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Extreme Sea Levels for Section 105 Surveys

Summary Report

July 1998

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REVISION HISTORY

Revision Ref./ Date Issued	Amendments	Issued to
Final Summary Report 27 August 1998	-	Tim Palmer, EA Warrington (8 No Copies)

CONTRACT

This report describes work commissioned by The Environment Agency under Order N°. 200000112 of 6th April 1998. The Agency's representative for the contract was Tim Palmer and the work was carried out by Jeremy Benn, Craig Robson, Jane Ellis and Dr Paul Garrad of Jeremy Benn Associates Ltd, with support from Dr Andrew Metcalf of the University of Newcastle upon Tyne.

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Date : 1 August 1998

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SUMMARY

Calculation of Extreme Sea Levels

Extreme sea levels have been calculated at 10 sites around the North West coast of the UK using three different methods. These methods include; (i) the Spatial Revised Joint Probability Method (SRJPM) described by Dixon and Tawn (1997), (ii) a General Extreme Value (GEV) distribution fitted to the annual maximum data by the method of maximum likelihood (GEV-MLE), and (iii) a General Extreme Value distribution fitted by probability weighted moments (GEV-PWM).

A comparison of these 3 methods, and those provided by Graff (1981) and Coles and Tawn (1990), indicates that the SRJPM overestimates extreme sea levels at most locations around the north-west coast. Dixon and Tawn (1997) suggest using local data to revise the 1-year level based on 6 or preferably 12 months of hourly tidal data. However, it is considered that this would influence the origin of the relationship between return period and sea level and not the slope of the relationship, which is shown to be inaccurate at many locations, and thus little improvement would be gained.

To effect an improvement in the SRJPM, the slope of the relationship was revised by recalculating the return period adjustment factors at relevant nodes based on the GEV-MLE estimates described above. However, comparison of the GEV with the original and revised SRJPM estimates indicates that the SRJPM does not accurately predict extreme sea levels. It is therefore considered that the GEV-MLE distribution provides the best fit to the data.

GEV Estimates of Extreme Sea levels

Extreme sea levels for selected return periods based on the GEV-MLE distribution are shown in the table below.

Recommended Extreme Sea Levels (m AODN) using GEV–MLE method (Llandudno = GEV-PWM)

Site	No Yrs Data	Return Period (Years)											
		1	5	10	20	25	50	75	100	150	200	500	1000
Llandudno	4	4.63	4.72	*4.80*	*4.94*	~~5.01~~	~~5.32~~	~~5.60~~	~~5.86~~	~~6.36~~	~~6.83~~	~~9.36~~	~~13.06~~
Hilbre	82	4.27	5.22	5.38	5.53	5.57	5.71	5.79	5.85	5.92	*5.98*	6.14	~~6.26~~
Eastham	21	5.18	6.07	6.17	6.26	6.29	*6.36*	*6.40*	*6.42*	~~6.45~~	~~6.47~~	~~6.53~~	~~6.57~~
Gladstone	29	4.70	5.63	5.76	5.88	5.92	6.02	*6.08*	*6.11*	*6.16*	~~6.20~~	~~6.30~~	~~6.37~~
Princes Pier	45	4.86	5.73	5.89	6.03	6.08	6.22	6.30	*6.35*	*6.43*	*6.48*	~~6.65~~	~~6.78~~
Fleetwood	54	4.82	5.86	5.96	6.04	6.06	6.11	6.14	6.16	*6.19*	*6.20*	~~6.24~~	~~6.27~~
Heysham	49	5.30	6.05	6.18	6.29	6.32	6.43	6.49	*6.53*	*6.58*	6.62	~~6.74~~	~~6.82~~
Barrow	19	5.13	5.66	5.80	5.94	5.99	*6.15*	*6.25*	~~6.33~~	~~6.44~~	~~6.52~~	~~6.80~~	~~7.04~~
Workington	6	4.22	5.36	5.48	*5.57*	*5.59*	~~5.67~~	~~5.70~~	~~5.73~~	~~5.76~~	~~5.78~~	~~5.83~~	~~5.87~~
Silloth	40	4.82	6.06	6.22	6.35	6.39	6.51	6.57	*6.61*	6.66	6.70	~~6.81~~	~~6.88~~

4.22 = estimates to 2N (where N = the number of years of record)
5.25 = estimate to 5N
~~6.36~~ = estimates to 10N - to be used with caution
~~7.12~~ = estimates greater than 10N - cannot be recommended

Extrapolation of GEV Estimates

As with Flood Studies estimates, it is generally recommended that the GEV distribution should be extended to a maximum return period of 2N (where N is the number of years of record) as the level of confidence in the estimates is greatly reduced beyond this limit. In view of the requirement to obtain the 200-year extreme sea level for coastal defence purposes and the lack of a suitable period of data at all sites, it is suggested that the relationship could be extended to 5N. Extension to 10N may be required for certain sites but it is recommended that the results at these higher return periods should be used with caution and consideration given to the standard errors associated with these relationship at each site.

Application of GEV Methods to Other Locations

The results detailed above suggest the SRJPM may provide inaccurate estimates of extreme sea levels. To generate a realistic set of extreme sea levels at an unmonitored site it is therefore recommended that the GEV-MLE distribution be used to provide a best fit distribution at sites with a sufficiently long period of record. A weighted distance factor from 2 adjacent tidal gauge sites should then be used to interpolate the extreme sea levels derived by GEV-MLE. It is considered that this would provide results with greater accuracy than the SRJPM.

Return Period of 1990 and 1997 Extreme Tides

Using the GEV-MLE distribution the return period of the high tides of 26/2/90 and 10/2/97 have been calculated for each site. These return periods are given in the Table below;

Return Periods of the High Tides of 26/2/90 and 10/2/97

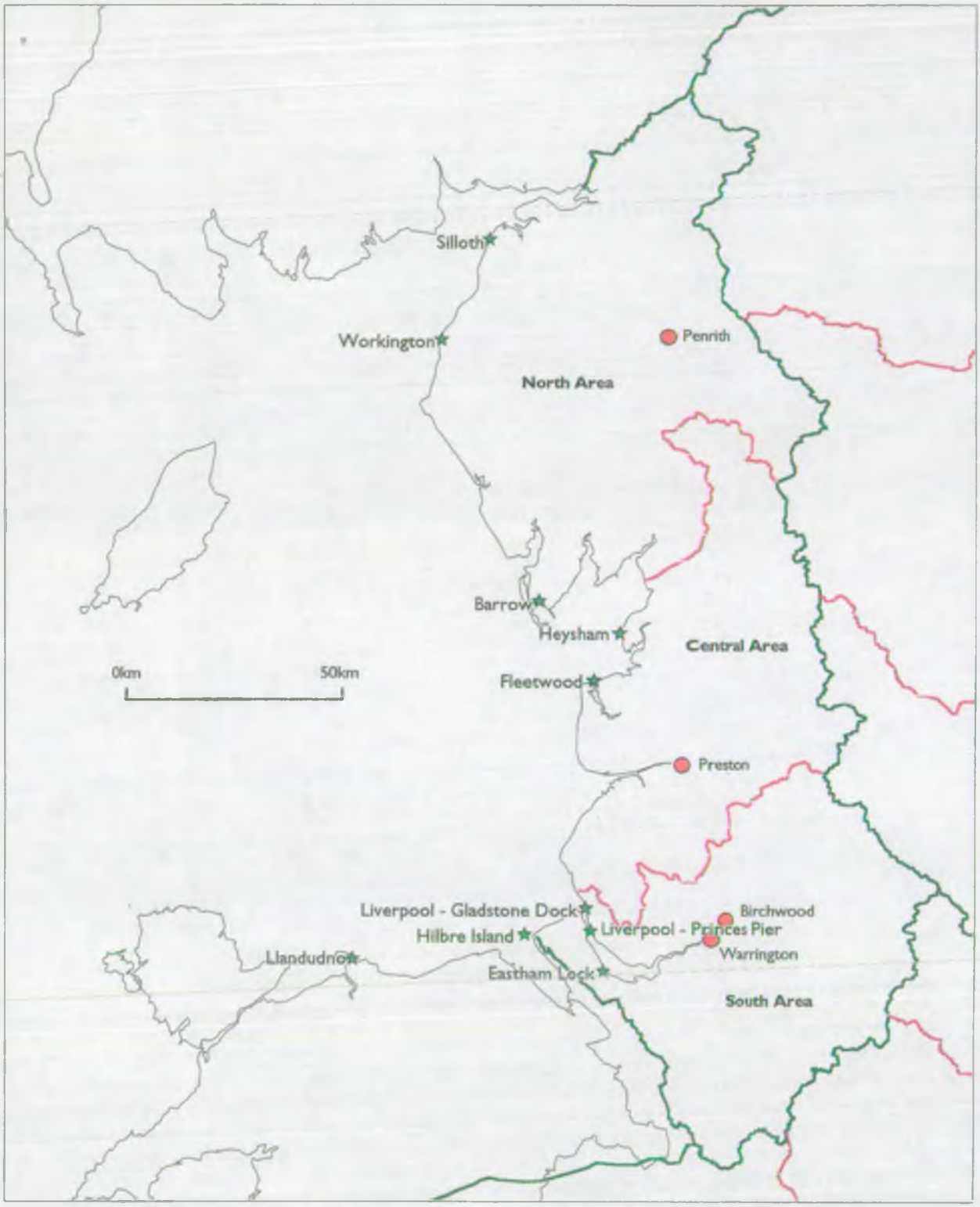
Location	Event of 26/2/90		Event of 10/2/97	
	Tide Level (m AODN)	Return Period (Years)	Tide Level (m AODN)	Return Period (Years)
Llandudno	n/a	-	5.100	31.2
Hilbre Island	5.970	191.8	5.650	36.3
Eastham Dock	6.390	70.0	6.070	5.0
Liverpool - Gladstone Dock	6.040	58.0	5.890	21.1
Liverpool – Princes Pier	6.220	49.8	6.290	71.1
Fleetwood	6.200	194.7	6.500	***
Heysham	6.270	17.9	6.390.	39.2
Barrow	5.950	20.6	6.350	107.7
Workington	n/a	-	5.589	23.9
Silloth	5.900	2.84	6.600	93.0
	(*** = not possible to extrapolate distribution)			

Return Periods of Operation Neptune Flood Warning Levels

Using the GEV-MLE distribution the return periods of the 'Operation Neptune' flood warning levels at Liverpool - Gladstone Dock have been calculated. These equate to the 2.81 year event for the 5.5m AODN level and 43.67 years for the 6.0m AODN level. The equivalent tide levels for these return period events have been calculated at Heysham, Workington, Llandudno and Fleetwood by rearranging the GEV equation an are given in the Table below

Flood Levels (m AODN) for Operation Neptune Return Periods at Liverpool (Gladstone Dock)

Location	2.81 year event	43.67 year event
Llandudno	4.68	5.26
Fleetwood	5.75	6.11
Heysham	5.94	6.41
Workington	5.23	5.65



Key

- ★ Extreme Sea Level Data Locations
- ⛔ Environment Agency North West Region Office
- Environment Agency Regional Boundary
- Environment Agency Area Boundary

ENVIRONMENT AGENCY NORTH WEST REGION

Extreme Sea Levels for Section 105 Surveys

Figure 1: General Location Plan

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