | 0.84 | | | |
| *Carex crus-corvi* | Crow's food sedge | N | | | 0.69 | | 1.14 | |
| *Carex festucacea* | Fescue sedge | N | 0.23 | | 0.18 | | | |
| *Carex sp.* | Sedge | N | | | 1.74 | | 4.19 | |
| *Celtis laevigata* | Sugarberry | N | | 0.41 | | 0.05 | | |
| ***Chamaecrista fasciculata*** | **Partridge pea** | **NS** | **0.19** | | | | | |
| *Chasmanthium latifolium* | Inland seaoats | N | | | 0.23 | | | |
| *Chenopodium album* | Lambsquarters | I | | | | 0.04 | | |
| *Cirsium texanum* | Texas thistle | N | 0.2 | | | | | |
| *Conyza canadensis* | Canadian horseweed | N | 1.28 | | 0.95 | | | |
| ***Coreopsis tinctoria*** | **Plains coreopsis** | **NS** | **1.86** | | **2.20** | | **2.21** | |
| *Croton texensis* | Texas croton | N | | | | | 0.49 | |
| *Cyclachaena xanthifolia* | Giant sumpweed | N | | | | 0.13 | | |
| *Cynodon dactylon* | Bermuda grass | I | | 3.38 | | 2.82 | | 2.53 |
| *Cyperus echinatus* | Globe flat sedge | N | | 0.10 | | | | |
| *Cyperus erythrorhizos* | Umbrella sedge | N | | 0.30 | | | | |
| *Cyperus esculentus* | Yellow nutsedge | N | | | | 0.40 | | 1.06 |
| *Cyperus* sp. | Cyperus | N | 2.12 | | | | | |
| *Daucus carota* | Queen Anne's lace | I | | | | 0.13 | | |
| ***Desmanthus illinoensis*** | **Illinois bundle flower** | **NS** | **2.52** | | **1.98** | | **4.43** | |
| *Digitaria ischaemum* | Smooth crabgrass | I | | 0.50 | | 0.04 | | |
| ***Dracopis amplexicaulis*** | **Clasping coneflower** | **NS** | **5.34** | | **7.29** | | **4.53** | |
| *Echinochloa colona* | Junglerice | I | | 3.19 | | | | |
| *Echinochloa crus-galli* | Barnyardgrass | I | | 0.39 | | 0.62 | | |
| *Eleocharis acicularis* | Needle spikerush | N | 0.34 | | | | | |
| *Eleocharis palustris* | Flatstem spikerush | N | 0.24 | | | | | |
| *Eleocharis sp.* | Spikerush | N | | | | 0.59 | | 0.41 |
| *Eleusine indica* | Goosegrass | I | | | | 0.04 | | 0.30 |
| ***Elymus canadensis*** | **Canada wild rye** | **NS** | **0.48** | | **0.23** | | | |
| *Elymus virginicus* | Virginia wild rye | N | 4.12 | | 5.25 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Engelmannia pinnatifida*** | **Cutleaf daisy** | **NS** | | | **0.04** | | | |
| *Erodium cicutarium* | Redstem stork's bill | I | | | | 3.06 | | 1.04 |
| *Euphorbia* sp. | Spurge | N | | 0.21 | | | | 0.23 |
| *Fraxinus pennsylvanica* | Green ash | N | | | | 0.22 | | |
| ***Gaillardia pulchella*** | **Firewheel** | **NS** | **0.07** | | **0.09** | | **0.11** | |
| *Galium sp.* | Bedstraw | N | | | 0.13 | | | |
| *Gaura sp.* | Beeblossom | N | | | 0.40 | | | |
| *Glandularia bipinnatifida* | Dakota vervain | N | 0.07 | | | | | |
| *Grindelia papposa* | Wax goldenweed | N | 0.18 | | 0.04 | | 0.11 | |
| *Helianthus annuus* | Common sunflower | N | 0.07 | | 0.04 | | 0.36 | |
| ***Helianthus maximiliani*** | **Maximillion Sunflower** | **NS/P** | | | **0.04** | | **0.11** | |
| *Heterotheca subaxillaris* | Camphorweed | **N** | | | | | 0.25 | |
| *Hordeum pusillum* | Little barley | N | | | 1.61 | | 1.59 | |
| *Ipomoea purpurea* | Common morning glory | I | | 0.21 | | 0.79 | | 0.91 |
| *Ipomoea wrightii* | Wright's morning-glory | I | | | | 0.59 | | |
| *Iva annua* | Marsh-elder | N | | 0.45 | | 2.93 | | 1.18 |
| *Juncus* sp. | Rush | N | 1.04 | | 0.74 | | 0.55 | |
| *Koeleria macrantha* | Prairie Junegrass | N | | | 0.36 | | | |
| *Lactuca serriola* | Prickly lettuce | I | | 1.61 | | | | |
| *Lathyrus hirsutus* | Caley pea | I | | | | 1.29 | | 0.59 |
| *Lepidium austrinum* | Pepperwort | N | | | 0.19 | | 0.43 | |
| *Lepidium virginicum* | Virginia pepper-grass | N | | | 1.04 | | 0.16 | |
| *Limnodea arkansana* | Ozarkgrass | N | | | | | 0.76 | |
| *Lippia nodiflora* | Frogfruit | N | 2.05 | | 1.18 | | 2.06 | |
| *Lolium perenne* | Ryegrass | I | | 4.17 | | 9.94 | | 15.24 |
| *Ludwigia peploides* | Creeping water primrose | N | 0.13 | | 2.21 | | | |
| *Ludwigia sp.* | Water primrose | N | | | | 0.10 | | 0.25 |
| *Lycopus americanus* | American water-horehound | N | | | 0.35 | | | |
| *Medicago orbicularis* | Button medic | I | | 0.21 | | 0.66 | | |
| *Medicago polymorpha* | Burclover | I | | | | 0.52 | | |
| *Melilotus officinalis* | Yellow sweetclover | I | | 2.02 | | 0.35 | | 1.09 |
| ***Monarda citriodora*** | **Lemon beebalm** | **NS** | **0.13** | | | | | |
| *Morus* sp. | Mulberry | N | | 0.13 | | | | |
| *Neptunia lutea* | Yellowpuff | N | | | | | 0.15 | |
| ***Oenothera speciosa*** | **Pink evening primrose** | **NS** | | | **3.02** | | **5.89** | |
| *Oxalis stricta* | Common yellow oxalis | N | | | | | | |
| *Panicum coloratum* | Klein Grass | I | | 0.75 | | | | |
| ***Panicum virgatum*** | **Switchgrass** | **NS/P** | **0.31** | | **0.66** | | **1.53** | |
| *Parthenocissus quinquefolia* | Virginia creeper | N | 0.13 | | | | | |
| *Paspalum distichum* | Knotgrass | N | 0.75 | | | | 1.13 | |
| *Paspalidium geminatum* | Egyptian panicgrass | N | | | | | 0.11 | |
| *Phalaris canariensis* | Canarygrass | I | | | | 3.34 | | 4.21 |
| *Phyllanthus polygonoides* | Knotweed leaf-flower | N | 2.24 | | 0.74 | | | |
| *Physalis angulata* | Ground cherry | N | | | | | | 0.08 |
| ***Physostegia intermedia*** | **Obedient plant** | **NS** | **0.14** | | | | **0.25** | |
| *Polygonum hydropiperoides* | Swamp smartweed | N | 0.07 | | | | | |
| *Polygonum lapathifolium* | Willow smartweed | N | 1.40 | | | | | |
| *Polygonum pennsylvanica* | Pink smartweed | N | 2.31 | | | | | |
| *Polygonum* sp. | Smartweed | N | 0.38 | | 2.03 | | 1.28 | |
| *Populus deltoides* | Cottonwood | N | | 0.57 | | 0.10 | | |
| *Pyrrhopappus pauciflorus* | Texas dandelion | N | | | 1.90 | | 2.84 | |
| *Ranunculus macounii* | Buttercup | N | | | 0.92 | | 0.49 | |
| *Rosa sp.* | Rose | N | | | | | 0.16 | |
| *Rubus sp.* | Dewberry | N | | | 0.18 | | | |
| ***Rudbeckia hirta*** | **Black-eyed Susan** | **NS** | **0.07** | | | | | |
| *Rumex crispus* | Curly dock | I | | 4.30 | | 2.97 | | 4.92 |
| *Salix nigra* | Black willow | N | | 0.78 | | 0.49 | | |
| ***Salvia azurea*** | **Azure blue sage** | **NS** | | | **0.22** | | **0.11** | |
| *Schoenoplectus pungens* | American bulrush | N | **0.10** | | | | | |

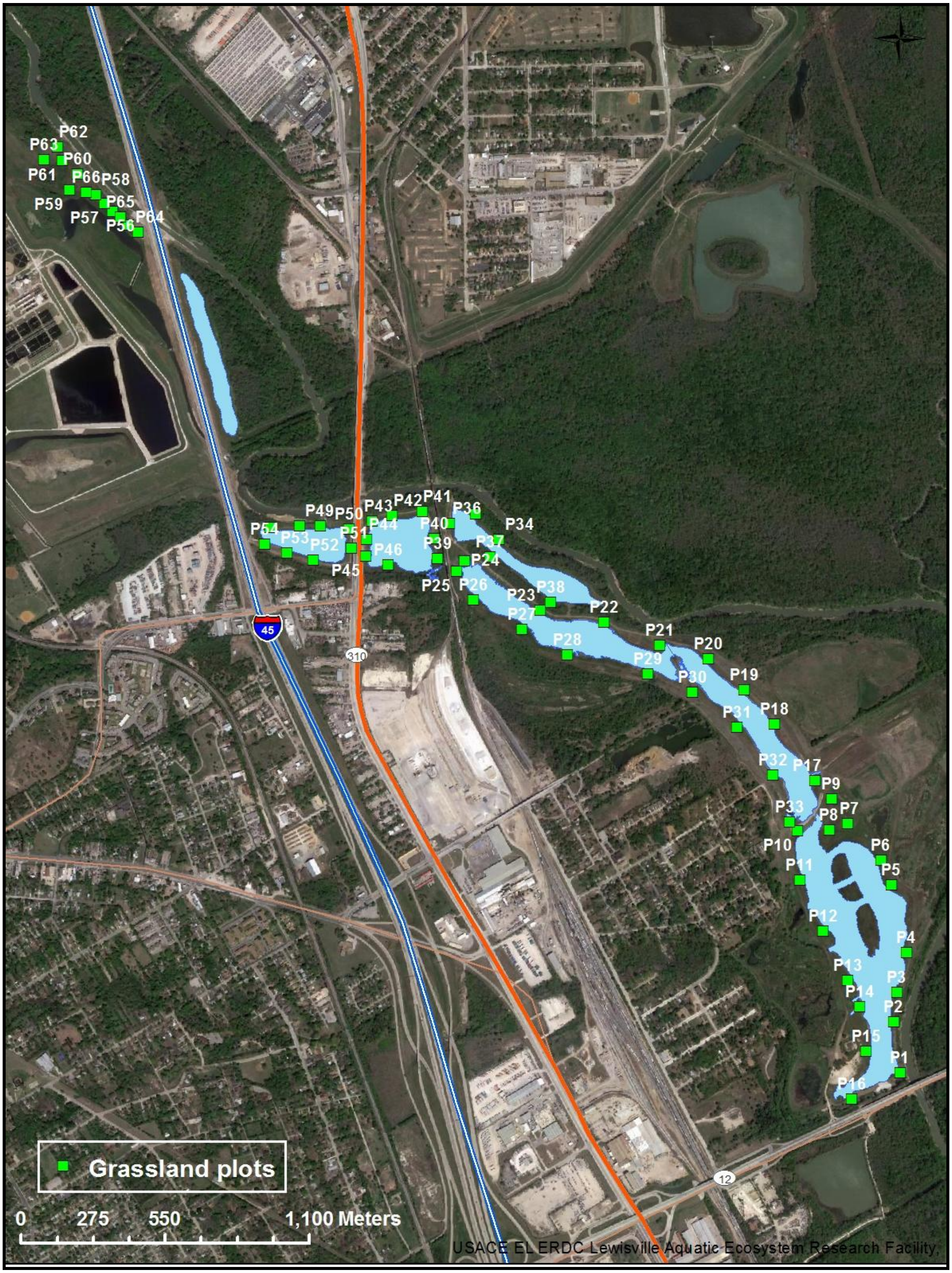
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Secale cereale* | Rye | I | 6.42 | | 0.13 | | 4.76 | | |
| *Sesbania herbacea* | Coffee-bean sesbania | N | 0.53 | | 0.25 | | 0.25 | | |
| *Setaria parviflora* | Knotroot bristlegrass | N | 1.92 | | | | | | |
| *Setaria viridis* | Green bristle grass | I | | 0.49 | | | | | |
| *Smilax sp.* | Green briar | N | 0.13 | | 0.10 | | | | |
| *Solanum elaeagnifolium* | Silver-leaf nightshade | N | | 0.07 | | 0.04 | | | |
| *Solidago sp.* | Goldenrod | N | | | 0.10 | | | | |
| *Sonchus sp.* | Sowthistle | I | | | | 2.11 | | 2.66 | |
| *Sorghum halepense* | Johnsongrass | I | | 2.63 | | 3.07 | | 3.34 | |
| *Symphyotrichum subulatum* | Slim aster | N | 5.68 | | 4.69 | | 3.33 | | |
| *Tetragonotheca ludoviciana* | Sawtooth | N | | 0.35 | | | | | |
| *Torilis arvensis* | Spreading hedgeparsley | I | | 1.62 | | 3.12 | | 3.36 | |
| *Toxicodendron radicans* | Poison Ivy | N | | 0.41 | | | | | |
| *Tragia sp.* | Noseburn | N | | | 0.18 | | 0.11 | | |
| *Tridens texanus* | Texas tridens | N | 1.12 | | | | | | |
| *Tridens sp.* | Fluffgrass | N | | | 0.25 | | 0.33 | | |
| *Triodanis sp.* | Venus' looking-glass | N | | | 0.54 | | | | |
| ***Tripsacum dactyloides*** | **Eastern gamagrass** | **NS/P** | | | **0.25** | | **0.49** | | |
| *Typha latifolia* | Cattail | N | | | | 0.22 | | | |
| Ulmus americana | American elm tree | N | | | | | | 0.25 | |
| Unknown | Unknown | | | 5.08 | | 0.08 | | | |
| *Vicia sp.* | Vetch | I | | | | 0.26 | | | |
| *Viola missouriensis* | Missouri violet | N | 0.21 | | | | | | |
| *Xanthium strumarium* | Cocklebur | N | | 0.70 | | 0.10 | | | |
| ***Total number of species*** | | | | **73** | | **95** | | **64** | |

# <u>Appendix I</u>

**Dallas Floodway Extension**

## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Plot Layout for 2012-2013 Large-scale Planting


P62
P63
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P18
P32
P17
P9
P33
P8
P7
P10
P6
P11
P5
P12
P4
P13
P3
P14
P2
P15
P1
P16
45
310
12
Grassland plots
0
275
550
1,100 Meters
USACE EL ERDC Lewisville Aquatic Ecosystem Research Facility

# Appendix J

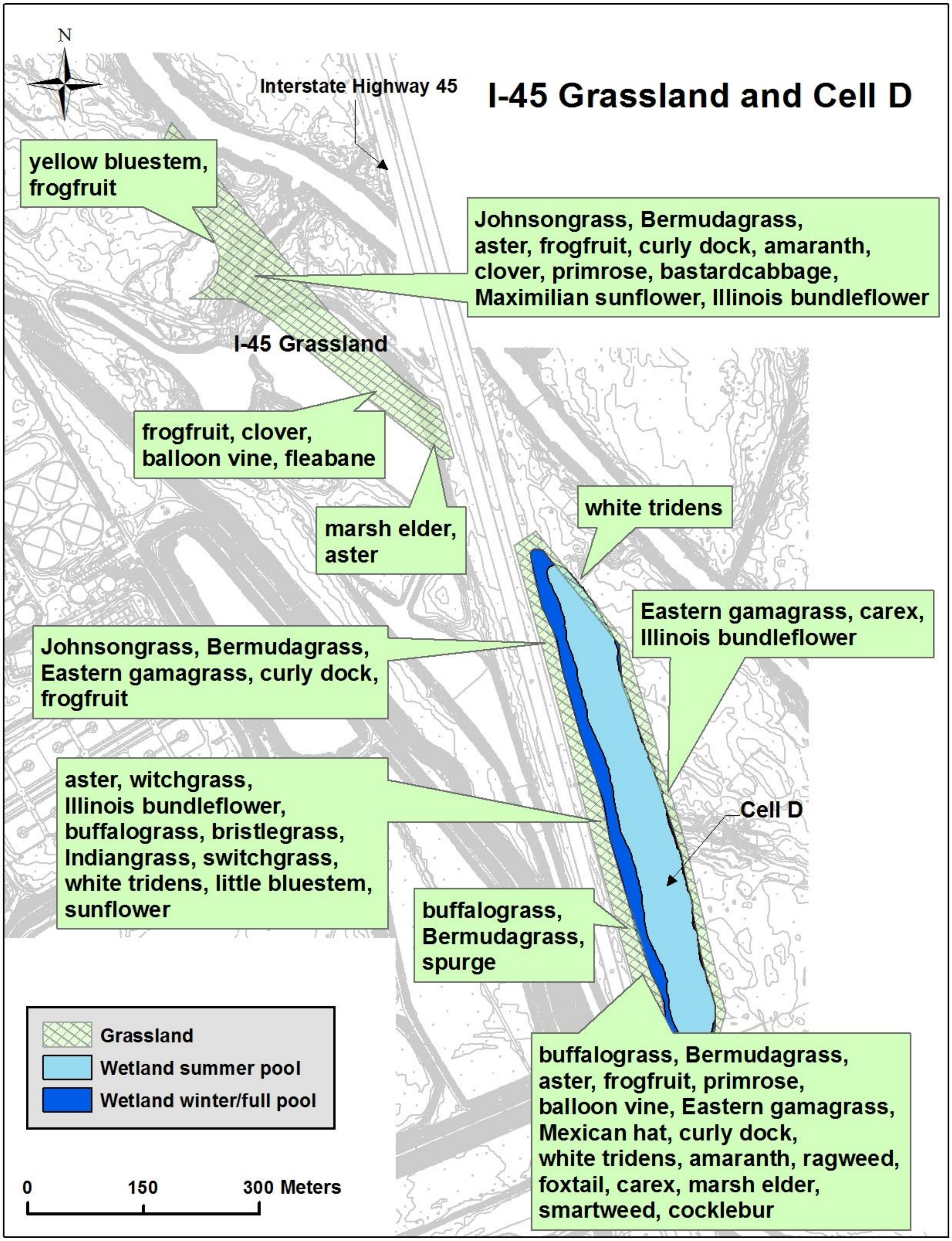
**Dallas Floodway Extension**

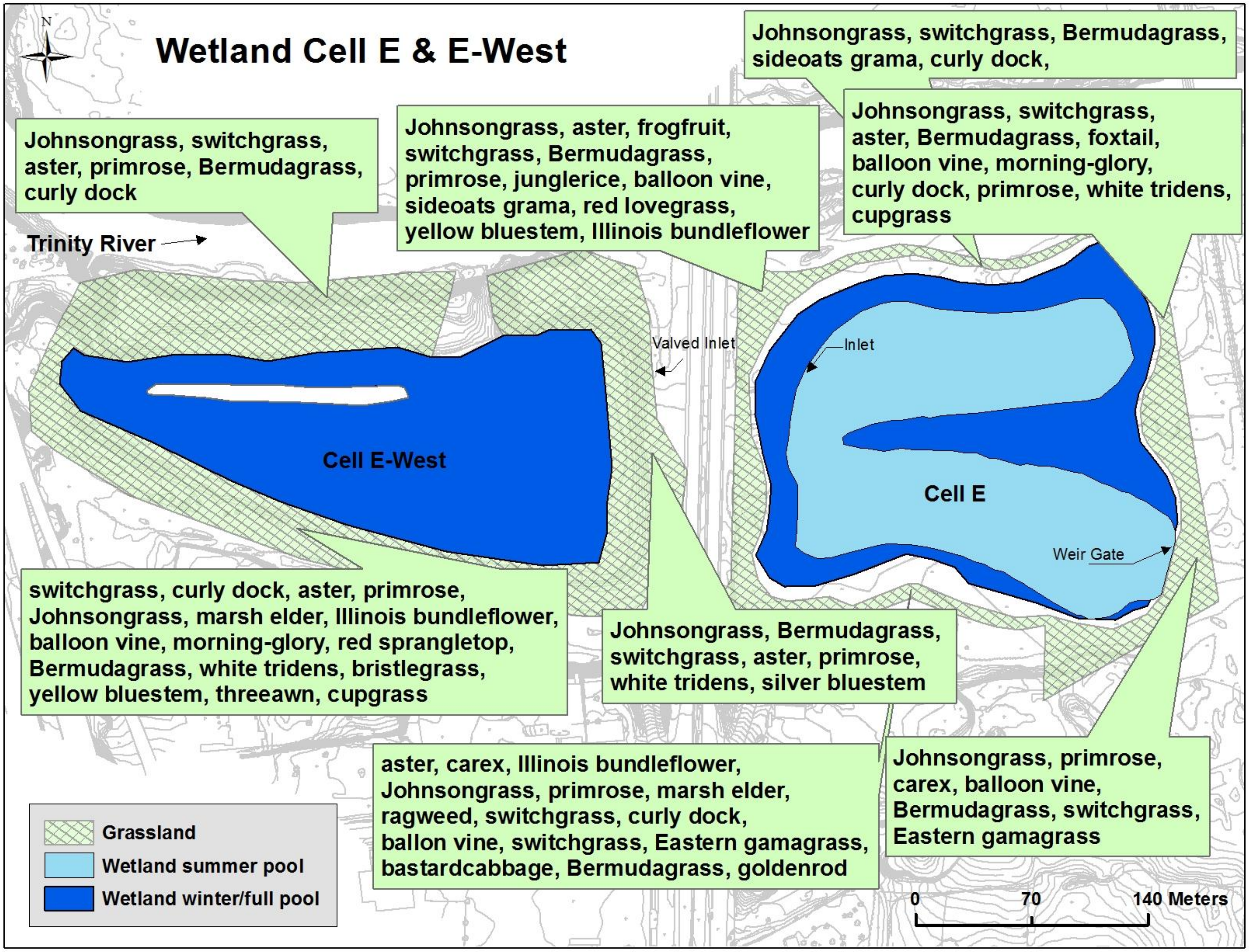
## Establishment, monitoring, and adaptive management of native aquatic vegetation and adjacent native grasslands; and monitoring aquatic organism utilization of project aquatic features:

## Fall 2012 Meander Surveys

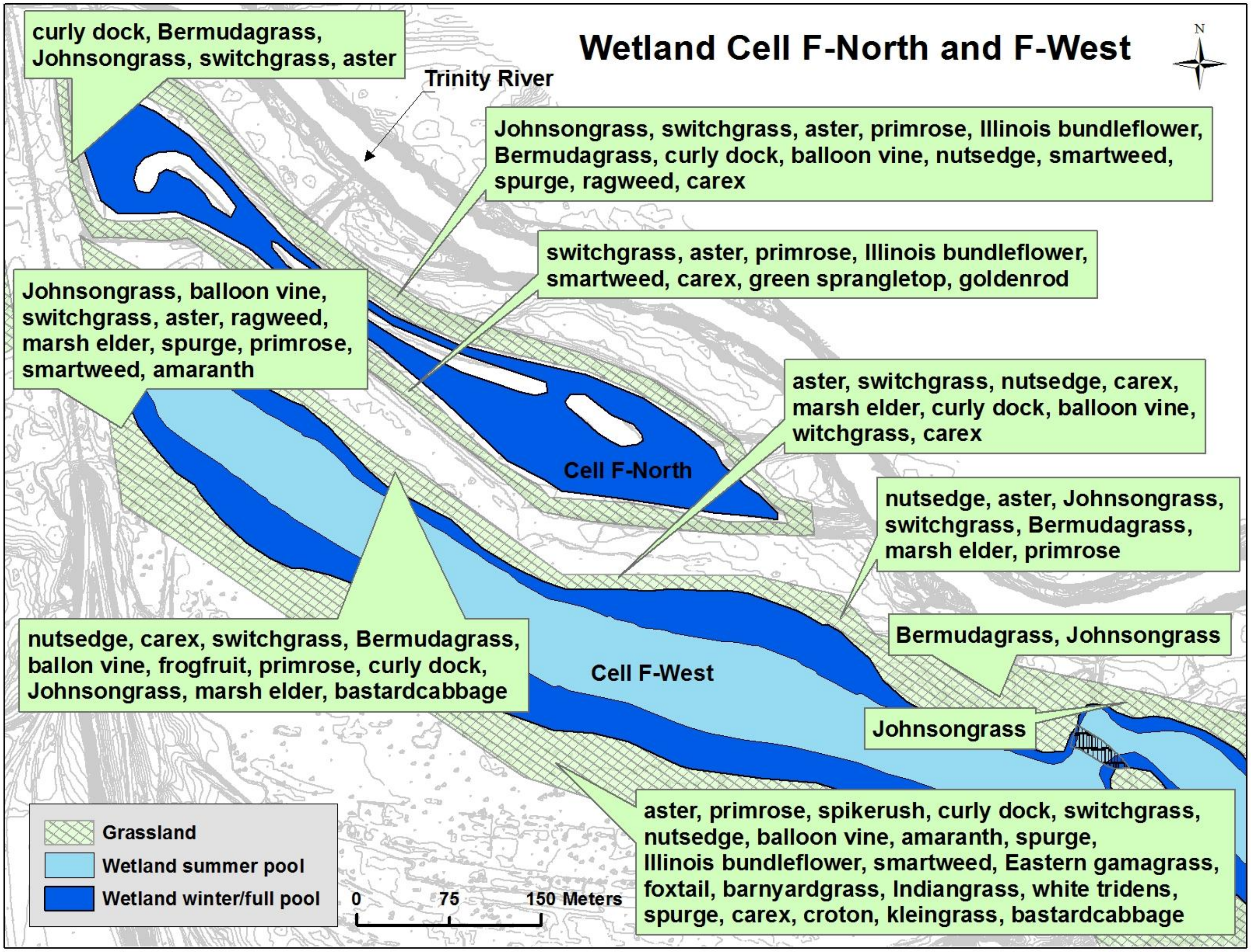
**Table J-1. Plant species observed during meandering survey conducted Fall 2012. Status: N = native; NS = native seeded, P = planted; I = introduced. Category: U = undesirable grassland plant; D = desirable grassland plant.**

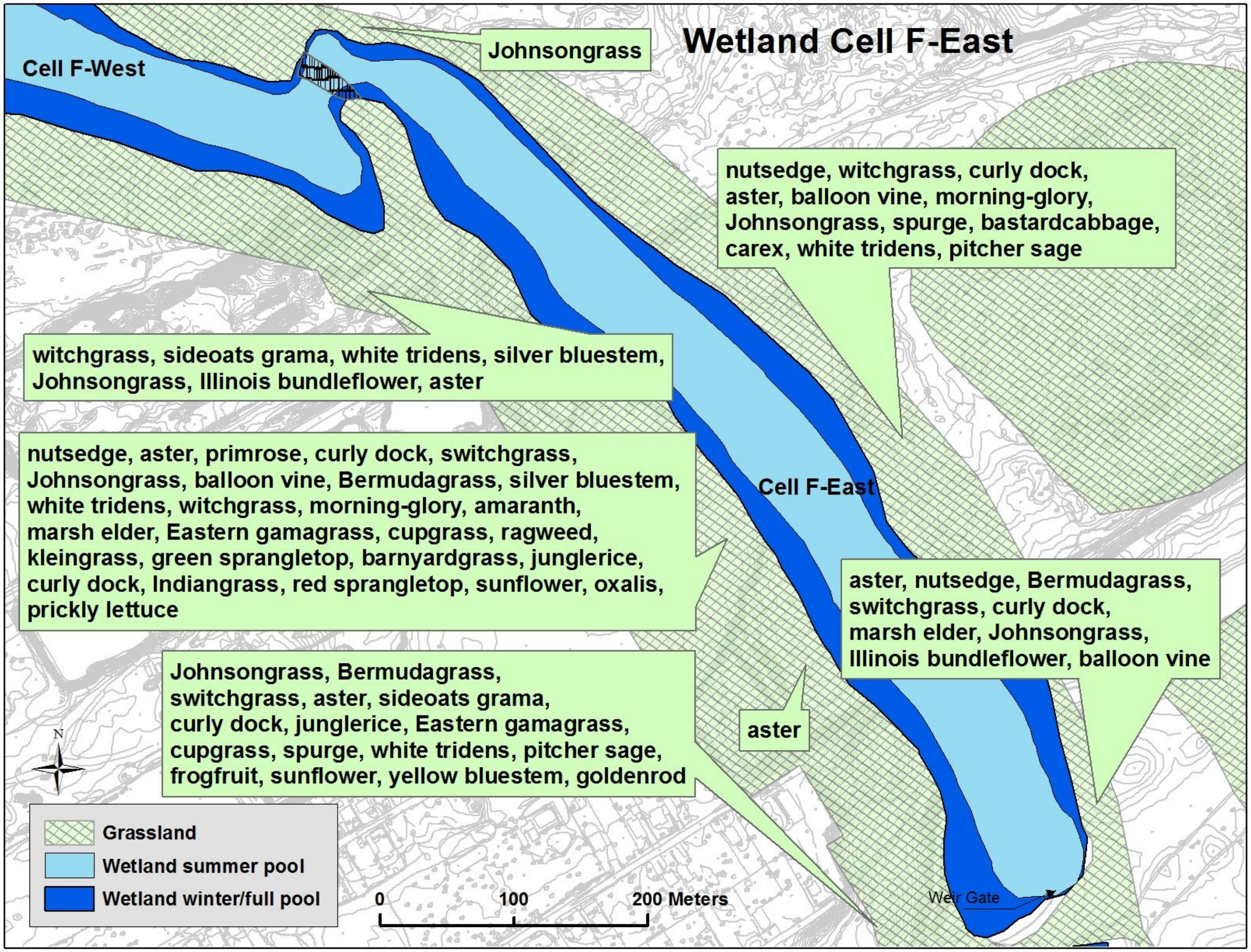
| Scientific Name | Common name | Status | Category |
|---|---|---|---|
| *Amaranthus sp.* | Amaranth | **N** | **D** |
| *Allium drummondii* | Drummond's onion | **N** | **D** |
| *Ambrosia artemisiifolia* | Common ragweed | **N** | **U** |
| *Ambrosia trifida* | Giant ragweed | **N** | **U** |
| *Andropogon gerardii* | Big bluestem | **NS/P** | **D** |
| *Aristida sp.* | Three awn grass | **N** | **D** |
| *Bothriochloa ischaemum* | Yellow bluestem | **I** | **U** |
| *Bouteloua curtipendula* | Sideoats grama | **NS** | **D** |
| *Bouteloua dactyloides* | Buffalograss | **NS** | **D** |
| *Cardiospermum halicacabum* | Balloon vine | **I** | **U** |
| *Carex sp.* | Sedge | **N** | **D** |
| *Croton texensis* | Texas croton | **N** | **D** |
| *Cynodon dactylon* | Bermudagrass | **I** | **U** |
| *Cyperus esculentus* | Yellow nutsedge | **N** | **D** |
| *Desmanthus illinoensis* | Illinois bundleflower | **NS** | **D** |
| *Echinochloa colona* | Junglerice | **I** | **U** |
| *Echinochloa crus-galli* | Barnyardgrass | **I** | **U** |
| *Eleocharis sp.* | Spikerush | **N** | **D** |
| *Elymus virginicus* | Virginia wildrye | **N** | **D** |
| *Eriochloa sericea* | Texas cupgrass | **NS** | **D** |
| *Erigeron sp.* | Fleabane | **N** | **D** |
| *Euphorbia sp.* | Spurge | **N** | **U** |
| *Helianthus annuus* | Common sunflower | **N** | **D** |
| *Helianthus maximiliani* | Maximillian sunflower | **NS/P** | **D** |
| *Hibiscus sp.* | Rosemallow | **N** | **D** |
| *Ipomoea purpurea* | Common morning-glory | **I** | **U** |
| *Iva annua* | Marsh elder | **N** | **U** |
| *Lactuca serriola* | Prickly lettuce | **I** | **U** |
| *Leptochloa dubia* | Green sprangletop | **NS** | **D** |
| *Leptochloa mucronata* | Red sprangletop | **N** | **D** |
| *Lippia nodiflora* | Frogfruit | **N** | **D** |
| *Melia azedarach* | Chinaberry | **I** | **U** |
| *Oenothera speciosa* | Pink evening primrose | **NS** | **D** |
| *Oxalis stricta* | Common yellow oxalis | **N** | **D** |
| *Panicum capillare* | Witchgrass | **N** | **D** |
| *Panicum coloratum* | Kleingrass | **I** | **U** |
| *Panicum virgatum* | Switchgrass | **NS/P** | **D** |
| *Paspalum dilatatum* | Dallisgrass | **I** | **U** |
| *Paspalum distichum* | Knotgrass | **N** | **D** |
| *Polygonum pennsylvanica* | Smartweed | **N** | **D** |
| *Rapistrum rugosum* | Annual bastardcabbage | **I** | **U** |
| *Ratibida columnifera* | Mexican hat | **NS** | **D** |
| *Rumex crispus* | Curly dock | **I** | **U** |
| *Salvia azurea* | Azure blue sage | **NS** | **D** |
| *Schizachyrium soparium* | Little bluestem | **N** | **D** |
| *Setaria macrostachya* | Plains bristlegrass | **NS** | **D** |
| *Setaria parviflora* | Knotroot bristlegrass | **N** | **D** |
| *Solidago sp* | Goldenrod | **N** | **D** |
| *Sorgastrum nutans* | Indiangrass | **NS** | **D** |
| *Sorghum halepense* | Johnsongrass | **I** | **U** |
| *Symphyotrichum ericoides* | White heath aster | **N** | **D** |
| *Symphyotrichum subulatum* | Slim aster | **N** | **D** |
| *Taraxacum officinale* | Common dandelion | **I** | **U** |
| *Tridens albescens* | White tridens | **N** | **D** |
| *Tripsacum dactyloides* | Eastern gamagrass | **NS** | **D** |
| *Xanthium strumarium* | Cocklebur | **N** | **U** |


N
Interstate Highway 45
I-45 Grassland and Cell D
yellow bluestem, frogfruit
Johnsongrass, Bermudagrass, aster, frogfruit, curly dock, amaranth, clover, primrose, bastardcabbage, Maximilian sunflower, Illinois bundleflower
I-45 Grassland
frogfruit, clover, balloon vine, fleabane
marsh elder, aster
white tridens
Eastern gamagrass, carex, Illinois bundleflower
Johnsongrass, Bermudagrass, Eastern gamagrass, curly dock, frogfruit
aster, witchgrass, Illinois bundleflower, buffalograss, bristlegrass, Indiangrass, switchgrass, white tridens, little bluestem, sunflower
Cell D
buffalograss, Bermudagrass, spurge
Grassland
Wetland summer pool
Wetland winter/full pool
buffalograss, Bermudagrass, aster, frogfruit, primrose, balloon vine, Eastern gamagrass, Mexican hat, curly dock, white tridens, amaranth, ragweed, foxtail, carex, marsh elder, smartweed, cocklebur
0
150
300 Meters

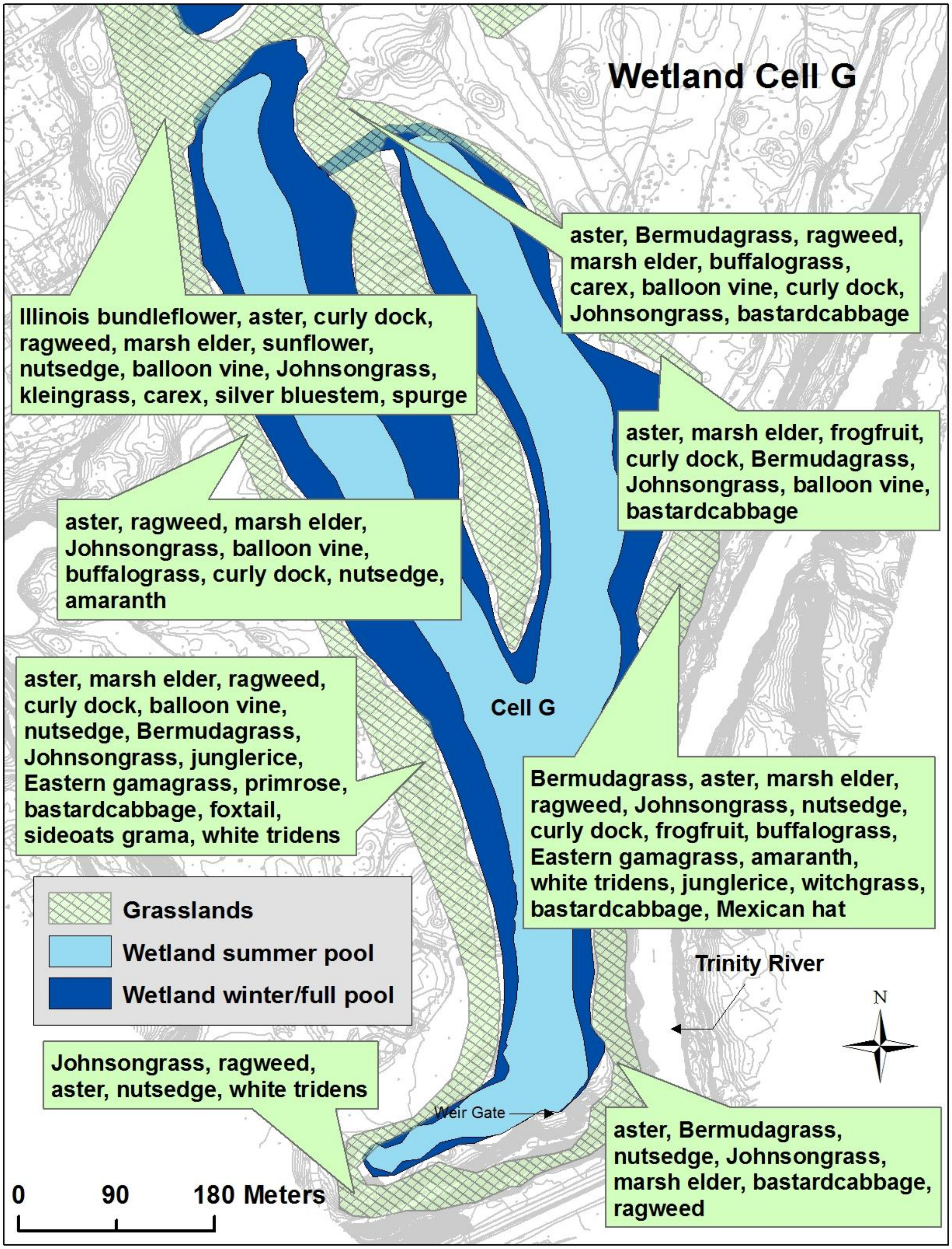


Wetland Cell E & E-West
N
Johnsongrass, switchgrass, Bermudagrass, sideoats grama, curly dock,
Johnsongrass, switchgrass, aster, primrose, Bermudagrass, curly dock
Johnsongrass, aster, frogfruit, switchgrass, Bermudagrass, primrose, junglerice, balloon vine, sideoats grama, red lovegrass, yellow bluestem, Illinois bundleflower
Johnsongrass, switchgrass, aster, Bermudagrass, foxtail, balloon vine, morning-glory, curly dock, primrose, white tridens, cupgrass
Trinity River
Valved Inlet
Inlet
Cell E-West
Cell E
Weir Gate
switchgrass, curly dock, aster, primrose, Johnsongrass, marsh elder, Illinois bundleflower, balloon vine, morning-glory, red sprangletop, Bermudagrass, white tridens, bristlegrass, yellow bluestem, threeawn, cupgrass
Johnsongrass, Bermudagrass, switchgrass, aster, primrose, white tridens, silver bluestem
aster, carex, Illinois bundleflower, Johnsongrass, primrose, marsh elder, ragweed, switchgrass, curly dock, ballon vine, switchgrass, Eastern gamagrass, bastardcabbage, Bermudagrass, goldenrod
Johnsongrass, primrose, carex, balloon vine, Bermudagrass, switchgrass, Eastern gamagrass
Grassland
Wetland summer pool
Wetland winter/full pool
0
70
140 Meters


Wetland Cell F-North and F-West
N
Trinity River
curly dock, Bermudagrass, Johnsongrass, switchgrass, aster
Johnsongrass, switchgrass, aster, primrose, Illinois bundleflower, Bermudagrass, curly dock, balloon vine, nutsedge, smartweed, spurge, ragweed, carex
switchgrass, aster, primrose, Illinois bundleflower, smartweed, carex, green sprangletop, goldenrod
Johnsongrass, balloon vine, switchgrass, aster, ragweed, marsh elder, spurge, primrose, smartweed, amaranth
aster, switchgrass, nutsedge, carex, marsh elder, curly dock, balloon vine, witchgrass, carex
Cell F-North
nutsedge, aster, Johnsongrass, switchgrass, Bermudagrass, marsh elder, primrose
Bermudagrass, Johnsongrass
nutsedge, carex, switchgrass, Bermudagrass, ballon vine, frogfruit, primrose, curly dock, Johnsongrass, marsh elder, bastardcabbage
Cell F-West
Johnsongrass
aster, primrose, spikerush, curly dock, switchgrass, nutsedge, balloon vine, amaranth, spurge, Illinois bundleflower, smartweed, Eastern gamagrass, foxtail, barnyardgrass, Indiangrass, white tridens, spurge, carex, croton, kleingrass, bastardcabbage
Grassland
Wetland summer pool
Wetland winter/full pool
0
75
150 Meters



Wetland Cell F-East
Cell F-West
Johnsongrass
nutsedge, witchgrass, curly dock, aster, balloon vine, morning-glory, Johnsongrass, spurge, bastardcabbage, carex, white tridens, pitcher sage
witchgrass, sideoats grama, white tridens, silver bluestem, Johnsongrass, Illinois bundleflower, aster
nutsedge, aster, primrose, curly dock, switchgrass, Johnsongrass, balloon vine, Bermudagrass, silver bluestem, white tridens, witchgrass, morning-glory, amaranth, marsh elder, Eastern gamagrass, cupgrass, ragweed, kleingrass, green sprangletop, barnyardgrass, junglerice, curly dock, Indiangrass, red sprangletop, sunflower, oxalis, prickly lettuce
Cell F-East
aster, nutsedge, Bermudagrass, switchgrass, curly dock, marsh elder, Johnsongrass, Illinois bundleflower, balloon vine
Johnsongrass, Bermudagrass, switchgrass, aster, sideoats grama, curly dock, junglerice, Eastern gamagrass, cupgrass, spurge, white tridens, pitcher sage, frogfruit, sunflower, yellow bluestem, goldenrod
aster
N
Grassland
Wetland summer pool
Wetland winter/full pool
0
100
200 Meters
Weir Gate



Wetland Cell G
aster, Bermudagrass, ragweed, marsh elder, buffalograss, carex, balloon vine, curly dock, Johnsongrass, bastardcabbage
Illinois bundleflower, aster, curly dock, ragweed, marsh elder, sunflower, nutsedge, balloon vine, Johnsongrass, kleingrass, carex, silver bluestem, spurge
aster, marsh elder, frogfruit, curly dock, Bermudagrass, Johnsongrass, balloon vine, bastardcabbage
aster, ragweed, marsh elder, Johnsongrass, balloon vine, buffalograss, curly dock, nutsedge, amaranth
aster, marsh elder, ragweed, curly dock, balloon vine, nutsedge, Bermudagrass, Johnsongrass, junglerice, Eastern gamagrass, primrose, bastardcabbage, foxtail, sideoats grama, white tridens
Cell G
Bermudagrass, aster, marsh elder, ragweed, Johnsongrass, nutsedge, curly dock, frogfruit, buffalograss, Eastern gamagrass, amaranth, white tridens, junglerice, witchgrass, bastardcabbage, Mexican hat
Grasslands
Wetland summer pool
Wetland winter/full pool
Trinity River
N
Johnsongrass, ragweed, aster, nutsedge, white tridens
Weir Gate
aster, Bermudagrass, nutsedge, Johnsongrass, marsh elder, bastardcabbage, ragweed
0
90
180 Meters

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