Water Resource Inventory and Assessment (WRIA):
Erwin National Fish Hatchery, Unicoi County, Tennessee

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Unicoi County, Tennessee

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COVER PHOTO: Aerial View of Erwin National Fish Hatchery. Photo credit: Herbert Bollin (retired), USFWS 1990.

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Table of Contents

List of Figures

List of Tables

1 Executive Summary

The Water Resource Inventory and Assessment (WRIA) for Erwin National Fish Hatchery (Erwin NFH or the hatchery) summarizes available and relevant information for hatchery water resources. One of the primary emphases of the document is to provide recommendations to address any perceived threats, needs, or concerns (immediate and long-term) on the hatchery related to water resources. Topics addressed within the WRIA report include the hatchery's natural setting (topography, climate, geology, soils, hydrology), impacts of development within the associated watershed(s), potential effects from climate change, hatchery infrastructure in relation to water resources, historic and current water monitoring activities on and near the hatchery, water quality and quantity information, and state water use regulatory guidelines. All of this information was compiled from publicly available reports (e.g., published research reports), databases (e.g., websites maintained by government agencies, academic institutions, and non-governmental organizations), and geospatial datasets from federal, state, and local agencies. The primary drivers of the threats and issues of concern identified in this WRIA are the anthropogenic and environmental stressors occurring within the Nolichucky River watershed, and more specifically within the North Indian Creek subwatershed, which is identified by the 12-digit Hydrologic Unit Code (HUC) 060101080605. Because hatchery water supply is dependent on groundwater from a local spring, determining a region of hydrologic influence (RHI) for Erwin NFH based solely on surface water was complicated. However, the North Indian Creek subwatershed was identified as the most appropriate classification for inventorying water resources and includes areas of potential groundwater recharge as related to hatchery operations.

1.1 Findings

- The potential for concerns regarding impacts to the water resources for Erwin NFH are highly warranted, especially when considering that the identified RHI includes some uncertainty in regards to groundwater supply, rate of recharge, and susceptibility to contamination.

- The identified RHI for the hatchery encompasses a drainage area of 37,897 acres. Within the hatchery's RHI, there are approximately 250 miles of streams, including 70 miles of named streams.

- There appears to be two distinct groundwater supplies on the hatchery. While the Erwin NFH RHI is located entirely within the Blue Ridge physiographic province, Valley and Ridge and Blue Ridge crystalline rock aquifers are both found within the RHI and this may explain the two different groundwater sources at the Erwin NFH.

- Historic groundwater mean discharge for the spring monitoring well located within the hatchery property boundary is 2.5 cubic feet per second (cfs), with a range of 1.9 to 3.2 cfs.

- There are eight identified USGS stream gages near the hatchery. However, none of the gages are currently actively monitored.

- The hatchery, and the RHI, is located on lands with an expansive karst system. This poses issues with groundwater because karst systems are vulnerable to contamination due to the lack of natural filtering systems such as vegetation and soils.

- The primary water quality problems experienced by the hatchery are sediment contamination from runoff and potential contamination from wildlife vectors. The majority of these issues stem from non-point sources of erosion and runoff outside the hatchery's boundaries.

- Approximately 26 miles of stream within the Erwin NFH RHI are identified for TMDL (total maximum daily load) classifications. A siltation/habitat alteration TMDL has been created for portions of North Indian Creek and its tributaries of Scioto Creek, Oldfield Branch, and Cove Branch.

- Detailed and clearly defined water law rights are lacking for Tennessee. Tennessee follows a system of riparian rights for surface water use with minimal regulation. Land owners are entitled to reasonable water use, which may include purpose, suitability to the aquifer or watercourse, economic value, social value, extent or potential for harm caused, practicality of avoidance or adjustment and impacts on the rights of others.

- Tennessee has less water resources planning, supply management, coordination and regulations restricting groundwater use than many other states and its existing statute lacks substance and specificity. The absence of state water rights regulations could negatively affect the hatchery when changes in water availability become problematic as a result of climate change, increased upstream development, or other unforeseen circumstances.

1.2 Key Water Resources Issues of Concern

Groundwater quantity and quality is a major concern for Erwin National Fish Hatchery. The hatchery's water supply is completely dependent upon groundwater. This groundwater is supplied in the form of a spring (Tate Branch Spring) and a well. Testing indicates that the spring and well are potentially drawing from two separate aquifer units/formations. Because of the dependency on these groundwater resources, any threats in the form of water quantity (e.g., increased demand) or water quality (e.g., contamination) could have detrimental impacts to hatchery operations.

Multiple issues warrant concern for the hatchery's available water supply (quantity). One such example includes the lack of regulatory authority within the state in regards to groundwater use and subsequent water rights. The absence of state water rights regulations could negatively affect the hatchery when changes in water availability become problematic as a result of climate change (e.g., impacts from drought conditions) and increased upstream development, which would result in increased demand and use of those aquatic resources.

Water quality issues are largely related to the topography and geological formations of the area. Karst terrain, which underlies the area beneath Erwin NFH, typically has very high rates of contamination transport under rapid recharge conditions, such as storm events. This is particularly concerning to public and private water supplies that utilize wells or springs. Pathogens and contaminants can quickly spread to groundwater sources when surface water is introduced from heavy storm events.

Also of concern is increased surface water runoff associated with heavy rain events. Development upslope of the hatchery, perceived increases in extreme precipitation events (potentially associated with climate change), and infrastructure surface water drainage constraints, can all complicate hatchery operations with increased amounts of runoff. Additionally, contamination from these surface runoff waters is a potential concern.

1.3 Recommendations

Highlights of the needs and recommendations for Erwin NFH are summarized below. A more in-depth discussion of needs and recommendations is provided in Section 6.2.

Generalized recommended actions to begin addressing potential impacts to hatchery water resources include: 1) Identify areas/issues that are most likely to be negatively impacted by effects of climate change, 2) Identify opportunities to increase the understanding of groundwater and recharge rates within the RHI and associated relationship to hatchery operations, 3) Establish a decision-making process that places emphasis on, prioritizes, and addresses any hatchery operational constraints (e.g., infrastructure, staffing, etc.), and 4) Continue with the development and coordination of local support for the hatchery, including working with state and federal partners to gain a better understanding of the issues and needs associated with the water resources within the area.

From the generalized recommended actions, one of the primary recommendations is to establish, or build upon, partnerships with local, state, and federal agencies. By developing better and more collaborative partnerships, most of the additional recommendations (e.g., monitoring groundwater resources, distinction of the two groundwater sources, water quality monitoring, addressing runoff issues, etc.) will be easier to facilitate and accomplish. In addition to developing and maintaining partnerships, a complete assessment of the hatchery's drainage capacity (as related to runoff) and infrastructure is needed. This assessment should consider the practicality of implementing actions to divert storm water around/away from areas that are susceptible and the possibility of conducting cost/benefit risk analyses to identify and evaluate potential priority infrastructure upgrades.

2 Introduction

This Water Resource Inventory and Assessment (WRIA) Summary Report for Erwin National Fish Hatchery (NFH) describes current hydrologic information, provides an assessment of water resource needs and issues of concern, identifies critical data gaps and makes recommendations regarding hatchery water resources. This Summary Report synthesizes more comprehensive water resource data contained in the national interactive online WRIA database. The document is intended to be a reference for ongoing water resource management and strategy development. However, the report is not meant to be an exhaustive or historical summary of activities at Erwin NFH or within the RHI. This WRIA was developed in conjunction with the hatchery manager, hatchery staff, and regional U.S. Fish and Wildlife Service (USFWS) staff. The document incorporates hydrologic information compiled between May 2013 and December 2014. The information contained within this report and supporting materials will be entered into the national WRIA database for storage, online access, and consistency with future WRIAs.

The long term goal of the National Wildlife Refuge System (NWRS) and National Fish Hatchery System (NFHS) WRIA effort is to provide up-to-date, accurate data on system water quantity and quality in order to acquire, manage, and protect adequate supplies of clean and fresh water. An accurate water resources inventory is essential to prioritize issues and tasks, and to take prescriptive actions that are consistent with the established purposes of the hatchery. Reconnaissance-level water resource assessments evaluate water rights, water quantity, known water quality issues, water management, potential water acquisitions, threats to water supplies, and other water resource issues for each facility.

WRIAs are recognized as an important part of the NWRS Inventory and Monitoring (I&M) initiative and are outlined in the I&M Operational Blueprint as Task 2a (USFWS 2010). The Erwin National Fish Hatchery, located in USFWS Region 4 (Figure 1), has been prioritized based on the Service's Risk Assessment Matrix (RAM) and Risk Management Matrix (RMM) analyses for climate change and non-climate change stressors to National Fish Hatcheries (Figiel Jr. and Dikeman 2011). Additionally, hatchery responses to a questionnaire which focused on the impacts of climate change on water resources were considered in prioritizing Erwin NFH (USFWS 2012) for WRIA development.

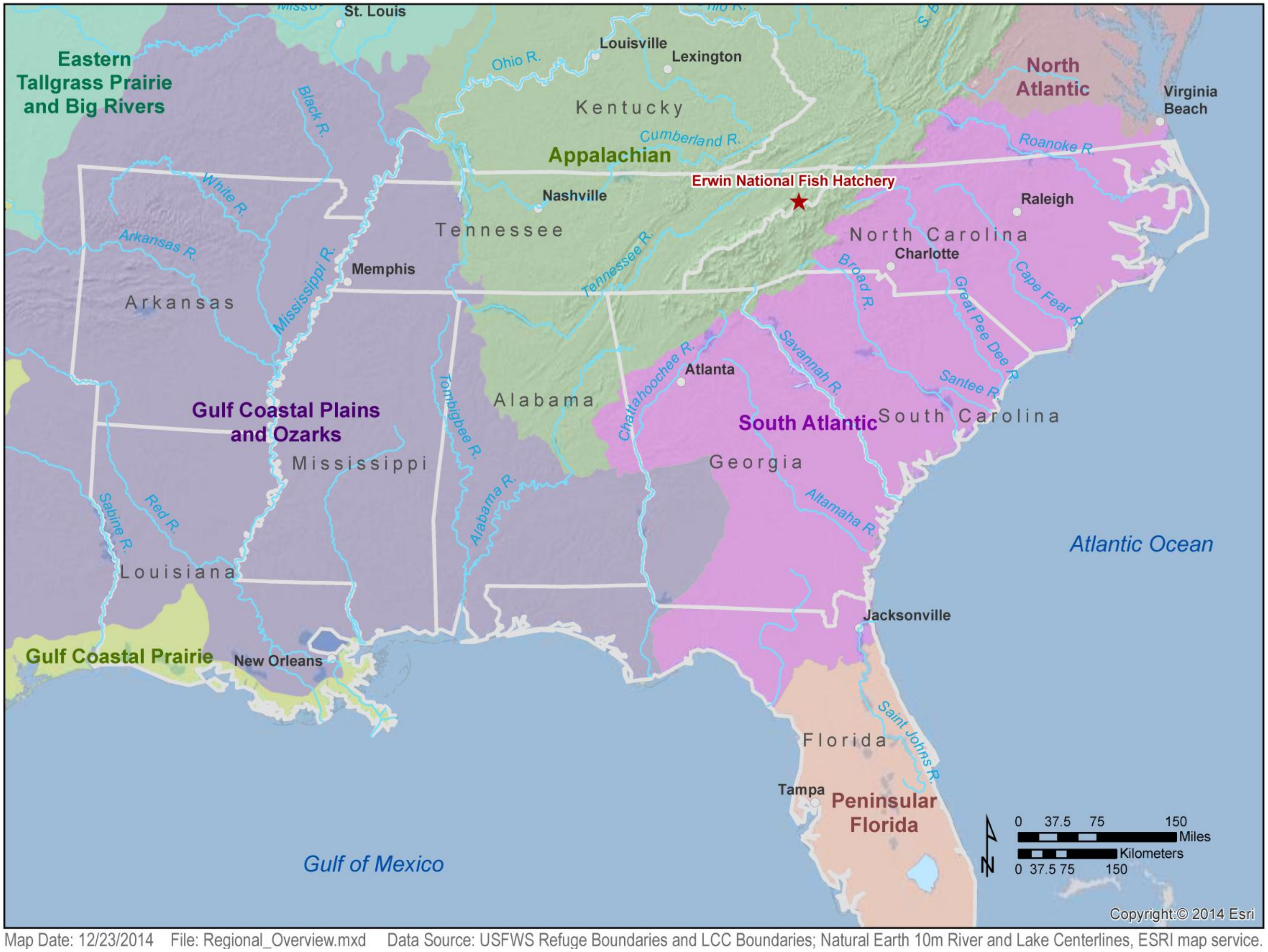


Figure 1. Location of Erwin NFH in relation to U.S. Fish and Wildlife Service (USFWS) Region 4 Landscape Conservation Cooperative Boundaries.

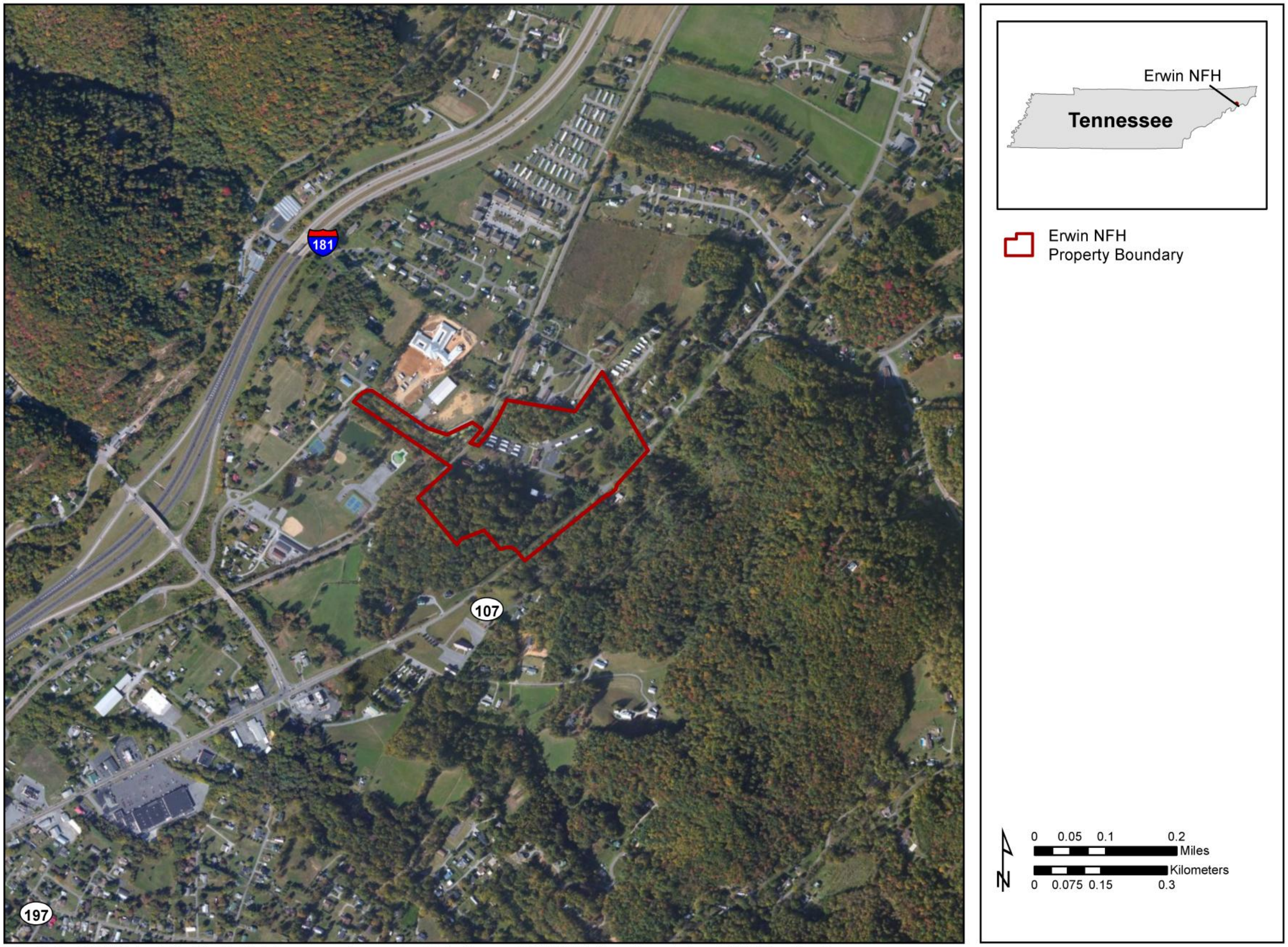
3 Facility Information

The Erwin NFH (the hatchery) is located in northeastern Tennessee, in Unicoi County near the town of Erwin, approximately 14 miles south of Johnson City, TN and 50 miles north of Asheville, NC. It is located in the Appalachian Landscape Conservation Cooperative (Figure 1). The hatchery, established by the USFWS in 1894, produces 10 to 15 million disease-free trout eggs annually. Erwin NFH is one of only three federal facilities that produce broodstock rainbow trout eggs. These eggs are produced from three unique domestic strains of rainbow trout broodstock that can no longer be obtained from the wild (USFWS 2013). These eggs are shipped to other Federal, State and Tribal hatcheries to support their fishery management efforts. The hatchery also provides eggs to research centers, classrooms, universities, and non-profit organizations (e.g., Trout Unlimited).

Fish stockings are a vital component of promoting outdoor recreational activities throughout much of the U.S., especially in the Southeast. For instance, nearly 7 million trout are stocked in the waters of Tennessee, Georgia, Alabama, Arkansas, Kentucky, North Carolina and Oklahoma annually. These stocking efforts have contributed to the economies of each respective state by promoting recreational activities. The overall total economic impact associated with such stocking efforts has been estimated to provide over 3,000 jobs and generate approximately $300 million in total economic output. As such, it is understandable why and how the Erwin NFH is considered to be an important driver for the Unicoi County (TN) economy and community. The Erwin NFH also has played a critical role in helping generate the aforementioned economic output by supplying the National Fish Hatchery System (NFHS) with high-quality trout eggs (Heil 2013).

The current Erwin NFH property encompasses approximately 31 acres[1] with no established acquisition boundary (Figure 2). The hatchery derives its water supply from a spring located on the property that produces approximately 1,200 gallons per minute (gpm), with supplemental water provided by a groundwater well located approximately 300 feet from the spring. Effluent from the hatchery flows underneath railroad tracks at the backside of the property into a settling pond, which eventually discharges into North Indian Creek and then to the Nolichucky River. Further details about the hatchery's water supply and facilities are provided in Sections 5.1 and 5.2, respectively.

[1] For the purposes of this report, all units are expressed in English measures, unless citing information from a primary source where the native data are presented in metric units. In those cases, the English unit conversions are also provided.



Map Date: 12/23/14 File: Fig_2_Hatchery_overview.mxd Data Source: USFWS Refuge Boundaries, ESRI Map Service.

Figure 2. Erwin NFH location map.

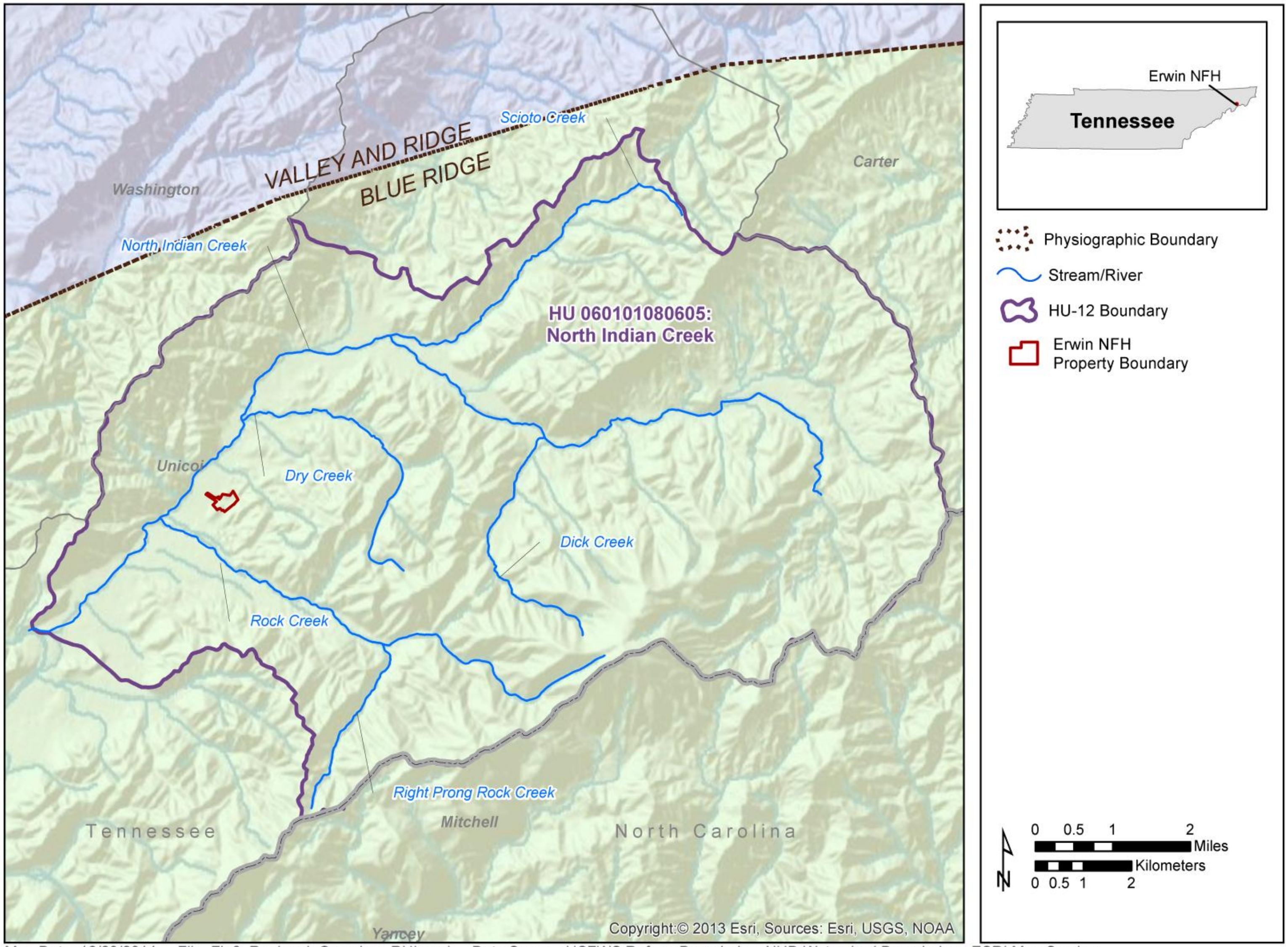
4 Natural Setting

4.1 Region of Hydrologic Influence (RHI)

This assessment focuses on water resources within the geographic extent of the hatchery property boundary, and more broadly on water resources within a Region of Hydrologic Influence (RHI) containing the hatchery (Figure 3). Generally, the RHI describes some portion of the watershed – either the entire or partial watershed – upstream of the hatchery that affects the condition of water resources at the hatchery. This construct anchors the hatchery in the greater watershed and thereby provides a reference for discussing the hatchery within a watershed context. Because water travels down gradient, it is the activities occurring upstream of the hatchery that will tend to most directly affect water quantity (e.g., diversions, withdrawals, land cover changes) or water quality (e.g., pollution from agricultural, urban, or industrial land uses) on the hatchery. The RHI for this WRIA is based on the North Indian Creek subwatershed, which is identified by the following 12-digit Hydrologic Unit Code (HUC): 060101080605 (Figure 3). Hatchery water supply is dependent on groundwater from a local spring, so determining a RHI for Erwin NFH based on a surface water catchment may not accurately reflect the area within the groundwater catchment of the spring. However, in the absence of specific information on the groundwater catchment area for the spring, the North Indian Creek subwatershed was selected as an appropriate RHI for this WRIA. Given its topographic position as a headwaters catchment, it is probable that the North Indian Creek subwatershed includes the recharge areas for groundwater feeding the spring upon which the hatchery relies. This subwatershed captures the underlying geologic formations that likely contain the spring's source water, and also includes the town of Erwin and the ridges upslope of the hatchery. The RHI for Erwin NFH includes a total drainage area of 37,897 acres.

4.2 Topography and Landforms

The hatchery is located in the North Fork Indian Creek subwatershed, a subwatershed of the Nolichucky River subbasin, which is a part of the Tennessee River drainage basin. The hatchery is located within the Blue Ridge physiographic province (Figure 3). The Valley and Ridge physiographic province is located very close to the Erwin RHI, but is outside of the RHI boundaries. It is likely that both Blue Ridge as well as Valley and Ridge aquifers are located within the Erwin RHI. See Section 4.3 for more information about Erwin RHI aquifers. The region is rugged with steeply sloped and narrow ridges, broad mountains and high relief. The elevation of the Erwin NFH is at approximately 1,760 feet mean sea level (MSL). The hatchery is located in a low area with a sloping ridge across Highway 107 to the southeast and is located within the greater North Indian Creek Valley between Unicoi and Erwin, TN.



Map Date: 12/23/2014 File: Fig3_Regional_Overview_RHI.mxd Data Source: USFWS Refuge Boundaries, NHD Watershed Boundaries, ESRI Map Service.

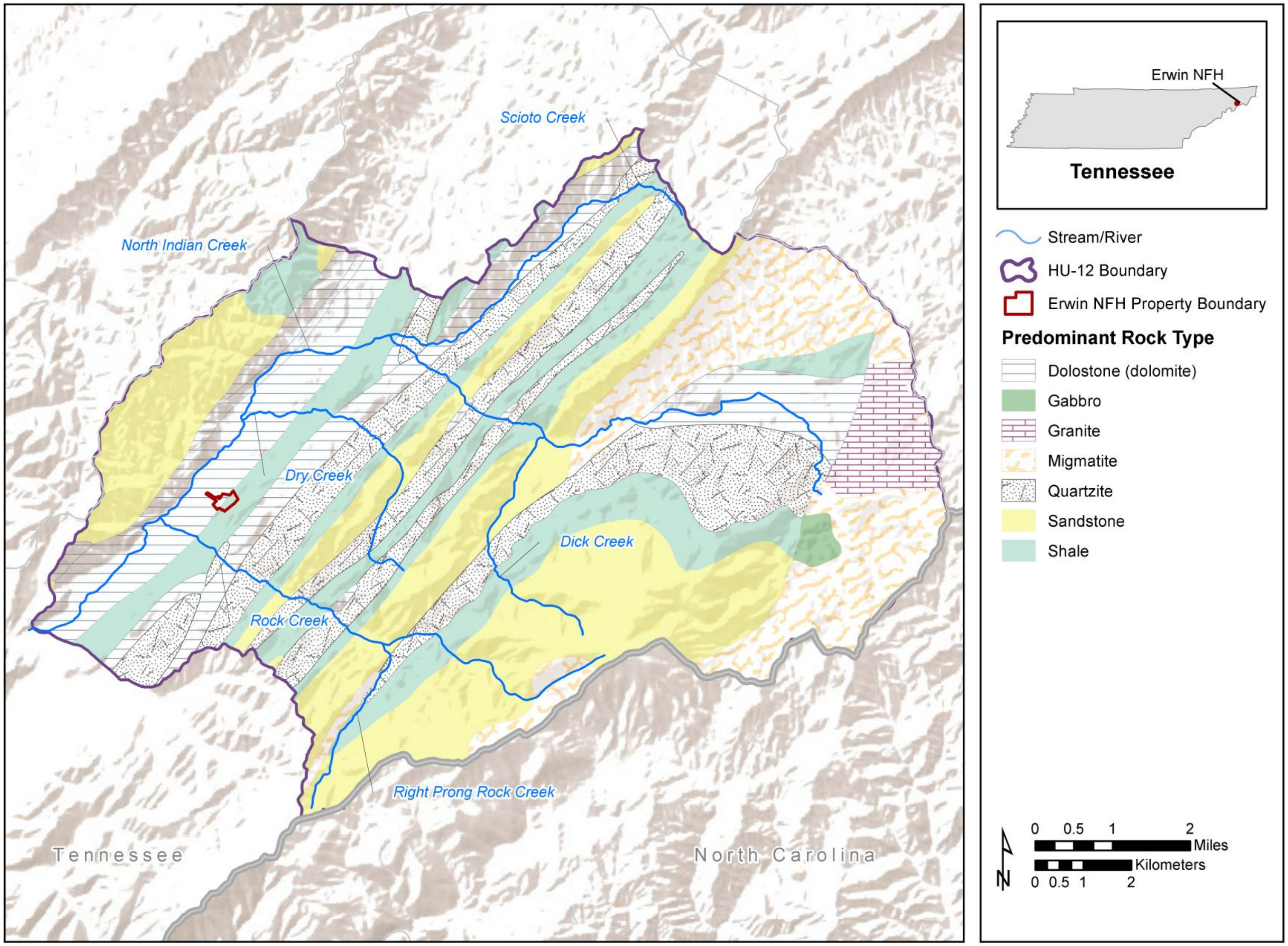
Figure 3. Topographic overview map showing Erwin NFH in relation to its Region of Hydrologic Influence (RHI), major named streams, and physiographic provinces.

4.3 Geology and Hydrogeology

The entire Erwin NFH RHI lies within Unicoi County and falls within the Unaka Mountain range of the Blue Ridge Province. The Unaka Mountains consist of two parallel subordinate beds, which are separated by a long straight valley. The Buffalo and Rich mountains make up the western bed, and the Bald Mountains make up the eastern bed. Faulting and folding has occurred throughout the county, causing deep gorges and valleys cut by geologic erosion. Mountain ranges make up about 85% of the county, with areas underlain by granite, gneiss and schist found primarily in the southern part of the county (NRCS 1985). Three dolomite formations underlie the main valley – the Honaker, Shady and Knox Formations. These formations are associated with a large band of siltstone, sandstone, shale, dolomite and limestone (Figure 4, NRCS 1985).

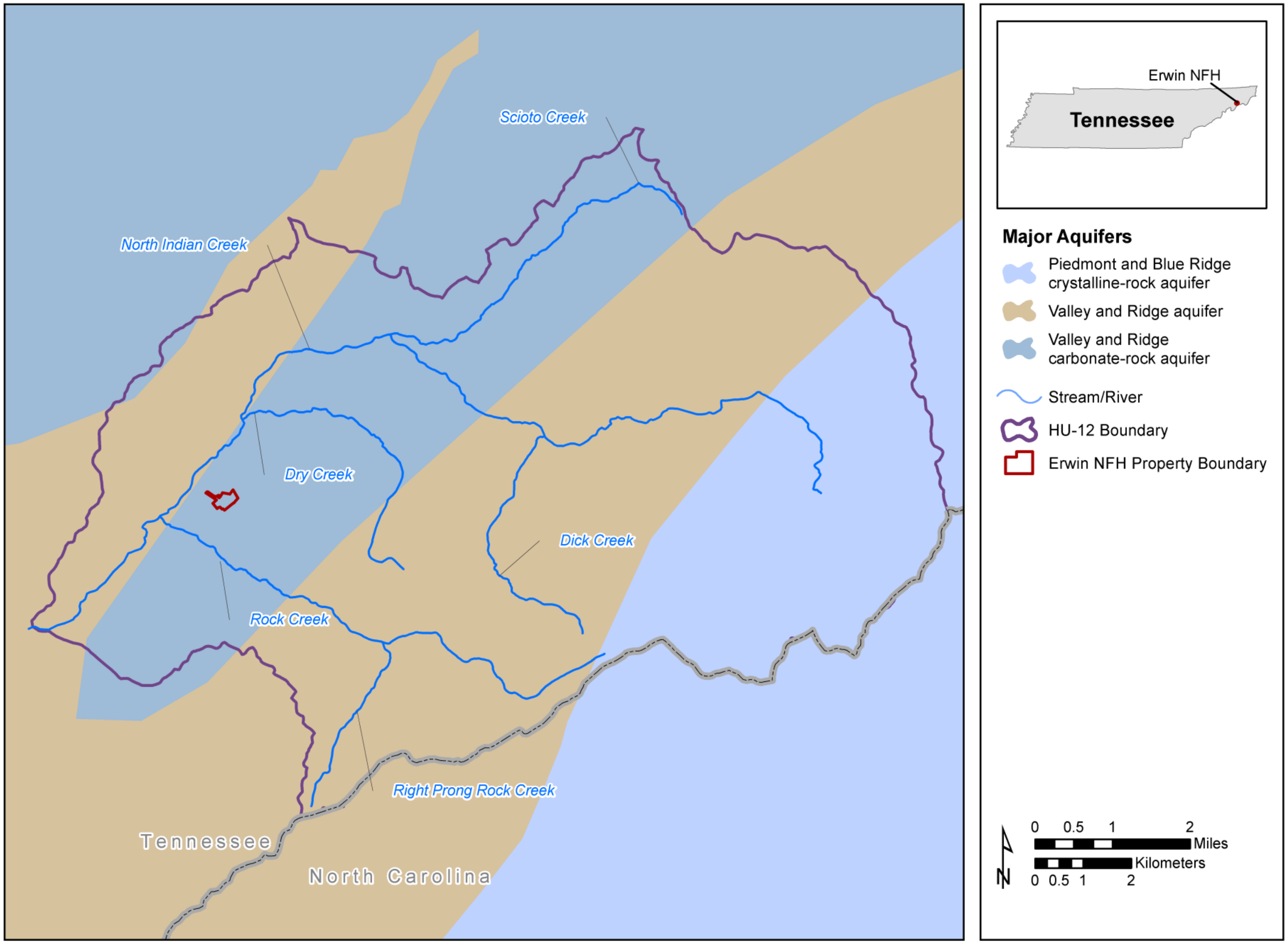
About 450 million years ago, the crystalline rocks of the Blue Ridge were forced up and over younger carbonate rocks to the west. In places such as the valley surrounding Erwin NFH, the Precambrian Blue Ridge rocks have eroded through to the Cambrian-Ordovician carbonates (TDEC 2008a). As such, the underlying geology is subject to karst development and cave formation (Figure 4). The term karst refers to limestone and dolomites (magnesium-rich limestone) where the dissolution of rocks creates enlarged channels and micro fractures for groundwater flow. Karst terrain typically includes sinkholes, springs, caves and disappearing surface water flow. Groundwater within the vicinity of the hatchery is further described in sections 5.1.3 and 5.1.4.

The East Tennessee aquifer system spans the Blue Ridge and Valley and Ridge physiographic provinces. Unlike other regional aquifers, the East Tennessee system is delineated on the basis of its structural and physiographic setting, rather than its stratigraphy. The area is underlain by rocks of Precambrian to Mississippian age which have repeatedly been structurally deformed and faulted during the Appalachian orogeny (Brahana et al 1986). The aquifers in the Blue Ridge province, which can be found in the eastern portion of the RHI, are crystalline rock aquifers composed of Precambrian and Cambrian dolomite, granite gneiss, phyllite and metasedimentary rocks overlain by thick regolith. The system is generally unconfined and high yields occur in the Shady Dolomite, a principal aquifer, or deep colluviums and alluvium (Webbers 2003). In the Valley and Ridge aquifers near the hatchery, water circulation is largely limited to interconnected fractures and solution openings (Brahana et al 1986). Rock in the Valley and Ridge carbonate-rock aquifer consists of structurally complex limestone, dolomite, sandstone and shale formations of Cambrian-Ordovician age (Figure 5). The Knox Group and Honaker Dolomite are principal water-bearing units. They commonly range between 100-300 feet in depth, and may exceed 400 feet. Common yields are 5-200 gallons per minute (gpm). Water is generally hard and may be brine below 3,000 feet (Webbers 2003).



Map Date: 12/23/2014 File: Fig4_Generalized_Geology.mxd Data Source: USFWS Refuge Boundaries, USGS Mineral Resources, NHD Watershed Boundaries, ESRI Map Service.

Figure 4. Generalized geology in the vicinity of Erwin NFH.



Map Date: 12/23/2014 File: Fig5_Regional_Overview_Aquifers.mxd Data Source: USFWS Refuge Boundaries, USGS Major Aquifers, NHD Watershed Boundaries, ESRI Map Service.

Figure 5. Regional aquifers in the vicinity of Erwin NFH.

4.4 Soils

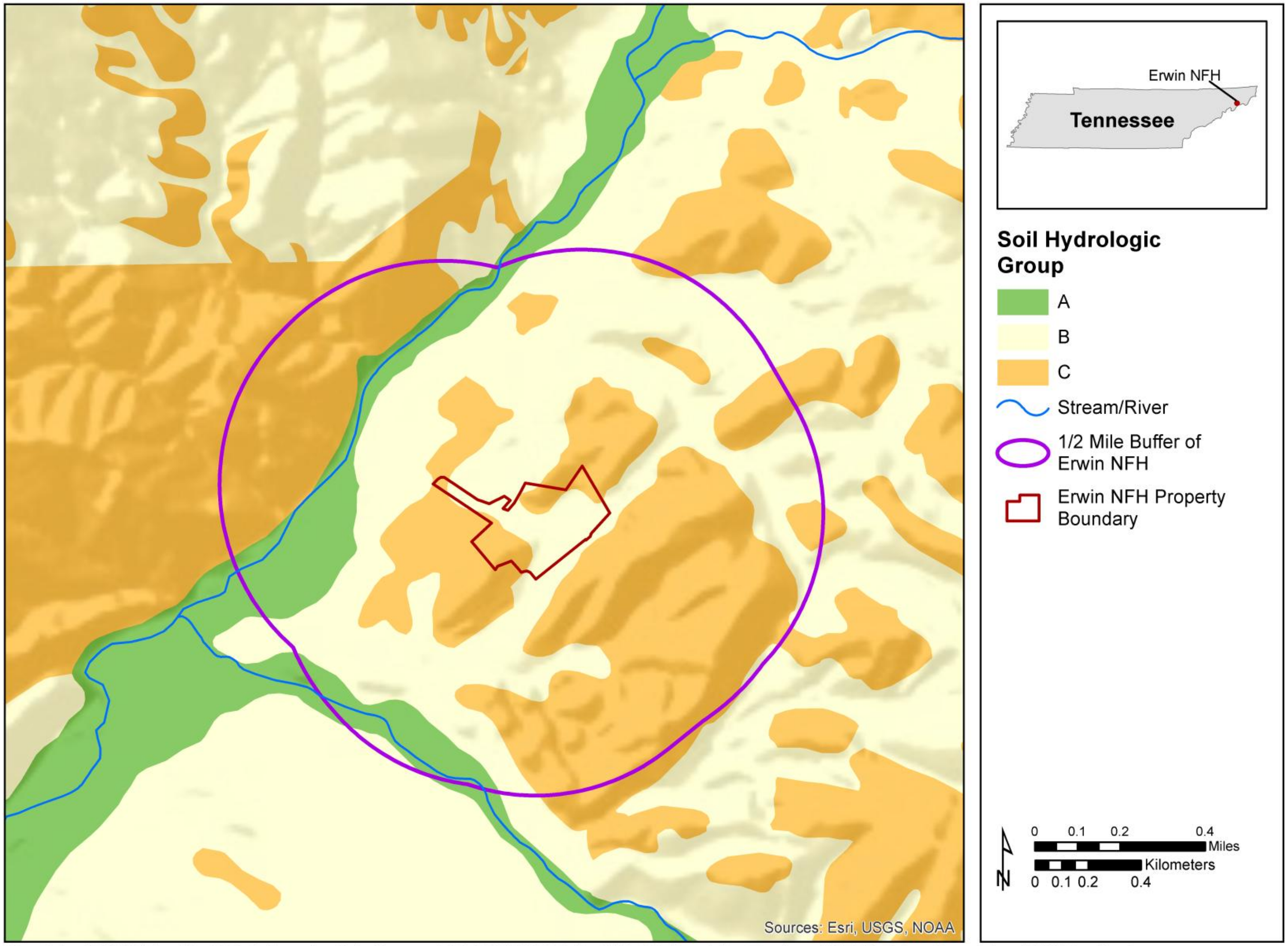
Within the RHI, soils tend to be moderately deep and loamy. The stratigraphy of the RHI is very complex due to the folding and faulting that has occurred. Deep gorges and valleys have been cut by erosion, leaving very steep slopes, cliffs, and areas of rock material (NRCS 1985). As a result, the properties of soils located near Erwin NFH are highly dependent on slope and location with regard to parent material. For the purposes of this WRIA, only soils located within a ½-mile buffer of Erwin NFH will be discussed.

The Natural Resources Conservation Service (NRCS) defines a hydric soil as "soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part." The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation (i.e., wetland vegetation). Soils that are sufficiently wet because of artificial measures are also included in the concept of hydric soils. NRCS maintains a national list of hydric soil components (USDA 2013). Within the Soil Survey Geographic (SSURGO) Database, "hydric soils" include all map units in which the majority of soil components meet hydric criteria. "Partially hydric soils" may have some hydric components within a larger matrix of non-hydric components (SSURGO undated). Using these NRCS criteria, none of the soils near Erwin NFH are classified as hydric or partially hydric.

NRCS also assigns a hydrologic group to each map unit as an indicator of the runoff (and indirectly, recharge) potential for the soil unit when thoroughly wet. Hydrologic soil group is different from the concept of hydric soil discussed earlier, though related. There are four groups, ranging from A (high infiltration/low runoff) to D (very slow infiltration/high runoff). The majority of soils near Erwin NFH (91%) fall into hydrologic groups B (moderately high infiltration/moderately low runoff) and C (moderately low infiltration/moderately high runoff) (Figure 6, Table 1). Half of the soils series near the hatchery (50%) are in hydrologic group C. These soils are mainly located on ridge tops and steep slopes surrounding the hatchery.

Table 1. Soils located within ½ mile of Erwin NFH. Series with an asterisk (*) are found within the Erwin NFH property. [Source: SSURGO undated].

Hydrologic Group	**Series**	**Acres within 1/2 mile of Erwin NFH**	**% of Acres within 1/2 mile of Erwin NFH**
A	Maymead variant	86.9	9.8
B	*Dunmore	5.9	0.7
	Sensabaugh	10.5	1.2
	*Shouns	107.1	12.1
	*Tate	204.5	23.1
	Toccoa	3.7	0.4
	Tusquitee	28.1	3.2
	Total B	*359.7*	*40.6*
C	Calvin	219.6	24.8
	*Cotaco	49.4	5.6
	Ditney	106.4	12.0
	*Sequoia	63.8	7.2
	Total C	*439.3*	*49.6*
	Total	***886.0***	***100.0***



Map Date: 12/23/2014 File: Fig6_Soils.mxd Data Sources: NRCS SSURGO Soils, NHD High Resolution Flowlines, USFWS Refuge Boundaries, ESRI Map Service.

Figure 6. Soil hydrologic groups with proximity to Erwin NFH. Soils in group C have moderately high runoff potential (moderately low infiltration) and are typically located on ridge tops and steep slopes. Group A soils have low runoff potential (high infiltration) and are typically found in valley bottoms, while group B soils have intermediate hydrologic properties.

Table 1 summarizes the distribution of soil series located within ½ mile of Erwin NFH. Soil series are based upon similarities in soil profiles. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. Each map unit in the RHI is a unique natural landscape. Typically, a map unit consists of one or more major soil series and some minor soil series. It is named for the major soil. Descriptions of the map units which occur within the Erwin NFH property are provided below.

Cotaco loam: Slopes are 1 to 5 percent. This component is on stream terraces on mountains. The parent material consists of loamy alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. Permeability is moderate, and available water capacity is high. The natural drainage class is generally moderately well drained. Mapped units of this component also include small areas of well drained soils, as well as soils that have a weakly developed fragipan horizon which restricts water flow. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 24 inches during January, February, March, April, May, November, and December. Organic matter content in the surface horizon is about 2 percent (NRCS 1985).

Dunmore silt loam: Slopes are 10 to 20 percent. This component is on ridges on mountains. The parent material consists of clayey residuum weathered from limestone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent (NRCS 1985).

Sequoia silt loam: Slopes are 10 to 20 percent and 20 to 35 percent. This component is on ridges on mountains. The parent material consists of clayey residuum weathered from shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is low. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent (NRCS 1985).

Shouns loam: Slopes are 12 to 25 percent and 5 to 12 percent. This component is on ridges on mountains. The parent material consists of loamy colluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent (NRCS 1985).

Tate loam: Slopes are 4 to 12 percent. This component is on ridges on mountains. The parent material consists of loamy colluvium derived from igneous and metamorphic rock. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent (NRCS 1985).

4.5 Hydrology and Geomorphology

The Erwin NFH is located in the North Indian Creek subwatershed of the larger Nolichucky River subbasin. The Nolichucky River drainage area covers 1,756 square miles of eastern Tennessee and western North Carolina. It is formed by the convergence of the North Toe and Cane rivers in North Carolina, southeast of Erwin, TN. It flows southwesterly for 110 miles until it reaches the French Broad River near White Pine, TN. North Indian Creek enters the Nolichucky River at river mile 68.6. Approximately one-third of the watershed is located within the Blue Ridge physiographic province and the remaining two-thirds are located in the Valley and Ridge province (TVA 2006). The Erwin RHI is located entirely within the Blue Ridge physiographic province.

The Nolichucky River was impounded in 1912 and used for hydroelectric power until the early 1970s. In 1972, the Tennessee Valley Authority (TVA) retired the dam as a power source but continues to maintain the dam for flood control and recreational purposes. The dam is located outside of the Erwin RHI.

In eastern Tennessee, underlying rock formations play a significant role in determining surface hydrology. In the Blue Ridge physiographic province, steep terrain and low permeability generally result in high runoff rates and drainage densities (Webbers 2003). Where carbonate formations are exposed at the surface, few surface streams are found and most of the drainage is through a well-developed underground drainage system. As such, the water table is likely to be deeper than in other areas (Brahana et al 1986). Unregulated perennial streams often go dry in late summer or sustain low flow with small amounts of groundwater in-flow (Webbers 2003).

4.6 Anthropogenic Landscape Changes

The area that is now Unicoi County, which contains the RHI, began receiving European settlers in the late 1770s (Padgett 2010) and land clearing for farming began. The area experienced increased growth once railroad construction began in 1886 (Padgett 2010). In 1900, the county had 5,851 residents (US Census Bureau 2013). Railroads were the major employer until 1916 when Southern Potteries opened in Erwin. Peak employment reached more than 1,000 during the 1940s, but faded after the war.

By 1992, over 80 percent of the RHI was still forested with only 15 percent in disturbed (urban or agricultural) land use. Since 1920 the vast majority of the forest land has been conserved as part of the Cherokee National Forest, which occupies 57,318 acres in Unicoi County and approximately 60 percent of the RHI (Davis 1983). Most of the disturbed land uses are clustered along highways in the county. Between 1992 and 2001, less than 2 percent of the RHI changed land use, mostly from forest to agriculture (Homer et al 2007). From 2001 to 2006, the rate of land use change slowed even further, to less than 0.2 percent (Fry et al 2011). In 2007, Unicoi County had 4,742 acres in farms (USDA 2009).

Immediately upslope of the hatchery, land use is a mix of forested, maintained (grassed areas, agricultural fields), and impervious areas (residential buildings, driveways, roads). Landscape changes that have increased the amounts of maintained and impervious areas have led to increased runoff potential in heavy storm events. This runoff has potential to cause problems for the Erwin NFH, which is located in the valley below. Stormwater BMPs placed upslope of the hatchery property could provide an opportunity to alleviate runoff concerns for the hatchery and are discussed further in Section 6.

Unicoi County's population has fluctuated very little since 1960. In 1960, 15,082 people lived in the county. The county's population in 2000 was 17,667. The county, as a whole, is projected to lose population between 2000 and 2030. This decline is based on projections that death rates will be higher than that of birth rates, and migration patterns will be dampened from 2015-2030 (Middleton and Murray 2009).

4.7 Climate

4.7.1 Historical Climate

Climatic information presented in this WRIA comes from two sources: the U.S. Historical Climatology Network (USHCN) of monitoring sites maintained by the National Weather Service and the Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate mapping service, which is the U.S. Department of Agriculture's (USDA) official source of climatological data. The period of record for the USHCN data is 1888-2012 for precipitation and 1893-2012 for temperature data. The PRISM data represent 1971-2000 climatological normals. The closest USHCN station to the Erwin NFH is Station 406534 in Newport, TN, approximately 60 miles away.

4.7.1.1 Temperature

The climate of eastern Tennessee is mild and moderately humid with average monthly temperatures in the vicinity of the hatchery ranging from approximately 38°F to 77°F (Figure 7). Mean monthly temperatures exhibit the greatest year-to-year variability in fall through early spring (October through March) and the least variability in the spring and summer (April through September) (Figure 7). The PRISM dataset shows that monthly average minimum and maximum temperatures in the vicinity of the hatchery range from approximately 25°F in January to 85°F in July (Table 2). Annual average daily maximum, mean, and minimum temperature by water year reveals no apparent trends over the period of record (Figure 8). However, all three temperature measures show an increasing trend since about 1970, following a dip in temperatures after 1950.

4.7.1.2 Precipitation

The region receives an average of approximately 49.1 inches of precipitation annually with mean monthly precipitation ranging from 2.7 to 5.1 inches (Table 2). According to the PRISM dataset, May receives the greatest amount of precipitation at an average of 5.1 inches, whereas October receives the least at an average of approximately 2.7 inches (Table 2). Data from USHCN for Newport, TN (from 1888-2012) show the average water year precipitation at 44.5 inches, with March and July receiving the most precipitation, and October being the driest month (Figure 9, Figure 10). The USHCN data also reveals a high degree of year-to-year variability in monthly precipitation, with most months having years in which precipitation was less than 1 inch and years in which precipitation exceeded 6-8 inches.

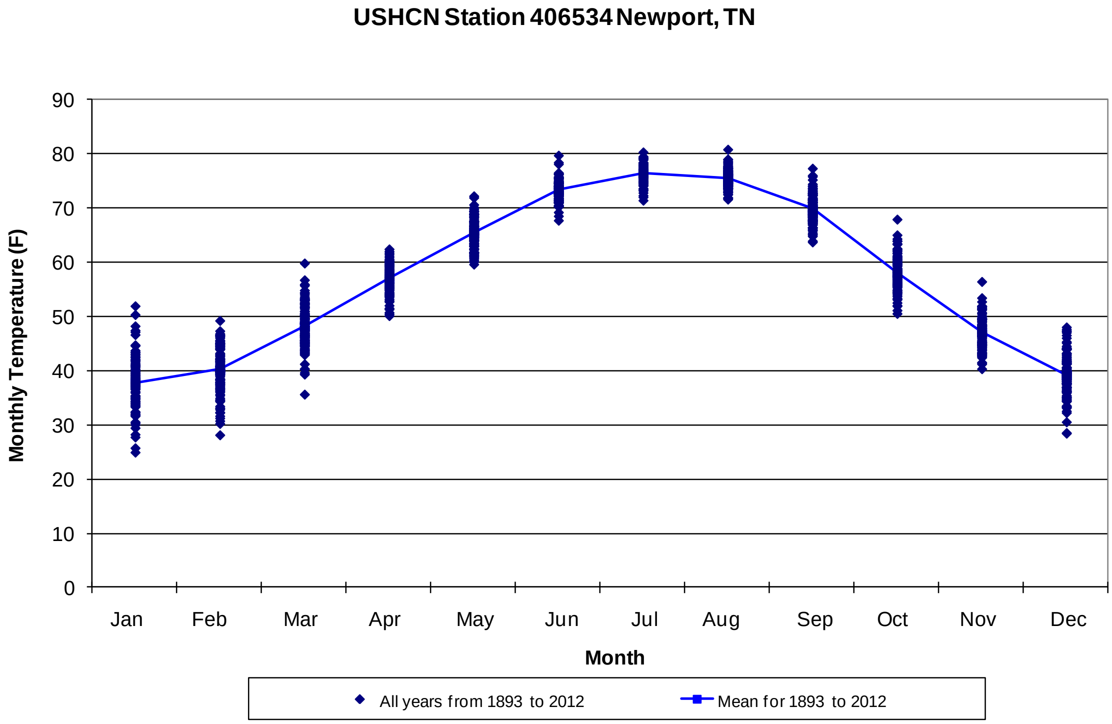


Figure 7. Mean and distribution of monthly temperature for 1893 – 2012 for U.S. Historical Climatology Network (USHCN) Station 406534 at Newport, TN. [Source: Menne et al. undated].

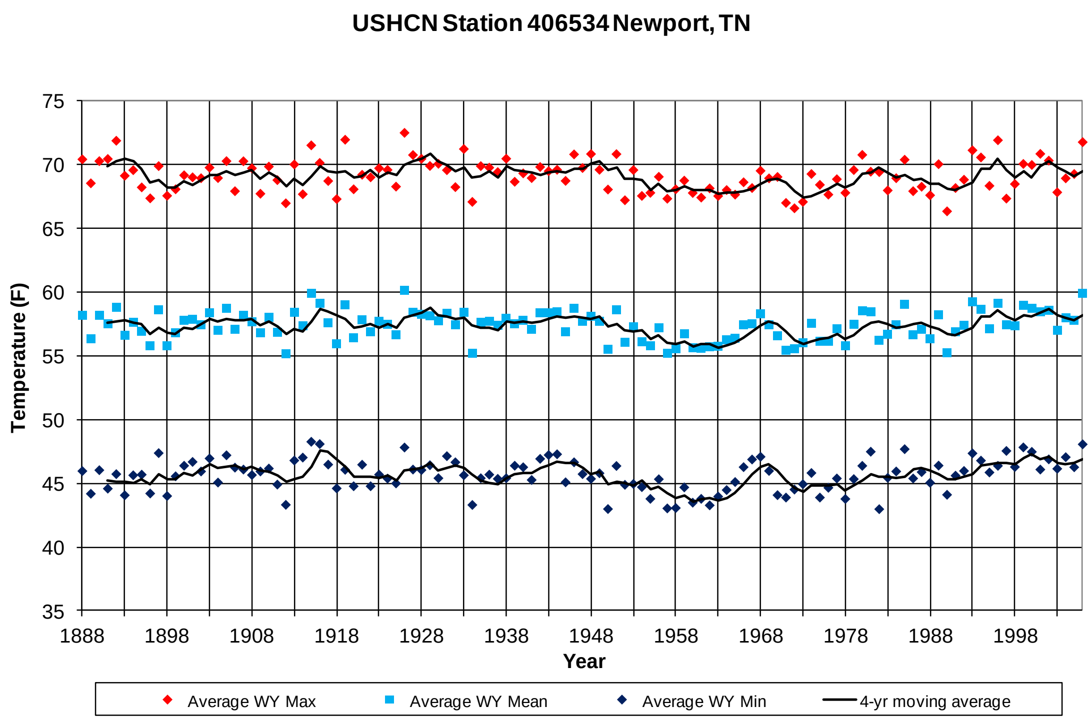


Figure 8. Average daily maximum, mean, and minimum temperature by water year (1893 – 2012) at Newport, TN (USHCN Station 406534). [Source: Menne et al. undated].

Table 2. Parameter-elevation Regressions on Independent Slopes Model (PRISM) Monthly Normals (1971-2000) for precipitation and maximum and minimum temperature at Erwin NFH. [Source: PRISM 2010].

Month	Precipitation (In)	Max Temperature (°F)	Min Temperature (°F)
January	4.19	46.04	25.36
February	4.07	50.56	27.52
March	4.45	59.38	34.34
April	3.94	68.49	40.98
May	5.08	75.85	49.35
June	4.93	82.62	57.67
July	5.01	85.68	62.35
August	4.31	84.72	60.94
September	3.41	79.54	54.93
October	2.66	69.80	42.57
November	3.46	59.34	34.86
December	3.58	49.96	28.53
Total Precipitation	**49.09**		
Mean Temperature		**67.66**	**43.29**

1971-2000 Normals for -82.388591, 36.164992. Downloaded 11/19/13 from http://prismmap.nacse.org/nn/. Copyright 2010. PRISM Climate Group, Oregon State University.

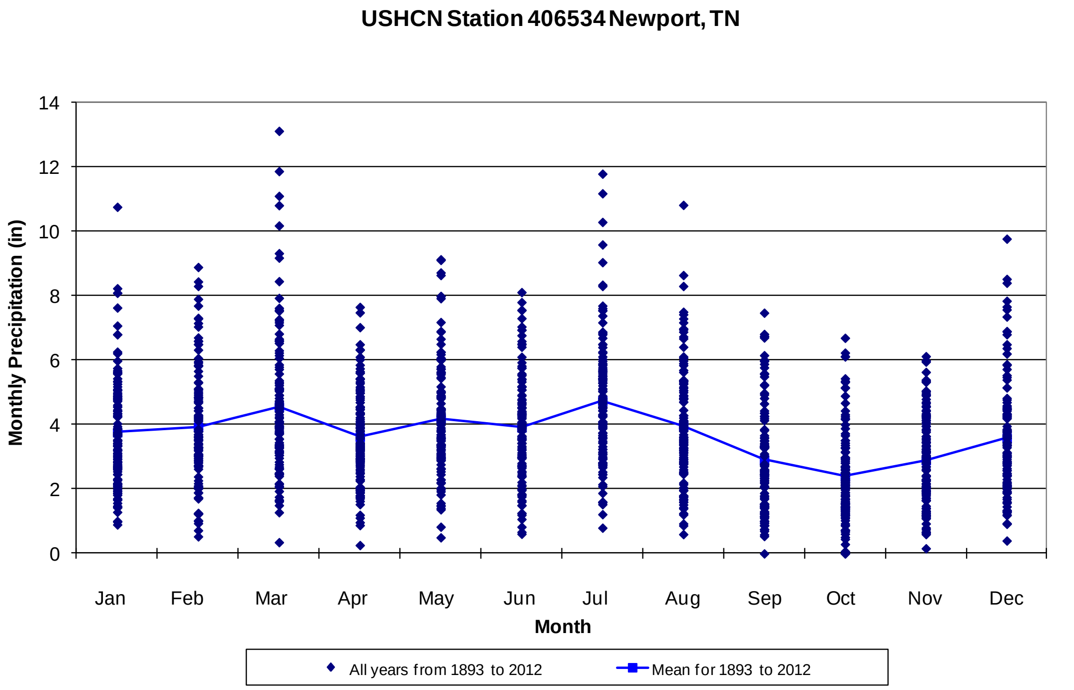


Figure 9. Mean and distribution of monthly precipitation for 1888 – 2012 for U.S. Historical Climatology Network (USHCN) Station 406534 at Newport, TN. [Source: Menne et al. undated].

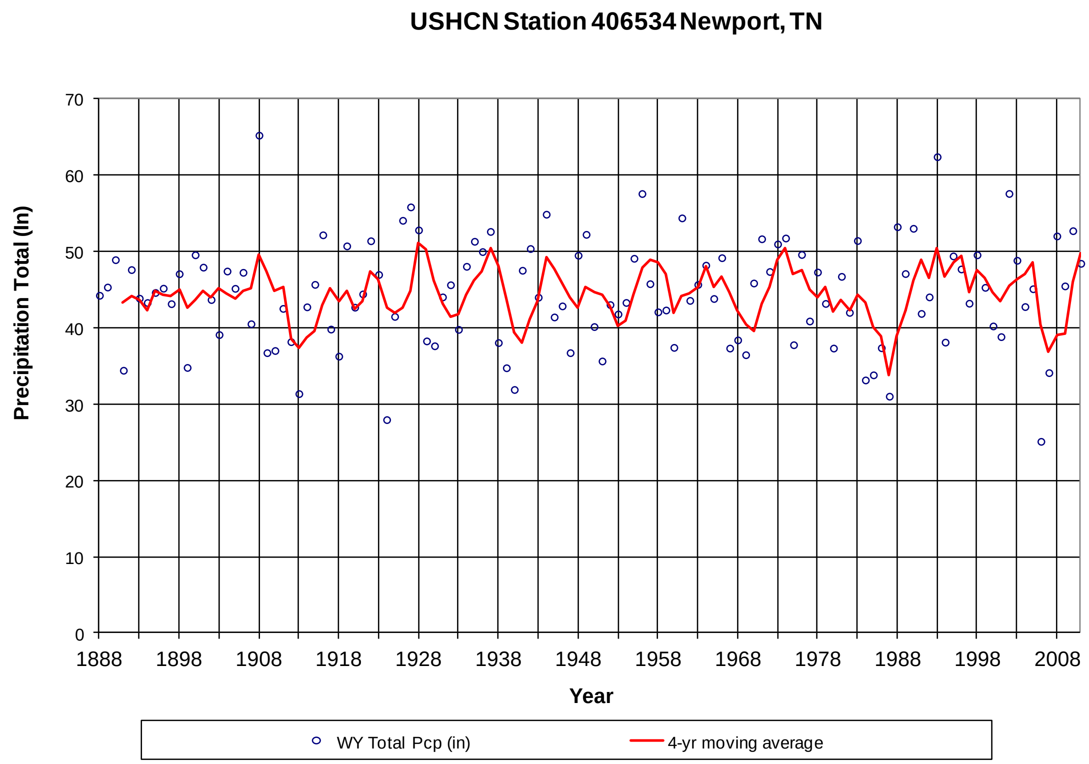


Figure 10. Total annual precipitation by water year (1888 – 2012) at Newport, TN (USHCN Station 406534). [Source: Menne et al. undated].

4.7.1.3 Streamflow

Seasonal and annual discharges on the Nolichucky River at Embreeville, TN from 1920-2012 are presented in Figure 11 and Figure 12. The average annual discharge is approximately 1,370 cubic feet per second (cfs). The average monthly discharge is highest between January and May and lowest between June and December. The average monthly discharge peaks in March whereas the month with the lowest average discharge is in October. From 1991 to 2000, mean annual flow remained above the annual average for the period of record (Figure 12). While short and extended periods of above and below average discharge did occur throughout the period of record, there are no apparent trends in the average annual discharge.

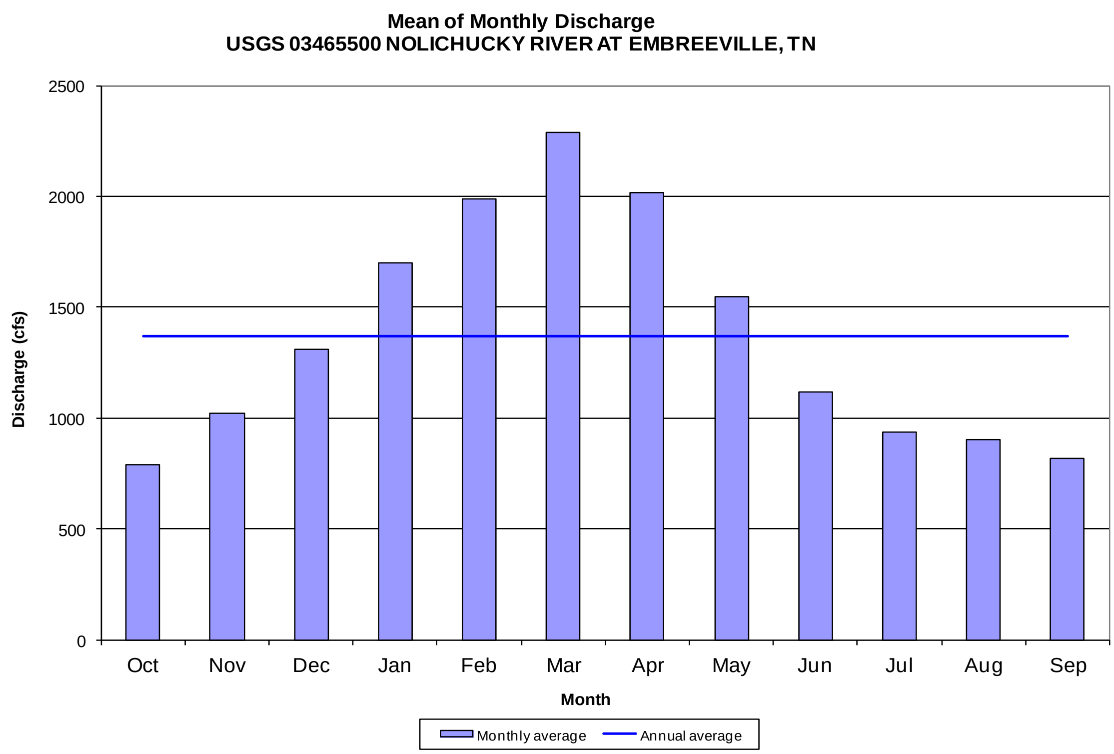


Figure 11. Average monthly discharge (1920 – 2012) of the Nolichucky River near Embreeville, TN (USGS gage no. 03465500). [Source: USGS 2013].

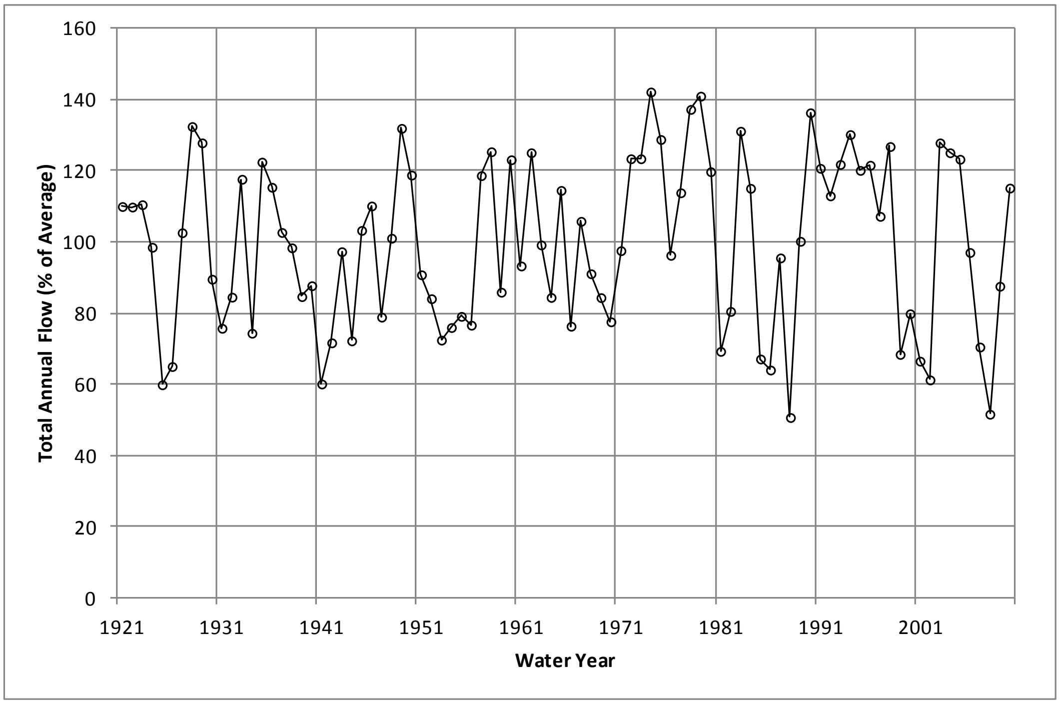


Figure 12. Percent of average annual flow (water year 1921 – 2012) on Nolichucky River near Embreeville, TN. Average annual flow from the period of record is 1,370 cubic feet per second (cfs). 1 cfs = 448.8 gallons per minute. [Source: USGS 2013].

4.7.2 *Climate Change Projections*

The U.S. Global Change Research Program's 2009 report, *Global Climate Change Impacts in the United States* (Karl et al. 2009), synthesized a large body of scientific information composed of numerous peer-reviewed scientific assessments. Climate models project continued warming in the southeastern United States, and an increase in the rate of warming through the year 2100. The projected rates of warming are more than double those experienced since 1975, with the greatest temperature increases projected to occur in the summer. Projected mean temperature increases by the 2080s range from about 4.5°F under a low emissions scenario to 9°F (10.5°F in summer) under a higher emissions scenario. In eastern Tennessee, the number of days per year with a peak temperature over 90°F is expected to triple, from an average of around 30 days to more than 90 days by 2080 (Karl et al. 2009).

By the last decade of the 21st century, global average surface temperature is projected to rise by 2.8 C (37°F), with a likely range of 1.7-4.4 C (3.1-7.9°F) under the A1B (moderate) emissions scenario. The A2 (high) emissions scenario predicts an increase of 3.4 C (6.1°F), with a likely range of 2.0-5.4 C (3.6-9.7°F). Both scenarios are relative to a 1980-1999 baseline (IPCC 2007). Based on the ensemble average of downscaled projections from 15 climate models obtained via the Climate Wizard website (Girvetz et al. 2009), the increase in estimated annual temperature for the same period for the North Indian Creek subwatershed (nearest subwatershed to Erwin NFH) under the A2 scenario is about 1.8 C (3.2°F), with fall and summer temperatures increasing by 0.6 C (1.1°F) more than winter and spring temperatures (Figure 13A). While individual model predictions vary, they generally show the same seasonal pattern and agree fairly closely on the magnitude of the overall increase in mean temperature, with a range of about 0.9 -1.0 C (1.6-1.8°F) between the 10th and 90th percentile model predictions.

Climate models show less agreement on future precipitation, with individual models diverging widely in their predictions in both the direction and magnitude of likely changes. The median prediction is for an increase of 50 mm (1.9 in), but the predictions range from a decrease of nearly 95 mm (3.7 in) to an increase of nearly 100 mm (3.9 in) (Figure 13B). There is a fairly high degree of uncertainty about both the direction and magnitude of likely changes in seasonal precipitation.

Potential evapotranspiration (PET) is predicted to increase by 85 mm (3.3 in) annually due to increased temperatures, with the bulk of the increase of 31-63 mm (1.2-2.5 in) occurring in the summer months (Figure 13C). This could lead to increased moisture stress for plants and decreased water availability for the surrounding watershed during the summer and fall. Climatic moisture deficit, a metric quantifying potential moisture stress (calculated as monthly PET minus precipitation, with a value of zero for months where precipitation is greater than PET) is predicted to increase by 9 to 82 mm (0.4-3.2 in) annually, with the largest increase of 1 to 66 mm (0.04-2.6 in) during the summer months (Figure 13D), but the range of predicted values is large due to the divergent model predictions for precipitation.

Spatial and temporal changes in temperature and rainfall patterns will add substantial complexity to management planning on Erwin NFH. In the eastern United States, documented seasonal warming patterns, extended growing seasons, high spring stream flow, decreases in snow depth, and increased drought frequency are projected to continue (Scott et al. 2008). Although the specific impacts climate change will have on the Erwin NFH are not known, these regional changes to the quantity and timing of available water are likely to magnify the influences of other identified threats and challenges currently impacting the system. Watersheds in the southern Appalachians are particularly vulnerable to changing water conditions exacerbated by climate change (Hurd et al. 1999).

Projected increases in storm severity may lead to problems caused by runoff from areas of development upstream of Erwin NFH. This runoff could lead to potential contamination of the raceway water supply. Based on hatchery responses to a USFWS climate change questionnaire, super saturation of nitrogen resulting from drought conditions has caused mortality of broodstock at Erwin NFH for the first time in 30 years and may present an on-going threat if climate change leads to enhanced drought conditions (USFWS 2012).

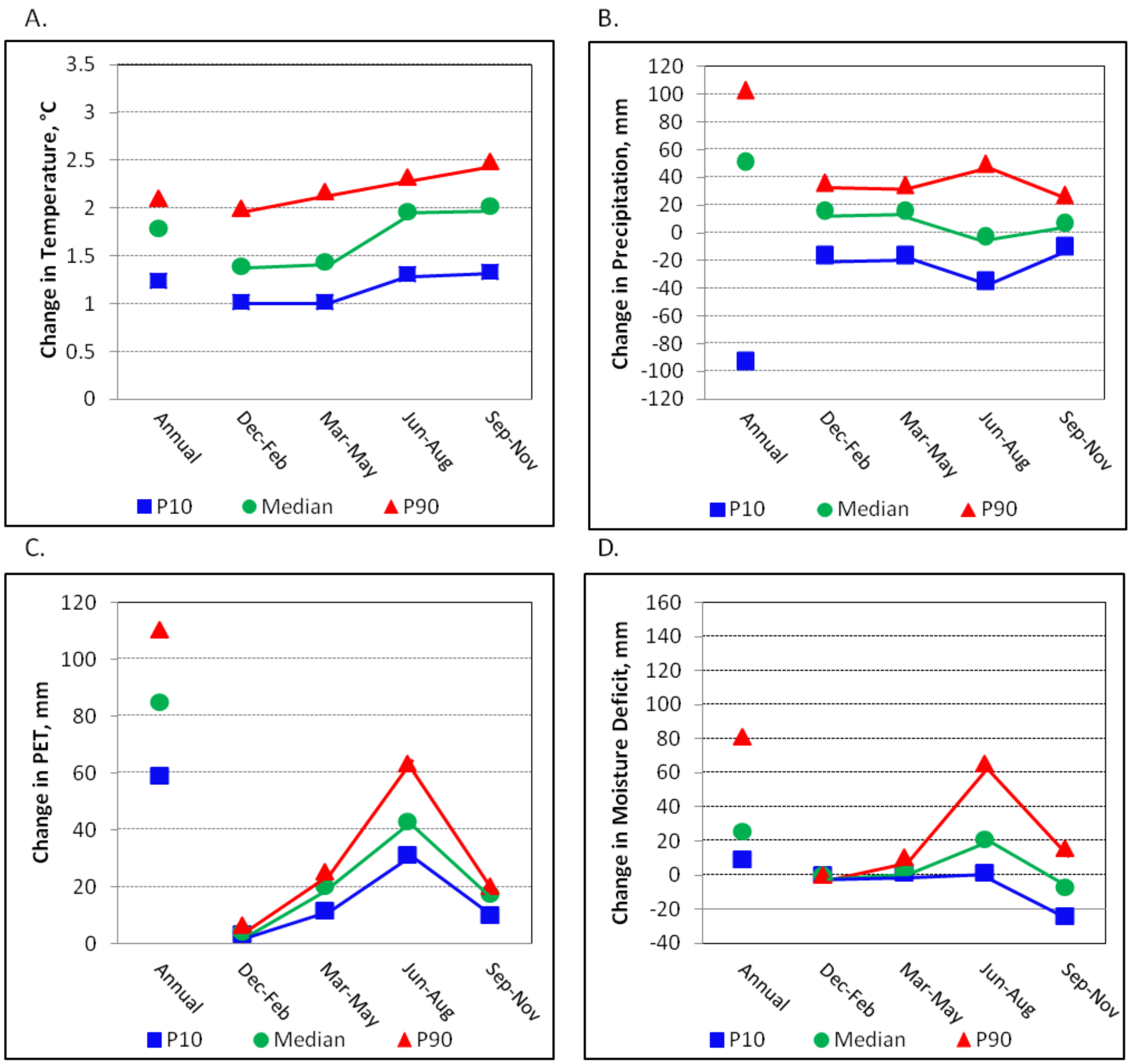


Figure 13. Ensemble downscaled climate model projections for the North Indian Creek subwatershed (Erwin NFH subwatershed) under the A2 (high) emissions scenario. Plots show predicted changes in 30-year mean for selected annual and seasonal climate metrics for the period 2071-2100 vs. 1961-1990: (a) Mean air temperature, (b) total precipitation, (c) potential evapotranspiration (PET), and (d) climatic moisture deficit (a measure of moisture stress; see text for details). In each panel, the green line shows the median value of 15 climate model projections, while the blue and red lines show the 10^{th} and 90^{th} percentile values, respectively. Abbreviation: P10/P90 – 10^{th} and 90^{th} percentile model predictions, respectively. [Source: Climate Wizard Custom (http://climatewizardcustom.org; accessed 28 June 2013) (Girvetz et al. 2009)].

5 Inventory Summary and Discussion

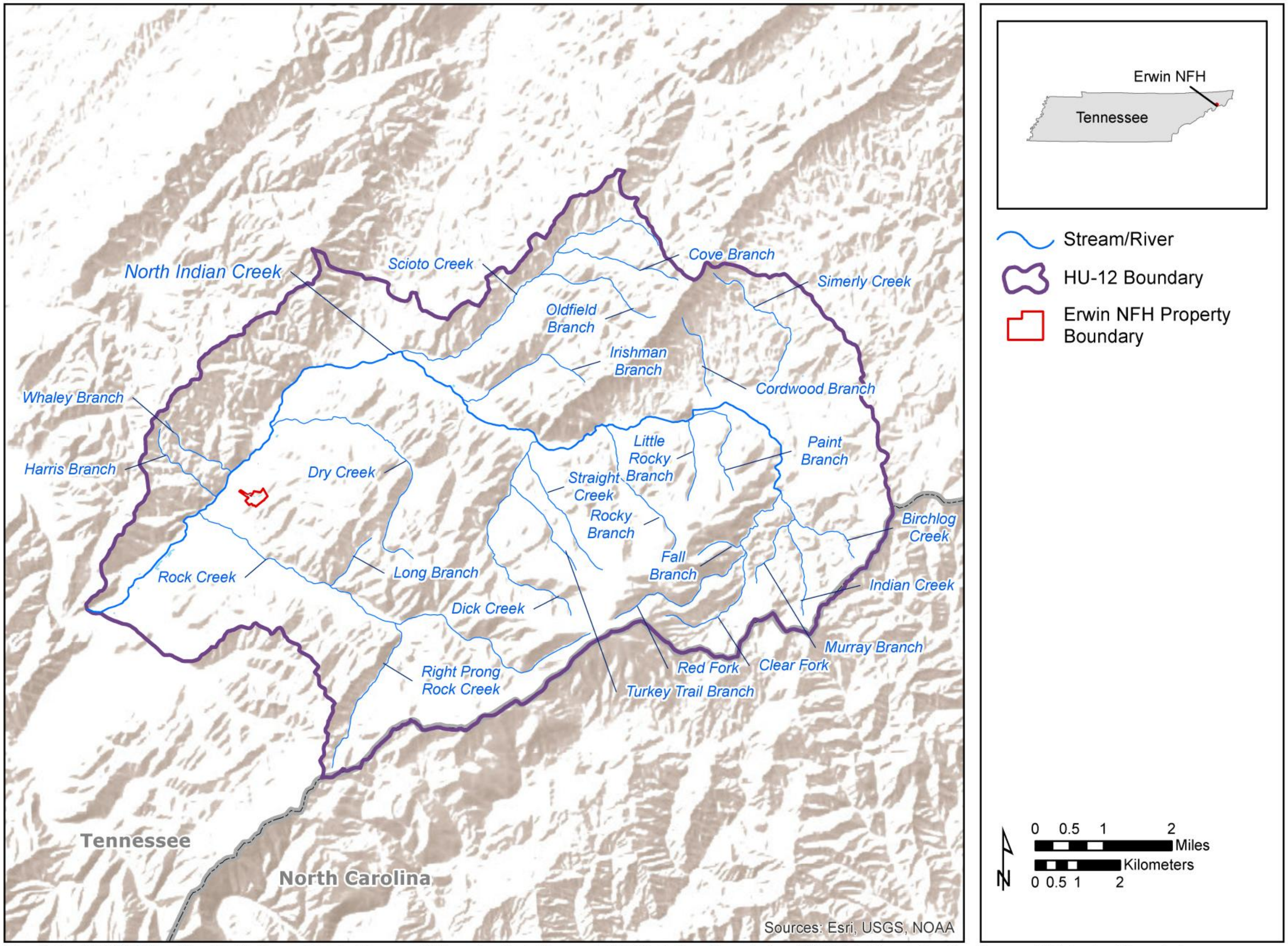
5.1 Water Resources

5.1.1 Rivers/Streams/Creeks

The hatchery is situated adjacent to North Fork Indian Creek in the Nolichucky River watershed in eastern Tennessee between the towns of Erwin and Unicoi. There are approximately 249 miles of streams within the Erwin RHI, including 70 miles of named streams (Table 3, Figure 14). The Erwin RHI contains small to medium cool water tributaries that flow to the Nolichucky River, which is outside of the Erwin RHI. There are no rivers or streams within the hatchery property boundary.

Table 3. Named streams with mileage inside the Erwin NFH RHI (see Figure 14 for locations). [Source: USGS 2013].

Stream Name	Miles within RHI
Birchlog Creek	1.2
Clear Fork	2.0
Cordwood Branch	1.3
Cove Branch	1.9
Dick Creek	3.6
Dry Creek	4.3
Fall Branch	0.7
Harris Branch	1.5
Indian Creek	2.1
Irishman Branch	2.2
Little Rocky Branch	1.2
Long Branch	0.9
Murray Branch	1.1
North Indian Creek	14.5
Oldfield Branch	2.0
Paint Branch	1.7
Red Fork	3.9
Right Prong Rock Creek	2.5
Rock Creek	7.0
Rocky Branch	2.3
Scioto Creek	5.0
Simerly Creek	2.3
Straight Creek	2.1
Turkey Trail Branch	1.6
Whaley Branch	1.4
Total Named	***70.3***
Total Unnamed	*178.9*



Map Date: 12/23/2014 File: Fig14_NamedCreeksStreams_RHI.mxd Data Source: USFWS Refuge Boundaries, NHD High Resolution Flowlines and Watershed Boundaries, ESRI Map Service.

Figure 14. Named streams within the RHI.

5.1.2 Lakes/Ponds

There are 23 unnamed waterbodies (i.e., ponds) covering a combined total of 13.5 acres within the RHI for Erwin NFH. Most ponds are either small stormwater containment ponds or agricultural ponds. These small ponds are not likely to affect hydrology at Erwin NFH.

5.1.3 Springs and Seeps

The primary spring that supplies water to Erwin NFH is located on a small ridge in the eastern corner of the property and is approximately 0.5 acre in size (#10 on Figure 15). The spring is referred to as Tate Branch Spring on most mapping, but historically was named Tap Spring and is referred to as U.S. Fishery Spring in some publications. The spring was an open pool until the early 1980s, when a spring covering project was undertaken to prevent wildlife-associated pathogens and diseases from contaminating the water supply (Norm Heil, USFWS, personal communication, August 1, 2013). Water control structures that once existed at the spring have been buried and underground piping now supplies spring water to the hatchery. The spring has an output of 1,200 gpm of 56°F groundwater. Effluent (i.e., discharge of wastewater from fish farm operations) from the hatchery flows underneath railroad tracks at the backside of the property into a settling pond, which eventually discharges into North Indian Creek and then to the Nolichucky River. An additional groundwater well utilized by the hatchery is located approximately 300 feet from the spring. The well is located in a small pump house adjacent to the public viewed raceways (#7 on Figure 15). There is a 5-ft deep collection basin at the top of the well (David Teague, USFWS, personal communication, December 31, 2014). The well is cased with galvanized steel and the depth to water is 22.2 feet from the top of the casing; total depth is 366 feet (Peakflow PLLC 2008).

Based on water chemical analyses conducted by the hatchery, the well and the spring seem to be from two different sources of water (Norm Heil, USFWS, personal communication, August 1, 2013). In 2008, specific conductance measured between the spring and well differed by over 40 micro-siemens (µS) (Peakflow PLLC 2008). It is likely that these two sources are from two different aquifers (i.e., two different units/formations within one aquifer system). According to Sun et al. (1963), what is referred to as the U.S. Fishery Spring is located in the Honaker Formation of the Conasauga Group (within the Valley and Ridge carbonate aquifer system), near contact with the Rome Formation. Both the well and the spring require aeration for hatchery operations and both sources maintain consistent pH and hardness.

5.1.4 Groundwater

Valley and Ridge and Blue Ridge crystalline rock aquifers are both found within the Erwin RHI and may explain the two different groundwater sources at the Erwin NFH previously mentioned. In November 2008, an investigation and subsequent testing by a private firm (Peakflow PLLC from Elizabethton, TN) (David Teague, USFWS, personal communication, September 2, 2014) determined that the groundwater from the pump station and the spring at Erwin NFH have different conductivities, suggesting two different sources of water. As described in Section 4.3, groundwater sources in this area are typically found in interconnected fractures and solution openings of sandstone or carbonate aquifers as well as fractures and solution openings of the Blue Ridge crystalline rock aquifer; however, what is referred to as the U.S. Fishery Spring is located in the Honaker Formation within the Valley and Ridge carbonate aquifer system (Sun et al. 1963). The Honaker Formation is composed of medium-bedded dolomite with minor dark limestone beds (NRC 2011). This formation underlies the hills and mountains and is the most productive unit in the area (Maclay 1962). The Honaker Formation is the source of water for Erwin Utilities. The spring is located in close proximity to the Rome Formation, which is composed of sandstone, shale, dolomite and limestone, with sandy shale being the dominant rock type. The Rome Formation is found closer to the Nolichucky River in this area (NRC 2011).

5.2 Infrastructure

Figure 15 is a diagram of the features of the Erwin NFH. The primary infrastructure located at Erwin NFH is a groundwater supply and conveyance system that moves groundwater from the spring and pump house (features 10 and 7, respectively) through the facility while maintaining proper oxygen levels. The conveyance system begins with a gravity oxygenating system at the upper production raceways (5). The water flows through the upper raceways and then is circulated to the lower broodstock raceways (6). Water that passes through the lower raceways is collected and then pumped into an aeration building (8) where oxygen is added to the reused water and re-circulated through the lower raceways. In addition to the gravity systems, the facility has a liquid oxygen storage tank (9) that is used to oxygenate the lower broodstock raceway as well as the upper production raceways via underground piping.

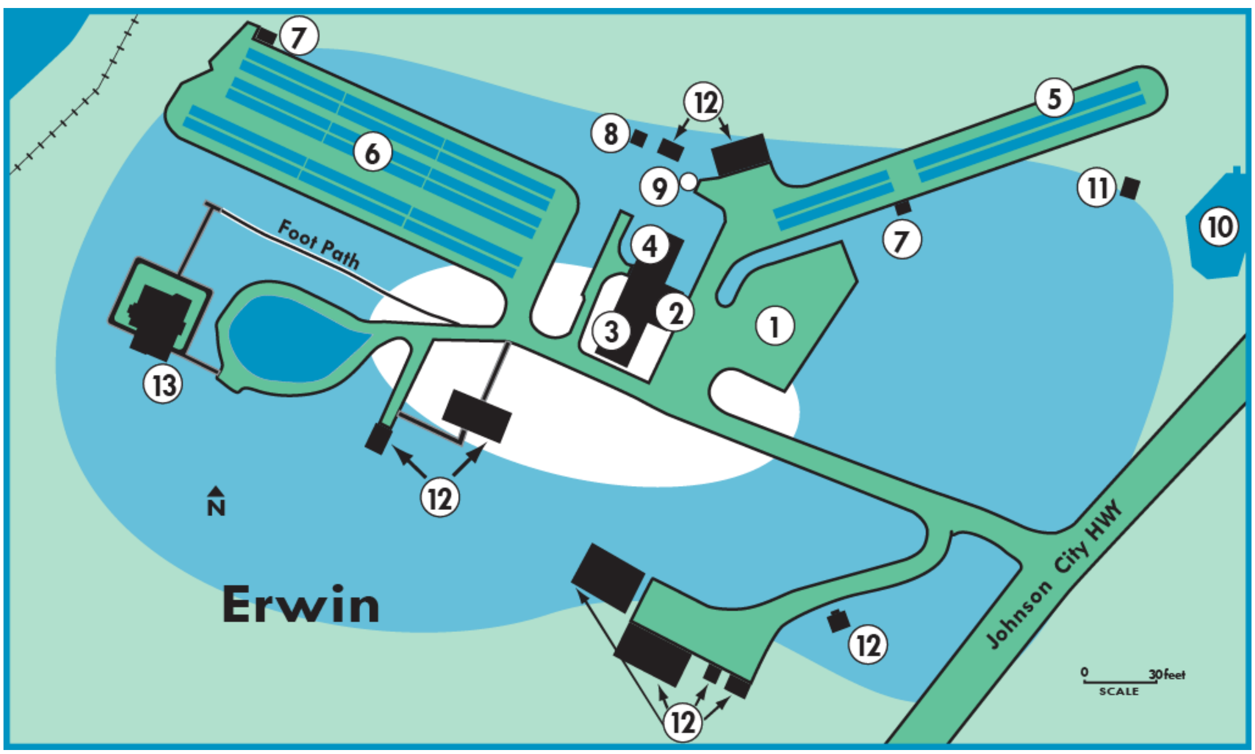


Figure 15. Erwin NFH facility diagram.

Legend: (1) Visitor Parking, (2) Visitor Center, (3) Hatchery Office, (4) Hatchery Building, (5) Upper Production Raceways, (6) Lower Broodstock Raceways, (7) Pump House, (8) Aeration Building, (9) Liquid Oxygen Storage Tank, (10) Main Spring, (11) Picnic Pavilion, (12) Maintenance Buildings, Garages, Residence, (13) Heritage Museum

5.3 Water Monitoring

Water Resource Inventory and Assessments identify water-related monitoring that is taking place on or near refuges and fish hatcheries. For the purpose of this review, the WRIA collects information stored in the USGS' National Water Information System (NWIS) database for the entire Erwin NFH RHI, as well as other state or local monitoring data as available. Water monitoring can be broadly categorized as either water quality or water quantity focused. Water quality monitoring typically consists of collecting surface water or groundwater samples for chemical analyses in a laboratory or with sensors deployed in the field. Alternative protocols may use techniques such as aquatic invertebrate sampling as a proxy for water quality. Water quantity monitoring typically includes the flow rate in a stream, the water level in a groundwater aquifer, or water levels in refuge impoundments. WRIAs also consider weather stations and tide gages as other types of water-related monitoring.

5.3.1 Surface Water

5.3.1.1 Hydrography

This WRIA effort identified 8 USGS surface water monitoring sites or stream gages near the hatchery (Table 4, Figure 16). None of the monitoring sites are currently actively monitored, and the last sample was taken in 1980 from Site #1 on North Indian Creek at Erwin, TN. Site #3 on North Indian Creek near Unicoi, TN has the longest period of record, from 1944-1957.

Table 4. U.S. Geological Survey (USGS) surface water discharge monitoring sites inside the Erwin NFH RHI (see Figure 16 for locations). [Source: USGS 2013].

ID on Figure 16	Site Number	Site Name	Agency	Sample History
1	03465220	North Indian Creek at Erwin, TN	USGS	1978-1980 (6 measurements)
2	03464990	North Indian Creek above Unicoi, TN	USGS	1932-1941 (3 measurements)
3	03465000	North Indian Creek near Unicoi, TN	USGS	1944-1957 (daily - 4870 values)
4	03465100	North Indian Creek at Unicoi, TN	USGS	1900-1932 (2 measurements)
5	03465204	Rock Creek near Erwin, TN	USGS	1958-1961 (9 measurements)
6	03465205	Right Prong Rock Creek Park near Erwin, TN	USGS	1958-1961 (15 measurements)
7	03465206	Rock Creek below Right Prong near Erwin, TN	USGS	1960-1961 (7 measurements)
8	03465210	Rock Creek AB Mouth near Erwin, TN	USGS	1900 (1 measurement)

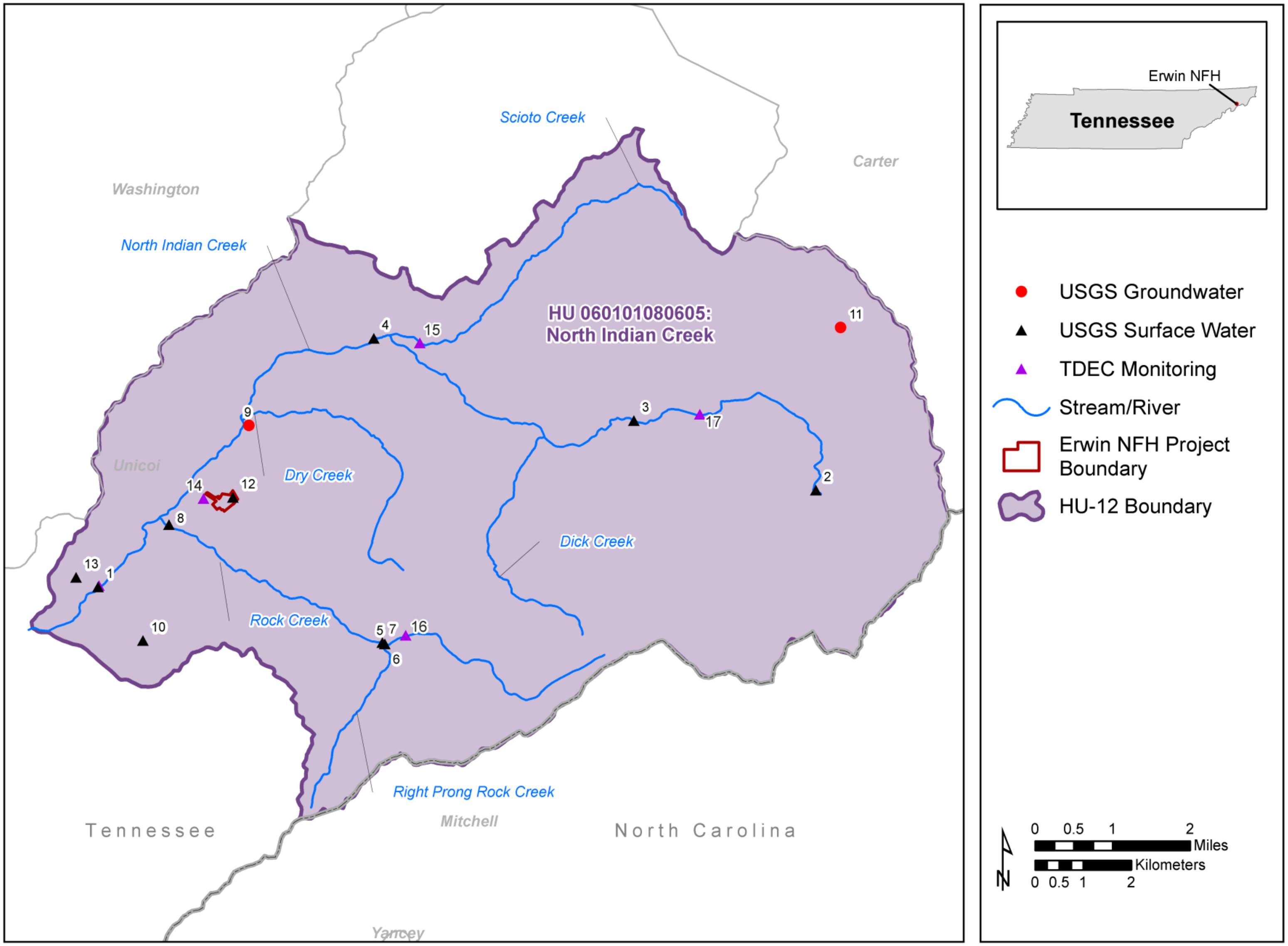
5.3.1.2 Water Quality Monitoring

This WRIA effort identified two monitoring sites near the hatchery where water quality samples have been taken; however, neither one is currently being monitored. These sites were historically monitored by the USGS with the last sample taken in 1980 (Table 5, Figure 16).

Tennessee Department of Environment and Conservation (TDEC) also conducts water quality monitoring as part of its Clean Water Act responsibilities. The agency maintains fixed-station water quality monitoring sites throughout the Nolichucky watershed, which are sampled quarterly or monthly, as well as ecoregion, watershed screening, and special survey sites. Site information is stored in the U.S. Environmental Protection Agency's (EPA's) STOrage and RETrieval (STORET) database. The assessment cycle for the Nolichucky watershed was completed in 2008 and a Watershed Management Plan was prepared (TDEC 2008a).

Table 5. U.S. Geological Survey (USGS) and Tennessee Department of Environment and Conservation (TDEC) surface water quality monitoring sites inside the Erwin NFH RHI (see Figure 16 for locations). [Source: USGS 2013, TDEC 2008a].

ID on Figure 16	Site Number	Site Name	Agency	Sample History
1	03465220	North Indian Creek at Erwin, TN	USGS	1978-1980 (12 samples)
1	NINDI001.2UC	North Indian Creek	TDEC	2005-2006 (10 samples)
3	03465000	North Indian Creek near Unicoi, TN	USGS	1944-1957 (1 sample)
15	SCIOT000.1UC	Scioto Cr.	TDEC	2005-2006 (11 samples)
16	ROCK1T0.1UC	Rock Cr.	TDEC	2003-3004 (4 samples)
17	NINDI010.5UC	N. Indian Cr.	TDEC	2004 (3 samples)



Map Date: 1/2/2015 File: Fig16_NWIS_Monitoring_RHI.mxd Data Source: USFWS Refuge Boundaries, USGS NWIS, US EPA STORET, NHD Streams and Watershed Boundaries, ESRI Map Service.

Figure 16. Surface and groundwater monitoring sites near Erwin NFH. Sites are referenced in Tables 4–7.

5.3.1.3 Aquatic Habitat and Biota

Due to the relative small size (31 acres) of the hatchery's property boundary and considering the primary water sources are from Tate Branch Spring and a groundwater well, specific issues associated with surface water are mostly irrelevant. However, it should be noted that during periods of high rainfall, surface water runoff can be an issue. Additionally, extreme drought conditions can also potentially impact the aquifers associated with hatchery production needs.

Historically, one of the primary concerns was with wildlife-associated pathogens and diseases contaminating the open pool water supply of Tate Branch Spring (Norm Heil and David Teague, USFWS, personal communication, August 1, 2013). Thus, in the early 1980's, a construction project resulted in the installation of a network of pipes in the open pool area of the spring. Following the pipe installation, the area was filled with small rock and gravel and covered to reduce the likelihood of contamination from wildlife pathogens.

Within the RHI, there are approximately 250 miles of surface streams. Tennessee Wildlife Resources Agency (TWRA) biologists have conducted surveys and inventories of the aquatic resources within several of these streams, including: North Indian Creek (Habera et al. 2004); Dry Creek, Rocky Branch, Simerly Creek, and Birchlong Creek (Habera et al. 2011); and Dick Creek (Habera et al. 2012). In addition, a summary of data from TWRA Region IV sampling efforts from the 1990's through 2013 is provided in a report (Habera et al. 2014). In this report, information for several of the waterbodies in proximity to the hatchery is provided and includes quantitative fish samples utilizing removal depletions (year of collection) for North Indian Creek (1994-95 and 2003), Rock Creek (1991), Right Prong Creek (1998), Clear Fork (1993) and Red Fork (1998). Additionally, the report also summarizes qualitative (presence/absence) wild trout survey data and includes information for the following streams (year of collection) within the RHI: Dry Creek (2010), Dick Creek (2011), Rocky Branch (2010), Simerly Creek (2010), and Birchlog Creek (2010).

5.3.2 Groundwater

5.3.2.1 Groundwater Level and Quality Monitoring

This WRIA effort identified three groundwater quality and quantity monitoring sites with online data near the hatchery, with one site (Figure 16, Site #9) being monitored as recently as 2013. Two sites within the Erwin NFH RHI have no data available online. All of these sites are monitored by the USGS (Figure 16, Table 6).

According to USDHHS (2007), TDEC annually monitors Erwin Utilities' Railroad Well for water quality parameters. TDEC's Groundwater Management Program conducts monitoring; however, the state lacks an ambient groundwater monitoring program (TDEC 2012a). The Tate Spring was monitored in 2010 and 2011 as a part of TDEC's Clean Water Act quality monitoring. Dates of monitoring, characteristics monitored, and values are presented in Table 7.

There is one USGS spring monitoring site located within the hatchery property boundary (Site #12 on Figure 16). Based on information from Hollyday and Smith (1990), 40 discharge measurements were made at the spring sometime between 1947 and 1963. The authors also reported that Site #13 (Birchfield Spring at Erwin, TN, Figure 16, Table 6) had 29 discharge measurements made during that time period (see Section 5.4.2). Data for the two sites are not available from the USGS online.

Table 6. U.S. Geological Survey (USGS) groundwater quantity and quality monitoring sites inside the Erwin NFH RHI (see Figure 16 for locations). GW = Groundwater, SP = Spring. [Source: USGS 2013].

ID on Figure 16	Site Number	Site Name	Category	Agency	Sample History
9	361045082225501	UC:G-105 UTEN98-23	GW	USGS	1998-2013 (1 water-level measurement, 4 quality samples)
10	360825082243101	Obrien Spring	SP	USGS	1989-1990 (2 quality samples)
11	361130082144101	UC:J-001	GW	USGS	1990 (1 water-level measurement, 1 quality sample)
12	03465200	US Fishery Spring at Erwin, TN	SP	USGS	No Data Available Online
13	03465225	Birchfield Spring at Erwin, TN	SP	USGS	No Data Available Online
14	TNW000006479	Tate (Tapp) Spring	SP	TDEC	2010-2011 (10 quality samples)

Table 7. Tennessee Department of Environment and Conservation (TDEC) Sampling Results for TNW000006479 (Tate Spring) [Source: USEPA 2014].

Characteristic Name	Date	Value/Units
Alkalinity, total as CaCO3	8/31/2010	94 mg/l
	11/8/2010	94 mg/l
	3/2/2011	111 mg/l
	4/13/2011	116 mg/l
Ammonia, total as NH3	8/31/2010	0.11 mg/l
	11/8/2010	0.03 mg/l
	3/2/2011	Not Detected
	4/13/2011	0.26 mg/l
Conductivity	3/13/2010	209 umho/cm
	7/7/2010	195.8 umho/cm
	8/31/2010	202 umho/cm
	9/8/2010	206 umho/cm
	9/20/2010	193 umho/cm
	9/27/2010	205 umho/cm
	1/18/2011	210 umho/cm
	3/2/2011	260 umho/cm
	4/13/2011	246.5 umho/cm
Dissolved oxygen (DO)	3/13/2010	9.7 mg/l
	7/7/2010	6.6 mg/l
	8/31/2010	8.96 mg/l
	9/8/2010	8.34 mg/l
	9/20/2010	8.68 mg/l
	9/27/2010	11.08 mg/l
	3/2/2011	9.75 mg/l
	4/13/2011	9.42 mg/l
Escherichia coli, total	3/13/2010	96 cfu/100ml
	7/7/2010	137 cfu/100ml
	8/31/2010	2419 cfu/100ml
	9/8/2010	411 cfu/100ml
	9/20/2010	770 cfu/100ml
	9/27/2010	488 cfu/100ml
	11/8/2010	33 cfu/100ml
	1/18/2011	33 cfu/100ml
Inorganic nitrogen (nitrate and nitrite), total	8/31/2010	0.72 mg/l
	11/8/2010	0.8 mg/l
	3/2/2011	1.1 mg/l
	4/13/2011	0.97 mg/l
Kjeldahl nitrogen, total	8/31/2010	1 mg/l
	11/8/2010	Not Detected
	3/2/2011	0.27 mg/l
	4/13/2011	0.37 mg/l

Characteristic Name	Date	Value/Units
Organic carbon, total	8/31/2010	2.4 mg/l
	11/8/2010	0.58 mg/l
	3/2/2011	0.73 mg/l
	4/13/2011	0.84 mg/l
pH	3/13/2010	7.64
	7/7/2010	7.37
	8/31/2010	7.38
	9/8/2010	7.58
	9/20/2010	7.57
	9/27/2010	7.3
	1/18/2011	7.46
	3/2/2011	7.37
	4/13/2011	7.5
Phosphorus as PO4, total	8/31/2010	0.16 mg/l
	11/8/2010	0.066 mg/l
	3/2/2011	0.081 mg/l
	4/13/2011	0.1 mg/l
Temperature, water	3/13/2010	16.2 deg C
	7/7/2010	15.7 deg C
	8/31/2010	15.39 deg C
	9/8/2010	15.49 deg C
	9/20/2010	15.21 deg C
	9/27/2010	14.77 deg C
	1/18/2011	9.41 deg C
	3/2/2011	10.87 deg C
	4/13/2011	12.58 deg C
Total dissolved solids	8/31/2010	92 mg/l
	11/8/2010	100 mg/l
	3/2/2011	122 mg/l
	4/13/2011	116 mg/l
Total suspended solids	8/31/2010	53 mg/l
	11/8/2010	Not Detected
	3/2/2011	Not Detected
	4/13/2011	Not Detected
Turbidity, total	8/31/2010	28 NTU
	11/8/2010	4.5 NTU
	3/2/2011	3.8 NTU
	4/13/2011	4.9 NTU

5.4 Water Quantity and Timing

5.4.1 Historical Streamflows

The Hydro-Climatic Data Network (HCDN) is a network of USGS stream gaging stations that are considered well suited for evaluating trends in stream flow conditions. Sites in the network have periods of record that exceed 20 years and are located in watersheds that are relatively undisturbed by surface water diversions, urban development, or dams. The closest HCDN gage is located on the Nolichucky River in Embreeville, TN, which is outside the RHI for Erwin NFH. The station has a period of record from 1900 to present. Figure 11 and Figure 12 in Section 4.7.1 depict streamflow conditions on the Nolichucky River over the period of record.

5.4.2 Historical Groundwater

Sun et al. (1963) measured discharge of the U.S. Fishery Spring (Site #12, Figure 16, Table 6) and the Birchfield Spring (Site #13, Figure 16) during the period from July 1951 to June 1954. Both springs were found to be third magnitude springs (1 to 10 cfs). In a broader study by Hollyday and Smith (1990), discharge measurements from a larger sample of springs over a longer time period (1947 to 1990), including the Sun et al. (1963) data, were analyzed and summarized. Data compiled from the two studies are summarized in Table 8.

Table 8. Historical groundwater discharge data for U.S. Fishery and Birchfield springs. Locations are shown on Figure 16.

Spring Name	Mean Discharge	Range	No. of Observations	Reference
U.S. Fishery Spring (Site #12)	1,140 gpm	893 to 1,430 gpm	36 measurements made monthly from July 1951 to June 1954	Sun et al. (1963)
	2.52 cfs (1,128 gpm)	1.99 to 3.18 cfs	40 measurements (Sun et al. (1963) data plus 4 additional values from unknown study conducted between 1947 and 1990)	Hollyday and Smith (1990)
Birchfield Spring (Site #13)	1,380 gpm	902 to 2,100 gpm	24 measurements made monthly from July 1951 to June 1953	Sun et al. (1963)
	3.09 cfs (1,384 gpm)	2.01 to 4.84 cfs	29 measurements (Sun et al. (1963) data plus 5 additional values from unknown study conducted between 1948 and 1990)	Hollyday and Smith (1990)

5.4.3 Hydrologic Alterations

There are no dams or major impoundments that influence hydrology within the RHI for Erwin NFH.

5.4.4 Land Use Activities Affecting Water Quantity and Timing

Given that the RHI contains no dams (Arnwine et al. 2006; USACE 2013) and Unicoi County had only 5 groundwater wells in 2011 (TDEC 2012a), it is unlikely that land use in the RHI has altered water quantity or timing in a meaningful way.

Groundwater availability in the vicinity of Erwin NFH could potentially be affected by future development upstream as well as changing climate conditions. There is little available data that indicates nearby groundwater recharge rates and the area of groundwater influence for Erwin NFH; however, a Public Health Assessment for the nearby Nuclear Fuel Services, Inc. facility cited a USGS estimate that approximately 22% of rainfall recharges groundwater in the area (USDHHS 2007).

Any continued residential development immediately upstream of the hatchery could impact the quantity and quality of the hatchery's water resources. Erwin Utilities operates three wells and one spring nearby in the Honaker Dolomite formation. Their wells have an average daily production of 1.9 million gallons per day (MGD). Due to the strong interaction between surface and groundwater in the area, the utility has established a wellhead protection area and plan to protect groundwater resources from pollution from surface contaminants (Erwin Utilities 2013).

5.5 Water Quality Conditions

According to hatchery staff, the groundwater sources on the hatchery have not been contaminated from surface water sources in the past. However, contamination from surface water runoff during heavy rain events is a possibility, especially if storm drains become clogged. Raceways in proximity to the spring have been completely underwater from storm events in the past (David Teague, USFWS, personal communication, December 22, 2014). If flooding of the spring and well were to occur, the most likely contaminants would be sediment, sewage or septic discharge from non-point sources and runoff from outside the hatchery's boundaries. Hatchery staff also report past issues with nitrogen levels in spring water, which are thought to be attributed to groundwater properties rather than surface water contamination (David Teague, USFWS, personal communication, December 22, 2014).

5.5.1 Federal and State Water Quality Regulations

5.5.1.1 Designated Uses

The North Indian Creek subwatershed upstream of Erwin, TN is designated for five of the seven uses assigned by TDEC: domestic water supply, industrial water supply, fish and aquatic life, recreation, and livestock watering and wildlife. It is not designated for naturally reproducing trout stream or navigational uses (TDEC 2007).

5.5.1.2 Water Quality Standards

TDEC is responsible for water quality regulation and Clean Water Act (CWA) reporting. Water quality standards are established for individual waterbodies by identifying the most stringent water quality criteria (numeric and narrative) for each use, considering the waterbody's antidegradation status (TDEC 2012b). Information on waters found to be impaired within the RHI is presented within section 5.5.2.1.

5.5.1.3 NPDES

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program regulates point sources that discharge pollutants into waters of the United States. NPDES permits are required for operation and sometimes construction associated with domestic or industrial wastewater facilities or activities (e.g., wastewater treatment facilities, mines, etc.). In Tennessee the EPA has delegated administration of the NPDES permit program to TDEC. Information on specific NPDES permits within the RHI is found in section 5.5.2.2.

5.5.1.4 Groundwater Regulations

Groundwater is protected by law at both the federal and state levels. The EPA is responsible for groundwater protection through the Safe Drinking Water Act (SDWA), which was intended to protect the quality of ground water serving as a source for public water supply wells through the requirement of maximum contaminant level standards for drinking water. SDWA established the Underground Injection Control, Wellhead Protection, and Source Water Protection Programs.

TDEC's Groundwater Management Program is responsible for coordinating with the EPA and other state agencies in developing a Comprehensive State Ground Water Protection Plan. A major focus of the Groundwater Management Program is wellhead protection for public water supply systems that rely on groundwater sources. This program also regulates groundwater discharges under the authority of the Water Quality Control Act through management of the Underground Injection Control (UIC) program, which includes both deep well injection and shallow non-hazardous injection such as stormwater discharge. Information on groundwater quality within the RHI is presented in section 0.

5.5.2 Impaired Waters, TMDLs, and NPDES Permits

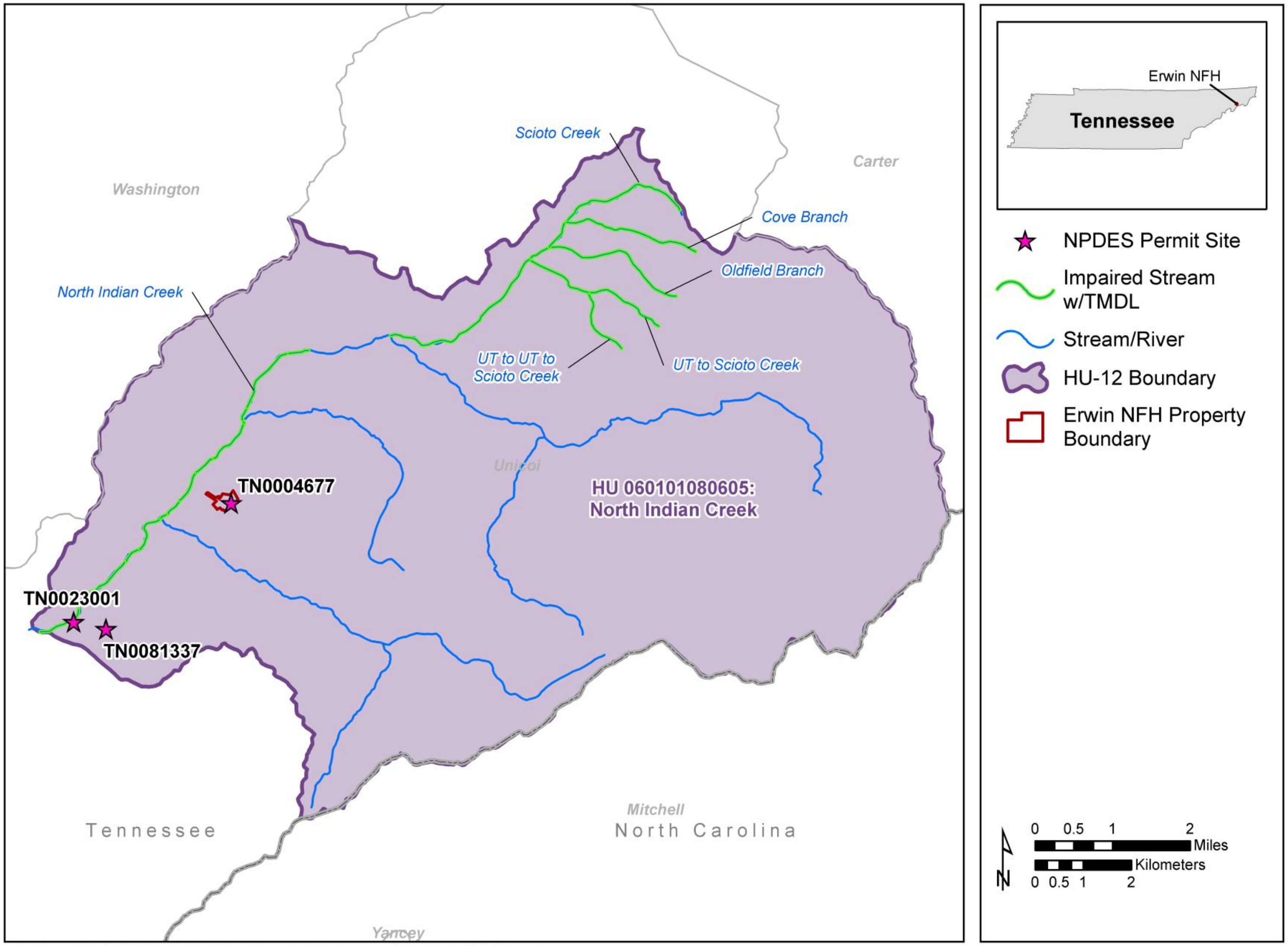
5.5.2.1 Impaired Waters and TMDLs

Section 305(b) of the Clean Water Act requires that each state produce a comprehensive biennial report on the quality of the state's waters, and Section 303(d) requires states to identify waterbodies where water quality standards are not met. In Tennessee, TDEC's Division of Water Resources (TDEC DWR) is responsible for fulfilling the requirements of Section 305(b) and 303(d) as well as defining total maximum daily loads (TMDLs). All of the watersheds in the state have been divided into five groups for monitoring and assessment purposes. According to the group's schedule the TDEC DWR conducts sampling of waterbodies within the watershed to determine if they are impaired (see Section 5.3.1.2). The Nolichucky River watershed is in Group 5; it was last monitored in 2010 and will next be monitored in 2015 (TDEC 2012b). Waterbodies that are considered impaired are then scheduled for development of a TMDL. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. TMDLs may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA 1991). As of the 2010 assessment, there were no new waters found to be impaired and in need of TMDL development (TDEC 2012b).

In 2008, a TMDL was issued for the Nolichucky River watershed in Cocke, Greene, Hamblen, Hawkins, Jefferson, Unicoi and Washington counties in Tennessee for Siltation and Habitat Alteration (TDEC 2008b). Approximately 26.3 miles of stream within the Erwin NFH RHI are included in this TMDL (see Table 9 for further details); however, none are located within the Erwin NFH property boundary (Figure 17).

Table 9. Impaired waterbodies with total maximum daily loads (TMDLs) within the Erwin NFH RHI (see Figure 17 for locations).

River Name	Listing Type	Cause	Miles within Erwin NFH RHI
North Indian Creek	TMDL	Siltation	14.52
UT to Scioto Creek	TMDL	Siltation	1.97
UT to UT to Scioto Creek	TMDL	Siltation	0.92
Scioto Creek	TMDL	Siltation	4.99
Cove Branch	TMDL	Siltation	1.92
Oldfield Branch	TMDL	Siltation and Habitat Alteration	1.99



Map Date: 12/23/2014 File: Fig17_ImpairedWaters_TMDL_NPDES_RHI.mxd
Data Source: USFWS Refuge Boundaries, EPA-RAD Assesed, Listed Impaired w/TMDL streams, ICIS NPDES sites, NHD Watershed Boundaries, ESRI Map Service.

Figure 17. Impaired waters with total maximum daily loads (TMDLs) and National Pollutant Discharge Elimination System (NPDES) permit sites near Erwin NFH.

5.5.2.2 NPDES

There are three NPDES permits within the Erwin NFH RHI and one NPDES permit within the hatchery property boundary, at Erwin National Fish Hatchery. The hatchery's NPDES permit (TN0004677 on Figure 17) allows the discharge of industrial wastewater from fish farm operations via a single outfall to Tate Spring Branch. The two facilities located within the RHI that are not within the Erwin NFH property boundary include a water treatment plant (WTP) and a sewage treatment plant (STP) (shown on Figure 17). The Erwin Railroad Well WTP (TN0081337 on Figure 17) has a general permit to discharge filter backwash and/or sedimentation basin washwater to North Indian Creek. The Erwin STP (TN0023002 on Figure 17) is classified as a major NPDES permittee (design flow greater than 1.0 MGD or with a pre-treatment program) and discharges into the Nolichucky River. NPDES permits require regular quantitative and/or qualitative monitoring specific to the industry.

5.5.3 Groundwater Quality

Karst terrain, which underlies the area beneath Erwin NFH, typically has very high rates of contaminant transport under rapid recharge conditions, such as storm events (USGS 2012). This is particularly concerning to public and private water supplies that utilize wells or springs; as pathogens and contaminants can quickly spread to groundwater sources when surface water is introduced from heavy storm events (TDEC 2012a).

Additionally, karst systems are further vulnerable to contamination since groundwater can travel relatively long distances through conduits with little to no chance for natural filtering processes from soil or bacteria (TDEC 2012a). The karst-forming area is constrained along the valley extending to the northeast and southwest from the Erwin NFH. Groundwater is localized and typically flows along shallow, short paths with recharge from precipitation percolating downward to the aquifers (Lloyd and Lyke 1995).

As noted previously, the hatchery obtains its water supply from a spring located in the Honaker Dolomite, which is also the source for Erwin Utilities. According to the most recent Water Quality Report (2013), Erwin Utilities has designated a wellhead protection program to prevent groundwater contamination within the Nolichucky watershed. TDEC's Groundwater Management Section is responsible for groundwater protection strategy development and wellhead protection. There are two wellhead protection zones established for each well or spring -- an inner zone (Zone 1) around the well or spring to protect the immediate area from spills, etc., and a larger management zone (Zone 2) which takes into account the wide variety of geologic conditions across Tennessee to provide for long-term management for the well, wellfield or spring. According to TDEC's 2003 Source Water Assessment, there were two facilities of concern within the inner zone (Zone 1), as well as 17 hazardous waste facilities, three Superfund facilities, and 58 facilities with priority standard industrial classification (SIC) codes. Additionally, there are four facilities with underground injection control (UIC) discharges within the larger management zone (Zone 2) area. Several highways also cross the Zone 2 protection area. The occurrence of two known toxics release inventory (TRI) releases to land or water within the wellhead protection area (USDHHS 2007) have been documented. The 2003 Source Water Assessment report found the wellfield to be "highly susceptible," primarily due to prior detection of contaminants and its vulnerability to contamination as part of an unconfined sand or karst/fractured rock aquifer (TDEC 2003).

5.5.4 Land Use Activities Affecting Water Quality

Sedimentation is the main water quality issue in the Nolichucky River Basin. A Siltation/Habitat Alteration TMDL has been created for portions of North Indian Creek and its tributaries Scioto Creek, Oldfield Branch, and Cove Branch in the RHI. Upstream or up gradient development could potentially threaten hatchery water quality; however, little population growth is forecasted for the surrounding area (Middleton and Murray 2009).

In 1957, Nuclear Fuel Services, Inc. (NFS) operations began in Erwin, TN. NFS primarily prepares high-enriched uranium to be processed into fuel for the Department of Energy's Naval Reactor Program along with other activities involving potential pollutants. NFS is located approximately 3.4 miles down gradient of Erwin NFH and outside of the RHI. Although no contamination issues are expected or have existed in the past, NFS remains a potential source of groundwater contamination in the area.

Based on the proximity of hazardous waste, Superfund, UIC discharge and other industrial facilities, as well as past toxic releases to land and water in the wellhead protection area, the 2002 Source Water Assessment for Erwin Utilities found its wellfield to be “highly susceptible” to contamination (TDEC 2003); however, more recent water quality reports prepared by Erwin Utilities report that TDEC has downgraded this assessment to “reasonably susceptible” (Erwin Utilities 2013).

In the Blue Ridge physiographic province, steep terrain and low permeability result in high runoff rates (Webbers 2003). However, total impervious area within the Erwin RHI is estimated to be from 2-5% (Exum et al 2005). Despite this overall low total for impervious areas, upslope development and insufficient upslope stormwater BMP design has led to occasional stormwater runoff issues for the hatchery. In heavy rain events, runoff from upslope can flow into the valley where the Erwin NFH facility is located, causing potential contamination of the hatchery raceways and an overloading of the hatchery stormwater structures. Improvements to upslope stormwater BMPs and land use can alleviate stormwater runoff concerns for Erwin NFH.

5.6 Water Law/Water Rights

5.6.1 State Water Law Overview

The Tennessee Department of Environment and Conservation Division of Water Pollution Control is responsible for water withdrawal regulation. Tennessee follows a system of riparian rights for surface water use with minimal regulation. Riparianism is defined as water use rights associated with ownership of land that abuts or underlies a surface water course. Landowners are entitled to reasonable water use, which may include purpose, suitability to the aquifer or watercourse, economic value, social value, extent or potential for harm caused, practicality of avoidance or adjustment and impacts on the rights of others. One landowner’s reasonable use may not interfere with the same use rights to which another landowner is entitled. The doctrine of reasonable use is also applied to groundwater extraction in most eastern states, allowing the landowner to extract water for use on the overlying tract of land, in most cases without regard to other landowners extracting from the same aquifer (Steele 2011).

5.6.1.1 Surface Water Withdrawals

Tennessee regulates surface water withdrawals or groundwater withdrawals that impact surface waters through its Aquatic Resource Alteration Permit (ARAP). While ARAP mostly focuses on surface water and surface water quality, it acts as a back entrance to reach at least a minimal level of water quantity regulation in the state (Steele 2011).

The Tennessee Water Resources Information Program (WRIP) collects information on the withdrawal and use of water within Tennessee. The information is used to identify water resources that may require management at critical times, such as in drought conditions and over-utilization. Under the authority of the Water Resources Information Act of 2002, TCA, Section 69-7-301, surface and groundwater withdrawals of 10,000 gallons per day, on average for the number of days of withdrawal, must be registered; however, there is no permitting requirement. Withdrawals for agricultural purposes or emergencies involving human health are excluded from this requirement. All entities withdrawing water, including those excluded from registration, are encouraged to report annual water withdrawal volumes. According to Brown-Kobil (2014), there is no regulation of use, even though that could be inferred from the language used in the statute, and there are no regulations under the Act.

5.6.1.2 Groundwater Withdrawals

In Tennessee, it is possible to install a water well on your land and pump groundwater for your use with little common law or regulatory constraints. In general, Tennessee groundwater regulation is based on reasonable use and correlative rights. Groundwater rights may be restricted to use on the overlying land or within the same basin. Separate landowners over a common source of groundwater share a similar right to utilize the groundwater source as long as it does not affect their neighbor's access to the groundwater. There are no priority use designations in Tennessee or quantification of rights amongst landowners over a connected groundwater source, unlike what is common in western states (Steele 2011).

Tennessee's ARAP program focuses on groundwater withdrawals that affect surface waters. If withdrawal from a groundwater well is not expected to reduce flow in or to a surface water body, ARAP will not be required. Despite the requirements set forth in the ARAP and other state regulations, Tennessee has less water resources planning, supply management, coordination and regulations restricting groundwater use than many other states. No policies are in place to evaluate the impact of major state actions on water quantity.

5.6.2 Legal or Regulatory Issues Potentially Affecting the Hatchery

The hatchery does not have formal water rights, in terms of rights to or restrictions on withdrawals from the aquifer and spring on the property (Norm Heil, USFWS, personal communication, July 24, 2014). It does maintain a NPDES discharge permit, as detailed in Section 0. In accordance with the Water Resources Information Act, Erwin NFH prepares an annual report specifying the volume of water withdrawn every year.

Steele (2011) questioned whether the Water Resources Information Act of 2002 may lead to more direct regulation of water supply and withdrawals, including consumptive use permitting of groundwater withdrawals, as water supply issues become more of a concern.

5.6.3 Aspects of State Water Law That May Negatively Affect the Station

As previously mentioned, Tennessee has less water resources planning, supply management, coordination and regulations restricting groundwater use than many other states and its existing statute lacks substance and specificity. For example, Steele (2011) questioned whether landowners would have the right to withdraw and transport water elsewhere (e.g., by pipeline) within the same watershed or outside of the area as long as no other landowners are negatively affected.

The absence of state water rights regulations could negatively affect the hatchery when changes in water availability become problematic as a result of climate change and increased upstream development. For example, groundwater availability in the vicinity of Erwin NFH could be affected by withdrawals by Erwin Utilities if future development requires increased groundwater use. Erwin Utilities has adopted a wellhead protection plan to protect groundwater resources and recharge areas. A possible strategy for Erwin NFH is to adopt a wellhead protection plan to secure and protect groundwater resources from future threats.

6 Assessment

In this section, the focus will be to highlight and briefly discuss the perceived major threats or issues of concern related to the water resources for the hatchery. The primary drivers of these threats are the anthropogenic and environmental stressors occurring within the RHI and issues regarding the use of groundwater and withdrawals from the associated aquifers. For discussion and recommendation purposes, the perceived threats or issues of concern are identified by two temporal categories: 1) urgent/immediate issues (those for which impacts have already manifested) and, 2) long term issues (currently not an immediate threat but if current practices continue, then impacts are likely).

6.1 Water Resource Issues of Concern

Threats or issues of concern include alterations and disturbances to the availability of surface and groundwater on temporal and seasonal scales. Specific threats and issues of concern are most related to anthropogenic changes and climate change issues within the basin and are associated with potentials to deplete groundwater/aquifer supplies. This relates directly to water quantity and quality issues. Anthropogenic changes within the hydrologic unit (such as the construction of roadways, community/urban development, etc.), groundwater withdrawals, and climate change issues, all have the potential to greatly influence the hydrology (surface and subterranean) within the RHI.

6.1.1 Urgent/Immediate Issues

6.1.1.1 Water Quantity

Many of the threats or issues of concern for water quantity are potential problems for both surface water and groundwater due to the hydrology of the area and associated soil and landscape composition. Thus, issues were not differentiated based on water type (i.e., surface vs. ground water), but rather were identified and considered as potential issues for all water resources within the RHI.

- Landscape changes have increased the amounts of maintained and impervious areas and that has led to increased runoff during heavy storm events. This increased runoff has the potential to create problems for the Erwin NFH. For example, during heavy rain events, runoff from upslope can inundate the hatchery facility to such an extent where it causes an overload to the storm water structures and can potentially result in contamination of raceways.

- No active stream monitoring (e.g., discharge, stage, etc.) appears to be occurring in proximity to the hatchery. Eight USGS stream gages were identified near the hatchery but none are currently actively monitored. Of these, the last active monitoring was conducted in 1980. Re-establishing stream monitoring efforts will allow hatchery staff to monitor stream conditions (e.g., stage) and make associations between the frequency/occurrence of high water events and storm water runoff related impacts to the hatchery.

- Available data is limited that identifies nearby groundwater recharge rates and the area of groundwater influence for Erwin NFH. However, a Public Health Assessment for the nearby Nuclear Fuel Services, Inc. facility cited a USGS estimate that approximately 22% of rainfall recharges groundwater in the area (USDHHS 2007), indicating that approximately ¼ of all groundwater supply in the area is reliant upon annual rainfall patterns and associated climatic conditions. Additional information associated with potential climate change issues are discussed under Long Term Issues.

- Continued development and potential population growth within, and in proximity to, the RHI will increase demand on water supplies. Although there is no forecast for local population growth in the near future, it still warrants concern and attention. An increase in water supply demand will potentially have direct or indirect adverse impacts to groundwater supplies utilized by the hatchery.

- Tennessee has less water resources planning, supply management, coordination and regulations restricting groundwater use than many other states and its existing statute lacks substance and specificity. The absence of state water rights regulations could negatively affect the hatchery when changes in water availability become problematic as a result of climate change and increased upstream development

6.1.1.2 Water Quality

Many of the threats or issues of concern for water quality are potential problems for both surface water and groundwater due to the hydrology of the area and associated soil/landscape formations. Thus, issues were not differentiated based on water type (i.e., surface vs. groundwater), but rather were identified and considered potential issues for all water resources within the RHI.

- During heavy rain events, runoff from upslope can flow into the valley where the Erwin NFH facility is located, causing an overload of the hatchery storm water structures and result in potential contamination of hatchery raceways.

- Surface water quality data for the watershed is somewhat limited. Two historic USGS water quality monitoring sites were identified near the hatchery. Both sites are not currently monitored, and the last reported sample from either of these sites was collected in 1980. However, TDEC also conducts water quality monitoring as part of its Clean Water Act responsibilities and has fixed-station chemical monitoring sites throughout the Nolichucky watershed.

- There have been two known toxic release inventory (TRI) releases to land or water within the wellhead protection area (USDHHS 2007).

- Karst terrain, as found within the RHI and which underlies the area beneath Erwin NFH, typically has very high rates of contamination transport under rapid recharge conditions, such as storm events (USGS 2012). This is particularly concerning to public and private water supplies that utilize wells or springs. Pathogens and contaminants can quickly spread to groundwater sources when surface water is introduced from heavy storm events (TDEC 2012a).

- Additionally, karst systems are further vulnerable to contamination since groundwater can travel relatively long distances through conduits with little to no chance for natural filtering processes from soil or bacteria (TDEC 2012a). The karst-forming area is constrained along the valley extending to the northeast and southwest from the Erwin NFH. Groundwater is localized and typically flows along shallow, short paths with recharge from precipitation percolating downward to the aquifers (Lloyd and Lyke 1995).

- The Tennessee Department of Environment and Conservation 2003 Source Water Assessment report found the well field in the area to be “highly susceptible,” primarily due to prior detection of contaminants and its vulnerability to contamination as part of an unconfined sand or karst/fractured rock aquifer (TDEC 2003).

- Based on the proximity of hazardous waste, a Superfund site, UIC discharge and other industrial facilities, as well as past toxic releases to land and water in the wellhead protection area, the 2002 Source Water Assessment for Erwin Utilities found its well field to be “highly susceptible” to contamination (TDEC 2003). More recent water quality reports prepared by Erwin Utilities report that TDEC has downgraded this assessment to “reasonably susceptible” (e.g., Erwin Utilities 2013). All of these areas are in proximity to Erwin NFH and potentially pose a threat to the water resources utilized for hatchery operations.

6.1.2 Long Term Issues

6.1.2.1 Unknown Impacts Related to Climate Change

- Climate change issues are associated with projected increases in storm severity and frequencies and will further exasperate the problems of runoff. This runoff could lead to potential contamination of the raceway water supply.

- Another effect associated with climate change is periods of extreme drought. Based on hatchery staff responses to a USFWS climate change questionnaire, a super saturation of nitrogen resulting from drought conditions caused mortality of broodstock fish in May/June of 2007. This was the first time in 30 years that such an event had occurred and now presents an on-going threat if climate change leads to enhanced drought conditions (USFWS 2012).

- Alterations to climatic seasonal patterns within the RHI could lead to extended periods of drought or excess precipitation (rain and snow) and adversely impact the water supplies. Extreme drought conditions could lead to increased depletions to groundwater supplies that are a necessity for hatchery operations. Abnormal amounts of excess precipitation can complicate runoff issues and potentially contaminate surface and groundwater supplies associated with the hatchery.

- Although the specific impacts climate change will have on the Erwin NFH are not known, regional changes to the quantity and timing of available water are likely to magnify the influences of other identified threats and challenges currently impacting the system. Watersheds in the southern Appalachians are particularly vulnerable to changing water conditions exacerbated by climate change (Hurd et al 1999).

6.2 Needs/Recommendations

In this section, prioritized recommendations based on a review of the information collected during the WRIA process are provided. Suggested generalized actions to begin addressing potential impacts include: 1) Identify areas/issues that are most likely to be negatively impacted by effects of climate change, 2) identify opportunities to increase the understanding of groundwater and recharge rates within the RHI and associated relationship to hatchery operations, 3) Establish a decision-making process that places emphasis on, prioritizes, and addresses any hatchery operational constraints (e.g., infrastructure, staffing, etc.), and 4) continue with the development and coordination of local support for the hatchery, including working with state and federal partners to gain a better understanding of the issues and needs associated with the water resources within the area. The following information provides specific recommendations on how to better address (immediate or long term) the aforementioned generalized actions.

6.2.1 Immediate

The following recommendations are some potential options that should be considered to immediately begin addressing runoff issues at Erwin NFH.

- Consider if immediate actions could be implemented to assist in diverting storm water around or away from areas that are most susceptible, especially during normal rainfall events, or as needed.

- Conduct cost/benefit and risk analyses to evaluate the need and priority for infrastructure upgrades. Such analyses should include information on the frequency, timing, magnitude, and duration of rainfall events and attempt to identify those types of events that have the most impact/damage from associated runoff.

- From the analyses, identify and prioritize needed upgrades to hatchery drainage infrastructure.

6.2.2 Long Term

Long term planning to address various water resource issues are critical and often require the consideration of various aspects and constraints. The information below is not intended to be all inclusive, but is rather recommendations for some of the potential aspects to consider for long term planning and implementation of any action items.

6.2.2.1 Partnerships

In order to most effectively manage and protect the associated water resources within the watershed, continued, enhanced, and expanded support of partnerships is critical. Establishing new partnerships with agencies and entities where previous coordination and collaboration did not exist is imperative. These partnership opportunities can potentially provide additional resources and perspectives on issues regarding the water resources within the watershed and on the hatchery. Examples of such recommendations include:

- Work with federal, state, and local agencies/municipalities to implement/improve storm water BMPs (best management practices) upslope of the hatchery property in an effort to provide an opportunity to alleviate runoff concerns.

- Work with USGS to identify priority stream gages near the hatchery to consider for re-initiating active monitoring. Eight gages were identified in proximity to Erwin NFH and none are actively being monitored. The most recent monitoring from these gages was in 1980.

- Collaborate with state and federal partners to effectively identify issues regarding the respective aquifers and how adverse long-term impacts to those aquifers could affect the aquatic resources on the hatchery. Solicit assistance from TDEC to establish a groundwater monitoring program within the watershed.

- Work with TDEC and/or other appropriate partners to provide a solid conclusion/confirmation on the status of the two (apparent) different water supplies on the hatchery.

6.2.2.2 Water Quantity Information

Critical data are needed for the hatchery documenting the magnitude, frequency, timing, and duration of storm water runoff throughout the year. As part of this data need, the development of a hydrological inundation model of the surface waters within the RHI would provide a better understanding of how runoff impacts the watershed and more specifically, the hatchery. An example of how such a model could be developed and utilized can be found in a publication by USGS staff at the Arkansas Water Science Center (Westerman and Clark 2013). Additional surface water and groundwater information can be obtained from various state and federal agencies, including TDEC and USGS.

6.2.2.3 Groundwater Information

Additional research is needed to document and evaluate rainfall contributions to groundwater and associate this information with surface flow within the RHI. Analysis of aquifer hydrogeology and vulnerability to contamination for the physiographic region is also needed.

As development and land use practices increase in the watershed, and climate change influences both aspects of surface water and groundwater recharge and discharge, the need for long-term groundwater information will increase. Continued and supplemental monitoring of active wells within the watershed should be maintained and be implemented throughout the associated watersheds.

According to USDHHS (2007), TDEC annually monitors Erwin Utilities' Railroad Well for water quality parameters. TDEC's Groundwater Management Program conducts monitoring; however, the state lacks an ambient groundwater monitoring program (TDEC 2012a). A possible strategy for Erwin NFH is to adopt a wellhead protection plan to secure and protect groundwater resources from future threats.

6.2.2.4 Water Quality Monitoring

Stay informed with the TDEC watershed monitoring efforts and more specifically the scheduled monitoring for the Nolichucky River watershed (Group 5). This area is scheduled next to be monitored in 2015 (TDEC 2012b).

Evaluation of TMDLs (as designated) in the watershed and monitoring of those associated impaired streams should continue over time. In addition, potential research could focus on biological monitoring, as well as nutrient and sediment modeling for any impaired streams within the watershed. This information could be linked and utilized to the development of any hydrologic model.

Specific groundwater monitoring objectives for the hatchery should be developed and implemented. Specific tasks should ideally supplement existing water monitoring work already being conducted (or previously conducted) in the watershed and in proximity to the hatchery (e.g., USGS spring monitoring well located within the hatchery property boundary; Site #12 US Fishery Spring at Erwin, TN). Groundwater contamination issues should be further evaluated and monitored to record any potential changes or issues.

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