Report # ##-##-##/##/##/##

Delaware Rapid Assessment Procedure

Version 6.0

User's Manual and Data Sheets

2010

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Delaware Wetlands

Purify Provide Protect

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GENERAL GUIDANCE

Use of Method

The intended use of the Delaware Rapid Assessment Procedure (DERAP) is to assess the general condition of wetland based on the presence and intensity of stressors related to habitat, hydrology, and buffer features at a site. Stressors are correlated to intensive tier 3 condition data (DECAP) to assign a condition score. The State of Delaware uses DERAP in conjunction with DECAP to assess and report on the condition of wetlands by watershed and to assess status and trends over time. DERAP stressor data is also used to identify the types of impacts to wetlands which is then applied to develop wetland restoration and protection priorities.

Development and Validation of DERAP

DERAP was developed to meet the needs of users that require a rapid assessment of the general condition of a wetland site. Our goal was to develop a method that could be used in any type of wetland in Delaware, was relatively quick to perform in the field, resulted in a single score of condition, and could be validated with the DECAP. Scoring for the DERAP to produce one overall score of condition was developed through a process to calibrate the presence of stressors at a site to comprehensive wetland condition data using the DECAP Index of Wetland Condition (IWC). We developed the DECAP IWC using a process to screen hydrogeomorphic (HGM) variables specific to wetland subclass to select the strongest variables that would represent the condition of the primary wetland attributes (plant community, hydrology, and buffer) (Jacobs et al. 2010). The DERAP was then calibrated to the DECAP IWC using a data set of over 250 sites from the Nanticoke, Inland Bays, and Delaware Bay watersheds in Delaware (Sifneos et al. 2010). We selected stressors using step-wise multiple regression and Akaike's information criteria (AIC) to develop the best model that correlated with the DECAP IWC without over-fitting the model to this specific dataset. Coefficients or weights associated with each stressor were assigned using multiple linear regression. We calculated the DERAP IWC score by summing the stressor coefficients for each of the selected stressors that were present and subtracting the sum from the linear regression intercept.

We feel confident that the rapid assessment is providing a relative measure of condition compared to reference standard (minimally disturbed) sites. The weighted DERAP score is significantly correlated with the DECAP IWC scores with r^2 values of 0.83 for flats, 0.87 for riverine and 0.67 for depressions with $P<0.001$ for all wetland types.

Related Delaware Comprehensive Assessment Procedure

The Delaware Comprehensive Assessment Procedure (DECAP) is a detailed method that can be used to determine the condition of a wetland site relative to reference condition. Data are collected on the plant community composition and structure, hydrology, soils, topography, and surrounding land use. Data collection typically takes a field crew of 3-4 people about 4 hours.

DECAP is an HGM-based method that uses reference data to develop variables that are responsive to disturbance and are scaled from least disturbed to most disturbed. These variables are then combined into functions and an Index of Wetland Condition (IWC). The IWC is a single composite score that represents the overall condition of the site. Comprehensive variables were screened and scored in a manner analogous to that used in developing macroinvertebrate and fish indicators of biotic integrity (IBI) in EMAP stream surveys. This included screening for signal:noise ratio, range test, responsiveness and redundancy. Variables that passed each of these

tests were used in the final IWC, and variables that did not were dropped (Jacobs et al. 2010). Variables within the IWC were weighted based on their contribution to three categories: hydrology, plant community, and buffer/ landscape. The IWC is used to calibrate the condition score of the DERAP. Protocols for the DECAP are available at: **http://www.wr.dnrec.delaware.gov/Information/OtherInfo/Pages/WetlandMonitoringandAssessment.aspx** or contacting the DNREC Watershed Assessment Section.

Geographic and Hydrogeomorphic scope

DERAP has been calibrated with data from the Nanticoke, Inland Bays and Delaware Estuary watersheds and continues to be updated as more data are collected as part of the Delaware Wetland Monitoring and Assessment Program. DERAP is applicable to all non-tidal wetlands in the Outer Coastal Plain regions of Maryland and Delaware, however, we suggest checking for updated weights frequently, since we continue to refine the stressor weights as more sites are sampled with both the DECAP and DERAP. Additional testing is planned to continue to validate the DERAP with the Delaware Comprehensive Assessment Procedure (DECAP) and to test DERAP in tidal freshwater systems and the Piedmont. To assess tidal estuarine emergent wetlands refer to the MidAtlantic Tidal Rapid Assessment Method (MidTRAM) available at: **http://www.wr.dnrec.delaware.gov/Information/OtherInfo/Pages/WetlandMonitoringandAssessment.aspx**

Training and User Precision

The DERAP should only be performed by individuals who have completed a training course on how to properly use this method. Users of DERAP should have experience and/or education in the identification of wetlands including an understanding of the various stressors that impact different wetland types, native flora of the region and soil properties. A study of user precision has showed that users that received training on how the use the method had significantly higher precision in identifying stressors and assigning a condition score than users that did not have training (Herlihy et al. 2009).

Landowner Permission

Permission should be obtained before accessing private property. Our experience is that if contact can be made with the landowner there is a high probability that they will allow access to their property. Georeferenced parcel data can be obtained through the State intranet and landowner information can be found using the following websites:
Sussex County: **http://www.sussexcountyde.gov/.**

Kent County: **http://www.co.kent.de.us**

New Castle County**:** **http://www.nccde.org/defaulthome/home/webpage1.asp**

Time and Effort Involved

The time to complete the DERAP will vary by site depending on the distance to the site from the nearest access point, the density of the vegetation and level of difficultly navigating through the site, the complexity of the site in determining the presence of stressors, and the experience of the person performing the assessment. On average this method should take 2 people no more than 1 hour once at the site.

Equipment Needed

- Clipboards
- Pencils
- Auger
- Munsell Color Chart
- Mid-Atlantic Hydric Soil Indicators
- Compass
- Waders
- Field Protocol
- GPS
- Pruners
- Increment borer
- Angle gauge

TASKS TO BE COMPLETED BEFORE GOING INTO THE FIELD

1) Determine stream order (riverine sites only)
2) Landowner contact information and permission for access
3) Print and review maps
   a) Wetlands and hydrology (1:3000)
   b) Wetlands and hydrology (1:24000)
   c) Tax Parcels (1:5000)
   d) Road Map (1:24000)
   e) Soils (1:5000)
   f) Old aerials 1937, 1954, 1961, 1968, 1992, 1997, 2002 (1:3000)

WETLAND CLASSIFICATION

Although DERAP can be used on any type of nontidal wetland in Delaware's Coastal Plain Region[1], it is important to identify the type of wetland to properly assess the site and to compute a final condition score. If the wetland type is unknown, perform the methods and consult additional resources to determine the wetland subclass. There are six wetland classes in the Coastal Plain of Delaware (modified from Whited and Ainslie (2000)). Several of these classes also include distinguishing subclasses such as intermittent low order and perennial under riverine. A table of all wetland subclasses and types with descriptions is provided in Appendix A. Identification of wetlands should be performed to the lowest possible level.

Depression

Wetlands located in low points in the landscape characterized by closed elevation contours that allow the accumulation of surface water. Potential water sources are precipitation, overland flow and groundwater. Depressional wetlands may have any combination of inlets and outlets or lack them completely. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from

[1] Currently the DERAP has only been tested and verified on Flat, Riverine, and Depressional wetlands

diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater.

Mineral – mineral soils, most common in Delaware

Organic – organic soils, most common in Great Cypress Swamp

Sea Level Fen - Herbaceous/graminoid peatlands that occur at the upland edges of ocean tidal marshes; uncommon in Delaware.

Flat

Wetlands that are most common on interfluves, in the headwaters of watersheds, or large floodplain terraces. The dominant water source is generally precipitation; however, groundwater has some contribution to these systems. During late winter/ early spring saturation of upper soil horizons meets with saturation of lower soil horizons caused by rising ground water tables to a continuous saturated soil from the surface to the groundwater table. These zones then separate when the groundwater lowers and the surface wide subsides due to evapotranspiration. Flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage, slow lateral drainage, and low hydraulic gradients.

Mineral – mineral soils, most common in Delaware
Organic – organic soils, most common in Great Cypress Swamp

Riverine

Wetlands that occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from channel or subsurface hydraulic connections between the stream channels and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flow down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface water flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration. Associated slope wetlands which are typically located at the toe-slope of the floodplain in the coastal plain physiographic region and are dominated by ground water inputs are included in this subclass. They are not identified as a separate subclass because they are typically very small and are always located within a riverine wetland. There are 4 subclasses of riverine wetlands:

Intermittent – Upper perennial – Typically first and second order streams that serve as headwaters to the watershed. These systems may or may not have a defined channel. Floodplains associated with these systems are fairly narrow and flow may be intermittent or perennial.

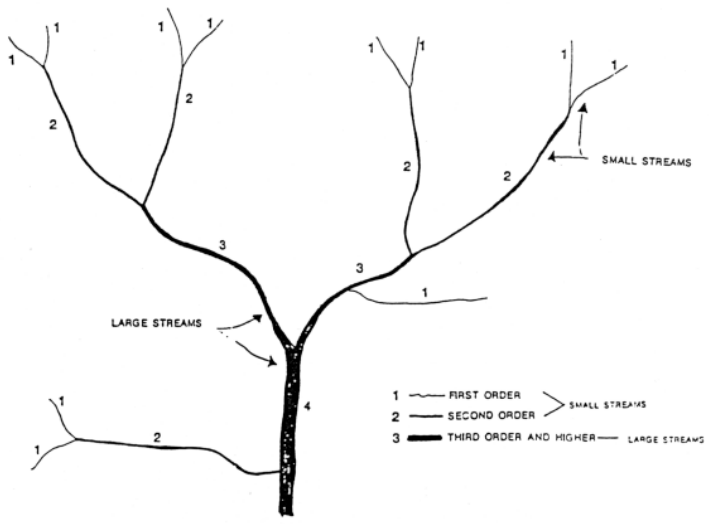
Lower Perennial- Typically third order and higher along the mid-reach or mainstem of the system. Floodplains are wide with a defined channel and surface water is perennial.

Beaver Impounded – wetlands that are or have been impounded by beaver. Floodplains are generally dominated by herbs and emergent vegetation. Snags and dead trees may be present. Canopy tends to be open. Signs of beaver activity such as dams, lodges, chewed stumps and feeding platforms are generally present.

Human Impounded – Typically associated with wetlands along the edge of mill ponds or other manmade bodies of water.

Stream Order (for riverine sites only): Assign the Strahler stream order to the stream associated with the riverine wetland. Using topo maps and NHD GIS data, start at the headwaters of the watershed upstream of the assessment site. Headwater streams that do not have any tributaries entering them (they may not be shown as blue-line streams or ditches) are considered first-order streams. When two **first-order** streams come together, they form a **second-order** stream. When two second-order streams come together, they form a **third-order** stream. Streams of lower order joining a higher order stream do not change the order of the higher stream. Thus, if a first-order stream joins a second-order stream, it remains a second-order stream. It is not until a second-order stream combines with another second-order stream that it becomes a third-order stream.

FIGURE 1
STREAM ORDER HIERARCHY



Slope

Wetlands normally found where there is discharge of groundwater to the land surface, either on sloping land or flat areas at the base of a slope (i.e. toe slope). The dominant hydrologic source is

groundwater and flows downslope in a unidirectional flow. Slope wetland may not have a channel but if a channel is present, it carries water away from the wetland

Estuarine Tidal Fringe

Wetlands that occur along estuaries and rivers and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Two subclasses are distinguished in Delaware, freshwater tidal fringe and saltwater tidal fringe.

Marine Tidal Fringe

Wetlands that occur along the Atlantic Coast in Delaware and are under the influence of sea level. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration.

Key to Determining Wetland Class in the Coastal Plain

1. Is the wetland influenced by tidal cycles from a Bay or Ocean?
   No – go to step 3
   Yes – go to step 2
2. Is the wetland influenced by tidal cycles from the Ocean?
   Yes – Marine Tidal Fringe subclass (refer to MidTRAM for assessment)
   No – go to step 3
3. Is the wetland brackish or salt water?
   Yes ~~- Estuarine Tidal Fringe subclass (refer to MidTRAM for assessment)~~go to step 4
   No – go to step 5
4. Is the wetland emergent?
   Yes - Estuarine Tidal Fringe subclass (refer to MidTRAM for assessment)
   No – Estuarine Tidal Fringe (tidal Riverine – DERAP being tested for this type)

5. Is the wetland in a valley or stream channel where it gets inundated by overbank flooding from that stream or river in an unaltered condition (i.e. if a stream has been channelized and no longer receives overbank flooding it could still be a riverine wetland in an altered condition)?
   No – go to step 6
   Yes – Riverine subclass
6. Is the wetland in a topographic depression, outside areas that are inundated by overbank flooding, in which water ponds during at least part of the year?
   No – go to step 7
   Yes – Depressional subclass
7. Is the wetland at the bottom of a topographic slope?
   No – Flat Subclass
   Yes – Slope subclass

Classification of Created and/or manipulated Wetlands

The State of Delaware, in an effort to track and report progress in the State that is comparable with other on-going tracking efforts is using the definitions as defined by the Federal Geographic Data Committee, Wetlands Subcommittee. This subcommittee developed definitions for restoration and related activities designed to aid agencies in accurately reporting wetland increases due to their program activities. The definitions, below, provide standard terminology for the more than 15 agencies involved in wetland restoration, related activities, and/or mitigation.

Restoration: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former or degraded wetlands. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- *Re-establishment:* the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres. Restore acreage and function

- *Rehabilitation:* the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function, but does not result in a gain in wetland acres. Restores only function, but not acreage

Establishment: the manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist on an upland or deepwater site. Establishment results in a gain in wetland acres. Create a new wetland from a different ecosystem type.

Enhancement: the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s) and can lead to a decline in other wetland function, but does not result in a gain in wetland acres. This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration. Improves a specific function of a site not necessarily to reference condition

Protection/Maintenance: the removal of a threat to or preventing decline of, wetland conditions by an action in or near a wetland. This includes purchase of land or easement, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation. Protection/Maintenance does not result in a gain of wetland acres or function

LOCATING ASSESSMENT AREA

The Assessment Area (AA) is the area within a wetland that will be sampled using the DERAP. Most measurements will be performed in the AA, however, some measurements will assess conditions surrounding the AA. The center of the AA is a random point located in a mapped wetland that has been selected using a probabilistic sampling design for a watershed scale study. If the method is being used for a site assessment more than one AA may need to be placed on the site for a complete assessment if the project site is >0.5ha. AAs should be placed to cover any changes in vegetation types, hydrology, topography, and disturbance history throughout the site.

Note: If this method is being used to sample a subjectively selected reference site, a center point for the AA should be located such that it is representative of the wetland and the ecological condition that it is representing (i.e. clear cut flat, channelized low-order riverine).

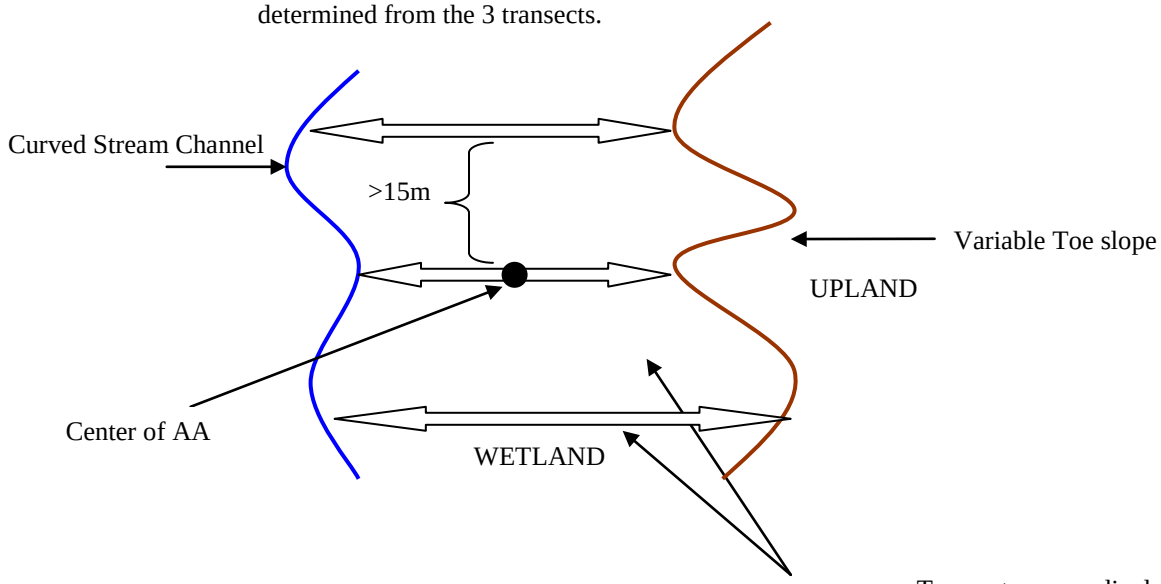
- Mark the center of the AA with a large piece of flagging.
- Establish the AA as a 0.5 ha area around the point (40-m radius circle centered on the point)

Several situations may occur that would require that the AA to be positioned differently than above. Each of these circumstances is detailed below. Please note: **If the location of the AA is moved make detailed notes on the datasheet explaining why the AA was moved and record the lat/long of the new center:**

1) If the mapped wetland does not extend 40m from the point in all directions, move the center of the AA so that the entire AA is within the wetland boundaries.
2) If the assessment area is within a naturally occurring upland inclusion in the wetland, move the center of the AA so that the uplands are excluded from the AA. If the upland inclusion is due to a disturbance i.e. a pile of fill, do not move the center of the AA.
    a) If the location of the original point is determined to be upland, examine the entire 40m radius circle around the original point for a wetland.
        i) If a wetland is found within this area, move the AA the least distance necessary to locate the AA in the wetland.
        ii) If no wetland if found, the site should be dropped and recorded as upland
3) If the AA is within a wetland that is smaller than 1.0 ha, the AA is the same size as the wetland (see below rules for riverine wetlands).
4) If the center of the AA is located in a riverine wetland:
    i. that is >80m wide on the side of the stream where the point falls, the stream channel should not be included in the AA and the AA should be located on the side of the channel where the original point fell
    ii. that is <80m wide
        1. The channel should be included in the AA if the stream is wadable and permission to access both sides of the channel is granted. A stream is wadable if the deepest part of the stream is <1 m deep.

2. If the stream is not wadable or permission is only received to access one side of the channel, make the AA a 0.5ha rectangle with the width being from the edge of the channel to the toe slope (i.e. upland). If the distance varies between the edge of the channel and the toe slope, measure 3 transects, at least 15 m apart perpendicular from the stream to the upland. Locate transects over the approximate length of the AA. Average the lengths of these 3 transects and use this as the average width of the AA. Use the calculated average width to determine the length of your rectangle (see figure below).

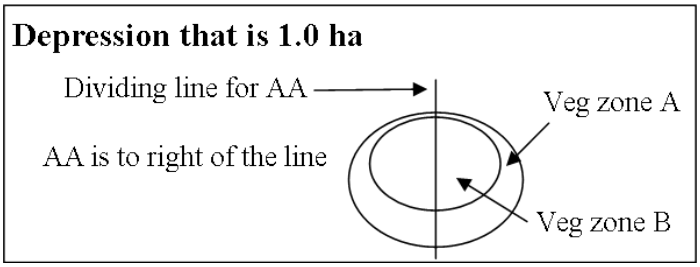
To determine the rectangle length, use the average distance between the channel edge and toe slope as determined from the 3 transects.

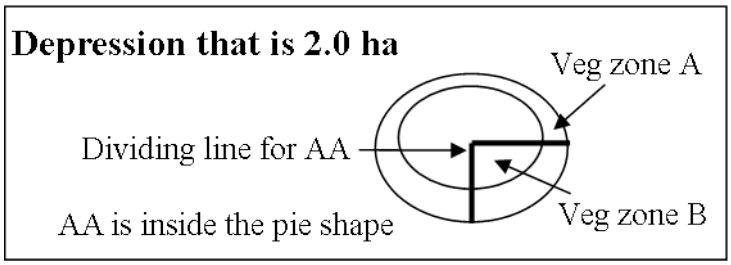


Transects perpendicular to stream channel and upland.

3. Adjust the shape of the AA to a rectangle that is 5,000 sq.meters with the width being the average width of the transects (ex. If the average transect length is 50 meters, the AA would be 100m in length). If the average transect length is less than 50m in width use a maximum length for the AA of 100m and note this on the datasheet. The resulting rectangular AA should be variable in width (i.e. following the contours of the stream and upland) but a determined length.

5) If the AA is located in a depression ≤ 1,0 ha assess the entire wetland .
6) If the depressional wetland is >1.0 ha the AA should be placed as to encompass all vegetation zones present in the site, this will typically involve sampling half of the site or a pie-shaped section to include all vegetation zones. Even when depressional sites are split in half, you should still walk the entire site because some stressors may occur outside of the AA (see stressor scoring).





DATASHEET

Header Information

Site #: Unique EMAP number for site including a watershed abbreviation and 4 digit site number (ex: MU0023)

Site Name: Unique names are given to each site

Date: Month, day and year of sampling

Observer: All members of the field crew that participated in sampling the site

HGM Class and Subclass: HGM wetland class and subclass according to definitions and key above

Stream Order (for riverine sites only): Assign the Strahler stream order to the stream associated with the riverine wetland as described above.

Natural, re-establishment, establishment, rehabilitation, enhancement (circle one): Select the appropriate choice based on the definitions provided above. If the wetland is any category other than natural a DE Restoration Info sheet should also be filled out in addition to all of the standard dataforms with this method.

Reference or Assessment Site: circle which applies. Reference sites are subjectively selected because they represent a specific condition such as minimally disturbed or impacted by a specific stressor or represent an ecological variation of a wetland class. Reference sites can span the range of condition. Reference Standard sites represent the least disturbed condition of a wetland class within a watershed. Assessment sites are sites that have been randomly selected using a probabilistic sampling design.

Watershed and subwatershed: record the watershed that the site is located in and can be determined by overlaying the DE watershed layer of the lat/long that is taken on site. Record subwatershed in areas where appropriate.

Year Restored: Only for restoration sites.

Photos: The frames that are shot should be marked on the data sheet. Photos can point in cardinal directions from center point or to depict a major stressor. If more than two are taken, the range can be given

Lat/Long: Latitude and longitude coordinates in digital degrees

AA size and shape: In most cases the AA will be 0.5ha and circular. Note if adjusted to a rectangle or smaller due to wetland size.

AA moved from original location? Circle yes or no to indicate if the center of the AA was moved from its original location. This only applies to assessment sites that are based on randomly located AA. If the center was moved record reason that the AA was moved.

Qualitative Disturbance Rating: To be agreed upon by entire field crew upon the assessment completion. Through observation of stressors and alterations to the vegetation, soils, hydrology in the wetland site, and the landuse surrounding the site, assessors determine the level of disturbance. Observers should use best professional judgment (BPJ) to assign the site a numerical Qualitative Disturbance Rating (QDR) from least disturbed (1) to highly disturbed (6) relative to other sites in the watershed based on BPJ. General description of the minimal disturbance, moderate disturbance and high disturbance categories are provided below.

Minimal Disturbance Category (QDR 1 or 2): Natural structure and biotic community maintained with only minimal alterations. Minimal disturbance sites have a characteristic native vegetative community unmodified water flow into and out of the site, undisturbed microtopographic relief, and are located in a landscape of natural vegetation (250m buffer). Examples of minimal alterations include a small ditch that is not conveying water, low occurrence of non native species, individual tree harvesting, and small areas of altered habitat in the surrounding landscape, which does not include hardened surfaces along the wetland/upland interface. Use BPJ to assign a QDR of 1 or 2.

Moderate Disturbance Category (QDR 3 or 4): Moderate changes in structure and/or the biotic community. Moderate disturbance sites maintain some components of minimal disturbance sites such as unaltered hydrology, undisturbed soils and microtopography, intact landscape, or characteristic native biotic community despite some structural or biotic alterations. Alterations in moderate disturbance sites may include one or two of the following: a large ditch or a dam either increasing or decreasing flooding, mowing, grazing, moderate stream channelization, moderate presence of invasives, forest harvesting, high impact landuses in the buffer, and minimal hardened surfaces along the wetland/upland interface. Use BPJ to assign a QDR of 3 or 4.

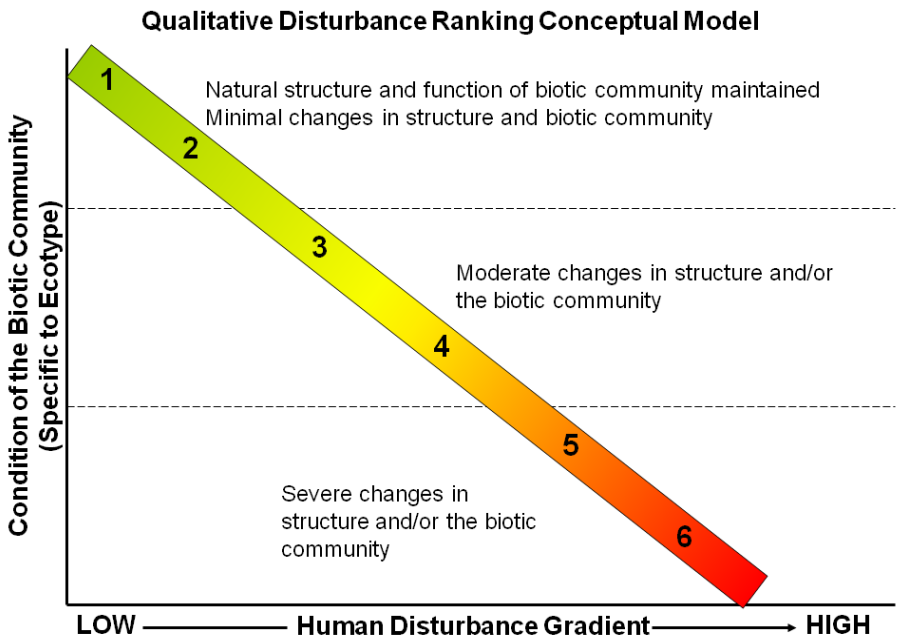


Figure 4. Diagram of narrative criteria for qualitative ranking of disturbance

High Disturbance Category (QDR 5 or 6): Severe changes in structure and/or the biotic community. High

disturbance sites have severe alterations to the vegetative community, hydrology and/or soils. This can be a result of one or several severe alterations or more than two moderate alterations. These disturbances lead to a decline in the wetland's ability to effectively function in the landscape. Examples of severe alterations include extensive ditching or stream channelization, recent clear cutting or conversion to a non-native vegetative community, hardened surfaces along the wetland/upland interfaces for most of the site, and roads, excessive fill, excavation or farming in the wetland. Use PBJ to assign a QDR of 5 or 6.

General Guidance

Once the Assessment Area is defined and flagged each field crew member must walk the entire AA. All members should meet at the center of the assessment area to complete the rapid worksheet. First, sketch the AA identifying the location of major stressors, the major overstory habitat and location of forestry activities- if any. Complete the Rapid Worksheet as a group. Once complete discuss and assign QDR.

When completing the DERAP minimize double counting the same impact. Only the most intense stressor of the impact should be recorded. Several examples are provided below:

i) If a site is farmed – under Habitat Category record Farmed;
   (1) DO NOT record Forest Harvesting land not recovering
   (2) DO NOT record mowing if there is a grass filter strip associated with the farm because this is encompassed in the farming practice
ii) If a road goes through the AA, record the presence of a road
   (1) DO NOT record mowing if the edge of the road is mowed as well
iii) If there is a golf course in the buffer record golf course in the Buffer Category
   (1) DO NOT record mowing for areas within the golf course
iv) In Hydrology Category, roads should be recorded either in the Weir/Dam/Road Stressor if they are affecting the flow of water in the site, or in the Fill Stressor if they are not affecting flow.
   (1) DO NOT include roads in the Microtopography Stressor.
v) In Habitat or Buffer Category only record the most intense road type present
   (1) DO NOT record mowing that is general maintenance for roads

One exception to this rule is the use of windrows as an indicator of microtopography alteration and fill. If windrows are present, they are used to indicate that the site has been mechanically cleared. The entire area inclusive of windrows (area in and between the windrows) should be included in the area estimation for microtopography alteration. Only the footprint of the windrows should be used under the fill stressor.

ANALYZING OLD AERIAL PHOTOS CAN PROVIDE INSIGHT INTO PAST LAND USE PRACTICES, FORESTRY OPERATIONS AND SITE HISTORY.

Habitat Stressors

Stressors that have the potential to impact the habitat and plant community of the wetland. Only consider the presence of these stressors if they are within the assessment area.

Dominant Forest Age and Harvesting within 50 years

Utilize aerial photographs to assist in determining forestry activities that occurred within the past 50 years Harvesting includes all forestry activities where trees were harvested and/or removed from the site. Indicators of clear cutting include an even aged stand of regenerating trees and/or site preparations such as bedding and wind rows.

- Selective cutting indicators include a mixed age stand with patches of trees that are much younger and the presence of tree stumps with older aged trees. Thinning operations should be included under selective cuts.

Dominant Forest Age
Determine the age of the dominant forest (the majority of the forested area within in the AA) through aerial photography and/or increment boring of pine, ash or poplar. If area was selective cut forest age is based on the remaining trees.

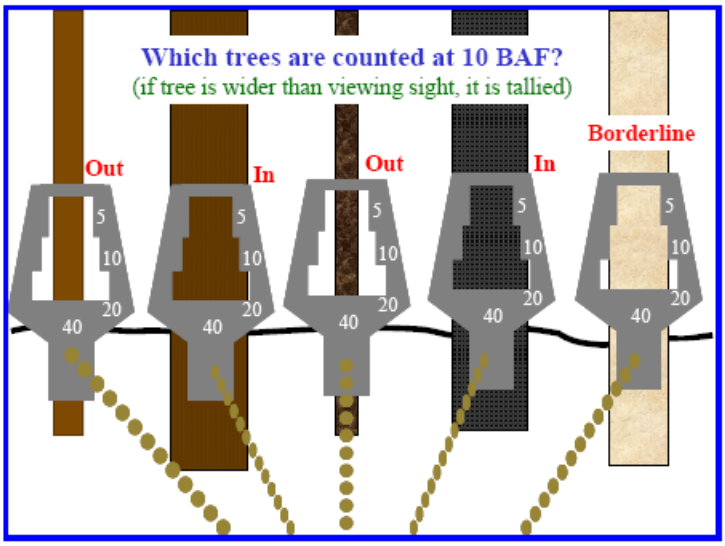
Dominant trees are ≤ 50 and >30 years old
Dominant trees are ≤30 and >15 years old
Dominant trees are ≤15 and >2 years old
Dominant trees are ≤2 years old

Harvesting within 50 years
If the dominant forest age is ≤ 50 years, the appropriate box should be checked to indicate the type of harvesting that occurred (clearcutting or selective cut). The percent of the AA affected by clear cutting should be determined (<10%, 11-50% or >50%).

% of AA Forested
Record the percent of the AA that is in a forested vegetative cover type. Cover types that should not be included as forested include emergent or shrub wetland with no forested canopy or a cleared or disturbed area with natural regeneration of a forest not occurring. Young forests that are regenerating are considered forested.

BAF(10) of Dominant Forest Cover

This is a test metric this is being assessed for its correlation with basal areas determined using DECAP. ***Only complete if a comprehensive assessment is also being performed at the site.*** Assess the basal area of the dominant forest (that for which the age was estimated in the stand age section above) using a 10 factor angle gauge. This is a plotless sampling procedure where the inclusion of a tree depends on the basal area (cross sectional area of a tree at breast height) of the tree and its proximity (distance) to the sample point. The basal area factor (BAF) is the number of units of basal area per acre.



Standing at the center of the AA, hold the end of the chain on the angle gauge against your chin and extend the gauge perpendicular from your body until the chain is fully extended. Rotate in a 360 degree circle keeping your eye over the center of the AA and count each tree **≥ 15cm DBH** that is larger than the angle gauge opening using the 10BAF opening. (see figure). If a tree is behind another tree, carefully step to the side of your point center while keeping the same distance from the tree. You should then be able to see if it's in, out or borderline.

Borderline trees: For borderline trees, measure the dbh and the distance to the tree. The distance should be measured to the "center" of the tree, NOT THE FACE of the tree. If the tree is equal to or closer than the

limiting distance for its dbh, then it is tallied. Limiting distances for 10 BAF prisms and gauges are listed in Appendix D. The table goes to 10ths of a cm. For an example, the limiting distance for a 39.1cm dbh tree is 12.9 m. Any 39.1cm dbh tree 12.9m or closer to the sample point is counted.

Forest Management

Pine Plantation- the AA is managed or converted to pine. The AA is either converted to a loblolly pine plantation by planting pines after harvest, or is being managed to encourage the growth of pines and discourage the growth of other species that are naturally regenerating. This is typically evidenced by an even-aged stand of pine. If a site is a mix of pine and hardwood and the management intent is unclear, additional information may be gained from the landowner.

Chemical Defoliation - A broad leaf chemical herbicide was applied to the site, which defoliated all herbaceous and broadleaved woody plants. This is a common practice in areas that have been recently harvested and are naturally regenerating to kill the broad-leaf species to release the pines to grow.

Vegetation Alteration

Determine if any of the following are present in your Assessment Area (check all present):

Mowed – any re-occurring activity that inhibits the natural succession of vegetation through mechanical means, i.e. mowing of grass or brush adjacent to development, on ditch spoil banks, and powerline right-of-ways

Farmed – part or all of the assessment area is cultivated as part of a farming operation to grow crops

Grazed – grazing activity as part of an animal rearing operation such as goats, pigs, sheep, cows, etc. Do not include browsing by wildlife which should be considered under excessive herbivory.

Cleared Not Recovering – area that has been affected by a disturbance such as land clearing, excavation etc. where natural regeneration of the natural vegetation is not occurring.

Other - The cleared not recovering category applies to areas that were cut and are being maintained in an early successional habitat. Examples include sites maintained as emergent wetlands or borrow pits that were cut and then flooded and therefore cannot recover.

Presence of Invasive Species

Invasive species as identified by the DE Natural Area Program (see Appendix B) are identified within the AA. Percent cover of invasive species within the AA should be estimated in the following categories: Not Dominating (<1% of AA, 1-5% of AA, 6-50% of AA) or Dominating (>50% of AA).

Excessive Herbivory (Pine Beetle/Gypsy Moth/Nutria)

Assessment area has been impacted by intense herbivory or infestation by southern pine beetle or gypsy moth. Herbivory by deer or nutria is evidenced by browse lines on the vegetation due to deer activity or large mud flats exposed due to nutria activity. Pine beetle and gypsy moth damage is evidenced by high densities of either dead or downed pine trees for the southern pine beetle or oaks for the gypsy moth.

Areas affected by southern pine beetles are characterized by a central host tree with a large radius of dead trees, similar to a bulls eye. Affected trees can be wiped out in a week's time. Almost exclusively occurs in over-mature tree stands or stressed trees (drought, flooding, fire, poor nutrition).



Left: Gypsy moth tent; *Middle*: Southern Pine Bark larvae; *Right*: Nutria damage in tidal marsh

Increased nutrients

Dense algal mats – the presence of algae over a portion of the wetland surface or growing in dense mats beneath the surface. Do not include algae that are naturally occurring on the surface of large downed wood or vegetation.

Depressional Wetlands Only: Presence of Nutrient Indicator Species– nutrient indicator species as identified by the DE Natural Heritage Program (see Appendix C) are identified within the AA. Indicator species are considered to dominate the site if all the indicator species combined comprise >50 of the vegetative cover in the site. These species have been found to be associated with depressions that have sustained nutrient enrichment. This indicator can only be used for wetlands in the depression subclass.

Roads

Note the presence of roads in the assessment area. Check most intensive type present and record others under comments. The degree of impact the road is categorized by amount of impervious, amount of fill and the type of use of the road. Use the following definitions:

Non-Elevated Road (logging, dirt road or ATV trail)- roads that cut through an area, but were not filled to elevate the surface of the road higher than the surrounding area, includes ATV trails. Does not include walking or deer trails.

Elevated Road (Dirt or Gravel): Permeable roads created by filling the wetland and used by either motorized vehicles for non-motorized recreation. (i.e. hiking/horse trail maintained in a park)

Paved Road: Impervious roads where fill was brought on site or excavated from ditches to elevate the surface of the road higher than the surrounding area.

Other - Record any other stressors that are observed in the site that could potentially be affecting the habitat and/or plant community of the assessment area.

Hydrologic Stressors

Record stressors that have the potential to impact the hydrology of the assessment area. This may include stressors that are physically outside of the assessment area if their presence is impacting the hydrology inside the assessment area. For Riverine wetlands the stream channel will always affect the hydrology of the AA.

Ditches (flats and depressions only)

Presence of man-made ditches within the assessment area, constructed in areas that were not former streams for the purpose of conveying water into or out of the site.

Slight - Presence of 1-3 shallow (≤0.3mdeep) ditches within the AA.

Moderate - Presence of many (>3) shallow ditches within the AA **or** presence of a moderate depth ditch (0.3 – 0.6m deep) within the AA **or** presence of 1 deep ditch (>0.6m deep) within 25m of the AA.

Severe - Presence of >1 moderate ditch within the AA **or** presence of a deep ditch in the AA (>0.6m deep)

Stream Alteration (Riverine Only)

A stream that has been altered by mechanical or hand excavation or is incised. Streams that have been channelized typically have less meanders than natural streams and often have an elevated area next to one or both sides of the stream where the dredge spoil was disposed (spoil bank/spoil pile).

Not maintained, reverted to natural morphology - historic channelization detected from presence of spoil piles on one or both sides of stream that are typically small mounds directly adjacent to the stream. Natural morphology (meanders and bottom substrates) have returned over time. Usually only found in low order streams that were channelized by hand. If a meandering stream is forming inside of a ditch or channelized stream this should not be considered reverting to natural morphology, rather the entire channel is developing meanders through the floodplain.

Spoil bank - spoil pile (deposition of materials that were dredged from the channel) located on one or both sides of the channel. Check box to indicate if the spoil bank is located on the same side of the stream as the AA.

Natural Stream Channel incision - in riverine wetlands, the stream channel that is associated with the riverine channel has been excessively incised creating an abnormally deep channel. Incised channels often lower the water table and decrease the occurrence of overbank flooding to the riverine wetland. Stream Incision should not be checked if the stream has been channelized.

Weir/ Dam/ Road

Includes any man-made structure including dams, weirs, roads, railroads, culverts, etc. in a wetland that is impacting the flow of water through a site by either impounding water in the site and/ or inhibiting water getting to the site. The effect of the structure on the hydrology should be evaluated to determine if the structure is impeding flow to the site or is impounding flow in the site. If the structure is impounding water in the site, the percent of the assessment areas that is impacted should be estimated. If the structure is within the assessment area and is impeding flow on one side and inhibiting flow on the other side then points for both categories should be deducted.

Flooding

This is a test metric that is currently not scored. The information is being used to characterize the hydrology at wetland types in various condition classes and will be analyzed to determine if this can be used as a rapid indicator of hydrologic disturbance to a site. Determine the percent of the AA that is permanently flooded and inundated using the following definitions.

Permanently flooded – percent of the AA that is covered with standing water continually throughout the entire year.

Inundated – percent of the AA that is covered with standing water sometime during the year but not the entire year. This can be determined by indicators that standing water was present previously such as blackened leaves, water marks on trees or other hydrologic indicators. The percent inundated should be equal or greater than the percent permanently flooded.

If standing water is present indicators such as the presence of vegetation and depth of water should be used to determine if the water is likely to be permanent throughout the year (included with permanently flooded percent) or transient and likely to dry up during the drier part of the year (included with inundated percent)

Stormwater and Point Sources

Stormwater inputs - Evidence of rain and snow runoff from the urban/suburban landscape, primarily runoff from impervious surfaces. To determine if stormwater is affecting the AA a stormwater pipe must be present in the AA or **two** of the following indicators must be present:
-Impervious surfaces adjacent to the wetland and in immediate drainage of the wetland
-Flashy water table fluctuations in AA (evidenced from water marks and wrack lines) and/or large amounts of water impounding in the AA for short periods
-Racks of debris and trash that have moved into the AA via transport from high water
-Storm water pipes directly entering the wetland within 100m of AA

Point source (non-stormwater) - a source of pollutants which may be traced to a discrete point of emission. The pollutant discharge is from a discrete conveyance and must be effluent from the end of a pipe or ditch.

Excessive sedimentation - sedimentation is observed on the soil surface that is not attributed to normal accretion processes. Sources of sedimentation may include adjacent construction or agricultural activities. Sedimentation can often be detected because it is usually a subsurface soil material that is deposited on top of an A or O horizon.

Filling and/or Excavation

Evaluate the assessment area and determine the percent of the area that is being impacted by fill or excavation according to the below definitions

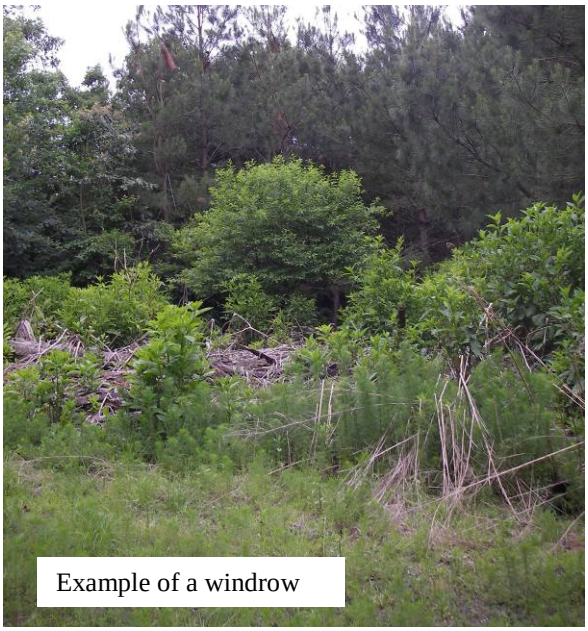
Fill – man-made deposits of soil material, rock products, waste materials including organic materials such as brush and lawn clippings, etc. added to the wetland not due to a natural process. Garbage, trash and yard waste should be considered as fill if they are in amounts large enough to cover an area and raise the surface of the wetland.

- Isolated pieces of trash should be recorded under the habitat category.
- Windrows that are associated with logging activities should be considered as fill because they typically develop into upland "ridges" through the sites and usually have upland vegetation

associated with them. Only the "footprint" of the windrows should be used to estimate the % of the AA covered by fill.

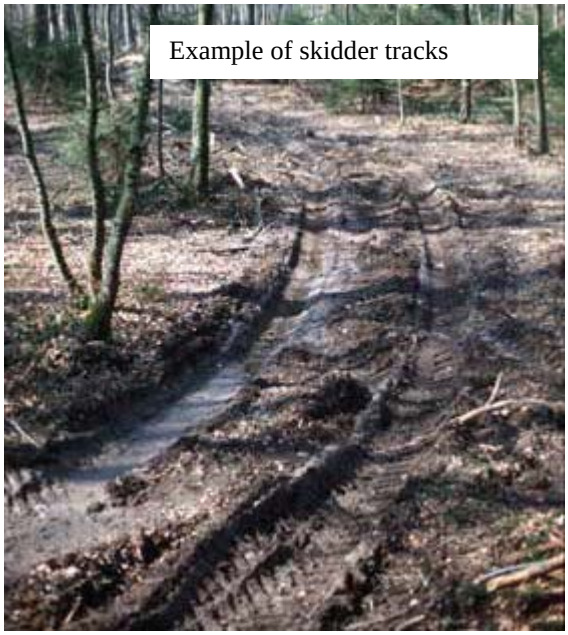
- Spoil excavated from a ditch and deposited in the AA
- Road or railroads within a site that ARE NOT IMPEDING flow of water through the site should be considered as fill
- Excessive sedimentation due to alterations in the surrounding land use should not be included as fill, but recorded under the Excessive Sedimentation stressor

Excavation - the process of digging, cutting or scooping, and removing of material


Example of a windrow

Check the box indicating what percent of the AA that has been filled or excavated.

Microtopographic Alterations


Example of skidder tracks

Any alteration to the natural soil surface such as plowing, bedding for forestry operations, skidder or ATV ruts, etc. Bedding is a planting preparation that forms small mounds to elevate seedling root zones above water. Established roads should be recorded under roads on the habitat/plant community box. Estimate the area of the assessment area where the natural microtopography has been altered by human disturbance. If windrows are present, they are used to indicate that the site has been mechanically cleared. All of the area in and between the windrows should be included in the area estimation for microtopography alteration (i.e. if the entire site has been windrowed then the area of impact would be 100%). Roads should not be included in microtopography alteration, but recorded under either the Weir/dam/road Stressor if they are affecting the flow of water through the site, or in the Fill Stressor if they are not impacting flow. Check the box indicating the percent of the AA that has human altered microtopography.

Soil Subsidence/ Root Exposure

The settling or sinking of the ground as a result of the collapse of porous formations, lack of support from underlying soils or strata, decrease in ground water or the oxidation of organic materials on the surface. This stressor is typically associated with riverine wetlands that have been channelized and the soils are subsiding due to the altered hydrology. However, other types of wetlands including flats and depression may also have subsidence where the hydrology has been altered. Associated with soil subsidence is the exposure of tree roots to the surface that would typically be covered with soil.

Example of soil subsidence/ root exposure in a flat in the Inland Bays watershed. Photo from Chris Bason

Other – record any other stressors that are observed in the site that could potentially be affecting the hydrology of the assessment area.

Buffer Stressors

Stressors that are present in the buffer area surrounding the assessment area and that may affect the condition of the assessment area. This category is an indicator of how well the wetland is protected from disturbances that are present in the surrounding landscape. The buffer area is a 100m radius circle from the edge of the assessment area or approximately 140m from the center of the assessment area, assuming a circular 0.5ha assessment area. Recent aerial photographs are useful to determine if stressors are present in addition to the on-site observations.

Development

Includes any type of human development in the buffer such as commercial/ industrial including any businesses, stores, plants, factories, etc. and residential including single family houses and apartments.

Roads

Presence of constructed roads in the buffer area. If more than one type of road is present in the buffer area, score the category based on the highest intensity type. Active and maintained logging roads for vehicle use should be scored as a dirt or gravel road. Railroads should be scored as a dirt or gravel road. Roads encompassed within a residential development are accounted for under Development stressor (i.e. residential). Do not double count residential roads. Trails and old logging roads are not considered stressors in the buffer. .

Landfill/ Waste Disposal

Presence of anthropogenically derived materials that were deposited over an extended period of time (i.e. not an isolated incident). Includes both municipal landfills as well as areas on private property

Channelized Streams or Ditches
Evidence of channelized streams or ditches > 0.6m deep in the buffer

Row crops, nursery plants, orchards
Includes soybeans, corn, wheat, truck crops (i.e. tomatoes, potatoes, bean, watermelons), nursery plants (i.e. shrubs and trees for landscaping), and orchards. Excludes forestry and pine plantations

Poultry or livestock operation
Includes chicken houses, pigs, cows or other livestock rearing operations

Forest harvesting in past 15 years
Forest harvesting activities including selective cutting, clearcutting, thinning etc. have occurred in the buffer within the last 15 years. Refer to aerial photos for additional insight

Golf Course
The presence of a golf course in the buffer

Mowed area
Any re-occurring activity that inhibits the natural succession of vegetation through mechanical means, i.e. mowing of grass or brush adjacent to development, on ditch spoil banks, and powerline right-of-ways, etc. **This does not** include mowing that is associated with a more intensive stressor such as residential lawns, golf courses, roads and agriculture.

Sand/gravel operation
The presence of a sand and gravel operation in the buffer

Other - record any other stressors that are observed in the site that could potentially be affecting the buffer of the assessment area.

Computing Total Score

The total score for the DERAP is computed using the following steps:

(1) Assign weights to the habitat and hydrology stressors that are present according to the scoring sheet in Appendix E. Stressor weights vary by HGM class so it is important to correctly identify the HGM subclass of the site.
(2) Tally the number of buffer stressors present and determine the weight by subclass.
(3) Sum all of the weights for the stressors that were present at the site.*
(4) Subtract the total stressor weight from the intercept of the wetland subclass.
(5) If no stressors are present the score for the site equals the intercept score.

* Stressors that are recorded in the "Other" category should be assigned a weight using best professional judgment and considering the effect of the stressor relative to other stressor weights in the same category. In the Buffer category, an "Other" stressor in included in the final tally of stressors to determine the weight.

Determining Condition Class

For reporting purposes, we established condition breakpoints using the Total Score based on the upper 25th percentile and lower 75th percentile of sites as compared to QDR ratings based on data from over 200 sites in the Coastal Plain. We report the condition of wetlands in three categories:

Minimally or Not Stressed – 25th percentile of sites with QDR of 1 or 2. Exhibiting soil and/or vegetative structure and function similar to natural communities of the same wetland type; no or incidental anomalies; ecosystem level functions are highly maintained.
Moderately Stressed – Sites between minimally and severely stressed. Evident changes in soil and/or vegetative structure including shifts in size, relative abundance and/ or presence of more tolerant taxa and/ or absence of characteristic taxa; some ecosystem level functions maintained.
Severely Stressed – 75th percentile of sites with QDR of 5 or 6. Large changes in soil and/or vegetative structure including changes in dominant taxa; ecosystem functions are altered and exhibit reduced complexity and redundancy.

The percent agreement of assigning sites using the DECAP versus the DERAP was 76% for flats, 76% for riverine, and 65% for depressions. Almost all of the sites that were classified differently using the two methods were due to the DERAP scoring sites "Minimally or Not Stressed" or as "Severely Stressed" and the DECAP scoring sites "Moderately Stressed". No sites were classified as Minimally or Not Stressed by one method and Severely Stressed by the other method. This illustrates that the DERAP is producing a similar assessment of condition but it is a coarser measure of the condition and in some situations is unable to detect condition based solely on the presence of stressors that are easily observable. Some sites are found to be in lower or higher condition when the DECAP is used because this method is using more detailed indicators to determine condition.

A condition class for each assessment site can be determined using the subclass and Total Score in the table below. The root mean square error (root MSE) was used to create "grey zones" on the upper end of the severely stressed and moderately stressed condition classes. Sites that score within the grey zone are within the margin of error of being in the next higher condition class. The root MSE was 7.5 for flats, 9.5 for riverine, and 16 for depressions. To best protect the resource in higher condition classes, sites that score within the grey zone can either be categorized in the higher condition class or a comprehensive assessment can be performed using the DECAP to more accurately determine the condition class.

Condition Class based on DERAP Total Score

Subclass	Minimally or Not Stressed	Moderately Stressed		Severely stressed	
Flats	**≥ 88**	**< 88 and ≥ 80.5**	**<80.5 and ≥ 65**	**<65 and ≥57.5**	**< 57.5**
Riverine	**≥ 85**	**< 85 and ≥ 75.5**	**<75.5 and ≥ 47**	**<47and ≥ 37.5**	**< 37.5**
Depression	**≥ 73**	**< 73 and ≥ 57**	**<57 and ≥ 53**	**<53 and ≥ 37**	**< 37**

Glossary

Assessment Area (AA) – area within the wetland that is sampled using the Delaware Rapid Assessment Procedure. All stressors are evaluated based on their potential effect on the AA with the exception of the buffer category. To locate the assessment area in the wetland, refer to instructions in the Locating Assessment Area section.

Channelized Stream– a natural stream channel that has been straightened, widened, deepened or otherwise modified to provide improved drainage of surrounding areas.

Constructed Road – road where fill was either brought on site or excavated from ditches on either side of the road to elevate the surface of the road higher than the surrounding area

Ditch - A man-made, open drainage-way in or into which excess surface water or groundwater drained from land, stormwater runoff, or floodwaters flow either continuously or intermittently

Fill – man-made deposits of soil material, rock products, waste materials etc. added to the wetland not due to a natural process.

Invasive Species – a non-native or introduced species that has developed a tremendous capacity for reproduction and distribution throughout its new home and that also has a negative impact on environmental, economic, or public welfare priorities. Appendix B. is a list of invasive species found in Delaware.

Logging road - roads that are cut through an area but that were not filled excessively to elevate the surface of the road higher than the surrounding area

Microtopography – the natural configuration of the surface of the land on a small scale including changes in elevation due to the presence of hummocks, mounds and depressions.

Random Site – a randomly generated site produced by the EPA's Environmental Monitoring and Assessment Program (EMAP). The site was selected from a group of wetlands that fit a specific Hydrogeomorphic subclass (HGM). The classification of the wetland group was derived from a modified version of the National Wetlands Inventory Map (NWI).

Reference Standard Site - a site that has minimal man induced alterations or disturbance is in a least altered state compared to other wetlands in Delaware.

Spoil pile – pile of soil material that was excavated or dredged from an adjacent ditch or stream.

Storm water - Stormwater is water that accumulates on land as a result of storms, and can include runoff from urban areas such as roads and roofs.

Weir - a dam in a stream or river to raise the water level or divert its flow

APPENDIX A - Classification of Delaware's wetlands using hydrogeomorphic attributes and descriptive examples

HYDROGEOMORPHIC CLASS[2] Subclass	Dominant water sources of class and flow dynamics	Major source of variation within subclass	NWI vegetation classes[3]	Regional example	Citation
FLAT	Precipitation; Vertical fluctuation				
Mineral soil		Hydroperiod and fire frequency	FO, SS, EM	Wet pine flatwoods/ pine savannas: Broad areas with poor drainage on mineral soils	Walker and Peet (1983); Rheinhardt et al. (2002)' Rheinhardt and Rheinhardt (2000)
Organic soil		Peat depths (from histic epipedons to histosols)	FO, SS, EM	Southern peat bogs such as pocosins: Broad areas with poor drainage that accrete organic matter	Richardson (1981)
SLOPE	Groundwater discharge and interflow; Unidirectional & horizontal				
Mineral soil		None available	FO, SS, EM	Spring seep	Cole et al. 1997
Organic soil		None available	FO, SS, EM	Forested fen	WPC 1998
Sea-level fen	Groundwater seepage, oligotrophic, acidic freshwater		EM		

[2]Upper case in bold are HGM classes; lower case in bold are regional subclasses, except for deepwater environments.

[3] NWI vegetation classes: forested (FO), scrub-shrub (SS), emergent (EM), aquatic bed (AB), unconsolidated shore (US), unconsolidated bottom (UB), riverine (R), Lacustrine (L), estuarine (E), marine (M).

DEPRESSION	Precipitation or groundwater; vertical fluctuation				
Inland	With our without inlet and outlets		FO, SS, EM,	Coastal plain ponds, forested depressions	
Interdunal Swale	Groundwater driven	Groundwater withdrawal causing intrusion of salt water, ditching, dune crossings, OMWM, invasive species	PEM	Along Atlantic coastal strand and barrier islands, shallow depressions behind primary dune ridges	DENHP (1994)
Human impounded or excavated		Size of catchment	SS, EM, AB	Borrow pits; some farm ponds; some created wetlands	xxxx

RIVERINE – non-tidal	Overbank flow from channel and groundwater discharge; Unidirectional				
Intermittent-Upper perennial	Non-tidal	Range of hydroperiods within riparian zone (usually < third order), gradient high, water velocities fast.	FO, SS, EM, AB	Riparian forest	Rheinhardt et al. (1998); Rheinhardt et al. (2000)
Lower Perennial	Non-tidal	Range of hydroperiods within 100-y floodplain, including in-stream terraces and bars (usually > third order) Gradient is typically low; water velocities slow.	FO, SS, EM, AB	Bottomland or floodplain forest	NRC (2002)
Beaver-impounded		Dam more temporary than human-impounded; usually < third order	FO, SS, EM, AB	Beaver pond	Klotz (1998) Bason and Brinson (in preparation)
Human-impounded[4]		Range of water residence times based on impoundment volume and discharge	FO, SS, EM, AB	Mill ponds; large farm ponds not deemed to be Depression	xxxx

ESTUARINE TIDAL FRINGE	Mixture of sea and fresh water; bi-directional and horizontal				
Estuarine lunar intertidal					
	Freshwater tidal		FO, EM, AB	Freshwater tidal swamps	
	Brackish tidal	**Regularly flooded zone:** Flooding by semidiurnal tides **Irregularly flooded zone:** Flooding by spring and storm tides and precipitation	EM, AB	*Spartina alterniflora*-dominated zone *Juncus roemerianus* and *S. patens* dominated zone	Stevenson et al. (1977) Simpson et al. (1983); Rheihnhardt (1992)
Estuarine subtidal		Low energy regime allows SAV establishment (Salinity ranges - 0 to >30ppt)	FO	Mud and sand flats; SAV beds; Oyster reefs	Rybicki et al. (2001) Southrworth and Mann (2004)
Estuarine impounded		Flow is blocked by dike, gate, or dam; water source precipitation except for controlled delivery of estuarine water of varying salinity	FO, EM, AB	Waterfowl impoundments?	xxxx
MARINE TIDAL FRINGE	Marine source; bi-directional and horizontal				
Marine intertidal		N/A	US	High energy beach	
Marine subtidal		N/A	UB	Shallow littoral	

APPENDIX B - DELAWARE INVASIVE SPECIES LIST

Draft from W.A. McAvoy, 6-08-2010

Acer platanoides Norway maple
Acorus calamus European sweetflag
Ailanthus altissima tree-of-Heaven
Akebia quinata five-leaf akebia
Alliaria petiolata garlic mustard
Ampelopsis brevipedunculata porcelain-berry
Aralia elata Japanese angelica-tree
Arthraxon hispidus joint-head arthraxon
Berberis thunbergii Japanese barberry
Bromus inermis awnless brome
Bidens polylepis awnless beggar-ticks
Cabomba caroliniana Carolina fanwort
Carex kobomugi Japanese sand sedge
Celastrus orbiculata Oriental bittersweet knotweed
Centaurea stoebe subsp. micranthos spotted knapweed
Cirsium arvense Canada thistle
Clematis terniflora Japanese virgin's-bower
Conium maculatum poison-hemlock
Echinochloa crus-galli barnyard grass
Egeria densa Brazilian waterweed
Elaeagnus umbellata autumn olive
Euonymus alatus winged euonymus
Euonymus fortunei winter creeper
Ficaria verna/Ranunculus ficaria lesser celandine
Galanthus nivalis snowdrops
Gleditsia triacanthos honey-locust
Hedera helix English ivy
Hemerocallis fulva orange daylily
Humulus japonicus Japanese hops
Hydrilla verticillata hydrilla
Iris pseudacorus yellow iris
Leucojum aestivum summer snowflake
Ligustrum obtusifolium border privet
Lisustrum sinense Chinese privet
Ligustrum vulgare European privet
Lonicera japonica Japanese honeysuckle
Lonicera maackii Amur honeysuckle
Lonicera morrowii Morrow's honeysuckle
Ludwigia leptocarpa water-willow
Ludwigia peploides subsp. glabrescens floating seedbox
Lysimachia nummularia creeping loosestrife
Lythrum salicaria purple loosestrife
Magnolia kobus Kobus magnolia
Microstegium vimineum Japanese stilt grass
Miscanthus sinensis Chinese silver grass
Murdannia keisak marsh dewflower
Myriophyllum aquaticum parrot's-feather
Ornithogalum umbellatum Star-of-Bethlehem
Pachysandra terminalis pachysandra
Persicaria longiseta/Polygonum cespitosum longbristle
Persicaria perfoliata/Polygonum perfoliatum mile-a-minute
Phalaris arundinacea reed canary grass
Photinia villosa oriental redtip
Phragmites australis subsp. australis common reed
Phyllostachys aurea bamboo
Pinus thunbergiana Japanese black pine
Poa trivialis rough bluegrass
Pyrus calleryana Callery pear
Quercus acutissima sawtooth oak
Reynoutria japonica/ Polygonum cuspidatum Japanese knotweed
Rhodotypos scandens jetbead
Rosa multiflora multiflora rose
Rubus phoenicolasius wineberry
Rubus triphyllus three-leaf blackberry
Schoenoplectus mucronatus/Scirpus mucronatus alien bulrush
Sorghum halepense Johnson grass
Thlaspi alliaceum roadside penny-cress
Typha angustifolia narrowleaf cattail
Urtica dioica subsp. dioica stinging nettle
Viburnum dilatatum exotic arrow-wood
Viburnum setigerum tea viburnum
Vinca minor lesser periwinkle
Wisteria sinensis Chinese wisteria

APPENDIX C – Nutrient Enrichment Indicator Species List

Scientific Name	Common Name
Amaranthus spp.	pigweed's
Ambrosia spp.	ragweed's
Arctium spp.	burdock's
Artemisia spp.	wormwood's
Azolla caroliniana	eastern mosquito-fern
Barbarea spp.	mustard's
Betula nigra	river birch
Bidens spp.	tickseed sunflowers
Brassica spp.	mustard's
Carex annectens	yellow-fruited sedge
Carex frankii	Frank's sedge
Carex vulpinoidea	fox sedge
Chenopodium spp.	goosefoot's
Conyza canadensis	mare's tail
Cornus amomum	silky dogwood
Cyperus spp.	flatsedges and nutsedges
Decodon verticillatus	hairy swamp loosestrife
Echinochloa spp.	barnyard grasses
Eleocharis obtusa	blunt spike-rush
Eupatorium capillifolium	small dog-fennel thoroughwort
Hibiscus moscheutos	swamp rosemallow
Iris pseudacorus	yellow iris
Juncus effusus	smooth rush
Leersia oryzoides	rice cutgrass
Ludwigia spp.	seedboxes
Microstegium vimineum	Japanese stilt grass
Murdannia keisak	marsh dewflower
Nuphar advena	spatterdock
Panicum dichotomiflorum	spreading panic grass
Phalaris arundinacea	reed canary grass
Phragmites australis	alien common reed
Phytolacca americana	common pokeweed
Poa trivialis	rough bluegrass
Polygonum spp.	smartweed and knotweeds
Populus heterophylla	swamp cottonwood
Rumex verticillatus	swamp dock
Salix nigra	black willow
Saururus cernuus	lizard's tail
Solanum dulcamara	climbing nightshade
Sonchus spp.	sowthistle's
Sparganium spp.	bur-reeds
Typha angustifolia	narrow-leaf cattail
Typha latifolia	broadleaf cattail
Utricularia macrorhiza	large bladderwort
Xanthium spp.	cockleburs

APPENDIX D – Horizontal Limiting Distance for BAF

Table 1: Horizontal limiting distance in feet for BAF 10 point-sampling instruments

DBH, cm	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
12	3.96	3.99	4.03	4.06	4.09	4.13	4.16	4.19	4.22	4.26
13	4.29	4.32	4.36	4.39	4.42	4.46	4.49	4.52	4.55	4.59
14	4.62	4.65	4.69	4.72	4.75	4.79	4.82	4.85	4.88	4.92
15	4.95	4.98	5.02	5.05	5.08	5.12	5.15	5.18	5.21	5.25
16	5.28	5.31	5.35	5.38	5.41	5.45	5.48	5.51	5.54	5.58
17	5.61	5.64	5.68	5.71	5.74	5.78	5.81	5.84	5.87	5.91
18	5.94	5.97	6.01	6.04	6.07	6.11	6.14	6.17	6.20	6.24
19	6.27	6.30	6.34	6.37	6.40	6.44	6.47	6.50	6.53	6.57
20	6.60	6.63	6.67	6.70	6.73	6.77	6.80	6.83	6.86	6.90
21	6.93	6.96	7.00	7.03	7.06	7.10	7.13	7.16	7.19	7.23
22	7.26	7.29	7.33	7.36	7.39	7.43	7.46	7.49	7.52	7.56
23	7.59	7.62	7.66	7.69	7.72	7.76	7.79	7.82	7.85	7.89
24	7.92	7.95	7.99	8.02	8.05	8.09	8.12	8.15	8.18	8.22
25	8.25	8.28	8.32	8.35	8.38	8.42	8.45	8.48	8.51	8.55
26	8.58	8.61	8.65	8.68	8.71	8.75	8.78	8.81	8.84	8.88
27	8.91	8.94	8.98	9.01	9.04	9.08	9.11	9.14	9.17	9.21
28	9.24	9.27	9.31	9.34	9.37	9.41	9.44	9.47	9.50	9.54
29	9.57	9.60	9.64	9.67	9.70	9.74	9.77	9.80	9.83	9.87
30	9.90	9.93	9.97	10.00	10.03	10.07	10.10	10.13	10.16	10.20
31	10.23	10.26	10.30	10.33	10.36	10.40	10.43	10.46	10.49	10.53
32	10.56	10.59	10.63	10.66	10.69	10.73	10.76	10.79	10.82	10.86
33	10.89	10.92	10.96	10.99	11.02	11.06	11.09	11.12	11.15	11.19
34	11.22	11.25	11.29	11.32	11.35	11.39	11.42	11.45	11.48	11.52
35	11.55	11.58	11.62	11.65	11.68	11.72	11.75	11.78	11.81	11.85
36	11.88	11.91	11.95	11.98	12.01	12.05	12.08	12.11	12.14	12.18
37	12.21	12.24	12.28	12.31	12.34	12.38	12.41	12.44	12.47	12.51
38	12.54	12.57	12.61	12.64	12.67	12.71	12.74	12.77	12.80	12.84
39	12.87	12.90	12.94	12.97	13.00	13.04	13.07	13.10	13.13	13.17
40	13.20	13.23	13.27	13.30	13.33	13.37	13.40	13.43	13.46	13.50
41	13.53	13.56	13.60	13.63	13.66	13.70	13.73	13.76	13.79	13.83
42	13.86	13.89	13.93	13.96	13.99	14.03	14.06	14.09	14.12	14.16
43	14.19	14.22	14.26	14.29	14.32	14.36	14.39	14.42	14.45	14.49
44	14.52	14.55	14.59	14.62	14.65	14.69	14.72	14.75	14.78	14.82
45	14.85	14.88	14.92	14.95	14.98	15.02	15.05	15.08	15.11	15.15
46	15.18	15.21	15.25	15.28	15.31	15.35	15.38	15.41	15.44	15.48
47	15.51	15.54	15.58	15.61	15.64	15.68	15.71	15.74	15.77	15.81
48	15.84	15.87	15.91	15.94	15.97	16.01	16.04	16.07	16.10	16.14
49	16.17	16.20	16.24	16.27	16.30	16.34	16.37	16.40	16.43	16.47
50	16.50	16.53	16.57	16.60	16.63	16.67	16.70	16.73	16.76	16.80
51	16.83	16.86	16.90	16.93	16.96	17.00	17.03	17.06	17.09	17.13
52	17.16	17.19	17.23	17.26	17.29	17.33	17.36	17.39	17.42	17.46
53	17.49	17.52	17.56	17.59	17.62	17.66	17.69	17.72	17.75	17.79
54	17.82	17.85	17.89	17.92	17.95	17.99	18.02	18.05	18.08	18.12
55	18.15	18.18	18.22	18.25	18.28	18.32	18.35	18.38	18.41	18.45
56	18.48	18.51	18.55	18.58	18.61	18.65	18.68	18.71	18.74	18.78
57	18.81	18.84	18.88	18.91	18.94	18.98	19.01	19.04	19.07	19.11
58	19.14	19.17	19.21	19.24	19.27	19.31	19.34	19.37	19.40	19.44
59	19.47	19.50	19.54	19.57	19.60	19.64	19.67	19.70	19.73	19.77
60	19.80	19.83	19.87	19.90	19.93	19.97	20.00	20.03	20.06	20.10
61	20.13	20.16	20.20	20.23	20.26	20.30	20.33	20.36	20.39	20.43
62	20.46	20.49	20.53	20.56	20.59	20.63	20.66	20.69	20.72	20.76
63	20.79	20.82	20.86	20.89	20.92	20.96	20.99	21.02	21.05	21.09

64	21.12	21.15	21.19	21.22	21.25	21.29	21.32	21.35	21.38	21.42
65	21.45	21.48	21.52	21.55	21.58	21.62	21.65	21.68	21.71	21.75
66	21.78	21.81	21.85	21.88	21.91	21.95	21.98	22.01	22.04	22.08
67	22.11	22.14	22.18	22.21	22.24	22.28	22.31	22.34	22.37	22.41
68	22.44	22.47	22.51	22.54	22.57	22.61	22.64	22.67	22.70	22.74
69	22.77	22.80	22.84	22.87	22.90	22.94	22.97	23.00	23.03	23.07
70	23.10	23.13	23.17	23.20	23.23	23.27	23.30	23.33	23.36	23.40
71	23.43	23.46	23.50	23.53	23.56	23.60	23.63	23.66	23.69	23.73
72	23.76	23.79	23.83	23.86	23.89	23.93	23.96	23.99	24.02	24.06
73	24.09	24.12	24.16	24.19	24.22	24.26	24.29	24.32	24.35	24.39
74	24.42	24.45	24.49	24.52	24.55	24.59	24.62	24.65	24.68	24.72
75	24.75	24.78	24.82	24.85	24.88	24.92	24.95	24.98	25.01	25.05
76	25.08	25.11	25.15	25.18	25.21	25.25	25.28	25.31	25.34	25.38
77	25.41	25.44	25.48	25.51	25.54	25.58	25.61	25.64	25.67	25.71

APPENDIX E – Stressor Weights for Delaware's Coastal Plain

Updated June 2010	Weights		
Description	**Flats**	**River**	**Dep**
Habitat Category			
Forest Age and Harvest History			
Forest age 31-50 years	0	0	0
Forest age 16-30 years and/ or <10% clear cut	5	4	2
Forest age < 15 years and /or > 10% clear cut	19	7	12
Forest Management (managed or converted to pine and/ or chemical defoliation)	5	9	1
Vegetation Alteration (mowing, farming, grazing, cleared not recovering, other clearing)	15	3	24
Excessive Herbivory/ Pinebark Beetle/Gypsy	4	2**	2**
Invasive Species			
Dominating site (>50%)	2**	20	7
NOT dominating (<50%)	0*	5	7
Nutrients (algal mats or dominated by indicator species)	10	12	10
Road within AA (non-elevated, elevated, paved)	2	2**	2**
Hydrology Category			
Ditching (Flats and Depressions only)			
Slight or moderate	10		5
Severe	17		5**
Stream Channel Condition (Riverine Only)			
Channelized stream not maintained		13	
Channelized with spoil banks on one or both sides		31	
Natural channel incised		21	
Flooding weir/dam/road decreasing or increasing flooding of site	2**	17	2**
Stormwater Inputs (stormwater, point source, sedimentation)	2**	2**	2**
Filling, Excavation			
<10%	2	0*	8
10-75% or >75%	2	12	19
Microtopography alterations and subsidence			
Microtopography alterations <10% and/ or subsidence	7	0*	0*
Microtopography alteration >10% (10-75%, >75%)	16	11	2**
Buffer Category			
1 Buffer Stressor	3	1	4
2 Buffer Stressors	6	2	8
>3 Buffer Stressors	9	3	12
Intercept	95	91	82
R-square	0.83	0.87	0.67

Note: stressors weights that are hashed out are not used for that wetland type.

**Stressor did not show correlation with condition based on existing data set and receives a zero weight. We will continue to collect information to further evaluate.*

*** Sample size of the occurrence of this stressor was too low to determine a correlation with wetland condition. Currently given the minimum weight of a lesser stressor until more data are collected. These stressors were not included in the final regression. .*