PUBLIC WORKS TECHNICAL BULLETIN 200-1-114
15 DECEMBER 2011

GPS-BASED UNDERWATER VIDEO MAPPING FOR AQUATIC THREATENED AND ENDANGERED SPECIES HABITAT

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

CECW-CE

Public Works Technical Bulletin 15 December 2011

No. 200-1-114

FACILITIES ENGINEERING
ENVIRONMENTAL

GPS-BASED UNDERWATER VIDEO MAPPING FOR AQUATIC THREATENED AND ENDANGERED SPECIES HABITAT

1. Purpose.

a. This PWTB gives an overview on how underwater video mapping can be used to create a continuous river habitat map along extended river sections and to identify river sections requiring more intensive surveys. This document describes a river survey to acquire georeferenced video images, to develop GIS maps of the river sections, and to use aquatic habitat maps for determining optimal habitat locations for the Rayed Bean mussel(*Vilosa fabalis*).

b. All PWTBs are available electronically at the National Institute of Building Sciences' Whole Building Design Guide webpage, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to all U.S. Army facilities engineering activities.

3. References.

a. Army Regulation (AR) 200-1, "Environmental Quality, Environmental Protection and Enhancement," Headquarters, Department of the Army, Washington, DC, December 2007.

b. Clean Water Act of 1977 (Public Law 95-217, U.S. Code, Title 33 Part 1251).

c. The Sikes Act, 16 United States Code (USC) §§ 670a-670o, available at the following URL: http://www.fws.gov/laws/lawsdigest/SIKES.HTML

d. Memorandum, Army Species at Risk Policy and Implementing Guidance, Department of the Army, 15 September 2006.

e. Endangered Species Act of 1973 (PL 93-205; 16 USC 1531 et seq., as amended).

4. Discussion.

a. AR 200-1 provides the Army’s policy and responsibilities for the conservation, management, and restoration of land and natural resources so that they are in agreement with federal policies. Protection and management of Threatened and Endangered Species (TES) also are covered as part of federal policy. Additionally, non-point source pollution, generated from erosion, plays into multiple laws and regulations including the Sikes Act, Clean Water Act, etc., which all affect how Army training lands are managed for water quality and aquatic TES.

b. This report provides a description of the devices used for the underwater mapping system and outlines the results including aquatic attributes and species-specific optimal habitat maps. This PWTB provides an approach to conducting evaluations of stream systems on military installations.

c. Appendix A provides information on the equipment used by University of Tennessee-Knoxville for this study for underwater video mapping at Camp Atterbury, Indiana. Appendix A, “Underwater Mapping Equipment,” delves into the details of how the equipment was mounted, used, and how it relates to mapping of TES habitat.

d. Appendix B contains guidelines for determining aquatic attributes with georeferenced images.

e. Appendix C contains GIS river habitat maps specific to Camp Atterbury’s river system running along the eastern border of the installation.

f. Appendix D contains information for determining the optimal habitat location for the Rayed Bean mussel (*Villosa fabalis*).

g. Appendices A-D contains the report, figures, and maps developed by personnel from the University of Tennessee - Knoxville, with contributions from ERDC-CERL researchers. The final report was submitted in May 2010 to ERDC-CERL and has been edited for format and clarity as part of this PWTB effort.

h. Appendix E lists acronyms used in this document.

i. Appendix F contains references cited in the document.

5. Points of Contact.

a. Headquarters, US Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

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Appendix A

UNDERWATER MAPPING EQUIPMENT

Acknowledgements

This project was administered by the U.S. Army Engineer Research and Development Center–Construction Engineering Research Laboratory (ERDC–CERL) at Champaign, IL. The study was conducted at Camp Atterbury by academic personnel from the University of Tennessee at Knoxville, TN, in cooperation with a team of ERDC-CERL researchers.

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  Camp Atterbury, Indiana

The figures and tables within the report were created by the authors unless otherwise indicated.

Introduction

Protecting natural resources while maintaining quality military training and testing areas is critical to sustaining military installations. Understanding the impact of military training on unseen aquatic habitat is necessary to promote the protection of natural habitats. Historically, labor intensive surveys and population counts have been used to access streams and rivers on military installations.

Underwater video habitat mapping involves conducting surveys of large river and creek reaches (sections) to develop large-scale aquatic habitat maps. This new method utilizes a GPS-based mounted camera that can make rapid assessments in habitat change of stream systems. Canoe and kayak-mounted above and underwater cameras and a sonar depth sensor capture georeferenced images of aquatic attributes and river depth. Aquatic attributes determined include: (1) river characteristics (pool, riffle, run), (2) substrate classifications, (3) depth, and (4) embeddedness. These GIS-based river habitat classifications are utilized to develop species-specific optimal habitat maps for the possible threatened and endangered species (TES) such as the Rayed Bean mussel (*Villosa fabalis*).

The Underwater Video Mapping System (UVMS) was developed to examine underwater ecosystems and record their location using a differentially corrected Global Positioning System (GPS). Both canoe- and kayak-mounted UVMS were used in the Driftwood River survey at Camp Atterbury. For the kayak-mounted UVMS, a Wilderness Systems Tarpon 100 kayak (Figure A-1) was used to float the thalweg section of Driftwood River. A Splashcam Deep Blue video camera was mounted to the bow (Figure A-2), to acquire above-water footage. Mounted to the hull of this kayak were two Dropshot 20/20 underwater video cameras, one to photograph straight down and one to photograph at an angle to the substrate, and two underwater laser pointers (Figure A-3). A weatherproof case located at the rear of the kayak housed three digital video recorders, a global-positioning system receiver (Garmin GPS 18), and a video mapping system (VMS 200).

The Garmin GPS18 receiver is a 12-channel GPS receiver. The receiver is programmed to output the $GPRMC and $GPGGA NMEA 0183 strings at one-second intervals. The Garmin GPS 18 receiver uses wide-area augmentation system (WAAS) for differential correction to produce accuracy within 3 m. The digital video recorders featured audio/video input and output, which made it possible to connect the VMS 200 and the underwater camera.

The digital video recorders were used to collect the above-water and underwater, georeferenced, digital video images. River-depth measurements were recorded by utilizing the two parallel lasers, which provided both a depth indicator and a measurement scale visible in the underwater images. In addition, a flush-mounted depth sensor was used to record depth approximately every second. The float path was attempted through the main section (thalweg) of the river.

Figure A-1. Wilderness Systems Tarpon 100 kayaks, used in the study of Driftwood River, Camp Atterbury.

Figure A-2. The Splashcam Deep Blue video camera, mounted to the kayak bow to acquire above-water footage

Figure A-3. A flush-mounted camera (middle) and two parallel laser pointers (top and bottom) on the kayak hull.

For deeper sections of the river, a drop-down camera is needed, and a canoe-based UVMS is utilized (Figure A-4). The canoe-mounted UVMS incorporates a Splash Cam II underwater camera (Figure A-5), a Trimble AgGPS 132 Receiver, a VMS 200 video mapping system, two digital recorders, a Lowrance LMS-350A sonar depth sounder, and a serial data recorder. These components worked together to georeference all the digital images by recording the digital GPS (DGPS) position on each video frame.

The Splash-Cam II is a compact, color, underwater video camera. with an adjustable strain relief feature that allows the operator to view the substrate. This underwater camera also has a stabilizer fin to keep the camera oriented forward, and two underwater laser-pointers to provide a reference for scale. It has a cable length of 60 m (200 ft) and a cable breaking strength of 3100 N (700 lb). A reel stores the cable, and the camera is manually raised and lowered to the desired height above the substrate. A head-mounted LCD color screen allows the operator on the canoe to see the underwater images and adjust the camera height.

The VMS 200 is a spatial multimedia system — a tool that creates “video maps” and interactively displays pictures or video footage of the mapped locations. The system includes hardware that embeds GPS data on the left channel of the videotape and software that automatically builds maps using the video-acquired data. The VMS 200 can be used with an external camera so that the images will be identified with a GPS location. The VMS 200 records the GPS position with each frame of the digital videotape, thus georeferencing images.

The Trimble AgGPS 132 is a 12-channel, high-performance, sub-meter GPS receiver. It features a combination of a GPS receiver, a Coast Guard beacon, and a satellite differential correction receiver in the same housing. The Trimble receiver is programmed to output the $GPGGA and $GPRMC strings. The $GPGGA string contains time, latitude, longitude, GPS quality (2D/3D fix and differential correction), number of satellites, horizontal dilution of precision (HDOP), altitude, age of differential correction, and the differential reference station identity. The $GPRMC string contains time, latitude, longitude, speed over ground, course over ground, date, and magnetic variation. Position accuracies of less than 1 m are attained for the GPS device.

The digital video recorder records the underwater image and the GPS data by using the audio input jack (RCA brand) instead of the microphone. The serial data recorder records the depth measurement from the Lowrance depth sensor. A diagram of the equipment setup for data collection can be seen in Figure A-6.

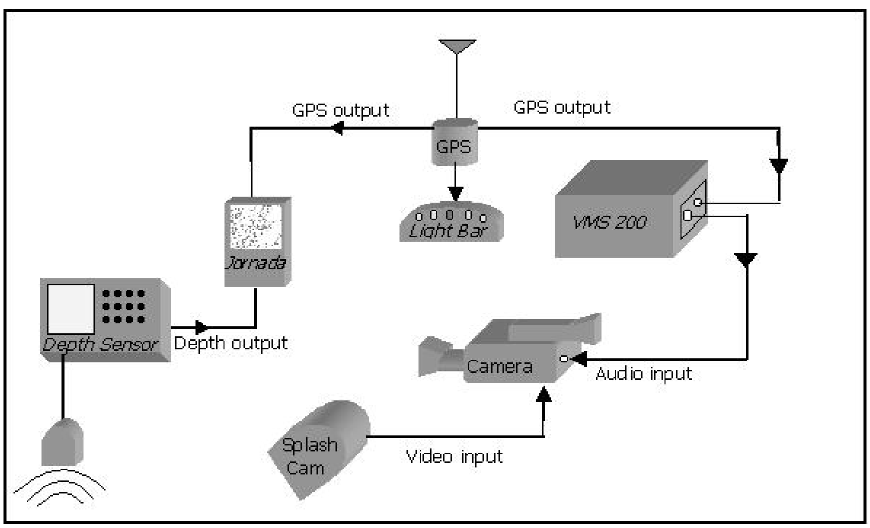

Figure A-6. Equipment setup for data collection.

Appendix B

DETERMINING AQUATIC ATTRIBUTES WITH GEOREFERENCED IMAGES

Video mapping system technology was utilized to georeference the images. This technology embeds the GPS location (from the Garmin 18 or Trimble 132 GPS receivers) on the audio track of the video image. Thus, because each video image then has a GPS location, it is "georeferenced." The georeferenced attributes were classified by reviewing/comparing the digital images and field notes. GIS river habitat maps were developed in ArcGIS 9.3.

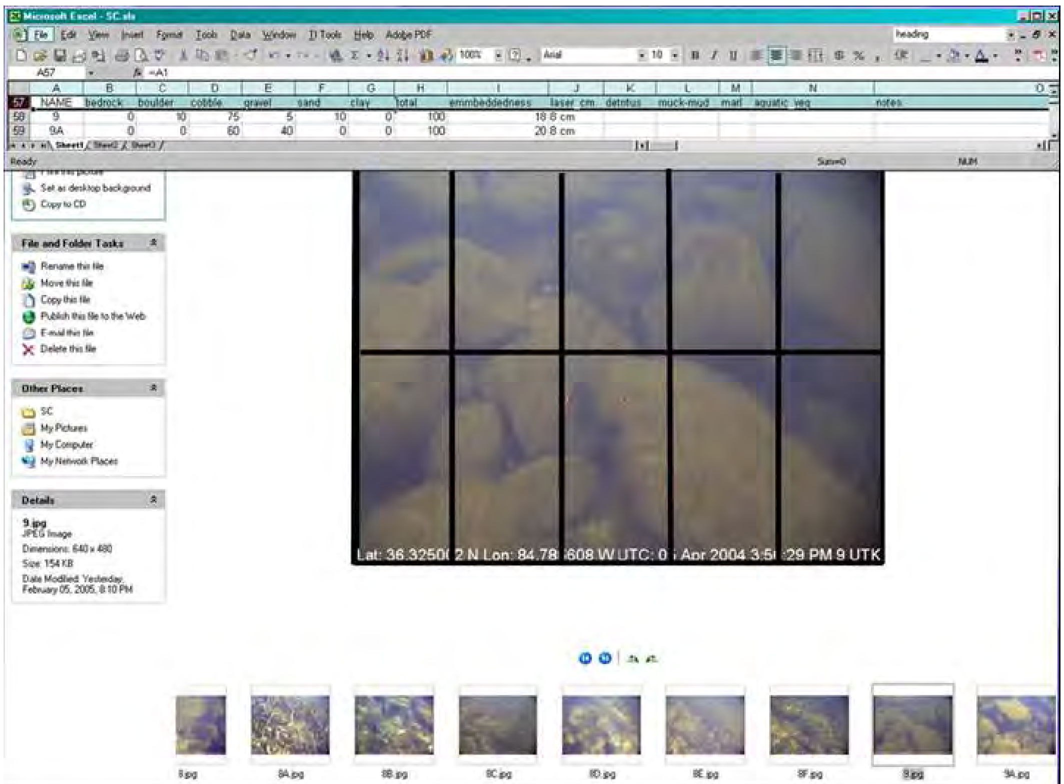

Figure B-1. Screenshot of the habitat substrate which was analyzed using the Wentworth scale for particle size.

The above-water video images were viewed to define river characteristics (pool, riffle, run) based on the EPA guidelines shown (Figure B-2). Observations of underwater video were also used to define substrate classification and embeddedness (based on EPA guidelines). River depth was obtained using the depth sonar and underwater lasers.

Flow Characteristics of the River		
habitat parameter	description	example pictures
pool	Areas characterized by smooth undisturbed surface, generally slow current, and deep enough to provide protective cover for fish (75 to 100% deeper than the prevailing stream depth).	
riffle	Area characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches). Shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing agitation.	
run	Fast-moving section of a stream with defined thalweg and little surface agitation. Runs are deeper than a riffle and shallower than a pool.	

Figure B-2. River flow characteristics (data from NRCS 1998; photos and figure created by Fiscor 2005, p 64).

Appendix C

GIS RIVER HABITAT MAPS

GIS aquatic habitat maps also were developed in ArcGIS 9.3 and are shown on the following two pages (Figure C-1 and Figure C-2).

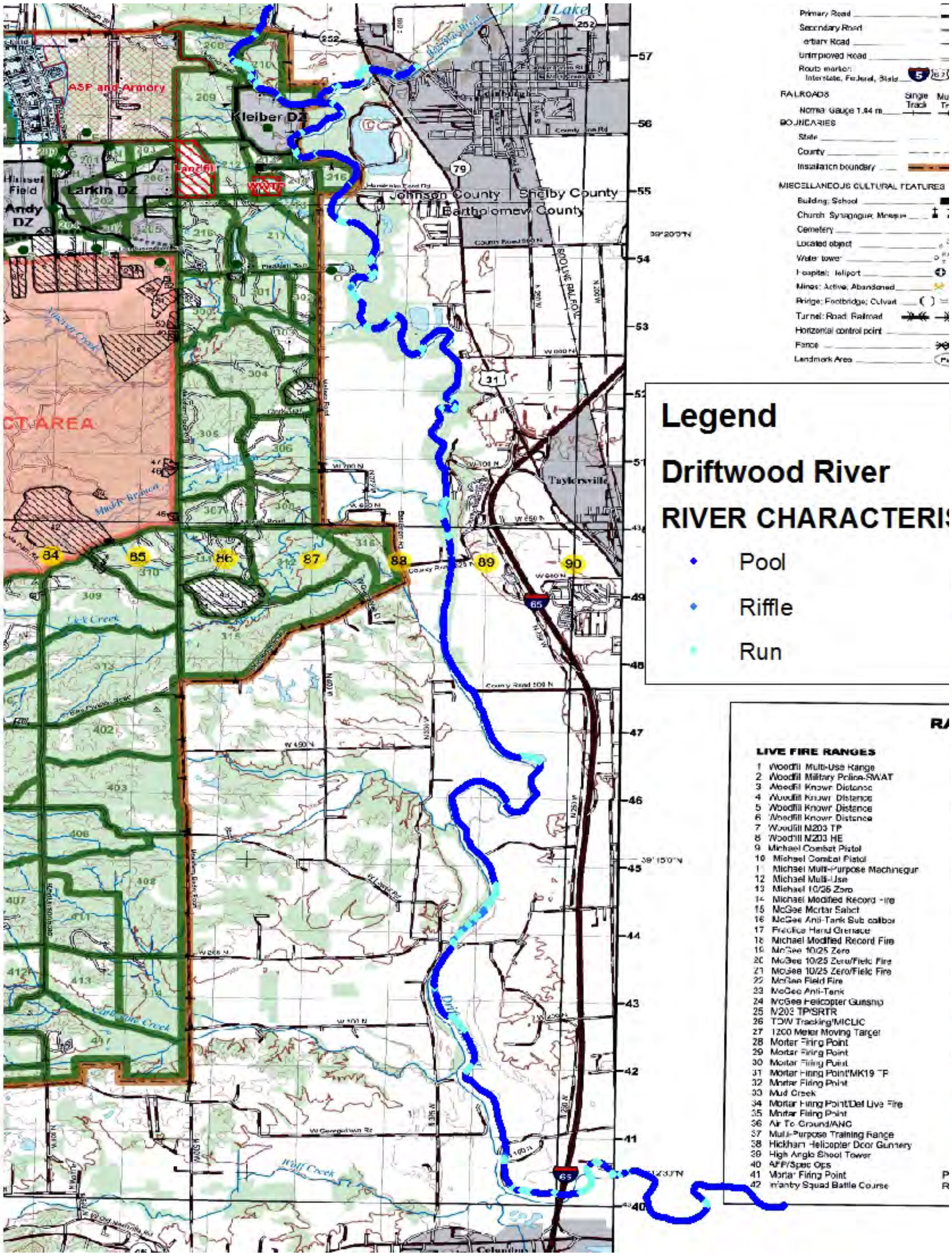

Figure C-1. ArcGis-created map of Driftwood River at Camp Atterbury, indicating the type of hydraulics present at various points, as represented by the varying shades of blue.

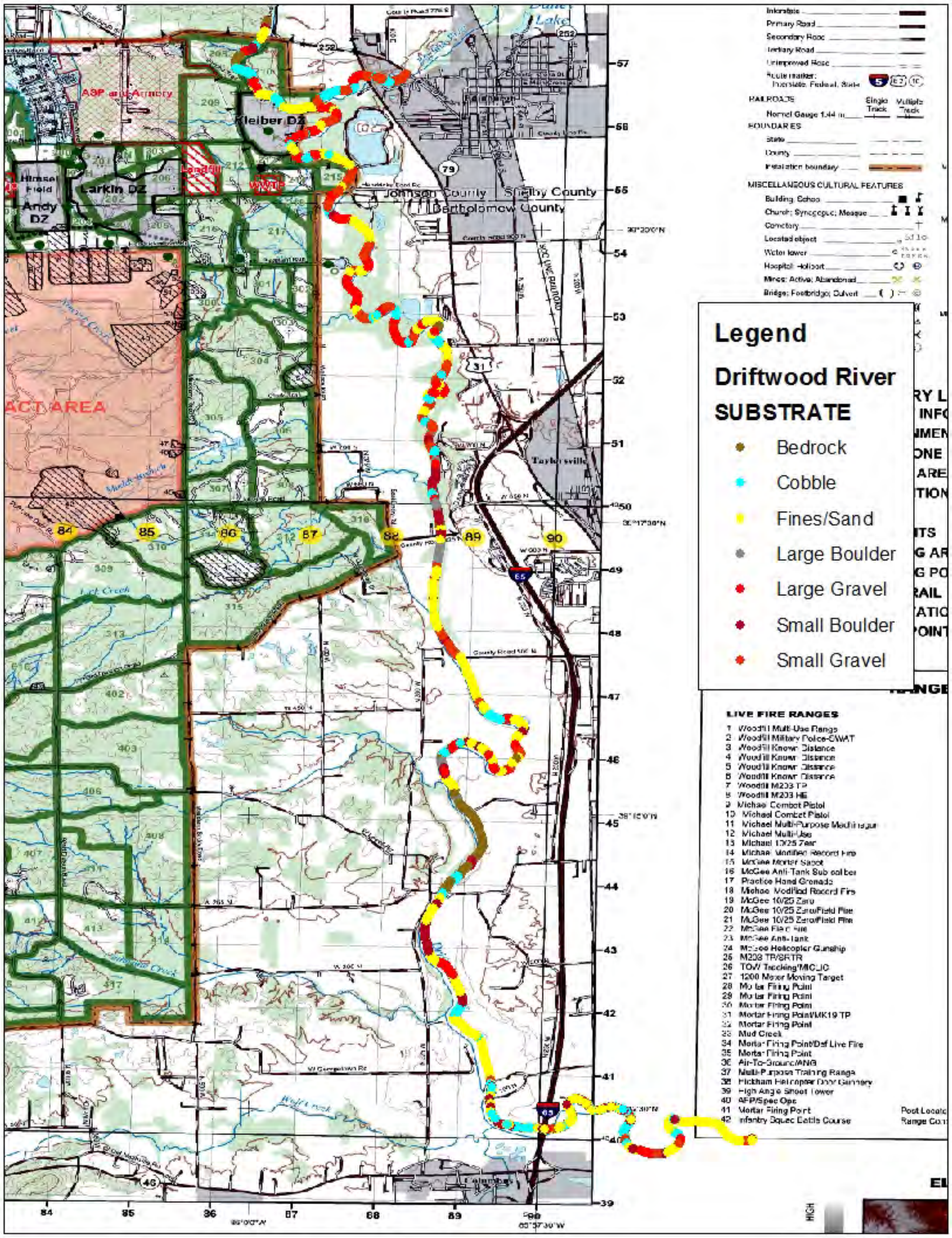

Figure C-2. ArcGis-created map of Driftwood River at Camp Atterbury, showing location of various substrate materials as indicated by the varying colors shown.

Appendix D

OPTIMAL HABITAT LOCATION DETERMINATION FOR THE RAYED BEAN

The Rayed Bean mussel is primarily found in and near riffles of small, shallow rivers that are usually about 4 ft deep. The Rayed Bean occurs in small, shallow rivers, in and near riffles, where it is buried deep in sand and/or gravel, often near aquatic vegetation. It particularly has been found buried around the roots of the American water willow (*Justicia Americana*), which thrives in rocky or sandy soils in shallow waters along the edges of streams or lakes.

The only noted host fish of the Rayed Bean is the Tippecanoe Darter (*Etheostoma Tippecanoe*). In order for a species of mussel to flourish, a host fish must be present because the mussel’s glochidia (or larvae) must come into contact with a specific host fish in order to survive. The Tippecanoe darter, a now-threatened fish species, can be found in clean rivers and large creeks with a high-velocity bottom current. Host fish to a similar species of mussel as the Rayed Bean include: Black Sculpin, Greenside Darter, Rainbow Darter, Fantail Darter, and many other types of darter fish.

Based on this description, the search criteria for the Rayed Bean’s optimal habitat consists of: (1) water depth of less than 4 ft, (2) a river characteristic of riffle or run, (3) a substrate of sand or small gravel, and (4) an embeddedness from 0%–50%.

Using these search criteria, 6.7% of the habitat within the 20-mile river section was determined to be optimal habitat for the Rayed Bean. A map, marked in red for the optimal habitat of the Rayed Bean, is shown below (Figure D-1).

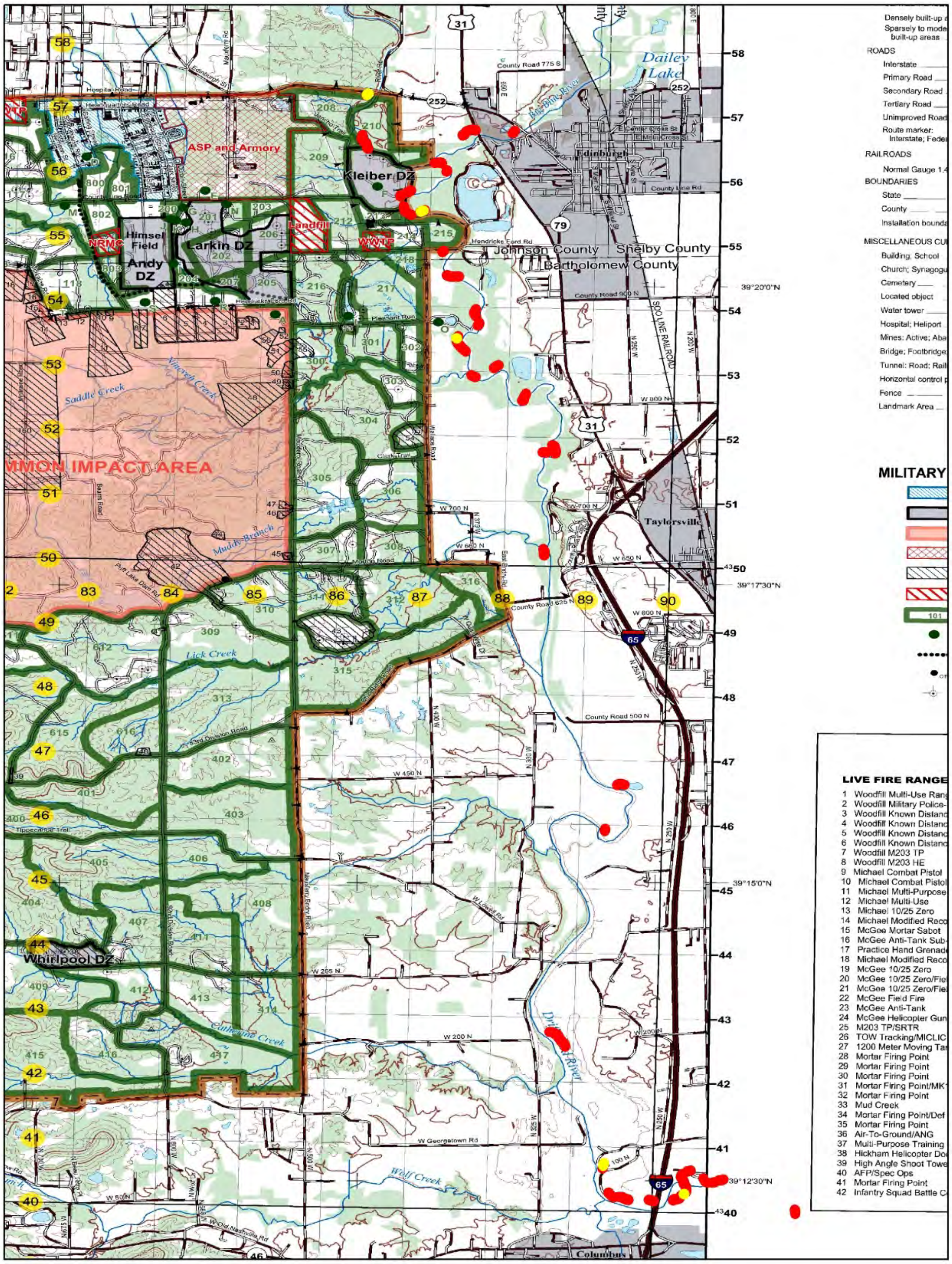

Figure D-1. Areas of optimal habitat for the Rayed Bean in the Driftwood River are shown in red.

Appendix E

ABBREVIATIONS

Term	Spellout
AR	Army Regulation
CECW	Directorate of Civil Works, U. S. Army Corps of Engineers
CEMP	Directorate of Military Programs, U. S. Army Corps of Engineers
CERL	Construction Engineering Research Laboratory
CFR	Code of the Federal Regulations
CONUS	Continental United States
DA	Department of the Army
DPW	Directorate of Public Works
DoD	Department of Defense
EPA	Environmental Protection Agency; also USEPA
ERDC	Engineer Research and Development Center
GIS	geographic information system
GPS	global positioning system
HDOP	Horizontal Dilution of Precision
HQUSACE	Headquarters, U.S. Army Corps of Engineers
LCD	liquid crystal display
OCONUS	outside Continental United States
PDF	portable document file
POC	point of contact
PWTB	Public Works Technical Bulletin
URL	universal resource locator
USACE	U.S. Army Corps of Engineers
UVMS	underwater video mapping system
VMS	video mapping system
WBDG	Whole Building Design Guide
WAAS	Wide Area Augmentation System
WWW	World Wide Web

Appendix F

REFERENCES

Fiscor, Adam John. 2005. *Mussel Habitat Mapping in the Big South Fork National River and Recreation Area (BISO)*, thesis for Master of Science degree. Knoxville, TN: University of Tennessee.

Natural Resources Conservation Service (NRCS). 1998. *Stream Visual Assessment Protocol*, National Weather and Climate Center Technical Note 99-1. Washington, DC: U.S. Department of Agriculture (USDA).