TP 77-13

Development of Surge II Program With Application to the Sabine-Calcasieu Area for Hurricane Carla and Design Hurricanes

by

Robert O. Reid, Andrew C. Vastano, and Thomas J. Reid

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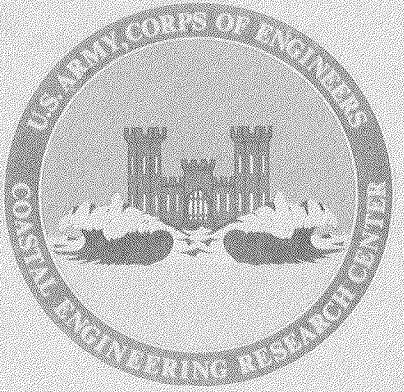

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Hurricane surge model
Inland flooding model
Sabine-Calcasieu region
Surge II program

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

SURGE II is a program for calculation of storm surges and tides in a bay or estuary of the type where frictional resistance dominates over Coriolis force. It includes the provision for subgrid scale barriers and channels as well as allowing for overtopping of barriers and flooding of and recession from normally dry regions adjoining the bay or estuary. The theory and numerical algorithm is discussed in detail. A user's guide for the program is also provided. Application of the program, in respect to astronomical tides and

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hurricane surges, is made for the Sabine-Calcasieu region which straddles the Texas and Louisiana boundary. For normal tide conditions, cities such as Beaumont, Orange, and Lake Charles are connected to the sea via rivers, which in the numerical model must be represented as subgrid scale channels as long as the basic grid scale is of the order of a nautical mile. Under hurricane surge conditions, however, the overland flooding can greatly expand their connection to the sea.

Calibration of channel friction is carried out via the astronomical tide simulation. Calibration of the block friction is carried out using data on a previous storm of record, Hurricane Carla. An example application is provided for standard project hurricanes (SPH). The response for a large radius SPH of slow speed and one of moderate speed of translation is examined. Also, the effect of rainfall is examined by running the latter storm with and without rainfall.

PREFACE

This report is published to assist coastal engineers in the study of storm surge and inland flooding for use in the planning and design of protective coastal works. The work was carried out under the coastal processes program of the U.S. Army Coastal Engineering Research Center (CERC).

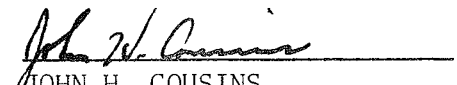
The report was prepared by Robert O. Reid, Andrew C. Vastano, and Thomas J. Reid, Coastal Studies, Inc., who are also on the staff of the Department of Oceanography, Texas A & M University, College Station, Texas, under CERC Contract No. DACW64-74-C-0015 to the U.S. Army Engineer District, Galveston.

The authors acknowledge the help of many individuals of the Galveston District, in providing most of the data necessary in schematizing the Sabine-Calcasieu system, the data for tidal calibration, the wind fields and observed water level data for Hurricane Carla, and the necessary input data for the Standard Project Hurricanes. G. Marinos and M. Choate assisted with various stages of the development and carried out the runs for the Standard Project Hurricane via the GE series 400 computer.

G. Marinos was the Galveston District contract monitor for the report under the general supervision of S. Tanner, Chief, Coastal Planning Section. Dr. Jon Hubertz was the CERC technical monitor of the report under the general supervision of Dr. D.L. Harris, Chief, Coastal Oceanography Branch, Research Division.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.



JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

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SUBROUTINE SAVE       74/74   OPT=2                FTN 4.6+420        08/22/77  16.51.06

                      J=JGAGE(K)                                                SAVE0046
   55                 IF (I.GT.KCM) GO TO 199                                   SAVE0047
                      HS(K,N)= HC(I)                                            SAVE0048
                  199 IF(J.NE.0) HS(K,N)= H(I,J)                                SAVE0049
                  200 CONTINUE                                                  SAVE0050
                C
   60                 DO 300 J=1,NFLOW                                          SAVE0051
                      K=KFLOW(J)                                                SAVE0052
                      KEY= KEN(1,K)                                             SAVE0053
                      IF(KEY.NE.0) GO TO 205                                    SAVE0054
                      KEY= 2                                                    SAVE0055
   65                 IF(IWCX(K).NE.0) KEY= 1                                   SAVE0056
                  205 GO TO(210,220,230,240,210,220,230,240), KEY               SAVE0057
                  210 QS(J,N)= QCXN(K)/1000.                                    SAVE0058
                      GO TO 300                                                 SAVE0059
                  220 QS(J,N)= QCYN(K)/1000.                                    SAVE0060
   70                 GO TO 300                                                 SAVE0061
                  230 QS(J,N)= QCXP(K)/1000.                                    SAVE0062
                      GO TO 300                                                 SAVE0063
                  240 QS(J,N)= QCYP(K)/1000.                                    SAVE0064
                  300 CONTINUE                                                  SAVE0065
   75                 NU=72                                                     SAVE0066
                      IF(N.EQ.72) GO TO 310                                     SAVE0067
                      RETURN                                                    SAVE0068
                C
                 3000 NU = (NW-INTIME)/INTER                                    SAVE0069
   80                 IF(NU.EQ.0) RETURN                                        SAVE0070
                  310 PRINT 400                                                 SAVE0071
                  400 FORMAT(20X,'WATER LEVEL HYDROGRAPHS (FT) AND KEY FLOWS (1000 CFS)'SAVE0072
                     1 ,///)                                                    SAVE0073
                      PRINT 410, (J,J=1,NGAGE), (K,K=1,NFLOW)                   SAVE0074
   85                 410 FORMAT(2X,'HOUR',I6,15I8)                             SAVE0075
                      DO 500 N=1,NU                                             SAVE0076
                      PRINT 420, TIME(N), (HS(J,N),J=1,NGAGE), (QS(K,N),K=1,NFLOW)SAVE0077
                  420 FORMAT(F6.1,15F8.2)                                       SAVE0078

   90                 425 FORMAT(F6.1,12F8.2)                                   SAVE0080
                  500 CONTINUE                                                  SAVE0081
                      DO 510 N=1,NU                                             SAVE0082

                  430 FORMAT(F6.1,10F8.2)                                       SAVE0084
   95                 510 CONTINUE                                              SAVE0085
                      PRINT 10                                                  SAVE0086
                   10 FORMAT(1H1)                                               SAVE0087
                      IF(NU.EQ.72) INTIME=NTIME                                 SAVE0088
                      RETURN                                                    SAVE0089
  100             C
                      END                                                       SAVE0090


    1             C
                  C
                      SUBROUTINE CONTIN(L)                                      CONT0001
                C
    5                 COMMON/BLK1/A(822)/BLK2/B(1961)/BLK3/C(42)/BLK4/D(2585)/  CONT0002
                     1BLK5/E(2759)/BLK6/F(2800)/BLK7/G(44)/BLK9/H(25)/BLK10/P(34)  CONT0003
                C
                      GO TO (100,200),L                                         CONT0004
                C
   10                 100 CONTINUE
                      700 FORMAT(2044)                                          CONT0006
                      RETURN                                                    CONT0007
                C
                  200 CONTINUE
   15                 RETURN                                                    CONT0009
                C
                      END                                                       CONT0010
```

IDNT= 6 BLOCK TOPOGRAPHY= Z VALUES IN FEET

1	-24	-8	1	1	2	3	3	8	7	16
1	11	19	23	26	32	35	30	20	35	100
2	-24	-10	0	1	2	2	3	8	8	11
2	7	14	15	23	25	35	30	20	35	100
3	-24	-13	1	1	1	1	1	2	6	9
3	4	7	11	16	22	25	30	7	7	100
4	-24	-12	1	1	1	0	1	1	1	4
4	12	13	14	20	23	15	3	7	7	100
5	-24	-10	-1	0	1	-1	-1	-1	5	8
5	15	17	15	1	1	1	7	7	7	100
6	-16	-7	1	1	0	1	2	3	3	3
6	15	7	1	1	7	1	10	20	25	100
7	-8	1	1	1	-5	-5	-4	5	-1	5
7	13	1	3	16	18	15	20	25	25	100
8	-4	1	2	0	1	-5	-6	2	5	12
8	12	1	6	15	18	20	25	25	30	100
9	-15	2	2	1	1	-6	-7	-6	2	7
9	1	1	13	15	17	15	25	27	30	100
10	-20	-8	1	1	1	-5	-8	-8	-6	-4
10	1	7	11	12	18	21	22	28	30	100
11	-22	-10	1	3	1	1	-6	-7	-7	-6
11	1	7	8	11	18	20	22	30	35	100
12	-22	-13	3	2	1	1	1	1	-4	-3
12	4	6	12	12	16	20	22	25	30	100
13	-23	-15	5	2	1	1	1	1	1	1
13	1	4	10	12	13	18	22	30	32	100
14	-23	-13	4	1	1	1	1	1	1	1
14	1	1	3	7	13	18	20	25	20	100
15	-23	-12	2	1	1	1	0	0	1	1
15	2	2	1	2	3	7	7	10	12	100
16	-23	-12	1	1	1	1	0	0	1	1
16	1	1	3	8	8	10	10	15	15	100
17	-23	-12	1	1	1	0	0	0	1	3
17	1	1	1	9	16	20	15	25	30	100
18	-22	-11	1	1	1	0	0	1	3	3
18	2	2	4	10	15	18	20	25	30	100
19	-19	-8	-1	1	1	1	1	1	1	4
19	5	8	8	11	14	18	20	20	32	100
20	-17	1	1	1	1	1	1	1	1	1
20	3	8	10	14	14	18	20	22	25	100
21	-15	1	1	1	-4	1	0	7	-1	1
21	3	6	10	12	14	18	20	22	25	100
22	-15	1	1	-3	-4	1	1	5	0	1
22	5	6	10	12	14	14	20	22	25	100
23	-8	1	1	-4	-5	1	1	5	1	1
23	4	6	12	13	14	14	20	22	25	100
24	-10	1	1	-6	-7	-7	-7	-6	-6	1
24	3	1	10	12	15	15	20	22	25	100
25	-10	1	1	-5	-6	-5	-2	-6	1	1
25	5	8	8	12	15	15	20	22	25	100
26	-10	1	1	1	1	1	1	1	1	1
26	4	8	1	-5	15	15	20	22	25	100
27	-10	1	1	1	1	1	1	1	1	1
27	4	8	8	1	12	15	20	22	25	100
28	-10	100	100	100	100	100	100	100	100	100
28	100	100	100	100	100	100	100	100	100	100

CHANNEL REACH 3

37	10	10	0.000	0.	0.	.396	2106.	1266.	.390	0.	0.	-823.	0.
38	11	10	0.000	0.	0.	.390	1266.	348.	.416	0.	0.	-866.	0.
39	12	10	0.000	0.	0.	.416	348.	-924.	.467	0.	0.	-1211.	0.
40	12	11	.467	-924.	-1013.	.505	-355.	-443.	.494	0.	0.	0.	0.
41	13	11	0.000	0.	0.	.494	-1456.	-1542.	.511	0.	0.	0.	0.
42	14	11	0.000	0.	0.	.511	-1542.	-1627.	.527	0.	0.	0.	0.
43	14	12	.527	-452.	-535.	.543	616.	535.	.535	0.	0.	0.	0.
44	13	12	.511	0.	0.	0.000	0.	0.	.543	0.	0.	0.	0.
45	13	13	.543	-616.	-695.	0.000	0.	0.	.549	0.	0.	0.	0.
46	14	13	.535	0.	0.	.549	-695.	-772.	.555	0.	0.	0.	0.
47	14	14	.555	-772.	-962.	0.000	0.	0.	.557	0.	0.	0.	0.
48	15	14	0.000	0.	0.	.557	-962.	-1094.	.560	0.	0.	0.	0.
49	15	15	.560	-1094.	-1224.	.568	1297.	1224.	.562	0.	0.	0.	0.
50	14	15	.557	0.	0.	0.000	0.	0.	.568	0.	0.	0.	0.
51	14	16	.568	-1297.	-1368.	0.000	0.	0.	.573	0.	0.	0.	0.
52	14	17	.573	-1368.	-1439.	0.000	0.	0.	.586	0.	0.	0.	0.
53	14	18	.586	-1439.	-1470.	0.000	0.	0.	.752	0.	0.	0.	0.
54	-14	19	.752	-1470.	-1500.	0.000	0.	0.	.917	0.	0.	0.	0.

CHANNEL REACH 4

55	11	11	.416	0.	0.	0.000	0.	0.	.505	0.	0.	0.	0.
56	11	12	.505	355.	266.	.522	-178.	-266.	.515	0.	0.	0.	0.
57	10	12	0.000	0.	0.	0.000	0.	0.	.522	0.	0.	0.	0.
58	10	13	.522	178.	89.	.531	-44.	-89.	.526	0.	0.	0.	0.
59	9	13	0.000	0.	0.	0.000	0.	0.	.531	0.	0.	0.	0.
60	-9	14	.531	44.	0.	0.000	0.	0.	.532	0.	0.	0.	0.

CHANNEL REACH 5

61	15	11	0.000	0.	0.	.527	-1175.	-1304.	.534	0.	0.	0.	0.
62	16	11	0.000	0.	0.	.534	-1304.	-1434.	.538	0.	0.	0.	0.
63	17	11	0.000	0.	0.	.538	-1434.	-1564.	.540	0.	0.	0.	0.
64	18	11	0.000	0.	0.	.540	-1564.	-1693.	.540	0.	0.	0.	0.
65	19	11	.532	1947.	1821.	.540	-1693.	-1821.	.537	0.	0.	0.	0.
66	19	10	0.000	0.	0.	0.000	0.	0.	.532	0.	0.	0.	0.
67	20	10	0.000	0.	0.	.532	-1947.	-2067.	.526	0.	0.	0.	0.
68	21	10	0.000	0.	0.	.526	-2067.	-2180.	.518	0.	0.	0.	0.
69	22	10	0.000	0.	0.	.518	-2180.	-2283.	.509	0.	0.	0.	0.
70	23	10	.484	5789.	5677.	.509	-2283.	-2373.	.500	0.	0.	0.	0.

CHANNEL REACH 6

71	-22	1	.590	54557.	54640.	0.000	0.	0.	.574	0.	0.	0.	0.
72	23	1	0.000	0.	0.	.574	12789.	12843.	.565	0.	0.	0.	0.
73	23	2	.565	12843.	12868.	.544	-12884.	-12868.	.555	0.	0.	0.	0.
74	22	2	.574	41852.	41875.	0.000	0.	0.	.544	0.	0.	0.	0.
75	22	3	.544	54759.	54752.	0.000	0.	0.	.495	0.	0.	0.	0.
76	22	4	.495	54752.	41901.	0.000	0.	0.	.371	0.	13290.	0.	0.
77	22	5	.371	41901.	25348.	0.000	0.	0.	.372	-11303.	5237.	0.	0.
78	23	5	0.000	0.	0.	.372	25348.	20711.	.393	0.	0.	-4574.	0.
79	23	6	.393	20711.	20625.	0.000	0.	0.	.415	0.	0.	0.	0.
80	23	7	.415	20625.	20533.	0.000	0.	0.	.438	0.	0.	0.	0.
81	23	8	.438	20533.	20434.	0.000	0.	0.	.461	0.	0.	0.	0.
82	23	9	.461	20434.	20327.	0.000	0.	0.	.484	0.	0.	0.	0.
83	24	9	0.000	0.	0.	.484	14539.	2173.	.495	0.	0.	-12163.	0.
84	24	10	.495	2173.	1949.	.500	3304.	3027.	.508	0.	0.	0.	0.
85	24	11	.508	4423.	4210.	0.000	0.	0.	.524	0.	0.	0.	0.
86	24	12	.524	4210.	3984.	0.000	0.	0.	.542	0.	0.	0.	0.
87	24	13	.542	3984.	3750.	0.000	0.	0.	.554	0.	0.	0.	0.
88	25	13	0.000	0.	0.	.554	3750.	3532.	.566	0.	0.	0.	0.
89	25	14	.566	3532.	2353.	0.000	0.	0.	.581	0.	1115.	0.	0.
90	26	14	0.000	0.	0.	.581	2353.	-389.	.589	0.	0.	-2599.	0.
91	27	14	0.000	0.	0.	.589	-389.	-528.	.591	0.	0.	0.	0.
92	27	15	.591	-528.	-665.	0.000	0.	0.	.592	0.	0.	0.	0.
93	-28	15	0.000	0.	0.	.592	-665.	-800.	.592	0.	0.	0.	0.

CHANNEL REACH 7

94	25	10	0.000	0.	0.	.508	553.	468.	.523	0.	0.	0.	0.
95	26	10	.547	-285.	-377.	.523	468.	377.	.536	0.	0.	0.	0.
96	26	9	0.000	0.	0.	0.000	0.	0.	.547	0.	0.	0.	0.
97	27	9	.561	-95.	-190.	.547	285.	190.	.556	0.	0.	0.	0.
98	27	8	0.000	0.	0.	0.000	0.	0.	.561	0.	0.	0.	0.
99	-28	8	0.000	0.	0.	.561	95.	0.	.563	0.	0.	0.	0.

CHANNEL REACH 6

71	-22	1	7.000	317627.	335432.	3.200	0.	0.	6.062	-14111.	-32523.	0.	0.
72	23	1	3.200	0.	0.	6.062	114307.	99863.	5.334	0.	0.	32077.	47784.
73	23	2	5.334	99863.	45264.	5.135	9628.	-45264.	5.072	9258.	67216.	82334.	138703.
74	22	2	6.062	221125.	181264.	3.200	0.	0.	5.135	0.	41783.	0.	0.
75	22	3	5.135	171616.	136769.	3.200	0.	0.	4.768	0.	36195.	0.	0.
76	22	4	4.768	136769.	91854.	3.200	0.	0.	4.318	-27876.	19793.	0.	0.
77	22	5	4.318	91854.	62018.	3.200	0.	0.	4.265	-121862.	-92366.	0.	0.
78	23	5	3.200	0.	0.	4.265	62618.	53652.	4.214	0.	0.	91177.	100122.
79	23	6	4.214	53652.	44860.	3.200	0.	0.	4.205	-6737.	0.	0.	0.
80	23	7	4.205	44860.	41430.	3.200	0.	0.	4.201	-5363.	0.	0.	0.
81	23	8	4.201	41430.	41319.	3.200	0.	0.	4.199	0.	0.	0.	0.
82	23	9	4.199	41319.	31814.	3.200	0.	0.	4.192	-9464.	0.	0.	0.
83	24	9	3.200	0.	0.	4.192	26510.	18303.	4.149	0.	0.	-14730.	-6813.
84	24	10	4.149	18303.	11786.	4.206	12911.	9212.	4.164	-30137.	-27870.	23952.	27297.
85	24	11	4.164	9333.	6483.	3.200	0.	0.	4.183	447.	0.	0.	0.
86	24	12	4.183	6483.	13347.	3.200	0.	0.	4.206	7214.	0.	0.	0.
87	24	13	4.206	13347.	12997.	3.200	0.	0.	4.225	0.	0.	0.	0.
88	25	13	3.200	0.	0.	4.225	12997.	12664.	4.204	0.	0.	0.	0.
89	25	14	4.204	12664.	10648.	3.200	0.	0.	4.220	0.	1897.	0.	0.
90	26	14	3.200	0.	0.	4.220	10648.	6910.	4.196	0.	0.	-3524.	0.
91	27	14	3.200	0.	0.	4.196	6910.	-462.	4.168	0.	0.	-7162.	0.
92	27	15	4.158	-462.	-683.	3.200	0.	0.	4.184	0.	0.	0.	0.
93	-28	15	3.200	0.	0.	4.184	-683.	-900.	4.155	0.	0.	0.	0.

CHANNEL REACH 7

94	25	10	3.200	0.	0.	4.184	14666.	13275.	3.928	0.	0.	-1345.	0.
95	26	10	3.608	-9603.	-11328.	3.928	13275.	11328.	3.736	-11871.	-10231.	-1907.	0.
96	26	9	3.200	0.	0.	3.200	0.	0.	3.608	0.	0.	0.	0.
97	27	9	3.459	-200.	-5435.	3.608	9603.	5435.	3.502	-5108.	0.	13392.	17490.
98	27	A	3.200	0.	0.	3.200	0.	0.	3.459	0.	0.	0.	0.
99	-28	A	3.200	0.	0.	3.459	200.	0.	3.397	0.	0.	0.	0.

CHANNEL REACH 8

100	-1	4	3.200	0.	0.	7.603	0.	4713.	7.573	0.	0.	18851.	13965.
101	2	4	3.200	0.	0.	7.573	4713.	6561.	7.467	0.	0.	24550.	22509.
102	3	4	3.200	0.	0.	7.467	6561.	5627.	7.352	0.	0.	25098.	25845.
103	3	5	7.352	5627.	4621.	3.200	0.	0.	7.385	-25209.	-24380.	0.	0.
104	4	5	3.200	0.	0.	7.385	4621.	3341.	7.269	0.	0.	22611.	23746.
105	5	5	3.200	0.	0.	7.269	3341.	-248.	7.147	0.	0.	32412.	35883.
106	5	6	7.147	-248.	-3989.	3.200	0.	0.	7.167	-21252.	-17606.	0.	0.
107	5	7	7.167	0.	0.	3.200	0.	0.	7.090	0.	0.	0.	0.
108	5	8	7.090	-602.	-5247.	7.240	4607.	5247.	7.153	29979.	34510.	63646.	62858.
109	4	A	3.200	0.	0.	7.456	0.	0.	7.240	0.	0.	0.	0.
110	4	9	7.240	-4607.	-3041.	7.412	94.	3041.	7.305	-32403.	-34062.	8351.	5303.
111	3	9	7.456	3557.	6915.	3.200	0.	0.	7.412	-42020.	-45538.	0.	0.
112	3	8	3.200	0.	0.	7.599	229.	3557.	7.456	0.	0.	-35191.	-38636.
113	2	8	3.200	0.	0.	7.732	270.	229.	7.599	0.	0.	0.	0.
114	-1	8	3.200	0.	0.	7.841	0.	270.	7.732	0.	0.	5977.	5704.

CHANNEL REACH 9

115	3	10	7.412	6822.	10088.	7.288	-5973.	-10088.	7.325	0.	-3453.	0.	4156.
116	2	10	3.200	0.	0.	3.200	0.	0.	7.288	0.	0.	0.	0.
117	2	11	7.288	5973.	2157.	3.200	0.	0.	7.256	0.	3805.	0.	0.
118	-2	12	7.256	2157.	0.	3.200	0.	0.	7.268	0.	2082.	0.	0.

CHANNEL REACH 10

119	6	8	6.956	75150.	68077.	7.153	0.	0.	6.423	12809.	20123.	0.	0.
120	-7	8	6.906	0.	0.	6.423	68077.	78401.	3.390	0.	0.	3729.	-7978.

CHANNEL REACH 11

121	-7	5	7.191	-30076.	-53478.	7.135	0.	0.	7.239	-89976.	-75915.	0.	0.

VOLUME OF WATER ABOVE MSL = 162254.6 MILLIONS OF CU FT
(THE SEAWARD REAS THRU JX 2 ARE EXCLUDED)