GROVE CREEK MITIGATION PLAN

DUPLIN COUNTY
NORTH CAROLINA

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1.0 INTRODUCTION

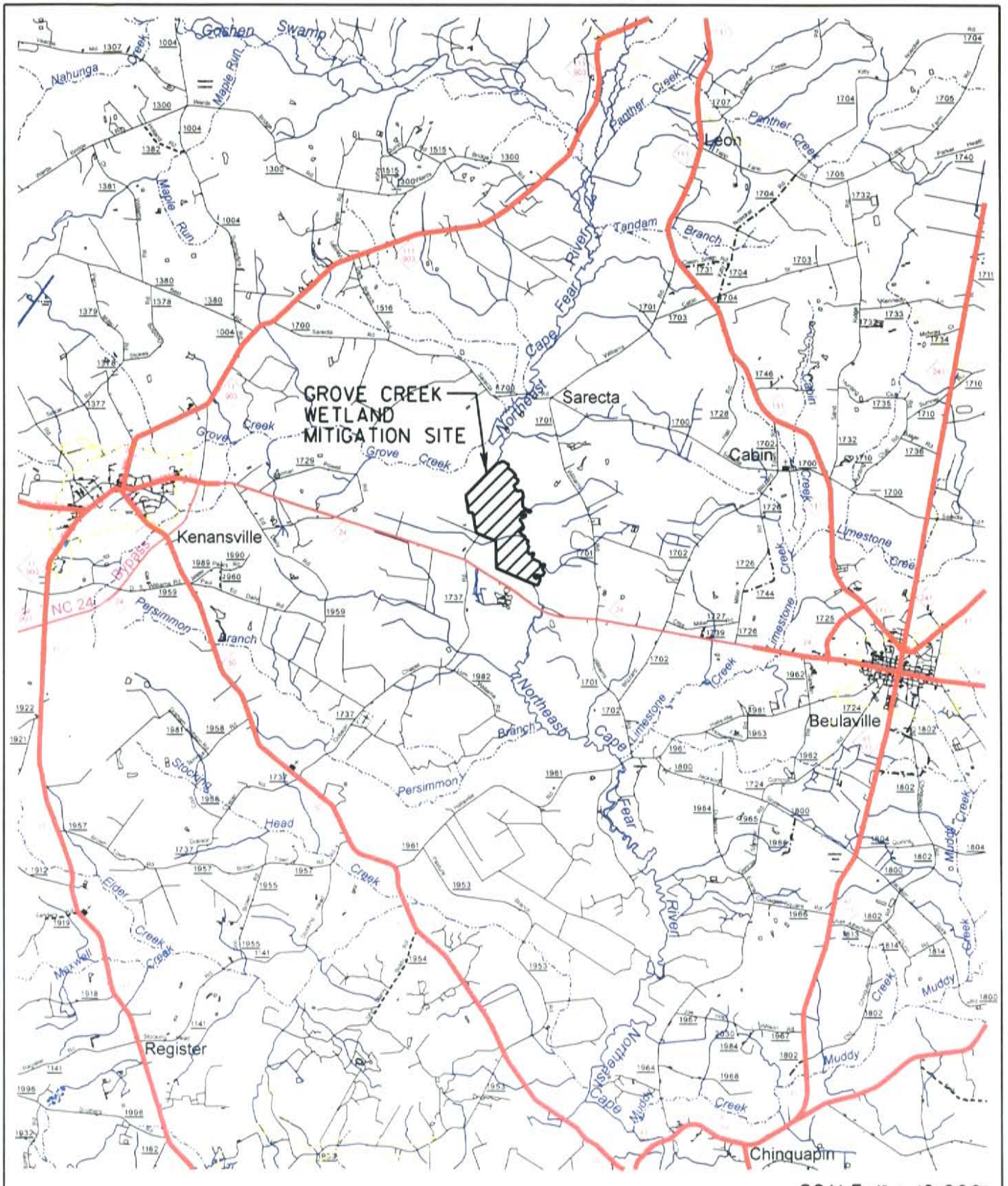
The North Carolina Department of Transportation (NCDOT) is developing a large-scale wetlands mitigation site in Duplin County, North Carolina to mitigate for unavoidable wetland impacts occurring from yet-to-be determined highway projects. The 549-acre Grove Creek Mitigation Site (hereafter referred to as "the Grove Creek Mitigation Site" or "the Site") is located east of Kenansville, North Carolina (Figure 1) and will be utilized as a mitigation site for wetland impacts occurring within Hydrologic Unit 03030007 of the Lower Cape Fear River Basin (Figure 2).

The proposed Grove Creek Mitigation Site is owned by the NCDOT and consists of active agricultural fields, mixed hardwood forests, and a large Bottomland Hardwood/Cypress-Gum Swamp wetland system located adjacent to the Northeast Cape Fear River. Historical activities within the Site have included agricultural practices (including ditching) within areas of mapped hydric soils and timber harvesting within the existing wetlands system.

Mitigation components planned for the Grove Creek Site consist of the restoration of previously ditched and filled riverine wetlands, restoration and creation of riverine wetlands within existing agriculture fields, hydraulic enhancement of previously ditched riverine wetlands, preservation of the existing Coastal Plain Bottomland Hardwoods/Cypress-Gum Swamp Forest wetlands complex, restoration of a previously drained nonriverine wetland area, enhancement of deforested upland areas through planting, and preservation of existing upland hardwood forests.

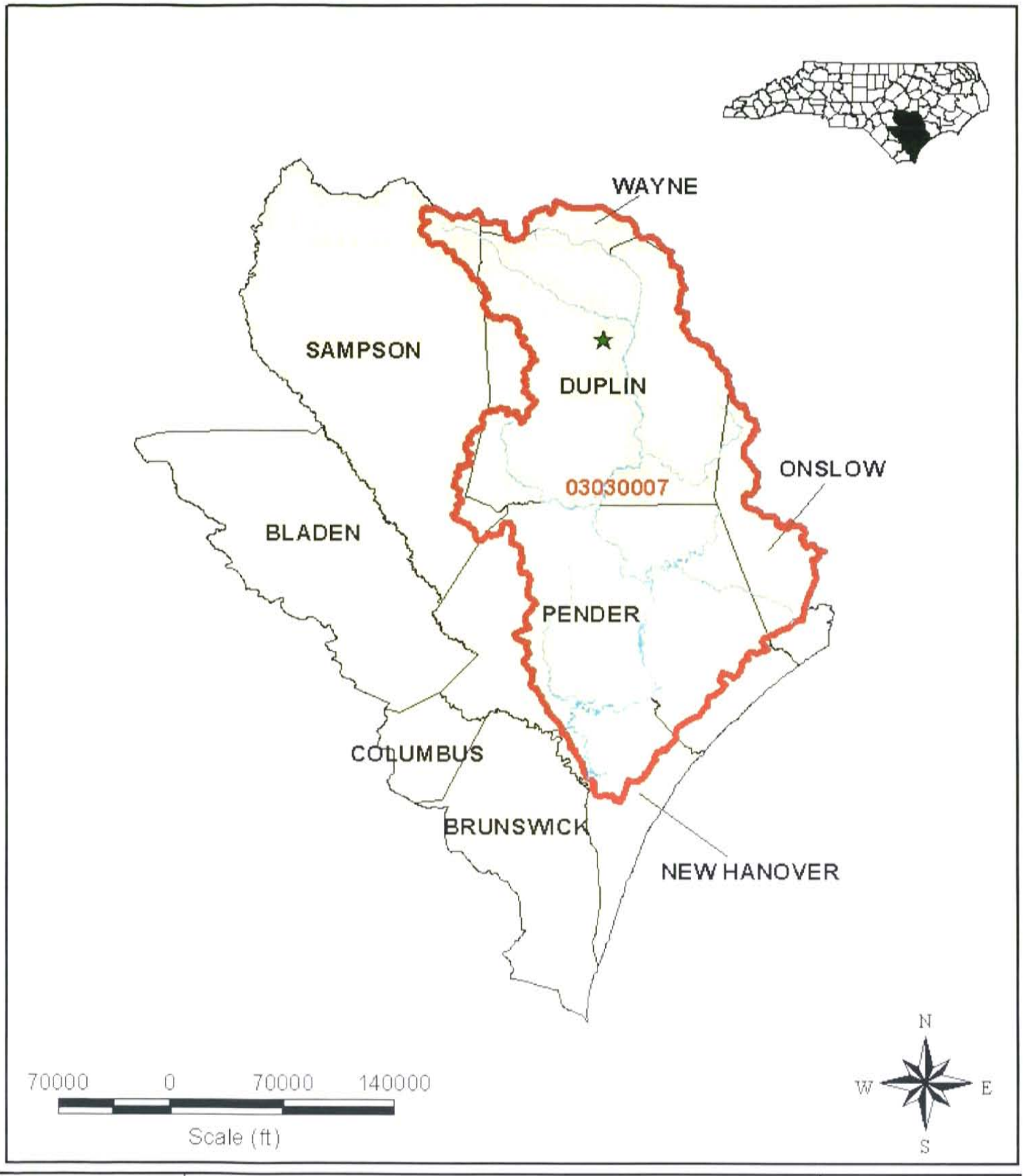
Specifically the proposed mitigation credits consist of:

- restoration of 6.0 acres (2.4 hectares) of previously ditched and filled riverine wetlands,
- restoration of 3.9 acres (1.6 hectares) of previously drained nonriverine wetlands,
- enhancement of 7.6 acres (3.1 hectares) of ditched riverine wetlands,
- creation of 3.3 acres (1.3 hectares) of riverine wetlands within existing agriculture fields,
- preservation of 352 acres (142.5 hectares) of existing riverine wetlands (Coastal Plain Bottomland Hardwoods/ Cypress-Gum Swamp wetland system),
- enhancement of 113.2 acres (45.8 hectares) of existing upland buffers, and
- preservation of 63.0 acres (25.5 hectares) of existing forested uplands.



GROVE CREEK SITE MAP
CAPE FEAR RIVER BASIN
WETLAND MITIGATION PLAN
DUPLIN COUNTY, NORTH CAROLINA

FIGURE 1



Grove Creek Mitigation Site
Service Area Map

Figure 2

2.0 EXISTING CONDITIONS

2.1 Physiography, Site History, and Land Use

The Grove Creek Mitigation Site is located south of the confluence of Grove Creek and the Northeast Cape Fear River in the Coastal Plain Physiographic Province of the Cape Fear River Basin (HU 03030007). The Site is bounded to the north by forested upland and wetland areas that include the Grove Creek floodplain, to the east and south by forested upland and wetland areas that include the Northeast Cape Fear River and its associated floodplain, and to the west by agricultural fields. Elevations on the site range from 52 feet above mean sea level (msl) in the existing agriculture fields to 46 feet (msl) within the Northeast Cape Fear River floodplain.

Aerial photographs available for the Site indicate that overall land use practices have remained unchanged since 1954. These practices have included agriculture and forestry. Photos of the site indicate that specific land use has changed in several areas within the site. Land use changes include the abandonment of previously ditched wetland areas that were used for crop production. Current land practices consist of only crop production within the historical agriculture fields. Forestry activities were initiated again in 1999 with the construction of a logging road within the existing Bottomland Hardwood/Cypress-Gum Swamp wetland system. The property was purchased by the NCDOT prior to the commencement of logging operations.

2.2 Geology

The geology underlying the Site is located within the Pee Dee Formation of the Cretaceous Stratigraphy of the Carolina Coastal Plain. This formation consists of sand, clayey sand, and clay that is dominantly dark greenish to gray, sparingly micaceaous and glauconitic, argillaceous sand that appears to be massive (Horton and Zullo 1991). Other characteristics of this formation include calcareous cemented concretions that are locally fossilferous with patches of sandy molluscan mold limestone in the upper parts.

2.3 Water Resources

2.3.1 Streams

There are two jurisdictional streams located within the proposed Grove Creek Mitigation Site. These streams include the Northeast Cape Fear River (DWQ Index Number 18-74-(1), Class "C Sw"), and a perennial Unnamed Tributary (UT) to the Northeast Cape Fear River (DWQ Index Number 18-74-(1), Class "C Sw"). Other nonjurisdictional surface waters observed within the Site include drainage ditches located within the existing agricultural fields and linear sloughs located throughout Bottomland Hardwood/Cypress-Gum Swamp wetland system.

2.3.2 Wetlands

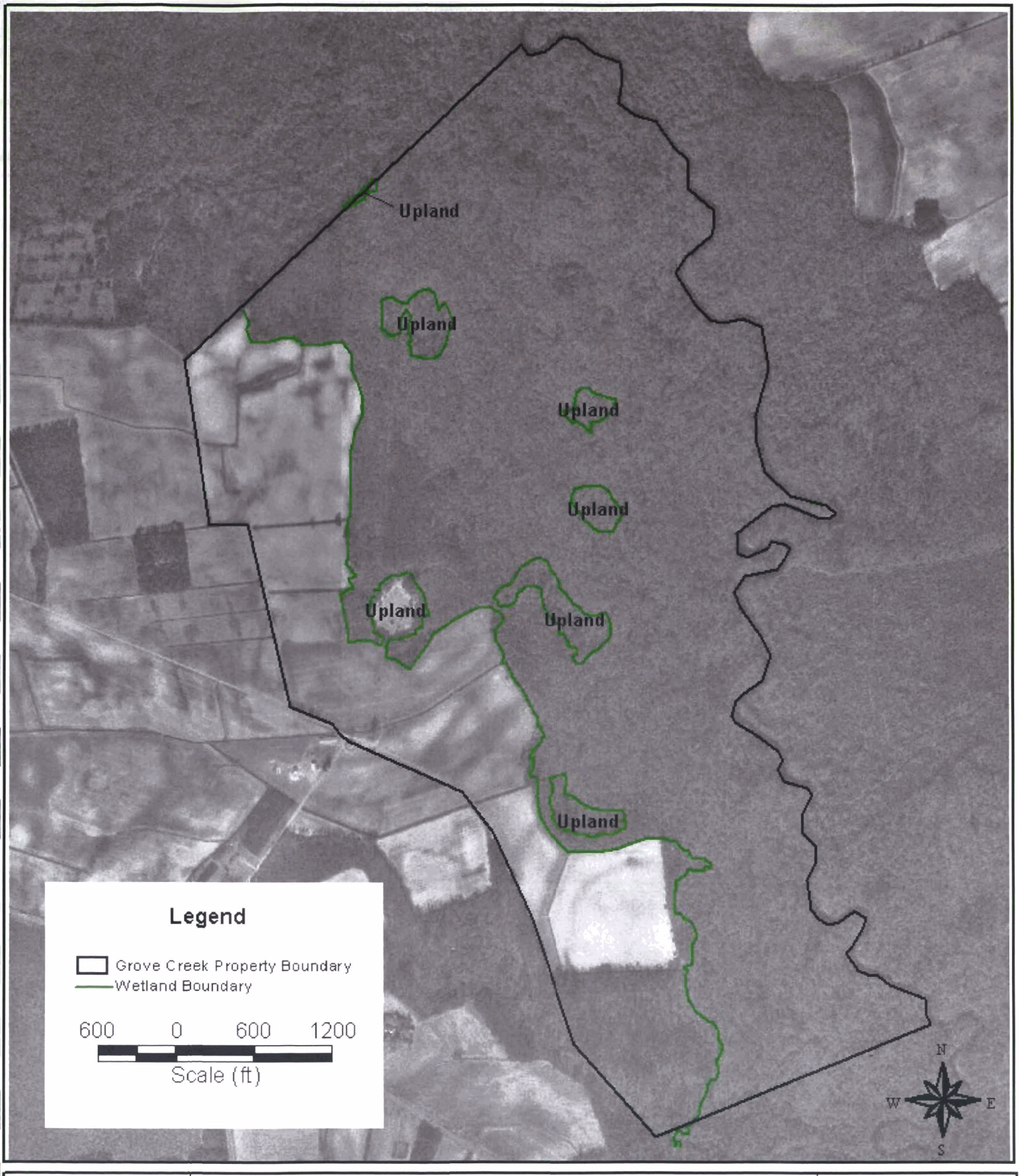
Two wetland communities are located within the Grove Creek Mitigation Site. These communities are located in the 100-year floodplain of the Northeast Cape Fear River and include a Coastal Plain Bottomland Hardwoods Forest and a Cypress-Gum Swamp. Both communities are interwoven within one complex wetland system in which areas of higher elevation make up the Bottomland Hardwoods and those areas of lower elevation (i.e. sloughs) make up the Cypress-Gum Swamp. Environmental scientists from Hayes, Seay, Mattern and Mattern, Inc. (HSMM) delineated the wetland boundary on November 6-9, 2001 using the methods described in the *1987 U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual* (Figure 3). Mr. Dave Timpy of the USACE Wilmington Field Office verified the wetland boundary on August 1, 2002 (Appendix A).

Hydrology associated with this system is composed of several sources. These sources include overbank flooding from the Northeast Cape Fear River and Grove Creek, and ground and surface water drainage from the adjacent uplands. A discussion of the vegetation associated with these wetland systems is included in Section 3.1.

2.3.3 Site Hydrology

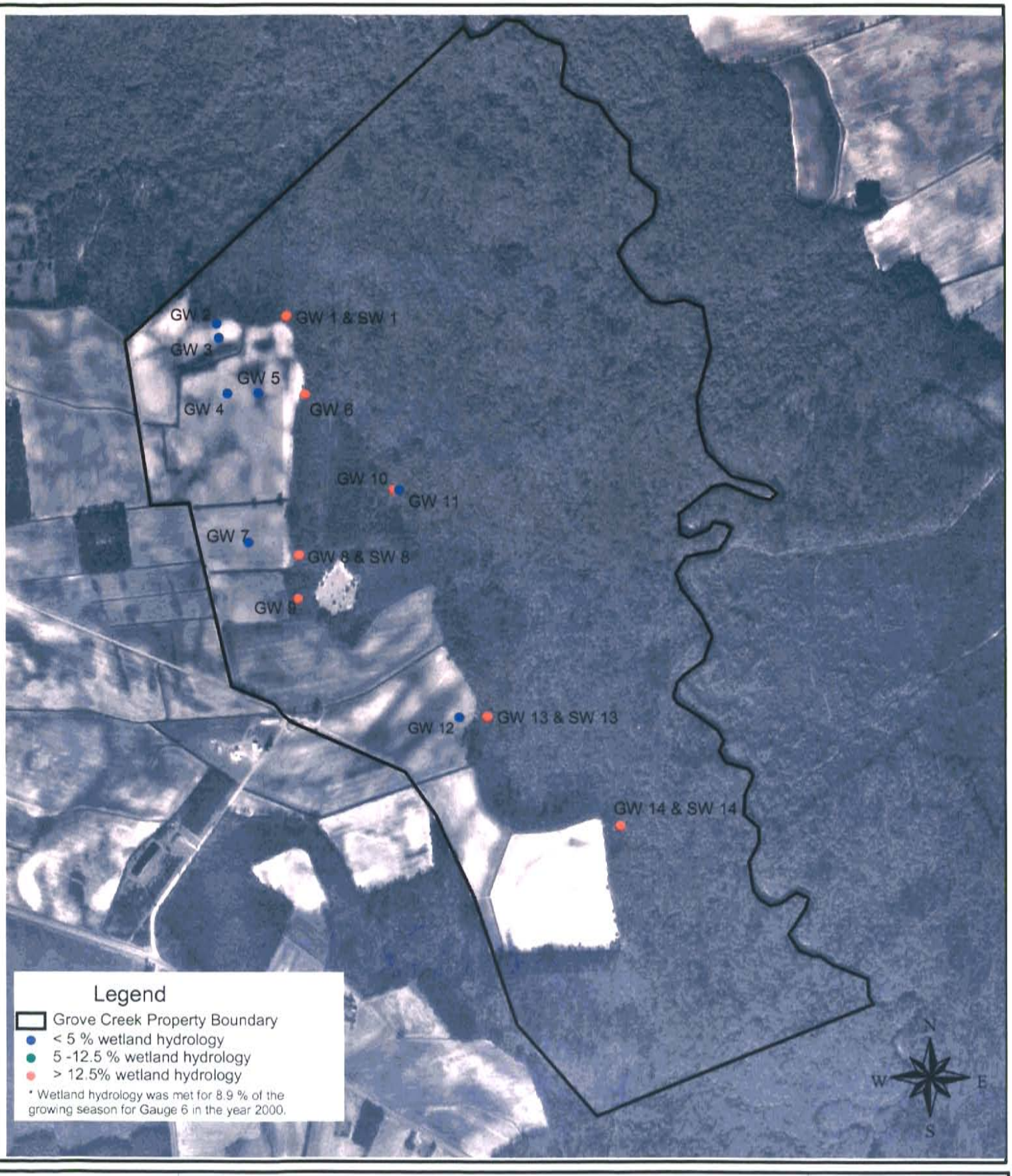
Wetland hydrology within the Grove Creek Mitigation Site consists of a seasonally inundated or saturated hydrologic regime. Hydrologic monitoring for the Site's wetland areas began in May 2000 with the installation of nine ground and surface water gauges. The placement of the gauges included five gauges within the Bottomland Hardwood wetlands (Gauges 1, 6, and 8), and four gauges within the Cypress-Gum Swamp wetlands (Gauges 13 and 14). In February 2002, an additional nine groundwater gauges and one rain gauge were installed within the Site. Five of these gauges were placed within the agricultural fields (Gauges 2, 3, 4, 7, and 12), two adjacent to and within the existing logging road (Gauges 10 and 11), and one within the Bottomland Hardwood wetlands (Gauge 9) (Figure 4).

The data used to determine the growing season is obtained from the spring and fall freeze dates estimated for a particular county by the U. S. Department of Agriculture (USDA). The data used consists of the probability of the temperature falling below and rising above 28°F for five of ten years. The Soil Survey for Duplin County is currently being revised, and the growing season data is not available. Consequently, the Soil Survey for Sampson County, North Carolina (USDA 1985) was used because of its proximity to Duplin County. The estimated growing season (five years out of ten) in Duplin County extends from March 18 to November 11, or 237 days. Eight percent of the growing season is equal to 19 days, and 12.5 percent is equal to 30 days.



Grove Creek Mitigation Site
Jurisdictional Wetland Boundary

Figure 3



Grove Creek Mitigation Site
Gauge Location Map

Figure 4

The gauges were evaluated for each year to determine duration of inundation and/or soil saturation to the ground's surface. The calculated range of percentages for soil inundation and/or saturation is presented in Table 1. The corresponding gauge data is presented in Appendix B.

Table 1. Grove Creek Mitigation Site Wetland Gauge Data

Community	Percentage of Growing Season Soil Inundated or Saturated		
	2000	2001	2002
Bottomland Hardwood	8.9 to 47	19 to 39	13 to 59
Cypress-Gum Swamp	48 to 82	62 to 100	31 to 70
Agriculture Fields	*	*	0 to 0.42
Logging Road	*	*	0

* Gauges were not installed.

2.4 Soils

A preliminary Duplin County Soil Survey (USDA 2002) indicates that the Site is underlain by eight soil series (Figure 5). These soils include: Bibb sandy loam, Eunola sandy loam, Johns fine sandy loam, Leon sand, Mandarin sand, Ogeechee fine sandy loam, Pactolus fine sand, and Torhunta soils. All soils were field verified by Mr. Lee Mallard of the Natural Resources Conservation Services (NRCS) on May 28, 2002 (Appendix C). Table 2 describes the drainage class and hydric classification for each of these soils.

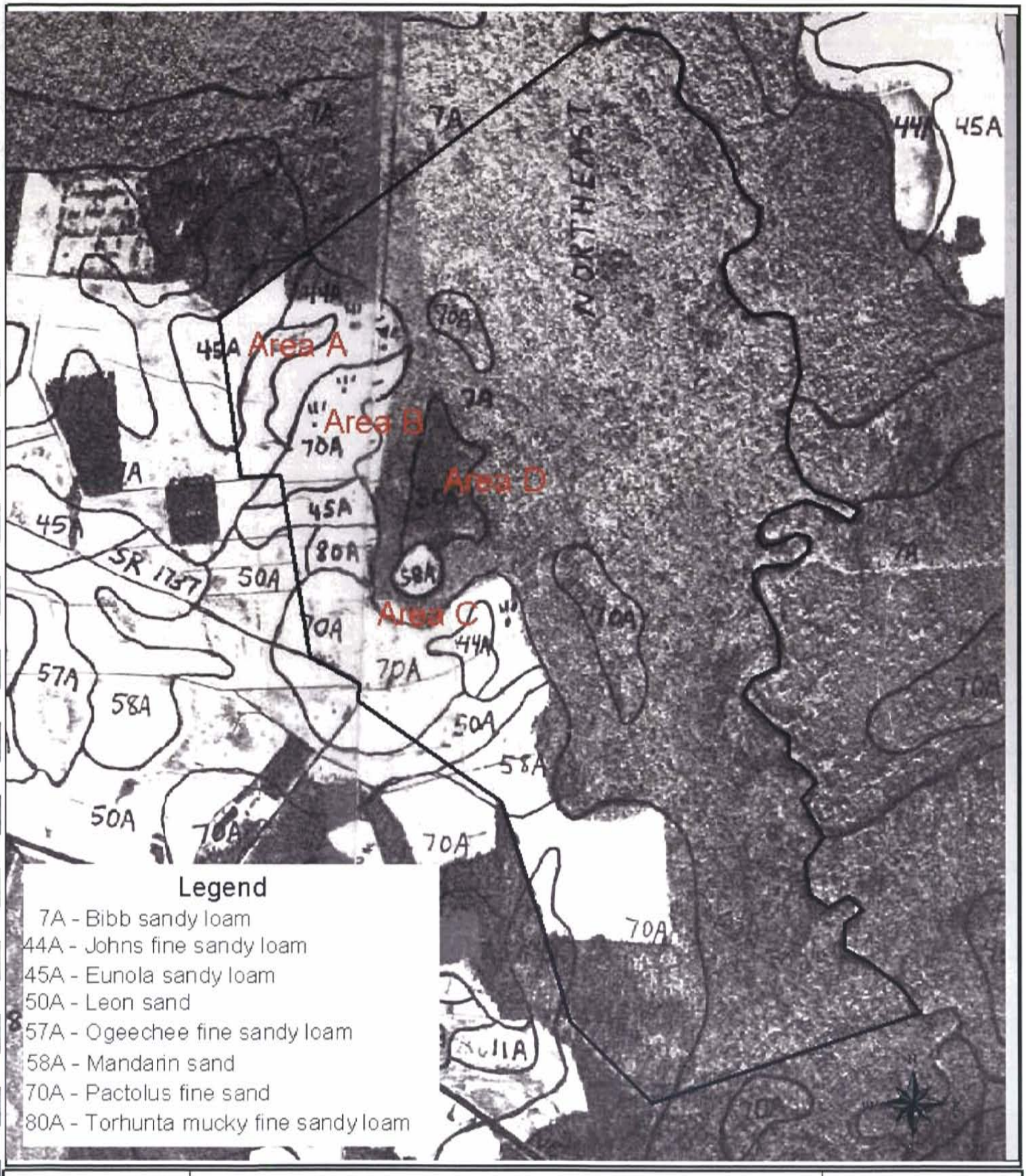
Table 2. Grove Creek Mitigation Site Mapped Soils

Soil Name	Map Symbol	Percent Slope	Drainage Class	Hydric Class
Bibb sandy loam	7A	0 to 1	Poorly drained	Hydric
Eunola sandy loam	45A	0 to 6	Moderately well drained	*
Johns fine sandy loam	44A	0 to 2	Moderately well to somewhat poorly drained	*
Leon sand	50A	0 to 2	Poorly to very poorly drained	Hydric
Mandarin sand	58A	0 to 3	Somewhat poorly drained	*
Ogeechee fine sandy loam	57A	0 to 2	Poorly drained	Hydric
Pactolus fine sand	70A	0 to 3	Moderately well to somewhat poorly drained	*
Torhunta mucky fine sandy loam	80A	0 to 1	Very poorly drained	Hydric

*Soils listed as having hydric inclusions.

2.4.1 Soils with Hydric Inclusions

Approximately 26 percent of the Site is underlain by soils having hydric inclusions. These soils are principally located within areas that are currently used for agriculture. Soil units mapped within these areas by the USDA consist of Eunola sandy loam, Johns fine sandy loam, Mandarin sands, and Pactolus fine sand.



Grove Creek Mitigation Site
2002 Soils Map

Figure 5

2.4.2 Hydric Soils

Approximately 74 percent of the Site is underlain by hydric soils. These soils are principally located within the Northeast Cape Fear River floodplain and drainage areas located within the agricultural fields. Hydric soil units mapped within these areas by the USDA consist of Bibb sandy loam, Leon sand, Ogeechee fine sand, and Torhunta mucky fine sandy loam soils.

3.0 Biological Resources

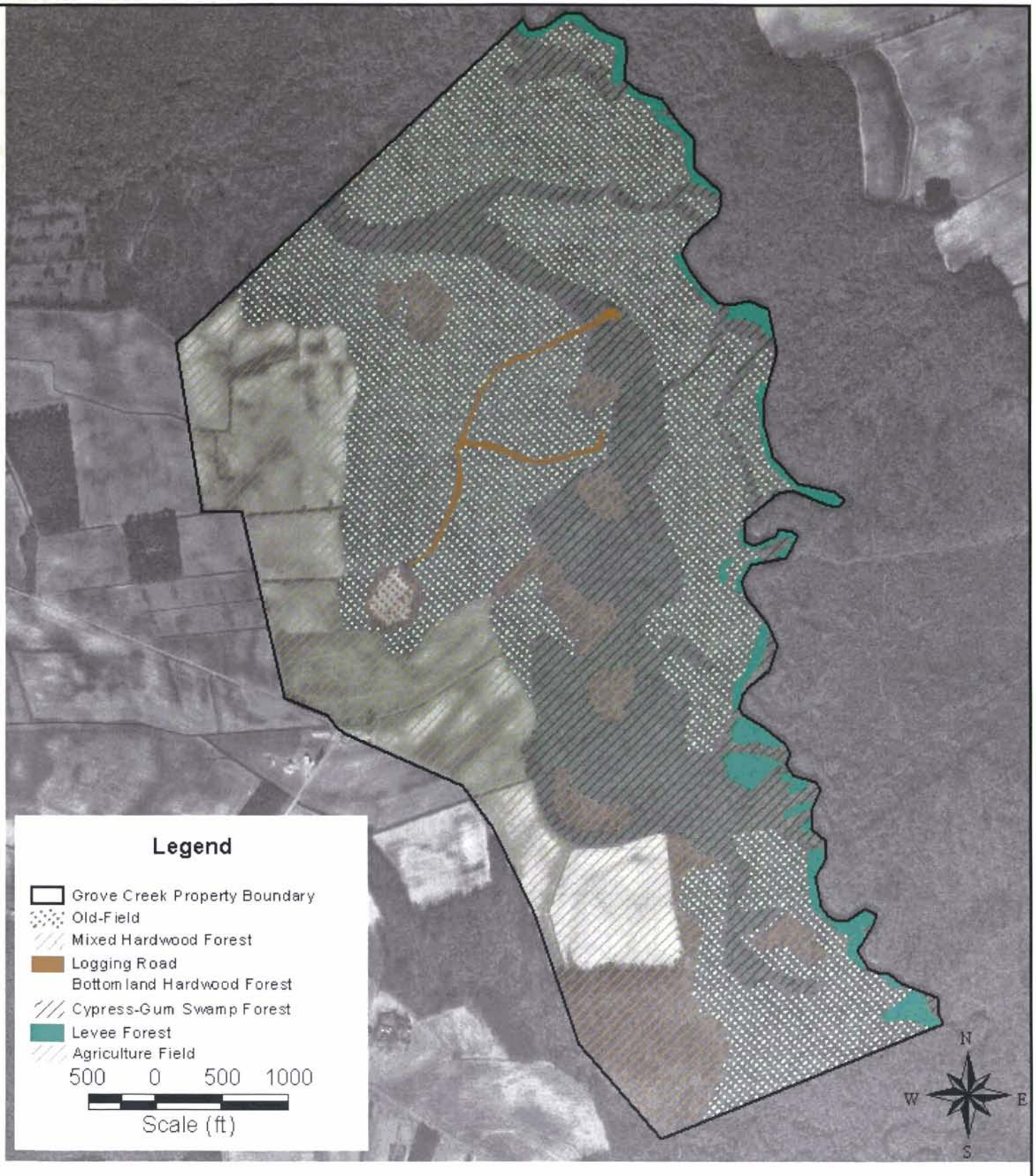
3.1 Natural Vegetation Communities

The Classification of Natural Communities of North Carolina, Third Approximation (Schafale and Weakley 1990) was used to categorize the Site's natural vegetation communities if possible. Consequently, the following natural communities were identified: Coastal Plain Bottomland Hardwoods (Blackwater Subtype), Cypress-Gum Swamp (Blackwater Subtype), and Coastal Plain Levee Forest (Blackwater Subtype). Other communities that could not be classified according to Schafale and Weakley included a mixed hardwood forest, old-field community, and agricultural fields (Figure 6).

3.1.1 Coastal Plain Bottomland Hardwoods (Blackwater Subtype)

Schafale and Weakley (1990) states that the Coastal Plain Bottomland Hardwoods Community (Blackwater Subtype) typically occurs on abandoned or relic natural levee deposits, point bar deposits, point bar ridges, and other relatively high parts of the floodplain, away from the stream channel. This description matched the location of the Coastal Plain Bottomland Hardwoods Community observed within the Grove Creek Mitigation Site. Within the Site, the Bottomland Hardwood communities occur along the gentle slopes separating the Cypress-Gum Swamp from the uplands.

The dominant canopy species observed within this community include sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), swamp chestnut oak (*Quercus michauxii*), tulip poplar (*Liriodendron tulipifera*), ironwood (*Carpinus caroliniana*), green ash (*Fraxinus pennsylvanica*), Carolina ash (*Fraxinus caroliniana*), water hickory (*Carya aquatica*), sycamore (*Platanus occidentalis*), and laurel oak (*Quercus laurifolia*). Dominant shrub and vine species include red bay (*Persea borbonia*), sweet bay (*Magnolia virginiana*), wax myrtle (*Myrica cerifera*), sweet pepperbush (*Clethera alnifolia*), fetterbush (*Lyonia lucida*), highbush blueberry (*Vaccinium corymbosum*), sweet leaf (*Symplocos tinctoria*), green briar (*Smilax rotundifolia*), honey suckle (*Lonicera japonica*), and poison ivy (*Toxicodendron radicans*). Dominant herbaceous species



Grove Creek Mitigation Site
Natural Communities Map

Figure 6

include giant cane (*Arundinaria gigantea*), lizard's tail (*Saururus cernuus*), false nettle (*Boehmeria cylindrica*), and three-way sedge (*Dulichium arundinaceum*).

It is estimated that 253 acres (102.8 hectares) of the Bottomland Hardwood natural community exists within the Grove Creek Mitigation Site.

3.1.2 Cypress-Gum Swamp (Blackwater Subtype)

A Cypress-Gum Swamp (Blackwater Subtype) community is located within the Site along the floodplain of the Northeast Cape Fear River. As described by Schafale and Weakley, the Cypress-Gum Swamp (Blackwater Subtype) occurs within back swamps, sloughs, swales, and featureless floodplains of blackwater rivers. This community was observed within the floodplain in areas of the lowest elevations and was bordered by communities typically found in higher elevations including the Coastal Plain Bottomland Hardwoods (Blackwater Subtype), Coastal Plain Levee Forest (Blackwater Subtype), and mixed hardwood communities.

The dominant tree species observed within this community include bald cypress (*Taxodium distichum* var. *distichum*), Carolina ash (*Fraxinus caroliniana*), swamp tupelo (*Nyssa aquatica*), river birch (*Betula nigra*), laurel oak, overcup oak (*Quercus lyrata*), sycamore (*Platanus occidentalis*), and black willow (*Salix nigra*). Dominant shrub and herbaceous species include buttonbush (*Cephalanthus occidentalis*), sedges (*Carex* spp.), woolgrass (*Scirpus cyperinus*), swamp dock (*Rumex verticillatus*), lizard's tail, and knotweed (*Polygonum punctatum*).

It is estimated that 107 acres (43.3 hectares) of the Cypress-Gum Swamp natural community exists within the Grove Creek Mitigation Site.

3.1.3 Coastal Plain Levee Forest (Blackwater Subtype)

The Coastal Plain Levee Forest Community (Blackwater Subtype) occurs along the channels of large blackwater rivers (Schafale and Weakley 1990). The Coastal Plain Levee Forest Community occurs as a discontinuous feature adjacent to the Northeast Cape Fear River. The dominant tree species present within this community include laurel oak, ironwood, red maple, and river birch. Dominant understory species include American holly (*Ilex opaca*), greenbriar, and blackberry (*Rubus* sp.).

It is estimated that 15 acres (6.1 hectares) of the Coastal Plain Levee Forest natural community (Blackwater Subtype) occurs within the Grove Creek Mitigation Site.

3.1.4 Mixed Hardwood Forest

The mixed hardwood forest community occurs as isolated pockets interspersed throughout the larger Coastal Plain Bottomland Hardwoods and Cypress-Gum Swamp Communities, and an upland forest located along the Northeast Cape Fear River terrace. The dominant tree species in this community include loblolly pine (*Pinus taeda*), American beech (*Fagus grandifolia*), red maple, post oak (*Quercus stellata*), tulip poplar, and pignut hickory (*Carya glabra* var. *glabra*). Understory species typically include American holly, greenbriar, heartleaf (*Hexastylis* sp.), and sweet leaf.

It is estimated that 48 acres (19.4 hectares) of the mixed hardwood natural community occurs within the Grove Creek Mitigation Site.

3.1.5 Old-Field Community

The old-field community occurs as a small cleared area adjacent to the existing agricultural fields. A review of aerial photographs taken in 1954 indicates that the area was previously used as an agricultural field. The vegetation associated with this community included young trees and saplings and early successional herbaceous species. The dominant tree and sapling species located in this community include American holly, water oak, loblolly pine, sweetgum, and persimmon (*Diospyros virginiana*). Understory species include broom sedge (*Andropogon* sp.), dog fennel (*Eupatorium* sp.), trumpet creeper (*Campsis radicans*), and yellow jessamine (*Gelsemium sempervirens*).

It is estimated that 3.8 acres (1.5 hectares) of the old-field community exists within the Grove Mitigation Site.

3.1.6 Agricultural Fields

The agriculture field communities occur along the western border of the Grove Creek Mitigation Site. The crops associated with this community include species such as corn (*Zea* sp.), cotton (*Gossypium* sp.), soybean (*Glycine* sp.), and tobacco (*Nicotiana* sp.). It is estimated that 118.6 acres (48.0 hectares) of the agricultural natural community exists within the Grove Creek Mitigation Site.

3.2 Wildlife and Wildlife Habitat

Habitat within the Site is composed of edge, open field, and forested ecotones. The Bottomland Hardwoods/Cypress-Gum Swamp forest located within the Northeast Cape Fear River floodplains provides a contiguous riparian wildlife corridor along the Northeast Cape Fear River.

The presence of mast producing trees such as pignut hickory, swamp chestnut oak, and willow oak (*Quercus phellos*) offer good sources of food for wildlife. Additionally, plentiful brush piles and dead trees resulting from Hurricane Floyd offer high quality cover and nesting habitat. Because of these characteristics, the riparian forest communities on the Grove Creek Mitigation Site are thought to provide high value wildlife habitat for the region.

Mammalian species or indicators of mammalian species observed (tracks, burrows, and scat) within the Site include beaver (*Castor canadensis*), opossum (*Didelphis virginiana*), nutria (*Myocastor coypus*), white-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), gray squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus floridanus*), and other small rodents.

Several varieties of avian species were observed within the Site. These species include the red-winged blackbird (*Agelaius phoeniceus*), Northern cardinal (*Cardinalis cardinalis*), hermit thrush (*Catharus guttatus*), killdeer (*Charadrius vociferous*), bobwhite (*Colinus virginianus*), American crow (*Corvus brachyrhynchos*), gray catbird (*Dumetella carolinensis*), horned lark (*Eremophila alpestris*), blue grosbeak (*Guiraca caerulea*), slate-colored junco (*Junco hyemalis*), belted kingfisher (*Megaceryle alcyon*), wild turkey (*Meleagris gallopavo*), barred owl (*Strix varia*), song sparrow (*Melospiza melodia*), brown-headed cowbird (*Molothrus ater*), tufted titmouse (*Parus bicolor*), Carolina chickadee (*Parus carolinensis*), indigo bunting (*Passerina cyanea*), common grackle (*Quiscalus quiscula*), ruby-crowned kinglet (*Regulus calendula*), eastern bluebird (*Sialia sialis*), field sparrow (*Spizella pusilla*), eastern meadowlark (*Sturnella magna*), eastern kingbird (*Tyrannus tyrannus*), great blue heron (*Ardea herodius*), green heron (*Butorides striatus*), great egret (*Casmerodius albus*), Carolina wren (*Thryothorus ludovicianus*), American robin (*Turdus migratorius*), mourning dove (*Zenaida macroura*), white-throated sparrow (*Zonotrichia albicollis*), and American woodcock (*Scolopax minor*).

Reptile species observed at the Site include the Carolina anole (*Anolis carolinensis*), yellowbelly slider (*Chrysemys scripta*), rat snake (*Elaphe obsoleta*), redbelly watersnake (*Nerodia erythrogaster*), ground skink (*Scincella lateralis*), copperhead (*Agkistrodon contortrix*), and eastern ribbon snake (*Thamnophis sauritus*). Although not observed, cottonmouth (*Agkistrodon piscivorus*) is reported to occur in wetter portions of the site.

Amphibian species inhabiting the riparian forest of the site include the southern cricket frog (*Acris gryllus*), American toad (*Bufo americanus*), green treefrog (*Hyla cinerea*), gray treefrog (*Hyla chrysoscelis*), spring peeper (*Hyla crucifer*), green frog (*Rana clamitans*), bullfrog (*Rana catesbeiana*), and southern leopard frog (*Rana sphenocephala*).

3.3 Federally Protected Species

There are two federally threatened or endangered species listed for Duplin County, North Carolina. As of July 2002, the Natural Heritage Programs database of threatened and endangered species (NHP) reported no individuals or populations of any federally protected species within 1.0 mile (1.6 kilometers) of the Site. Table 2 includes all federally protected species listed for Duplin County. A discussion of the findings pertaining to suitable habitat and the presence or likely presence of individual organisms or populations is provided in Sections 3.3.1 and 3.3.2.

Table 3. Federally Protected Species for Duplin County

Scientific Name	Common Name	Status
Alligator mississippiensis	American alligator	Threatened(S/A)
Picoides borealis	Red-cockaded woodpecker	Endangered

Threatened(S/A) – Threatened due to similarity of appearance.

3.3.1 American Alligator

The American alligator (*Alligator mississippiensis*) is a large aquatic reptile, measuring 5.9 to 19.0 feet (1.8 to 5.8 meters) in length, with a broadly rounded snout, heavy body, laterally compressed tail, and a dark gray or blackish color. The young are black with conspicuous yellow crossbands that may occasionally persist very faintly on adults.

Habitat for the alligator consist of rivers, streams, canals, lakes, swamps, bayous, and coastal marshes. The range of the species includes the east coast of the United States from Tyrrell County, North Carolina to Corpus Christi, Texas, and north in the Mississippi River drainage basin to Arkansas and southeastern Oklahoma. Their diet consists of anything of suitable size, including mammals, reptiles, amphibians, birds, fish, and crustaceans.

The American alligator is listed as Threatened Due to Similarity of Appearance, because of its similarity in appearance to the American crocodile. Consequently, the American alligator is not protected under Section 7 of the Endangered Species Act. Habitat in the form of rivers, streams, and swamps is present within the Site; however, formal surveys for the American alligator were not conducted for the species. Frequent review of the site revealed no presence of the American alligator.

3.3.2 Red-cockaded Woodpecker

The adult red-cockaded woodpecker (*Picoides borealis*) has plumage that is entirely black and white except for small red streaks on the sides of the nape in the male. Distinctive color patterns

for the red-cockaded woodpecker (RCW) include a large white cheek patch surrounded by the black cap, nape, and throat; black and white horizontal stripes along the back; and a white breast with streaked flanks.

Habitat for the red-cockaded woodpecker consists of old-growth open stands of southern pines, which are utilized for foraging and nesting grounds. The red-cockaded woodpecker shows a particular affinity for stands of longleaf pine (*Pinus palustris*). Inhabited stands typically contain more than 50 percent pine, lack a thick understory, and are contiguous with other suitable stands. The red-cockaded woodpecker nests exclusively in living pine trees that are greater than 60 years in age and are contiguous with pine stands that are at least 30 years in age.

The habitat observed within the Site consisted primarily of hardwood forests and therefore did not meet habitat requirements for the red-cockaded woodpecker. Additionally, the proposed construction will occur within the existing agriculture fields where *Pinus* tree species are absent. Consequently, construction of the Grove Creek Mitigation Site will have "No Effect" on the red-cockaded woodpecker or its preferred habitat.

3.4 Federal Species of Concern

There are four species listed as Federal Species of Concern for Duplin County (Table 4). As of July 2002, there have been no populations of any Federal Species of Concern listed within 1.0 mile of the Grove Creek Site. Of the species listed, habitat for the Croatan crayfish is the only habitat present on the site. Habitat for the Croatan crayfish includes rivers, ponds, ditches, and borrow pits in the eastern North Carolina coastal plain.

Table 4. Federal Species of Concern for Duplin County

Scientific Name	Common Name	NC Status	Habitat Present
Heterodon simus	Southern hognose snake	SR/PSC *	No
Procambarus pluminanus	Croatan crayfish	W3	Yes
Dionaea muscipula	Venus flytrap	C-SC	No
Oxypolis ternata	Savanna cowbane	W1	No

"C" A Candidate species is one which is very rare in North Carolina, generally with 1-20 populations in the state, generally substantially reduced in numbers by habitat destruction, direct exploitation or disease. The species is also either rare throughout its range or disjunct in North Carolina from a main range in a different part of the country or the world.

"SC" Any species of plant in North Carolina which requires monitoring but which may be collected and sold under regulations adopted under the provisions of [the Plant Protection and Conservation Act]" (GS 19B 106:202.12). (Special Concern species that are not also listed as Endangered or Threatened may be collected from the wild and sold under specific regulations. Propagated material only of Special Concern species which are also listed as Endangered or Threatened may be traded or sold under specific regulations.)

"SR" A Significantly Rare species is one which is very rare in North Carolina, generally with 1-20 populations in the state, generally substantially reduced in numbers by habitat destruction, direct exploitation or disease. The species is generally more common elsewhere in its range, occurring peripherally in North Carolina.

"W1" A Watch Category 1 species is a rare species whose status in North Carolina is relatively well known and which appears to be relatively secure at this time.
"W3" A Watch Category 3 species is a species that is poorly known in North Carolina, but is not necessarily considered to be declining.
"/P_" Denotes a species which has been formally proposed for listing as Endangered, Threatened, or Special Concern, but has not yet completed the listing process.

4.0 MITIGATION PLAN

Site performance and success criteria for the Grove Creek Mitigation Site will be based on the successful establishment of wetland hydrology and vegetation. All wetland restoration and creation monitoring efforts will be performed for a minimum of five years or until the success criteria are satisfied.

4.1 Wetland Restoration and Creation

Wetland restoration efforts for the Grove Creek Mitigation Site will consist of 3.9 acres (1.6 hectares) of nonriverine wetlands (Area A) and 6.0 acres (2.4 hectares) of riverine wetlands (Areas C and D) (Figure 5). The proposed restoration efforts in Area A will consist of plugging and filling the existing drainage ditch to restore wetland hydrology to the previously drained Ogeechee soils. Wetland restoration efforts in Area C will consist of plugging and filling the existing drainage ditches to restore wetland hydrology to the previously drained Bibb, Leon, and Torhunta soils. By filling these ditches, it is expected that groundwater elevations will be restored to their original elevations resulting in wetland restoration. Area D restoration efforts will include removing fill from wetland areas and restoring the effected areas to their original wetland elevations. Additionally, the previously excavated roadside ditches will be filled to eliminate the drainage of the adjacent wetland soils.

Wetland creation efforts for the Site will consist of 3.3 acres (1.3 hectares) of riverine wetlands (Area B). The proposed mitigation effort will consist of grading an approximately 100 feet (30.5 meters) wide band of hydric and nonhydric soils to the elevation of the contiguous Coastal Plain Bottomland Hardwood wetlands. Grading activities on the Site would lower existing ground elevations to within 12 inches (30 centimeters) of the existing groundwater elevations. This mitigation component is proposed for those areas where wetland restoration activities would result in hydrologic trespass, or in areas of nonhydric soils. A plan view of the proposed mitigation areas is provided in Appendix D.

4.1.1 Soils

All soils utilized for construction activities within the Grove Creek Mitigation Site will consist of *in situ* soils. Prior to planting wetland vegetation, all restoration and creation area soils will be

analyzed to ensure appropriate nutrient concentrations and pH are present. Appropriate soil amendments will be added, if necessary, to ensure successful growth of all planted vegetation.

4.1.2 Vegetation

The proposed restoration and creation areas will be planted with trees in the form of bare-root stock. All plantings will be performed between December 1 and March 15 while stock is dormant.

All trees will be planted within proposed Bottomland Hardwood and headwater forest areas to provide a minimum stem count of 680 stems per acre. This translates to planting on approximately 8-foot centers. Tree species to be planted will be consistent with those species located within the reference wetlands and derived from the following list (as available):

- *Quercus nigra* (water oak)
- *Quercus phellos* (willow oak)
- *Quercus laurifolia* (laurel oak)
- *Quercus michauxii* (swamp chestnut oak)
- *Fraxinus pennsylvanica* (green ash)
- *Betula nigra* (river birch)
- *Taxodium distichum* var. *distichum* (bald cypress)
- *Nyssa biflora* (swamp tupelo)

4.2 Wetland Enhancement

The wetland enhancement component for the Grove Creek Mitigation Site will consist of 7.6 acres (3.1 hectares) of Coastal Plain Bottomland Hardwoods wetlands (Areas C and D). Wetland enhancement efforts for the Site will consist of restoring hydrology within existing Bottomland Hardwood wetland areas by plugging and filling agricultural ditches located adjacent to and within jurisdictional wetland areas. The primary wetland function to be enhanced by the proposed activity is water storage and filtration.

All wetland enhancement acreages were estimated using the Boussinesq equation to determine the water table drawdown of the existing agricultural ditches. The Boussinesq equation is written as

$$\frac{1}{\eta} = \frac{\sqrt{\frac{K}{f} h_o t}}{x}$$

where f is the drainable porosity ratio (assume 0.05), K is the hydraulic conductivity (feet/hour), h_o is the initial elevation of the water table above the impermeable soil layer (feet), t is time

(Assume 14 days), and x is the lateral distance of drainage (feet). All calculations used to determine wetland enhancement acreages are included in Appendix E.

4.3 Wetland Preservation

The preservation component for the Site will consist of preserving 352 acres (142.4 hectares) of an existing Coastal Plain Bottomland Hardwood/Cypress-Gum wetland system. This mitigation measure includes approximately 245 acres (99.1 hectares) of Coastal Plain Bottomland Hardwoods and 107 acres (43.3 hectares) of Cypress-Gum Swamp. Future activities requiring the implementation of this mitigation component consists primarily of the logging operations initiated in 1999.

4.4 Upland Enhancement

The upland enhancement component will include 113.2 acres (45.8 hectares) of agricultural fields not included within the proposed wetland restoration and creation areas. Included in this mitigation component is 0.98 acre (0.40 hectare) of buffer planting along a perennial UT to the Northeast Cape Fear River. Tree species to be planted will be consistent with those species located within the adjacent uplands and derived from the following list (as available):

- *Fagus grandifolia* (American beech)
- *Ilex opaca* (American holly)
- *Quercus nigra* (water oak)
- *Quercus phellos* (willow oak)
- *Quercus laurifolia* (laurel oak)
- *Quercus michauxii* (swamp chestnut oak)

4.5 Upland Preservation

The upland preservation component for the Site will consist of preserving 63.0 acres (25.5 hectares) of existing forested upland areas. This mitigation measure includes approximately 48.0 acres (19.4 hectares) of mixed hardwood forest and 15.0 acres (6.1 hectares) of Coastal Plain Levee Forest.

5.0 MONITORING PLAN

Monitoring of wetland mitigation (restoration and creation) efforts will be performed for five years or until success criteria are satisfied. Monitoring is proposed for two wetland components, hydrology and vegetation.

5.1 Hydrology

Automated monitoring gauges utilized to monitor the Site's surface and groundwater hydrology will be designed and placed in accordance with specifications in the Corps of Engineers' *Installing Monitoring Wells/Piezometers in Wetlands* (WRP Technical Note HY-IA-3.1, August, 1993). The monitoring gauges installed will consist of Remote Data Systems, Inc. model RDS WL-40® automated groundwater monitoring gauges, or acceptable equivalents. These gauges will continuously record water level data along a 40-inch gradient.

5.1.1 Monitoring

RDS WL-40® (40-inch) automated groundwater monitoring gauges will be installed within the restored, created, and enhanced wetland areas to determine hydrologic success. Following installation, the automated groundwater, surfacewater, and rain gauges will be adjusted to record data once daily. The gauges will be in operation throughout the year, and data will be downloaded at intervals sufficiently spaced to provide effective monitoring and assessment of success criteria for wetland hydrology.

Surface water elevations will be monitored during times of flooding using RDS WL-40® groundwater monitoring gauges mounted above-grade on wooden poles. The poles will be appropriately anchored to ensure their stability during periods of site inundation and significant flow velocities. The bottom of each unit will be set at ground level. In this configuration, the RDS WL-40® groundwater monitoring gauges will be capable of recording water levels 40 inches above the ground surface. The purpose of these above-grade units is to provide evidence of riverine-influenced hydrology within the areas of wetland restoration and creation.

5.1.2 Success Criteria

Wetland hydrology success criterion will be satisfied in the restoration and creation areas during average climatic conditions when saturated soil conditions occur within 12 inches (30 centimeters) of the grounds surface for

- 12.5% of the growing season, or if the hydroperiod is within 20% of the hydroperiod of the average for reference gauges within the riverine wetlands,
- 8.0 to 12.5% of the growing season for nonriverine wetlands.

5.2 Vegetation

Monitoring methods for vegetation within mitigation areas have been developed in accordance with Corps of Engineers *Branch Guidance for Wetlands Compensation Permit Conditions and*

Performance Criteria (1995). A general discussion of the compensatory vegetation-monitoring plan is provided in the following sections.

5.2.1 Monitoring

Seven (50' x 50') quantitative sampling plots for vegetation will be established in the wetland restoration and creation areas. Upon completion of planting, an evaluation will be performed to determine the initial species composition and density. Subsequent quantitative sampling of vegetation plots will be performed after each growing season until vegetation success criteria is achieved. Permanent photography stations will be established at selected vantage points to provide a visual record of vegetation development over time. All vegetation monitoring plots will be correlated with hydrological monitoring sites where possible to allow for point-source data of hydrologic and vegetation parameters.

5.2.2 Success Criteria

Wetland vegetation success criterion is defined by a minimum mean density of 320 trees per acre of approved target species surviving for the first three years. The required success criteria will decrease by 10% per year after the third year to 290 stems per acre for year four and 260 stems per acre for year five.

5.3 Report Submittals

As-built plans will be submitted within 90 days following the completion of mitigation construction. The as-built plans will show final site grading along with a description of post-planting site conditions. Additionally, a discussion of the planting program will be provided that includes the species planted, species densities, and number of stems planted. The report will also provide a map of groundwater monitoring gauge locations, proposed photographic monitoring stations and proposed vegetation sampling plots.

Subsequent monitoring reports will be submitted annually to the Resource Agencies following each growing season. Submitted reports will include (1) sample plot data, (2) water level data from automated surface and groundwater monitoring gauges, and (3) a discussion of substantiated problems and proposed recommendations for problem resolution. The duration of wetland hydrology during the growing season will also be calculated at each monitoring gauge location and extrapolated to each restored or created community. Density, survival and percent composition of targeted tree species will be reported.

5.4 Contingency

In the event that vegetation and/or hydrology success criteria are not fulfilled, appropriate contingency measures will be implemented in coordination with the Resource Agencies. Examples of such actions include replanting and extension of the monitoring period if community mitigation types do not fulfill minimum species density and distribution requirements. Hydrologic contingency will require consultation with hydrologists and the Resource agencies in the event that predicted hydrology is not achieved during the monitoring period. Recommendations for altering hydrology to establish wetland hydrology will be implemented and monitored until the hydrology success criteria are achieved.

6.0 MITIGATION VALUES

The objective of the Grove Creek Mitigation Site is to expand, enhance, and preserve 549 acres of the Northeast Cape Fear River riparian ecosystem. As a contiguous component of the Northeast Cape Fear River and Grove Creek floodplains, the proposed mitigation components should be viewed from the perspective of their cumulative contribution to overall value of the riparian ecosystem rather than their individual values. The riparian ecosystem to be protected in perpetuity not only provides valuable habitat to a diverse assemblage of flora and fauna, but also serves as a contiguous wildlife corridor along the Northeast Cape Fear River. Wetland values associated with the mitigation site include water storage, shoreline stabilization, pollutant removal, aquatic/wildlife habitat, recreation, and education. The types of natural communities available for mitigation within the Site are shown in Table 5.

6.1 Mitigation Credit

The Grove Creek Mitigation Site will be designated as a regional wetlands mitigation site. Currently, the mitigation being provided within the Grove Creek Mitigation Site is "up-front"; with no NCDOT projects identified for which credits would be sought.

Preliminary mitigation credit ratios for restoration (2:1), creation (3:1), and enhancement (4:1) were determined using the general guidance provided by the Environmental Protection Agency (EPA). A credit ratio of 8:1 for preservation is proposed because of the quality of resources present at the Site and the values they provide (As discussed in Section 6.0). Additionally, the wetland preservation component protects the existing Bottomland Hardwoods/ Cypress-Gum Swamp wetland system from the logging activities proposed by the previous property owner.

Using the proposed mitigation ratios, the following formulas will be utilized for wetland mitigation credits:

Table 5. Mitigation Acreages for the Grove Creek Mitigation Site
Duplin County, North Carolina

WETLAND RESTORATION:	
• **Bottomland Hardwood**	**6.0 acres**
• **Headwater Forest**	**3.9 acres**
Subtotal	**9.9 acres**
WETLAND CREATION:	
• **Bottomland Hardwood**	**3.3 acres**
Subtotal	**3.3 acres**
WETLAND ENHANCEMENT:	
• **Bottomland Hardwood**	**7.6 acres**
Subtotal	**7.6 acres**
WETLAND PRESERVATION:	
• **Cypress-Gum Swamp**	**107.0 acres**
• **Bottomland Hardwood**	**245.0 acres**
Subtotal	**352.0 acres**
TOTAL WETLAND ACREAGE	**372.8 acres**
UPLAND ENHANCEMENT:	
• **Riparian Buffer Along Perennial UT to Northeast Cape Fear River**	**0.98 acres**
• **Mixed Hardwood Forest**	**112.2 acres**
Subtotal	**113.2 acres**
UPLAND PRESERVATION:	
• **Coastal Plain Levee Forests**	**15.0 acres**
• **Mixed Hardwood Forest**	**48.0 acres**
Subtotal	**63.0 acres**
TOTAL UPLAND ACREAGE	**176.2 acres**

Total Riverine Credits = 8.0

- 1 acre of riverine credit = 1.0 acre restoration + 4.0 acres preservation
- 1 acre of riverine credit = 1.0 acre restoration + 2.0 acres enhancement
- 1 acre of riverine credit = 1.5 acres creation + 4.0 acres preservation

Total Nonriverine Credits = 3.9 credits

- 1 acre of nonriverine credit = 1.0 acre restoration + 4.0 acres preservation

The remaining wetland preservation acreages will be utilized in conjunction with other offsite mitigation components to fulfill future mitigation requirements. All final mitigation ratios will be determined by the Natural Resource Agencies.

7.0 DISPENSATION OF THE PROPERTY

The NCDOT will convey its ownership title to a party acceptable to the Resource Agencies. Prior to conveying the Site, the USACE, the NCDOT, and the receiving party will execute a Memorandum of Understanding (MOU) concerning the disposition and long-term management of the Site. Terms of the MOU include the requirement that the NCDOT implement the recommendations of the Mitigation Plan. The deed of conveyance from the NCDOT shall have a restriction allowing the NCDOT access to the Site at all times to implement, monitor, and maintain the Site in a condition consistent with the Mitigation Plan. The NCDOT is responsible for the mitigation success of the Site, including any remedial activities, and monitoring to ensure success criteria are met throughout the monitoring period. The MOU will also include the requirement that the receiving party will insure the long-term maintenance and preservation of the Site in its restored state in perpetuity.

8.0 REFERENCES

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U.S. Fish and Wildlife Service. National Wetlands Inventory Map – Kenansville, North Carolina 7.5 Minute Quadrangle. Newton Corners, Massachusetts. 1994.

APPENDIX A

NOTIFICATION OF JURISDICTIONAL DETERMINATION

U.S. ARMY CORPS OF ENGINEERS
Wilmington District

Action ID: 200001463

County: Duplin

SEP 18 2002

Notification of Jurisdictional Determination

Property Owner:
Mr. William D. Gilmore, P.E., Manager
Project Development & Environmental Analysis
1548 Mail Service Center
Raleigh, N.C. 27699-1548

Authorized Agent:
Mr. Timothy E. Black
HSMM
1305 Navaho Drive
Suite 303
Raleigh, North Carolina 27609

Size and Location of Property (waterbody, Highway name/number, town, etc.): Grove Creek Mitigation Site, SR 1737, Duplin County, North Carolina.

Basis for Determination: Onsite field inspection of selected wetland sites.

Indicate Which of the Following apply:

- ☐ There are wetlands on the above described property which we strongly suggest should be delineated and surveyed. The surveyed wetland lines must be verified by our staff before the Corps will make a final jurisdictional determination on your property.
- ✓ On August 1, 2002, the undersigned inspected the Section 404 jurisdictional line as determined by the NCDOT and/or its representatives for the subject NCDOT project. A select number of wetland sites were inspected for the proposed project and all were found to accurately reflect the limits of Corps jurisdiction. The Corps believes that this jurisdictional delineation as depicted in the July 11, 2002 letter by HSMM, Inc can be relied on for planning purposes and impact assessment.
- ☐ The wetlands on your lot have been delineated and the limits of the Corps jurisdiction have been explained to you. Unless there is a change in the law or our published regulations, this determination may be relied upon for a period not to exceed five years from the date of this notification.
- ☐ There are no wetlands present on the above described property which are subject to the permit requirements of section 404 of the Clean Water Act (33 USC 1344). Unless there is a change in the law or our published regulations, this determination may be relied upon for a period not to exceed five years from the date of this notification.
- ☐ The project is located in one of the 20 Coastal Counties. You should contact the nearest State Office of Coastal Management to determine their requirements.

Placement of dredged or fill material in wetlands on this property without a Department of the Army permit is in most cases a violation of Section 301 of the Clean Water Act (33 USC 1311). A permit is not required for work on the property restricted entirely to existing high ground. If you have any questions regarding the Corps of Engineers regulatory program, please contact Mr. Dave Timpy at 910-251-4634.

Project Manager Signature _____

Date September 17, 2002

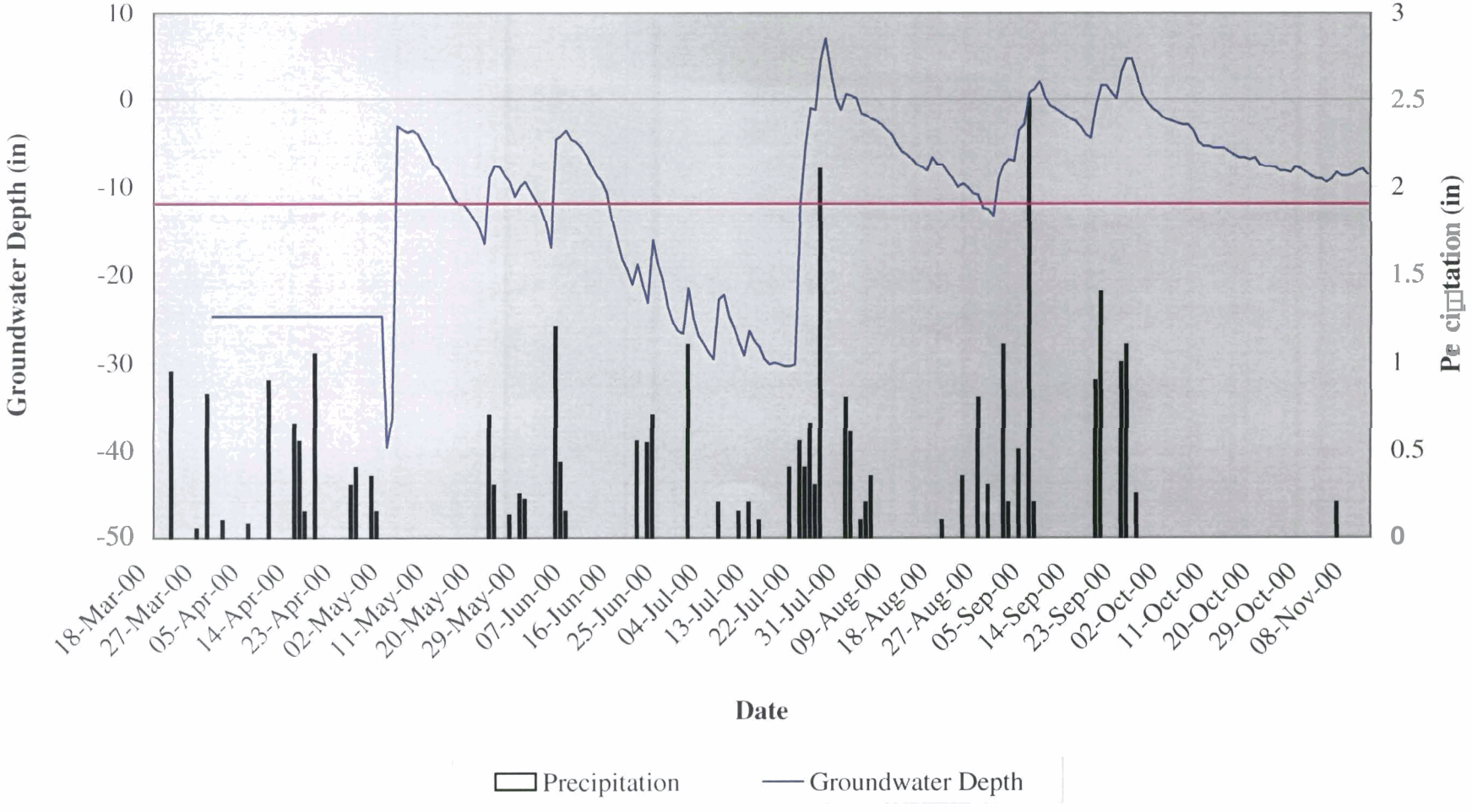
Expiration Date September 17, 2007

CF: Mason Herndon, NCDOT Division 3.

APPENDIX B

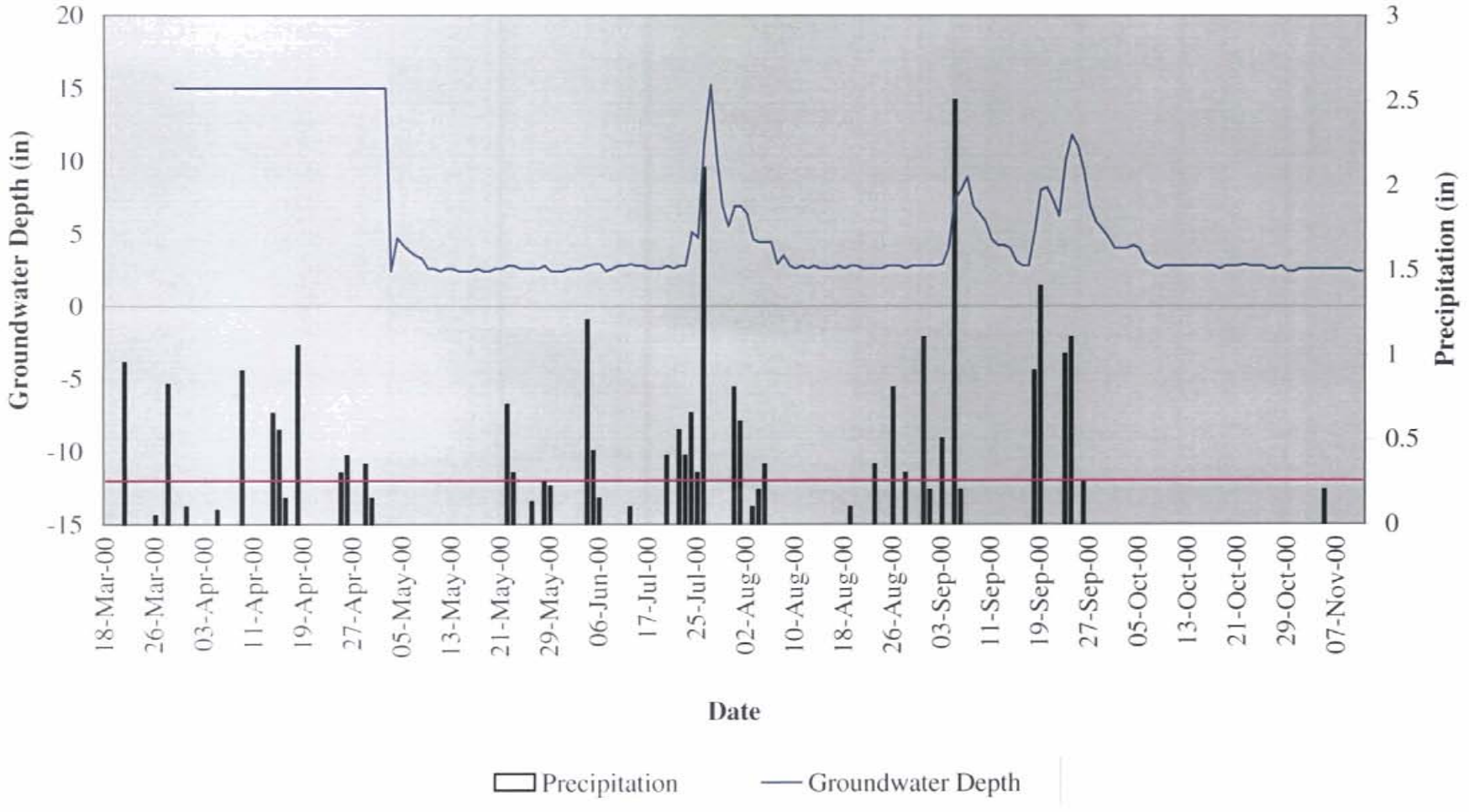
GROVE CREEK MITIGATION SITE GAUGE DATA

Grove Creek
Groundwater Gauge 1
2000
(Maximum Days Inundated or Saturated - 73)



Grove Creek
Surface Water Gauge 1
2000

(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



Grove Creek
Groundwater Gauge 6
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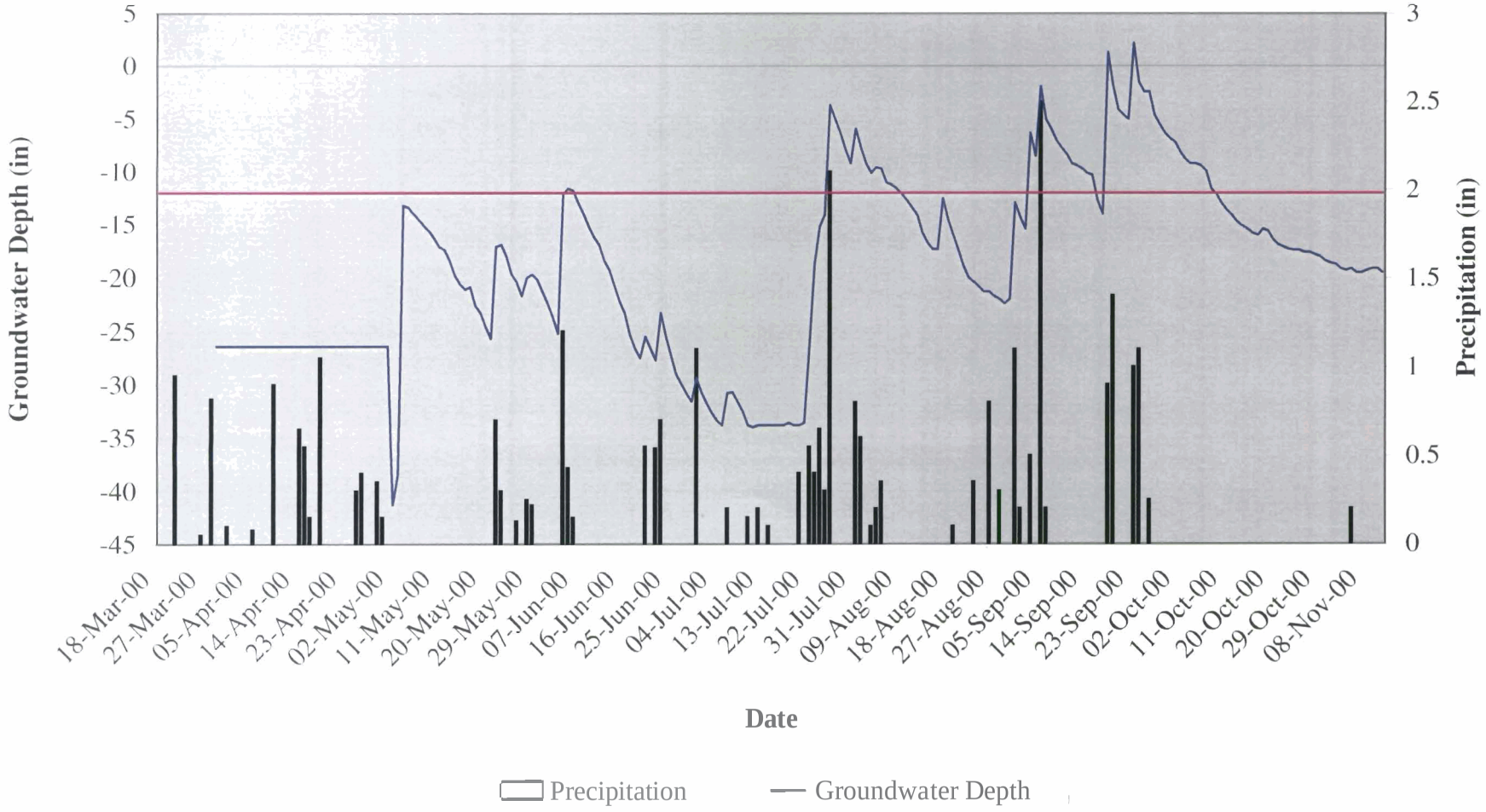
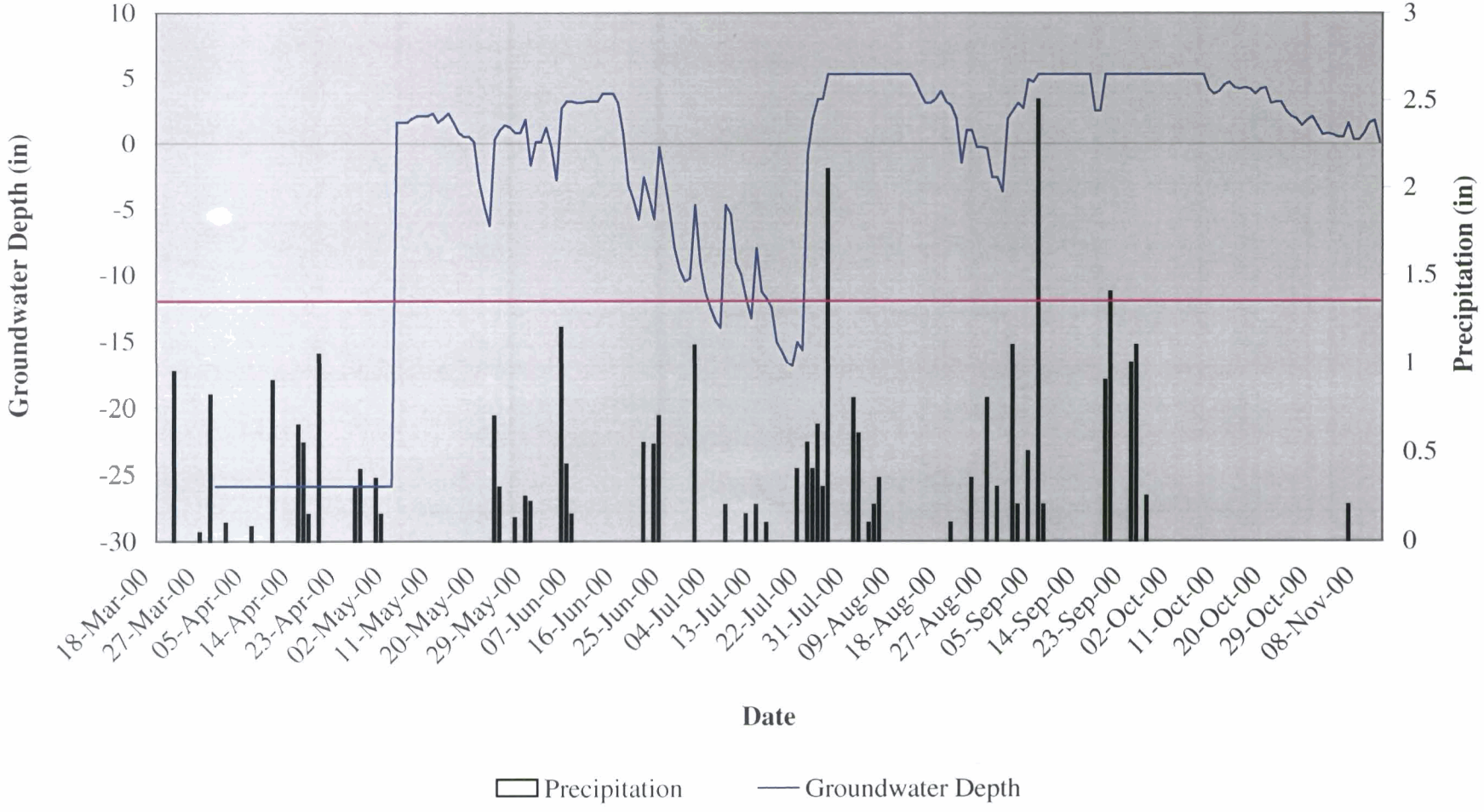


Grove Creek
Groundwater Gauge 8
2000
(Maxiumum Days Inundated or Saturated - 111)



Grove Creek
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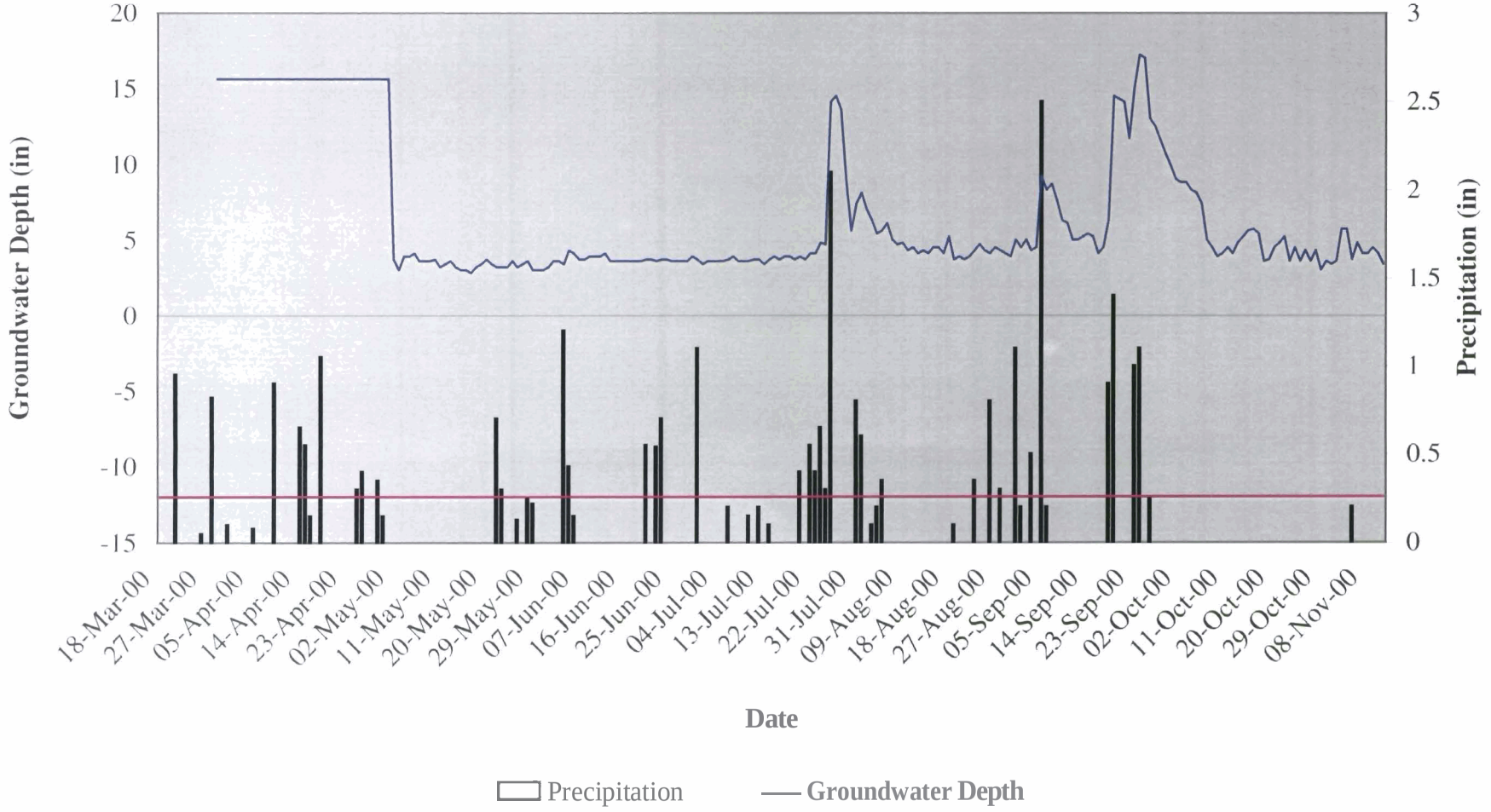

Grove Creek
Groundwater Gauge 13
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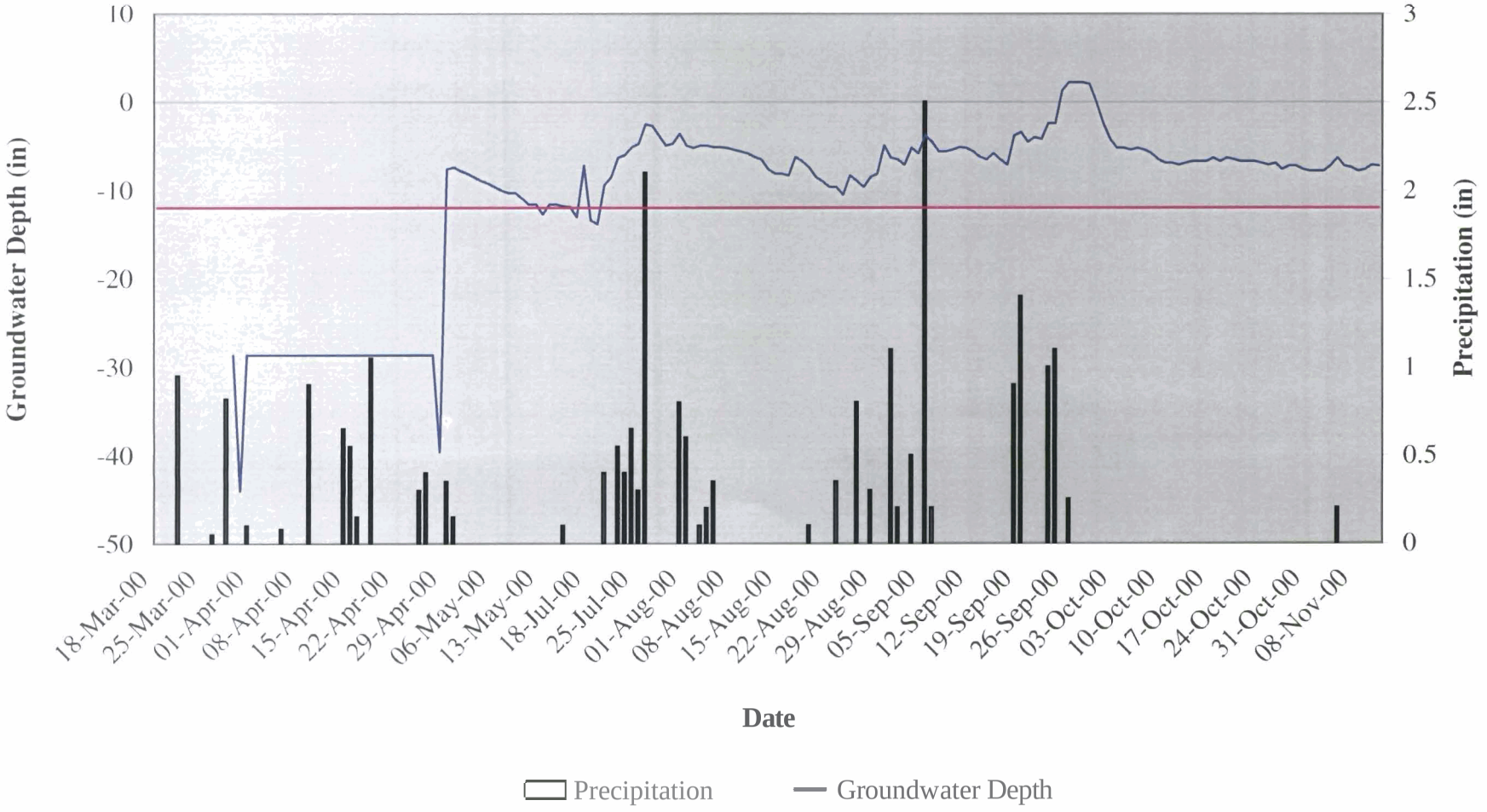

Grove Creek
Surfacewater Gauge 13
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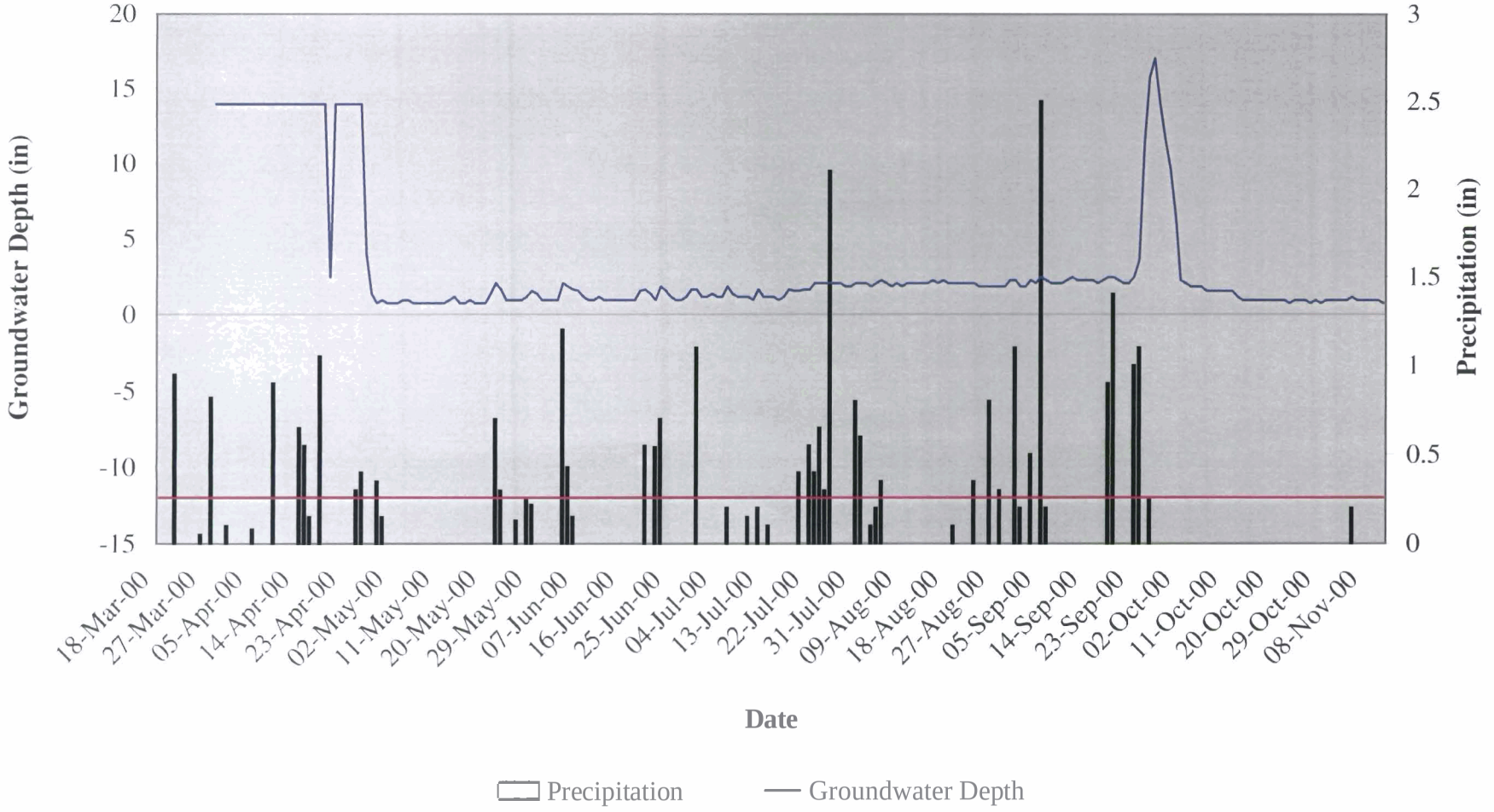
(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



Grove Creek
Groundwater Gauge 14
2000

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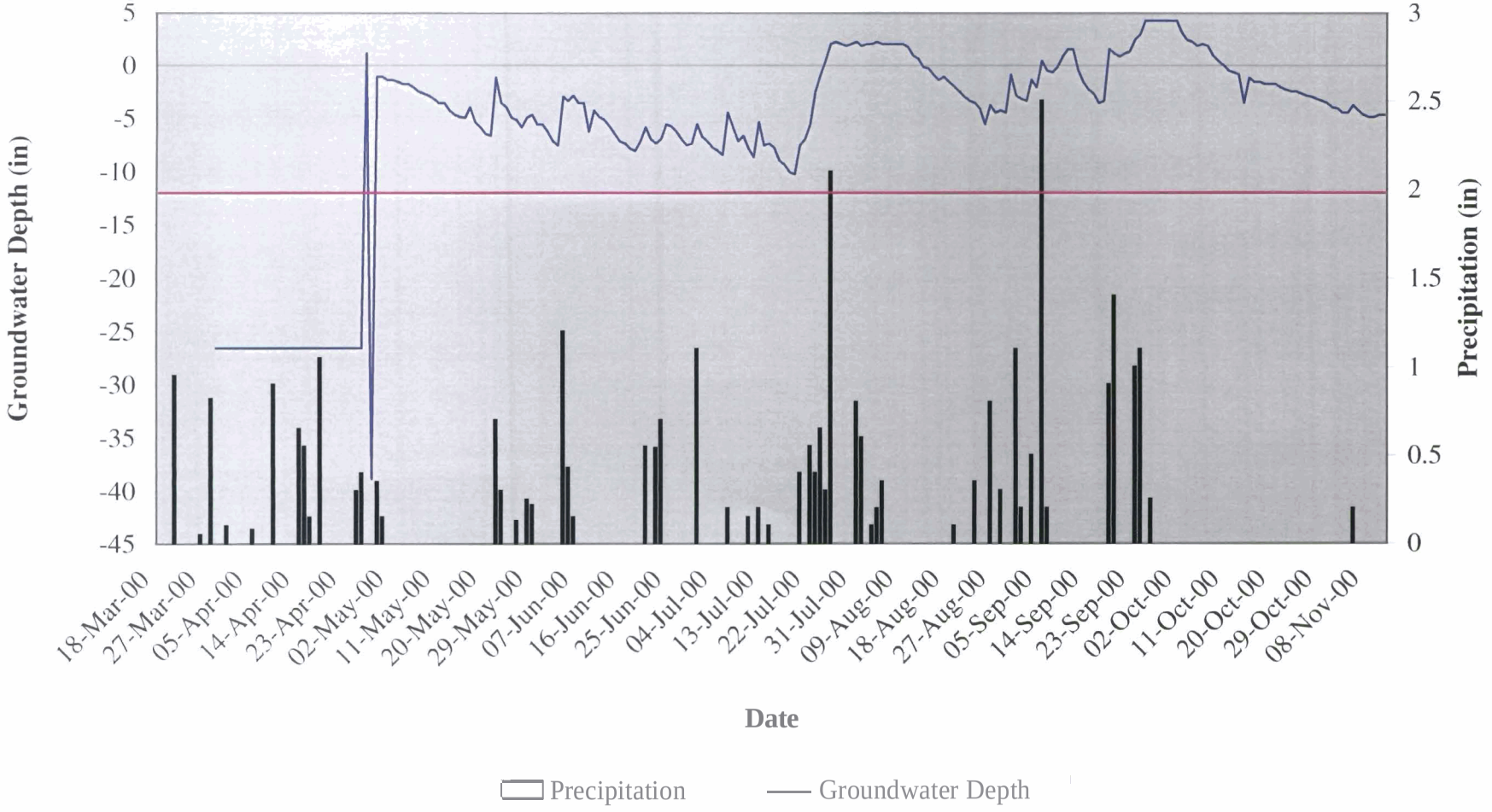

Grove Creek
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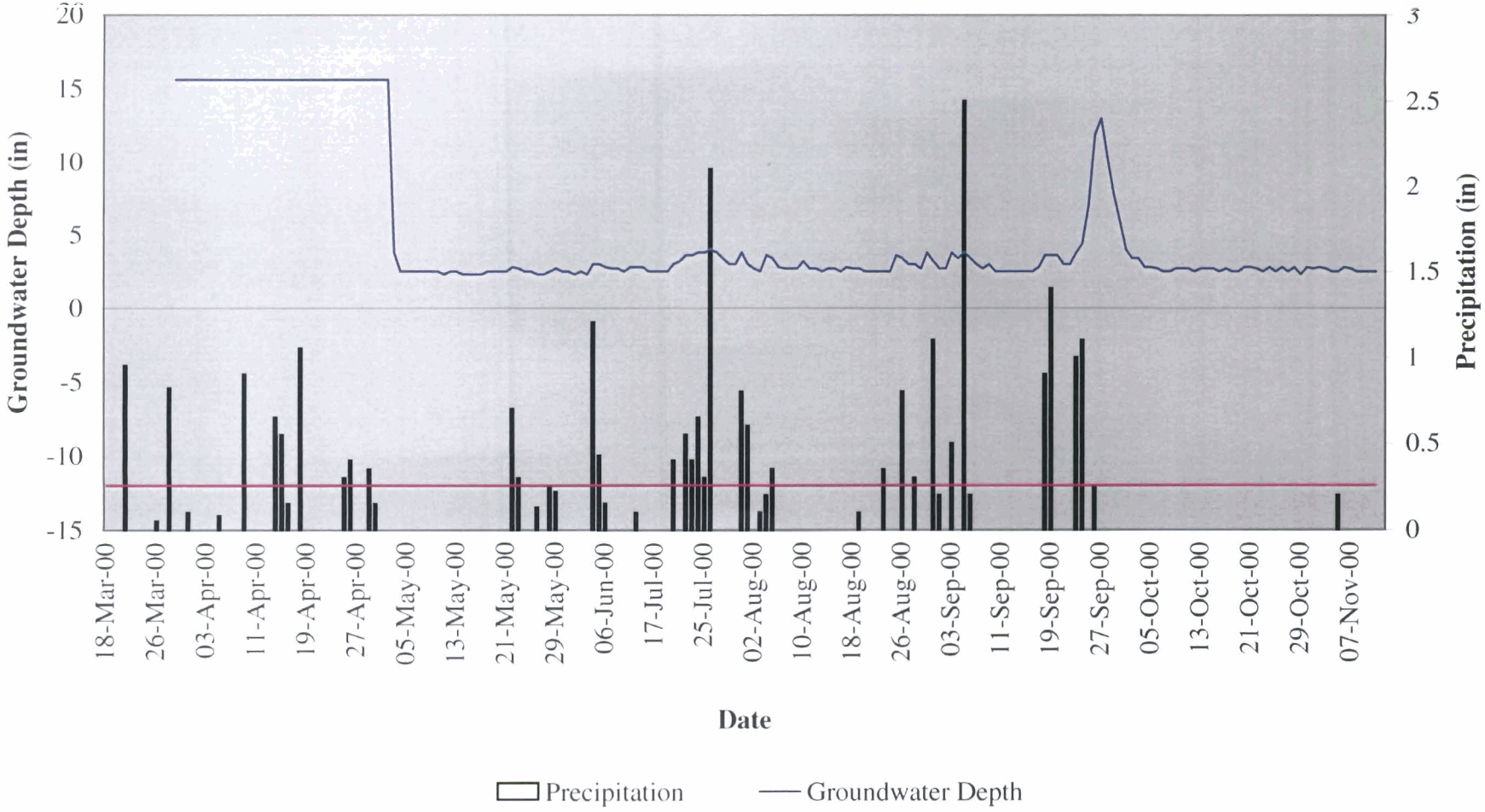
(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



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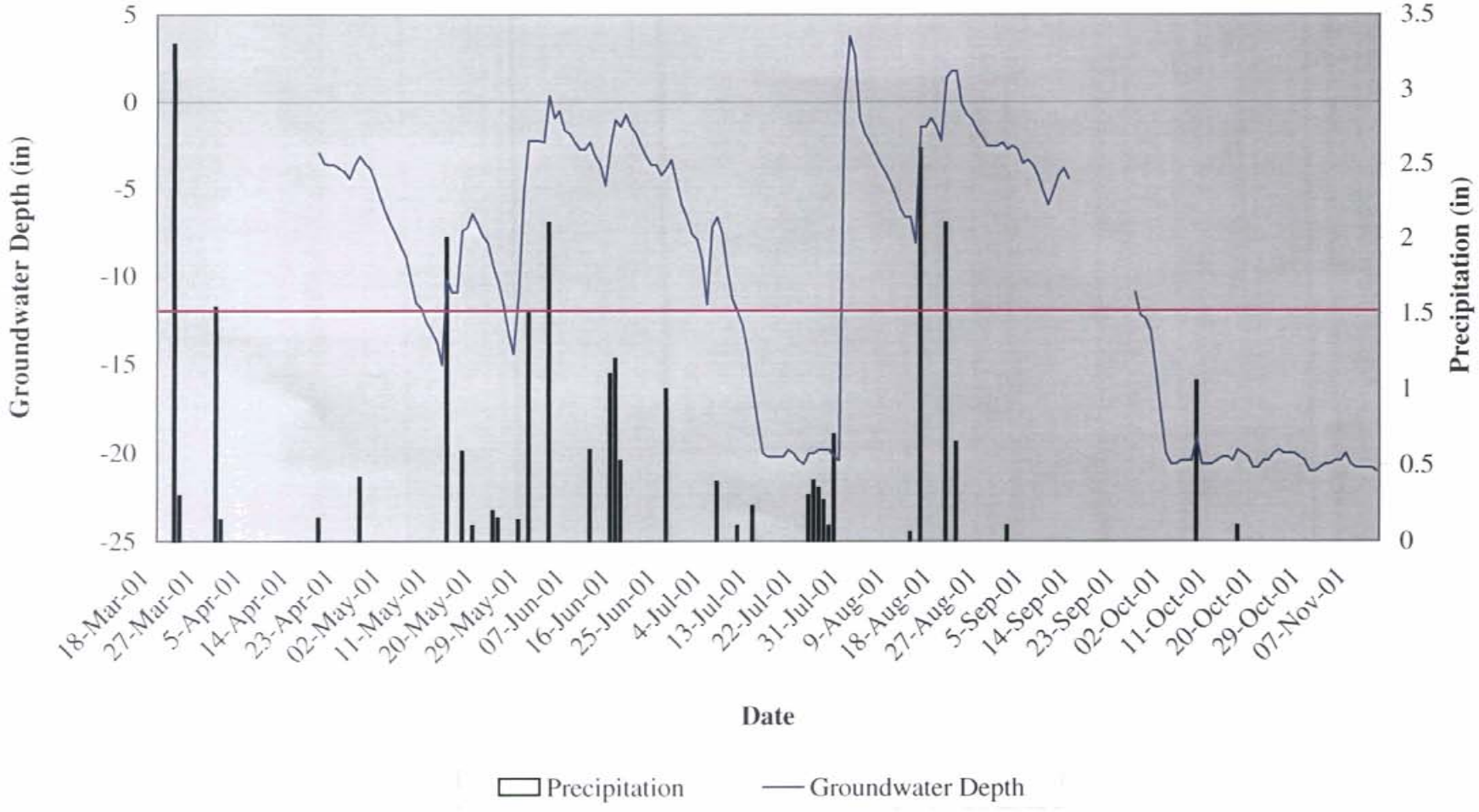
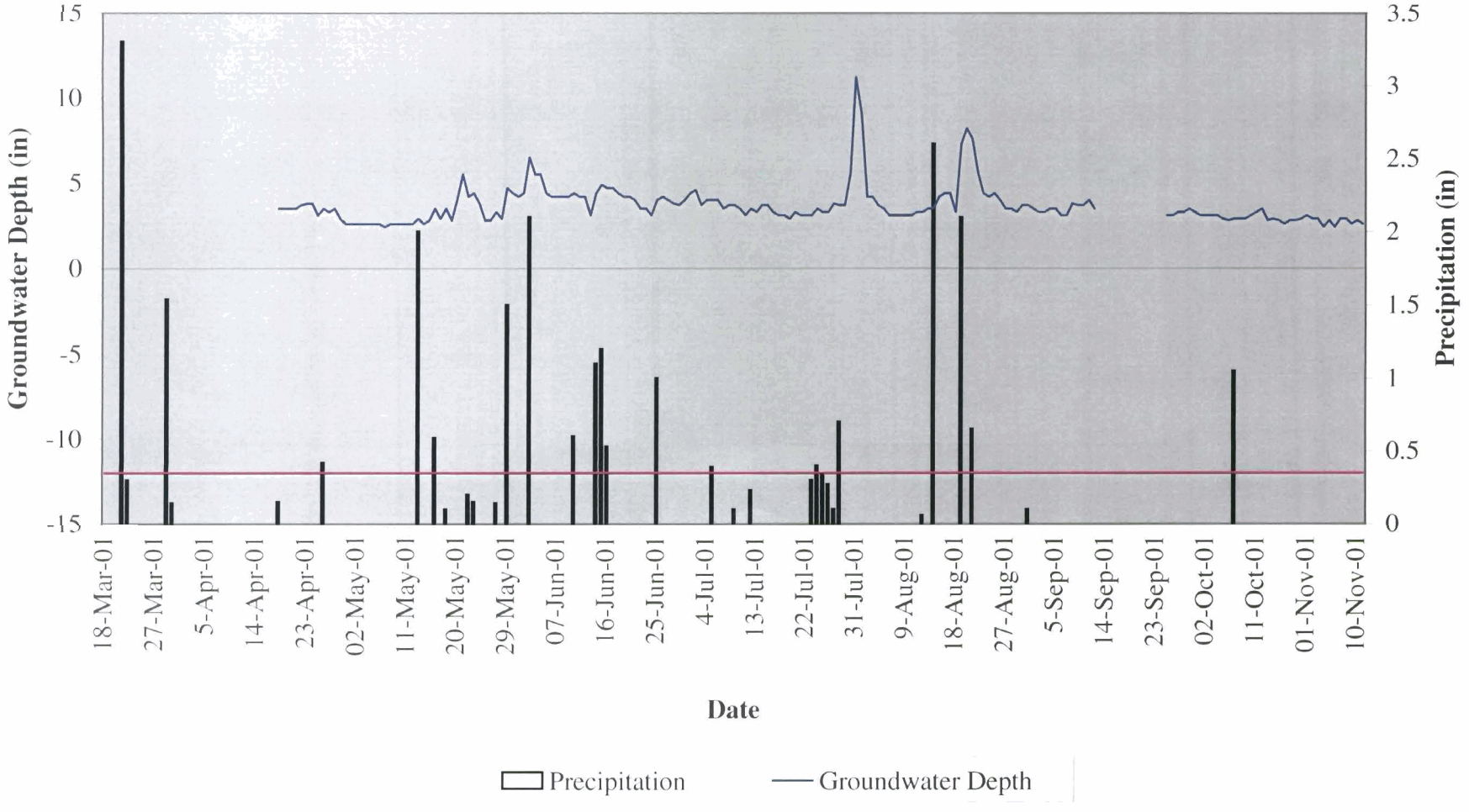


Grove Creek
Surfacewater Gauge 1
2001

(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



Grove Creek
Groundwater Gauge 6
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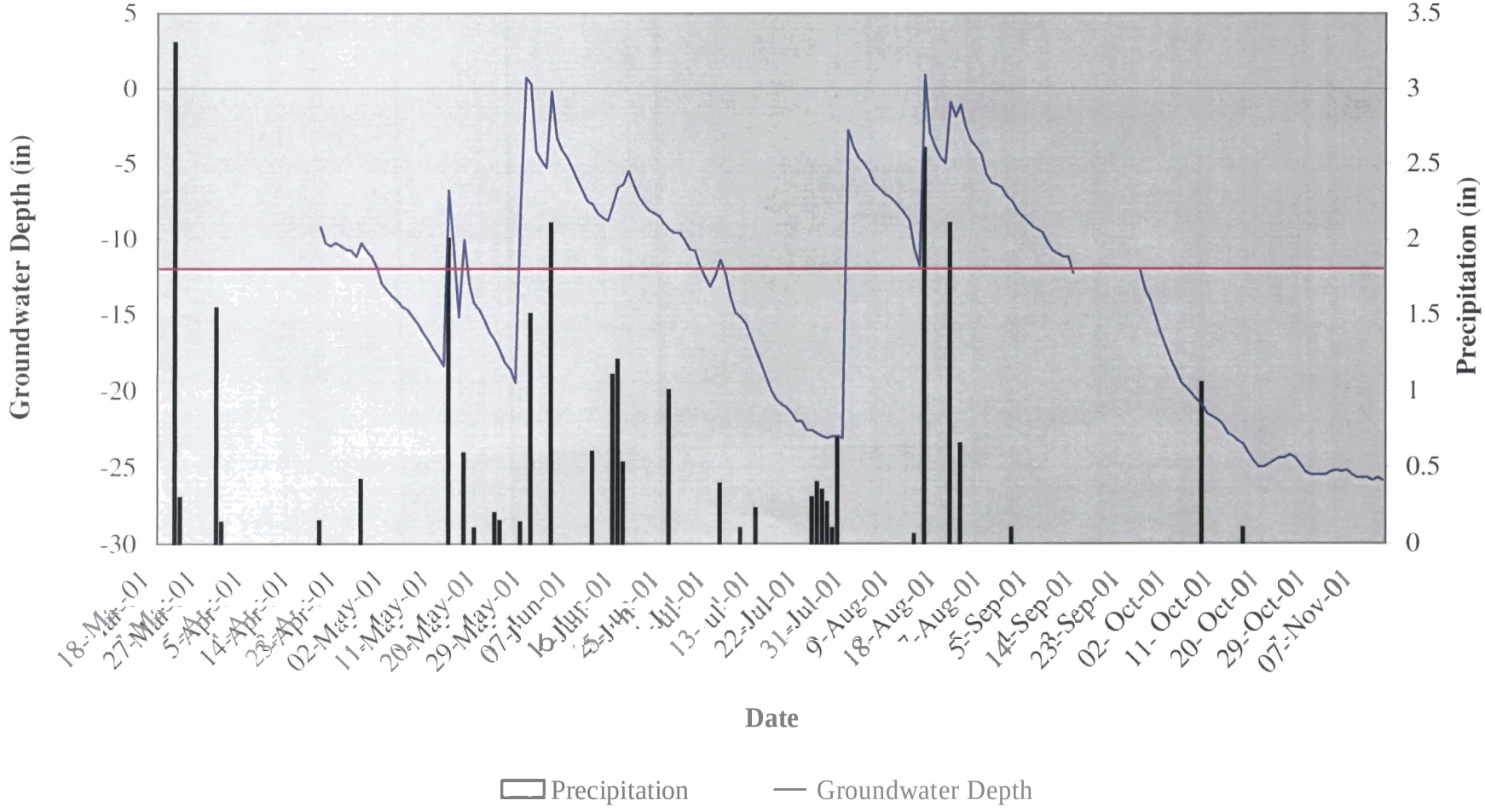

Grove Creek
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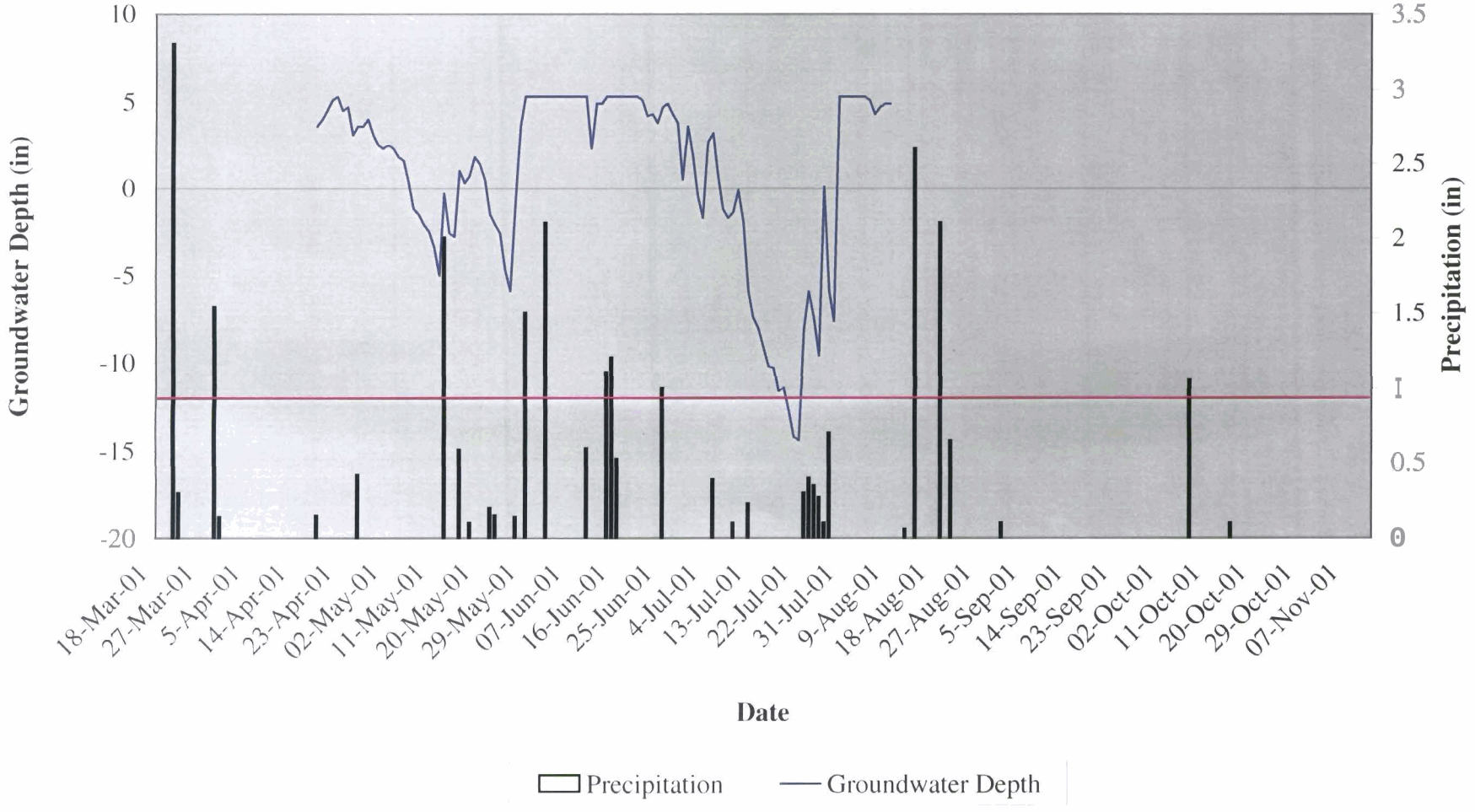

Grove Creek
Surfacewater Gauge 8
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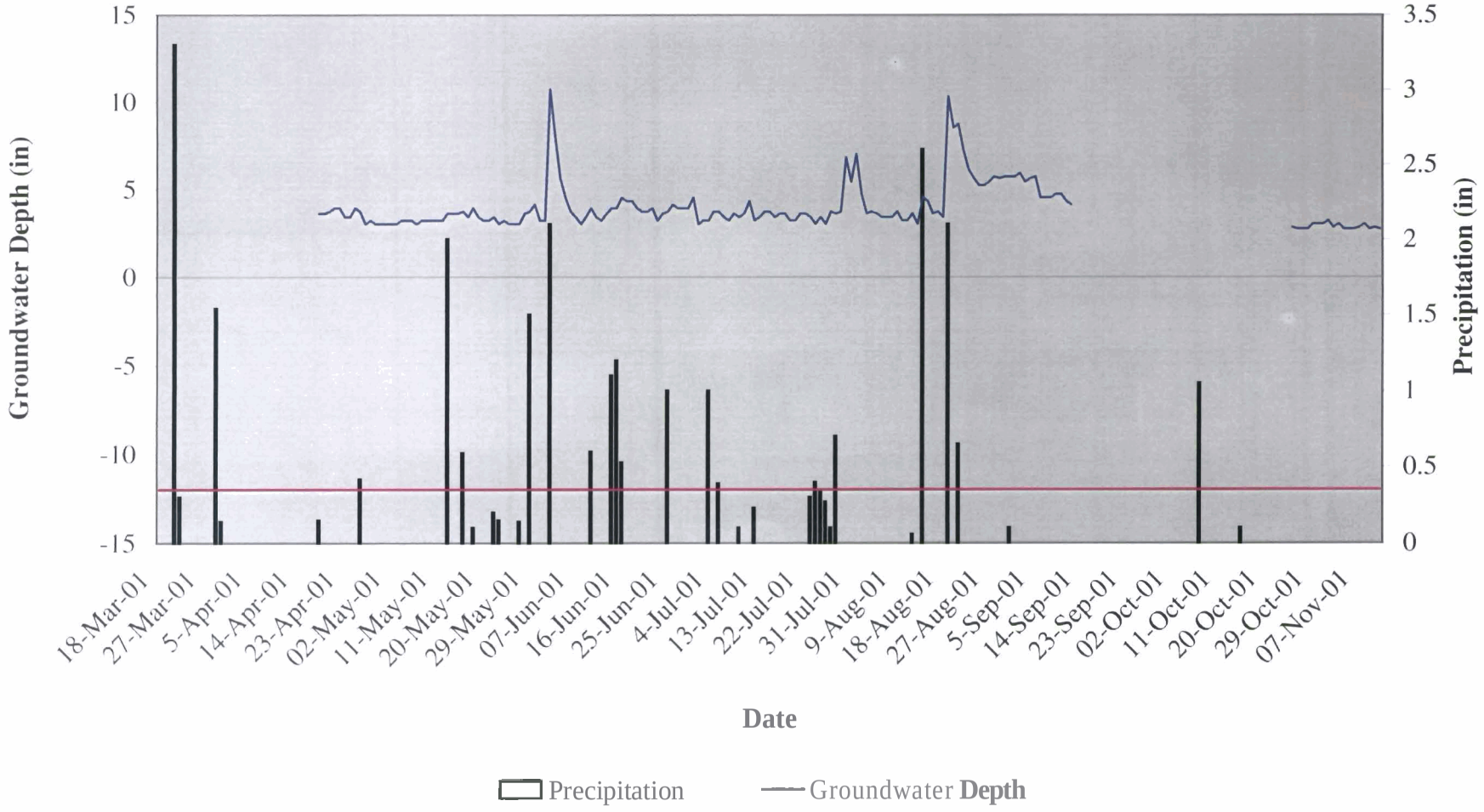

Grove Creek
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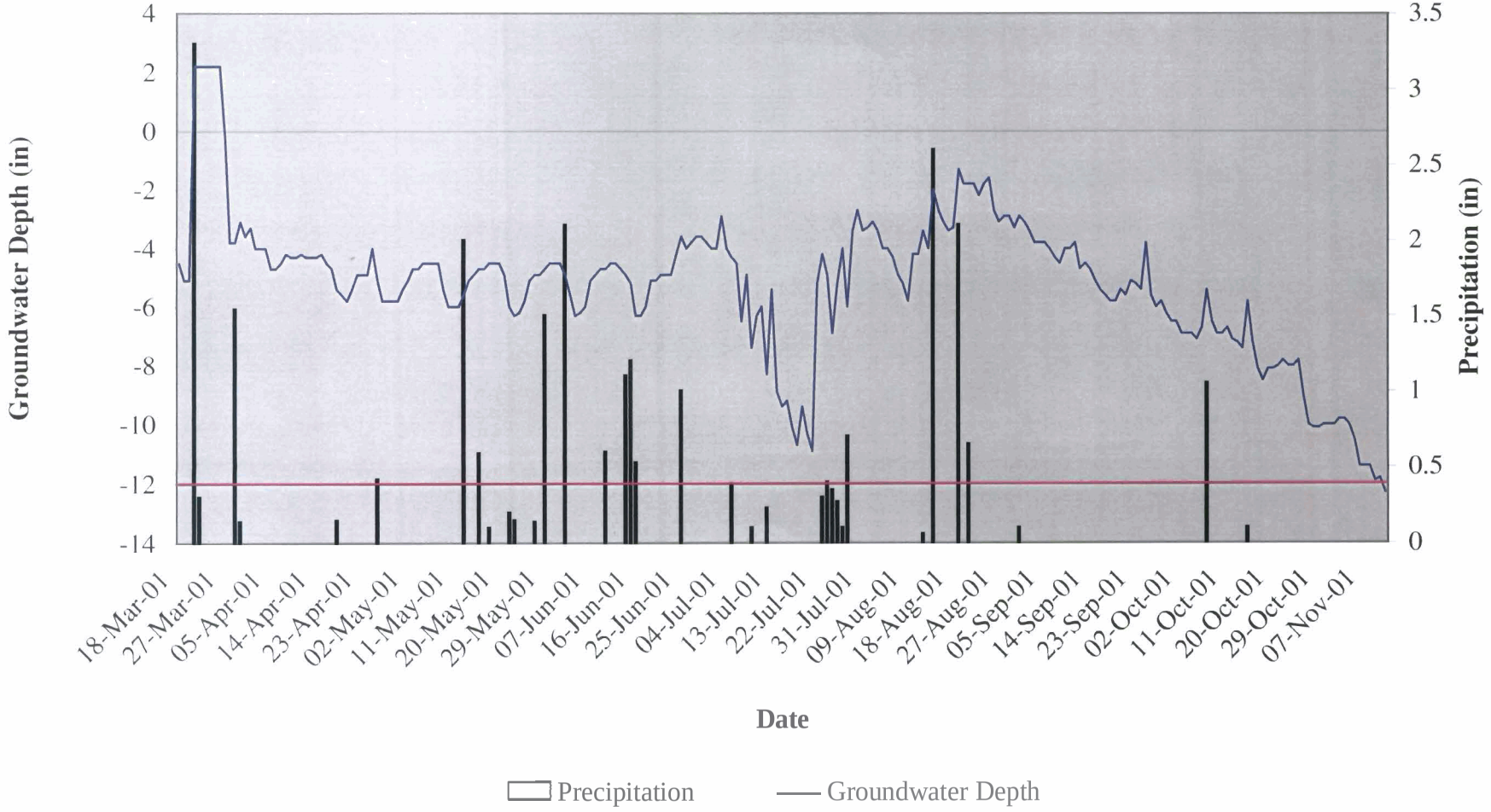

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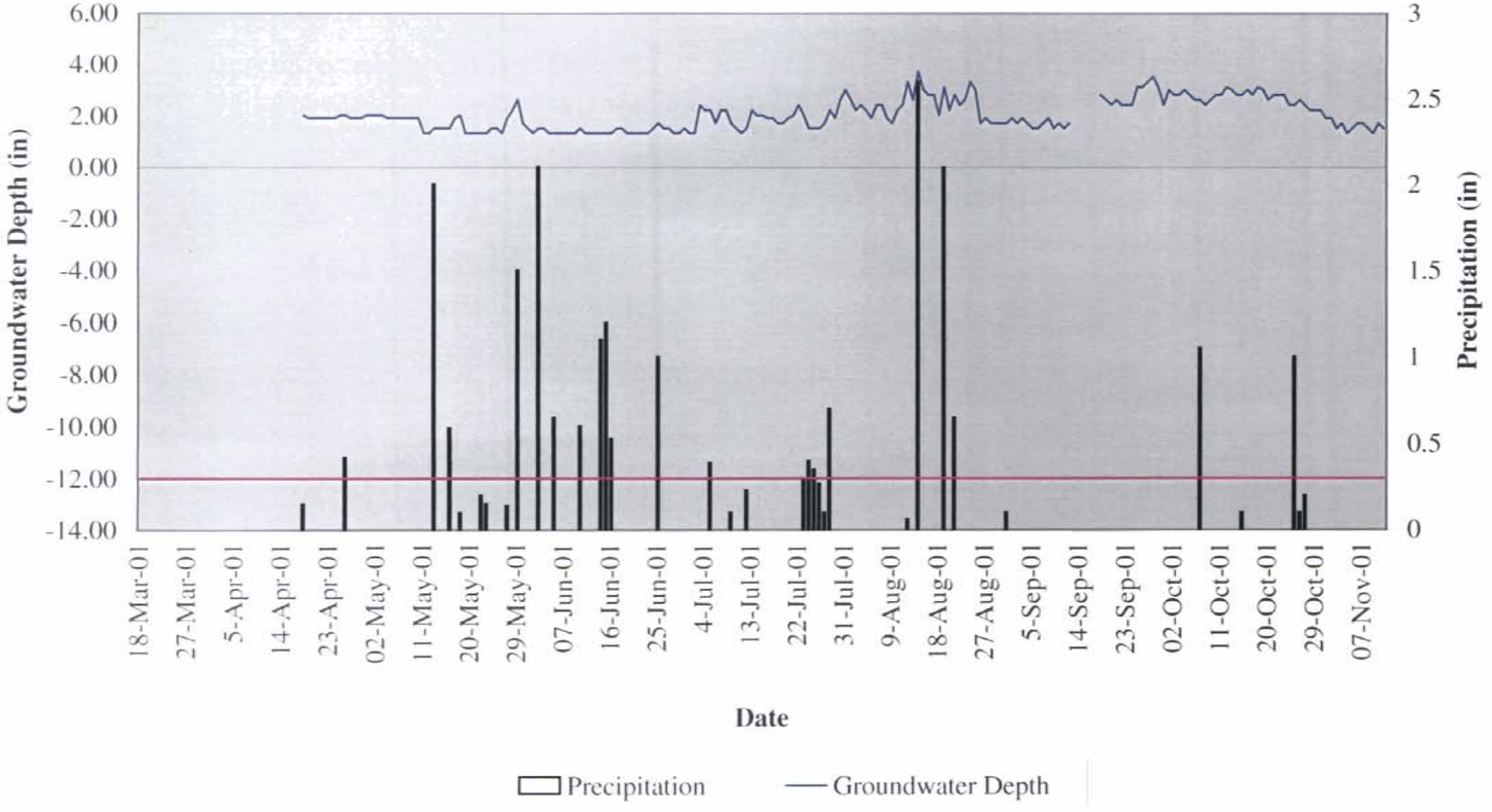

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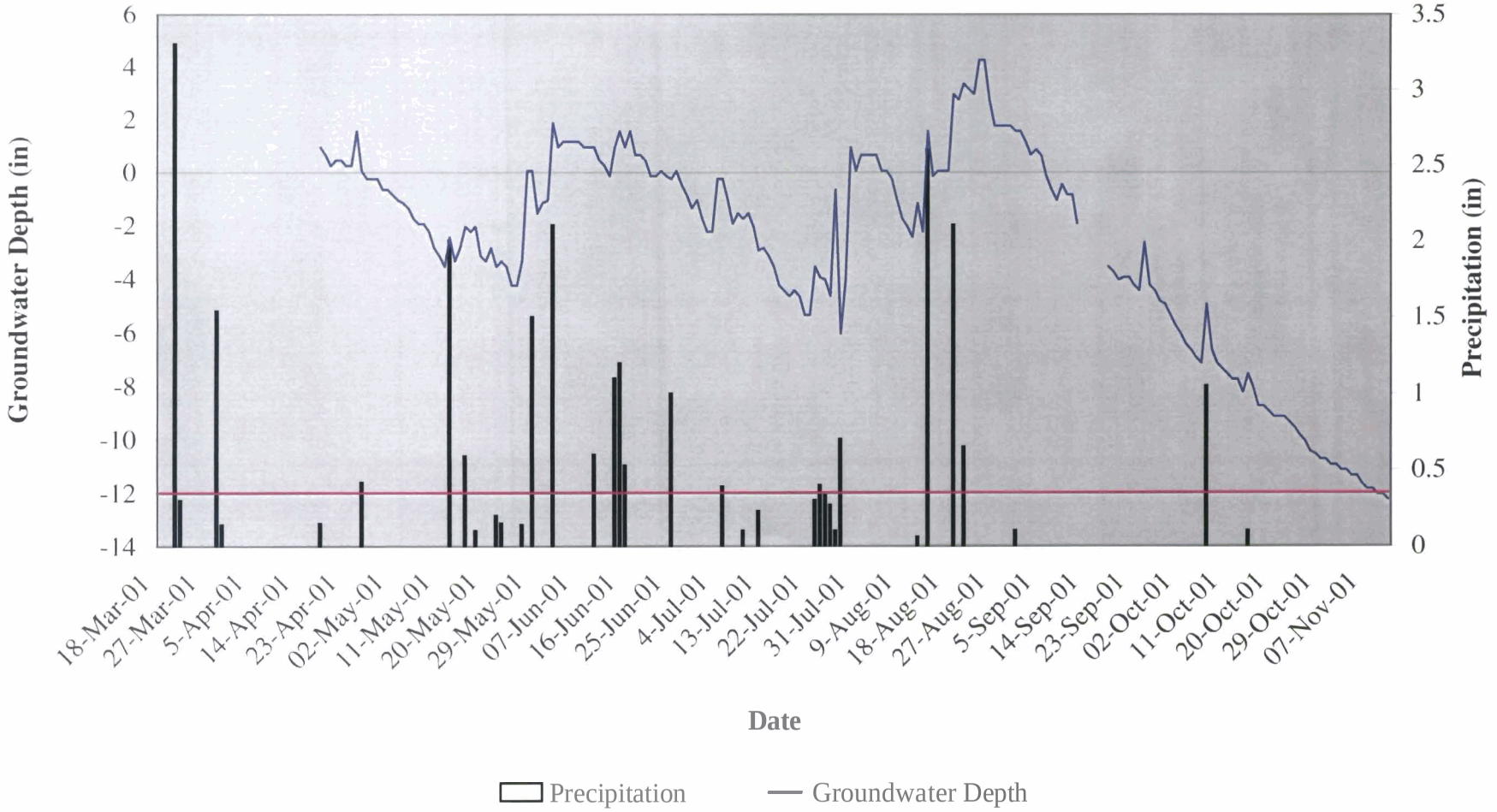

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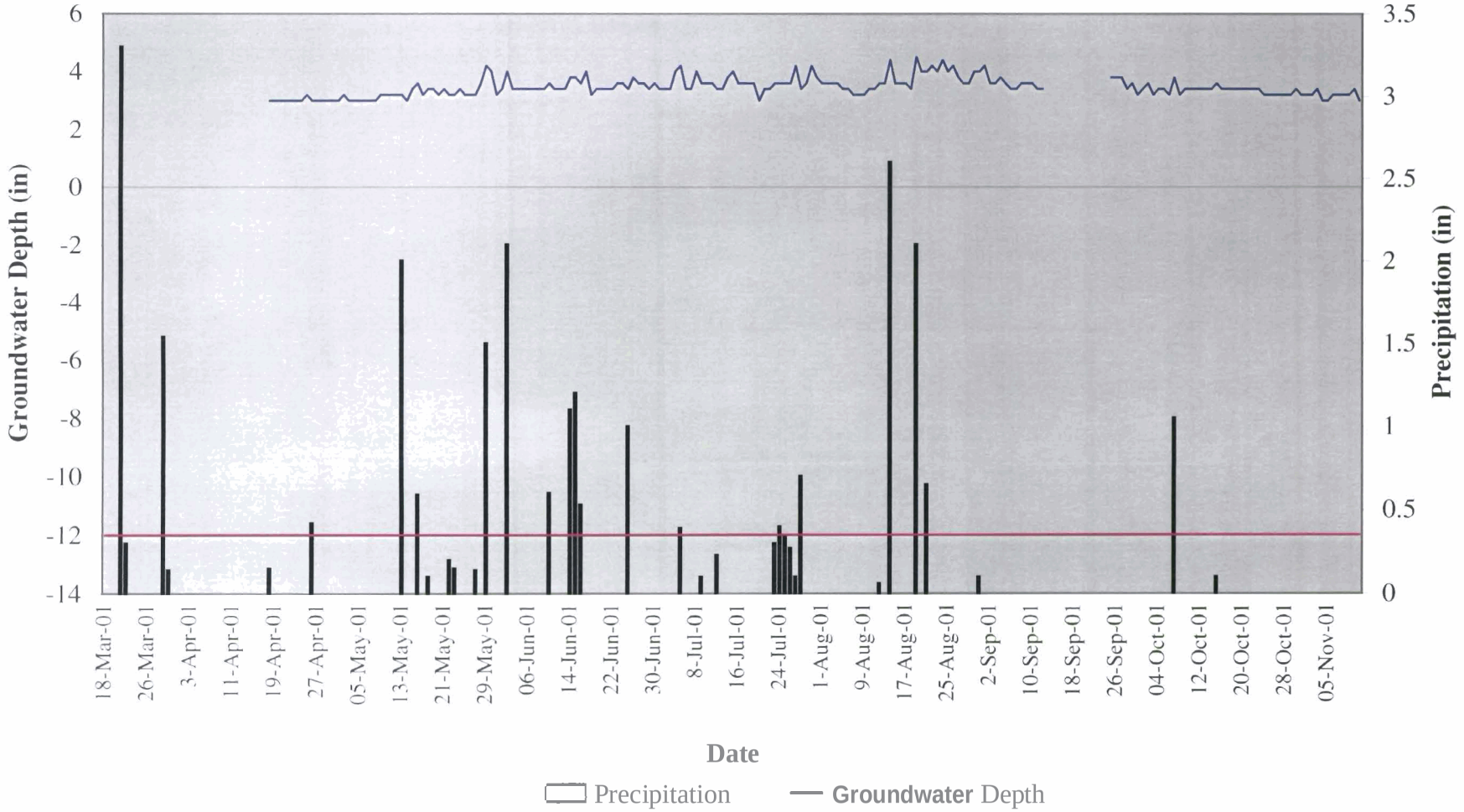

Grove Creek
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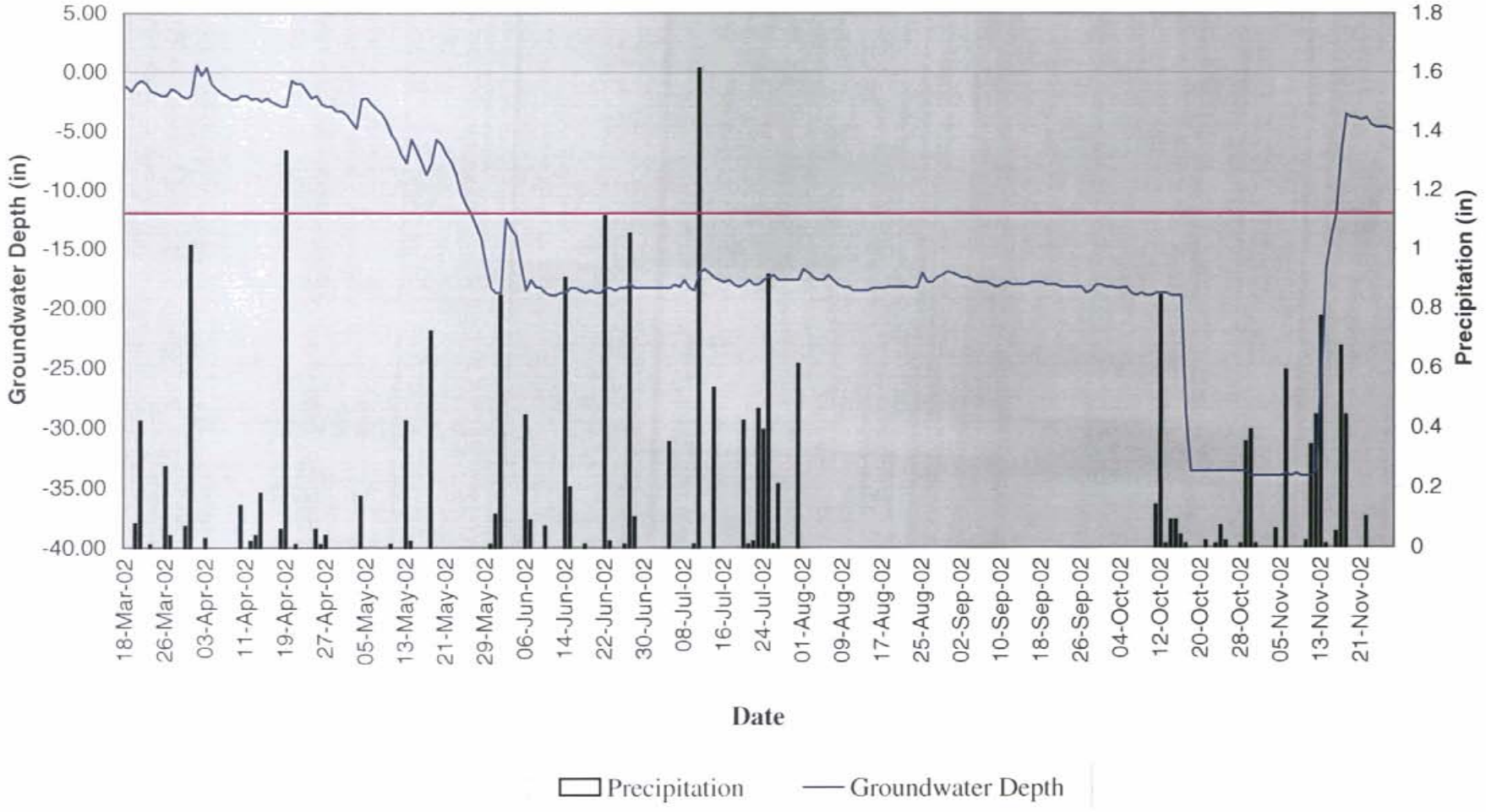

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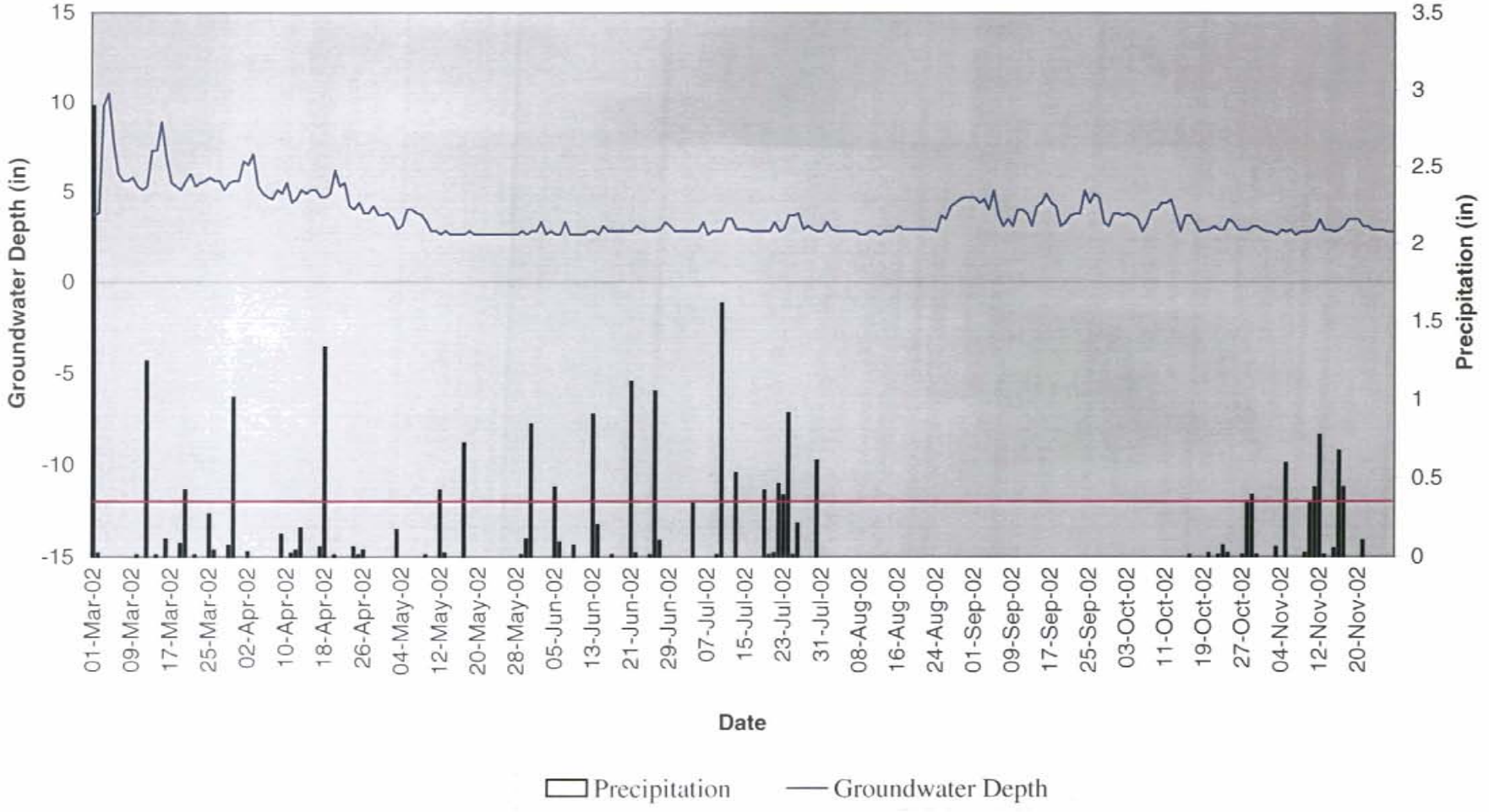

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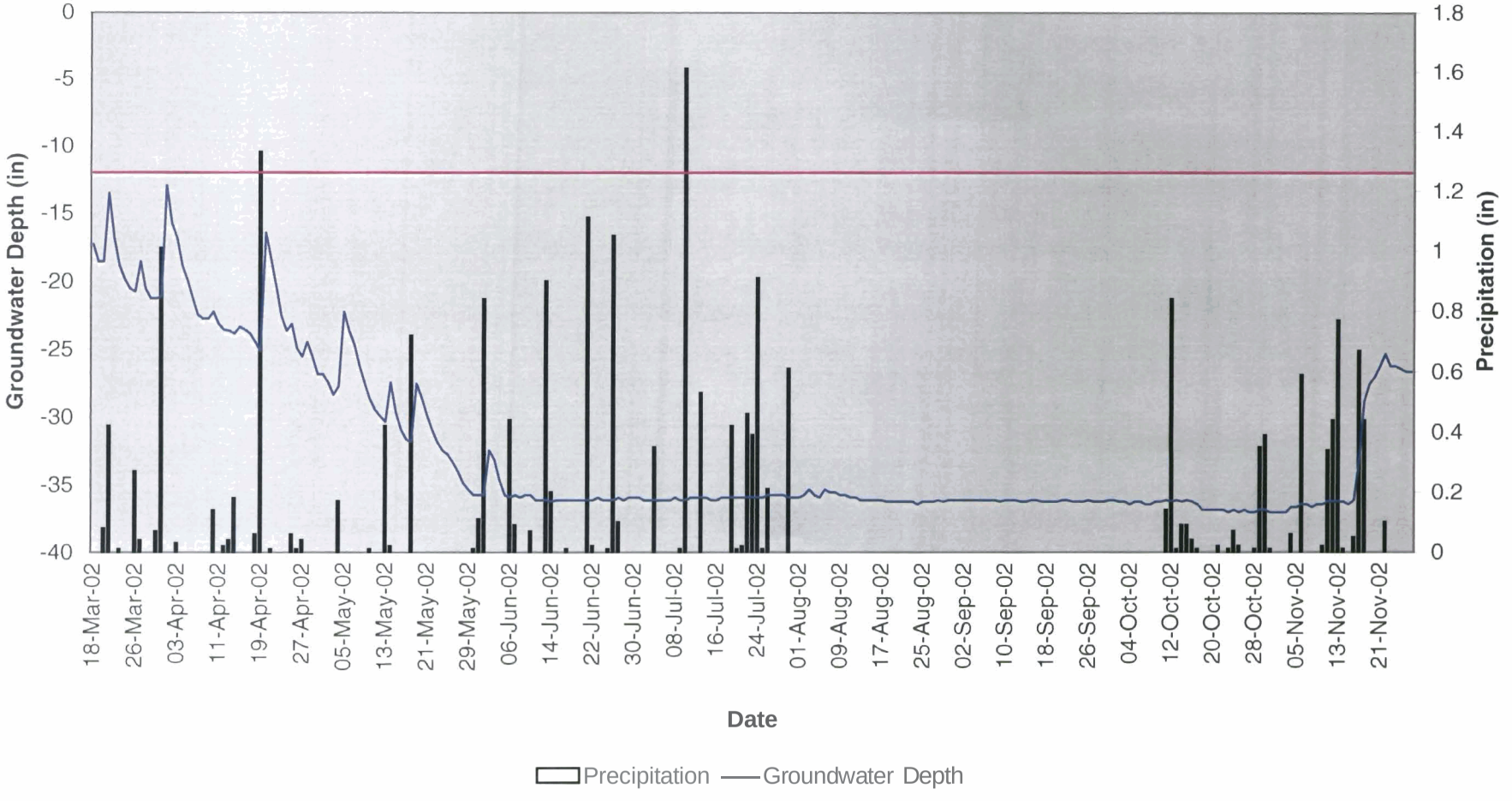

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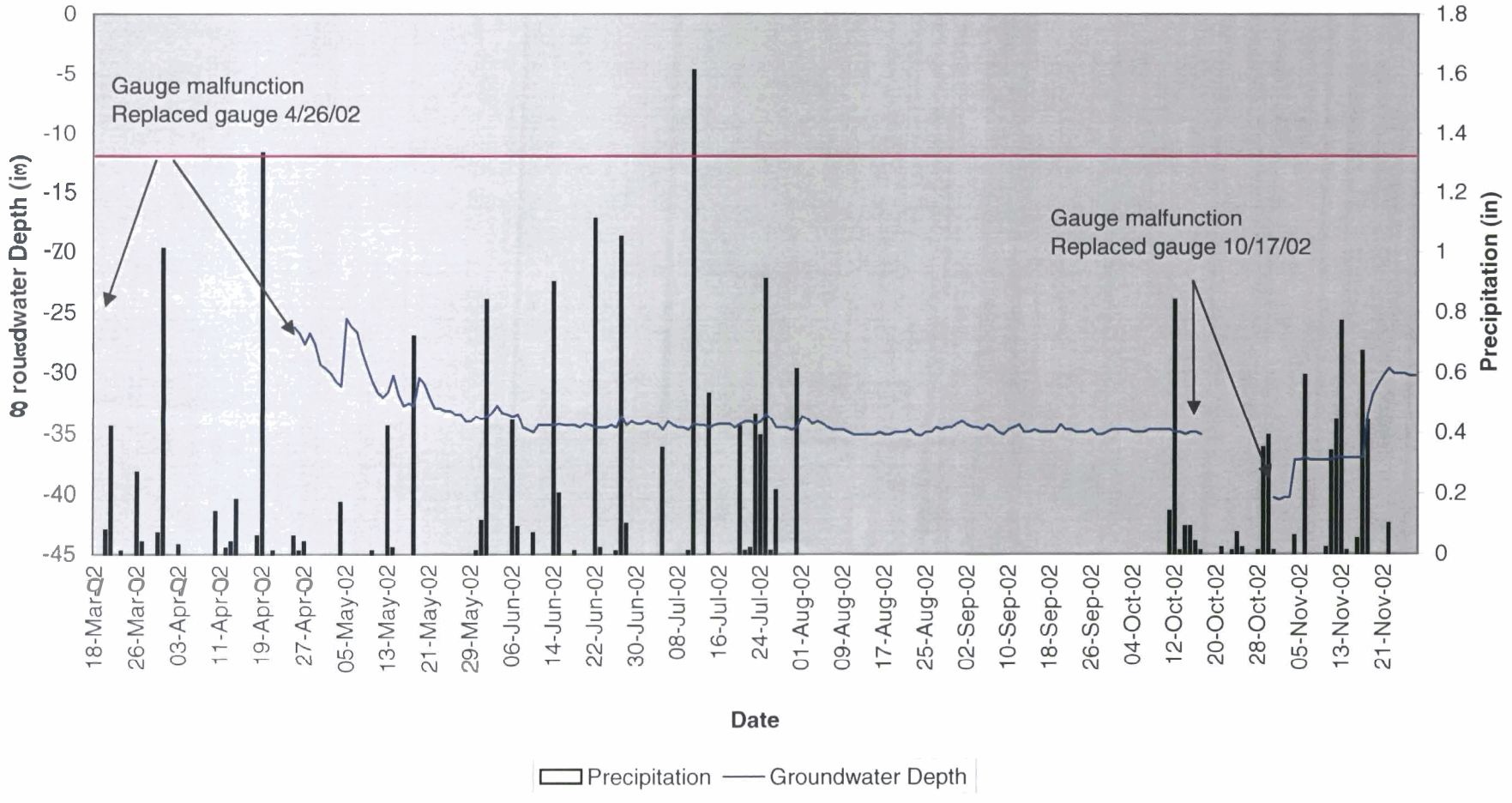

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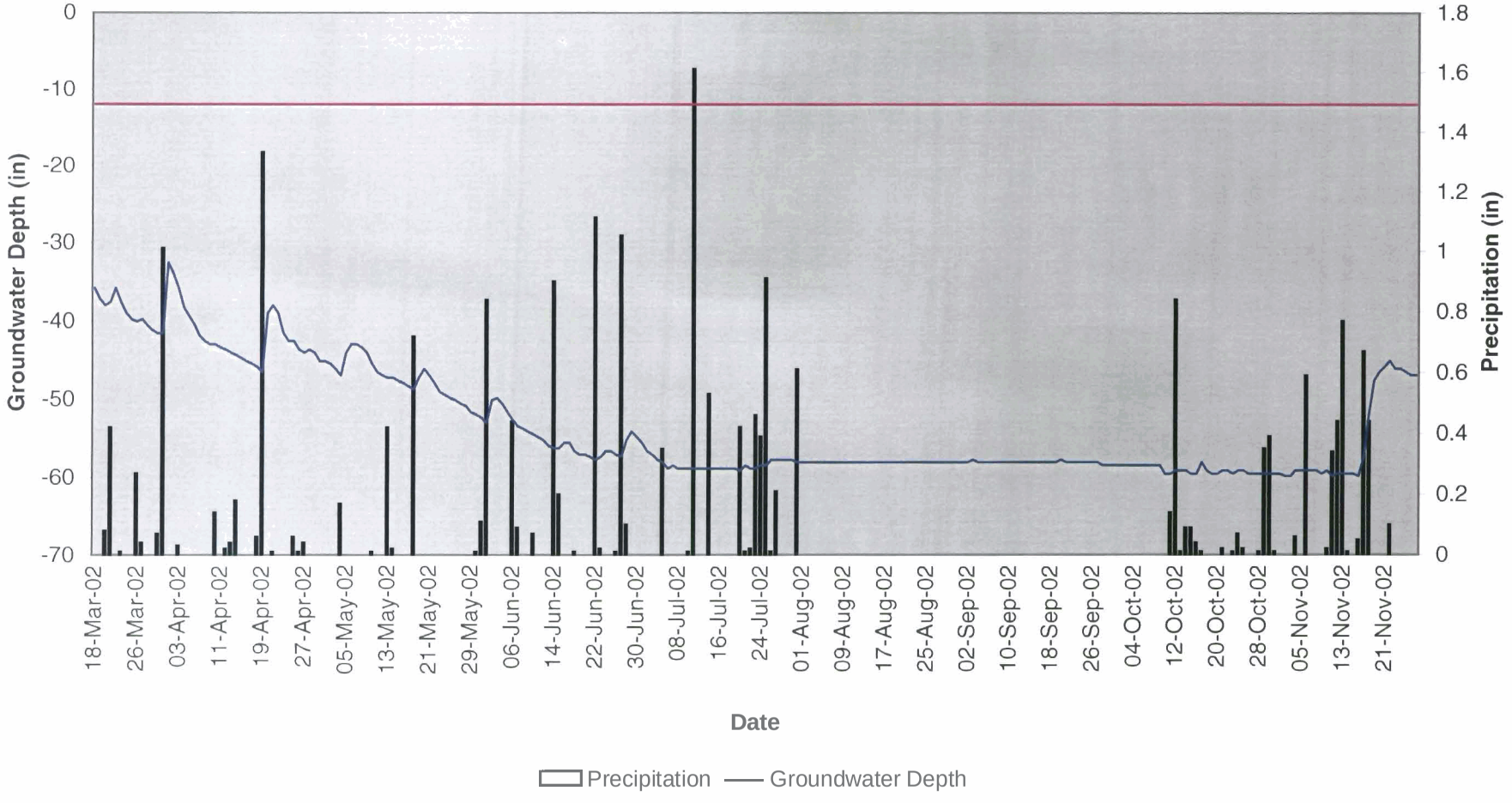

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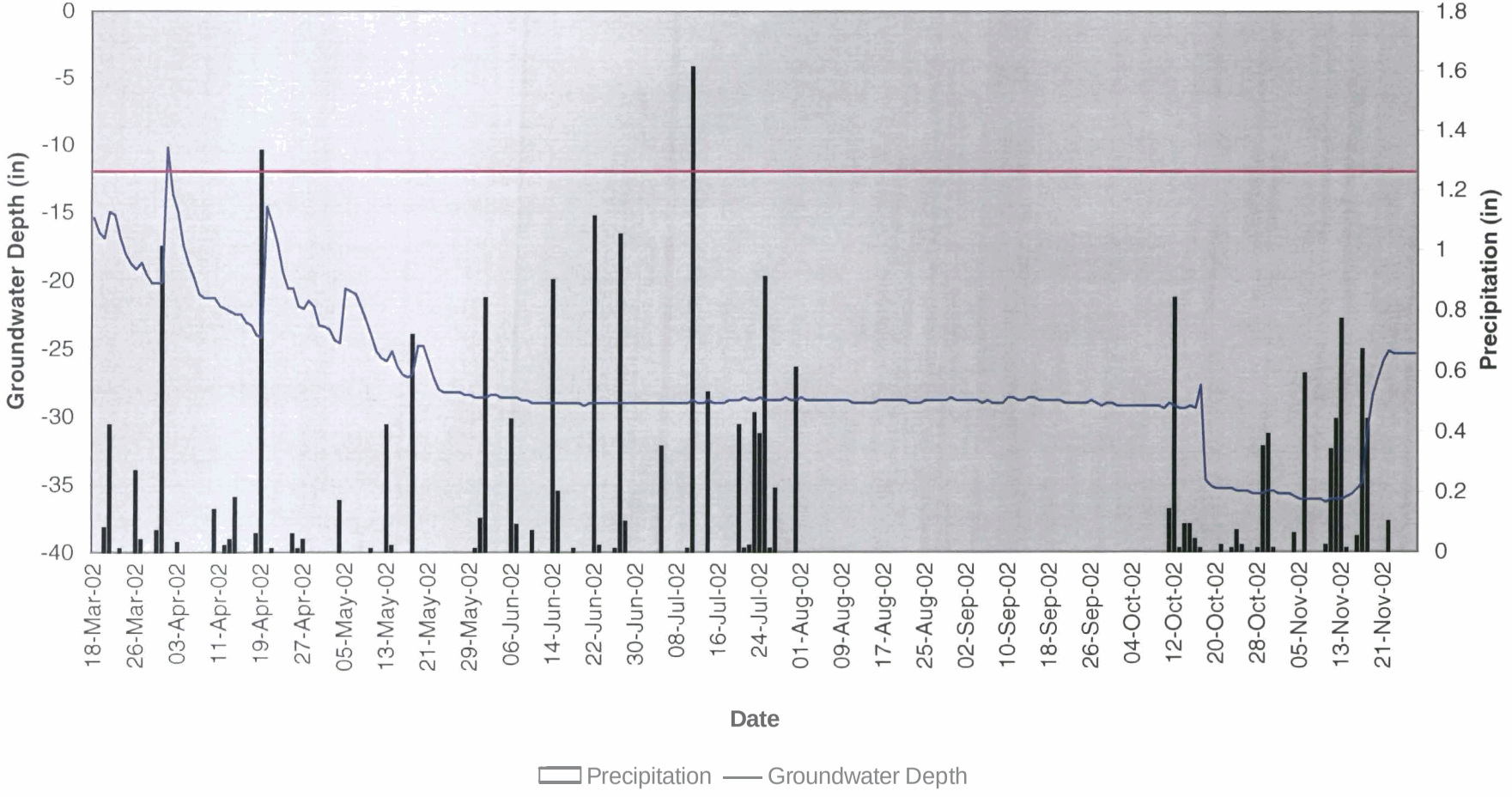

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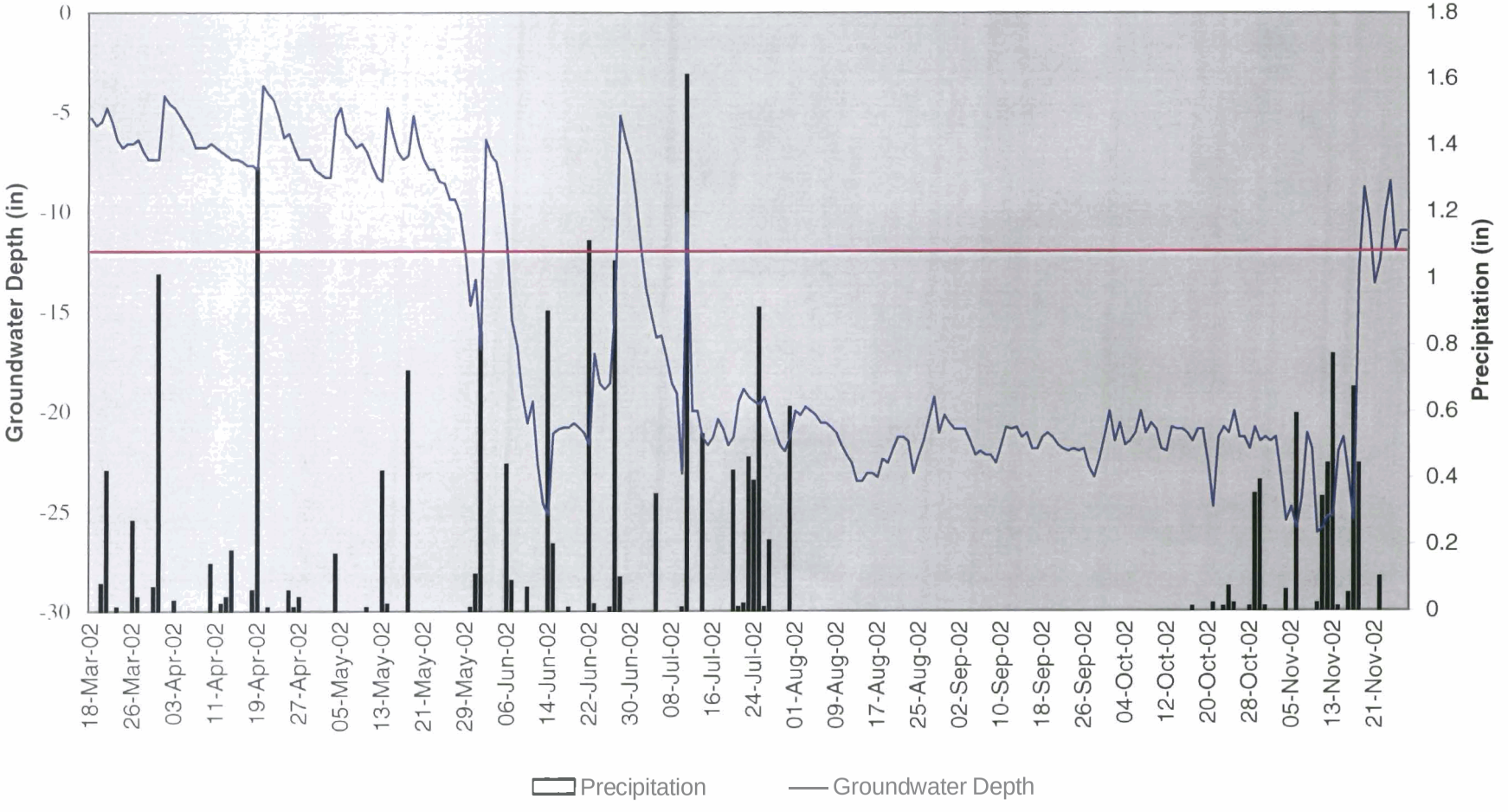

Grove Creek
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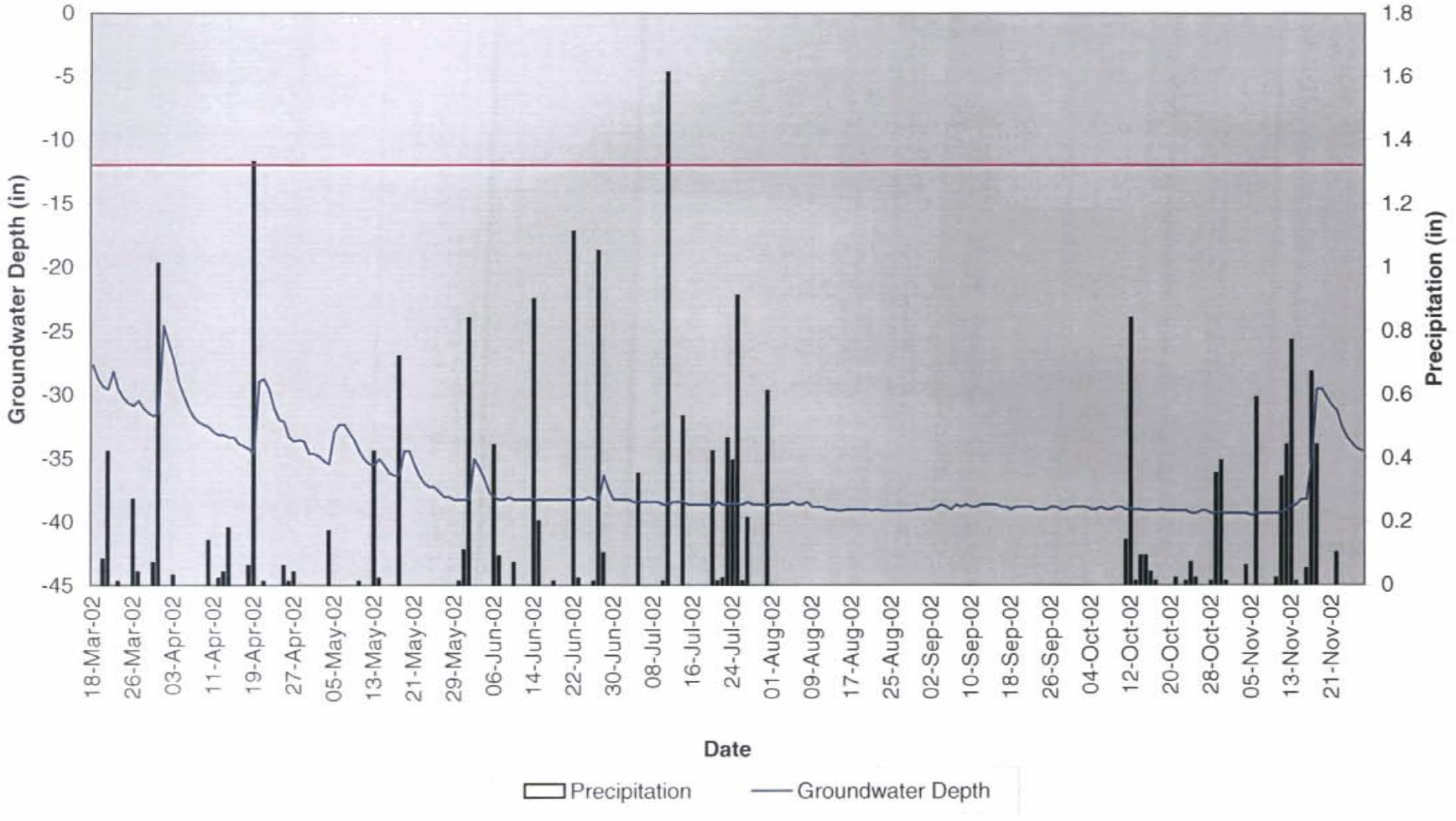
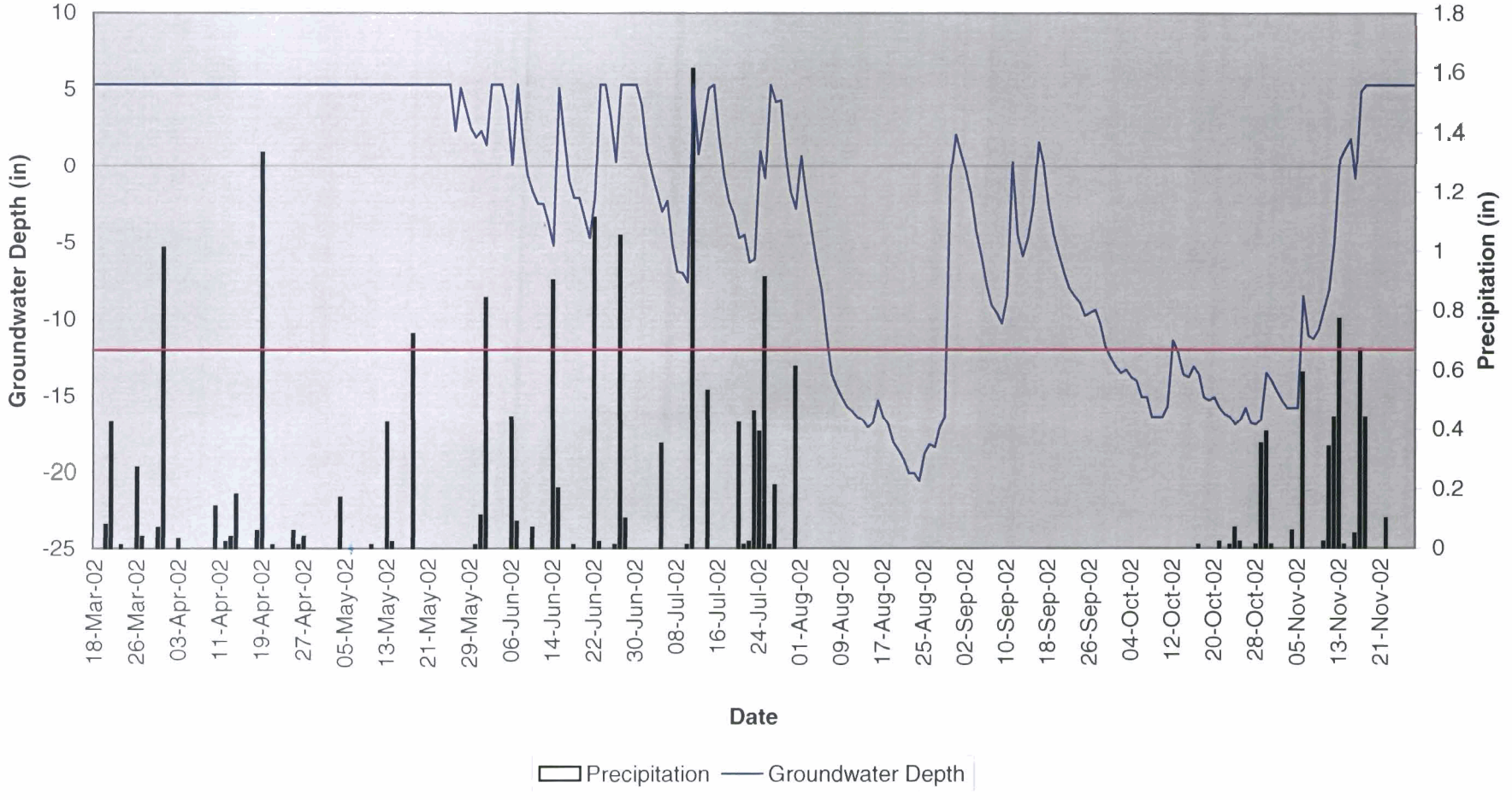
2002
(Maximum Days Inundated or Saturated - 0)

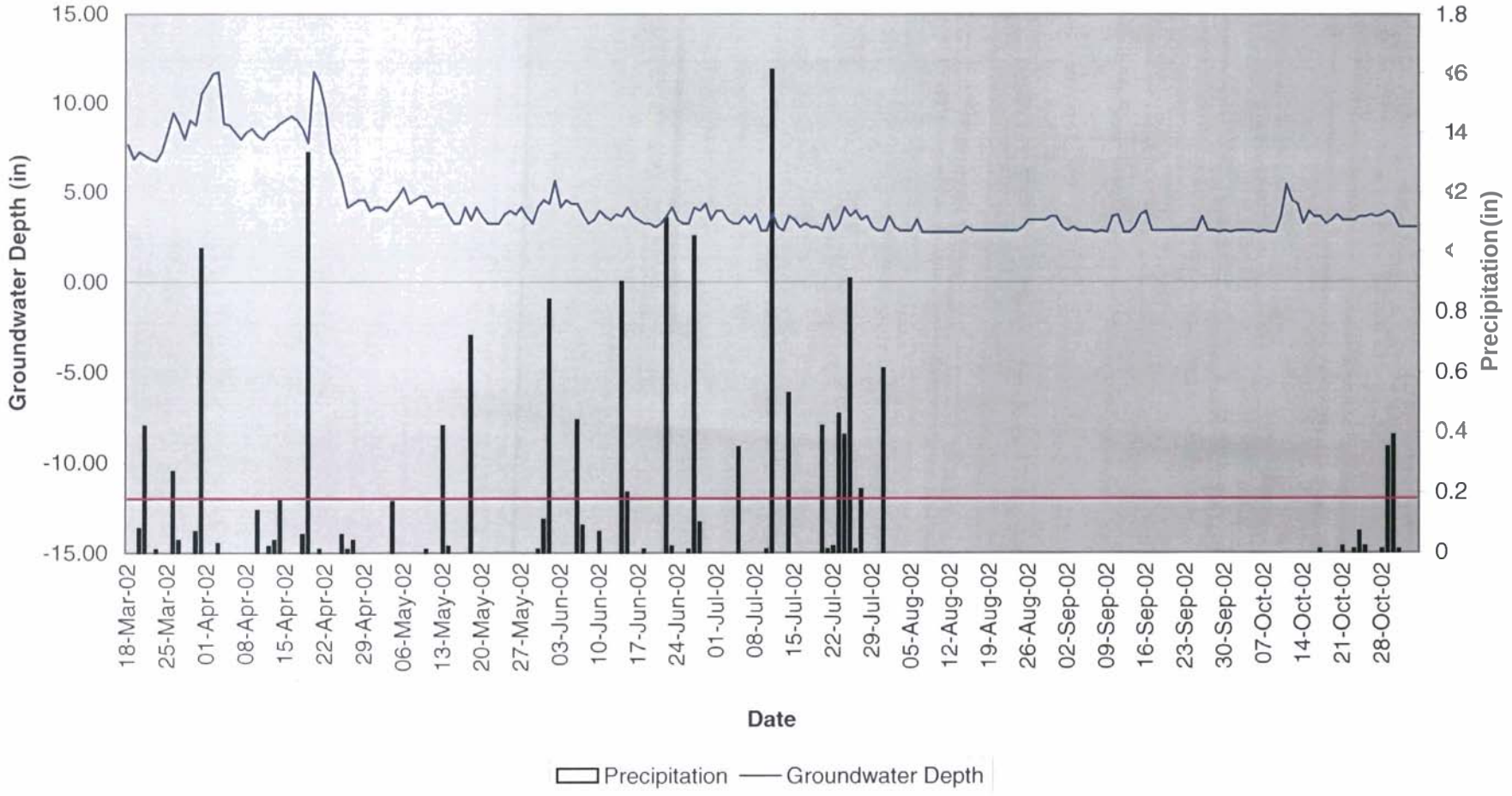


Grove Creek
Groundwater Gauge 8
2002
(Maximum Days Inundated or Saturated - 141)

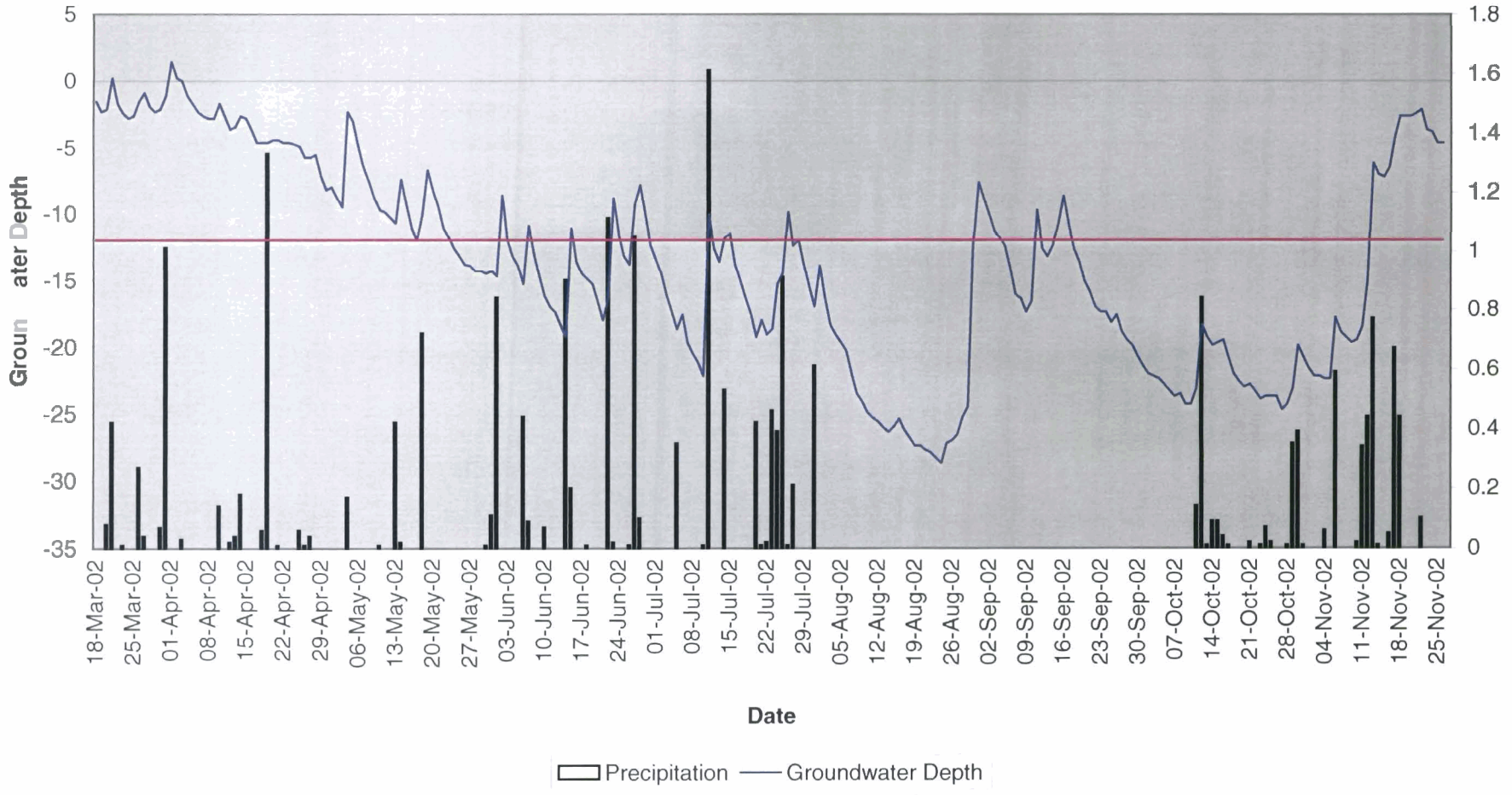


Grove Creek
Surfacewater Gauge 8
2002

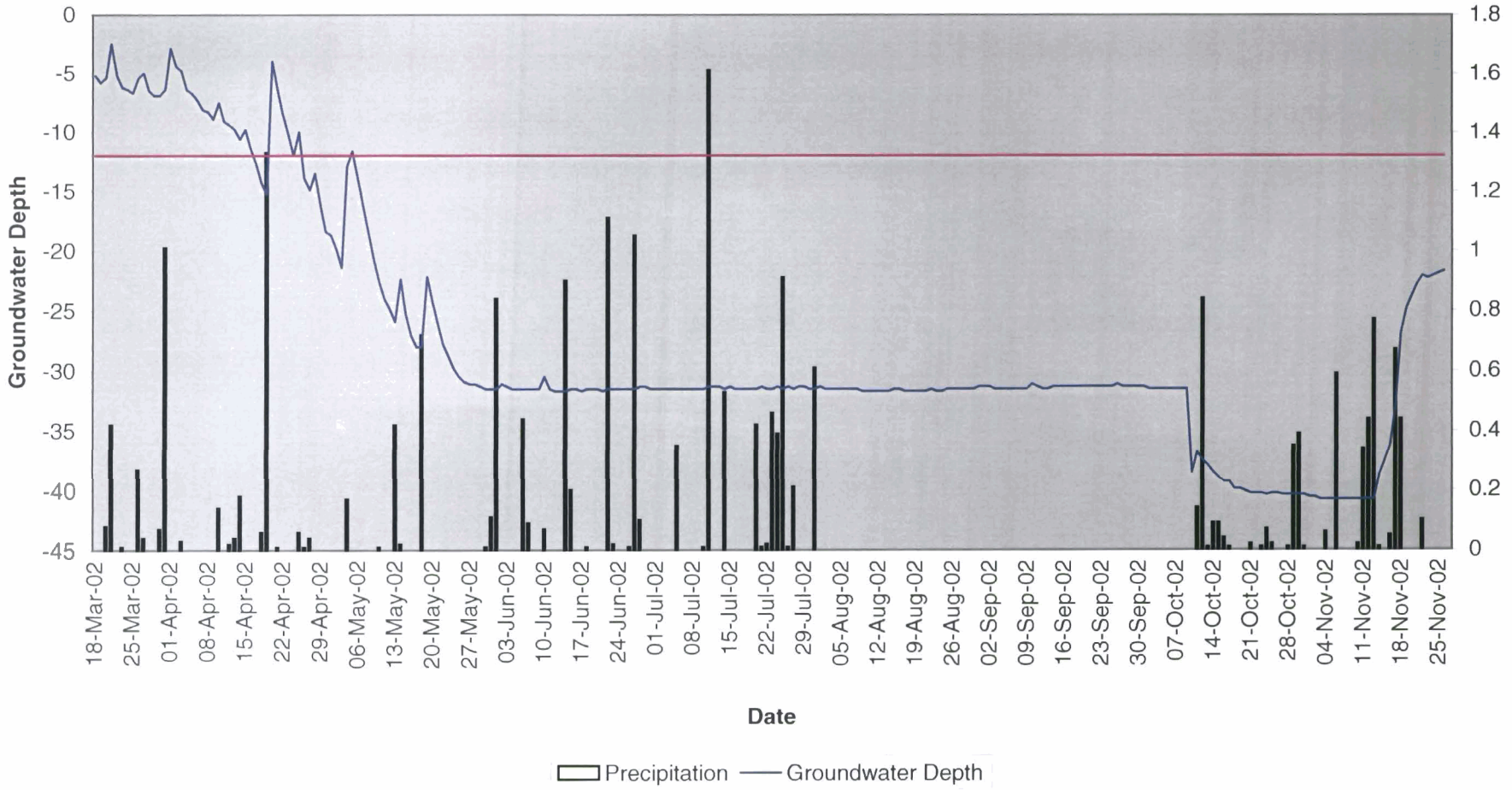
(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



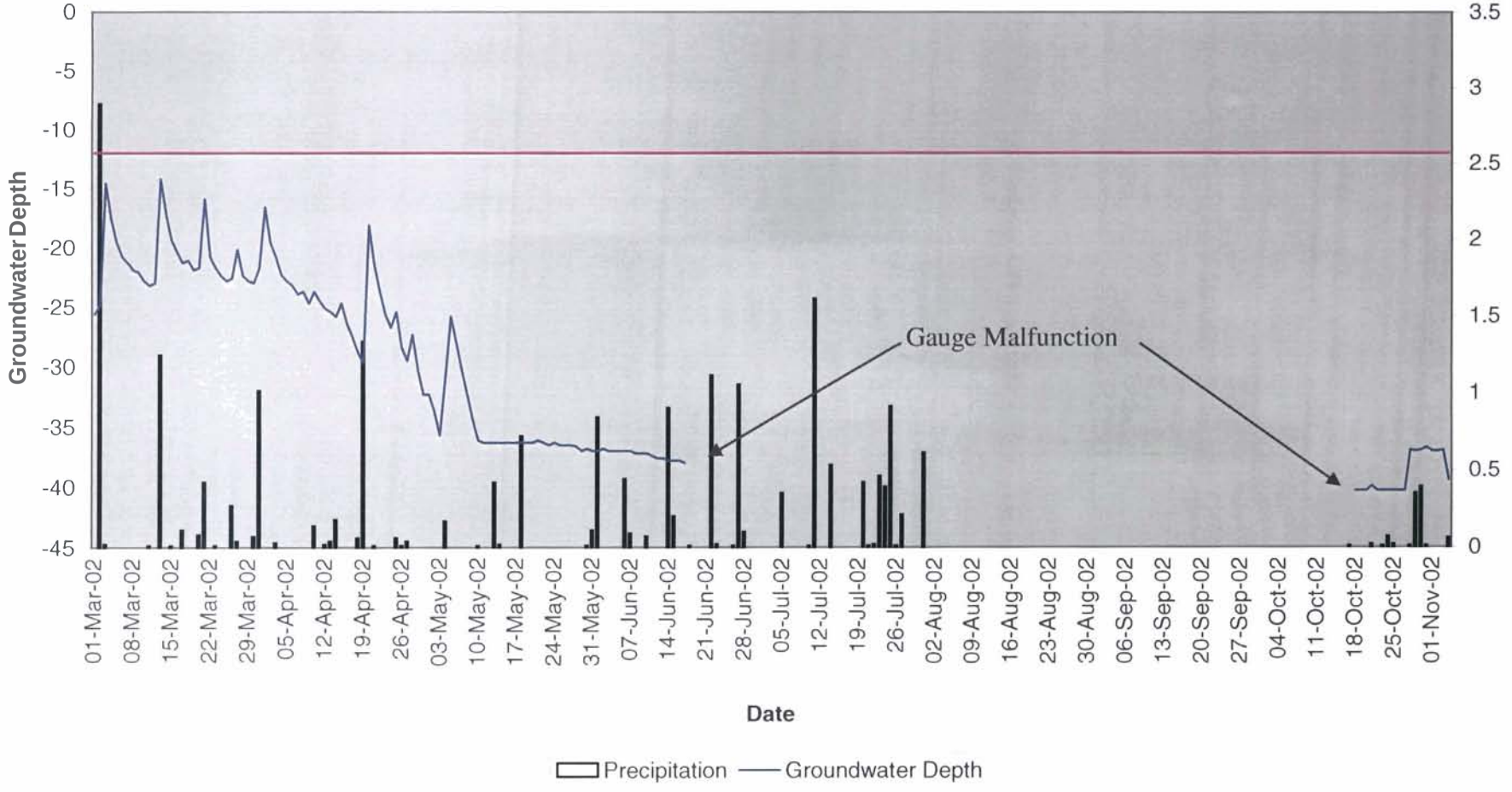
Grove Creek
Groundwater Gauge 9
Z00Z
(Maximum Days Inundated or Saturated - 66)



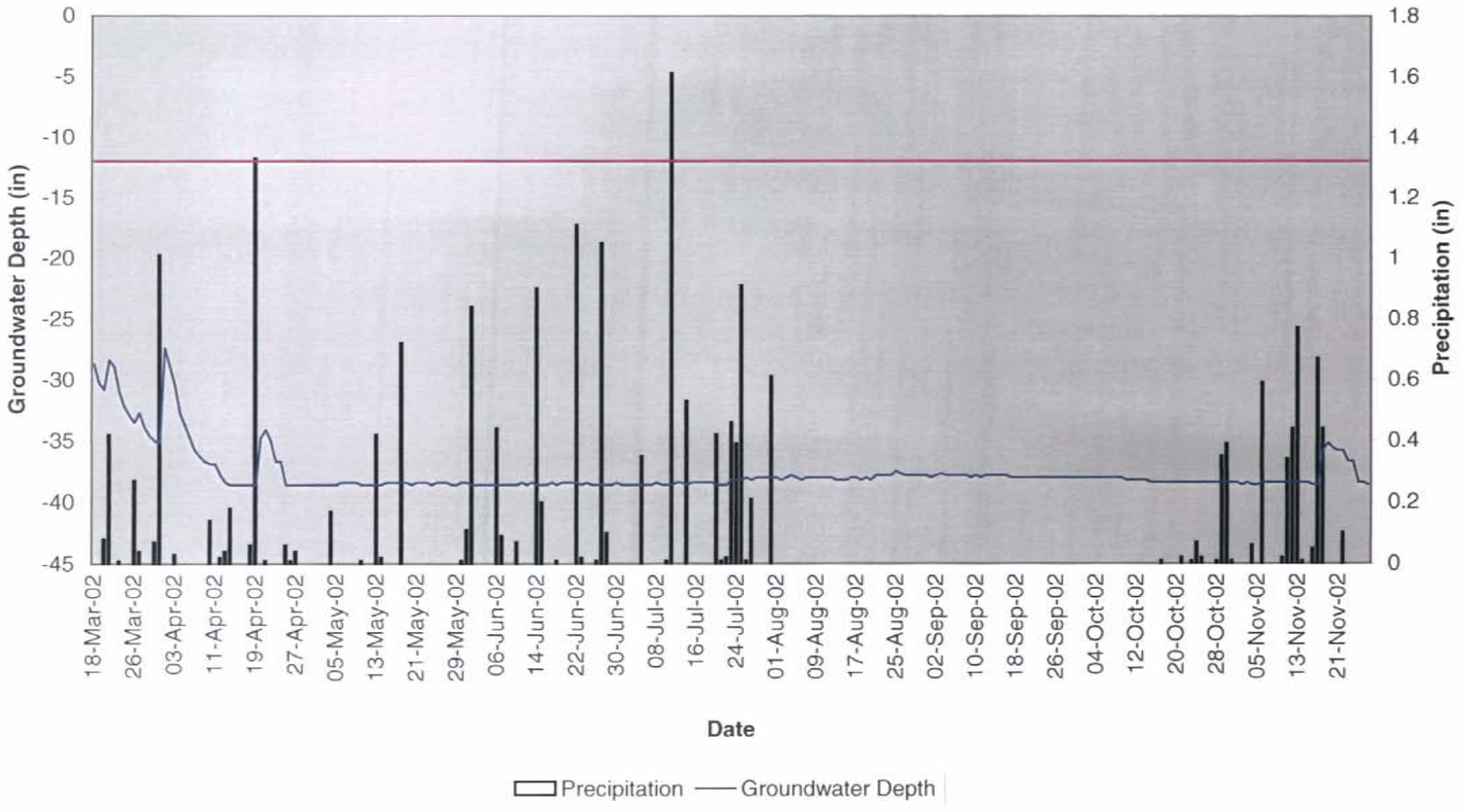
Grove Creek
Groundwater Gauge 10
2002
(Maximum Days Inundated or Saturated - 31)



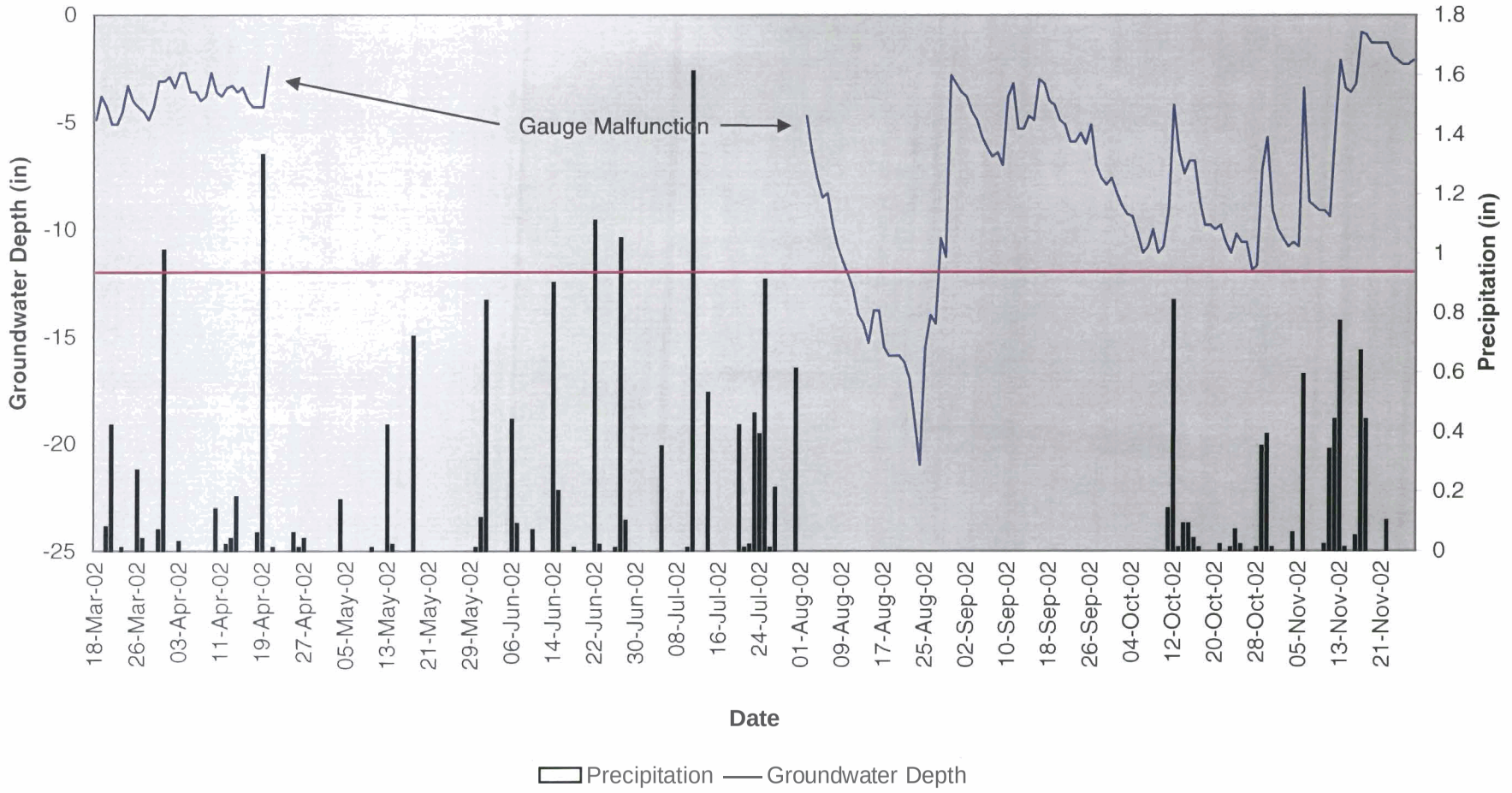
Grove Creek
Groundwater Gauge 11
2002
(Maximum Days Inundated or Saturated - 0)



Grove Creek
Groundwater Gauge 12
2002
(Maximum Days Inundated or Saturated - 0)

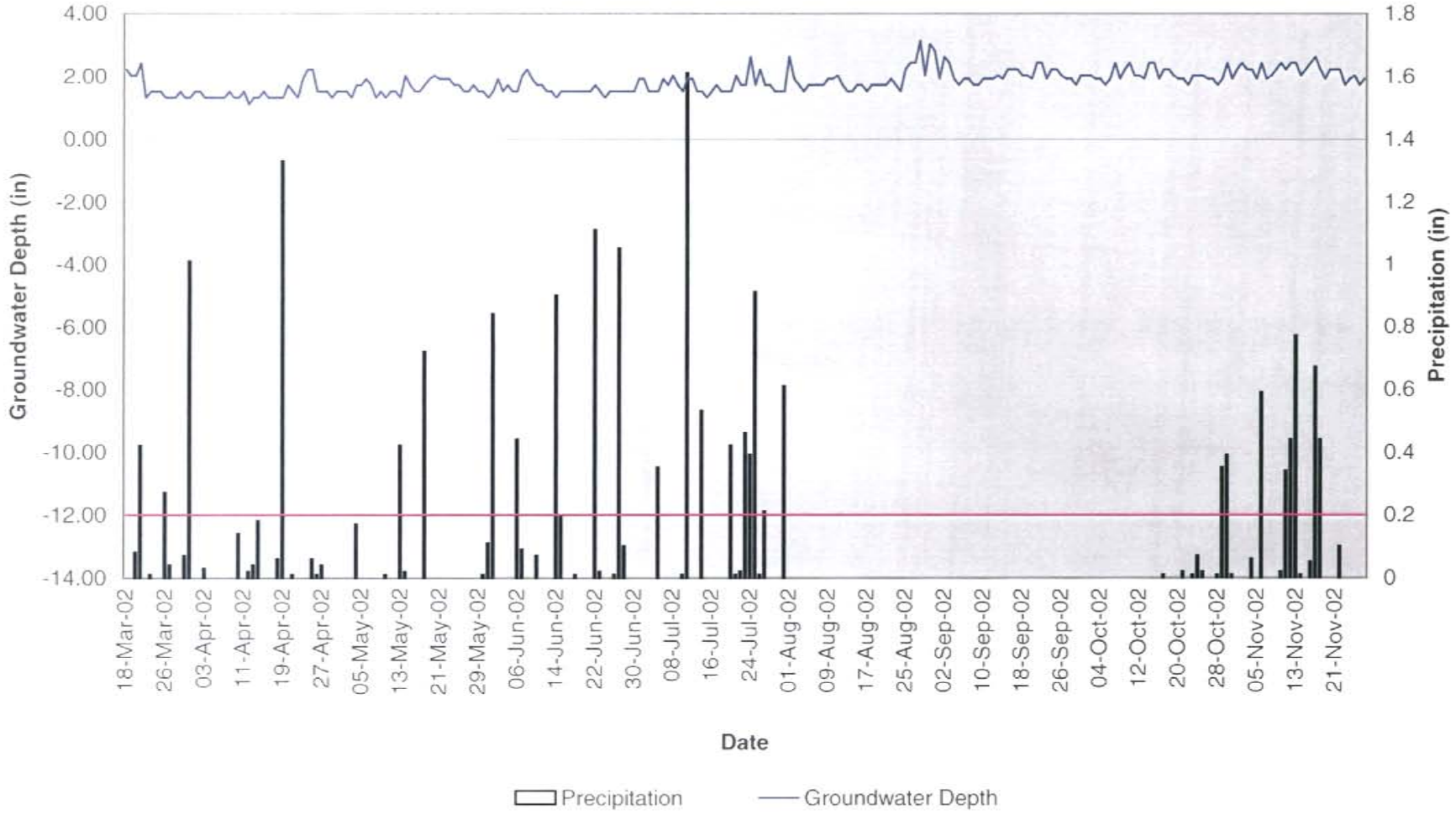


Grove Creek
Groundwater Gauge 13
2002
(Maximum Days Inundated or Saturated - 74)



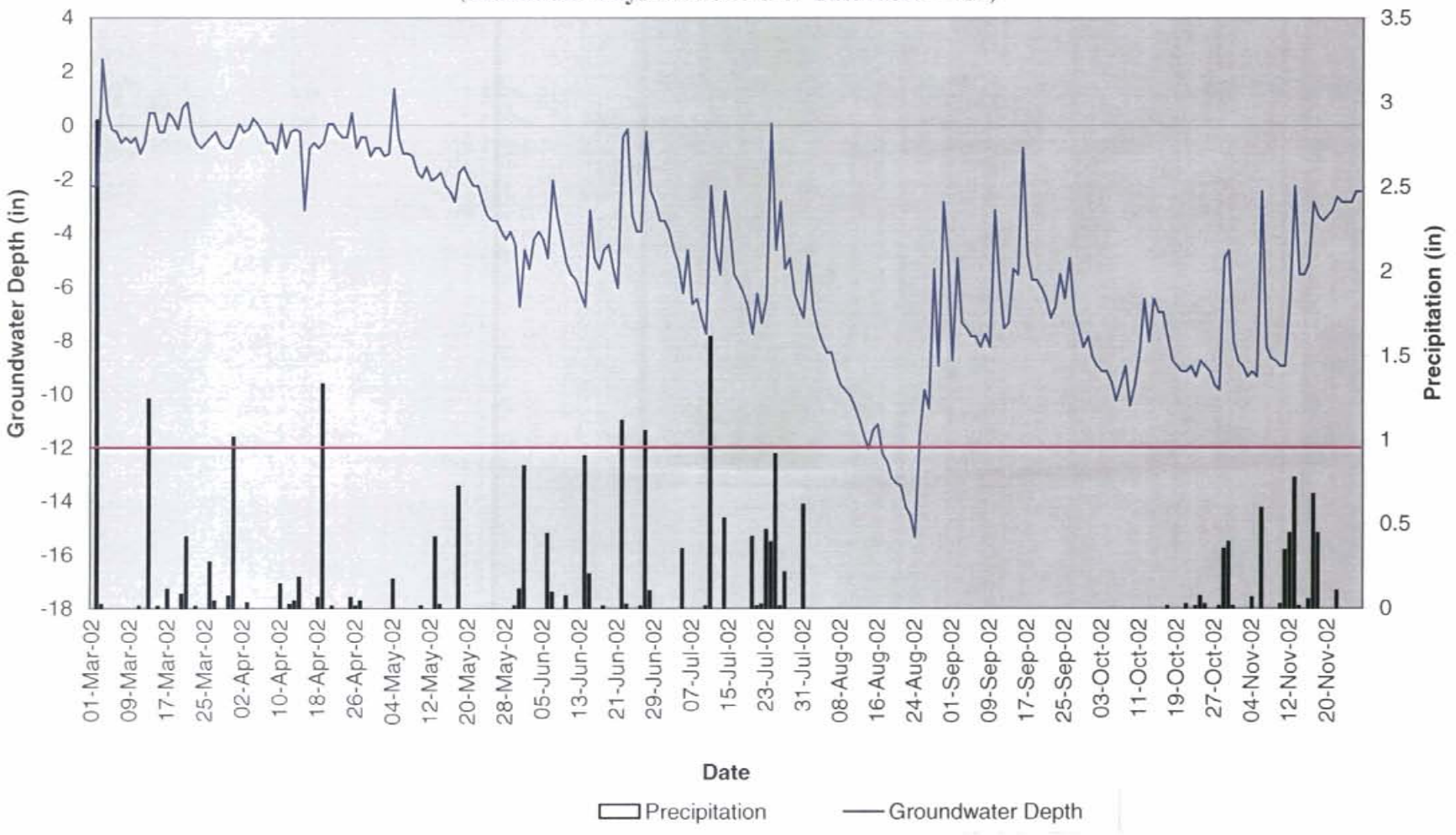
Grove Creek
Surfacewater Gauge 13
2002

(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



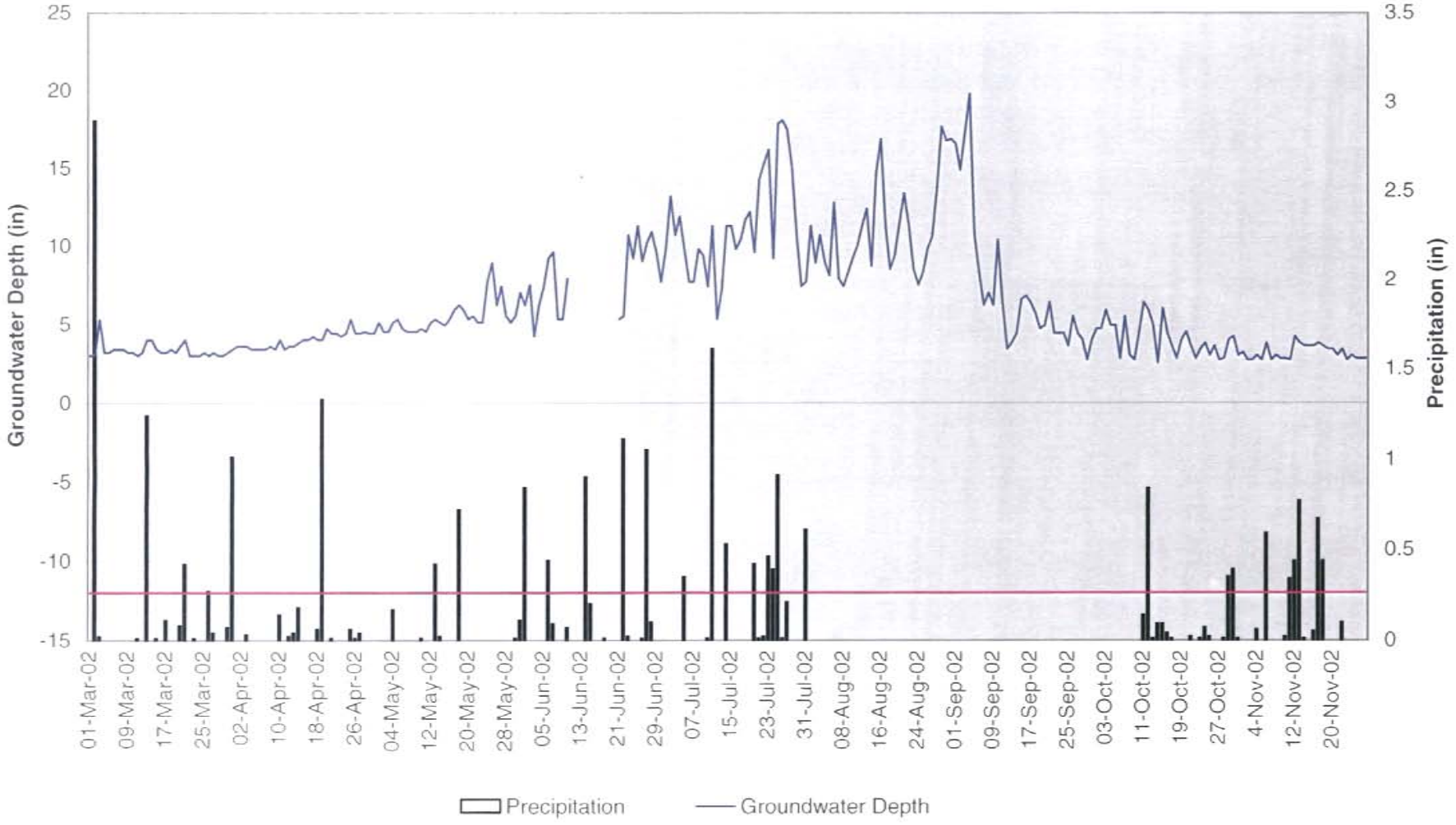
Grove Creek
Groundwater Gauge 14
2002

(Maximum Days Inundated or Saturated - 165)



Grove Creek
Surfacewater Gauge 14
2002

(Maximum Days Inundated or Saturated based on Groundwater Gauge Data)



APPENDIX C

NRCS SOIL VERFICATION LETTER

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
302 North Main Street, P. O. Box 219
Kenansville, NC 28349

June 17, 2002

Eric Black, Environmental Scientist
HSMM
1305 Navaho Drive, Suite 303
Raleigh, NC 27609

On May 28, 2002 I assisted you with soil identification at the Grove Creek area NC DOT tract which is east of Kenansville NC. I observed soil characteristics to determine the soil types at 33 sample sites where HSMM had previously gathered soil data. The USDA-NRCS Soil Survey update mapping was revised as a result of observations that were made.

HSMM Sample site	Map Unit Symbol	Map Unit Name	Special Symbol on USDA-NRCS mapping	USDA-NRCS observed soil and/or inclusion to the mapping	Observation: H=Hydric NH= Not Hydric
1.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Johnston with 14 inches overwash	H
2.	58A	Mandarin sand, 0 to 2 percent slopes	None	Echaw-like	NH
3.	58A	Mandarin sand, 0 to 2 percent slopes	None	Mandarin	NH
4.	58A	Mandarin sand, 0 to 2 percent slopes	None	Bibb-like	H
5.	58A	Mandarin sand, 0 to 2 percent slopes	None	Mandarin	NH
6.	50A	Leon sand, 0 to 2 percent slopes	None	Bisequal soil– Leon-like over Pactolus-like	H
7.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
8.	70A	Pactolus fine sand, 0 to 3 percent slopes	Wet spot	Bibb-like	H
9.	44A	John fine sandy loam, 0 to 2 percent slopes	None	Johns	NH
10.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
11.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Bibb	H
12.	80A	Torhunta mucky fine sandy loam, 0 to 1 percent slopes	None	Torhunta	H
13.	80A	Torhunta mucky fine sandy loam, 0 to 1 percent slopes	None	Torhunta-like	H
14.	80A	Torhunta mucky fine sandy loam, 0 to 1 percent slopes	None	Torhunta-like	H
15.	45A	Eunola sandy loam, 0 to 2 percent slopes, rarely flooded	None	Eunola	NH
16.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
17.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Lumbee	H
18.	70A	Pactolus fine sand, 0 to 3 percent slopes	Wet spot	Lumbee	H
19.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
20.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Johnston	H
21.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
22.	70A	Pactolus fine sand, 0 to 3 percent slopes	None	Pactolus	NH
23.	57A	Ogeechee fine sandy loam, 0 to 2 percent slopes	None	Ogeechee	H
24.	44A	John fine sandy loam, 0 to 2 percent slopes	None	Johns	NH

HSMM Sample site	Map Unit Symbol	Map Unit Name	Special Symbol on USDA-NRCS mapping	USDA-NRCS observed soil and/or inclusion to the mapping	Observation: H=Hydric NH= Not Hydric
25.	44A	John fine sandy loam, 0 to 2 percent slopes	Wet spot	Ogeechee with fine subsoil	H
26.	44A	John fine sandy loam, 0 to 2 percent slopes	None	Johns	NH
27.	44A	John fine sandy loam, 0 to 2 percent slopes	None	Pactolus	NH
28.	57A	Ogeechee fine sandy loam, 0 to 2 percent slopes	None	Lumbee	H
29.	57A	Ogeechee fine sandy loam, 0 to 2 percent slopes	None	Lumbee	H
30.	57A	Ogeechee fine sandy loam, 0 to 2 percent slopes	None	Eunola	NH
31.	58A	Mandarin sand, 0 to 2 percent slopes	None	Mandarin	NH
32.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Bibb	H
33.	7A	Bibb sandy loam, 0 to 1 percent slopes, frequently flooded	None	Leon	H

I hope this information will be helpful for you.

L. Lee Mallard III,
Duplin County Soil Survey Update Project Leader

APPENDIX D

GROVE CREEK MITIGATION SITE
PROPOSED MITIGATION AREAS PLAN VIEW

APPENDIX E

BOUSSINESQ DRAINAGE CALCULATIONS

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 1 of 11 DATE _____

COMM NO. 30036K CAL. BY _____ CKD. BY _____

Ditch 1

Soil - Ogeechee

$f = 0.05$

$d = 3.0$ ft

$h_0 = 7.5$ ft

$h = 6.5$ ft

$H = \frac{6.5}{7.5} = 0.87$

$D = \frac{4.5}{7.5} = 0.6$

$\frac{1}{\eta} = 0.90$

$K = 0.11$ ft/hr

$$x = \sqrt{\frac{0.11}{0.05} \times 7.5 \times 336}$$

$$0.90$$

$x = 82$ ft

Ditch 2

Soil - Ogeechee

$f = 0.05$

$d = 2.5$ ft

$h_0 = 6.25$ ft

$h = 5.25$ ft

$H = \frac{5.25}{6.25} = 0.84$

$D = \frac{3.75}{6.25} = 0.6$

$\frac{1}{\eta} = 1.05$

$K = 0.11$ ft/hr

$$x = \sqrt{\frac{0.11}{0.05} \times 6.25 \times 336}$$

$$1.05$$

$x = 65$ ft

EXHIBIT

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 2 of 11 DATE _____

COMM NO. 30036K CAL. BY _____ CKD. BY _____

Ditch 3

Soil - Ogeechee

$f = 0.05$

$d = 3.0$ ft

$h_0 = 7.5$ ft

$h = 6.5$ ft

$H = \frac{6.5}{7.5} = 0.87$

$D = 0.6$

$\frac{1}{\eta} = 0.9$

$K = 0.11$ ft/hr

$$x = \sqrt{\frac{\frac{0.11}{0.05} \times 7.5 \times 336}{0.90}}$$

$x = 82$ ft

Ditch 4

Soil - Pactolus

$f = 0.05$

$d = 4.5$ ft

$h_0 = 11.25$ ft

$h = 10.25$ ft

$H = \frac{10.25}{11.25} = 0.91$

$D = \frac{6.75}{11.25} = 0.6$

$\frac{1}{\eta} = 0.66$

$K = 1.08$ ft/hr

$$x = \sqrt{\frac{\frac{1.08}{0.05} \times 11.25 \times 336}{0.66}}$$

$x = 433$ ft

EXHIBIT

HAYES, SEAY, MATTERN & MATTERN, INC. ARCHITECTS ENGINEERS PLANNERS

HSMM Form Prod - 6

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 3 of 11 DATE _____

COMM NO. 30036K CAL. BY _____ CKD. BY _____

Ditch 5

Soil - Torhunta

$f = 0.05$

$d = 3.5$ ft

$h_o = 8.75$ ft

$h = 7.75$ ft

$H = \frac{7.75}{8.75} = 0.89$

$D = \frac{5.25}{8.75} = 0.6$

$\frac{1}{\eta} = 0.78$

$K = 0.67$ ft/hr

$$x = \sqrt{\frac{\frac{0.67}{0.05} \times 8.75 \times 336}{0.78}}$$

$x = 254$ ft

Ditch 6

Soil - Bibb, Pactolus, Torhunta

$f = 0.05$

$d = 2.0$ ft

$h_o = 5.0$ ft

$h = 4.0$ ft

$H = \frac{4.0}{5.0} = 0.80$

$D = \frac{3}{5} = 0.60$

$\frac{1}{\eta} = 1.35$

$K = 0.11$ ft/hr - Bibb

$K = 1.08$ ft/hr - Pactolus

$K = 0.67$ ft/hr - Torhunta

$$x = \sqrt{\frac{\frac{0.11}{0.05} \times 5.0 \times 336}{1.35}}$$

$x = 45$ ft - Bibb

$$x = \sqrt{\frac{\frac{1.08}{0.05} \times 5.0 \times 336}{1.35}}$$

$x = 141$ ft - Pactolus

$$x = \sqrt{\frac{\frac{0.67}{0.05} \times 5.0 \times 336}{1.35}}$$

$x = 111$ ft - Torhunta

EXHIBIT

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 4 of 11 DATE _____

COMM NO. 30036K CAL. BY _____ CKD. BY _____

Ditch 7

Soil - Bibb

$f = 0.05$

$d = 1.5$ ft

$h_0 = 3.75$

$h = 2.75$

$H = \frac{2.75}{3.75} = 0.73$

$D = \frac{2.25}{3.75} = 0.6$

$K = 0.11$ ft/hr

$\frac{1}{\eta} = 2.2$

$$x = \sqrt{\frac{0.11}{0.05} \times 3.75 \times 336} \Big/ 2.2$$

$x = 24$ ft

Ditch 8

Soil - Bibb, Pachalus

$f = 0.05$

$d = 2.5$ ft

$h_0 = 6.25$ ft

$h = 5.25$ ft

$H = \frac{5.25}{6.25} = 0.84$

$D = \frac{3.75}{6.25} = 0.6$

$\frac{1}{\eta} = 1.1$

$K = 0.11$ ft/hr - Bibb

$K = 1.08$ ft/hr - Pachalus

$$x = \sqrt{\frac{0.11}{0.05} \times 6.25 \times 336} \Big/ 1.1$$

$x = 62$ ft - Bibb

$$x = \sqrt{\frac{1.08}{0.05} \times 6.25 \times 336} \Big/ 1.1$$

$x = 194$ ft

EXHIBIT

HAYES, SEAY, MATTERN & MATTERN, INC. ARCHITECTS ENGINEERS PLANNERS

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 5 of 11 DATE _____

COMM NO. 30036K CAL. BY _____ CKD. BY _____

Ditch 9

Soil - Bibb, Pactolus

$f = 0.05$

$d = 2.0$ ft

$h_0 = 5.0$ ft

$h = 4.0$ ft

$H = \frac{4.0}{5.0} = 0.8$

$D = \frac{3.0}{5.0} = 0.6$

$\frac{1}{\eta} = 1.6$

$K = 0.11$ ft/hr

$K = 1.08$ ft/hr

$$x = \frac{\sqrt{\frac{0.11}{0.05} \times 5.0 \times 336}}{1.6}$$

$x = 40$ ft - Bibb

$$x = \frac{\sqrt{\frac{1.08}{0.05} \times 5.0 \times 336}}{1.6}$$

$x = 119$ ft Pactolus

Ditch 10

Soil - Bibb

$f = 0.05$

$d = 1.7$ ft

$h_0 = 4.25$ ft

$h = 3.25$ ft

$H = \frac{3.25}{4.25} = 0.76$

$D = \frac{2.55}{4.25} = 0.6$

$K = 0.11$ ft/hr

$\frac{1}{\eta} = 1.6$

$$x = \frac{\sqrt{\frac{0.11}{0.05} \times 4.25 \times 336}}{1.6}$$

$x = 35$ ft

EXHIBIT

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 6 of 11 DATE _____

COMM NO. 300361K CAL. BY _____ CKD. BY _____

Ditch - 11

Soil - Pactolus

$f = 0.05$

$d = 5.0$ ft

$h_0 = 12.5$ ft

$h = 11.5$ ft

$H = \frac{11.5}{12.5} = 0.92$

$D = 0.6$

$\frac{1}{n} = 0.66$

$K = 1.08$ ft/hr

$$X = \sqrt{\frac{1.08}{0.05} \times 12.5 \times 336}$$

$$0.66$$

$x = 456$ ft

Ditch 12

Soil - Mandarin

$f = 0.05$

$d = 6.0$ ft

$h_0 = 15$ ft

$h = 14$ ft

$H = \frac{14}{15} = 0.93$

$D = \frac{9}{15} = 0.6$

$\frac{1}{n} = 0.62$

$K = 0.83$ ft/hr

$$X = \sqrt{\frac{0.83}{0.05} \times 15.0 \times 336}$$

$$0.62$$

$x = 467$ ft

EXHIBIT

HSMM
FIFTY YEARS

PROJECT Grove Creek

TYPE _____ PREL. _____ FINAL _____

CONTENTS _____ SHEET NO. 7 of 11 DATE _____

COMM NO. 30076K CAL. BY _____ CKD. BY _____

Ditch 13

Soil - Ogeechee

$f = 0.05$

$d = 5.2$ ft

$h_1 = 13.0$ ft

$h = 13.0$ ft

$H = \frac{12}{13} = 0.92$

$D = \frac{7.8}{13} = 0.6$

$\frac{1}{\eta} = 0.62$

$K = 0.11$ ft/hr

$$X = \sqrt{\frac{0.11}{0.05} \times 13.0 \times 336}$$

$$0.62$$

$X = 158$ ft

Ditch 14

Soil - Ogeechee

$f = 0.05$

$d = 4.2$ ft

$h_0 = 10.5$ ft

$h = 9.5$

$H = \frac{9}{10} = 0.90$

$D = \frac{6.3}{10.5} = 0.6$

$\frac{1}{\eta} = 0.74$

$K = 0.11$ ft/hr

$$X = \sqrt{\frac{0.11}{0.05} \times 10.5 \times 336}$$

$$0.74$$

$X = 119$ ft

EXHIBIT

Ditch 15
Soil - Loam
$f = 0.05$
$d = 4.0$ ft
$h_0 = 10$ ft
$h = 9$ ft
$H = \frac{9}{10} = 0.90$

$D = \frac{6}{10} = 0.6$

$K = 0.68$ ft/hr
$\frac{1}{\eta} = 0.74$

$$x = \sqrt{\frac{0.68}{0.05} \times 10 \times 336}$$
$$0.74$$
$x = 288$ ft

Ditch 16
Soil - Bibb
$f = 0.05$
$d = 2.0$ ft
$h_0 = 5.0$ ft
$h = 4.0$ ft
$H = \frac{4.0}{5.0} = 0.8$

$D = \frac{3}{5} = 0.6$

$\frac{1}{\eta} = 1.3$

$K = 0.11$ ft/hr

$$x = \sqrt{\frac{0.11}{0.05} \times 5.0 \times 336}$$
$$1.3$$
$x = 47$ ft

EXHIBIT

HSMM
ARCHITECTS ENGINEERS PLANNERS

PROJECT Grove Creek COMM NO 30036K
TITLE
DATE
DES BY DEPT REV DATE
CKD BY SKETCH SK- SHEET NO 9 OF 11

Ditch 17

Soil - Bibb

$f = 0.05$

$d = 1.7$ ft

$h_0 = 4.25$ ft

$h = 3.25$ ft

$H = \frac{3.25}{4.25} = 0.76$

$D = \frac{2.55}{4.25} = 0.6$

$\frac{1}{\eta} = 1.60$

$K = 0.11$ ft/hr

$$y = \frac{\sqrt{\frac{0.11}{0.05} \times 4.25 \times 336}}{1.6}$$

$x = 35$ ft

Ditch 18

Soil - Leon

$f = 0.05$

$d = 1.0$ ft

$h_0 = 2.5$

$h = 1.5$

$H = \frac{1.5}{2.5} = 0.6$

$D = \frac{1.5}{2.5} = 0.6$

$\frac{1}{\eta} = 2.7$

$K = 0.68$ ft/hr

$$x = \frac{\sqrt{\frac{0.68}{0.05} \times 2.5 \times 336}}{2.7}$$

$x = 40$ ft

EXHIBIT

HSMM
ARCHITECTS ENGINEERS PLANNERS

PROJECT Grove Creek COMM NO 7007614
TITLE
DATE
DES BY DEPT REV DATE
CKD BY SKETCH SK- SHEET NO 10 OF 11

Ditch 19

Soil - Bibb
f = 0.05
d = 2.67 ft - Average Depth
h_0 = 6.68 ft
h = 5.68 ft
$H = \frac{5.68}{6.68} = 0.85$
$D = \frac{4.01}{6.68} = 0.60$
$\frac{1}{\eta} = 1.05$
K = 0.111 ft/hr

$$x = \frac{\sqrt{\frac{0.111}{0.05} \times 6.68 \times 336}}{1.05}$$

x = 67 ft

Ditch 20

Soil - Bibb
f = 0.05
d = 3.5 ft - Average Depth
h_0 = 8.75 ft
h = 7.75 ft
$H = \frac{7.75}{8.75} = 0.89$
$D = \frac{5.25}{8.75} = 0.6$
$\frac{1}{\eta} = 0.78$
K = 0.111 ft/hr

$$x = \frac{\sqrt{\frac{0.111}{0.05} \times 8.75 \times 336}}{0.78}$$

x = 103 ft

Ditch 21

Soil - Bibb
f = 0.05
d = 2.3 ft average
h_0 = 5.75 ft
h = 4.75 ft
$H = \frac{4.75}{5.75} = 0.82$
$D = \frac{3.45}{5.75} = 0.6$
$\frac{1}{\eta} = 1.2$
K = 0.111 ft/hr

$$x \sqrt{\frac{0.11}{0.05} \times 5.75 \times 336}$$
$$1.2$$

x = 54 ft

EXHIBIT

HSMM
ARCHITECTS ENGINEERS PLANNERS

PROJECT Grove Creek COMM NO 30036K
TITLE
DATE
DES BY DEPT REV DATE
CKD BY SKETCH SK- SHEET NO 11 OF 11

Ditch 22

Soil - B.bb

$f = 0.05$

$d = 2.5$ ft

$h_0 = 6.25$ ft

$h = 5.25$ ft

$H = \frac{5.25}{6.25} = 0.84$

$D = \frac{3.75}{6.25} = 0.6$

$\frac{1}{\eta} = 1.1$

$K = 0.11$ ft/hr

$$x = \frac{\sqrt{\frac{0.11}{0.05} \times 6.25 \times 336}}{1.1}$$

$x = 62$ ft

EXHIBIT