Appendix D26 – Post-Processing of Model Output

Please note this is a <u>working-draft document</u> currently undergoing review and revision. The final version will be posted in March 2012 along with the final version of the 2012 Coastal Master Plan.

1.1 Introduction

Model output cannot be directly utilized by the Planning Tool (Appendix E) in its 'raw' state; it must undergo some level of post-processing to transform it to formats that other groups can use, sum various outputs across spatial boundaries, provide averaged output over various temporal scales, etc. This document provides an overview of the steps necessary to complete model output post-processing and the quality review performed on the post-processing codes.

In order to reduce the number of individual model runs required from the modeling teams, projects were placed into modeling groups. These groups were arranged so the areas of influence for each project would remain separate and not influence one another on the landscape. Model output was provided for two environmental scenarios – moderate future conditions and less optimistic future conditions for 51 'modeling groups' (i.e., groups of individual projects on the landscape) for 50 year simulations. The goal of the post-processing was to provide the Planning Tool with summed model output for individual projects across twelve regions (described in greater detail in later sections) at specific time steps. Three FORTRAN codes were written to convert the Ecosystem Services, Wetland Morphology, and Nitrogen Uptake output files into a readable format for the Planning Tool. These steps included converting netCDF and raster files to CSV format, separating individual project results from their modeling groups, and summing each project output into twelve regions.

The following Ecosystem Service model outputs (habitat suitability indices) were processed for use in the Planning Tool to complete the project analysis: alligator, crawfish[1], oysters, freshwater fisheries (i.e., large mouth bass), saltwater fisheries (i.e., spotted sea trout), other coastal wildlife (i.e., combined output for river otter, muskrat, and roseate spoonbill) , white shrimp, brown shrimp, and a combined shrimp output, and waterfowl (i.e., combined output for mottled duck, green-wing teal, and gadwall). The following suitability indices were also processed: potential for fresh water availability, potential for surge/wave attenuation[2], potential for nature based tourism, potential for nitrogen uptake, and potential for agriculture/aquaculture. The following Wetland Morphology model outputs were also processed for inclusion in the Planning Tool: percent land and carbon sequestration potential.

1.2 Post-Processing Codes

The post-processing procedure is comprised of three codes:

- Model Output File Conversion
- Individual Project Results Separation

[1] Modeled crawfish output was not used in the final analysis of project outcomes. It has been set aside for additional revisions.

[2] Potential for surge/wave attenuation modeled output was not used in the final analysis of project outcomes. It has been set aside for additional revisions.

- Results Summation by Region

Figure 1 shows the workflow schematic of the post-processing codes.

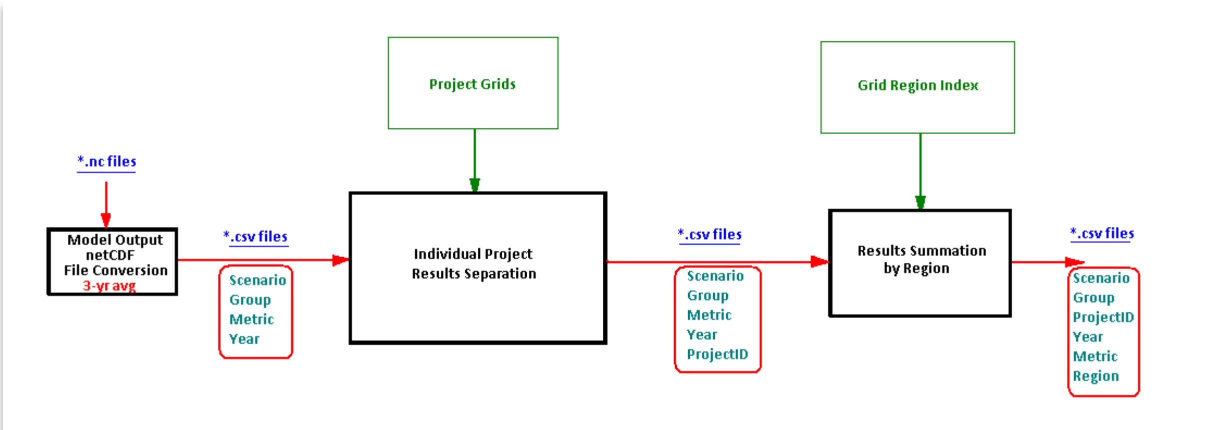

Figure 1. Overview of the post-processing code workflow. The term 'metric' refers to the particular model output (e.g., alligator or oyster).

1.3 Model Output File Conversion

Output files from the Ecosystem Services models were provided in netCDF format. The file conversion code read the model output and calculated a three year average at years 5, 10, 20, 30, 40, and 50. For example, year 10 output was the average of years 8, 9, and 10. Year 20 output was the average of years 18, 19, and 20. The results of this averaging were written to CSV files for each model group at each time step indicated. See Figure 2.

Input files (.nc) - Each input file contains annual averages for 50 years of output for each model group on the 500 meter model grid. The first portion of the code converts the information from binary format into a temporary ASCII type file. Then, the code rearranges the data and extracts the output values for the time steps needed to calculate the 3 year average at years 5, 10, 20, 30, 40, and 50.

Output files (.csv) - Subsequently, the file conversion code writes the output files in CSV format. The code reads the information from the temporary file and captures the output value and the x and y coordinates for each 500 meter grid cell. Then, it produces 3 year average values for each cell for each Ecosystem Service output for each 10 year interval.

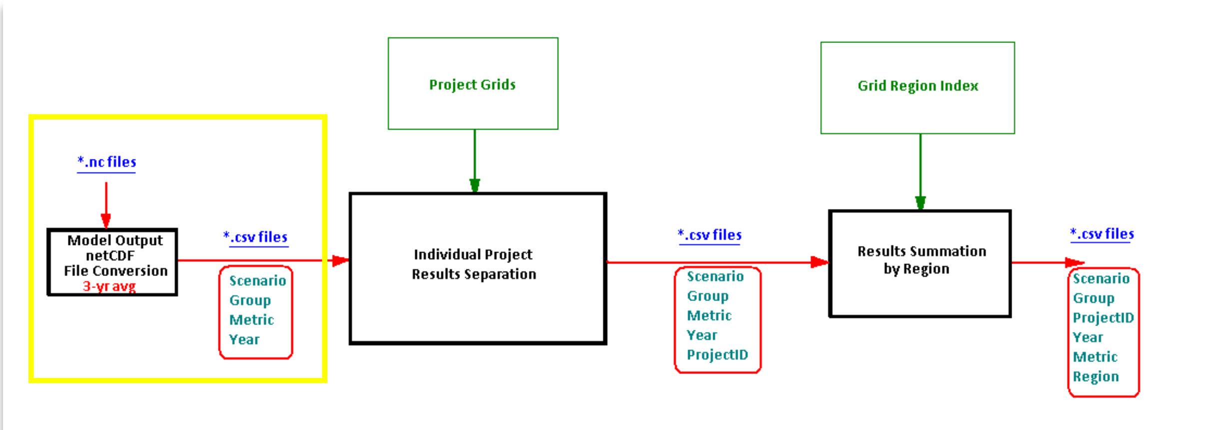

Figure 2. Post-processing workflow highlighting file conversion code.

Code Modifications - The percentage of land results are provided to the Planning Tool for the time increments at years 0, 10, 20, 30, 40, and 50. All other aspects of the file conversion are the same as described above.

The file conversion code needed modifications for use on the crawfish[3], surge/wave attenuation[4], and nature based tourism model outputs because these models did not provide results on an annual basis. The crawfish model provided monthly averages, so the code was modified to average 36 months of output values into a single time step result. The storm surge/wave attenuation and nature based tourism models provided output values in a 5 year interval. Due to the limited results over the 50 year modeling time frame, the results were not averaged.

Additionally, the file conversion code could not be used on the Wetland Morphology or Nitrogen Uptake model output files. Carbon sequestration and nitrogen uptake were both provided in a raster (.img) format at a 5 year interval on the same 500 meter grid used by the Ecosystem Service models. Each model group file was individually converted at years 5, 10, 20, 30, 40 and 50 from a raster grid to a point shapefile in GIS and the results were exported into a CSV format. Due to the 5 year model output interval, 3 year averages could not be calculated for these results.

1.4 Individual Project Results Separation

This post-processing code was written to separate the effects of each project within a modeled group using the areas of influence and to replace all other project effects in that group with the future without action modeling results in those areas. This was done so that the effect of each individual project could be separated out from all other project effects in that model group. The

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[4] Potential for surge/wave attenuation modeled output was not used in the final analysis of project outcomes. It has been set aside for additional revisions.

resulting output files include coast wide output values for every project at every time step required by the Planning Tool. See Figure 3.

Input files (.csv and .txt) - This piece of code has two main input files: Ecosystem Service output for the model group and the project grid for the model group.

The output files from the file conversion code become the input files for the project separation code. Each file is identified by its filename, scenario ID, model group number, Ecosystem Service data type, and year (i.e., 5, 10, 20, 30, 40, and 50). The information in the file includes the x and y coordinates of each 500 meter grid cell and the value associated with the Ecosystem Services model output.

These input files are generated based on a project's area of influence. For instance, Group 11 has two diversion projects:

- 001.DI.15 (influence area includes Pontchartrain System and east Birdsfoot Delta)
- 002.DI.03 (influence area includes Barataria Bay and west Birdsfoot Delta)

During this process the code:

1. Identifies the x and y coordinate from the project grid file for each project
2. Locates the coordinates in the data input file
3. Extracts the values from the input file for an individual project
4. Replaces the project values in the future without action model output

Output files (.csv) - The project separation code creates the output files in CSV format. Each file is identified by its filename, scenario ID, group number, Ecosystem Service model, average model year, and project ID. It contains the output value and the x and y coordinates of each grid point.

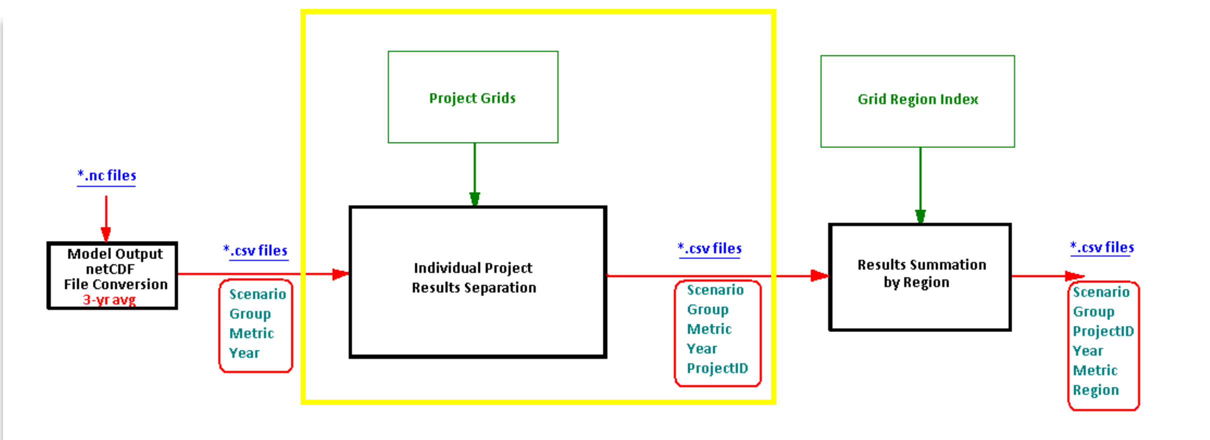

Figure 3. Post-processing workflow highlighting the project separation code.

1.5 Results Summation by Region

Because the 2012 Coastal Master Plan is a broad, planning-level analysis, CPRA decided to take a regional view of the modeled output and sum model outputs in 12 regions along the coast (Figure 4). All Ecosystem Service output values were summed into these regions for transfer to the Planning Tool. This third code was written to identify each grid point from the project separation code output into each region. Then, Ecosystem Service output values of each grid point were summed for each coastal region to output a single value. The code was also written to combine all Ecosystem Service model results and time steps into a single file for each project. See Figure 5.

Figure 4. Coast wide map of twelve regions.

Input files (.csv and .txt) - This code has two main input files: data from the project and grid data for each region. The output files from the data separation code are used as the input files, and the grid data classifies each point by region. The grid has been clipped to the final analysis area. In this step, the code sums the output value of every point that belongs to a specific region.

Output files (.csv) - The file shows a breakdown of the summed model output for the twelve regions. The data also includes the scenario (moderate vs. less optimistic), the modeled year, and the Ecosystem Service model output. Each file is identified by the project name and the scenario on its filename.

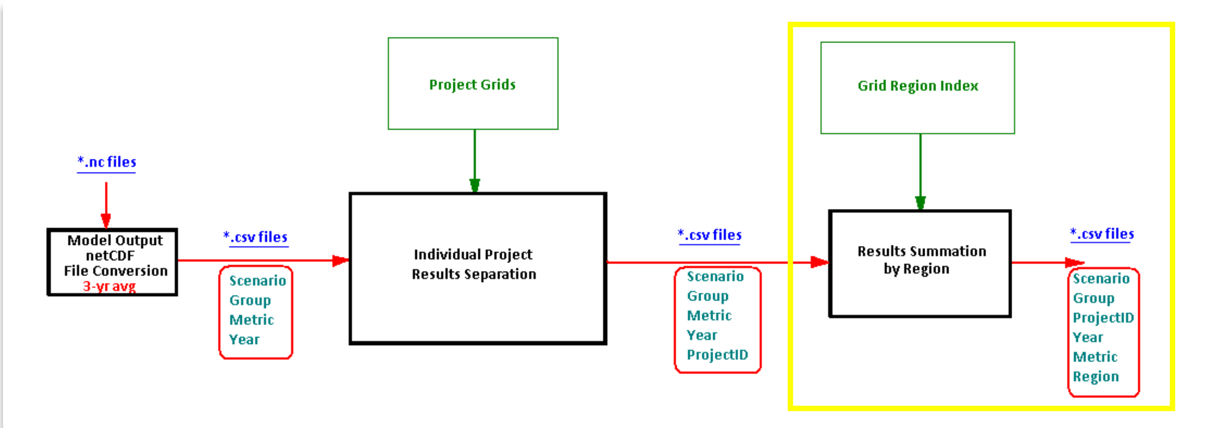

Figure 5. Post-processing workflow highlighting the summation code.

1.6 Test Case / Quality Review

The code was tested against two data sets for one time step. Data sets were labeled as follows:

- G80 (Data that represents the future without action model results)
- G81 (Data that represents the future with project for 22 individual projects included in group G81)
- G82 (Data that represents the future with project for 2 diversion projects included in group G82)

An Ecosystem Service model labeled "TST" was declared and assigned an output value of 1.0 for each point across the system for G80. The output value of 0.5 was assigned for each value point for the other two test groups G81 and G82. To evaluate the post-processing code the following procedure was used:

- Load the dataset in ArcGIS
  - G80 (future without action)
  - G81 (future with project for 22 projects)
  - G82 (future with project for 2 projects)
  - Corresponding project grid files for G81 and G82
  - Region Boundary Grid (i.e., which of the 12 regions from Fig 4)
- Spatially join the group file dataset with:
  - Region Boundary
  - Project Area of Influence Grid
- Count the number of points for each spatially joined group
- Assign a value of 0.5 to the points that are influenced by the project
- Assign a value of 1.0 to the points that are not influenced by the project
- Compare the post-processing sum results with the manually calculated values

Results

The code was compared against the manual calculations for both G81 and G82 groups. Table 1 shows the number of points, the manually calculated sum values, and the post-processing code for case G82.

G82 contains two projects: 001.DI.15, and 002.DI.03. Based on how the project grid was defined, the diversion project 001.DI.15 area of influence included output values for the West Bank of the Birdsfoot Delta, the Lower Pontchartrain region, and the Middle Pontchartrain region. The East Bank of the Birdsfoot Delta, the Lower Barataria region, and the Upper Barataria region are influenced by the diversion project 002.DI.03.

Table 1. Comparison between manual calculations and the post-processing code for G82

Region	Number of Points / EcoRegion			Manual Sum Results		Post-Processing CODE Sum Results	
	G80	001.DI.15	002.DI.03	001.DI.15	002.DI.03	001.DI.15	002.DI.03
AVB	24059	-	-	24059.0	24059.0	24064.0	24064.0
BFD	8736	4661	4070	**6405.5**	**6701.0**	**6388.5**	**6685.0**
CAS	7863	-	-	7863.0	7863.0	7874.0	7874.0
CHR	9353	-	-	9353.0	9353.0	9307.0	9307.0
LBA	12674	-	12674	12674.0	**6337.0**	12653.0	**6326.5**
LPO	17096	17083	-	**8541.5**	17096.0	**8525.0**	17045.0
LTB	15519	-	-	15519.0	15519.0	15490.0	15484.5
MEL	7836	-	-	7836.0	7836.0	7861.0	7861.0
MPO	14540	14533	-	**7266.5**	14540.0	**7277.0**	14554.0
UBA	7471	-	7471	7471.0	**3735.5**	7479.0	**3739.5**
UPO	11692	11692	-	**5846.0**	11692.0	**5855.5**	11711.0
UTB	4629	-	-	4629.0	4629.0	4640.0	4640.0

There were slight differences between the manually calculated values and those produced by the code (Table 2). These small discrepancies are also consistent with the results from group test case G81. It is suspected that the differences are due to slight variations between the project grids and the grid region boundaries. Despite the small differences due to variations between these boundaries, the post-processing code reproduced reasonable results.

Table 2. Percent difference between manual and code summation.

Region	001.DI.15	002.DI.03
AVB	-	-
BFD	**0.26%**	**0.23%**
CAS	-	-
CHR	-	-
LBA	-	**0.17%**
LPO	**0.19%**	-
LTB	-	-
MEL	-	-
MPO	**0.14%**	-
UBA	-	**0.11%**
UPO	**0.16%**	-
UTB	-	-