Appendix A:
Excerpt from PRRIP Remote Geomorphology and Vegetation Monitoring Protocol

(Background Information – NOT PART OF RFP SCOPE OF WORK)

IV. Data Analysis

A. Preliminary Processing of Aerial Imagery and LiDAR

- The aerial imagery and LiDAR products delivered from the aerial mapping contractor will be processed prior to analyzing the data to reduce file size to a manageable level using the following procedure:
- The imagery and LiDAR surfaces will be degraded to 3-foot pixel resolution, clipped to the channel shapefile discussed in Section IV. A., snapped to a common raster grid system, and merged to facilitate vegetation classification using the Trimble eCognition software. Through this process, care must be taken to ensure that all 4 bands in the aerial imagery are maintained in the processed aerial imagery files.
- A vegetation-height raster file will be created by subtracting the Hydroflattened DTM raster from the highest hit DSM raster.
- A topographic DEM of differences (DOD) will be created by subtracting the processed topobathymetric DTM for the current year from the DTM from the previous year. The DTM will provide base elevation data for cross sections and two-dimensional (2-D) model nodes for the habitat-related analyses, and the DOD will be used to quantify aggradation/degradation changes for purposes of monitoring the system-wide sediment transport balance.

B. Volume Change Analysis

Channel bed-sediment volume change (aggradation/degradation) for each geomorphic reach will be calculated from the topobathymetric DOD by developing a histogram of volume change with bins in 0.1 foot increments, multiplying the number of points in each bin by the square of the pixel resolution (i.e., 9 ft^2) and the magnitude of the corresponding elevation change, and summing the resulting volumes. A consistent sign convention will be used for the analysis, with negative (-) values indicating degradation and positive (+) values indicating aggradation. Consistent with recommendations in Lane, et al., (2000), all pixel values, regardless of their magnitude, will be used in computing the best-estimate magnitude of the volume change. Uncertainty in the estimate will then be computed based on the reported uncertainty for the subaerial and subaqueous portions of the surfaces using the following formula (Lane, et al., 2000):

$$\sigma_v = \pm t * d^2 \left(\sum_{i=1}^{4} N_i \sigma_i^2 \right)^{\frac{1}{2}} \quad (1)$$

Where σ_v is the uncertainty in the estimate volume change, t is the t-statistic associated with the desired level of confidence (e.g., t-1.96 for the 90% confidence bands), d is the pixel resolution, N_i is the number of pixels in each error category (i), and σ_i is the propagated error between the two comparative surfaces, computed by the following formula:

$$\sigma_i = \left(\sigma_j^2 + \sigma_k^2\right)^{1/2} \qquad (2)$$

where σ_j and σ_k are the Root Mean Square Errors (RMSE) of the relevant zones for the current and previous-year surfaces, respectively. Since the mapping error for the LiDAR is different for subaerial and subaqeous areas, there will be two values for σ_j and σ_k for each year of data, and there are, therefore, four possible combinations (i) of j and k for each pixel:

1. Subaerial in both surfaces
2. Subaerial in the prior-year surface and subaqueous in the current-year surface
3. Subaqeous in the prior-year surface and subaerial in the current-year surface
4. Subaqeous in both surfaces

Degradational areas (negative elevation change) will also be differentiated into lateral and general bed erosion components by assuming degradational values of greater than 3 feet represent lateral bank erosion. The 3-foot value is based on EDO observations of average bank height in the AHR and may be adjusted in the future as more data becomes available. Areas initially identified as bank erosion will be manually checked, and those that occur in the middle of the channel reclassified back into bed erosion, because scour holes and erosion into the sides of mid-channel bars can also exceed 3 feet.

Volume change will be reported in cubic yards (CY) as well as tons using a conversion factor of 1.5 tons per CY.

C. Channel Morphology and Hydraulics Assessment and Analysis

Two-dimensional (2-D) hydrodynamic models will be developed internally and updated annually to identify changes in width, depth, and channel depth/height distribution over a range of discharges. Nine hydraulic models will be constructed, one for each geomorphic reach. The model geometries will be bound longitudinally by the adjoining bridges in the bridge segments and laterally by the eCognition analysis hulls. The model will be calibrated for the recorded discharges at the time of the LiDAR flights and ground surveys, and to water-surface profiles from the remote sensing data, surveyed water surface elevations, and stage loggers located throughout the analysis area. Manning's roughness values will be specified for the vegetation polygons from the eCognition analysis, and adjusted, as appropriate, to achieve calibration. A range of flows from 500 cfs to 5,000 cfs will then be run with the calibrated models. It is tentatively assumed that the following 5 discharges within this range will be sufficient to quantify the relationships: 500 cfs, 1,200 cfs, 2,000 cfs, 3,000 cfs and 5,000 cfs. The difference between the predicted water surface elevations and the corresponding channel bed elevation will be computed to quantify the following analysis metrics, by discharge, for each geomorphic reach:

- Total inundated area

- Water volume – Total volume of water within the reach at the indicated water-surface elevation
- Average depth – Ratio of water volume to total inundated area
- Average Top width –Ratio of total inundated area to channel length
- Width-Depth (W/D) ratio – Ratio of average top width to average depth
- Area of inundation of 0.7 foot or less

D. In-Channel Vegetation and Land Cover Classification and Analyses

Trimble eCognition software will be used, along with the training and validation data, to evaluate in-channel vegetation and land cover, primarily to assess the whooping crane metrics. For the basic vegetation and landcover analysis, annual vegetation classifications within the area of interest that include the active channel and approximately 50 feet to 100 feet of the overbanks, will be delineated from the annual aerial imagery using eCognition (Appendix A). To accommodate software limitations, the processed 3-foot pixel resolution fall aerial imagery and vegetation height DEMs developed under Section VII. A. will then be segmented into shorter reaches of river (generally Lexington – Odessa, Odessa – Shelton, Shelton – HWY 281, and HWY 281 – Chapman) prior to initiating the supervised classification to provide more manageable file size. The imagery and vegetation height DEM files will then be imported into eCognition and used to classify imagery into the vegetation and land cover classes defined in Section IV. D. 2. The final vegetation classification file will be exported as a shapefile and evaluated for accuracy in ArcGIS using the field-collected validation data. During the accuracy assessment, wet sand, dry sand, and water will be combined into a single class as these classes are highly variable depending on discharge.

Vegetation classifications will be validated annually to determine the accuracy of the remote-sensing results. For each remote survey, the accuracy for each vegetation classification will be calculated by dividing the number of correct classifications by the total number of field-based classifications collected in each class using the validation data set. In addition, a geodatabase will be developed with an attribute table that will detail the coverage of each vegetation class.

Maximum unvegetated channel width (MUVCW), to be used in evaluating drivers of vegetation change, will be computed by dividing the total unvegetated area (water, bare sand, and sparse short vegetation) by the reach length for each geomorphic reach. This metric will be reported in acres by geomorphic reach.

Final vegetation and land cover class areas and MUVCW will be compared to the corresponding areas from previous years to quantify yearly changes. The results will be reported in acres of change by geomorphic reach for both main and side channels.