NOAA Report NOS 115, CGS 8

IMPLEMENTATION OF NORTH AMERICAN DATUM OF 1983 INTO THE NOS NAUTICAL CHARTING PROGRAM

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EXECUTIVE SUMMARY

The National Ocean Service (NOS) publishes approximately 960 nautical charts in support of recreational, military, and commercial navigation on the coastal and inland Federal waters of the United States and its territories. More than 2 million charts are sold annually, with the military purchasing about 40 percent of this total. Intended to facilitate the movement of waterborne commerce and promote marine safety, the nautical chart is designed and compiled to provide accurate marine information for users ranging from the unsophisticated to those who employ satellite navigation for determining vessel position. The nautical chart has been recognized in the United States as such an indispensable navigation tool that the U.S. Code of Federal Regulations requires commercial vessels in excess of 1,600 gross tons to carry charts of the waters upon which they operate.

The conversion of the NOS suite of nautical charts to North American Datum of 1983 (NAD 83) will require careful planning to minimize the workload impact upon an already heavily strained cartographic system, to assure efficient utilization of resources, and to accomplish the full datum conversion in a timely manner. Although the datum conversion will require extensive cartographic effort to revise both the graphic and digital nautical charting data bases, most nautical chart users will not be aware of this change to the horizontal datum.

This report discusses the following problems or considerations that must be addressed before an effective datum conversion plan can be developed:

- NOS has approximately 140 charts that are not compiled on the North American Datum of 1927 (NAD 27).
- NOS has 236 charts and 187 insets that contain State plane coordinate grid ticks which will have to be revised to reflect the relationship of the various State plane coordinate systems to NAD 83.
- NOS has 262 charts containing LORAN and/or OMEGA electronic positioning lattices which have to be revised because of NAD 83.
- The magnitude of the datum shift varies from a few meters to more than ¼ nautical mile.
- No cartographic policy exists for identifying the criteria that justify shifting a chart's projection.

These important factors have been considered in formulating the conclusions and recommendations for the conversion of NOS nautical charts to NAD 83.

Several constraints are addressed that affect timely datum conversion. These constraints involve current personnel resources, current availability of only preliminary NAD 83 values, and the current and near-future production capability of the developing automated chart production system.

Several alternatives for conversion to NAD 83 are identified. Each alternative is a different mix of cartographic actions and production techniques producing a variety of nautical products. Each produces either a temporary or permanent conversion solution, requires different and varying amounts of resources to accomplish the conversion, and causes an impact on the normal cartographic workload associated with the annual production of charts.

Finally, four datum conversion plans are discussed with a hybrid manual/automated cartographic plan recommended as the most feasible for accomplishing NAD 83 conversion within a 5-year time frame. The cost of this conversion is estimated to be $1,098,400. The successful accomplishment of this conversion will require several policy decisions by upper management within the Office of Charting and Geodetic Services (C&GS). Specific datum conversion policy recommendations are also presented.

I. INTRODUCTION

On April 17, 1978, at the first meeting of the United States-Canada Hydrographic Commission (USCHC), R.Adm. Allen L. Powell (U.S. member), suggested that both the Canadian Hydrographic Service (CHS) and the National Ocean Service (NOS) should begin addressing the problems expected in adopting the new horizontal datum for North America.

In May 1979, Mr. David Gray, CHS, and Mr. William Monteith, NOS, were named by the USCHC as members of a two-person ad hoc Committee on Horizontal Datums to identify and study expected problems when each agency converted its nautical charts to the new geocentric datum. By then, the new datum had been identified as the "North American Datum of 1983," or "NAD 83."

A report was prepared by the committee and presented to the USCHC in March 1980 (appendix A). This report identified 16 major issues, questions, or problems which would have to be addressed for an effective and efficient transitioning to NAD 83 by both organizations. A review of that report finds the conclusions and recommendations drawn in 1980 to be essentially valid today.

The purpose of this 1985 report is to discuss several options available for datum conversion of nautical charts to NAD 83 within the NOS nautical charting program. Discussed will be the probable conversion time and resources required under each option for the suite of NOS charts. A recommended conversion schedule will be proposed which considers fully the operating realities faced by NOS today based on an expansion of the conclusions and recommendations formulated in 1980.

In preparing this report, the following questions were considered in arriving at the eventual conclusions and recommendations:

- Upon which datums are NOS chart projections referenced or compiled?
- Considering each existing chart datum, how much projection shift will be required for the chart to be on NAD 83?
- How will the State plane coordinate grids be affected?
- How will NAD 83 affect the "graphic" nautical chart?
- How will NAD 83 affect the automated nautical charting data base?

- What constraints are imposed on immediate conversion of nautical charts to NAD 83?

- What options exist for implementing NAD 83 on the graphic chart?

II. DATUM CONVERSION CONSIDERATIONS

The Chief, Nautical Charting Division (NCD), has identified the timely conversion of all NOS nautical charts to NAD 83 as a primary operating objective for the Marine Chart Branch (MCB). To achieve this objective, several cartographic factors will be considered and their impacts on datum conversion discussed. The principal factor is the amount of actual positional shift required between the present chart datum and NAD 83. Knowing the magnitude of the shift and the scale of the chart, the effect of this shift on each nautical chart will be assessed and appropriate datum conversion methods discussed. The resulting costs of the cartographic and reproduction services workload also will be determined. Finally, datum conversion policy recommendations for implementing the new horizontal datum will be developed and a realistic implementation schedule proposed. A methodology was developed to evaluate various factors and arrive at this realistic implementation schedule. The following considerations were investigated and an assessment made of their respective impact on the production of nautical charts.

A. Existing Chart Datums

The current suite of NOS nautical charts is compiled on or referenced to the following datums:

Datums	No. of charts	Percentage
North American Datum of 1927	830	85.6
U.S. Standard Datum*	51	5.3
Old Hawaiian Datum	36	3.7
Puerto Rico Datum	29	3.0
Local Astronomic Datum	15	1.5
Guam 1963 Datum	2	0.2
Preliminary NAD 27	2	0.2
Preliminary NAD 83	1	0.1
Local datum	1	0.1

*Sometimes referred to as "1902 Datum" or "NAD 1902".

In addition, two charts are compiled on unknown datums, and the recreational chart of the New York State Barge Canal is published without a datum projection. In total, there are 140 charts which are not compiled on NAD 27. These charts are referred to in this report as "orphan datum" charts and their respective impact on NAD 83 conversion will be discussed later.

Appendix B provides a complete listing of all NOS nautical charts and their respective datum.

B. Magnitude of Datum Shift

Figures 1 and 2 portray graphically the amount of latitudinal and longitudinal shift in meters between NAD 27 and preliminary NAD 83 values for the coastal areas of the continental United States, including the Great Lakes. Overall, the smallest amount of shift occurs in the Great Lakes region while the greatest shift in both latitude and longitude is in the Aleutian Islands of Alaska (in excess of 150 m along both axes). In general, the range of shift varies from 0 to 25 m in the Great Lakes, 15 to 50 m along the Atlantic coast, 20 to 40 m along the coast of the Gulf of Mexico, 80 to 100 m along the Pacific coast, and 100 to 160 m in Alaska.

The shift between the "orphan" datums and NAD 83 will be greater in most cases. For example, the National Geodetic Survey (NGS) reports that for charts of the Hawaiian Islands, the shift between the Old Hawaiian Datum and NAD 83 will be approximately 360 m in latitude and 285 m in longitude. The resultant shift between the Puerto Rico Datum and NAD 83 is about 220 m.

The NOS charts of the Pacific Islands (Guam, Wake Island, Kingman Reef, Palmyra Atoll, Samoa Islands, Johnson Atoll, and others) will be converted to the World Geodetic System 1984 (WGS 84) datum and will require a projection shift in excess of 150 m. Final WGS 84 datum values had not been released by the Defense Mapping Agency (DMA) at the time this report was prepared.

C. Criteria for Changing Projection

Once the probable magnitude of datum shift had been determined, it was necessary to define the criterion that would determine whether the chart projection would be shifted cartographically. In developing these criteria, the existing line weights for projections and other charted features were considered. Table 1 lists three line weight groups of cartographic features routinely found on NOS nautical charts. Since the standard width for a chart projection line is 0.1 mm, or 0.004 inch, it was decided that a projection would be revised whenever the datum shift resulted in a space between the old and new projections equal in width to one projection line. This meant that whenever the datum shift at chart scale equalled or exceeded 0.2 mm, the projection would be reconstructed; when less than 0.2 mm, only a revision to the datum reference note would be required. The 0.2 mm is the centerline-to-centerline dimension between the old and new projection lines with a 0.1 mm space between the lines.

Using this 0.2 mm projection shift as a criterion, a 1:50,000-scale chart, for example, would have its projection revised when the datum shift exceeds 10 meters.

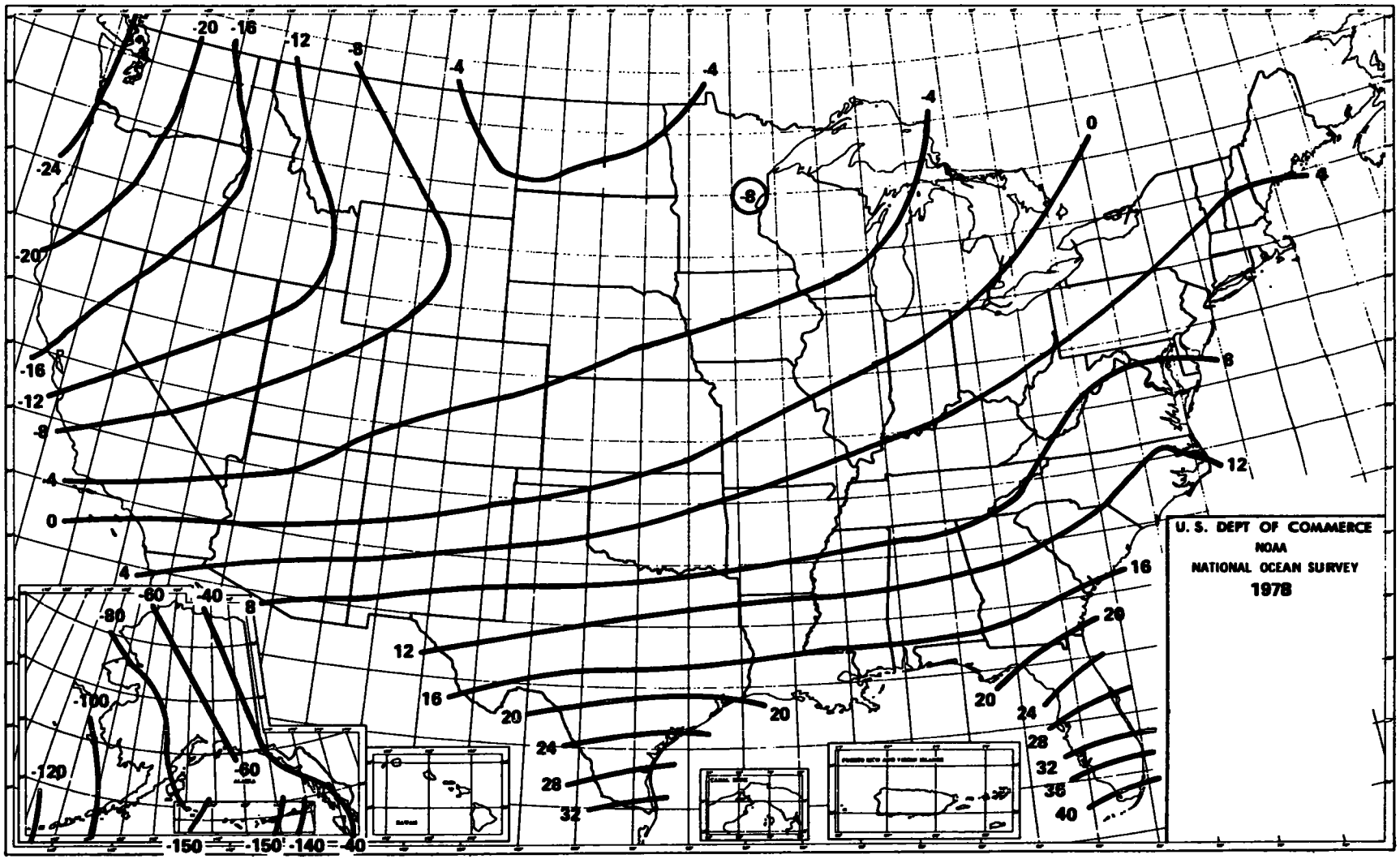

Figure 1.--Expected latitude change from NAD 27 to NAD 83 (in meters).

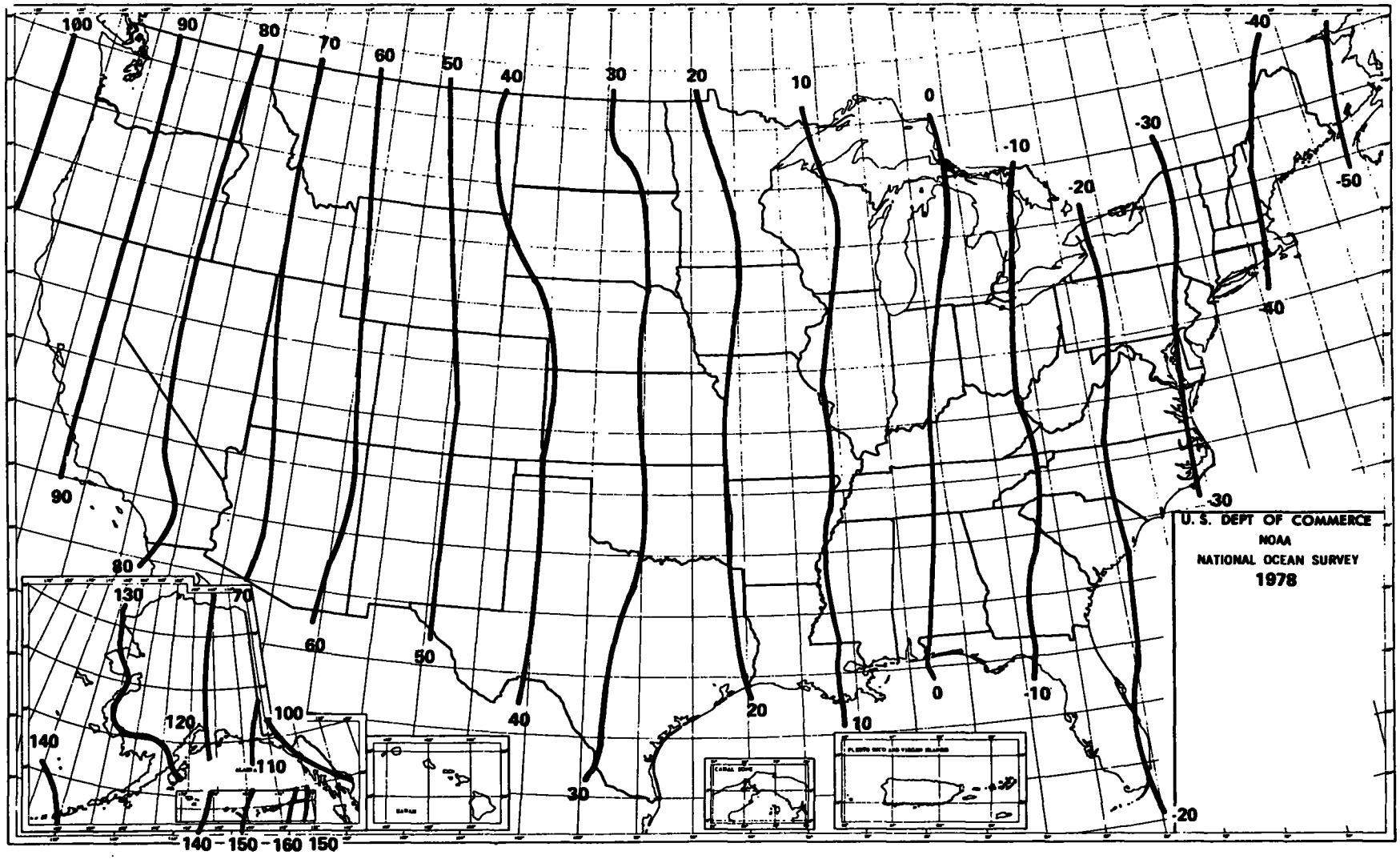

Figure 2.--Expected longitude change from NAD 27 to NAD 83 (in meters).

Table 1.--Specifications for standard features appearing on NOS nautical charts

Line weight	Feature
0.10 mm (0.004")	Contour line--topographic (intermediate) Depth curves Tint outline--blue, gold, green (when not low water line) Traffic lane precautionary area--outline for screen Projection lines Electronic positioning lattice--LORAN and OMEGA lines
0.15 mm (0.006")	Bridge detail (including fenders) Crib--bare at shoreline datum (to scale) Line, misc.--runway, tunnel entrance, fort, etc. Mineral lease block boundary--block subdivisions Groin and jetty Range line--navigable portion Shoreline--apparent --manmade Structure--large, hatchured (to scale) --visible (generally detached from shoreline); i.e., crab pen, floating drydock, hulk (to scale) Wharf, bulkhead, breakwater, and pier
0.20 mm (0.008")	Anchorage berth Anchorage area Isogonic and agonic lines Mineral lease block boundary--exterior Contour line--topographic (index)

Figure 3 shows the relationship between chart scale and datum shift, or the condition where the user of NAD 83 data would incur a 0.2 mm plotting error if the existing chart projection was not shifted. For the purpose of evaluating the cartographic impact of implementing NAD 83, the controlling scale for each chart was considered to be the largest scale panel or inset on the chart. Table 2 is a tabulation of the charts by scale, including controlling insets, which were evaluated against the 0.2 mm projection change criterion. This evaluation identified those charts that would require only a revision to the existing datum reference note. The remainder would require a revision of the chart projection. Appendix B provides a detailed chart-by-chart analysis. More than 80 percent of the charts and chart panels are compiled at a scale larger than 1:100,000. Since most coastal areas have a total shift in either latitude or longitude greater than 20 m, it was concluded that more than 90 percent of the charts would require a projection shift before they could be considered as having been compiled on NAD 83.

D. State Plane Coordinate Systems

The NOS receives an extensive amount of new data each year which is used to revise existing nautical charts or to compile new charts. Not all of the data received are referenced to the same geodetic projection of the chart, but may be referenced instead to a local or State plane coordinate system. For example, even though most of the charts are compiled on a Mercator projection, the majority of new charting data received from the U.S. Army Corps of Engineers (COE), such as channel improvement depths, breakwater and pier construction, etc., are usually referenced to a local or State plane coordinate system. These data would normally be converted to a projection common to the chart before being applied.

State plane coordinate systems for the United States were defined for most States in the 1930's. These coordinate systems were initially intended to render greater utility to geodetic control stations for highway engineers, land surveyors, and others who were accustomed to using grid (rectangular) coordinates (x and y) rather than geodetic (geographic) coordinates (latitude and longitude). The State plane coordinate projections were designed so that the scale factor (the ratio of the geodetic to grid distances) did not exceed 1 part in 10,000. Actually the scale factors range from 0.99990 to 1.00010. This required the larger States to be divided into several zones. The Lambert conformal conic projection was chosen for those States, or zones, that were long in the east-west direction, such as Pennsylvania. The transverse Mercator projection was chosen for States or zones of long north-south extent, such as Indiana.

When the COE began using the State plane coordinate systems for referencing or controlling their surveying, dredging, breakwater construction, and other harbor and waterway improvement projects,

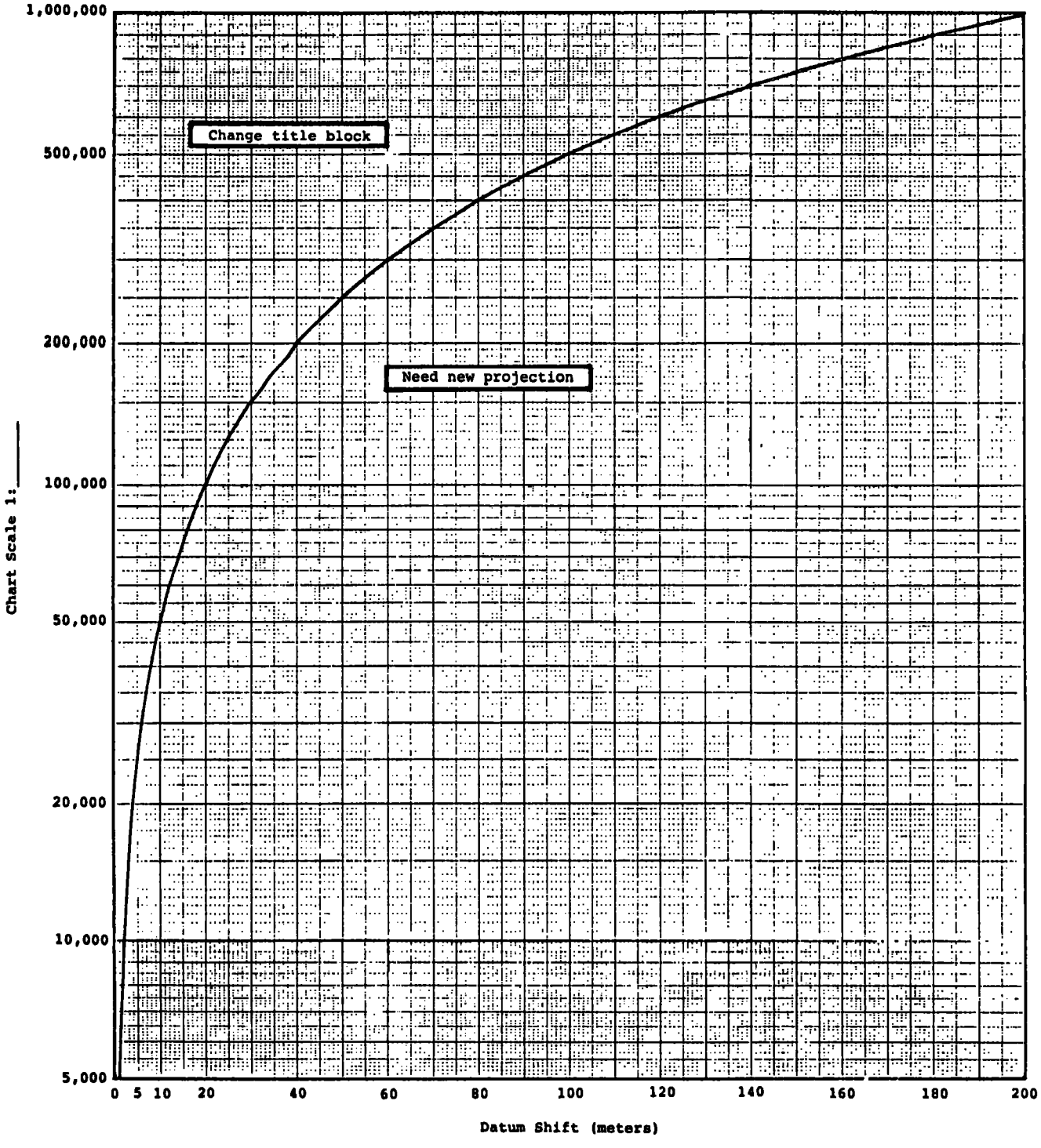

Figure 3.--Plot of projection shift criterion.

Table 2.--NOS charts/insets: summary by scales

Scale (1:K)	Charted area						Total	
	Atlantic Gulf		Pacific		Great Lakes			
	Charts	Insets*	Charts	Insets*	Charts	Insets*	Charts	Insets*
5	4	9	11	24	4	19	19	52
10	44	63	39	84	15	4	98	191
15	14	14	8	13	18	27	40	54
20	64	77	61	73	3	8	128	158
25	7	7	17	16	4	2	28	25
30	3	4	10	9	19	10	32	23
40	126	106	93	66	24	20	243	192
50	6	5	42	40	1	0	49	45
60	1	1	-	-	7	2	8	3
80	89	75	57	34	17	2	163	111
100	5	2	14	7	3	1	22	10
120	-	-	1	0	19	2	20	2
150	4	4	6	4	1	0	11	8
200	2	2	21	16	-	-	23	18
250	1	1	3	3	1	1	5	5
300	2	2	11	8	2	0	15	10
400	11	11	1	1	2	2	14	14
500	1	1	-	-	3	3	4	4
600	2	2	11	10	2	2	15	14
1000	3	3	5	4	-	-	8	7
1500	-	-	4	3	1	1	5	4
2000	1	1	2	2	-	-	3	3
3500	-	-	5	5	-	-	5	5
10000	-	-	1	1	-	-	1	1
TOTAL	390		423		146		959	

*Figures represent the number of charts or insets (panels) in the NOS nautical chart suite for the scale shown. Whenever a chart contained multiple scales, insets or panels, the largest scale was counted.

the NOS cartographers soon recognized the benefit of having a State plane coordinate grid system on the chart to facilitate application of COE data. The NOS has printed State plane coordinate grid ticks along the borders and within selected charts and insets for almost 40 years. NOS currently publishes 236 charts and 187 insets that contain State plane coordinate grid ticks. Generally, the scale of these charts and/or insets is 1:40,000 or larger.

The implementation of NAD 83 will require the existing State plane coordinate systems to be revised. Correspondingly, every nautical chart and/or inset containing State plane coordinate grid ticks will also have to be revised. Some of the reasons for these revisions are as follows:

1. The State plane coordinate systems currently shown on charts and insets are mathematically dependent upon NAD 27. The NAD 83 is based on a different ellipsoid than NAD 27. This ellipsoid is earth-centered rather than the North American "best fit" position for NAD 27. This will result in a shift in the present State plane coordinate systems when the charts are converted to NAD 83. Whether the shift is noticeable will depend on the magnitude of the shift and the scale of the chart or inset.

2. The NAD 83-dependent State plane coordinate systems will have grid values published in meters. The present NAD 27-dependent State plane coordinate grid values are published in feet. The impact of this units' change will be evident in the rounding of metric coordinate values assigned to the initial point in each State plane coordinate system. For example, if the longitudinal false easting value for the initial point in a Lambert conformal projection zone was 2,000,000 ft under the NAD 27-system, a value of 609,600 m would result for the NAD 83-system if a true conversion of units was performed. However, to preserve easy-to-use values for the new metric grid system, a value of 600,000 m might be selected. This rounding off in selecting values for the initial point in each State plane coordinate system will require every State plane coordinate system charted to be recompiled.

3. Many of the State plane coordinate zones will change numerical values because the States have selected new false northings and false eastings that are radically different from the simple feet to meter conversion. For example, most NAD 27 false northings were selected to be 0 ft. Many States are choosing false northings of 100,000, 200,000, or 1,000,000 m for the initial point in the new NAD 83 State plane grids.

To assess the impact of and justification for converting the charts and insets to the new State plane coordinate values, three questions must be addressed. The first is the timetable for when the preponderance of NAD 83-dependent State plane coordinate referenced data will begin to arrive from suppliers such as the Corps of Engineers. The second is whether there will be an

orderly and timely transition by all COE districts? The third question results from recognizing that the State plane coordinate grid ticks are shown for the primary use and benefit of NOS cartographers. Therefore, is the cost of correcting the existing charts justified when evaluated against the benefit derived by the cartographers? These questions will be addressed when developing NAD 83 implementation recommendations later in this report.

E. Datum Conversion Constraints

1. Personnel Resources

In the past year the number of production cartographers (i.e., cartographers available to manually compile and review nautical charts) has steadily declined due to transition of the NOS nautical charting program from manual to automated cartographic operations. Recently a large number of cartographers previously available for manual production were transferred to the Automated Cartographic Production Group (ACPG). The remaining small staff of cartographers who were not transferred to the ACPG will have difficulty maintaining these manually produced charts. The impact of adding NAD 83 conversions to their already heavy workload will be discussed later in this report. A correspondingly similar reduction in the number of negative engravers supporting chart production has occurred also in recent years. During the last 4 years, the number of NOS negative engravers has been reduced by 74 percent, while over the past 9 months the number of manual nautical cartographers has been reduced by 63 percent.

2. Preliminary NAD 83 Data

At present, only preliminary NAD 83 figures are available. The final values will not be available until December 1985. The difference between the preliminary and the final figures is estimated by NGS to be approximately 3 to 5 m. A 5-meter error translates into a longitudinal error of about 0".2 along the North Carolina coast, or a shift of about 0.2 mm at a scale of 1:25,000. The impact of using preliminary NAD 83 values on the manual and automated data bases is assessed as follows:

a. Manual Data Base. The manual data base is graphic in nature and chart-scale dependent. The data base is made up of individual discrete charts. Datum shifts below a certain threshold, at chart scale, would have no effect on the data base. When the datum shift at chart scale is less than the 0.2 mm plotting threshold, the chart's horizontal datum will be considered to be NAD 83 with no revision to the projection required.

b. Automated Data Base. This data base comprises charting data that, prior to loading, are either position-dependent or scale-dependent. Position-dependent data, for example, have been obtained from the digital records of contemporary NOS field surveys, while scale-dependent data have been obtained by

digitizing an existing graphic, such as a chart. Even though chart feature data are either position-dependent or scale-dependent, once loaded these data are qualified or treated alike; i.e., the data are defined as having a positional accuracy of a hundredth of a second in latitude and longitude regardless of their source.

In summary, preliminary NAD 83 values can be used to convert many of the graphic charts to NAD 83 because the expected shift between preliminary and final values will not be significant at the scale of the chart. However, final values may change the number of charts currently requiring a projection shift depending on the magnitude and direction of the change between preliminary and final NAD 83 values. In the case of the automated data base, use of preliminary values will require that the data base be revised once again when final NAD 83 figures become available.

3. "Orphan" Datums

Charts which are not compiled on NAD 27 are classified as being compiled on "orphan datums." In section II A it was stated that 51 charts of the Great Lakes are currently published on the U.S. Standard Datum. In other regions, an additional 15 charts are published on astronomic datums (mainly in Alaska and the Pacific Islands), 36 charts are on the Old Hawaiian Datum, and 29 charts are on the Puerto Rico Datum. In addition, two charts are compiled on unknown datums, and a recreational chart is published without a datum projection. An assessment is being made of each of these charts to determine if NAD 83 datum conversion can be achieved with the information currently available. It may be necessary to request special field survey support to obtain NAD 83 positions for prominent features on several of these orphan datum charts before new chart projections can be constructed. Appendix B lists the approximately 140 orphan datum charts.

Even though NAD 83 can be extended to the NOS charts of other Pacific Islands, such as Guam and Samoa, it was decided by the director of Charting and Geodetic Services that these charts will be compiled on WGS 84. For charting purposes, there is virtually no difference between WGS 84 and NAD 83, and the use of WGS 84 will satisfy a Department of Defense requirement. It is expected that DMA will be able to provide the information necessary to accomplish the datum conversion in these areas.

4. Electronic Positioning Lattices

Because of the great distances between the master and slave transmitting stations comprising a LORAN or OMEGA chain, it is expected that the datum conversion values for the position of each transmission station will vary. What is not known at present is how these variations will affect the hyperbolic lattice for those charts which are located in the outer reaches of the lattice. It is possible that many of the LORAN and OMEGA lattices will have to be recompiled and this might require

assigning a higher production priority for these charts. At present, NOS publishes 248 LORAN charts, 22 additional charts containing both OMEGA and LORAN lattices, and 2 charts containing only OMEGA. These charts are identified in appendix B. The same 0.2 mm criteria used to justify a projection shift will be employed in assessing the need to shift or replot an electronic lattice.

III. DATUM CONVERSION ALTERNATIVES

A. Cartographic Datum Conversion Options

The NOS employs a variety of chart printing classifications and other nautical products in an effort to update its nautical charts, or transmit critical nautical information to chart users in the interim between new edition printings of the charts. Some of these methods may be applicable for accomplishing the conversion to NAD 83. Before discussing these options, however, it is necessary to identify those cartographic actions which could be used to accomplish the datum conversion. These specific actions are used in the production of a type of chart printing or the publishing of a separate product; i.e., Notice to Mariners.

1. Cartographic Actions

Several cartographic actions are appropriate options for converting an existing nautical chart to NAD 83, for producing new charts on NAD 83, or for transmitting NAD 83 conversion information to the chart user independent of a chart printing. Before these cartographic actions can occur, however, the nautical chart data base must be updated. Update of the data base and possible cartographic actions that may follow are discussed under the following headings:

a. Data base update (graphic and/or digital)
b. Temporary datum conversion note
c. Datum reference note revision
d. New projection
e. NAD 83 projection ticks
f. State plane coordinate grid ticks
g. Chart overprinting
h. Chartlet

a. Data Base Update. Before a new edition of a chart can be published on NAD 83, the appropriate manual and/or automated data base must be updated to reflect NAD 83 chart projection information. For the manual data base, this will involve applying NAD 83 note and projection information to the current chart drawing. For the automated data base, this will involve converting the existing digital data base to NAD 83 and loading new data only after they have been converted to NAD 83. It is concluded that new digital source data and the existing digital data base should be converted using only final NAD 83 values.

b. Temporary Datum Conversion Note. When the shift in projection is plottable, the projection on the black plate should be revised on the next new edition of the chart. If available resources or other considerations do not permit revising the projection at that time, a temporary note describing the magnitude of the shift

to NAD 83 could be added to the new edition. The values shown in the note will represent the mean difference, over the limits of the chart, between the chart datum and NAD 83. An example of a temporary note follows.

HORIZONTAL DATUM

The horizontal reference datum of this chart is (name and date). Geographic positions on North American Datum of 1983 (NAD 83) must be corrected an average of _____ " northward/southward and _____ " eastward/westward to agree with this chart. For charting purposes, NAD 83 is considered equivalent to the World Geodetic System 1984 (WGS 84) datum. The correction values are based on preliminary NAD 83 data.

This note would be retained until the chart is fully converted (projection shifted) to NAD 83. At that time the wording of the note would be reversed to facilitate the transfer of data from NAD 83 to the previous datum. This revised note would remain on the chart until it was deemed no longer necessary. An example of the revised note follows.

HORIZONTAL DATUM

The horizontal reference datum of this chart is North American Datum of 1983 (NAD 83), and for charting purposes is considered equivalent to the World Geodetic System 1984 (WGS 84). Geographic positions referred to the (name and date) must be corrected an average of _____ " northward/southward and _____ " eastward/westward to agree with this chart. The correction values are based on preliminary NAD 83 data.

Note: The reference to preliminary NAD 83 data will be deleted from all horizontal datum notes when final values are published.

c. Datum Reference Note Revision. When the magnitude of the shift between the existing chart datum and NAD 83 will not result in a significant plottable difference (less than 0.2 mm), the conversion to NAD 83 can be accomplished by revising the datum reference note in the title block of the chart and, for informational purposes, adding a temporary chart note describing the magnitude of the datum shift. An example of this note follows.

HORIZONTAL DATUM

The horizontal reference datum of this chart is North American Datum of 1983 (NAD 83), and for charting purposes is considered equivalent to the World Geodetic System 1984 (WGS-84). Geographic positions referred to the (name and date) do not require conversion to NAD 83 for plotting on this chart.

d. New Projection. Whenever the shift between the present chart datum and NAD 83 is significant (0.2 mm or greater at chart scale), the chart projection will have to be revised. The most efficient and cost-effective method available to recompile the chart on the new projection is to use the NOS Automated Information System (AIS). The AIS is basically comprised of a nautical charting digital data base and a computer/work station interactive system by which the digital chart information can be loaded and updated. These data are then used to drive plotters in the automated nautical charting system which make the different graphic plates used to print a chart when a new edition is required. However, the production capability of the AIS is not up to a level required for an ambitious program such as the datum conversion of the suite of NOS nautical charts. Even if the production level existed, much of the data for the charting area of responsibility is not yet loaded into the digital data base, nor will it be loaded in the near future. Therefore, it is not possible to convert all of the new editions to NAD 83 using the AIS. The alternative is to revise the projections manually at the time the chart is scheduled for printing a new edition. The recompilation of the projection would become part of the new edition compilation procedure and would use computer-assisted cartographic techniques. The amount of shift at chart scale would be determined from data provided by the NGS. The cartographer would make the necessary projection corrections to the drawing. This action will be hampered by the fact that in most cases automated plots of the NAD 83 projection cannot be used to revise the chart. These mathematically correct projection plots will not fit the existing chart drawings due to distortions in the graphic that have occurred over the years.

e. NAD 83 Projection Ticks. When the shift between the datums is significant, the NAD 83 projection ticks could either be added along the neatline or at the projection intersections within the chart. Adding projection ticks has some of the same drawbacks as revising the projections; i.e., it is both time-consuming and labor-intensive. Unlike revised projections, however, projection ticks add little useful information and they tend to degrade chart clarity.

f. State Plane Coordinate Grid Ticks. State plane coordinate grid ticks are currently printed on 236 nautical charts and 187 insets. These grid ticks are primarily used by NOS cartographers in the application of charting information received from the COE. For this reason, these NAD 27-dependent grid ticks will not become obsolete until the COE begin to furnish charting data on the new NAD 83-dependent State plane coordinate systems. Discussions with COE personnel have indicated that it will be close to 10 years before they begin extensive implementation of NAD 83 State plane coordinate control in their survey and waterway maintenance programs. In-house discussions with NOS cartographers have led to the conclusion that it might be justified to simply delete the existing grid ticks when the chart projection is converted to NAD 83 and allow the cartographers to use other methods to apply future COE data. If it is decided to publish NAD 83 State plane coordinate grid ticks when the COE begin to use this control, then the present cartographic methods will prevail when the charts and insets are revised.

g. Chart Overprinting. Whenever a projection requires a shift of 0.2 mm or greater for the chart to be on NAD 83, this conversion could be accomplished by overprinting the NAD 83 projection in a screened color on the next new edition, or revised printing of the chart. However, this option is a temporary solution posing the following problems: it would increase chart clutter, add to the already heavy cartographic workload, and it would be costly. Furthermore, a degradation of projection accuracy could result from the projection being produced on a plate independent of the black plate. A poor projection registration could exceed the 0.2 mm projection change criterion, thereby defeating the intent of this cartographic action. It was concluded that overprinting an NAD 83 projection on an NAD 27 chart should be avoided.

h. Chartlet. The compilation of a chartlet as part of a Notice to Mariners would be a temporary solution for NAD 83 conversion of a small-scale chart containing large-scale insets. The cartographic work involved to achieve this result is considered too great, and it was concluded that using a chartlet to achieve NAD 83 conversion should be avoided.

2. Types of Printings/Products

The previously discussed cartographic actions can be used to produce several types of nautical products for either temporarily or permanently converting the nautical charts to NAD 83. These

products are the traditional Notice to Mariners and/or the various types or classifications of chart printings; i.e., new edition, revised printing, reprint, new chart, and reconstructed chart. Table 3 shows the relationship between the cartographic action and the type of product or printing which it impacts.

Table 3.--Datum conversion options

Cartographic Actions	Printing Classifications*					
	NM	Rep	RP	NE	RC	NC
a. Data base update	X		X	X	X	X
b. Temporary datum conversion note	X		X	X	X	X
c. Datum reference note	X		X	X	X	
d. New projection			X	X	X	X
e. NAD 83 projection ticks			X	X		
f. State plane coordinate grid ticks			X	X	X	X
g. Chart overprinting			X	X		
h. Compile a chartlet	X					

* NM = Notice to Mariners
Rep = Reprint of existing chart
RP = Revised printing of chart
NE = New edition of chart
RC = Reconstruction of chart
NC = New chart (1st edition)

When the available cartographic actions are analyzed against the product produced, several general conclusions can be reached. One, the "reprinted" (Rep) chart will not aid in the conversion to NAD 83. Two, only actions c, d, and f will result in nontemporary conversion results. This, of course, recognizes that data base maintenance is a priority activity for all subsequent cartographic actions taken in the production of NOS charts.

B. Impact on Chart Production

The manual revision of the chart projection and State plane coordinate grid ticks, would have a significant impact on the number of charts produced, given the present number of production cartographers available. The amount of impact can be roughly estimated by examining the amount of time it now takes to compile an average chart and then determining how much extra time it will take to revise the chart projection and/or the projection on any chart panel or inset.

In 1983, Arthur Young & Company (AYC) conducted a management efficiency study of the MCB. To develop their conclusions and recommendations, AYC first had to collect workload data associated with the production of nautical charts. AYC concluded

that MCB personnel required 229 hours to produce a new edition of an existing nautical chart from a maintained data base. An additional 42 hours per chart were required in the compilation and review processes associated with the compilation of Notice to Mariners published during the period between new editions. Collectively, these hours (271) were determined to be essential if the nautical charting data base was to be maintained at a level which prevented an accumulation of unapplied source data between new editions. A separate in-house study completed in 1984 concluded that 245 hours per chart were necessary to respond to the same nautical charting and Notice to Mariners workload identified by AYC. Both the AYC and the in-house studies were consistent in identifying the generic tasks performed in the production of a new edition. These tasks include:

Receive and evaluate source data
Update the nautical chart data base
Approve data base update
Compile Notice to Mariners for production
Prepare chart drawing for production
Order type
Review of compilation
Clear new edition for distribution

For the present suite of nautical charts, approximately 500 new editions must be produced annually to maintain the present edition cycle for each chart. As a conservative measure, using the workload hours per chart developed by the in-house study team in 1984, approximately 70 cartographers would be required to handle the inherent cartographic workload. In June 1984, the MCB had a cartographic staff of 71. With the present staffing (June 1985) of 26 cartographers, the annual manual chart production capability is estimated to be 185 charts.

In addition to the routine compilation hours discussed above, the cartographic time required to revise the projection on a chart will require an additional 24 hours, and on a chart panel, 20 hours. A count of the insets and panels on the existing chart suite shows that there is an equivalent of 0.45 insets per chart. Therefore, considering the number of panels per chart, each chart requiring a projection shift would require an average of 33 hours additional cartographic compilation time. This amounts to a workload increase of 13 percent, or an annual chart production decrease of 22 charts if additional resources are not provided. The 26 cartographers will only be able to produce 163 charts annually as a result of increased NAD 83 conversion workload, down from 185 charts.

Chart production would be further impacted by revisions to the electronic navigation lattices; i.e., LORAN and OMEGA. These revisions are estimated to require an additional 32 hours per chart. Of the 272 charts containing electronic lattices, it is estimated that 163 will require revisions. This will result in a

cartographic workload increase of 5,216 hours. If these revisions are spread over 5 years, a decrease in chart production of 4¼ charts per year would result.

An additional workload impact will also result from the conversion to NAD 83 of the NAD 27-dependent State plane coordinate systems which are currently published on various charts and insets. All existing grid ticks will require revision when NAD 83 is implemented as a result of both the difference between NAD 27 and NAD 83 and the related decision to publish the NAD 83-dependent State plane coordinate grid values in metric units. It was estimated that the time, and therefore cost, to revise the grid ticks on the charts will be about 50 percent of the effort required to shift a chart projection, or 12 hours per chart. Revising the grid ticks on chart insets would require an additional 5 hours per inset. The impact of revising the State plane coordinate grid ticks on the 236 charts and 187 insets on which they are currently shown will result in an increase in the cartographic workload of 3,770 hours. If the total revision was to be accomplished during a 1-year period, a decrease in production of 16 charts would result. If the revision was spread over 5 years, the chart production decrease would be approximately 3¾ charts per year.

Reproduction time required to shift an existing chart projection is estimated to be 35 hours, and for a chart panel, 20 hours. Therefore, each chart requiring a projection shift would require an average of 44 hours additional reproduction time. The reproduction time required to revise the State plane coordinate grid ticks would approximate the same percentage of compilation time identified above, or 17½ hours per chart and 5 hours per inset.

As stated above, the conversion of NOS charts to NAD 83 by adding or revising a datum reference and/or transformation note would have little impact on chart production because these notes require little in the way of resources. This assumes that source data are received on the same datum as the chart. If source is received on some other datum, a datum conversion will be required and the cost incurred would adversely impact available resources.

It should be noted that the continuing decline in the number of nautical cartographers is also compounding the problems of effective and timely nautical chart production. Any increase in the cartographic workload resulting from NAD 83 conversion will only add to this problem.

C. Resource Requirements

Of the seven cartographic actions discussed in section III A, exclusive of maintaining the data base, two accomplish the datum conversion through the use of notes. These actions should require relatively little in the way of additional cartographic

compilation time, reproduction services time, and materials. However, these two actions, as well as the others mentioned, do depend on the data base being maintained as a priority effort. Initially, the resources required to add these notes are considered to be within the realm of normal chart production costs and, therefore, these costs have not been computed for this report. However, all incoming chart (source) data will not be on NAD 83. Therefore, compilation and review time can be expected to increase because of the conversions required to plot the data on the new datum. It is difficult at this time to assess this impact and the resultant cost on future manual chart production. However, it will be easier to handle if automated procedures can be employed. This will depend on the extent of the digital data base and the production capabilities of the automated nautical charting system under development.

Of the five other actions discussed, all would accomplish the conversion by an actual change to the chart's reference system; i.e., geodetic projection and/or State plane coordinate grid. As such, these methods would require a significant amount of personnel resources and material to implement if accomplished using manual cartographic procedures. However, if the projection and grid shifts were performed employing the AIS, the costs would be negligible once the digital data base has been converted to NAD 83. The reason for this is that the first edition of an AIS-generated chart will have a new black plate which contains the new projection. Under automation, a new projection can be generated each time a new edition is prepared for printing. Therefore, it makes no difference which datum the data are on. Furthermore, those AIS-generated charts not on NAD 83 will be easily converted once the AIS data base has been updated to NAD 83. It has been estimated by the ACPG that this data base conversion could cost $50,000.

If the datum conversion is accomplished manually by adding NAD 83 projection lines or grid ticks onto the existing projection, the amount of resources required for cartographic services and materials would be roughly the same as required for shifting the projection, but would be somewhat less for reproduction services. Overall, however, this alternative would be more costly since it is considered to be only a temporary solution and would eventually require additional cartographic effort to permanently place the projection on NAD 83.

To assess the resources required to convert the NOS charts to NAD 83, the additional workload associated with the conversion of inset or chart panel projections must be considered. At a cost of $19.89 per staff-hour for cartographic services and $21.50 for reproduction services, the labor cost of shifting a projection is estimated to be $1,602 per chart. An additional cost of $615 per chart and $207 per inset will be required to revise the State plane coordinate grid ticks. When material costs of $60 per chart and $30 per panel are included, the total cost of implementing NAD 83 is approximately $1,675 for each chart requiring a projection shift.

When LORAN lattices need revision, even though the plotting is done by automation, it is estimated that an additional 32 hours of cartographic services and 35 hours of reproduction services would be required. Material costs would add an additional $150. In total, an additional $1,540 would be necessary for each chart requiring a change in the LORAN or OMEGA lattice.

In summary, it will require $1,507,000 to shift the projections on approximately 900 NOS nautical charts if accomplished by manual cartographic methods, and $420,000 to revise the electronic positioning lattices on 272 charts if accomplished by manual and automated cartographic methods. An additional $145,000 will be required to publish new State plane coordinate grid ticks on 236 charts and $39,000 to revise the grids on another 187 insets.

D. Conclusions

Whenever the required shift of the existing chart projection to NAD 83 is less than 0.2 mm at chart scale, the conversion shall be accomplished by revising the datum reference note on the chart. For informational purposes, a temporary datum transformation note will also be added to the new edition of the chart. Approximately 72 charts will be converted to NAD 83 in this manner.

For the remaining charts, only two cartographic options were concluded to be cost effective and feasible under present operating conditions. These two options are (1) the addition of a temporary datum transformation note or (2) the shifting of the chart projection. Another option considered, the addition of projection ticks, was concluded to be inefficient, not in the best interests of the chart user, and should not be used.

The decision to either revise the chart projection or to add a datum transformation note can be interpreted as deciding to fully implement NAD 83 or to partially implement NAD 83. If NAD 83 is implemented fully, the majority of the NOS chart suite, about 93 percent or 900 charts, will require a projection revision. A projection revision will result in increased costs and, without additional cartographic personnel, a decrease in the annual production of new editions. If NAD 83 is to be implemented as soon as possible, in lieu of waiting for increased production capability of the AIS, then the use of a temporary datum transformation note is considered justified as an interim measure because of the inherent cost of shifting a chart projection by manual cartographic procedures. Again, manually revising a chart projection is time consuming and costly, and would result in a correspondingly significant reduction in annual chart production. On the other hand, revising the chart projection using the AIS would cost virtually nothing once the data base has been converted to NAD 83. The drawback of using the AIS to implement the new datum is that it will take about 10 years to accomplish the conversion.

It is concluded that the least costly strategy for converting a chart to NAD 83 is to add an interim datum transformation note until a future new edition of the chart can be produced at a later date by the AIS using a data base on NAD 83. A faster implementation schedule can be realized through a hybrid manual/ automated cartographic effort. This would require some chart projections to be manually revised which will require additional chart compilation time, additional reproduction services and materials, and would result in decreased annual production of new editions.

The State plane coordinate grid ticks were added to the nautical charts to assist the NOS cartographers in the application of COE data referenced to these coordinate systems. Although the implementation of NAD 83 as the national horizontal control datum is close at hand, the COE is not expected to convert to an NAD 83-dependent State plane coordinate system in the near future. Until it can be determined with some certainty when the COE will begin publishing their survey data on an NAD 83-referenced control system, it is concluded that NOS should delay shifting the existing grid ticks to the new NAD 83 positions. However, if this conclusion is accepted, it would result in nautical charts compiled on NAD 83 projections which would contain NAD 27-dependent State plane coordinate grid ticks. This could lead to confusion for any user outside of NOS. Another alternative is to delete the existing grid ticks when the chart projection is converted to NAD 83. This would require the NOS cartographers to employ other cartographic procedures in the application of COE data. This alternative is under consideration within NOS.

IV. DATUM CONVERSION PLAN OPTIONS

A. Objectives

The objective of a datum conversion plan is to identify an effective process for converting the suite of NOS nautical charts to NAD 83 in a timely and efficient manner, or to WGS 84 for the nautical charts of the Pacific territorial islands. It is considered essential that any conversion plan recommended result in minimal adverse impact on normal chart production. It is also essential that the recommended plan fully consider the contemporary budgetary and personnel resources available to NOS.

B. Plan Options

In considering the above objectives, it is concluded that NOS has several options available for implementing NAD 83 into its nautical chart program. The options available, however, are dependent upon the level of conversion to be accomplished and the desired time frame for completing the conversion.

The level of conversion can be categorized as: (1) charts requiring only a change in the datum reference note and the addition of a datum transformation note, and (2) charts requiring a change in the datum reference note, the addition of a datum transformation note, and a shift in the chart projection and/or State plane coordinate grid.

Category 1

A chart would be identified under category 1 when its required projection shift is less than the 0.2 mm plotting threshold discussed previously. A preliminary assessment of the probable datum shift required for each chart and the scale of the chart indicates that approximately 72 charts require only a revision in the datum reference note for the chart to be considered on NAD 83. A datum transformation note would be necessary also for information purposes. Because of the varying life cycle of each edition and the projected printing schedule of these charts, table 4 shows that 5 years will be required for their datum conversion .

Table 4.--"Conversion note" implementation schedule

FY	Charts
1985	22
1986	31
1987	9
1988	9
1989	1
TOTAL	72

These charts could be converted more quickly through the issuance of a Notice to Mariners or by issuing a "revised print" (RP) in lieu of a normal new edition. The issuing of a Notice to Mariners is considered a temporary solution that would be of benefit only until a new edition could be printed.

Category 2

Charts falling under category 2 (approximately 900) will require significant cartographic action before they can be considered constructed or compiled on NAD 83. Four viable options were identified for converting these charts to NAD 83. These options are as follows:

Option 1. Automated Nautical Charting System

This option would accomplish the conversion to NAD 83 using exclusively the automated nautical charting system.

Option 2. Automated and Manual Nautical Charting Systems

This option would employ a realistic blend of automated and manual cartographic procedures to convert nautical charts to NAD 83. Manual procedures would be concentrated in areas where a digital data base is not scheduled to be operational for several years; i.e., Pacific coast and Alaska.

Option 3. Hybrid Cartographic System

This option would accomplish the conversion to NAD 83 at the time of the next printing of the chart using the most efficient cartographic methods available; i.e., automated and/or manual.

Option 4. Constrained Hybrid System

This option would also accomplish the conversion to NAD 83 using both manual and automated cartographic procedures, but would accomplish the conversion within a specified time frame.

C. Discussion of the Options

The major difference between the four options presented is the number of projection revisions that would be accomplished using manual cartographic procedures. In general, the sooner the datum conversion is accomplished, the greater the number of projections or grids that will have to be revised manually. The greater the number of manual revisions required, the higher the cost and the greater the impact on the annual production of new editions.

Specific comments on each option follow:

Option 1: Automated Nautical Charting System

Option 1 would rely entirely on the automated nautical charting system to convert the existing charts to NAD 83. Manually maintained charts would have an interim transformation note placed on the next edition of the chart which would remain until the projection or grid could be shifted using the AIS. A Notice to Mariners could be issued and distributed citing interim transformation notes prior to the publication of the new edition. While the primary drawback of this option is the time required to complete the conversion, the temporary nature of this note would be an additional disadvantage. While the conversion cost and impact on chart production using the AIS are concluded to be low, the length of time to convert fully the entire suite of charts is considered excessive. If the AIS can achieve a production capability of at least 100 charts per year by FY 1989, if the AIS can perform required chart maintenance in support of annual increases in the number of new editions produced by automation, and if resources are provided consistent with these chart production and maintenance requirements, it is estimated that at least 10 years would be required to complete the NAD 83 conversion (table 5). This estimate considers also the projected data base load schedule, so that even if the AIS could produce more than 100 charts per year, the data base would constrain production to the levels indicated.

Table 5.--Option 1: Automated information system (AIS) datum conversion schedule

FY 1986	Convert existing data base to NAD 83
FY 1987	25 charts
FY 1988	45 charts
FY 1989	100 charts
FY 1990	100 charts
FY 1991	100 charts
FY 1992	100 charts
FY 1993	100 charts
FY 1994	100 charts
FY 1995	100 charts
FY 1996	100 charts
FY 1997	60 charts

Option 2: Automated and Manual Nautical Charting Systems

The major emphasis under this option would still be on using the AIS to convert a majority of the charts. However, projections and grids on manually maintained charts would also be revised whenever resources could be made available. This would increase the datum conversion cost somewhat, but should have

little impact on chart production. The time required to fully implement NAD 83 would also be reduced somewhat. This option would permit the shifting of the chart projection and State plane coordinate grid using manual cartographic procedures. It assumes that required resources would be available. This option is presented as a method for a more timely datum conversion in areas where the digital data base would not be operational for several years. It is intended that this option could be used to address emergency NAD 83 chart production requirements, such as the compilation of new and reconstructed charts.

Option 3: Hybrid Cartographic System

This option would convert all charts to NAD 83 at the time the next new edition is printed. Since the vast majority of the nautical charts are manually maintained, and will be for the next few years, most of the projections and grids would be revised manually. This would result in higher costs and have a major impact on either chart production or chart completeness (e.g., if this option is chosen, only critical corrections could be accommodated on the next edition.) On the other hand, this option has the advantage of rapidly implementing NAD 83. With the present level of resources, it would be extremely difficult to expect that full conversion could be completed within 8 years. However, if resources can be provided consistent with the Resource Requirements stated in this report (Sec. III B), about 90 percent of the nautical chart suite can be converted in 4 years. The disadvantages of this option are the additional manual cartographic workload and the high cost of conversion.

Option 4: Constrained Hybrid System.

This option sets a 5-year time constraint for the full implementation of NAD 83 using hybrid manual/automation datum conversion methods. Within this framework, the datum revision would be accomplished using the AIS to the maximum (assuming "estimated" production capabilities of the system) with a realistic blend of manual cartographic conversion support. Through careful scheduling, the impact on the manual-production chart schedule would be minimized. However, it is expected that the amount of noncritical revisions applied to the charts during this period would be reduced significantly. Although this option would result in a moderate cost, and have a moderate impact on chart production, it would provide the benefit of full NAD 83 implementation in a reasonably short period of time. This option was developed to strike a "happy medium" between time of conversion and resource requirements. As such, it is the only option where artificial time restraints have been imposed and detailed scheduling has been developed. In developing the conversion schedule under Option 4, the impact of several cartographic and charting factors was collectively considered. These factors, and the special consideration or impact of each, are discussed below:

a. Location of the chart. The geographic location of the chart is important in assessing the status of the AIS in the

corresponding area. Is the area presently loaded in the digital data base? Has the ACPG established a probable date for loading data for the area? Is the area not presently considered for automated chart production in the near future? For example, digital data for the charts along the coasts of New Hampshire and Maine are scheduled for loading in 1985. Therefore, the conversion of these charts to NAD 83 would be performed by automated techniques and would be reflected in the AIS first editions published in the post-1985 time frame.

b. Scale. When the magnitude of shift to NAD 83 is known, its relationship to chart scale dictates whether only a change in the datum reference note will suffice or whether a projection shift is necessary as well.

c. Datum. Knowledge of the existing chart datum is necessary to determine whether a direct conversion to NAD 83* is possible or whether additional survey data will be required. This is a major scheduling consideration in evaluating the impact of those charts currently on orphan datums.

d. Magnitude of datum shift. Knowledge of the magnitude of shift between the existing datum and NAD 83 is necessary to determine the type of cartographic action required to convert the chart. This provides a measure of the overall cartographic workload involved; i.e., actual shift in the projection and State plane coordinate grid or simply a revision to the datum reference note, which is essential in developing an annual conversion schedule.

e. Print cycle. Knowledge of the general print cycle (table 6) is essential to the scheduling of the chart conversions. Because there is less flexibility in scheduling charts having extended print cycles, those charts having print cycles in excess of 36 months were considered on a priority basis when developing recommendations on a schedule for datum conversion.

Table 6.--Chart edition (print) cycles

Charts on issue	Edition cycle (months)								
	6	12	18	24	36	48	60	96	144
953+	10	215	0	243	116	266	1	32	70

+Six additional charts are printed on variable cycles when requested by the Defense Mapping Agency.

*Charts produced of Guam and the associated trust territories will be converted to WGS 84.

f. Conversion Method. The identification of whether a manual or automated cartographic method will be used to convert an existing chart to NAD 83 is also important in identifying the most appropriate time for accomplishing the conversion. Because of the state of flux of the automation development, it was often necessary to venture a "best guess" on the chart production capabilities in future years.

Appendix B lists the charts published by NOS with information provided relative to each of the above factors.

The conversion schedule developed under this option integrates the expanding automation capabilities, including the probable loading of the digital data base, with the remaining manual cartographic capability within the NCD. While the chart-by-chart conversion schedule is presented in appendix B, table 7 summarizes how the NAD 83 conversion will be accomplished over the next 5 years. The heading "Datum Note" refers only to those charts which do not require a projection shift. "Manual" and "Automation" indicate the mode of cartographic technique to be used in shifting or reconstructing the chart projection.

Table 7.--Option 4: Hybrid datum conversion schedule

FY	Projection Shift		Datum Note	Total
	Manual	Automated		
1985	4	6	22	32
1986	164	22	31	217
1987	122	110	9	241
1988	72	129	9	210
1989	120	138	1	259
TOTAL	482	405	72	959

For example, in FY 1985 a total of 32 nautical charts will be converted to NAD 83. Twenty-two will be converted by revising the existing datum reference note and adding an informational datum transformation note. The remaining 10 charts will have their projections shifted, 4 by manual cartographic techniques and 6 by automation. Consult appendix B for specifics on which charts would be converted and by what cartographic action.

V. RECOMMENDATIONS

Effective and timely implementation of NAD 83 into the NOS nautical charting program will involve establishing datum conversion policy as well as developing a realistic conversion schedule. Therefore, the recommendations contained in this report have been developed to: address (A) NAD 83 Datum Conversion Policy and propose (B) NAD 83 Datum Conversion Plan.

A. NAD 83 Datum Conversion Policy

It is recommended that a datum conversion priority be established which will have the least adverse impact on the nautical charting program as a result of using preliminary values.

It is recommended that a 0.2 mm projection shift be established as the criterion for deciding whether a chart requires a new projection or simply a revision to its datum reference note.

It is recommended that NOS begin conversion of its nautical chart suite to NAD 83 using preliminary values for the new datum on charts with a controlling scale smaller than 1:25,000. (Final values to be available in December 1985.)

It is recommended that minimal use be made of the AIS in accomplishing the datum conversion until the digital data base can be converted using final NAD 83 values. However, once the data base is converted, it is recommended that maximum use be made of the AIS to convert existing charts, and to compile new and reconstructed charts on NAD 83.

It is recommended that the MCB review all orphan datum charts and advise NGS where datum conversion problems are anticipated; e.g., New York State Barge Canal. Datum conversion coordination meetings between NGS and MCB personnel should be scheduled to identify areas where special field survey support is required to resolve chart datum conversion problems.

It is recommended that the contemporary requirement be determined for including State plane coordinate grid ticks on the nautical charts and/or insets. If a viable requirement is identified which justifies the cost of adding the new State plane coordinate values, then the grid ticks should be added at some future time consistent with the datum conversion plans of the suppliers of charting data; i.e., COE. If it is determined that the past users of State plane coordinate grid information contained on the nautical charts no longer require this information, the grid ticks shall be removed from the charts/insets when the chart/inset projection is converted to NAD 83.

It is recommended that the AIS and associated software be modified as soon as possible to reflect that NAD 83 is based on the new Geodetic Reference System 1980 ellipsoid instead of Clarke's Reference Spheroid of 1866. This is necessary before any NAD 83 chart projections can be plotted correctly.

It is recommended that all new and reconstructed charts be compiled exclusively on NAD 83, except for charts of the Pacific territorial islands which would be compiled on WGS 84.

It is recommended that any initial conversion to NAD 83 via the issuance of a Notice to Mariners be restricted to those charts requiring only a change in the datum reference note.

It is recommended that the automated data base be systematically converted to NAD 83 to minimize the impact on the existing chart production schedule. The ACPG expects to be able to convert the data base with a minimal impact on chart production through effective use of software.

B. NAD 83 Datum Conversion Plan

Of the several options presented, Option 4 was concluded to be the most effective in accomplishing the conversion in a timely (5 years) and efficient (hybrid) manner. The proposed "constrained hybrid conversion plan" integrates the changing operational capabilities of both the manual and automated cartographic systems. It considers the contemporary resource levels, availability of NAD 83 information, and the projected scheduling of new edition charts over the next 5 years, and is viewed as a balanced and achievable datum conversion plan.

As in any ambitious undertaking with so many combinations available for accomplishing a goal, many views were offered by other NOS cartographers, and much constructive criticism received before Option 4 was selected as the most acceptable plan for all concerned, both producers and users of nautical charts. Table 7 portrays the annual number of charts to be converted during the next 5 years through either a change in the datum reference note or in combination with a shift in the chart projection. These datum conversion actions would be accomplished by both manual and automated cartographic procedures. The cost of this conversion effort is estimated to be $1,098,400. (See appendix C for datum conversion costs.)

It is recommended that this datum conversion plan/schedule be approved and implemented immediately.

APPENDIX A

REPORT

to

THE UNITED STATES-CANADA HYDROGRAPHIC COMMISSION

by

COMMITTEE ON HORIZONTAL DATUMS

March 1980

David H. Gray
Canadian Hydrographic Service

William J. Monteith
National Ocean Survey

REPORT OF THE COMMITTEE ON HORIZONTAL DATUMS

Background

On May 14, 1979, acting upon formal recommendations of the Great Lakes Charting Advisers, the United States-Canada Hydrographic Commission (USCHC) established the ad hoc Committee on Horizontal Datums. The purpose of this Committee was to identify and study anticipated problems expected to be encountered by the Canadian Hydrographic Service (CHS) and the National Ocean Survey (NOS) when each agency converts its charting program to a new geocentric horizontal datum. Messrs. David H. Gray of CHS and William J. Monteith of NOS were appointed as members of this Committee.

The work of the Committee began in Ottawa, Ontario, on May 16, 1979, when a meeting was convened with several representatives of both agencies to clarify Commission objectives and to identify other related and pertinent subjects for the Committee to consider. On August 2, 1979, the Committee met in Rosslyn, Virginia, to consider the problems previously identified and to discuss the course of action necessary to prepare the required report for presentation at the next scheduled Commission meeting. Most of the contact between the committee members in conducting the study and preparing this report, particularly in resolving the minor problems which arose, was by telephone.

Problems (Questions) Considered

The problems and questions considered by the Committee and the answers or recommended course of action for each are presented below:

1.Q. What is the name of the new North American Datum?

A. The name of the new datum is "North American Datum of 1983." The accepted acronym is "NAD 83." This name and acronym will hold true regardless of the date the new datum becomes effective.

2.Q. What is the expected date that NAD 83 will become effective for use by Canada and the United States in their respective surveying and mapping programs?

A. The Geodetic Survey of Canada (GSC) and the National Geodetic Survey (NGS) of NOS advise that the framework of primary horizontal control adjustments for North America has slipped by 12 to 18

months so that it is now estimated that the NAD 83 primary adjustment will be completed in late 1984. Secondary and tertiary control will be adjusted or transformed to new coordinate values soon after that date.

3.Q. Besides conversion to an earth-centered (geocentric) system, what other results will be produced by NAD 83?

A. A major reason that the NGS and GSC are desiring the NAD 83 is to eliminate errors in the existing North American Datum of 1927 (NAD 27) and to provide the surveying and mapping programs of Canada and the United States with one common horizontal datum based on a world reference ellipsoid. For example, some known problems in the NAD 27 are:

- 100 ppm scale error in the north British Columbia coast and Alaska Panhandle

- 10 meter misclosure in the west Lake Superior area

- 10 ppm scale error in the Maritime Provinces

These problems and similar ones in the lower order surveys may mean that some charts may have to be reconstructed from the original data once the lower order control has been properly adjusted to the primary control framework. Reconstruction will depend on the magnitude of the errors and must be based on a chart-by-chart analysis.

4.Q. What are the expected changes in latitude and longitude between NAD 27 and NAD 83?

A. The NGS has published preliminary changes between NAD 27 and NAD 83 in NOAA Technical Memorandum NOS NGS-16, dated April 1979. These composite latitude and longitude differences (in meters) for North America are shown in Figure 1.

5.Q. Will there be differences between charts published by the Defense Mapping Agency (on WGS 72 Datum) and charts published by NOS and CHS (on NAD 83)?

A. Ground positional differences between these two earth-centered coordinate systems will be inconsequential for both the hydrographer and the mariner since it is estimated that the maximum difference will be about 5 meters, with the average difference being less than a

Anticipated Shift in Position (in meters)
due to Change to Earth-Centered Ellipsoid

Figure 1

meter. The Committee concludes that the difference between these two datums will not be observable when charts compiled on each datum are visually compared.

6.Q. What is the horizontal datum of the present charts?

A. The majority of the charts produced currently by CHS and NOS are on NAD 27, others on a variety of horizontal or reference datums, such as:

Old Hawaiian Datum
North American Datum of 1902 (U.S. Standard Datum)
Various Astronomic Datums
Uncontrolled Reference Datums

For the 977 charts currently published by the NOS, the following datums are used:

Datums	Charts	%
North American Datum of 1927	844	86.4
North American Datum of 1902 (Great Lakes)	50	5.0
Old Hawaiian Datum	36	3.7
Puerto Rico Datum	24	2.5
Local Astronomic Datums	21	2.2
Guam 1963 Datum	2	0.2
	977	100.0

Datums used by the CHS on charts currently published are:

North American Datum of 1927
North American Datum of 1902 (originally U.S. Standard Datum)
Local Astronomic Datums
(Chart distribution on these datums is not available)

7.Q. When should CHS and NOS publish charts on NAD 83?

A. Depending on the work load priority comprising each agencies' chart production schedule, the decision "not to convert to NAD 83" was recognized as a viable option for a limited number of charts currently produced. However, the Committee considered the relatively small number of charts which might fall into such a category and answered

this question on the assumption that CHS and NOS would ultimately convert all of their charts to NAD 83. The Committee agreed that conversion to NAD 83 should not begin until the final datum computations and adjustments have been completed and reliable positions are available for converting all existing chart data to the new datum. Unless some unforeseen reasons occur beforehand, the Committee recommends that production of charts on NAD 83 should be scheduled to begin in January 1985, or as soon thereafter as the data will permit.

8.Q. How should a chart be converted to NAD 83?

A. The Committee assumed that both manual and automated cartographic techniques would be available to each agency to accomplish this datum conversion. It was also decided that the cartographic method selected would be dependent upon the magnitude of the difference between NAD 83 and the various existing chart datums, the scale of the chart, and an evaluation of the basic survey data from which the chart was compiled. Whether performed by manual or automated techniques, the procedures expected to be used are:

- conversion of grid or projection points to NAD 83 using ΔX, ΔY, and ΔZ of nearby (or charted) geodetic control,

- recompilation of survey data used for compiling the chart including offshore hydrography acquired using hyperbolic or range-range survey positioning techniques,

- survey of selected charted features to obtain NAD 83 coordinates when the existing chart datum is in question.

The Committee recommends that each agency selects the best method for conversion to NAD 83 based on a chart-by-chart analysis of all factors.

9.Q. How will existing digitized data be converted to NAD 83?

A. The conversion method selected will be dependent on the source information. Since the digitized data are often used at a scale larger than the conventional chart manuscript, the Committee recommends that the accuracy standards for converting existing digitized data to NAD 83 be established to assure that a greater accuracy is achieved than is necessary for charting. NOS expects to use an existing computer program to apply a least squares adjustment to convert its existing digital data base to NAD 83 on a chart-by-chart basis. This program

requires that the position of the four neatline corners of each chart be known on NAD 83 and will be solvable using the procedures cited in the discussion of Question 8. There is the potential problem that some data might be transformed twice and safeguards should be established to eliminate this error.

10.Q. How long will it take to complete the conversion of all NOS and CHS charts to NAD 83?

A. (NOS) The Committee recognized that a reasonable time required for each agency to accomplish full datum conversion would depend on several factors with the most important being whether each agency (beginning in 1985) would have the cartographic capability to compile the changes at a rate to meet the projected printing cycle for each chart. The Committee assumed this capability would exist with now-developing methods and, therefore, concentrated its efforts on estimating the reasonable time that would be required to produce new chart editions on NAD 83. The NOS issues about 500 new editions per year.

The NOS has eight distinct printing cycles for charts. These cycles and the number of charts affected are listed below:

Print Cycle		
6 mos.	12	(Includes 1 mineral lease chart)
12 mos.	279	(Includes 3 mineral lease and 3 training charts)
18 mos.	9	
24 mos.	193	(Includes 1 mineral lease and 2 training charts)
36 mos.	112	
48 mos.	270	
96 mos.	32	(Includes 7 special use charts)
144 mos.	70	
	977	

Theoretically, the 12-year print cycle charts would extend the conversion period to 1996 if datum conversion were begun in 1985 and if 1984 were the latest edition of these 12-year charts. However, a review of the NOS long-range chart production schedule indicated that both the 8- and 12-year print cycle charts could be converted to NAD 83 by the end of 1991 (see below).

7

Year	Charts Printed	
	8-year Edition	12-year Edition
1985	12	0
1986	5	4
1987	4	18
1988	3 *	20
1989	4 *	10
1990	1	10
1991	3	8
	32	70

* Special Use Charts for U.S. Navy

A. (CHS) There are approximately 1,000 CHS navigational charts in stock at any one time. The number changes slightly as new charts are published and old ones are withdrawn. In any one year approximately 10 new charts, 95 new editions, and 98 corrected reprints are published. The distinction between new edition and corrected reprint is that the latter differs from the previous printing by application of information published in Notices to Mariners (NM) and hence the previous printing is not cancelled. Corrected reprints are issued to replace stock of a chart when there are no new surveys or to reduce the amount of hand corrections (the application of items published in the NM) that are necessary for a chart. At first glance it might appear that with almost 200 charts coming off the presses each year, that it would take only 5 years to go through the 1,000 navigational charts. Unfortunately, some charts are not printed as frequently as that and some much more frequently. By inspection of the CHS chart indexes, it takes about 7 1/2 years to get through approximately half of the charts, 15 years for three-quarters of the charts, and 30 years for 99 percent of the charts.

Over half of the charts sold are newer than 7 1/2 years old since they are in greater demand, whereas there is little demand for charts that are printed once every 30 years. Nevertheless it is obvious that CHS cannot match the NOS prediction of conversion of all charts to NAD 83 in 7 years. It will take a concerted effort by CHS to reduce the conversion period even to 15 years.

11.Q. What would happen to existing chart stock?

A. Until all charts are converted to NAD 83, the Committee recommends that a NM statement should be published annually which would identify each chart not on NAD 83 at that time and the respective $\Delta\varphi$ and $\Delta\lambda$ conversion values between the existing chart projection and NAD 83.

As conversion to NAD 83 occurs through the printing of new editions in conformance with prior established edition cycles, existing chart stock will continue to be treated as obsolete and cancelled, as is the present practice.

12.Q. Should CHS and NOS recognize that people use obsolete editions of charts and, therefore, recommend the publishing of NM information on individual items in the new and old chart datum for an interim period?

A. No! The publishing of information on more than one datum would be too confusing. Canadian and United States law require the use of the latest editions of charts and it is believed that any action to promote or support the use of obsolete charts would be inconsistent with the legal positions of both countries.

13.Q. How can a chart *not* on NAD 83 be referenced to, or used with, NAD 83 information?

A. The Committee recommends as an interim measure the addition of a "transformation" note on the chart which will inform the user of the amount of correction needed to shift the chart projection to NAD 83.

14.Q. How will NM information be published?

A. The Committee considered two basic procedures for publishing NM information. The first would require information be published consistent with the datum of the chart affected. Multiple charts affected by a single NM item could mean publishing that information on more than one datum, especially in the early period of transitioning the charts to NAD 83. It would be expected that the size of the NM would remain large until the number of charts not on NAD 83 is significantly reduced. This procedure will also require developing a fail-safe data checking system to assure a high credibility level for the data published. The CHS presently handles NM information affecting charts of different datums and scales in this way.

The Committee also considered the impact of publishing (after January 1985) NM information exclusively on NAD 83, regardless of the datum of the affected chart(s). This would also present a formidable task. Included in the NM would be a special note advising

the user on how to transform the NM information to the datum of each chart affected. This note would be opposite in content to the note proposed in the answer to question 13 above. It is believed the use of a note could reduce significantly the size of each NM and still enable the user to utilize this information correctly. The following is an example of a note in a NM pertaining to a NOS chart of Cape Hatteras:

PLOTTING ADJUSTMENT

Geographic positions of data given on North American Datum 1983 (NAD 83) may be plotted on this chart by applying the following corrections:

Latitude: +0.48", *or* +12.4 meters, *or* +13.5 yards
Longitude: -1.04", *or* -32.0 meters, *or* -34.0 yards

The World Geodetic System 1972 (WGS 72) datum is considered equivalent to NAD 83 for this chart.

The Committee believes this question can be answered following future discussions between CHS, Canadian Ministry of Transport, U.S. Coast Guard, Defense Mapping Agency Hydrographic/Topographic Center, and the NOS. These discussions would be scheduled in a period 3 to 6 months in advance of the implementation of NAD 83 into the respective charting programs of both countries. This question should be made a point of future discussions by the Commission as well.

15.Q. Should charts be drawn with a double border, one on NAD 83 and the other representing the existing chart datum?

A. No! Cartographically, it would mean drawing the neatline (border and projection ticks) twice, initially to show the old and new datum projections, and later to show only the NAD 83 projection. In the first case, it is believed the users would be confused by the two projections displayed, particularly in the adaptation of NM information. Until the charts are compiled on NAD 83, it is recommended that an interim note and example be added to the existing chart to instruct the user how to transfer from existing chart datum to NAD 83, as recommended in the answer to question 13.

16.Q. Will chart borders and lattices have to be redrawn?

A. Analysis to date indicates there should be no visible difference in charted area between chart neatlines (borders) drawn based on ellipsoid parameters defining NAD 83 and any other datum

previously used, such as NAD 27 (Clarke's Reference Spheroid of 1866). The neatlines of a chart define the "window," or the area charted, and regardless of the datum used in compiling the chart, the window remains the same even though the chart projection may be shifted. Where the chart projection intersects the neatline, new subdivisions will be required to reflect this projection shift to NAD 83.

Electronic positioning lattices, however, will probably have to be redrawn since both the ellipsoid parameters and the geographic coordinates of the electronic positioning system transmitters have been changed. These changes will produce non-uniform differences between new and old data used to generate these lattices.

Other Considerations and Summary

Although predicted shifts between NAD 27 and NAD 83 appear to be systematic and predictable, the Committee has concluded that there are many charts compiled on older datums and based on older surveys where a predicted shift in coordinates is not feasible. An individual analysis of each chart will have to be done to resolve the effect of shift in datums.

Beginning in early 1985, or as soon as final coordinates for charting control are available from NGS and GSC, the Committee recommends that chart projections (grids) be shifted to the NAD 83 at the New Edition stage of construction. It is further recommended that a list of chart projection shifts (latitude and longitude) should be published (annually) in NM for the mariner who wishes to change datums prior to an edition of the chart being published on NAD 83.

The Committee has not determined whether NM, Light Lists, Sailing Directions (Pilots) and other publications quoting geographic positions would use the projection datum of the current edition of the chart (if not NAD 83) or would use NAD 83 exclusively. Further study and coordination in this area is required prior to 1985. It is recommended the Commission identify this for Charting Advisers action at a later date.

Electronic positioning system lattices will have to be redrawn on the new datum. Some offshore surveys done in hyperbolic and range-range mode will require replotting because of the non-uniformity of the shifts in transmitter positions and because of new ellipsoid parameters. It is expected that CHS and NOS will not be able to handle this replotting manually, but will require automated cartographic techniques to effectively and efficiently accomplish transformation to the new NAD 83.

APPENDIX B

NAD 83 CONVERSION FACTORS

AND

PROPOSED IMPLEMENTATION SCHEDULE

FOR

NOS NAUTICAL CHARTS

Abbreviations are used extensively throughout Appendix B. The abbreviations, keyed to the major column headings, are defined below.

Area

AL = Alabama
AK = Alaska
BC = New York State Barge Canal
CA = California
CM = Canoe Maps (Minnesota-Ontario Border Lakes)
CR = Columbia River
CT = Connecticut
DE = Delaware
DR = Detroit River
FL = Florida
GA = Georgia
GAK = Gulf of Alaska
GM = Guam
HI = Hawaiian Islands
I = Jarvis, Baker & Howland Islands
ID = Idaho
JA = Johnston Atoll
KR = Kingman Reef
LA = Louisiana
LC = Lake Champlain
LE = Lake Erie
LH = Lake Huron
LM = Lake Michigan
LO = Lake Ontario
LSC = Lake St. Clair
LS = Lake Superior
LW = Lake of the Woods
MA = Massachusetts
MD = Maryland
ME = Maine
MS = Mississippi
NC = North Carolina
NH = New Hampshire
NI = Navassa Island
NJ = New Jersey
NV = Nevada
NY = New York
OR = Oregon
PA = Pennsylvania
PM = Palmyra Atoll
PR = Puerto Rico
RI = Rhode Island
RL = Rainy Lake
SC = South Carolina
SCR = St. Clair River
SI = Samoa Islands
SLR = St. Lawrence River
SMR = St. Marys River
TX = Texas
VA = Virginia
VI = Virgin Islands
WA = Washington
W CST = West Coast
WI = Wake Island

Chart

I International Chart
L Electronic Latticed Chart; e.g., LORAN, OMEGA
SC Small Craft Chart
RC Recreational Chart

SPC (State Plane Coordinates)

\+ On Charts Only
\- On Insets Only
* On Chart and Inset(s)

Print Cycle

— "Official Use Chart" (Printed When Requested By DMA)

Publish

. Probable Year For Printing New Edition
x Year For Converting Chart To NAD 83

Datum

A Local Astronomic Datum
* Charts Are On NAD 27 Unless Otherwise Noted
G Guam 1963 Datum
L Local Datum
None Chart Does Not Contain A Reference Datum
OHD Old Hawaiian Datum
PR Puerto Rico Datum
Pre27 Preliminary NAD 27
Pre83 Preliminary NAD 83
UNK Datum of Chart Is Unknown
02 U.S. Standard Datum or 1902 Datum

Compile

x Most Likely Method
\- To Be Done By Automation If System Has Capability

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
Pacific	I-50	10000						x		48	x					x	
Gulf Mexico	411	2160						x		12	x		x	.	.	.	.
Pacific	I-500L	3500						x		24	x		x		.		.
Pacific	I-501L	3500						x		24	x			x		.	
	I-513L	3500						x		48	x				x		
	I-514L	3500						x		24	x		.		x		.
	530L	4860						x		24	x		.		x		.
	531L	2100						x		24	x			x		.	
	540L	3121	OHD					x		48	x					x	
Gulf Mexico	11006L	875		28	-6	29		x		12	x		x	.	.	.	.
SE Atlantic	11009L	1200		20	-30	36		x		12	x		.	x	.	.	.
Strait/Fla	11013L	1200		44	-24	50		x		12	x		x	.	.	.	.
Gulf Mexico	11300L	460		24	22	33		x		12	x		x	.	.	.	.
-TX	11301L	80		30	26	40			x	24		x	.		.		x
	11302SC	40		32	26	41	+		x	12		x	.	.	.	x	.
	11303SC	40		30	26	40	*		x	24		x		.		x	
	11304L	80		30	25	39			x	48		x			x		
	11306SC	40		30	26	40			x	24		x		.		x	
	11307L	80		27	26	37			x	24		x		.		x	
	11308SC	40		27	26	37	*		x	24		x		.		x	
	11309	40		26	26	37	+		x	12		x	.	.	.	x	.
	11311	10		26	26	37	*		x	24		x	.		.		x
	11313L	80		25	25	35			x	24		-	.		.		x
	11314SC	40		25	26	36	*		x	24		x		.		x	
	11315SC	40		24	25	35	+		x	12		-	.	.	.	.	x
	11316L	80		24	24	34			x	12		-	.	.	.	.	x
	11317	50/20		23	25	34	*		x	12		-	.	.	.	.	x
	11319SC	40		23	24	33	+		x	12		-	.	.	.	.	x
	11321L	80		22	23	32			x	24		-		.		x	
	11322SC	40		22	23	32	*		x	12		x	.	.	.	.	x
	11323L	80		22	22	31			x	12		x	.	.	.	.	x
	11324	25		22	22	31			x	12		x	.	.	.	.	x
	11326SC	80		21	22	30			x	12		x	.	.	.	.	x
	11327	25		21	22	30	+		x	12		x	.	.	.	.	x
	11328	10		21	22	30	+		x	24		x	.		.		x
	11329	10		21	22	30	+		x	12		x	.	.	.	.	x
	11330L	250		22	20	30		x		12	x		.	x	.	.	.
	11331SC	40		20	21	29			x	24		x		.		x	
	11332L	80		21	20	29			x	24		x	.		.		x
	11340L	458		22	15	27		x		6	x		x	.	.	.	.
-LA	11341L	80		20	19	28			x	12	x		.	x	.	.	.
-TX	11342	40		19	20	28	+		x	12		x	.	.	x	.	.
	11343	40		19	20	28			x	12		x	.	.	x	.	.
-LA	11344L	80		19	17	26			x	12	x		.	x	.	.	.
	11345	175		19	16	25		x		12	x		.	x	.	.	.
	11347SC	50		19	18	26	*		x	12		-	.	.	.	.	x
	11348SC	40		19	16	25	*		x	24		-		.		x	
	11349L	80		19	14	24			x	12		-	.	.	x	.	.
	11350SC	40		18	14	23	*		x	12		-	.	.	.	.	x
	11351L	80		19	13	23			x	12		-	.	.	.	.	x
	11352	175		18	11	21		x		12	x		.	x	.	.	.
	11354SC	80		18	12	22	*		x	12		-	.	.	x	.	.

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	11355SC	40		18	10	21	*		x	12		-	•	•	•	•	x
	11356L	80		19	11	22			x	12		-	•	•	•	•	x
	11357L	80		20	10	22			x	12		x	•	•	x	•	•
	11358L	80		20	8	22			x	6		x	•	•	•	•	x
	11359L	50		20	8	22			x	12		x	•	•	x	•	•
-MS	11360L	456		20	0	20		x		12	x		x	•	•	•	•
-LA	11361L	80/40		20	6	21	*		x	6		x	•	•	•	•	x
	11363L	80		18	5	19	+		x	12		x	•	•	•	•	x
	11364	80		18	7	19	+		x	12		x	•	•	x	•	•
	11365SC	50		19	9	21			x	12		x	•	•	•	•	x
	11367SC	40		18	8	20	*		x	12		x	•	•	•	•	x
	11368	15		18	8	20			x	24		x		•		x	
	11369L	80		18	9	20			x	12		x	•	•	x	•	•
	11370SC	40		18	10	21	*		x	12		-	•	•	•	•	x
-MS	11371L	80		18	6	19			x	12		x	•	•	•	•	x
	11372SC	40		18	5	19	+		x	12		x	•	•	•	•	x
	11373L	80		18	4	18			x	12		x	•	•	x	•	•
	11374SC	40		18	4	18	*		x	12		x	•	•	•	•	x
	11375	20		18	4	18	+		x	12		x	•	•	x	•	•
-AL	11376L	80/25		17	2	17	+		x	12		x	•	•	•	•	x
	11378SC	40		17	2	17	*		x	12		x	•	•	•	•	x
-FL	11382L	80		17	-1	17			x	12		x	•	•	x	•	•
	11383	30		17	-1	17			x	12		x	•	•	x	•	•
	11384	10		17	-1	17			x	24		x		•		x	
	11385SC	40		17	-2	17	*		x	12		x	•	•	•	•	x
	11388L	80		18	-2	18			x	24		x		•		x	
	11389L	80		18	-4	18			x	12		x	•	•	x	•	•
	11390SC	40		18	-4	18	+		x	24		x	•		•		x
	11391	25		18	-4	18			x	24		x	•		x		•
	11393SC	40		18	-5	19	+		x	24		x		•		x	
	11400L	456		24	-10	26		x		12	x		x	•	•	•	•
	11401L	80		20	-6	21			x	12		x	•	•	•	•	x
	11402SC	40		19	-6	20	+		x	24		x		•		x	
	11404SC	40		19	-7	20	*		x	24		x		•		x	
	11405L	80		20	-7	21			x	12		x	•	•	•	•	x
	11406	15		19	-8	21	*		x	48		x			x		
	11407L	80/20		21	-9	23			x	24		x		•	x	•	
	11408L	80/20		23	-11	26			x	12		x	•	•	•	•	x
	11409L	80		25	-12	28			x	12		x	•	•	•	•	x
	11411SC	40		27	-13	30	+		x	12		x	•	•	•	x	•
	11412L	80		27	-13	30			x	12		x	•	•	x	•	•
	11413	40/20		28	-14	31	*		x	12		x	•	•	x	•	•
	11414	40		28	-13	31	+		x	12		x	•	•	•	•	x
	11420L	471		38	-15	41		x		24	x		x		•		•
	11424L	80		30	-13	33			x	24		x	•		•		x
	11425SC	40		30	-14	33	*		x	12		x	•	•	•	•	x
	11426L	80/40		32	-15	35			x	12		x	•	•	•	•	x
	11427SC	40		32	-15	35	*		x	12		x	•	•	x	•	•
	11428SC	40		34	-18	38			x	12		x	•	•	x	•	•
	11429L	80/30		37	-15	40	-		x	24		x		•		x	
	11430SC	40		37	-16	40	*		x	12		x	•	•	•	•	x
	11431L	80		40	-17	43			x	48		x			x		

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	11432SC	50		40	-18	44			x	24		x		•		x	
	11433SC	50		41	-17	44			x	24		x		•		x	
	11434L	180		42	-14	44			x	12		-	•	•	•	•	x
	11438	30/10		40	-11	41			x	48		x			x		
	11439L	80		42	-13	44			x	24		x	•		•		x
	11441	30		42	-14	44			x	12		x	•	•	•	•	x
	11442L	80		42	-15	45			x	12		x	•	•	x	•	•
	11445	40		42	-15	45	*		x	12		x	•	•	•	•	x
	11447	10		42	-14	44			x	12		x	•	•	•	•	x
	11448	40		42	-16	45			x	24		x	•		•		x
	11449	40		42	-18	46			x	24		x		•		x	
	11450L	180		44	-18	48			x	12	x		•	x	•	•	•
	11451SC	80		42	-19	46			x	12		x	•	•	•	•	x
	11452L	80		42	-18	46			x	24		x	•		•		x
SE Atlantic	11460L	467		34	-21	40		x		12	x		•	x	•	•	•
-FL	11462L	80		41	-20	46			x	24		x		•		x	
	11463	40		42	-20	47			x	24		x		•		x	
	11465	40		40	-20	45			x	12		x	•	•	x	•	•
	11466L	80/10		36	-20	41			x	12		x	•	•	•	•	x
	11467SC	40		36	-21	42	*		x	12		x	•	•	•	•	x
	11468	10		40	-20	45	+		x	12		x	•	•	•	•	x
	11470	10		39	-20	44	+		x	12		x	•	•	x	•	•
	11472SC	40/20		32	-21	38	*		x	12		x	•	x	•	•	•
	11474L	80		35	-21	41			x	48		x	•				x
	11475	10		32	-20	38	+		x	24		x	•		x		•
	11476L	80		29	-20	35			x	24		x		x		•	
	11477	60		29	-20	35	+		x	—		-	•			+	
	11478	10		28	-19	34	*		x	24		-	•		x		•
	11480L	450		22	-19	29		x		12	x		•	x	•	•	•
	11484L	80		28	-19	34			x	24		-	•		•		x
	11485SC	40		26	-18	32	*		x	12		-	•	•	•	•	x
	11486L	80		24	-18	30			x	48		-	•			x	
	11488L	80		22	-16	27			x	24		-		•		x	
	11489SC	40		22	-16	27	*		x	12	x		•	x	•	•	•
	11490	40/10		22	-17	28	+		x	48		-		•	x		
	11491SC	20		22	-15	27	*		x	12	x		•	x	•	•	•
	11492	40		23	-15	27	*		x	24		-		•		x	
	11495	40		24	-15	28	*		x	24		-		•	x	•	
-GA	11502L	80		21	-16	26			x	24		-		•		x	
	11503	20		21	-16	26	+		x	24		-	•		•		x
	11504	40		20	-16	26			x	48		-				x	
	11506	40		20	-16	26	+		x	24		-	•		•		x
	11507SC	40		18	-17	25			x	12		-	•	•	x	•	•
	11508	40		19	-17	26	+		x	48		-				x	
	11509L	80		17	-17	24			x	24		-	•		•		x
	11510	40		18	-17	25	+		x	24		-	•		x		•
	11511	40		17	-17	24			x	24		-	•		•		x
	11512	40		17	-18	25	+		x	12		-	•	•	•	•	x
-SC	11513L	80		16	-17	23			x	24	x			x		•	
	11514SC	20		16	-15	22	*		x	12		-	•	•	•	•	x
	11515SC	20		14	-15	21	*		x	24		-		•		x	
	11516	40		17	-18	25	+		x	24		x	•		x		•

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	Corr. Req'd LON	Corr. Req'd Max. Shift	S P C	Action Note	Action Proj	Print Cycle (Mo.)	Compile Man	Compile Auto	Publish (NAD 83) 85	86	87	88	89
	11517	40		16	-18	24			x	24		x		•		x	
	11518SC	40		16	-19	25			x	12		x	•	•	•	•	x
	11519	40		16	-18	24			x	48		x	•				x
	11520L	433		14	-26	30		x		12	x		•	x	•	•	•
	11521L	80		16	-18	24			x	24		x		•		x	
	11522	40		16	-18	24			x	24		x		•		x	
	11523	20		16	-19	25	+		x	24		x		•		x	
	11524	20		16	-19	25	+		x	12		x	•	•	x	•	•
	11526	20		16	-20	26			x	48		x	•				x
	11527	20		16	-20	26	+		x	24		x		•		x	
	11531L	80		15	-20	25			x	24		x		x		•	
	11532	40		15	-20	25	+		x	24		x		x		•	
	11534SC	40		15	-23	27			x	12		x	•	•	x	•	•
	11535L	80		15	-22	27			x	48		x				x	
M Atlantic	11536L	80		14	-24	28			x	48		x				x	
-NC	11537	40		14	-25	29			x	12		x	•	•	x	•	•
	11539L	80		14	-26	30			x	24		-	•		•		x
	11541SC	40		13	-29	32			x	12	x		•	x	•	•	•
	11542	40/10		13	-28	31			x	24		-	•		•		x
	11543L	80		13	-29	32			x	24	x			x		•	
	11544L	80		12	-30	32			x	12		-	•	•	•	•	x
	11545	40/20		13	-30	33	*		x	12		-	•	•	x	•	•
	11547	12		13	-30	33	+		x	12		-	•	•	x	•	•
	11548L	80		12	-30	32			x	12		-	•	•	•	•	x
	11550	40		12	-31	33			x	24	x			x		•	
	11552	40		13	-29	32			x	24		-	•		•		x
	11553SC	40		12	-31	33			x	24	x			x		•	
	11554	40		12	-30	32			x	24		-	•		x		•
	11555L	80		12	-31	33			x	12		-	•	•	x	•	•
	12200	417		10	-34	35		x		12	x		•	x	•	•	•
	12204L	80		12	-31	33			x	24		-		•		x	
	12205SC	40/10		12	-30	32	-		x	12		-	•	•	x	•	•
-VA	12206SC	40		11	-30	32			x	12		-	•	•	•	•	x
	12207	80		11	-30	32			x	24	x			x		•	
	12208	36		11	-30	32			x	—	x		•	+			
	12210L	80/20		10	-31	33			x	12		-	•	•	•	•	x
-MD	12211L	80/20		9	-32	33	*		x	12		-	•	•	x	•	•
-DE	12214L	80		8	-32	33			x	24		-		•		x	
	12216	40/10		8	-31	32	*		x	24		-	•		•		x
-VA	12220L	200		10	-30	32		x		12	x		•	x	•	•	•
	12221L	80		11	-30	32			x	6		-	•	•	x	•	•
	12222	40		11	-30	32	*		x	6	x		•	x	•	•	•
	12224	40		11	-30	32	+		x	24		-		•		x	
	12225L	80		10	-30	32			x	12		-	•	•	x	•	•
	12226	40		10	-30	32	*		x	24		-		•	x	•	
	12228	40		9	-30	31			x	12		-	•	•	x	•	•
-MD	12230L	80		9	-30	31			x	6	x		•	x	•	•	•
	12231	40		9	-30	31	+		x	12		-	•	•	x	•	•
	12233	40		10	-30	32	+		x	12	x		•	x	•	•	•
-VA	12235	40		10	-30	32			x	24		-		•		x	
	12237SC	20		10	-28	30			x	24	x			x		•	
	12238	40		10	-29	31	+		x	12		-	•	•	•	•	x

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	12241	20		11	-30	32			x	24	x			x		•	
	12243	40		10	-29	31			x	24		-		•		x	
	12245	20		11	-30	32	+		x	12		-	•	•	x	•	•
	12248	40/20		11	-30	32	*		x	12	x		•	x	•	•	•
	12251	20		10	-29	31	*		x	24		-		•		x	
	12253	20		11	-30	32	+		x	12		-	•	•	•	•	x
	12254	20		11	-30	32	+		x	12		-	•	•	•	•	x
	12255	5		11	-30	32			x	—	x		+				
	12256	20		11	-30	32			x	12		-	•	•	x	•	•
-MD	12260L	197		8	-29	30		x		12	x		•	x	•	•	•
	12261	40		8	-30	31	*		x	12		-	•	•	•	•	x
	12263L	80		8	-30	31			x	6	x		•	x	•	•	•
	12264	40		8	-29	30	*		x	24		-	•		•		x
	12266	40/10		8	-30	31			x	24	x			x		•	
	12268	40		8	-30	31	*		x	48	x			x			
	12270	40/20		8	-29	30			x	24		-	•		x		•
	12272	40/10		8	-30	31	*		x	12		-	•	•	x	•	•
	12273L	80		8	-30	31	+		x	6		-	•	•	•	•	x
	12274	40		8	-30	31			x	12		-	•	•	•	•	x
	12277	20		8	-30	31	*		x	12		-	•	•	x	•	•
	12278	40/10		8	-30	31	*		x	6	x		•	x	•	•	•
	12281	15		8	-29	30	+		x	12		-	•	•	x	•	•
	12282	25		8	-29	30	+		x	12	x		•	x	•	•	•
	12283	10		8	-29	30	+		x	24		-	•		x		•
	12284	10		8	-29	30	+		x	24		-	•		•		x
-VA	12285SC	80/20		8	-29	30			x	12		-	•	•	x	•	•
	12286	40		8	-28	29	+		x	24	x			x		•	
	12287	20		8	-29	30	+		x	24		-		•		x	
	12288	40		9	-27	28	+		x	24	x			x		•	
	12289	40/20		8	-27	28	*		x	12		-	•	•	x	•	•
	12300L	400		7	-39	40		x		12	x		•	x	•	•	•
-DE	12304L	80		8	-32	33	+		x	12		-	•	•	•	•	x
	12311	40		8	-31	32			x	12	x		•	x	•	•	•
-PA	12312	40		8	-31	32			x	12	x		•	x	•	•	•
	12313	15		7	-31	32			x	12	x		•	•	x	•	•
	12314	20		7	-31	32			x	24	x			•	x	•	
-NJ	12316SC	40		7	-33	34	*		x	12		-	•	•	•	•	x
	12317	10		8	-32	33	+		x	24	x			•	x	•	
	12318L	80/20		8	-33	34	-		x	12		-	•	•	•	•	x
	12323L	80		7	-34	35			x	24		-	•		x		•
	12324SC	40		7	-34	35	*		x	12		-	•	•	•	•	x
NE Atlantic	12326L	80		7	-34	35			x	12	x		•	x	•	•	•
-NY	12327	10		7	-34	35	+		x	6	x		•	x	•	•	•
-NJ	12330	10		7	-34	35			x	12	x		•	x	•	•	•
	12331	15		7	-34	35			x	24		-	•		•		x
	12332	20		7	-34	35	+		x	48	x				x		
	12333	15		7	-34	35	+		x	24	x			x		•	
-NY	12334	10		7	-34	35	+		x	12	x		•	•	x	•	•
	12335	10		7	-34	35	+		x	12		-	•	•	•	•	x
-NJ	12337	20		7	-34	35	*		x	48		-				x	
-NY	12338	5		7	-34	35	+		x	48		-				x	
	12339	10		7	-34	35	+		x	12	x		•	x	•	•	•

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	Corr. Req'd LON	Corr. Req'd Max. Shift	S P C	Action Note	Action Proj	Print Cycle (Mo.)	Compile Man	Compile Auto	Publish (NAD 83) 85	86	87	88	89
	12341	10		7	-34	35	+		x	24	x			•	x	•	
	12342	10		7	-34	35	+		x	48		-		•	x		
	12343	40		6	-34	35	*		x	24		-		•	x	•	
	12345	10		6	-34	35	+		x	48		-			x		
	12346	10		6	-34	35	+		x	48		-				x	
	12347	40		6	-34	35	*		x	24		-	•		•		x
	12348	40		6	-34	35	*		x	24	x			x		•	
	12349	10		7	-34	35	+		x	48		-			x		
	12350	20		7	-34	35	+		x	12	x		•	x	•	•	•
	12352SC	20		7	-34	35	*		x	12		-	•	•	x	•	•
	12353L	80		7	-34	35			x	24	x			x		•	
	12354L	80		6	-35	36			x	12	x		•	x	•	•	•
	12358	40/10		6	-35	36	*		x	24	x			x		•	
	12362	10		6	-35	36			x	48		-				x	
	12363L	80		7	-34	35	+		x	24		-	•		•		x
	12364SC	40		7	-34	35	*		x	12		-	•	•	x	•	•
	12365	20		7	-34	35	+		x	24	x			x		•	
	12366	20		7	-34	35	+		x	24	x			x		•	
	12367	20		7	-34	35	+		x	24		-	•		•		x
-CT	12368	20		7	-34	35	+		x	24	x			x		•	
	12369	20		7	-35	36	+		x	24	x			x		•	
	12370	20		7	-35	36	*		x	24	x			x		•	
	12371	20/10		6	-35	36	*		x	24	x			x		•	
	12372SC	40		6	-35	36			x	12	x		•	x	•	•	•
	12373	20		6	-35	36	+		x	48		-	•				x
	12374	20		6	-35	36	+		x	48		-				x	
	12375	20		6	-35	36	+		x	24	x			x		•	
	12377	20		6	-35	36	+		x	24		-	•		•		x
	13003L	1200		6	-42	42		x		12	x		x	•	•	•	•
	13006L	675		5	-45	45		x		12	x		x	•	•	•	•
-ME	13009L	500		5	-45	45		x		12	x		•	x	•	•	•
-MA	13200L	400		5	-44	44		x		12	x		•	x	•	•	•
	13204L	220		5	-46	46		-		48	x			x			
-NY	13205L	80		6	-39	39	+		x	24		-	•		•		x
	13209	40		6	-39	39	+		x	24	x			x		•	
-CT	13211	20		6	-39	39	+		x	48		-	•				x
	13212	20		6	-39	39	+		x	24		-	•		•		x
	13213	10/5		6	-39	39	*		x	12	x		•	x	•	•	•
	13214	20		6	-39	39			x	24		-	•		•		x
-RI	13215	40		6	-39	39	+		x	24	x		•	x	•		•
	13217	15		6	-40	40	+		x	24	x			x		•	
-MA	13218L	80		6	-40	40	+		x	12	x		•	x	•	•	•
-RI	13219	15		6	-40	40	+		x	48	x			x			
	13221	40		6	-40	40	+		x	12	x		•	x	•	•	•
	13223	20		6	-40	40	+		x	12	x		•	x	•	•	•
	13224	20		6	-40	40	*		x	12	x		•	x	•	•	•
	13225	10		6	-40	40	*		x	48		-	•				x
-MA	13227	10/2		6	-40	40	*		x	24	x			x		•	
	13228	20		6	-40	40	+		x	48		-		•	x		
	13229SC	40		6	-40	40	+		x	12	x		•	x	•	•	•
	13230	40		6	-41	41	+		x	12	x		•	x	•	•	•
	13233	40/20		6	-41	41	*		x	24	x			x		•	

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	13235	5		6	-41	41			x	12	x		.	x	.	.	.
	13236	20		6	-41	41	+		x	24	x			x		.	
	13237L	80		6	-42	42	+		x	12	x		.	x	.	.	.
	13238	20/10		6	-43	43	*		x	24		-	.		.		x
	13241	40		6	-43	43			x	24		-		.		x	
	13242	10		6	-43	43	+		x	48		-			x		
	13244	40		6	-43	43	+		x	24		-	.		.		x
	13246L	80		5	-43	43	+		x	12	x		.	x	.	.	.
	13248	20		5	-43	43	+		x	48		-	.				x
	13249	20		5	-43	43	+		x	24	x			x		.	
	13250	40/10		5	-43	43	*		x	48		-	.				x
	13251	20		5	-43	43	+		x	24	x			x		.	
	13253	20/10		5	-42	42	*		x	24		-	.		.		x
	13260L	378		4	-46	46		x		12	x		x		.	.	.
	13267L	80/20		5	-41	41	*		x	12		-	.	.	.	.	x
	13269	10		5	-41	41	+		x	48		-	.				x
	13270	25		5	-40	40	+		x	12		-	.	.	.	.	x
	13272	10		5	-40	40	+		x	24		-		.	x	.	
	13274SC	40		5	-41	41			x	12	x		.	x	.	.	.
	13275	25/10		5	-40	40	*		x	12	x		.	x	.	.	.
	13276	10		5	-40	40	+		x	24	x			x		.	
	13278L	80/30		5	-41	41	*		x	24		-	.		.		x
	13279	20/5		5	-41	41	*		x	12		-	.	.	.	.	x
	13281	10		5	-41	41	+		x	24	x			x		.	
	13282	20		5	-40	40	+		x	48		-			x		
-NH	13283	20/10		4	-40	40	*		x	24		x		x		.	
	13285	20		4	-40	40	*		x	48		x			x		
-ME	13286L	80/10		4	-42	42	-		x	12		x	.	x	.	.	.
	13287	20		4	-42	42	+		x	48		x	.				x
	13288L	80		4	-43	43	+		x	12		x	.	x	.	.	.
	13290	40		4	-42	42	+		x	12		x	.	x	.	.	.
	13292	20		4	-42	42			x	24		x	.	x	.		.
	13293	40/10		4	-43	43	*		x	24		x		x		.	
	13295	15		4	-43	43	+		x	48		x		.	x		
	13296	15		4	-43	43	+		x	24		x	x		.		.
	13298	15		4	-43	43	+		x	48		x		.	x		
	13301	40/10		4	-43	43	*		x	48		x				x	
	13302L	80		4	-44	44	+		x	24		x	.		.		x
	13303	40		4	-45	45	+		x	48		x			x		
	13305	40/20		4	-44	44	*		x	24		x		x		.	
	13307	20		4	-44	44	+		x	48		x			x		
	13308	15		4	-45	45	+		x	24		x	x		.		.
	13309	40/10		4	-45	45	*		x	24		x		x		.	
	13312L	80		4	-45	45	+		x	24		x		x		.	
	13313	40		4	-45	45	+		x	24		x		x		.	
	13315	20		4	-45	45	*		x	48		x				x	
	13316	40/20		4	-45	45	*		x	24		x	.		.		x
	13318	40		4	-46	46	+		x	24		x	x		.		.
	13321	10		4	-46	46	*		x	48		x		x			
	13322	10		4	-46	46	+		x	48		x	x				.
	13323	10		4	-46	46	+		x	48		x		x			
	13324	40		4	-47	47	+		x	48		x	x				.

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	13325L	80		4	-49	49	+		x	48		x		x			
	13326	40		4	-48	48	+		x	48		x				x	
	13327	40		3	-49	49	+		x	24		x		x		•	
	13328	40/5		3	-50	50	*		x	12		x	•	x	•	•	•
Great Lakes	14500L	1500		-2	-10	10		x		60	x				x		
-SLR	14761	30		+2	-30	30			x	36		-				x	
	14762	30		2	-30	30			x	36		-	•			x	
	14763	30		2	-29	29			x	36		-	•			x	
	14764	30/15		2	-28	28			x	36		-	•			x	
	14765	30		2	-27	27			x	36		-	•			x	
	14766	30/10		2	-26	26			x	36		-	•			x	
	14767	30/10		2	-26	26			x	36		-	•			x	
	14768	30		2	-26	26			x	36		-	•			x	
	14770	15		2	-28	28			x	36		-	•			x	
	14771	15		2	-27	27			x	36		-	•			x	
	14772	15		2	-26	26			x	36		-	•			x	
	14773	15		2	-26	26			x	36		-	•			x	
	14774	15		2	-26	26			x	36		-	•			x	
-LC	14781	40		3	-34	34			x	36		-	•			x	
	14782	40	02						x	36		-			x		
	14783	40		4	-34	34			x	36		-	•			x	
	14784	40	02						x	36		-			x		
	14785	10	02						x	36		-	•			x	
-BC	14786RC	170/20	None						x	36		-	•			x	
	14788	40	02						x	36		-	•			x	
	14791	60/10	02						x	36		-			x		
-LO	14800L	400		2	-23	23		x		36		-			x		
	14802L	80	02						x	36		-			x		
	14803L	80/15		3	-25	25			x	36		-			x		
	14804L	80/15	02						x	36	x			x		•	
	14805L	80/10	02						x	36		-	•			x	
	14806L	80/10	02						x	36		-			x		
	14810	100/10		1	-18	18			x	36		-				x	
	14811	30/5	02						x	36		-			x		
	14813	10		3	-26	26			x	36		-	•			x	
	14814	10	02						x	36				x			•
	14815	10		2	-23	23			x	36		-	•			x	
	14816	30	02						x	36		-	•			x	
-LE	14820L	400		1	-13	13		x		12	x		x	•	•	•	•
	14822L	80	02					-		24	x			x		•	
	14823L	120/5	02						x	36		-			x		
	14824L	80/10	02						x	36		-				x	
	14825L	80/10	02						x	36		-	•			x	
	14826L	80/5	02						x	36		-	•			x	
	14828L	100		2	-15	15		x		36		-			x		
	14829L	100/7		2	-12	12			x	36	x			x			•
	14830L	100/10		1	-8	8			x	12	x		•	x	•	•	•
	14832	30	02						x	36		-	•			x	
	14833	15		2	-20	20			x	36		-	•			x	
	14835	15	02						x	36		-	•			x	
	14836	5	02						x	36		-	•			x	
	14837	8		2	-13	13			x	36	x			x			•

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	14839	10		2	-11	11			x	36		-	.			x	
	14841	10		1	-10	10			x	36		-	.		x	.	
	14842RC	300/5		1	-8	8			x	36		-	.			x	
	14843	5		1	-9	9			x	36	x		.	x		.	
	14844	40/10	02						x	24		-	.		x		.
	14845	10	02						x	36		-	.			x	
	14846RC	300/5		1	-8	8			x	36	x			x			.
	14847	20		1	-7	7			x	36		-	.			x	
-DR	14848	30		0	-7	7		-		12	x		.	x	.	.	.
	14849SC	30		0	-7	7		-		36		-	.			x	
-LSC	14850L	60		0	-8	8		x		12	x		.	x	.	.	.
	14851SCL	60		0	-8	8		x		36		-	.			x	
-SCR	14852	40/15		0	-9	9			x	12		-	.	.	.	x	.
	14853RC	120/15		0	-8	8			x	36		-	.			x	
-DR	14854	15/10	02						x	36		-		.			x
-LH	14860L	500		-1	-9	9		x		24	x			x		.	
	14862L	120/5		0	-10	10			x	36		-	.			x	
	14863L	120/10		-1	-3	3		-		24		-	.		.		x
	14864L	120/12	02						x	36		-	.			x	
	14865	15		0	-10	10			x	36		-			x		
	14867	20		-2	-2	3		x		36	x			x			.
	14869	60/10		-2	-3	4			x	36	x			x			.
	14880L	120	02					-		36		-	.			x	
	14881L	80/10		-3	0	3		x		36		-	.			x	
-SMR	14882	40/20		-3	-1	3		x		36		-	.			x	
	14883	40		-3	0	3		x		36	x		x			.	
	14884	40/20		-4	0	4		x		36	x			x			.
-LH	14885	20		-3	0	3		x		36	x			x			.
	14886RC	50/15		-3	0	3		x		36	x		x				.
-LM	14900L	500		-3	+4	5		x		24	x			x		.	
	14901L	500		-3	4	5		x		24	x		x		.		.
	14902L	240	02					x		24	x			x		.	
	14903L	120/10		-4	5	6			x	36		-			x		
	14904L	120/5		-3	5	6			x	36		-	.			x	
	14905L	120/15	02						x	24		-	.		x		.
	14906L	120/10	02						x	36		-			x		
	14907L	120/10	02						x	36		-	.			x	
	14908L	80/15	02						x	36		-			x		
	14909L	80/20	02					-		36		-	.			x	
	14910L	80/10	02						x	36		-	.			x	
	14911L	80/10	02						x	36		-	.			x	
	14912L	80/5		-4	3	5			x	36	x			x			.
	14913L	80/10		-4	2	4			x	36		-			x		
	14915	30	02						x	36	x			x			.
	14916RC	80/5		-4	7	8			x	24	x		.	x	.		.
	14917	15	02						x	36		-	.			x	
	14918	25/10	02						x	36		-	.			x	
	14919	30/10	02						x	36		-	.			x	
	14922	10	02						x	36	x			x			.
	14924	10		-3	6	7			x	36		-			x		
	14925	10		-3	6	7			x	36		-			x		
	14926RC	60/10		-2	4	4			x	24	x			x		.	

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	14927	60/15		-2	4	4		-		24	x		x		.		.
	14928	15	02						-	36		-			x		
	14929	15	02						-	36	x			x			.
	14930	10		-1	3	3			x	36		-			x		
	14932	15		-2	3	4			-	36		-	.			x	
	14933	15		-2	3	4			-	36		-			x		
	14934	15		-2	3	4			-	36	x			x			.
	14935	10		-2	3	4			-	36		-	.			x	
	14937	5		-3	4	5			x	36		-	.			x	
	14938	10		-3	4	5			x	36		-	.			x	
	14939	10		-4	4	6			x	36		-	.			x	
	14942	30/10	02						x	36		-	.			x	
-LS	14960L	600		-5	5	7		x		36	x				x		
	14961L	600		-5	5	7		x		36		-	.			x	
	14962L	120/5		-4	0	4			x	36		-	.			x	
	14963L	120/5	02						x	36		-	.			x	
	14964L	120/5	02						x	36		-			x		
	14965L	120/2	02						x	36	x			x			.
	14966L	120/5	02						x	36	x			x			.
	14967L	120/10	02						x	36		-	.			x	
	14968L	120		-5	8	9		x		36	x		x			.	
	14969	30/15	02						x	36		-	.			x	
	14970	15	02						x	36		-	.			x	
	14971	30/10		-6	8	10			x	36		-			x		
	14972	30/10	02						x	36	x			x			.
	14973	60/10		-7	10	12			x	36		-	.			x	
	14974	15	02						x	36		-	.			x	
	14975	15	02						x	36	x			x			.
	14976	40		-5	8	9		x		36	x			x			.
-CM	14982	42		-6	10	12			x	144		-				x	
	14983	42		-6	10	12			x	144		-				x	
	14984	42		-6	10	12			x	144		-				x	
	14985	42		-6	10	12			x	144		-				x	
	14986	42		-6	11	13			x	144		-				x	
	14987	42		-6	11	13			x	144		-				x	
	14988	42		-6	12	13			x	144		-				x	
	14989	42		-6	12	13			x	144		-				x	
	14990	10		-6	12	13			x	144		-				x	
	14991	42		-6	13	14			x	144		-				x	
	14992	42		-6	14	15			x	144		-					x
	14993	42		-6	15	16			x	144		-					x
	14994	42		-5	15	16			x	144		-					x
	14995	42		-5	16	17			x	144		-					x
-RL	14996	25/12		-5	15	16			x	36		-	.			x	
	14997	25		-5	16	17			x	36		-	.			x	
	14998	25		-5	17	18			x	36		-			x		
-LW	14999	120/20		-4	19	19			x	36		-	.			x	
Artic Ocean	16003	1587		-55	+124	136		x		48	x			x			
	16004L	700		-39	120	126		x		48	x			x			
	16005L	700		-65	120	144		x		48	x				x		
Pacific-AK	16006L	1534		-89	132	159			x	24	x			.		x	
	16011L	1023		-104	137	172		x		24	x		x		.		.

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	16012L	1126		-156	151	217		x		48	x			x			
-GAK	16013L	969		-72	123	143			x	24	x				x		
	16016L	969		-41	102	110		x		24	x		x		.		.
Artic-AK	16041	51		-22	115	117			x	144	x		x		.		
	16042	51		-24	116	118			x	144	x			x			
	16043	50/20		-26	117	120			x	144	x			x			
	16044	50		-29	118	122			x	144	x						x
	16045	50		-32	119	123			x	144	x						x
	16046	50		-34	119	124			x	144	x			x			.
	16061	50		-36	120	125			x	144	x						x
	16062	49		-38	120	126			x	144	x						x
	16063	49		-40	121	127			x	144	x						x
	16064	49		-44	122	130			x	144	x						x
	16065	49		-45	122	130			x	144	x						x
	16066	48		-48	123	132			x	144	x						x
	16067	48		-50	123	133			x	144	x						x
	16081	48		-52	124	134			x	144	x						x
	16082	47		-54	124	135			x	144	x					x	
	16083	50		-56	125	137			x	144	x			x			
	16084	50		-58	125	138			x	144	x				x		
	16085	50		-60	126	140			x	144	x				x		
	16086	50		-61	126	140			x	144	x					x	
	16087	50		-63	127	142			x	144	x				x		
	16088	50		-66	127	143			x	144	x				x		
	16101	50		-68	128	145			x	144	x					x	
	16102	50		-70	128	146			x	144	x				x		
	16103	50		-72	129	148			x	144	x				x		
	16104	50		-74	129	149			x	144	x				x		
	16121	50		-74	130	150			x	144	x				x		
	16122	50		-75	130	150			x	144	x				x		
	16123	50		-76	130	151			x	144	x				x		
	16124	50		-76	130	151			x	144	x				x		
Pacific-AK	16200L	400		-85	130	155			x	144	x						x
	16204L	100		-85	131	156			x	144	x					x	
	16206	20/2		-85	130	155			x	144	x						x
	16240L	300/40		-86	129	155			x	24	x			x		.	
	16300L	200/80		-93	130	160			x	96	x			.	x		
	16322L	100/10		-88	131	158			x	96	x						x
	16323L	100		-86	131	157			x	96	x						x
	16343L	80		-91	133	161			x	96	x			.		x	
	16363L	80		-93	135	164			x	96	x		.				x
	16380L	200		-117	138	181			x	48	x					x	
	16381	50		-117	138	181			x	144	x						x
	16382	50		-117	138	181			x	144	x						x
	16420L	300		-145	136	199			x	48	x			x			
	16421L	160		-145	136	199			x	144	x						x
	16430	40		-144	134	197			x	144	x						x
	16431	20		-144	135	197			x	144	x					x	
	16432	25		-144	135	197			x	144	x				x		
	16433	20/5		-144	135	197			x	144	x						x
	16434	40		-145	136	199			x	144	x						x
	16435	20		-146	137	200			x	144	x						x

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	16436	20/5		-146	137	200			x	144	x						x
	16440L	300		-149	145	208			x	48	x				x		
	16441L	80		-149	145	208			x	144	x					x	
	16442	20		-149	145	208			x	144	x						x
	16446	10		-151	149	212			x	144	x				x		
	16460L	300		-152	155	217			x	48	x					x	
	16462	50		-153	154	217			x	144	x				x		
	16463	50		-152	155	217			x	144	x						x
	16471L	120/20		-150	158	218			x	48	x		.	x			
	16474	12/6		-150	158	218			x	144	x			x			
	16475	30		-150	158	218			x	144	x						x
	16476	10		-150	158	218			x	144	x						x
	16477	30		-150	158	218			x	144	x					x	
	16478	30/10		-150	158	218			x	144	x						x
	16480L	300/20		-140	152	207			x	48	x			x			
	16484	30		-148	160	218			x	144	x				x		
	16486	40		-146	160	217			x	144	x						x
	16487	40/10		-144	158	214			x	144	x						x
	16490	20		-140	152	207			x	144	x						x
	16500L	300		-114	140	181			x	48	x				x		
	16501L	80		-117	142	184			x	96	x						x
	16511	40/10		-114	140	181			x	96	x			x			
	16513	40		-111	140	179			x	96	x			.	x		
	16514	40		-110	140	178			x	96	x				x		
	16515	40		-110	140	178			x	96	x				x		
	16516	10		-110	140	178			x	96	x			x			
	16517	40		-108	137	176			x	96	x				x		
	16518	40		-108	137	176			x	96	x				x		
	16520L	300		-101	137	170			x	96	x			x			
	16521	40		-106	139	175			x	96	x			x			
	16522	40		-105	139	174			x	96	x			x			
	16528	40		-106	139	175			x	96	x						x
	16529	10		-106	139	175			x	96	x						x
	16530	10		-106	139	175			x	96	x						x
	16531L	80		-104	138	173			x	96	x				x		
	16532	20		-104	138	173			x	96	x			.	x		
	16535L	80		-99	137	169			x	96	x		.				x
	16540L	300/15		-94	135	165			x	48	x		.				x
	16547L	81/20		-98	136	168			x	96	x			x			
	16549L	80/5		-98	136	168	-		x	96	x						x
	16551L	80		-95	135	165			x	96	x			x	.		
	16553L	80/20		-94	135	165			x	48	x				x		
	16556L	80/20		-92	134	163			x	48	x				x		
	16566L	77/40		-87	133	159			x	48	x			x			
	16568L	106		-85	133	158			x	96	x				x		
	16570	50		-83	132	156			x	48	x		.				x
	16580L	350/53		-81	130	153			x	48	x		.				x
	16590L	81		-81	130	153			x	48	x				x		
	16591	20		-81	130	153			x	48	x		.				x
	16592L	80/20		-80	130	153			x	48	x		.				x
	16593L	80		-79	129	151			x	48	x				x		
	16594	78/20		-79	129	151			x	48	x		.				x

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	16595	20/10		-79	129	151			x	48	x			.	x		
	16596	10		-79	129	151			x	48	x			.	x		
	16597L	80		-80	130	153			x	48	x			x			
	16598L	80		-81	130	153			x	48	x		.				x
	16599	20		-81	130	153			x	96	x						x
	16601L	80		-81	130	153			x	48	x			x			
	16603	30		-81	130	153			x	48	x				x		
	16604L	78		-78	127	149			x	48	x				x		
	16605	20		-79	128	150			x	48	x				x		
	16606L	77		-78	127	149			x	48	x		.				x
	16608L	80		-79	129	151			x	48	x				x		
	16640L	200/5		-75	126	147			x	24	x		.		.		x
	16645	82/10		-73	125	145	-		x	48	x				x		
	16646	20		-73	125	145			x	48	x		.				x
	16648L	100/50		-78	127	149			x	24	x		.		x		.
	16660L	194/40		-70	123	142	-		x	12	x		.	x	.	.	.
	16662L	100/50		-72	123	143			x	24	x		.		x		.
	16664	40/15		-78	122	145			x	24	x		.		x		.
	16680L	200		-70	122	141			x	48	x		.				x
	16681L	83		-70	123	142			x	48	x		.				x
	16682L	81/10		-69	121	139			x	48	x			x			
	16683L	81		-65	120	136			x	48	x		.				x
	16700L	200		-62	117	132			x	48	x				x		
	16701	81		-64	118	134			x	48	x					x	
	16702	40		-65	119	136			x	48	x		.				x
	16704	20		-65	118	135			x	48	x		.				x
	16705L	80		-65	118	135			x	48	x			x			
	16706	20/10		-66	119	136			x	48	x					x	
	16707	40/10		-61	116	131			x	12	x		.	x	.	.	.
	16708L	79/40		-62	116	132			x	24	x			x		.	
	16709L	80		-60	115	130			x	48	x		.				x
	16710	30		-60	115	130			x	48	x				x		
	16723L	100		-58	111	125			x	48	x		.				x
	16741	40		-42	106	114			x	48	x		.		x		.
	16760L	300		-41	103	111			x	48	x		.				x
	16761L	80/10		-40	102	110			x	48	x					x	
	16762	20/10		-40	102	110			x	48	x			.	x		
	17300L	209		-37	100	107			x	24	x			x		.	
	17301	40		-40	101	109			x	96	x				x		
	17302	80/10		-40	101	109			x	48	x		.				x
	17303	40/10		-40	101	109			x	48	x		.		x		.
	17313	40		-36	99	105			x	48	x		.				x
	17314	20		-37	99	106			x	96	x						x
	17315	40/10		-37	100	107			x	24	x		.		x		.
	17316	80/20		-37	100	107			x	48	x			.	x		
	17317	80/10		-37	100	107			x	24	x		.		x		.
	17318	80/10		-38	100	107			x	24	x		.		x		.
	17320L	217		-42	102	110			x	24	x		.		.		x
	17321	40		-40	101	109			x	48	x			x			
	17322	40/10		-40	101	109			x	48	x		.				x
	17323	40/20		-41	101	109			x	48	x			.	x		
	17324	40/10		-41	101	109			x	48	x					x	

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	17325	40		-41	102	110			x	48	x			•	x		
	17326	40/5		-42	102	110			x	48	x		•				x
	17327	10/5		-42	103	111			x	24	x		•		x		•
	17328	40		-43	103	112			x	48	x		•				x
	17330	20		-44	104	113			x	48	x		•				x
	17331	10		-43	104	113			x	48	x		•				x
	17333	20		-42	103	111			x	48	x		•				x
	17335	20		-42	103	111			x	48	x		•				x
	17336	20		-42	103	111			x	48	x		•				x
	17337	40/20		-41	102	110			x	48	x		•				x
	17338	40		-41	102	110			x	24	x		x		•		•
	17339	30/10		-41	102	110			x	48	x				x		
	17341	20		-41	103	111			x	48	x			x			
	17360	217/20		-40	100	108			x	12	x		•	x	•	•	•
	17362	40		-40	100	108			x	48	x		•				x
	17363	40		-39	100	107			x	96	x						x
	17365	20		-39	100	107			x	96	x						x
	17367	40		-39	100	107			x	48	x		•				x
	17368	40/15		-40	101	109			x	48	x				x		
	17370	20/10		-40	101	109			x	48	x					x	
	17372	20/10		-40	100	108			x	48	x				x		
	17375	20/10		-39	100	107			x	48	x			x			
	17376	40		-40	101	109			x	48	x		•				x
	17378	20		-40	101	109			x	48	x			x			
	17381	20		-40	101	109			x	48	x		•				x
	17382	80/20		-39	101	108			x	48	x		•				x
	17384	20/10		-39	100	107			x	48	x					x	
	17385	80/20		-38	100	107			x	24	x			x		•	
	17386	40		-40	101	109			x	48	x			•	x		
	17387	40/10		-40	101	109			x	48	x		•				x
	17400L	229		-44	104	113			x	48	x		•				x
	17401	10		-40	101	109			x	48	x		•				x
	17402	40		-42	102	110			x	48	x			x			
	17403	40/10		-41	102	111			x	48	x			x			
	17404	40		-43	103	112			x	96	x						x
	17405	40/10		-42	103	111			x	48	x					x	
	17406	40		-44	104	113			x	48	x		•				x
	17407	40		-43	103	112			x	48	x		•				x
	17408	40		-43	104	113			x	48	x		•				x
	17409	40		-43	105	113			x	48	x		•				x
	17420L	229		-40	103	110			x	24	x		•		x		•
	17422	79/40		-40	101	109			x	48	x		•				x
	17423	40/10		-40	101	109			x	48	x		•				x
	17424	80		-39	101	108			x	48	x				x		
	17425	80		-37	100	107			x	48	x		•				x
	17426	40/10		-40	102	110			x	24	x		•		x		•
	17427	80		-38	101	108			x	48	x					x	
	17428	40/10		-40	101	109			x	48	x					x	
	17430	10		-40	102	110			x	48	x				x		
	17431	40		-41	103	111			x	48	x		•				x
	17432	40		-40	102	110			x	48	x		•				x
	17433	40		-40	103	111			x	48	x				x		

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	Corr. Req'd LON	Corr. Req'd Max. Shift	SPC	Action Note	Action Proj	Print Cycle (Mo.)	Compile Man	Compile Auto	Publish (NAD 83) 85	86	87	88	89
	17434	80/20		-40	102	110			x	48	x		.				x
	17435	40/5		-40	102	110			x	48	x				x		
	17436	40		-40	102	110			x	48	x		.				x
	17437	40		-39	102	109			x	48	x		.				x
-W CST	18003L	736		-26	100	103		x		24	x		.		x		.
	18007L	1200		-20	100	102		x		24	x			x		.	
	18010L	811		-18	97	99		x		24	x			x		.	
	18020L	1444		-12	95	96		x		24	x		x		.		.
	18022L	868		-8	90	90		x		12	x		x	.	.	.	.
	18400	200		-24	95	98			x	12	x		.	x	.	.	.
-WA	18421	80/30		-24	94	97			x	12	x		.	x	.	.	.
	18423SC	80/30		-23	93	96			x	12	x		.	x	.	.	.
	18424	40/20		-23	93	96			x	48	x				x		
	18427	25		-23	93	96			x	24	x		.		x		.
	18428	10		-23	93	96			x	48		-	.				x
	18429	25		-23	93	96	+		x	24	x		.		x		.
	18430	25		-23	93	96	+		x	24	x		.		x		.
	18431	25		-23	93	96	+		x	24	x		.		x		.
	18432	25		-24	94	97	+		x	24	x		.		x		.
	18433	25		-24	94	97	+		x	24	x		.		x		.
	18434	25		-23	93	96			x	24	x		.	x	.		.
	18440	150		-23	94	97			x	12	x		.	x	.	.	.
	18441	80		-23	93	96			x	12	x		.	x	.	.	.
	18443	40		-22	93	95			x	48	x			.	x		
	18444	10		-22	93	95	+		x	24	x			x		.	
	18445SC	80		-23	94	97			x	12	x		.	x	.	.	.
	18446	25/10		-23	93	96			x	24	x			x		.	
	18447SC	10		-22	92	94	*		x	24	x			x		.	
	18448	80		-23	93	96			x	12	x		.	x	.	.	.
	18449	25		-23	93	96			x	24	x			x		.	
	18450	10		-23	93	96	*		x	24	x		x		.		.
	18452	10		-23	93	96			x	48		-	.				x
	18453	15		-23	93	96			x	24	x			.		x	
	18456	20		-23	94	97			x	48	x					x	
	18457	10		-23	94	97			x	48	x				x		
	18458	25		-23	94	97			x	24	x		.		x		.
	18460	100		-25	98	101			x	24	x			x		.	
	18464	20		-24	94	97			x	24	x			x		.	
	18465	80		-24	95	98			x	12	x		.	x	.	.	.
	18468	10		-24	95	98			x	48	x					x	
	18471	40		-24	94	97			x	12	x		.	x	.	.	.
	18473	40		-23	93	96			x	12	x		.	x	.	.	.
	18474	40		-23	93	96			x	12	x		.	x	.	.	.
	18476	40		-24	94	97			x	12	x		.	x	.	.	.
	18477	25		-23	93	96			x	12	x		.	x	.	.	.
	18480L	176/10		-25	98	101			x	24	x			x		.	
	18484	10		-25	97	100	+		x	48	x					x	
	18485	40		-25	97	100			x	48	x					x	
	18500L	180		-25	98	101			x	24	x		.		x		.
	18502	40/10		-24	97	100	*		x	12	x		.	x	.	.	.
	18504	40		-24	97	100			x	12	x		.	x	.	.	.
-OR	18520L	185/30		-24	97	100			x	24	x		.		x		.

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
-OR	18521	40/20		-24	97	100	*		x	12	x		•	•	•	x	•
	18523	40		-24	96	99	+		x	12	x		•	•	•	x	•
	18524	40		-22	95	98	+		x	12	x		•	•	•	x	•
	18526	20/10		-22	95	98	*		x	12	x		•	•	•	x	•
	18527	5		-22	95	98			x	24		-	•		•		x
	18528	15		-23	95	98			x	48		-	•				x
	18531	40/10		-20	92	94	*		x	24	x		•		x		•
	18533	20		-20	90	92	*		x	24	x		•		x		•
	18535	20		-20	90	92	*		x	24	x			x		•	
	18536	20		-20	89	91	*		x	48	x			x			
	18537	20		-19	87	89	*		x	48	x			x			
	18539	20		-19	85	87	*		x	48		-	•				x
	18541	20		-18	85	87	*		x	48	x					x	
	18542	20		-18	85	87	*		x	48	x			x			
-WA	18545SC	20		-18	84	86	+		x	24	x		•		x		•
	18546SC	20		-18	83	85	*		x	24	x		•		x		•
	18547SC	20		-17	82	84	+		x	24	x			•		x	
	18548SC	20		-16	80	82			x	24		-	•		•		x
	18551	50		-17	82	84			x	48		-	•				x
	18553	50		-16	81	83			x	48		-	•				x
-ID	18554	50		-15	78	79			x	48	x				x		
-OR	18556	20		-24	96	99	+		x	48	x			•	x		
	18558	20		-24	96	99	+		x	48	x					x	
	18561	50/10		-22	97	99			x	24	x			•		x	
	18580L	191		-22	97	99			x	24	x		•		x		•
	18581	10		-22	97	99	*		x	24	x			•		x	
	18583	20		-22	97	99	+		x	24	x		•		x		•
	18584	20		-22	97	99	+		x	24	x		•		x		•
	18587	20		-22	97	99			x	12	x		•	•	•	x	•
	18588	10		-22	97	99	+		x	48		-	•				x
	18589	40/5		-21	98	100			x	48	x			•	x		
	18600L	196		-20	97	99			x	48	x					x	
	18601	40		-21	97	99			x	48		-	•				x
	18602	40/10		-21	97	99	-		x	48	x			x			
-CA	18603	40/10		-20	97	99	-		x	48	x					x	
	18605	15		-20	97	99	+		x	48	x				x		
	18620L	200/10		-19	96	98			x	24	x		•		x		•
	18622	25		-20	97	99	+		x	24	x		•		x		•
	18623	40		-19	97	99			x	48	x				x		
	18626	40/10		-18	95	97	-		x	48		-					x
	18628	10		-18	95	97			x	48	x				x		
	18640L	207		-16	95	96			x	24	x			•		x	
	18643	30/10		-16	95	96	-		x	24	x			•		x	
	18645L	100/20		-16	94	95			x	24	x			•		x	
	18647	40		-16	93	94			x	48		-	•				x
	18648	20		-16	93	94			x	—	x		•	+			
	18649	40		-15	93	94	+		x	12	x		•	•	•	x	•
	18650	20		-15	93	94	*		x	12	x		•	•	•	x	•
	18651	40/20		-14	93	94	-		x	12	x		•	•	•	x	•
	18652SC	40		-15	93	94			x	12	x		•	•	•	x	•
	18654	40		-15	93	94	*		x	12	x		•	•	•	x	•
	18655	10		-15	93	94	+		x	24	x			•		x	

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	LON	Max. Shift	S P C	Action Note	Proj	Print Cycle (Mo.)	Compile Man	Auto	Publish (NAD 83) 85	86	87	88	89
	18656	40		-15	92	93			x	12	x		.	.	.	x	.
	18657	10		-15	92	93	+		x	48	x					x	
	18658	10		-15	92	93	+		x	12	x		.	.	.	x	.
	18659	10		-15	91	92	+		x	48	x			x			
	18661SC	40		-15	91	92	*		x	12	x		.	.	.	x	.
	18662SC	40		-16	91	92			x	24	x			x		.	
	18664	20		-16	91	92			x	24	x		.		x		.
	18665	40		-14	81	88			x	48	x			.	x		
	18680L	210		-13	92	93			x	24	x			.	x	.	
	18682	20		-14	92	93	+		x	48	x				x		
	18685	50/10		-12	92	93	-		x	24		-	.		.		x
	18686	40		-11	92	93			x	48	x				x		
-NV	18687SC	48		-3	75	75			x	24	x		.		x		.
-CA	18700L	216		-7	90	90			x	24	x			x		.	
	18703	40/10		-7	90	90	-		x	12	x		.	x	.	.	.
	18704	20		-7	90	90			x	48	x					x	
	18720L	232		-4	90	90			x	24	x			x		.	
	18721L	100		-4	89	89			x	48	x			x			
	18722	25		-4	89	89			x	—	x					+	.
	18723	25		-4	89	89			x	—	x						+
	18725	50/12		-4	87	87	*		x	12	x		.	.	.	x	.
	18727	40/20		-4	89	89			x	24	x			x		.	
	18728	40		-4	88	88			x	48	x			.	x		
	18729	40/20		-4	87	87			x	24	x			x		.	
	18740L	234		0	84	84			x	12	x		.	x	.	.	.
	18744	40/10		-2	85	85	-		x	24	x		.		x		.
	18746L	80		0	84	84	-		x	12	x		.	.	.	x	.
	18749	20/12		-1	84	84	-		x	12	x		.	.	.	x	.
	18751	12		-1	84	84			x	12	x		.	.	.	x	.
	18754	10		-1	83	83			x	48		-	.				x
	18755	40		0	86	86			x	48	x				x		
	18756	20		-1	85	85			x	48		-	.				x
	18757	40/10		0	84	84			x	48	x				x		
	18762	40		+1	84	84			x	24	x			.		x	
	18763	20/5		1	84	84			x	48		-	.				x
	18764	15		1	84	84			x	48	x					x	
	18765L	100/20		2	82	82			x	48	x				x		
	18722	20		2	82	82			x	12	x		.	.	.	x	.
	18733	12		2	82	82			x	12	x		.	.	.	x	.
	18774L	100/15		0	83	83			x	12	x		.	.	.	x	.
-HI	19004L	600	OHD	-360	-285	460			x	24	x			.		x	
	19007L	1650	OHD	-360	-285	460			x	24	x		.		x		.
	19010L	675	OHD	-360	-285	460			x	24	x		.		x		.
	19013L	675	OHD	-360	-285	460			x	24	x		.		x		.
	19016L	663/20	A	-360	-285	460			x	48	x			x			
	19019L	653	A	-360	-285	460			x	48	x		.				x
	19022L	642	A	-360	-285	460			x	48	x		.				x
	19320L	250	OHD	-360	-285	460			x	48	x			x			
	19322	2	OHD	-360	-285	460			x	48	x				x		
	19324	10	OHD	-360	-285	460			x	48	x				x		
	19326	5	OHD	-360	-285	460			x	48	x					x	
	19327L	80/5	OHD	-360	-285	460	-		x	48	x		.				x

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	Corr. Req'd LON	Corr. Req'd Max. Shift	S P C	Action Note	Action Proj	Print Cycle (Mo.)	Compile Man	Compile Auto	Publish (NAD 83) 85	86	87	88	89
	19329	5	OHD	-360	-285	460			x	48	x		•				x
	19330	10	OHD	-360	-285	460			x	48	x				x		
	19331	5	OHD	-360	-285	460			x	48	x		•				x
	19332	10	OHD	-360	-285	460			x	48	x		•				x
	19340L	250	OHD	-360	-285	460			x	24	x		•		x		•
	19341	5	OHD	-360	-285	460			x	48	x		•				x
	19342	30/10	OHD	-360	-285	460			x	48	x		•				x
	19347L	80	OHD	-360	-285	460			x	24	x			◦		x	
	19348	15	OHD	-360	-285	460			x	48	x		•				x
	19350	10	OHD	-360	-285	460			x	48	x					x	
	19351L	80/5	OHD	-360	-285	460			x	48	x			x			
	19353	5	OHD	-360	-285	460			x	48	x					x	
	19357L	80	OHD	-360	-285	460			x	24	x		•		x		•
	19358	20	OHD	-360	-285	460			x	12	x		•	•	•	x	•
	19359	15	OHD	-360	-285	460			x	48	x			•	x		
	19361	10	OHD	-360	-285	460			x	48	x		•				x
	19362	20	OHD	-360	-285	460			x	48	x			•	x		
	19364	20	OHD	-360	-285	460			x	24	x		•		x		•
	19367	5	OHD	-360	-285	460			x	24	x		•		x		•
	19380L	247	OHD	-360	-285	460			x	48	x		•				x
	19381L	80	OHD	-360	-285	460			x	48	x		•				x
	19382	5	OHD	-360	-285	460			x	48	x		•				x
	19383	5	OHD	-360	-285	460			x	48	x			•	x		
	19384	2	OHD	-360	-285	460			x	48	x					x	
	19385	20	OHD	-360	-285	460			x	48	x		•				x
	19386	10	OHD	-360	-285	460			x	48	x		•				x
	19401L	80	A	-360	-285	460			x	48	x		•				x
	19402	25	A	-360	-285	460			x	48	x					x	
	19421L	100/20	A	-360	-285	460			x	48	x			x			
	19441L	80	A	-360	-285	460			x	48	x		•				x
	19442	40/10	A	-360	-285	460			x	48	x		•				x
	19461	40	UNK	-360	-285	460			x	48	x					x	
	19480L	180	A	-360	-285	460			x	48	x		•				x
	19481	32	A	-360	-285	460			x	48	x		•				x
	19482	10	A	-360	-285	460			x	—	x						+
	19483	20	A	-360	-285	460			x	48	x		•				x
Atlantic-PR	25640L	326	PR	+220	+32	222			x	12		x	•	•	x	•	•
-VI	25641	100/20	PR	220	32	222			x	12		x	•	x	•	•	•
	25644	20/2	PR	220	32	222			x	24		x	•		x		•
	25645	10	PR	220	32	222			x	24		x		•		x	
	25647	15	PR	220	32	222			x	48		x	•				x
	25649	10	PR	220	32	222			x	48		x		•	x		
-PR	25650	100	PR	220	32	222			x	12		x	•	•	x	•	•
	25653	20	PR	220	32	222			x	48		x				x	
	25654	6	PR	220	32	222			x	48		x	•				x
	25655	10	PR	220	32	222			x	48		x	•				x
	25659	20	PR	220	32	222			x	48		x	•				x
	25661	10	PR	220	32	222			x	48		x	•				x
	25663	40	PR	220	32	222			x	12		x	•	•	x	•	•
	25664	25	PR	220	32	222			x	24		x		x		•	
	25665	20	PR	220	32	222			x	48		x			x		
	25666	10	PR	220	32	222			x	24		x		•		x	

Area	Chart	Scale 1:K	Datum *	Corr. Req'd LAT	Corr. Req'd LON	Corr. Req'd Max. Shift	S P C	Action Note	Action Proj	Print Cycle (Mo.)	Compile Man	Compile Auto	Publish (NAD 83) 85	86	87	88	89
	25667	10	PR	220	32	222			x	24		x	.		x		.
	25668	100/10	PR	220	32	222			x	24		x		.	x	.	
	25670	10	PR	220	32	222			x	24		x		x		.	
	25671	100	PR	220	32	222			x	48		x	.				x
	25673	15	PR	220	32	222			x	48		x		.	x		
	25675	10	PR	220	32	222			x	48		x				x	
	25677	100/20	PR	220	32	222			x	24		x	.		x		.
	25679	10	PR	220	32	222			x	48		x	x				.
	25681	10	PR	220	32	222			x	24		x	.		x		.
	25683	20	PR	220	32	222			x	48		x			x		
	25685	20	PR	220	32	222			x	48		x	.				x
	25687	20	PR	220	32	222			x	48		x	.		x		.
	25689	20	PR	220	32	222			x	48		x		x			
-NI	26194	15	Pre83						x	48		x		.	x		
Pacific-GM	81048	100/40	G						x	48	x					x	
	81054	10	G						x	24	x		.		.		x
-WI	81664	15	Pre27						x	48	x					x	
-I	83116	15	L						x	48	x			x			
-KR	83153	25	UNK						x	48	x		.				x
-PM	83157	10	A						x	48	x		.				x
-SI	83484	80/15	Pre27						x	48	x			.	x		
-JA	83633	200	A						x	48	x		.				x
	83637	50/12	A						x	48	x		.				x

APPENDIX C

OPTION 4: DATUM CONVERSION COSTS

The hybrid manual/automated datum conversion plan presented as Option 4 is intended to provide full conversion to NAD 83 within 5 years. During this time, 72 charts would be converted by revising the existing datum reference note on each chart and adding a datum transformation note. The remaining charts would require additional cartographic and reproduction actions to shift the existing chart projection. A total of 482 charts would have their projections shifted by manual cartographic procedures; 405 charts would be converted by automated methods.

In addition to the shift in projection, up to 272 charts could require a shift in their LORAN or OMEGA electronic positioning lattices. For planning purposes, it was estimated that 60 percent of the lattices would require revision.

In determining the conversion costs, it was assumed the compilation and reproduction costs under automation would be insignificant. These costs are estimated to be $50,000. The manual costs of datum conversion under Option 4 were computed as follows:

A. Cartographic Conversion Costs

1. Chart Projections

a. Number of charts for manual conversion = 482 charts
b. Staff-hours per chart for new projections = 24 hours
c. Cartographer cost per hour = $19.89*

Cost = $230,087

2. Inset Projections

d. Insets per chart = 0.45
e. Staff-hours per inset for new projection = 20 hours

Cost = $86,283

3. LORAN/OMEGA Lattices

f. Number of charts with lattices = 272 charts
g. Assume 60 percent will require shifting
h. Staff-hours per chart to shift lattice = 32 hours

Cost = $103,873

*based on salary of GS-11, step 7 (includes overhead, inhouse indirect and other service level user charges)

4. Total cartographic labor and materials costs to shift chart and inset projections, and LORAN/OMEGA lattices.

TOTAL Cost = $420,243

B. Reproduction Conversion Costs

1. Chart Projections

a. Number of charts for manual conversion = 482 charts
b. Staff-hours per chart for new projection = 35 hours
c. Reproduction cost per staff-hour = $21.50
d. Material cost per new projection = $60/chart

Cost = $391,625

2. Inset Projections

e. Insets per chart = 0.45
f. Staff-hours per inset for new projection = 20 hours
g. Material cost per inset = $30

Cost = $99,774

3. LORAN/OMEGA Lattices

h. Number of charts with lattices = 272 charts
i. Number of charts having lattices requiring shift = 60 percent
j. Staff-hours per chart = 32 hours
k. Material costs per chart = $150

Cost = $136,761

4. Total reproduction costs to shift chart and inset projections, and LORAN/OMEGA lattices.

TOTAL Cost = $628,160

C. Total conversion costs for manual cartographic and reproduction services for Option 4 is $1,048,400.

D. Estimated cost to convert the AIS Data Base to NAD 83 = $50,000

E. Total NAD 83 Conversion Costs are $1,098,400.