Wetbud – A New Water Budget Modeling Program for Created Wetland Design

W. Lee Daniels

and many more from many places!

http://www.landrehab.org
Who's doing what?

Zach Agioutantis, **Univ. of Kentucky** -- Programmer & MODFLOW

W. Lee Daniels, **Virginia Tech** -- Program coordinator & gadfly

Ben Hiza, **Old Dominion University** - Julie Metz models

Stephen Stone, **Old Dominion University** - Huntley Meadows models

Tess Thompson, **Virginia Tech** - Surface water

Rich Whittecar, **Old Dominion University** - Groundwater & MODFLOW

**Previous Graduate Students:** Kerby Dobbs, Matt Gloe, John McCleod, Eric Neuhaus, O. Waverly Parks, Candice Piercy, Tracy Thornton, Cal Smith

**Research Associates/Specialists:** Dan Evans, Katie Haering, Sara Klopf and Laura Lehman.
Objectives

• Review brief history of “water budgeting issues” for wetland creation in the mid-Atlantic region of the USA.

• Describe the historical development of our new water budget model – Wetbud

• Provide an overview of Wetbud’s data requirements, functions and outputs.
A commonly employed “simple” way to create a mitigation wetland is to create a perched system. Can work on hilltops with low permeability intentionally compacted subsoils. Assume negligible groundwater.
Wetland creation site in mineral flat or pocosin type landform. Here, designers presumed that excess rainfall vs. ET + minimal infiltration losses would drive the annual water budget. Before adjustments were made, this site was “too dry” in summer, but very wet in the winter.
Surface soil from an anonymous 3-year old mitigation wetland.

Note massive structure in surface breaking to firm plates at about 20 cm. This is the “traffic pan” that was designed to perch the water table, but also led to extremely dry summer conditions.
Fort Lee Water Budget Studied by USGS & Virginia Tech in late 1990’s.

> 20 wells/piezometers monitored for > 2 years along with direct measurements of all water budget components.
Hydroperiod of created soil vs native soil at Ft. Lee; the mitigation site soil was dominated by fac upland vegetation. Only ~20% of the site was characterized by this type of hydroperiod.
Ft. Lee Wetland

May 1, 1998 to April 30, 1999

Net Loss of 0.01 in (0.30 cm)

90 cm of rain In
(dry year)

10 cm of runoff In

Surface In

4.08 in
(10.36 cm)

Precipitation
35.43 in
(89.99 cm)

Evapotranspiration
38.32 in
(97.36 cm)

Surface Out

32.14 in
(81.64 cm)

Net Groundwater In

132 cm of GW In

52.24 in
(132.69 cm)

Net Groundwater Out

21.29 in
(54.08 cm)

55 cm of GW Out

98 cm of ET Out

80 cm of runoff out
Water Budget Model Issues Addressed by Wetbud

- “Bath Tub” vs. Sloped Systems
- Vegetative Flow Resistance
- Groundwater Inputs vs. data?
- Overbank Flow Contribution
- Which Precipitation Data?
- Variations in ET Estimators
- Complex topography
Wetbud History

Program originally funded via RFP #2 (Wetland Water Budgeting) by WSSI & Peterson Family Foundation in 2008. Original objectives and tasks:

- Review literature, survey regulatory and industry practices, and document all known water budget methodologies;
- Interview experienced wetland scientists and engineers about existing design and construction issues related to wetland water budgets (Gary Pierce involved in early years);
- Find existing constructed wetlands in the Virginia Piedmont with sufficient geologic data and hydrologic instrumentation from pre- and post-construction evaluations for model evaluation;
- Develop a library of historic rainfall data for all NOAA stations in Virginia and classify each year as “dry,” “typical,” or “wet”;
- Generate detailed tables with interpretative information of Piedmont soil conditions with respect to expected infiltration, permeability, and other important hydrologic and plant growth parameters;
Primary original focus of research funds for new water budget model (Wetbud) was Piedmont wetlands. The model also functions very well in the Coastal Plain. Wetland creation in any landscape must understand the HGM context of both the impact and proposed creation site and particularly account for groundwater and surface overbank additions/losses (if present).
Wetbud History

Program originally funded via RFP #2 (Wetland Water Budgeting) by WSSI & Peterson Family Foundation in 2008. **Original objectives and tasks:**

Assess existing software and individual process-models (e.g. Darcy, Thornthwaite, etc.) for applicability to the Virginia Piedmont, ease-of-use, and accuracy;

Work with project collaborators to adapt existing software or to develop independent software modules and package for use in wetland hydrologic assessments;

Test the new model using data sets developed from selected test sites;

Develop an instruction manual to explain how to collect or determine groundwater data for use in this model; collect, test, or verify topsoil and subsoil data; and install and use the associated computer model; and,

Develop training materials for use in workshops designed to teach others how to use the new software package.
Wetbud History

Program focused primarily on Piedmont (and Fall Zone) wetlands as research targets due to nature of funding.

Added support over time include more focus on MODFLOW, stream overbank (2011) and AET estimators (2013).

Continuing work at Huntley Meadows (FCPA) and at Julie Metz + North Fork (WSSI) sites to validate Wetbud components and compare ET estimators.

See www.huntleymeadows.org for more details on that site.
Design Standards Development

**Precipitation**
- Statistically based analysis for wet, normal, and dry rainfall years
- Recommended weather stations for VA/MD/DE
- Tools for auto download of any USA station

**Evapotranspiration**
- Calculates both Penman and Thomthwaite
- For W-N-D years selected by precipitation
- Options for input of pan data, Bowen Ratio, etc.

**Groundwater**
- Measurement protocol recommendations
- Wem: Projection of long term hydroperiod
- Soils data import for Ksat for all VA map units

**Hydroperiod “Library” (new work for 2016/2017)**
- Developing VA and MD Regional Collection of “typical hydroperiods”
- What is targeted design Hydroperiod for PFO, PSS, PEM?
Wetbud Basic Version

Wetbud is a design tool for wetland creation

GW flux modeled via Darcy flow approach assuming uphill head data available
Wetbud is freeware and available for download at www.landrehab.org/WETBUD
Basic Model via the Wizard

• Automatically downloads nearest applicable weather station data (30 years) in Virginia from 15 pre-selected locations and populates ppt and ET estimators for W-N-D years. Will download other data for other states, but “data clean-up” is required.

• In Wizard mode, assumes no overbank and GW input; assumes GW losses at 1”/month.

• User inputs wetland and watershed size and runoff CN.

• Model runs in < 10 minutes once simple inputs are made. Daily time-step but results are charted monthly.
The graph displays monthly water levels over the course of a year. The y-axis represents inches of water, while the x-axis shows months from January to December. The chart includes various data points and lines, each color-coded and labeled to represent different water budget components such as evapotranspiration, current fill/storage, actual water level, and net water loss/gain. The graph is interactive, allowing users to move the cursor to display chart values. The reference station options include range categories (Dry, Normal, Wet) and display options for different water budget components.
Wetbud Advanced Version

Allows for 3-D modeling including multiple water/soil/substrate layers, slopes, variable wetland topography, etc.

Incorporates more rigorous groundwater flux modeling via MODFLOW (basic model uses a simplified Darcy approach)

Generates daily models of water surface topography in 3D or for any cross-section. Will generate detailed hydroperiod prediction for any location in wetland.
WetBud – Advanced Version

流体模型中的不同部分：
- Ppt
- ET
- SW_in
- GW_in
- GW_out
- Stream
Model and Component Validation & Calibration

Huntley Meadows – Fairfax
(detailed ET x 4 and GW studies)

Northfork Bank – Haymarket
(basic model + overbank flow)

Cedar Run 3 – W. of Quantico

Others at Julie Metz, Bender Farms, Pocahontas, etc.
Where do I get Wetbud?

- The latest versions is always available at [www.landrehab.org/WETBUD](http://www.landrehab.org/WETBUD)
- The download is simple, but you need to wait while it loads and processes.
- You will also see a database program called “Firebird” being installed; that’s ok.
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