Appendix F
GRANDUC Appendix
(Generalized Risk AND Uncertainty – Coastal)

Appendix F
GRANDUC Appendix

Table of Contents

Part 1 – GRANDUC Documentation

1. Introduction F-1
2. Data Requirements F-1
3. Program Operation F-7

List of Figures

Figure 1 – Reference Line and Shoreline F-2
Figure 2 – Flood Damage Curve F-6
Figure 3 – Program Operation Reach Loop F-9
Figure 4 – Sample Project F-11
Figure 5 – Frequency Distribution F-12
Figure 6 – Cumulative Probability F-12

List of Tables

Table 1 – Sample Life Cycle Storm Histories F-4
Table 2 – Partial Results for the Sample Project F-10

Part 2 – Dare County GRANDUC Input

1. Global Data F-13
2. Reach Data F-13
3. Life Cycle Storm Histories F-14
4. Structure Database F-15
5. Flood Damage Curves F-15
6. Erosion Damage Curves F-16

List of Figures

Figure F-1a – Control File for North Project Global Data F-16
Figure F-2a – Control File for South Project Global Data F-18
Figure F-3a – Storm History (No Project Conditions)
1st Simulation (50-year cycle) of 500 Iterations F-21
Figure F-3b – Storm History (With 1350BD Project
1st Simulation (50-year cycle) of 500 Iterations F-22

Table of Contents (Cont'd)

Figure F-4a – Structure Database for North Project
Structure Database for 1st of 40 Reaches F-24
Figure F-4b – Structure Database for South Project
Structure Database for 1st of 118 Reaches F-25
Figure F-5 – Flood Damage Curves
Curve Types 1 and 2 out of 64 types F-27
Figure F-6 – Erosion Damage Curves
Curve Types 1 and 2 out of 10 Types F-28

List of Tables

Table F-1 – Surge Elevation and Wave Setup F-15

Appendix F
GRANDUC Documentation

GRANDUC
Generalized Risk AND Uncertainty - Coastal

1. Introduction

GRANDUC is a group of numerical programs that estimate the benefits and costs associated with shore protection projects and provide a measure of the risk and uncertainty associated with them. The programs are driven by storm water elevation, the associated erosion distances, erosion volumes and ground elevations. They calculate damages due to storm erosion, annual erosion (sea level rise, littoral sand deficits, etc.), inundation, and wave attack. Structure, contents, and land loss damages are determined along with nourishment costs. Present worth values for benefits and costs are calculated for each simulated life cycle. The life cycle storm data is generated by the Empirical Simulation Technique (EST). Armoring is modeled and an option to track all of the damages associated with one structure for one life cycle is available.

2. Data Requirements

The following is general information on data requirements for the programs. The specific information on running the programs is contained in the program documentation.

a. Project Reaches

The criteria for selecting reaches are as follows:

1) **Straight Shoreline.** The shoreline in each reach must be straight enough to satisfy the model assumption that the shoreline retreats uniformly.
2) **Similar Beach Profile**. The beach profile along the reach should not have large variations. This allows one set of storm response predictions to be applied to the reach.
3) **Resolution**. Long reaches make it difficult to determine the length of the project or how a limited quantity of sand should be distributed. Reach lengths of 500 to 1000 feet have been used satisfactorily. If longer reaches are used, structure data should be entered into the database in an order that allows the reaches to be subdivided without reordering the data.

Figure 1 is a sample reach that is 1000 feet long and contains 40 structures.

Structures for the sample reach are numbered in an across reach fashion rather than along the reach. This allows the reach to be subdivided into two reaches without having to sort the structure data again. A reference line and a shoreline are shown in the figure 1. The reference line is the location from which the structure distances are measured and the shoreline is the location from which the erosion is measured.

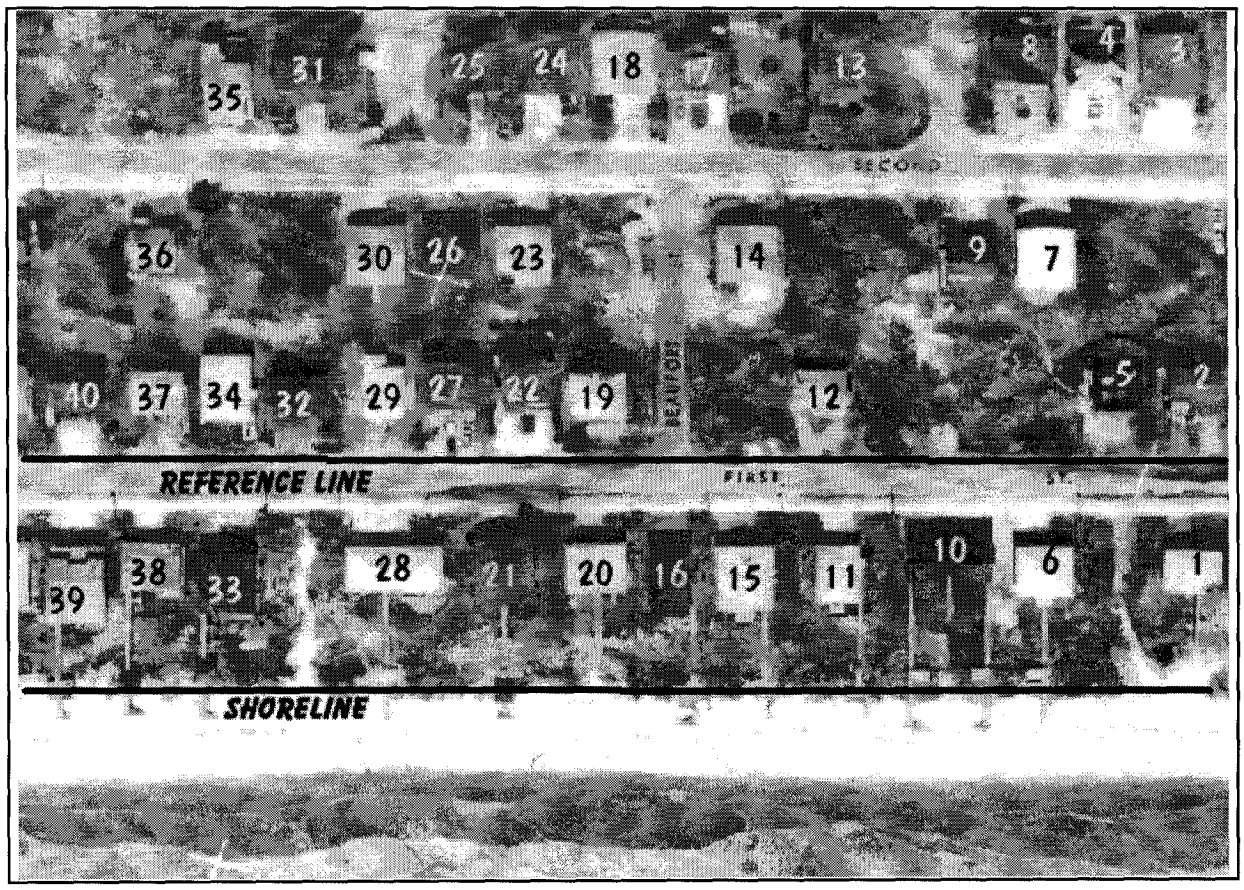

Figure 1

b. Structure Database

The structure database contains the following information:

1) Reach Number
2) Structure ID
3) Distance from the Reference Line to the Front of the Lot
4) Lot Length
5) Lot Width
6) Distance from the Reference Line to the Front of the Structure
7) Structure Length
8) Attack Angle Ratio - this is the cosine of the angle between the lot orientation and the direction of erosion
9) Structure Type - determines which flood damage curve to use
10) Structure Value
11) Contents Value
12) Ground Elevation - at the structure
13) First Floor Elevation
14) Active Flag - +1 the structure is used in the damage calculations
    -1 the structure is not used in the damage calculations
15) Erosion Type - determines which erosion damage curve to use
16) Armor Flag - +1 the structure is armored
    1 the structure is not armored
17) Flanking - the distance that erosion would have to occur in order for t the armor to be out flanked

c. Life Cycle Storm Histories

Each life cycle simulation needs a sequence of storms and storm responses to be generated for it. These sequences are generated by the Empirical Simulation Technique (EST) which uses a historic storm data base, a storm response model such as SBEACH, and a multidimensional interpolation procedure to generate a multitude of new storm histories. The data generated for each storm is:

1) Simulation Number - the number of the life cycle to which the storm belongs
2) Life Cycle Year - the year in the life cycle in which the storm occurred
3) Erosion Distance - the distance to the storm erosion measured from a point on the profile called the shoreline. The shoreline could be the vegetation line or any other point on the profile that moves in response to annual erosion or accretion. This input is normally calculated in a model like SBEACH. For the Dare County project the Wilmington District developed an empirically based method.
4) Erosion Volume - the volume of sand eroded by the storm
5) Surge Elevation - the peak storm water elevation

6) Wave Setup - the near shore setup as calculated in the Shore Protection Manual
7) Ground Elevation - the ground elevation at the erosion point

Table 1 contains a 54-year life cycle storm history. The economic period for the project would probably be 50 years but no damages would be recorded for the first 4 years since the project could not be constructed in less than 4 years. However, erosion and structure loss are accounted for during these pre-project years.

Table 1. Sample Life Cycle Storm Histories

Simulation Number	Life Cycle Year	Erosion Distance	Erosion Volume	Surge Elevation	Wave Setup	Ground Elevation
1	2	78	10.2	6.7	2.3	9.6
1	4	29	4.3	6.2	1.4	13.7
1	7	87	11.1	7.2	2.4	9.3
1	11	14	2.5	6.0	1.1	15.0
1	11	60	8.1	6.5	1.9	11.0
1	14	70	9.3	6.6	2.1	10.3
1	16	33	4.8	6.2	1.4	13.3
1	21	35	5.0	6.2	1.5	13.2
1	25	14	2.5	6.0	1.1	14.9
1	29	20	3.2	6.1	1.2	14.5
1	33	21	3.3	6.1	1.2	14.4
1	35	57	7.7	6.5	1.9	11.3
1	37	61	8.2	6.5	1.9	11.0
1	40	69	9.2	6.6	2.1	10.3
1	41	50	6.9	6.4	1.7	11.9
1	50	30	4.5	6.2	1.4	13.6
1	53	70	9.3	6.6	2.1	10.2

d. Global Data

The following data applies to all the reaches:

1) Run Title
2) The Number of Life Cycles to be Simulated
3) Interest Rate - the annual interest rate
4) Economic Period - the length of the life cycle
5) Base Year - the year to start the analysis. Storms that occur before the base year cause damage and can remove structures but the damages are not added to the output totals.
6) Switches to Vary Erosion Distance, Structure Distance, and Structure Elevation - if a switch is on, the program will introduce some uncertainty into the calculations using a number selected from a

distribution around the inputted number.

7) Nourishment Cycle in Years
8) Initial Benefits - such as benefits during construction
9) Annual Benefits - such as recreation
10) Initial Costs - construction, real estate, studies, etc.
11) Annual Costs - surveys, aerial photographs, reports etc.
12) Dredge Mobilization and Demobilization Cost for a Nourishment Operation
13) Nourishment Costs Other than Dredging
14) ID of Structure to be traced - all of the damages incurred by this structure during the first life cycle will be stored in a file.
15) The Number of Reaches

e. Reach Data

The following data is repeated for each reach:

1) Reach Distribution Factor - the fraction of the mobilization and other nourishment costs that should be applied to this reach.
2) Distance from the Shoreline to the Reference Line – erosion is measured from the shoreline and structures are measured from the reference line. This is a useful parameter when the project width shifts the shoreline seaward.
3) Long Term Erosion Rate for the Reach - this would be the rate calculated from historic photographs and is the result of all the different causes of erosion.
4) Annual Erosion Rate for the Reach - the erosion rate from non-storm related causes such as sea level rise.
5) Annual Volume Loss for the Reach - volume lost to non-storm related causes.
6) Storm Erosion Volume that Initiates Dune Repair - erosion volume associated with a storm that removes the dune. It is assumed that after a large storm some repairs to the dune, such as scraping or truck hauling, will take place
7) Repair Volume - the volume needed to repair the dune.
8) Unit Repair Cost - the cost per cubic yard to repair the dune.
9) Unit Dredging Cost - dollars / cubic yard and does not include mobilization.
10) Total Fill Placement Adjustment Ratio - overfill requirement and transport losses.
11) Land Value - dollars per square foot.
12) Reach Length
13) Parameters for Wave Attenuation - parameters relating drag losses and obstructions.
14) Wave Zone - this is a 200 to 300 foot zone from the erosion line in which a wave reduction is applied for an effective row of structures.

The wave reduction is calculated using all the structures located within this zone as a row of structures.

F. Flood Damage Curves

Two curves are given for each type of structure. One curve is for the structure damage and the second curve is for the content damage. The curves are the distance that the water is above or below the first floor elevation versus the percent damage. Figure 2 displays a sample curve.

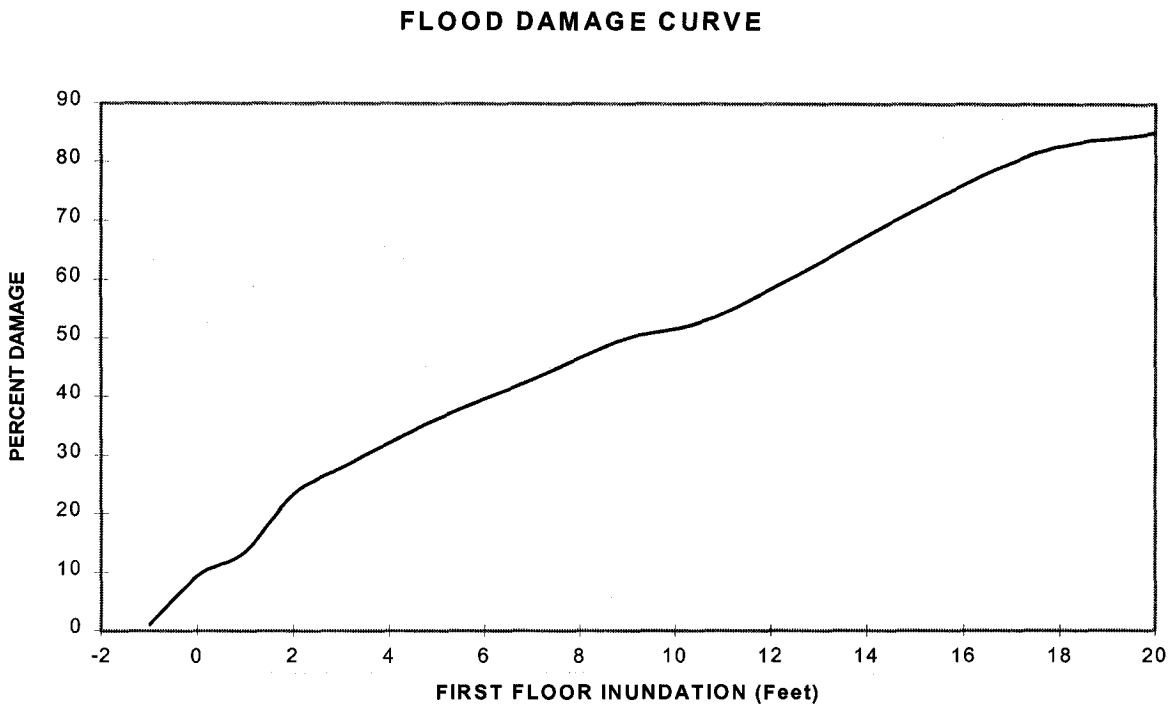

Figure 2

g. Erosion Damage Curves

Two curves are given for each type of structure. One curve is for the structure damage and the second curve is for the content damage. The curves are a representation of the percent undermining of the structure (the ratio of the erosion distance under the structure over the structure length) versus the percent damage.

3. Program Operation

The program starts by reading the global data and damage curves. Next a reach loop is begun in which reach data is read and all of the simulations are performed on the structures in the reach before proceeding to the next reach. Then the data for the next reach is read and all of the simulations are repeated on this reach. The loop proceeds until all of the reaches are analyzed. See figure 3.

At the beginning of the reach loop, the program reads in the long-term erosion data and the parameters used in calculating the flood profile. The structure is read in and the random number generators are reset.

The program then begins the life cycle simulation loop. Damage values are set to zero and all parameters are set to their initial value. All storms associated with this life cycle are then read in and for the without project runs the net erosion after recovery is calculated as follows

$$NetStormErosion = \frac{(LongTermErosion - AnnualErosion)\ x\ LifeCycleDuration}{CummulativeStormErosion}$$

This equation forces the net storm erosion to be consistent with the observed long-term erosion rate. Project runs require this parameter to be entered as input data. Project profiles may have a different recovery factor, however, the average of the calculated net storm erosion values is printed out and can be used if other information is unavailable.

The program then enters a year loop. At the beginning of the loop all structures that can be repaired are restored to their original value. The program checks if there has been storm. If there has been a storm, the erosion value is varied if this option was chosen. The flood profile is calculated by going to the point of erosion and using the storm surge, wave setup, and ground elevation to calculate the water depth and largest wave that can exist at that point. The wave height and wave setups are then reduced at landward points on the profile using the drag coefficient and obstruction parameters read in for the reach. In order to calculate the wave reduction due to a row of structures, the structures are sorted according to distance from the reference line. The structure distances are then summed until the distance between two structures is greater than the row distance parameter. If a distance is greater than the row distance parameter, then the distances of the previously summed structures are averaged and a wave reduction factor is applied. This procedure continues until all structures are checked. Since most of the wave activity can happen in the first couple of hundred feet of the erosion point and structures can be staggered which could prevent the row distance from being exceeded, a wave reduction is calculated

using the structures located in the wave zone as defined by the input parameter wave zone. The wave crest is used to define the flood profile. A wave impact profile is defined for areas where the wave height exceeds 3 feet and is two feet below the wave crest.

Having calculated the storm characteristics, a structure loop is begun. Erosion, flood, and wave damages are calculated for each structure. The maximum of these damages is multiplied by a present worth factor and is added to a cumulative variable. However, if the life cycle year is earlier than the base year, no damages are recorded. If the structure is armored, erosion is stopped at the armor line until the armor is out flanked. The value of the structure and its contents is reduced by the maximum storm damage amount. This is done to prevent double counting in case there are multiple storms in one year or if at the end of the year the structure is lost to long term erosion.

At the end of the year loop, the shoreline is adjusted for net storm erosion and annual erosion. Land losses are calculated and undermined structures are made inactive. At the end of each life cycle, the total damage is printed out.

Runs with projects differ from base condition runs in that there is no land loss and there is a periodic nourishment cycle. At the end of each periodic nourishment cycle, annual and storm erosion damage is repaired. During the periodic nourishment cycle, only minor repairs are made to the project after major storms that reduce project protection by causing the shoreline to retreat. The output for project runs includes project costs, partial benefits and damages.

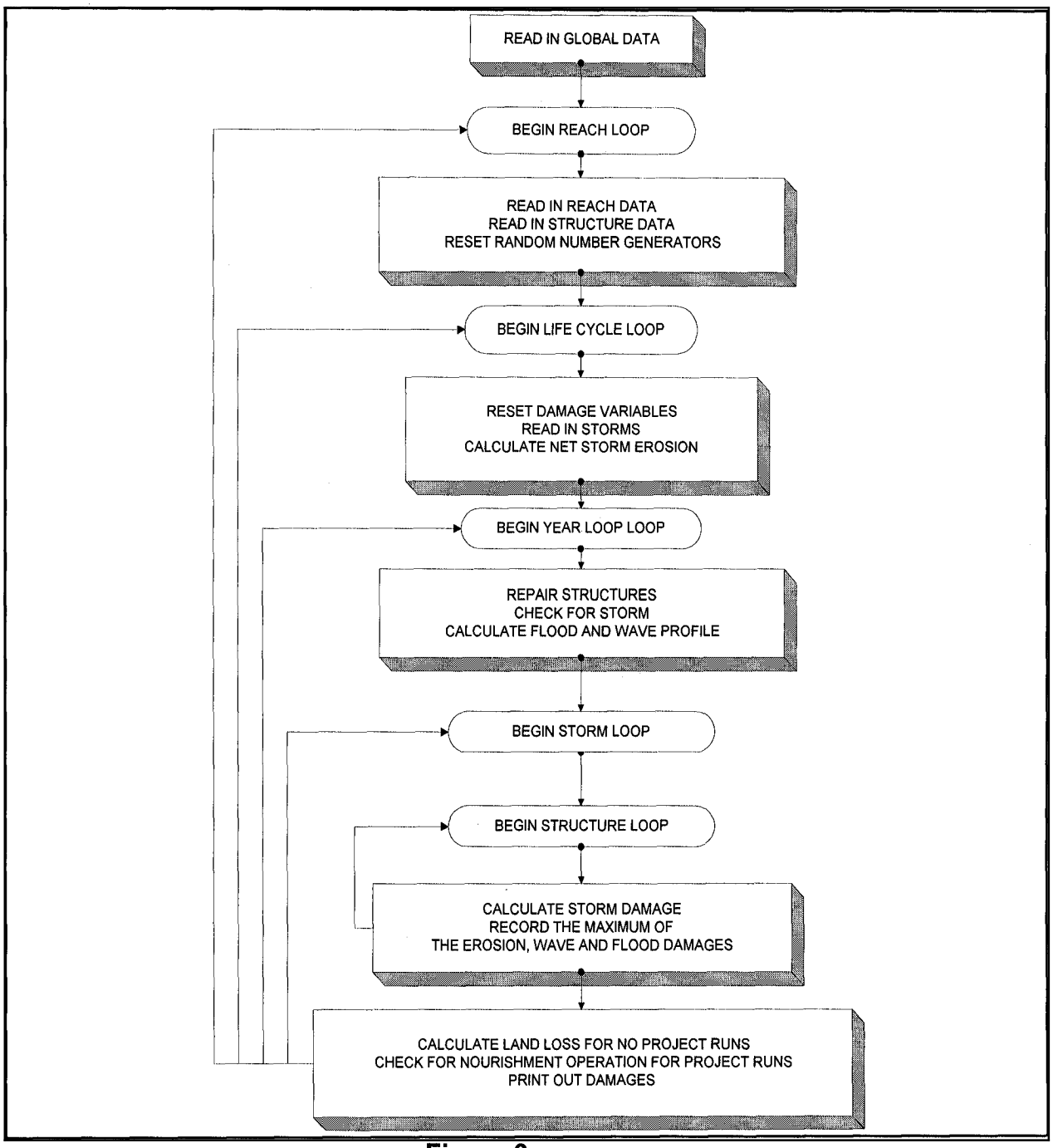
READ IN GLOBAL DATA
BEGIN REACH LOOP
READ IN REACH DATA
READ IN STRUCTURE DATA
RESET RANDOM NUMBER GENERATORS
BEGIN LIFE CYCLE LOOP
RESET DAMAGE VARIABLES
READ IN STORMS
CALCULATE NET STORM EROSION
BEGIN YEAR LOOP LOOP
REPAIR STRUCTURES
CHECK FOR STORM
CALCULATE FLOOD AND WAVE PROFILE
BEGIN STORM LOOP
BEGIN STRUCTURE LOOP
CALCULATE STORM DAMAGE
RECORD THE MAXIMUM OF
THE EROSION, WAVE AND FLOOD DAMAGES
CALCULATE LAND LOSS FOR NO PROJECT RUNS
CHECK FOR NOURISHMENT OPERATION FOR PROJECT RUNS
PRINT OUT DAMAGES

Figure 3

A separate program compares the damages from a project run and the base run to calculate benefits and outputs a probability versus net benefits table. Figure 4 contains a sample project profile, which was applied to the reach shown in Figure 1. Runs with and without the project were made and compared. The results for the first 15 life cycles are shown in Table 2.

Table 2
Partial Results for the Sample Project

Benefits	Costs	BCR	Net Benefits
1,758,779	723,043	2.43	1,035,736
1,922,766	710,440	2.71	1,212,326
1,758,698	714,167	2.46	1,044,531
2,699,991	783,825	3.44	1,916,166
1,662,882	714,438	2.33	948,444
1,859,573	710,070	2.62	1,149,503
2,672,781	724,054	3.69	1,948,727
1,942,507	70,8590	2.74	1,233,917
1,091,978	696,686	1.57	395,292
1,942,585	716,308	2.71	1,226,277
761,246	675,450	1.13	85,796
971,021	666,249	1.46	304,772
790,800	685,589	1.15	105,211
1,450,528	715,683	2.03	73,4845
1,041,401	683,001	1.52	358,400
1,880,998	710,466	2.65	1,170,532

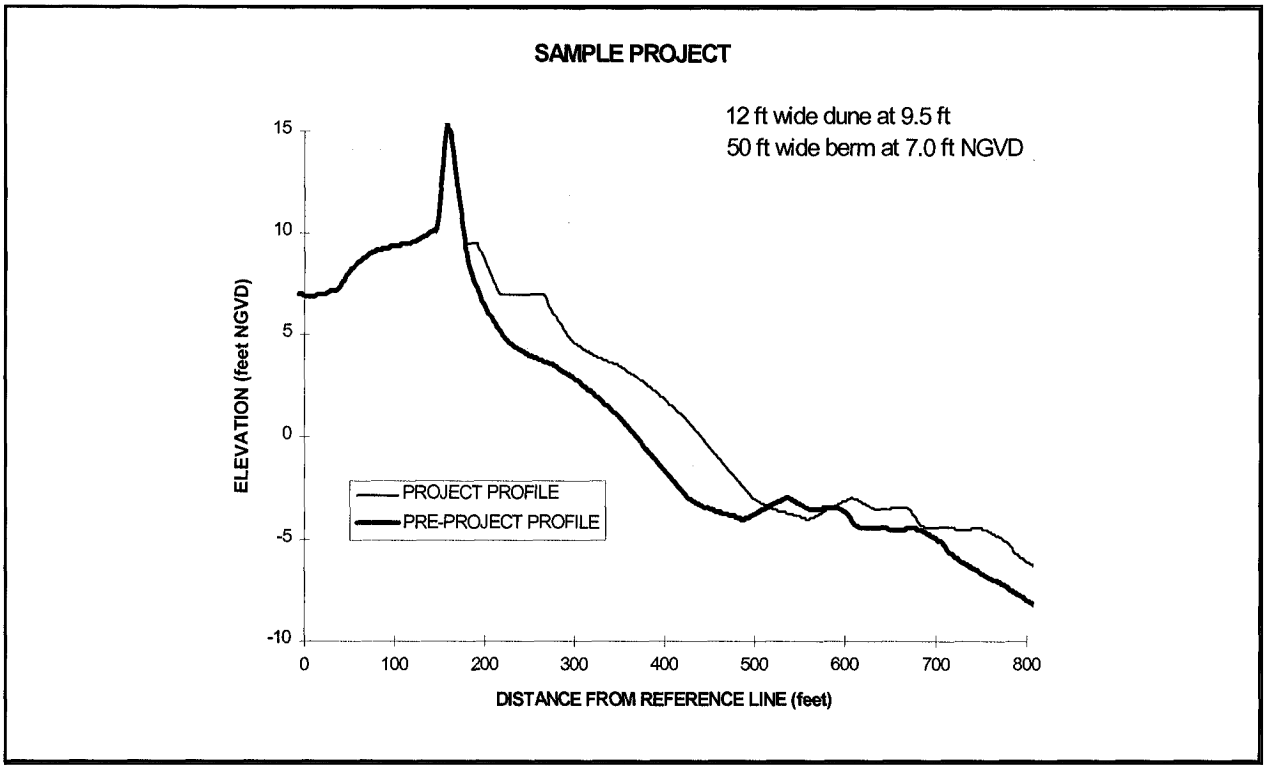

Figure 4

Figure 5 is a frequency plot of the net benefits output for 7,000 life cycles. The range of the net benefit outputs was divided into $50,000 intervals. The number of times a net benefit result occurred within an interval was tallied to produce the frequency plot. The frequencies in Figure 5 can be converted into probabilities by dividing them by the total number of life cycles. The probabilities can then be totaled to produce a cumulative probability distribution as shown in Figure 6. There are some negative net benefits results. These negative net benefits result from life cycle simulations in which there are few storms and no years in which there are more than one storm. It is difficult to read the probability from the graph but the data shows that there is less than a 3% chance that the net benefits will be negative.

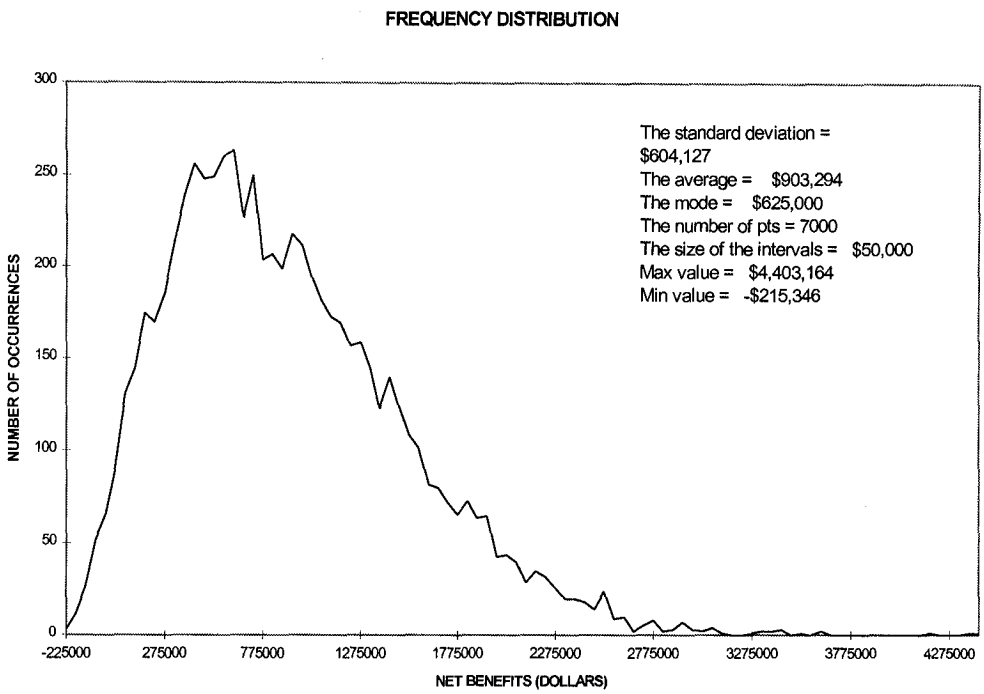

Figure 5

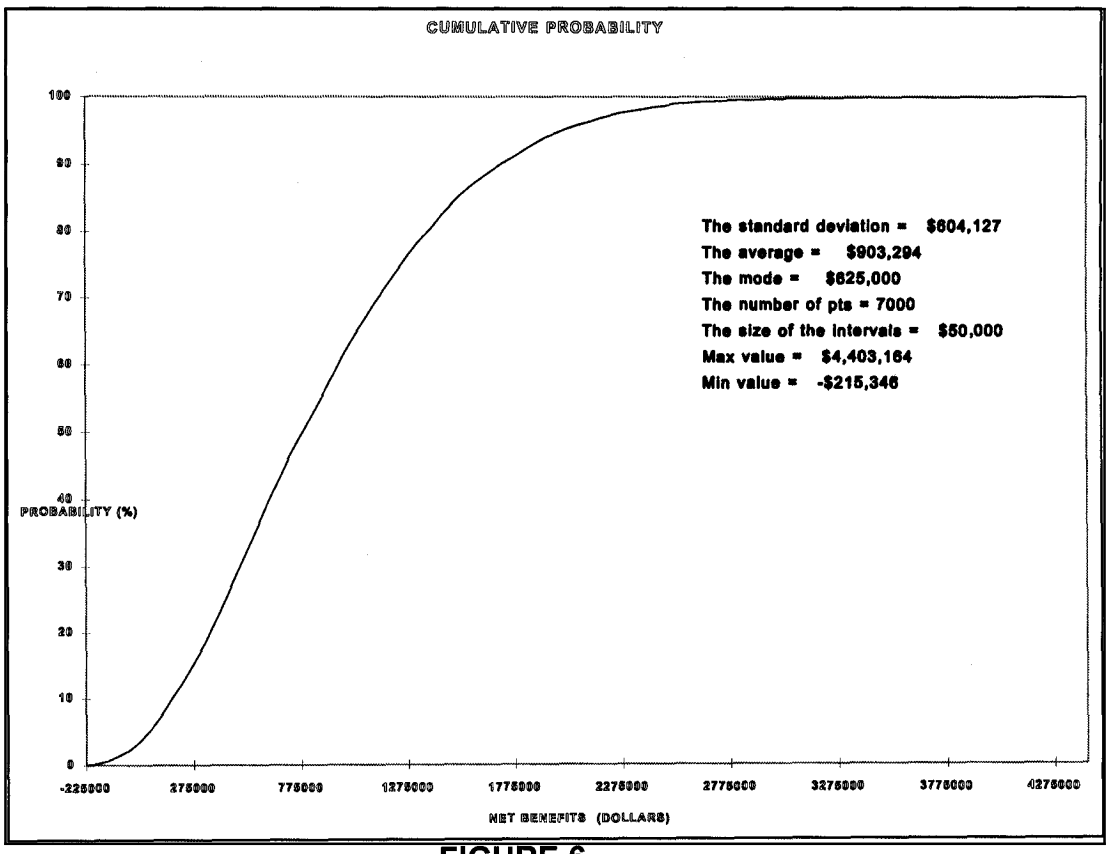

FIGURE 6

Part 2 – Dare County GRANDUC Input

1. Global Data

(See figures F-1a and F-2a for specific global input data for the North and South Project Areas, respectively)

a. **Number of Life Cycles**: To achieve model stability, 500 life cycles were simulated.

b. **Interest Rate:** An interest rate of 6 5/8% is used for this analysis.

c. **Economic Period:** A 50-year length of life cycle is used.

d. **Base Year:** The base year for GRANDUC analysis is the 1st year the project is in-place. Adjustments were made to the shoreline and structure database to reflect project in-place conditions.

e. **Uncertainty**: Uncertainty was introduced into the model via three variables: erosion distance, structure distance, and 1st floor structure elevation. A variance of ± 2-feet is used for erosion distance, ± 5-feet for structure distance, and ± 0.1 feet for 1st floor structure elevation.

f. **Nourishment Cycle:** A 3-year periodic nourishment cycle is used.

g. **Initial Benefits:** Initial benefits such as benefits during construction were assumed to be cancelled out by interest during construction; therefore, a value of "zero" was used for initial benefits.

h. **Initial Costs, Annual Costs, Dredging Mobilization and Demobilization Cost during Nourishment:** Study team members provided cost input data.

2. Reach Data. (See figures F-1b and F-2b for specific reach input data for the North and South Project Areas, respectively)

a. **Reaches:** The study area was broken into a total of 214 reaches for the study area. Of this total 35 were in Kitty Hawk, 52 were in Kill Devil Hills, 78 were in Nags Head, and 49 were in South Nags Head. The reaches were variable in length, ranging from 200 to 1200 feet with an average of 500 feet. Similar beach profiles were present in many of the reaches; therefore, 21 typical profiles were developed to represent the 214 reaches that were modeled. For the NED Plan (1350BD), there were 40 reaches for the North Project Area and 114 reaches for the South Project Area.

b. **Shoreline and Reference Line:** The existing vegetation line was used as both the shoreline and the reference line for modeling Dare County beach changes and damage assessments. Erosion is measured from the shoreline and structure setbacks are measured from the reference line.

c. **Long Term Erosion Rates:** For pre-project (base) conditions, North Carolina Division of Coastal Management (NCDCM) defined long-term erosion rates were used. For project conditions, long-term erosion losses were calibrated with results produced by GENESIS evaluations performed by WES for the Dare County Study.

d. **Annual Erosion:** An annual erosion of 0.65 feet was used to represent losses due to sea level rise.

e. **Dune Damage and Repair:** Scraping costs were input to the model to account for emergency repairs that may occur following severe storms.

f. **Unit Dredging Cost:** Initial construction dredging cost for the North Project Area was $3.40 per cubic yard and varied from $3.00 to $4.10 per cubic yard for the South Project Area. During periodic nourishment, dredging cost varied from $9.40 for the North Project Area and varied from $3.70 to $4.70 per cubic yard for the South Project Area.

g. **Total Fill Placement Adjustment Ratio:** An overfill ratio of 1.5 and 1.1 were required for the North and South Project Areas, respectively, during initial construction. During periodic nourishment, both the North and South Project Areas required an overfill ratio of 1.1.

h. **Land Value:** A land value of $6.19 per square foot was used throughout the study area. This equates to about $270,000 per acre.

3. Life Cycle Storm Histories

(See figures F-3a and F-3b for storm history data for the "no project plan" and for the "1350BD plan", respectively)

a. **Erosion Distance:** Erosion distance was calculated using an empirically based method developed by the Wilmington District.

b. **Surge Elevation and Wave Setup:** Surge elevation is the peak storm water elevation and wave setup is the near shore setup. Surge elevation and wave setup used in the Dare County study is shown in the table F-1.

Table F-1		
Surge Elevation and Wave Setup		
Frequency	Surge Elevation	Wave Setup
	(feet NGVD)	(feet)
1-year	4.30	1.78
5-year	5.00	2.07
10-year	5.70	2.31
25-year	7.00	2.54
50-year	8.00	2.73
100-year	9.10	3.01
500-year	11.70	3.34

4. Structure Database

(See figures F-4a and F-4b for the structural database input for the first reach of the North and South Project Areas, respectively)

The Economics Section of the Wilmington District developed all input data to the structure database. Most of the information in the database was determined simply by measuring distances from available project area mapping. These measurements included distance from the reference line to the front of the lot and structure, lot width and length for each structure, and structure length. However, values had to be assigned to each structure in the database for the following:

a. **Structure Type** selection determines which flood damage curve (piling, slab, etc) is assigned to a given structure.
b. **Structure Value** is normally taken from the tax database.
c. **Content Value** was taken as half of the structure value.
d. **Ground Elevation** (at the structure) was field surveyed.
e. **First Floor Elevation** for each structure was field surveyed.

5. Flood Damage Curves

(See figure F-5 for data descriptions for flood damage curve type 1 out of the total of 64 curve types)

For each type of structure in the study area, flood damage curves were developed for both the structure and contents. Damages for each structure are tied to the 1st floor elevation. A total of 64 flood/inundation type curves were selected by the Economics Section of the Wilmington District to represent all the structures in the study area.

6. Erosion Damage Curves.

(See figure F-6 for data descriptions for erosion curve type 1 out of the total of 10 curve types)

For each type of structure in the study area, erosion damage curves were developed for both the structure and contents. A total of 10 erosion damage curves were selected by the Economics Section of the Wilmington District to represent all the structures in the study area.

Figure F-1a
Control File for North Project
Global Data

(Plan-1350BD) North Project (Kitty Hawk/Kill Devil Hills) (02/2000) #
This is the number of iterations in the statistical loop. #
500
This is the number of iterations in the economic loop. Economic period. #
50
The number of year to skip. How many years until base year? #
0
The base year. #
1
The interest rate as a decimal. #
0.06625
The total length of the project (sum of the reaches) #
21581.00
The nourishment cycle in years. #
3
The nourishment dredging mobilization and demobilization costs. #
3348000.00
The nourishment costs other than Mob and pumping. #
1307000.00
Initial benefits. (such as benefits during construction) #
0.00
Annual benefits. (such as recreation) #
1983300.00
Initial cost. (construction, real estate, studies,etc) #
22359882.00
Annual costs. (surveys, photos, reports) #
103730.00
This is the name of the structure to be traced #
4688
Switch for variation in erosion distance -1 off +1 on #
+1
Maximum variation in erosion distance. Positive is a decrease in erosion #
+2

Figure F-1b
Control File for North Project
Reach Data for 1st of 40 Reaches
(continuation of figure F-1a)

Minimum variation in erosion distance #
-2
Switch for variation in structure distance for erosion calculations -1 off +1 on #
+1
Maximum variation in structure distance for erosion calculations #
+5
Minimum variation in structure distance for erosion calculations #
-5
Switch for variation in structure elevation -1 off +1 on #
+1
Maximum variation in structure elevation #
+0.10
Minimum variation in structure elevation #
-0.10
This is the number of reaches. #
40
The reach name. No spaces #
123
The path for the reach storm file. #
c:\granduc\storms\S01_50.dat
The reference line to shoreline adjustment for reach 23 #
11.00
The long term erosion for reach 23. #
-5.70
The annual erosion retreat for reach 23. (ft) #
-0.65
The annual volume loss for reach 23. (cubic yards) #
7.18
The net storm erosion for reach 23. As a decimal ratio of total storm erosion. #
-0.06
Storm erosion volume to initiate scraping. (cubic yards) #
14.50
Scraping volume. (cubic yards) #
12.40
Unit scraping cost. ($/cubic yard) #
1.55
Unit pumping cost. ($/cubic yard) #
11.70
Total fill adjustment ratio. (overfill and transport losses) #
1.10
The land value $ per sq ft. #
6.19
Drag coefficient for reach 23. #
1.00

Figure F-1c
Control File for North Project
Reach Data for 1st of 40 Reaches
(continuation of figure F-1b)

Wetted height for reach 23. #
2.00
Effective diameter for reach 23. #
1.00
Horizontal spacing for reach 23. #
1.50
Wave zone for reach 23. #
200.00
Length for reach 23. #
1021.00
Structure width for reach 23. #
50.00
Row distance for reach 23. #
50.00

Figure F-2a
Control Data for South Project
Global Data

(Plan-1350BD) South Project (N. Nags Head/S. Nags Head) (02/2000) #
This is the number of iterations in the statistical loop. #
500
This is the number of iterations in the economic loop. Economic period. #
50
The number of year to skip. How many years until base year? #
0
The base year. #
1
The interest rate as a decimal. #
0.06625
The total length of the project (sum of the reaches) #
54000.00
The nourishment cycle in years. #
3
The nourishment dredging mobilization and demobilization costs. #
4657200.00
The nourishment costs other than Mob and pumping. #
1609400.00
Initial benefits. (such as benefits during construction) #
0.00
Annual benefits. (such as recreation) #
2305400.00
Initial cost. (construction, real estate, studies,etc) #
46750245.00

Figure F-2b
Control File for South Project
Reach Data for 1st of 114 Reaches
(continuation of Figure F-2a)

Annual costs. (surveys, photos, reports) #
255530.00
This is the name of the structure to be traced #
6854
Switch for variation in erosion distance -1 off +1 on #
+1
Maximum variation in erosion distance. Positive is a decrease in erosion #
+2.00
Minimum variation in erosion distance #
-2.00
Switch for variation in structure distance for erosion calculations -1 off +1 on #
+1
Maximum variation in structure distance for erosion calculations #
+5.00
Minimum variation in structure distance for erosion calculations #
-5.00
Switch for variation in structure elevation -1 off +1 on #
+1
Maximum variation in structure elevation #
+.10
Minimum variation in structure elevation #
-.10
This is the number of reaches. #
114
The reach name. No spaces #
314
The path for the reach storm file. #
c:\granduc\storms\S14_50.dat
The reference line to shoreline adjustment for reach 14 #
65.00
The long term erosion for reach 14. #
-0.8
The annual erosion retreat for reach 14. (ft) #
-0.65
The annual volume loss for reach 14. (cubic yards) #
1.01
The net storm erosion for reach 14. As a decimal ratio of total storm erosion. #
-0.08
Storm erosion volume to initiate scraping. (cubic yards) #
14.50
Scraping volume. (cubic yards) #
12.30

Figure F-2c
Control File for South Project
Reach Data for 1st of 114 Reaches
(continuation of Figure F-2b)

Unit scraping cost. ($/cubic yard) #
1.55
Unit pumping cost. ($/cubic yard) #
4.72
Total fill adjustment ratio. (overfill and transport losses) #
1.10
The land value $ per sq ft. #
6.19
Drag coefficient for reach 14. #
1.00
Wetted height for reach 14. #
2.00
Effective diameter for reach 14. #
1.00
Horizontal spacing for reach 14. #
1.50
Wave zone for reach 14. #
200.00
Length for reach 14. #
314.00
Structure width for reach 14. #
50.00
Row distance for reach 14. #
50.00

Figure F-3a
Storm History (No Project Conditions)
1st Simulation (50-year cycle) of 500 Iterations

Simulation Number	Life Cycle Year	Erosion Distance	Erosion Volume	Surge Elevation	Wave Setup	Ground Elevation
0	0	18.2	10.1	4.8	2.0	10.7
0	1	15.9	7.2	4.6	1.9	10.7
0	2	19.1	11.3	4.9	2.0	10.7
0	4	18.5	10.5	4.9	2.0	10.7
0	4	15.8	7.1	4.6	1.9	10.7
0	6	16.5	8.0	4.7	1.9	10.7
0	6	98.2	19.6	5.9	2.3	10.7
0	7	16.8	8.4	4.7	2.0	10.7
0	8	23.0	12.6	5.0	2.1	10.7
0	8	19.3	11.4	4.9	2.0	10.7
0	9	14.8	6.0	4.5	1.9	10.7
0	11	14.0	4.9	4.5	1.9	10.7
0	11	16.3	7.7	4.7	1.9	10.7
0	13	12.4	2.9	4.3	1.8	10.7
0	17	15.1	6.3	4.6	1.9	10.7
0	20	16.3	7.7	4.7	1.9	10.7
0	21	12.2	2.7	4.3	1.8	10.7
0	22	212.5	42.5	9.9	3.1	10.0
0	23	89.6	18.1	5.7	2.3	10.7
0	23	67.6	16.3	5.5	2.2	10.7
0	24	57.0	15.5	5.4	2.2	10.7
0	25	67.9	16.3	5.5	2.2	10.7
0	28	89.2	18.1	5.7	2.3	10.7
0	28	17.7	9.5	4.8	2.0	10.7
0	28	16.2	7.7	4.7	1.9	10.7
0	29	13.3	4.0	4.4	1.8	10.7
0	30	15.3	6.6	4.6	1.9	10.7
0	30	17.9	9.8	4.8	2.0	10.7
0	30	13.5	4.3	4.4	1.8	10.7
0	32	19.1	11.2	4.9	2.0	10.7
0	32	19.8	12.2	5.0	2.1	10.7
0	33	17.8	9.6	4.8	2.0	10.7
0	34	12.1	2.6	4.3	1.8	10.7
0	37	14.2	5.2	4.5	1.9	10.7
0	37	19.1	11.2	4.9	2.0	10.7
0	39	14.3	5.2	4.5	1.9	10.7
0	43	13.3	4.1	4.4	1.8	10.7
0	43	16.2	7.7	4.7	1.9	10.7
0	43	14.3	5.3	4.5	1.9	10.7
0	44	18.7	10.7	4.9	2.0	10.7
0	46	12.9	3.6	4.4	1.8	10.7

Figure F-3b
Storm History (With 1350BD Project)
1st Simulation (50-year cycle) of 500 Iterations

Simulation Number	Life Cycle Year	Erosion Distance	Erosion Volume	Surge Elevation	Wave Setup	Ground Elevation
0	46	23.7	12.7	5.0	2.1	10.7
0	49	17.4	9.2	4.8	2.0	10.7
0	0	19.7	10.1	4.8	2.0	13.0
0	1	17.2	7.2	4.6	1.9	13.0
0	2	20.7	11.3	4.9	2.0	13.0
0	4	20.0	10.5	4.9	2.0	13.0
0	4	17.1	7.1	4.6	1.9	13.0
0	6	17.8	8.0	4.7	1.9	13.0
0	6	103.7	19.6	5.9	2.3	12.9
0	7	18.2	8.4	4.7	2.0	13.0
0	8	24.8	12.6	5.0	2.1	13.0
0	8	20.9	11.4	4.9	2.0	13.0
0	9	16.1	6.0	4.5	1.9	13.0
0	11	15.1	4.9	4.5	1.9	13.0
0	11	17.6	7.7	4.7	1.9	13.0
0	13	13.4	2.9	4.3	1.8	13.0
0	17	16.4	6.3	4.6	1.9	13.0
0	20	17.6	7.7	4.7	1.9	13.0
0	21	13.2	2.7	4.3	1.8	13.0
0	22	262.5	42.5	9.9	3.1	10.2
0	23	94.1	18.1	5.7	2.3	12.9
0	23	71.1	16.3	5.5	2.2	12.9
0	24	60.2	15.5	5.4	2.2	12.9
0	25	71.5	16.3	5.5	2.2	12.9
0	28	93.6	18.1	5.7	2.3	12.9
0	28	19.1	9.5	4.8	2.0	13.0
0	28	17.6	7.7	4.7	1.9	13.0
0	29	14.4	4.0	4.4	1.8	13.0
0	30	16.6	6.6	4.6	1.9	13.0
0	30	19.4	9.8	4.8	2.0	13.0
0	30	14.6	4.3	4.4	1.8	13.0
0	32	20.7	11.2	4.9	2.0	13.0
0	32	21.5	12.2	5.0	2.1	13.0
0	33	19.3	9.6	4.8	2.0	13.0
0	34	13.1	2.6	4.3	1.8	13.0
0	37	15.4	5.2	4.5	1.9	13.0
0	37	20.7	11.2	4.9	2.0	13.0
0	39	15.4	5.2	4.5	1.9	13.0
0	43	14.4	4.1	4.4	1.8	13.0
0	43	17.5	7.7	4.7	1.9	13.0
0	43	15.5	5.3	4.5	1.9	13.0

Figure F-3b

Storm History (With 1350BD Project)

1st Simulation (50-year cycle) of 500 Iterations

0	44	20.2	10.7	4.9	2.0	13.0
0	46	14.0	3.6	4.4	1.8	13.0
0	46	25.5	12.7	5.0	2.1	13.0
0	49	18.9	9.2	4.8	2.0	13.0

Figure F-4a

Structure Database for North Project

Structure Data for 1st of 40 Reaches

Reach Number	Structure ID	Distance to Lot	Lot Length	Lot Width	Distance to Structure	Structure Length	Attack Angle	Structure Type	Structure Value	Content Value	Ground Elevation	1st Floor Elevation	Active Flag	Erosion Type	Armor Flag	Flanking
123	83	290	150	71	330	45	1	59	70,125	35,063	7.7	7.7	1	2	-1	0
123	360	692	250	105	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	402	698	271	224	738	84	1	38	245,775	407,986	11.0	11.0	1	4	-1	0
123	669	539	118	151	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	1181	692	250	110	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	1221	692	250	105	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	1497	539	122	124	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	1538	539	120	126	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	1894	320	150	71	360	60	1	56	49,250	24,625	7.5	16.5	1	1	-1	0
123	1926	360	150	71	400	40	1	55	83,750	41,875	7.5	15.5	1	1	-1	0
123	1960	335	150	71	375	40	1	59	68,625	34,313	7.5	7.5	1	2	-1	0
123	2023	692	250	60	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	2071	135	150	100	175	61	1	55	89,500	44,750	10.3	19.0	1	1	-1	0
123	2356	492	124	122	532	49	1	56	125,000	62,500	8.0	18.0	1	1	-1	0
123	2729	328	150	50	368	50	1	55	64,875	32,438	8.3	16.3	1	1	-1	0
123	2745	330	150	50	370	45	1	56	88,563	44,281	8.8	16.8	1	1	-1	0
123	2770	332	150	50	372	43	1	56	92,750	46,375	8.6	16.6	1	1	-1	0
123	2927	692	194	100	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3176	539	128	108	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3216	539	126	120	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3557	359	150	50	399	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3572	359	150	50	399	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3606	332	150	50	372	47	1	55	71,875	35,938	8.3	16.3	1	1	-1	0
123	3621	359	150	50	399	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	3856	139	150	50	179	56	1	55	78,625	39,313	10.9	18.3	1	1	-1	0
123	3882	156	150	50	196	47	1	56	85,375	42,688	10.5	18.7	1	1	-1	0
123	3904	132	150	50	172	54	1	55	51,188	25,594	9.9	17.9	1	1	-1	0
123	3920	142	150	50	182	62	1	56	143,625	71,813	8.5	16.8	1	1	-1	0
123	4018	539	239	50	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	4035	539	239	50	579	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	4155	-31	212	50	10	73	1	55	52,000	26,000	12.1	16.3	1	1	-1	0
123	4181	-30	212	50	10	54	1	2	80,000	40,000	10.1	12.1	1	2	-1	0
123	4376	352	150	50	392	33	1	56	112,125	56,063	8.5	18.5	1	1	-1	0
123	4409	302	150	50	342	34	1	55	43,500	21,750	10.0	20.0	1	1	-1	0
123	4718	145	150	50	185	47	1	2	96,000	48,000	9.9	9.9	1	2	-1	0
123	4733	147	150	50	187	48	1	55	73,750	36,875	11.4	19.9	1	1	-1	0
123	5007	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	5033	-5	212	50	36	33	1	57	48,000	24,000	12.8	19.9	1	1	-1	0
123	5188	300	150	50	350	45	1	56	76,000	38,000	10.0	20.0	1	1	-1	0

Figure F-4a (continued)

Structure Database for North Project

Structure Data for 1st of 40 Reaches

Reach Number	Structure ID	Distance to Lot	Lot Length	Lot Width	Distance to Structure	Structure Length	Attack Angle	Structure Type	Structure Value	Content Value	Ground Elevation	1st Floor Elevation	Active Flag	Erosion Type	Armor Flag	Flanking
123	5228	300	150	50	350	48	1	56	101,875	50,938	10.0	20.0	1	1	-1	0
123	5244	300	150	50	350	83	1	59	98,750	49,375	9.8	9.8	1	2	-1	0
123	5302	359	150	50	399	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	5446	204	50	64	244	38	1	55	37,625	18,813	9.0	17.0	1	1	-1	0
123	5968	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	5984	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	6105	300	150	50	350	43	1	56	85,375	42,688	9.5	19.5	1	1	-1	0
123	6339	143	150	50	180	50	1	55	28,375	14,188	10.5	18.9	1	1	-1	0
123	6404	143	150	50	183	66	1	55	75,000	37,500	10.3	19.3	1	1	-1	0
123	6500	143	86	50	183	49	1	55	78,500	39,250	10.8	19.7	1	1	-1	0
123	6778	-7	212	75	33	37	1	55	50,000	25,000	10.7	20.4	1	1	-1	0
123	6836	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	6852	0	212	25	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	6910	-19	212	50	21	42	1	55	37,500	18,750	13.0	19.6	1	1	-1	0
123	7206	72	150	50	112	58	1	55	68,625	34,313	10.1	19.5	1	1	-1	0
123	7232	71	150	50	111	59	1	55	67,750	33,875	9.8	19.1	1	1	-1	0
123	7648	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	7680	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	7712	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	7794	692	194	130	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	8467	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	8516	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	8532	0	212	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	8578	692	213	117	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	8645	692	196	65	732	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	9348	0	250	100	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	9404	0	250	50	44	50	1	63	0	0	9.9	19.9	1	10	-1	0
123	9794	540	183	35	580	44	1	59	78,200	39,100	8.8	8.8	1	2	-1	0
123	9835	505	170	65	545	47	1	55	63,875	31,938	7.7	15.7	1	1	-1	0
123	9860	499	170	65	539	49	1	59	60,125	30,063	8.2	8.2	1	2	-1	0
123	4450A	271	75	50	311	32	1	55	58,625	29,313	9.1	17.1	1	1	-1	0
123	4450B	320	75	50	360	32	1	55	58,625	29,313	9.1	17.1	1	1	-1	0
123	4684A	204	150	100	244	39	1	2	83,750	41,875	9.6	9.6	1	2	-1	0
123	4684B	222	50	50	262	23	1	4	22,500	11,250	10.2	10.2	1	2	-1	0
123	4684C	149	100	50	189	50	1	1	25,000	12,500	11.4	11.4	1	2	-1	0
123	5536A	141	75	50	181	44	1	1	33,750	16,875	11.1	12.6	1	2	-1	0
123	5536B	208	75	50	248	44	1	1	33,750	16,875	11.1	12.6	1	2	-1	0
123	6373A	140	150	100	170	40	1	1	18,750	9,375	9.2	9.8	1	2	-1	0
123	6373B	140	150	50	180	40	1	58	72,500	36,250	10.6	14.6	1	1	-1	0
123	VDT12	0	0	0	90	24	1	64	242,488	0	10.0	10.0	1	9	-1	0
123	OTHRD	0	120	40	0	120	1	64	20,000	0	10.0	10.0	1	9	-1	0

Figure F-4b

Structure Database for South Project

Structure Data for 1st of 118 Reaches

Reach Number	Structure ID	Distance to Lot	Lot Length	Lot Width	Distance to Structure	Structure Length	Attack Angle	Structure Type	Structure Value	Content Value	Ground Elevation	1st Floor Elevation	Active Flag	Erosion Type	Armor Flag	Flanking
314	101	1103	100	50	1143	38	1	56	89,113	44,556	8.5	16.5	1	1	-1	0
314	277	974	150	50	1014	38	1	59	96,663	48,331	8.5	8.5	1	2	-1	0
314	1219	925	150	50	965	35	1	60	191,750	95,875	8.5	8.5	1	2	-1	0
314	1260	934	150	50	974	47	1	56	110,000	55,000	8.5	16.5	1	1	-1	0
314	1352	866	150	50	906	31	1	1	22,500	11,250	8.5	11.5	1	2	-1	0
314	2102	935	150	150	975	66	1	55	64,625	32,313	8.5	15.5	1	1	-1	0
314	2287	747	150	50	787	58	1	59	88,000	44,000	8.0	8.0	1	2	-1	0
314	2336	745	150	50	785	54	1	57	156,250	78,125	8.0	16.0	1	1	-1	0
314	2361	745	0	0	785	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	2410	745	0	0	785	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	3138	745	0	0	785	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	3202	749	150	50	789	55	1	55	65,375	32,688	8.0	16.0	1	1	-1	0
314	3488	632	0	0	672	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	4377	565	150	50	605	40	1	1	35,300	17,650	8.0	10.0	1	2	-1	0
314	4421	589	150	50	629	36	1	57	100,000	50,000	8.0	16.0	1	1	-1	0
314	4497	488	100	50	528	38	1	1	44,075	22,038	8.1	11.1	1	2	-1	0
314	5236	578	150	100	618	29	1	1	22,875	11,438	7.4	9.6	1	2	-1	0
314	5303	573	150	50	613	60	1	55	70,500	35,250	7.4	15.4	1	1	-1	0
314	6099	1400	100	63	1440	27	1	57	91,750	45,875	9.0	17.0	1	1	-1	0
314	6355	397	150	50	437	34	1	56	109,875	54,938	8.4	18.2	1	1	-1	0
314	6404	377	150	50	417	38	1	1	28,025	14,013	7.4	9.6	1	2	-1	0
314	6430	400	150	50	440	25	1	56	150,000	75,000	7.5	15.5	1	1	-1	0
314	6930	1434	0	0	1474	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	7071	1336	156	35	1376	47	1	55	62,125	31,063	9.0	17.0	1	1	-1	0
314	7141	1342	100	50	1382	29	1	55	57,625	28,813	9.0	16.0	1	1	-1	0
314	7193	1278	100	50	1318	33	1	55	51,750	25,875	9.0	16.0	1	1	-1	0
314	7975	1372	156	35	1412	50	1	55	63,750	31,875	9.0	17.0	1	1	-1	0
314	8034	1288	116	35	1328	33	1	55	58,875	29,438	9.0	17.0	1	1	-1	0
314	8087	1235	100	50	1275	36	1	55	58,250	29,125	8.5	16.5	1	1	-1	0
314	8136	1234	100	50	1274	33	1	55	55,588	27,794	9.0	17.0	1	1	-1	0
314	8188	1179	100	50	1219	39	1	57	80,375	40,188	9.0	18.0	1	1	-1	0
314	8679	0	320	50	123	70	1	56	161,988	80,994	9.8	19.5	1	1	-1	0
314	8694	0	320	50	124	69	1	56	210,100	105,050	9.8	19.3	1	1	-1	0
314	8743	0	320	50	148	49	1	56	160,738	80,369	9.8	19.5	1	1	-1	0
314	9029	1178	100	50	1218	36	1	55	70,313	35,156	8.5	16.5	1	1	-1	0
314	9177	1202	0	0	1242	50	1	63	0	0	9.9	19.9	1	10	-1	0
314	9233	1102	100	50	1142	52	1	55	58,625	29,313	8.5	16.5	1	1	-1	0
314	9509	0	320	60	115	59	1	60	224,225	112,113	11.5	11.5	1	2	-1	0
314	9544	0	320	70	155	69	1	60	606,000	303,000	12.6	13.2	1	2	-1	0
314	5516A	372	200	50	412	147	1	45	25,000	61,750	8.0	9.8	1	4	-1	0
314	5516B	523	200	50	563	63	1	45	18,000	44,460	8.9	8.9	1	4	-1	0
314	5570A	431	113	100	471	56	1	35	16,125	9,482	7.5	8.3	1	4	-1	0
314	5570B	377	113	100	417	46	1	56	82,500	41,250	7.5	16.4	1	1	-1	0
314	VDT12	0	0	0	323	24	1	64	74,575	0	7.2	7.2	1	9	-1	0
314	OTHRD	0	320	50	120	200	1	64	15,000	0	8.0	8.0	1	9	-1	0

Figure F-5
Flood Damage Curves
(Curve Type 1 out of 64)

The number of inundation types. #
64
The number of points in the structure damage curve type 1. #
13
The structure damage curve type 1 start with zero. #

-24	0
-7	0
-6	0.005
-1	0.01
0	0.093
1	0.136
2	0.233
5	0.361
10	0.523
15	0.725
16	0.8
20	0.85
24	0.85

The number of points in the contents damage curve type 1. #
13
The contents damage curve type 1 start with zero. #

-24	0
-1	0
0	0.112
1	0.24
2	0.364
3	0.429
4	0.46
5	0.52
10	0.865
15	0.955
16	1
17	1
24	1

Figure F-6
Erosion Damage Curves
(Curve Type 1 out of 64)

The number of erosion types. #
10
The number of points in the structure damage curve type 1. #
11
The structure damage curve type 1 start with zero. #
0 0
.1 .2
.2 .3
.3 .6
.4 .8
.5 1
.6 1
.7 1
.8 1
.9 1
1. 1
The number of points in the contents damage curve type 1. #
11
The contents damage curve type 1 start with zero. #
0 0
.1 .2
.2 .3
.3 .6
.4 .8
.5 1
.6 1
.7 1
.8 1
.9 1
1. 1