CHAPTER 4
COLUMBIA RIVER
STAGE FORECASTING SYSTEM ANALYSIS

4.1 Introduction

The demands of world trade place constant pressure on shippers and pilots to transit the Columbia River at deeper drafts. As a result, the Corps of Engineers and the seven Lower Columbia River ports are currently conducting the Columbia River Channel Improvement Feasibility Study to evaluate potential navigation channel improvements. An early finding of that study has been that many of the deepest draft outbound ships are not now taking full advantage of the water depths available in the existing 40-ft navigation channel.

Improvements to the existing river stage forecasting system, commonly referred to as "Loadmax", could allow ships to increase their drafts by providing better forecasts of the water depths available. An improved forecasting system could be implemented and operating in a short period of time. This report summarizes the existing navigation practices and forecasting system, the improvements that could be made to the forecasting system, and the potential benefits to shippers.

4.2 Background

The Columbia River navigation channel is currently authorized and maintained at the depth of -40 ft Columbia River Datum (CRD), from the mouth upstream to River Mile (RM) 105.5 (Figure 1). However, because the CRD is a low-low-water datum, ocean tides produce river stages that are above 0 ft CRD over 90 percent of the time (Figure 2). Figure 3, shows how the channel depth and stage combine to provide the water depth available for a transit.

For many years, the Columbia River pilots have taken advantage of high river stages to move deep-draft ships through the river. Prior to 1984, they relied on their own experience with the river to guide them in selecting safe drafts. In 1984, the Port of Portland, Portland District Corps of Engineers, National Weather Service, and National Ocean Service determined a need to develop an hourly river stage forecast and a real-time river stage monitoring network for the Columbia River deep-draft navigation channel. The Northwest River Forecast Center (NWRFC) created an interactive dynamic wave computer model, capable of providing a three day, hourly stage forecast for the six sites along the channel shown on Figure 1. The three day forecast allowed pilots and shippers to plan departure times to make better use of higher river stages to increase safe vessel drafts on the river. In 1988, NWRFC extended the forecast period to six days.

4.3 Forecasting System Limitations

The analysis of standard operating practices for 1991-1993 (Chapter 1 of this Appendix) found that while maximum drafts had increased to over 41-ft for bulk carriers and to 40-ft for container ships, the water depths available were not consistently being fully utilized. Ships are routinely limited to the predetermined target drafts listed in Chapter 1. However, Figures 4, 5, and 6 show that both bulk carriers and container ships sailing at their respective target drafts commonly had underkeel clearances that ranged from l-ft less to 4-ft greater than the minimum acceptable clearances. Bulk carriers occasionally may touch bottom on shoals with bed elevations above 40 ft CRD project depth. This does not seem to be a serious problem, but is a safety concern. The range of underkeel clearances indicates there are opportunities to increase both draft and safety for the deepest draft transits on the Columbia River.

It appears from Portland District's analysis of Columbia River navigation practices, that the existing river stage forecasting system is not providing an adequate forecast for shippers to make optimum use of water depths available.

A few general comments were made about the reluctance of some shippers to rely on the forecasts, but no specific explanation of its limitations came out during discussions with shippers or pilots in 1995. The Corps' own analysis suggests four main limitations in the existing river stage forecasting system:

1. Concern about the accuracy of the river stage forecast.

2. The forecast may not extend far enough into the future to allow container lines to adjust cargo schedules to take advantage of opportunities for greater than minimum available water depths.

3. Navigation channel shoal conditions are not included in the forecast, therefore the comprehensive water depth available is not being provided.

4. The river level forecast is presented in a tabular form that does not give a clear picture of expected river conditions, and may be difficult to understand for someone unfamiliar with the Columbia River.

Container ships that have design drafts of 38- to 41-ft are currently targeting a draft of only 36-ft. The container lines are concerned about the reliability of service, therefore they schedule only enough outbound cargo to be at the docks to load to a predetermined draft. To be useful to the container lines, the river stage forecast must provide reliable data far enough in advance to allow cargo scheduling to maximum drafts.

Bulk carriers use more of the water depth available to them than the container ships, but they still do not make maximum use of the water depths available. Bulk carriers with 40- to 41-ft drafts currently delay their departures for several hours to take advantage of higher river stages. To maximize their drafts and avoid touching bottom, bulk carriers need forecast and observed data available to them right up to their time of departure. The most recent shoaling conditions are also valuable to bulk carriers because of the zero underkeel clearance at which they may transit.

4.4 THE PROPOSED SOLUTION

The existing river stage forecasting system could be greatly improved upon. Providing a more detailed forecast, in a user-friendly format can solve limitations 2, 3, and 4 above, relatively easily. Concerns about the accuracy of the forecast can also be addressed, but will take longer to resolve.

The procedures used by Portland District to analyze deep-draft navigation practices can be adapted to provide forecasts of not only river stages, but also water depth available and estimated underkeel clearance. Updated one- or two-dimensional hydraulic models could be used to improve the accuracy of the river stage forecast. The controlling shoal elevations for each reach of the channel would come from Corps of Engineers' hydrographic surveys and can be updated at approximately three-month intervals. The resulting forecast could then present total water depths available along the channel for a scheduled transit, in a user friendly, graphical format.

The entire forecast could be computerized so those forecasts could be obtained in a few minutes. The Pilots and shippers could enter a desired departure time and sailing draft, and view the forecast river stages, current shoal conditions, and water depth available all along the river for the transit. The point of minimum water depth available could be located and last minute changes made to departure time or vessel speed to optimize draft and safety. The current six-day forecast could be extended if necessary for better container cargo scheduling.

The accuracy and reliability of the forecast could be enhanced through improved hydrodynamic computer modeling and monitoring of forecast results. A monitoring program could compare the actual river stages at the six stage measurement sites to the forecast stages. The results of that monitoring could be provided to the users and also used to improve the hydrodynamic model.

4.5 THE BENEFITS

Implementation of the proposed improved forecasting system would provide shippers better opportunities to take full advantage of the water depths available. The full benefits to shippers are difficult to estimate, but an immediate l-ft increase in the target drafts for containers and bulk carriers seems achievable. Figures 4, 5, and 6 give an indication of the potential draft increases that could have been gained by the ships included in the Corps' navigation practices analysis. Those figures indicate that about half the time, the deepest draft ships in 1991-1993 could have gained from 1- to 3-ft of outbound draft. With a more reliable extended forecast, container lines would frequently be able to fully load their 38-ft draft ships that make up the majority of the existing container fleet.

Increased safety will be an additional benefit of including shoaling conditions in the forecast. The negative underkeel clearances that were found during our analysis often occurred at shoals that had reduced channel depths to 37- to 39-ft CRD. These locations can be seen on the forecast plots and drafts or departure times adjusted to avoid undesirable conditions.

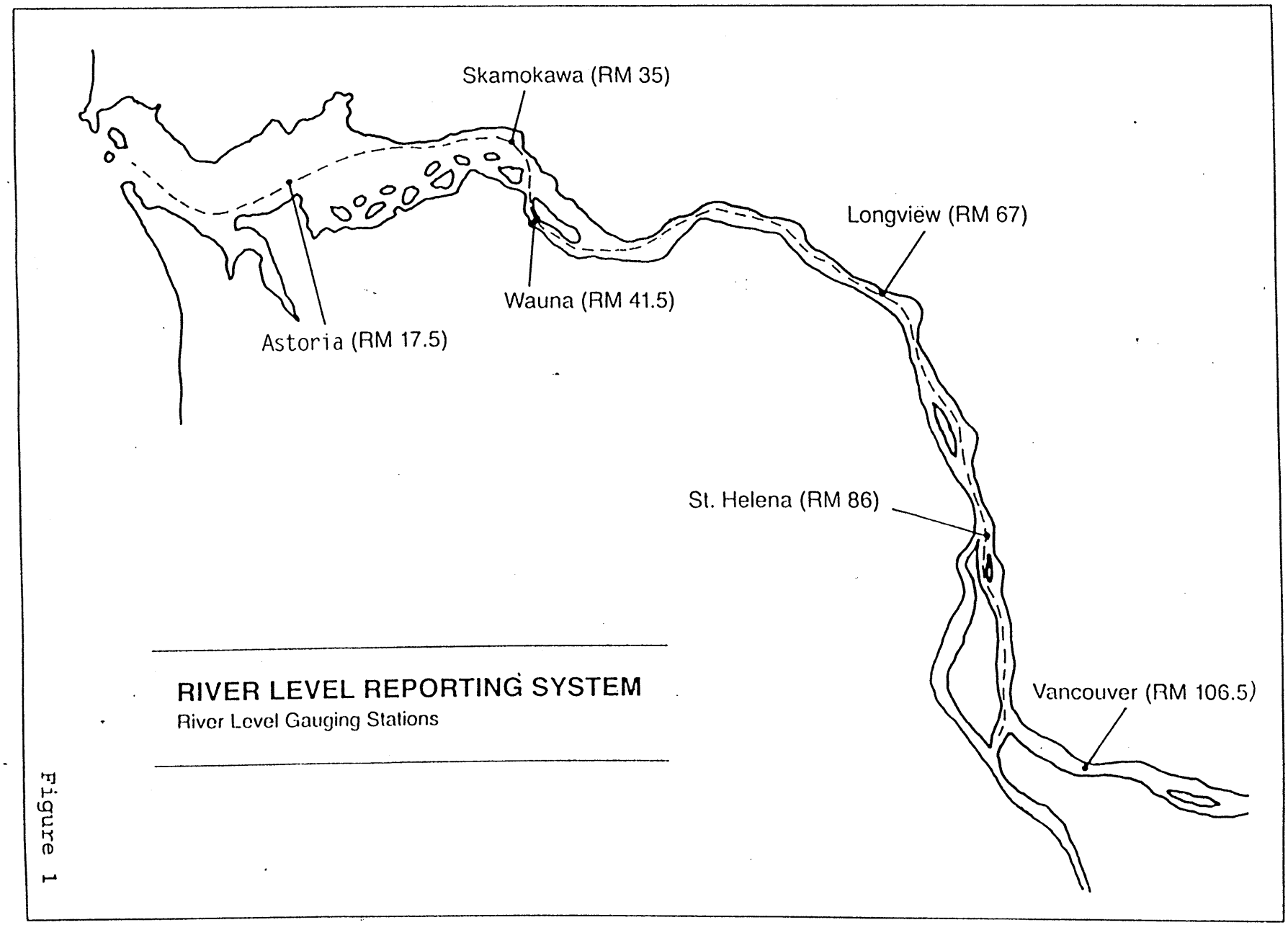
4.6 RECENT IMPROVEMENTS

Over the last two years (1998-1999), and as part of a national modernization effort, the NWS-NWRFC has made significant improvements to its hydrologic and hydraulic modeling that underlie the LoadMax system. At the same time, the River Forecast Center has implemented advanced technology in weather forecasting which is a key component of Columbia River flows. Additionally, the Port of Portland has installed technology at its river gauges to allow the pilots to call ahead from the vessel's bridge to obtain real-time river level information. The Port has also improved and automated the electronic delivery of the forecast data to the commercial users and research institutions who utilize the information on a regular basis.

The NW River Forecast Center estimates that the current accuracy of the LoadMax forecast is 0.3-0.4 feet for the first 24 hours, increasing to 1.0-1.4 feet for the 6^{th} day (the current forecast limit). A longer-range forecast might allow container lines to schedule cargo to take advantage of potential higher river stages, however there would be even more uncertainty in the river stage forecast.

4.7 CONCLUSION

Continuous improvement of LoadMax is an important priority for the ports, river and bar pilots, the NW River Forecast Center, and steamship line customers that utilize the projected and real-time tide and river-stage information system. Recent enhancements have improved the LoadMax forecast and data distribution. Future upgrades, including the addition of bathymetric information, are being planned. It is estimated that future improvements to the river stage forecast system would be implemented as part of the day-to-day operations.



RIVER LEVEL REPORTING SYSTEM

River Level Gauging Stations

Figure 1

Stage Duration Curves
Columbia River LOADMAX Stations
1991-1993 Data

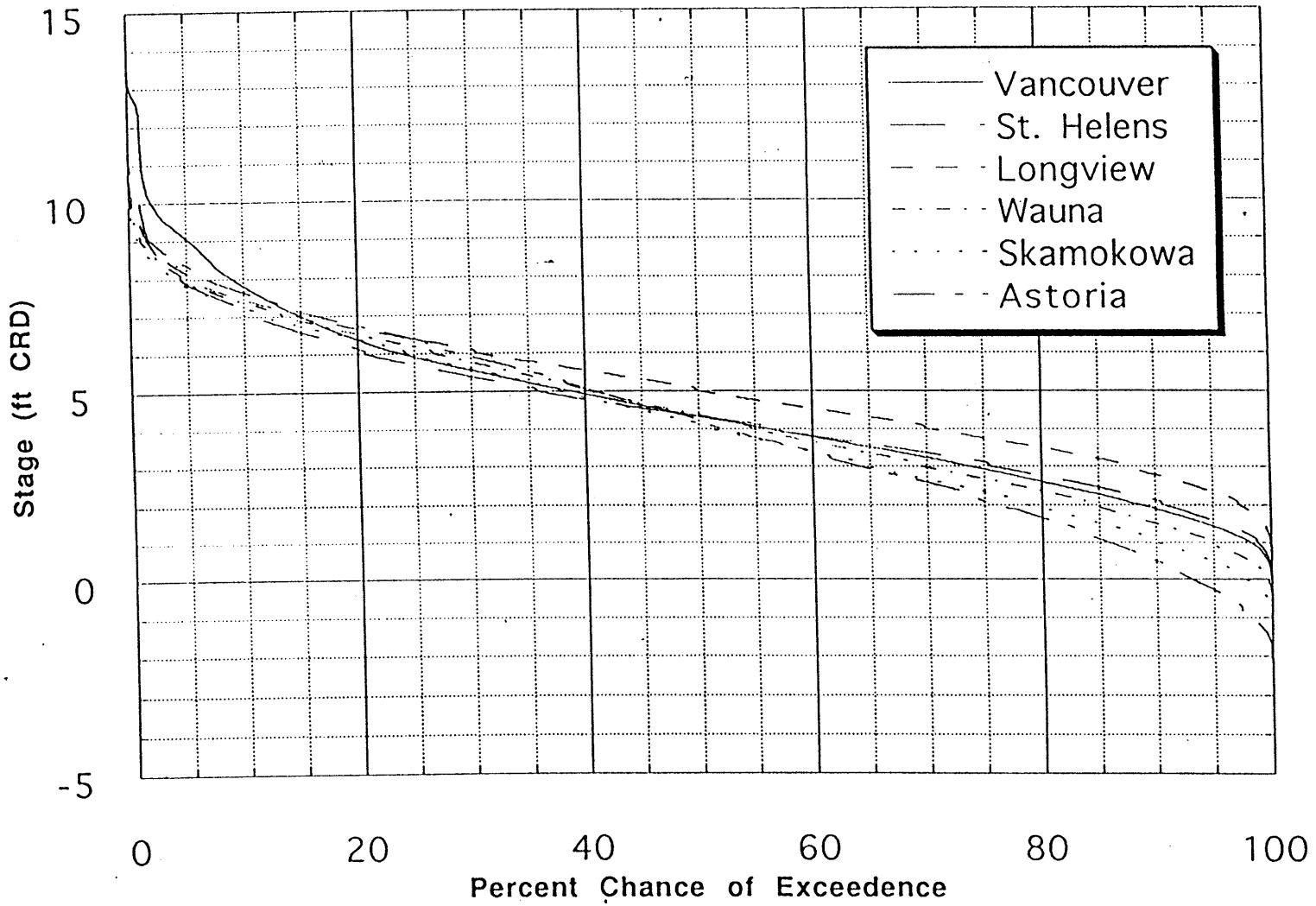
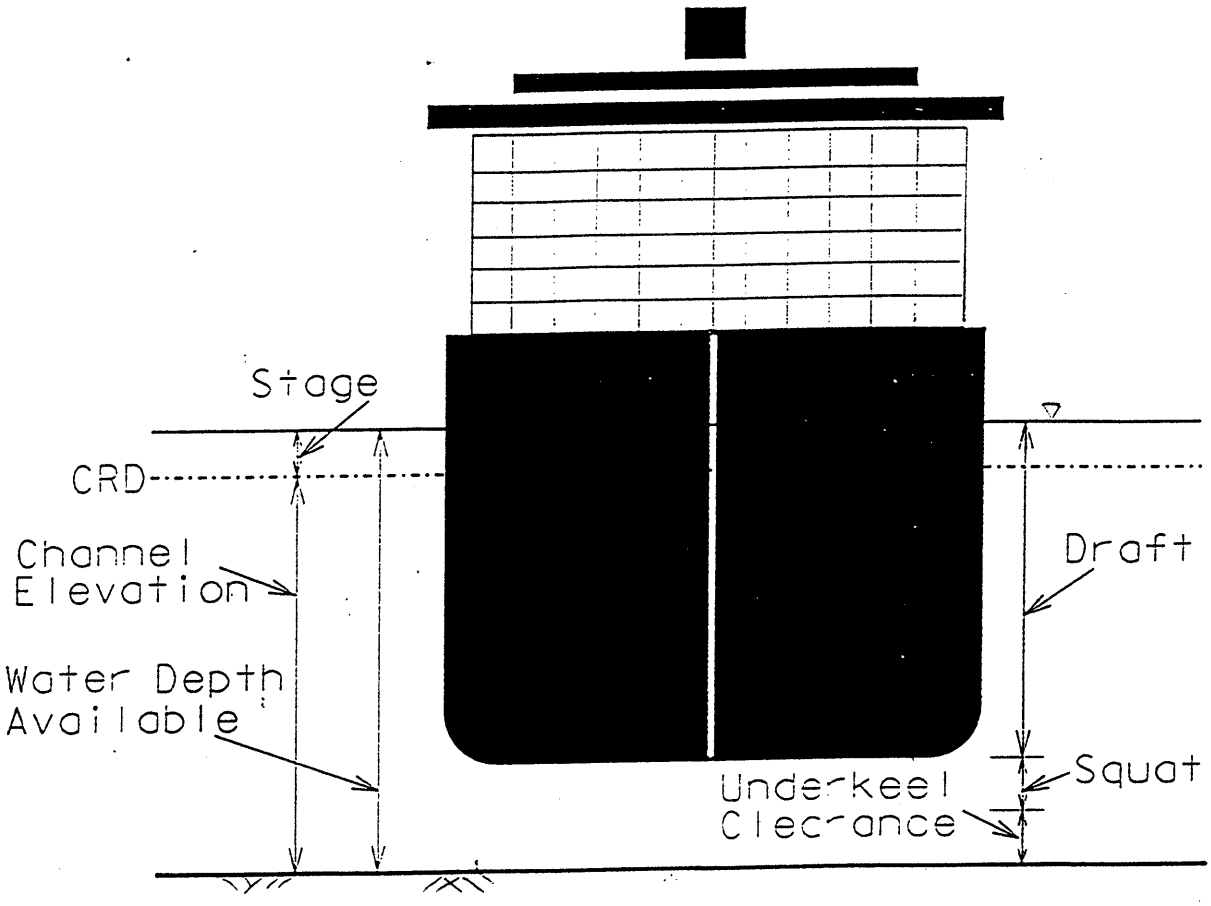


Figure 2



The total water depth available to a ship transiting the Columbia River is the sum of the channel elevation below Columbia River Datum (CRD) plus the river stage above CRD. The total depth of water required by a ship is the sum of its draft plus squat plus underkeel clearance.

Figure 3

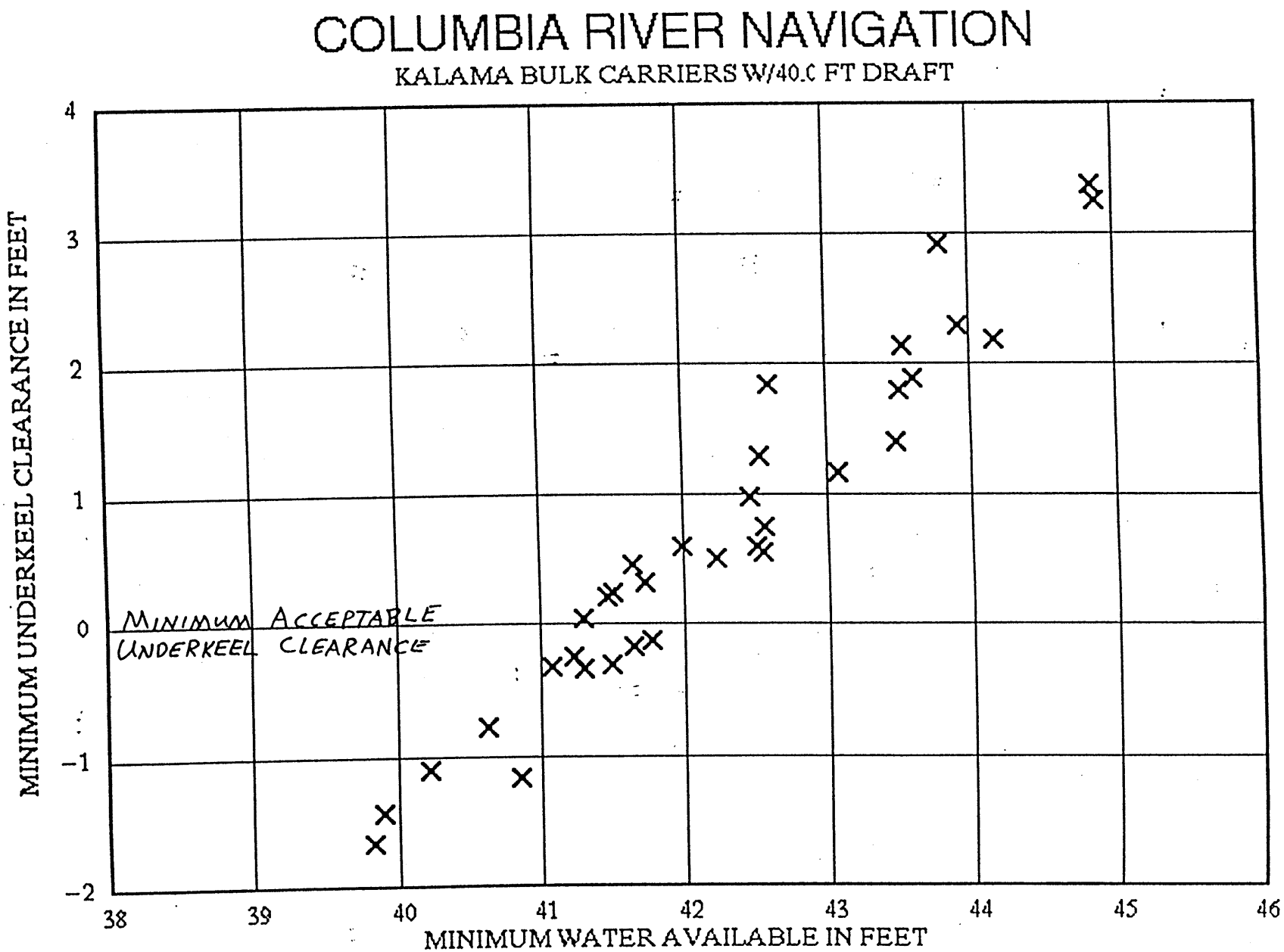

COLUMBIA RIVER NAVIGATION
KALAMA BULK CARRIERS W/40.0 FT DRAFT
MINIMUM UNDERKEEL CLEARANCE IN FEET
MINIMUM WATER AVAILABLE IN FEET
MINIMUM ACCEPTABLE UNDERKEEL CLEARANCE
4
3
2
1
0
−1
−2
38
39
40
41
42
43
44
45
46

Figure 4

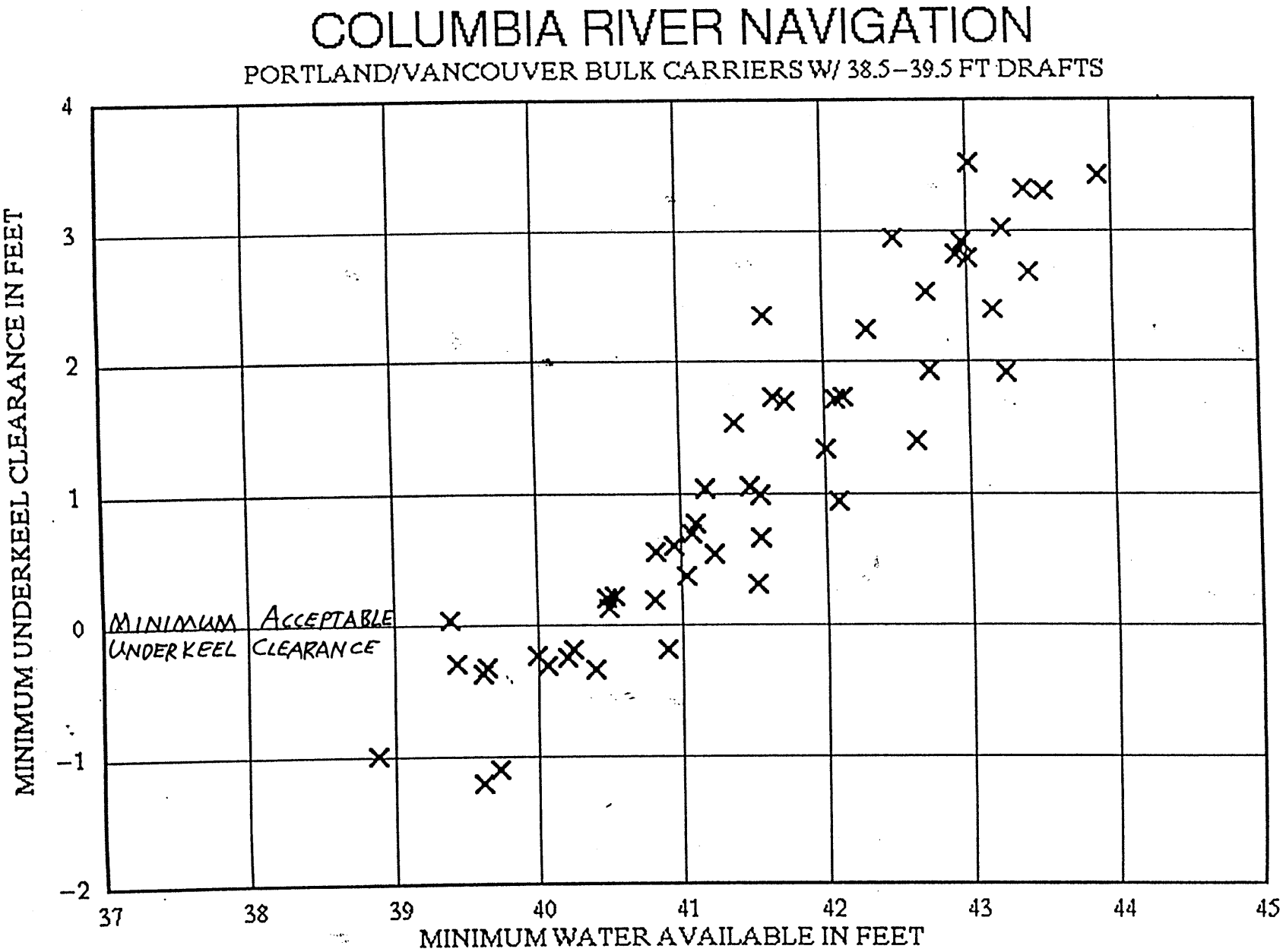

COLUMBIA RIVER NAVIGATION
PORTLAND/VANCOUVER BULK CARRIERS W/ 38.5–39.5 FT DRAFTS
MINIMUM UNDERKEEL CLEARANCE IN FEET
4
3
2
1
0
−1
−2
MINIMUM UNDER KEEL
ACCEPTABLE CLEARANCE
37
38
39
40
41
42
43
44
45
MINIMUM WATER AVAILABLE IN FEET

Figure 5

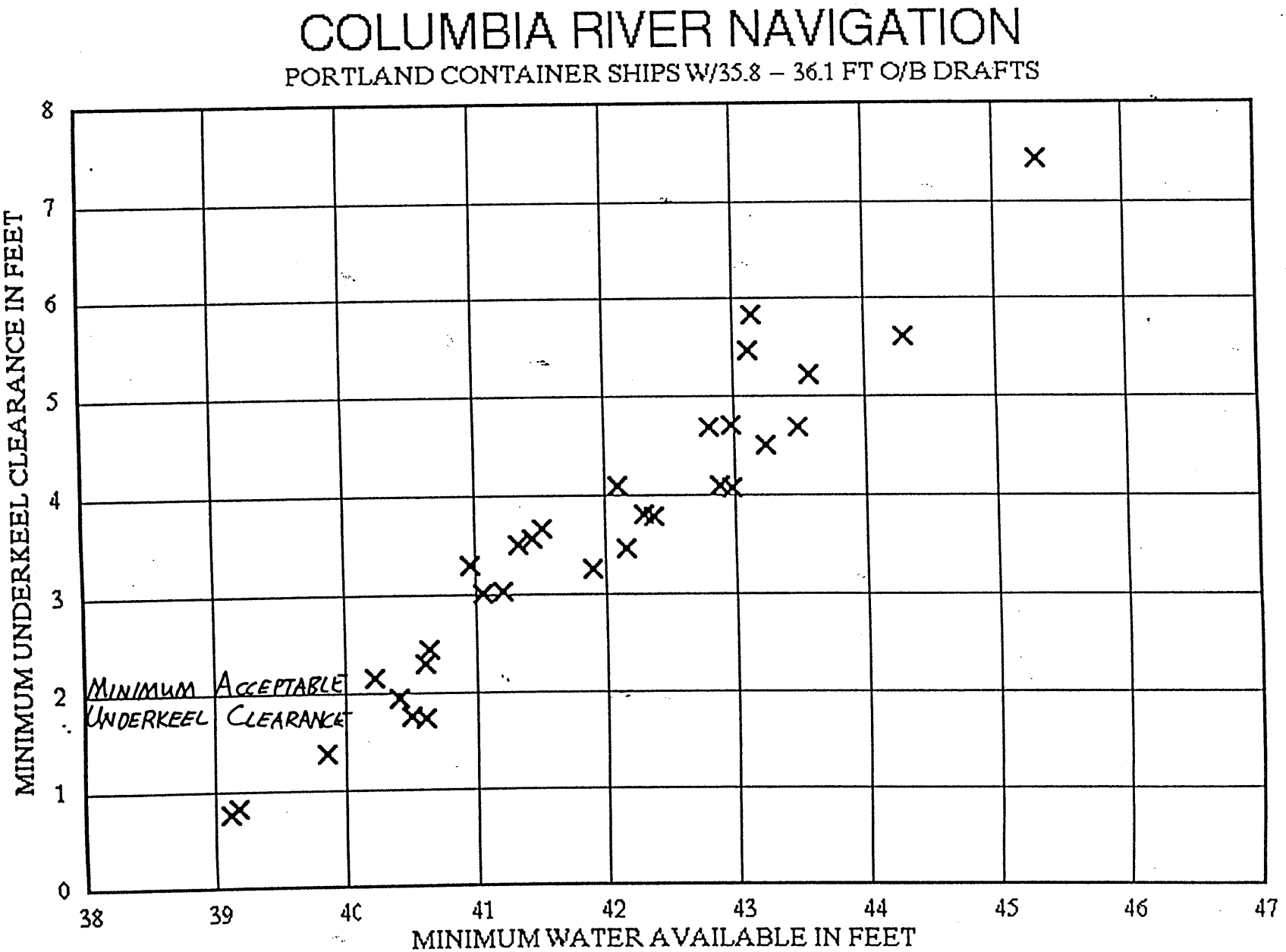

COLUMBIA RIVER NAVIGATION
PORTLAND CONTAINER SHIPS W/35.8 – 36.1 FT O/B DRAFTS
MINIMUM UNDERKEEL CLEARANCE IN FEET
MINIMUM WATER AVAILABLE IN FEET
MINIMUM ACCEPTABLE UNDERKEEL CLEARANCE
0
1
2
3
4
5
6
7
8
38
39
40
41
42
43
44
45
46
47

Figure 6