A Manual for Researching
Historical Coastal Erosion

by
Kim Fulton

Report No. T-CSGCP-003

University of California, Santa Cruz
Science Writing Program

A California Sea Grant
College Program Publication

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Cover photo: *1905 photograph looking south to Hotel Del Coronado following severe sea storms which eroded more than 110 feet of beach cliff sediments. Thirty thousand sandbags were placed north and south of the hotel. Note that Ocean Boulevard eroded all the way back to the curb in front of the homes shown. (Photo courtesy of U.S. Grant IV)*

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Preface and Acknowledgments

Because of sea level changes and regional tectonic warping of the North American continental land mass, the California coastline has been eroding for thousands of years. As long as sea bluffs and coastal areas were left undeveloped, or were used primarily for agriculture or low-density recreation, erosion did not present a major economic or public safety problem. When the first permanent structures were built, vacant land was still relatively plentiful, and houses were commonly located in stable areas, away from the most vulnerable parts of bluffs, canyons, and floodplains. Whether through fortunate circumstance or wise planning, some of these seventy-five to one-hundred-year-old houses still stand, while recent buildings nearby have already been undermined by cliff failures.

As coastal areas became more densely populated, the number of easily buildable lots declined. Yet bluff-top development has continued to accelerate over the last two or three decades. The desire for beautiful ocean views, convenient beach access, and prestige has induced many people to build at the ocean's edge. Others have been attracted by the great profits to be made through coastal construction and land speculation. At the same time, lessened erosion -- the result of relatively mild winters -- has lulled property owners into believing that their land is stable. For one or more of these reasons, expensive residential structures have been built even in high-risk locations. For such dwellings, each severe winter storm is a potential disaster.

Some coastal communities have dealt with such coastal erosion only on a case-by-case basis. Other more densely populated cities and counties have tried to plan for erosion by instituting building setbacks or other ordinances. Many buildings which met these requirements were nonetheless damaged during the moderately stormy winter of 1977-78 (Howe, 1978). This could indicate either a lack of strict enforcement or the use of inadequate baseline data in creating planning regulations.

In the wake of these recent erosional episodes, some jurisdictions have been charged with the legal and financial responsibility for protecting houses and apartments which they had approved for construction (Hildreth, 1980). Additionally, millions of dollars in low-interest public loans and community aid have been used to finance emergency protection measures and the reconstruction of private development.

But according to old newspaper articles, personal memoirs, tree ring data, and other historical information, the last thirty years have been relatively mild, and future storms may be more intense than any so far experienced by this generation of southern California residents, (Kuhn and Shepard, 1979). Thus, coastal erosion is likely to continue, or even to accelerate over the next decade. This could result in considerable property damage unless a better understanding of coastal processes can lead to improved siting of beach and cliff-top structures.

One means of understanding present erosion is to examine in detail when, where, and why erosional events have occurred in the past. Since 1973, Gerald Kuhn, a geologist and staff research associate at the Scripps Institution of Oceanography, has been comprehensively researching and analyzing historical erosion along the San Diego County coastline from Del Mar to Oceanside. Through this research, a great deal of previously unused and unknown information has been discovered. Kuhn and Scripps Professor Emeritus Francis P. Shepard plan to publish the results of their investigation covering the towns of Oceanside and Carlsbad in 1981.

Such historical research is timely and potentially useful for many other coastal regions. For this reason, Kuhn and Shepard's research methods and data are outlined and illustrated in this manual. It can serve as a practical guide for those who wish to obtain detailed information on coastal erosion in a specific area through historical research and documentation.

This manual would not have been possible without the assistance and advice of many people. However, I am solely responsible for its contents, and for any errors it may contain.

I am sincerely grateful to Gerald Kuhn, for accommodating my interminable questions and continuous browsing through his personal library and research records. He and Francis Shepard, our project advisor, both exemplify the curiosity, enthusiasm, and perseverance which are to me the essence of scientific pursuit. It was an honor to have worked with such knowledgeable and renowned individuals. I would also like to thank Jeffery Frautschy for the many patient hours he spent with me; Louise Eklund and Nance North for their personal and professional advice when it was most needed; Jens Sorensen, Dale Ingmanson, and everyone at Sea Grant for their friendly assistance; also, John Wilkes, Gary Griggs, and all those who reviewed the manuscript. Finally, my special thanks to Cindy Haight, whose friendship made it all worthwhile.

Kim Fulton
December, 1980

Introduction

This manual is intended to help land-use planners, geologists, engineers, and others concerned with coastal erosion to collect historical information about shoreline, sea bluff, and cliff retreat. Once collected, such specific information can be used in creating bluff-top or beach-front building or zoning regulations. If these regulations are to withstand legal tests, they must be based on "compelling evidence" of past or future coastal retreat in a specific area. The research methodology described in this manual can be used to compile such evidence, if it exists. For this reason, the manual emphasizes cross-correlation between sources and careful interpretation of data to rigorously document historical coastal changes in California over the last one-hundred to one-hundred and fifty years.

There are three major sections in this text. Part I contains the manual itself -- a step-by-step guide, describing the basic sources and methods of investigation used by Kuhn and Shepard. Through these methods, planners should be able to dramatically increase the scope of their historical data base with respect to significant episodes of beach and cliff erosion. Several additional research suggestions are outlined in Part II. These can be used to document recent and continuing erosional hazards. Part II also contains a section on how to compile both historical and current data into a comprehensive and useful format for coastal planning, decision making, and public education. Methods for applying historical erosion research to coastal planning itself are discussed in Part III. Appendix A summarizes the type of information available from a large number of sources, and Appendix B lists addresses of these sources.

The manual is written, as much as possible, in a non-technical fashion. Most of the historical research can be carried out by persons without specialized training, although a background in geology, geography, or planning may be necessary for interpretation of the data collected. For those who wish to obtain more information concerning the geological, meteorological, and coastal processes affecting coastal erosion, Part III of the bibliography provides a number of references. On the whole, however, the most important requirements for a historical researcher are enthusiasm, perseverance, and an inquisitive mind.

Almost all of the documents, maps, and photographs that appear in this manual relate to the communities of Solana Beach and Encinitas in northern San Diego County (figure 1). Thus, the reader can observe the same landforms and man-made features from many different perspectives and over various time periods.

Although parts of Encinitas have apparently eroded considerably since the late nineteenth century, Solana Beach appears, historically, to have been more stable until recent grading of the bluff top occurred altering existing drainage patterns. Since massive, multi-store development of south Solana Beach occurred in the early 1970s, the cliffs have begun to retreat much more rapidly, and property owners are now experiencing severe erosional difficulties.

Historical research sources relevant to California are identified in this manual, but a similar methodology can be used anywhere in the coastal zone of the United States. Pertinent state and local information might be stored in different files, or with different agencies in other states.

Historical research also can and should be applied to planning problems other than sea-cliff erosion. Many types of natural hazards, such as floods, earthquakes, or inland landslides could be better understood through systematic research, review, and analysis of old records. Such research would not only provide scientific evidence for planning, but what is more important, it might serve as a reminder to those who forget about the period of calm years between major storms and build houses in dry river valleys or on apparently stabilized sea cliffs.

James J. Sullivan
Program Manager

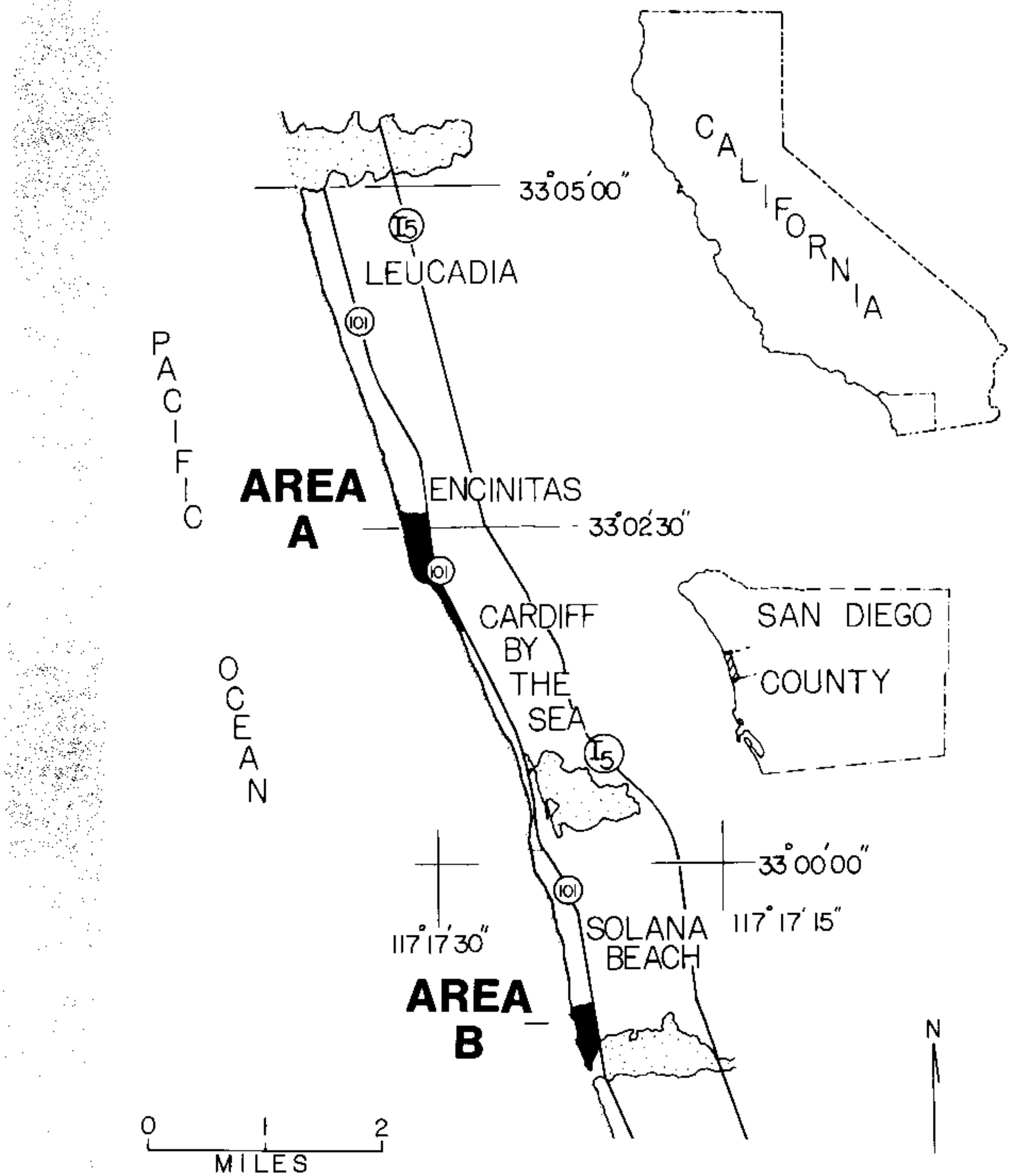


Figure 1. *Location of areas discussed in this manual. (Illustration courtesy of Gerry Kuhn)*

vised by an informed and interested member of the local planning department. In some instances, specialized professional advice might be needed to assess the validity of critical information, or to interpret some of the data collected.

Part 1

Research Methodology

Considerable research is necessary to adequately document historical erosion. Depending on the region being studied, such research could take as much as five to ten years, if all of the available sources were used. However, using the sources and methodology listed in this booklet, a satisfactory examination of limited scope could be completed in six months to a year. Within such a limited time span, careful decisions must be made as to which of the many possible leads should be pursued. Just a few basic sources are suggested in this manual, but literally hundreds of new ones are likely to surface during the research process itself. Whether these new leads should be investigated depends on their time and cost requirements, compared to the usefulness of the information they might provide.

Some of the major financial outlays necessary to this research are for transportation, photography, duplication costs, postage and purchasing of research materials. However, time *is by far* the most costly element of historical research. Because it is labor intensive, and does not require a great deal of technical expertise, a historical erosion research project might be ideally suited for a student or for a class internship. This could be arranged with a local university, college, or high school, and super-

Research Summary and Flowchart

The flowchart depicted in figure 2 is designed as a guide to historical erosion research. Each number and letter on the chart refers to a specific section of the manual and a particular step in the research process. The three parallel rows--A, B, and C--represent three different parts of the investigation. All three should be followed simultaneously so that time lags between ordering and acquiring data can be used to carry out other aspects of the investigation. Also, information obtained in one aspect of the research often will be relevant to other sections, and may even lead to entirely new sources of data.

In spite of this random aspect of research, each horizontal sequence on the flowchart is ordered so that an investigator can begin from a general frame of reference and progressively focus on more specific items. If one particular map or document is not available, this should not present a major obstacle, but will merely require adequate documentation from alternative sources. It is critical that a careful record be kept of all information sources, since final analysis may disclose real or apparent conflicts, and judgments about source reliability will have to be made.

The first step in the research process is to define a study area. The exact geographic boundaries of the study will depend on the jurisdiction of the sponsoring governmental agency, the environmental system or systems affecting the area, the amount of detail being sought, and the ever-present limitations of time and money. Few coastal processes confine themselves to single jurisdictions, and a cooperative study may be more productive in some coastal regions. The study area should be large enough so that regional trends and processes can be considered, but not so large that the research cannot eventually focus on those particularly critical locations which merit detailed study. *One of the greatest dangers lies in making generalizations about erosion over a large area when the physical factors controlling erosion may vary considerably from site to site within that area.*

Once the study area has been chosen, the acquisition of data should begin. Experience

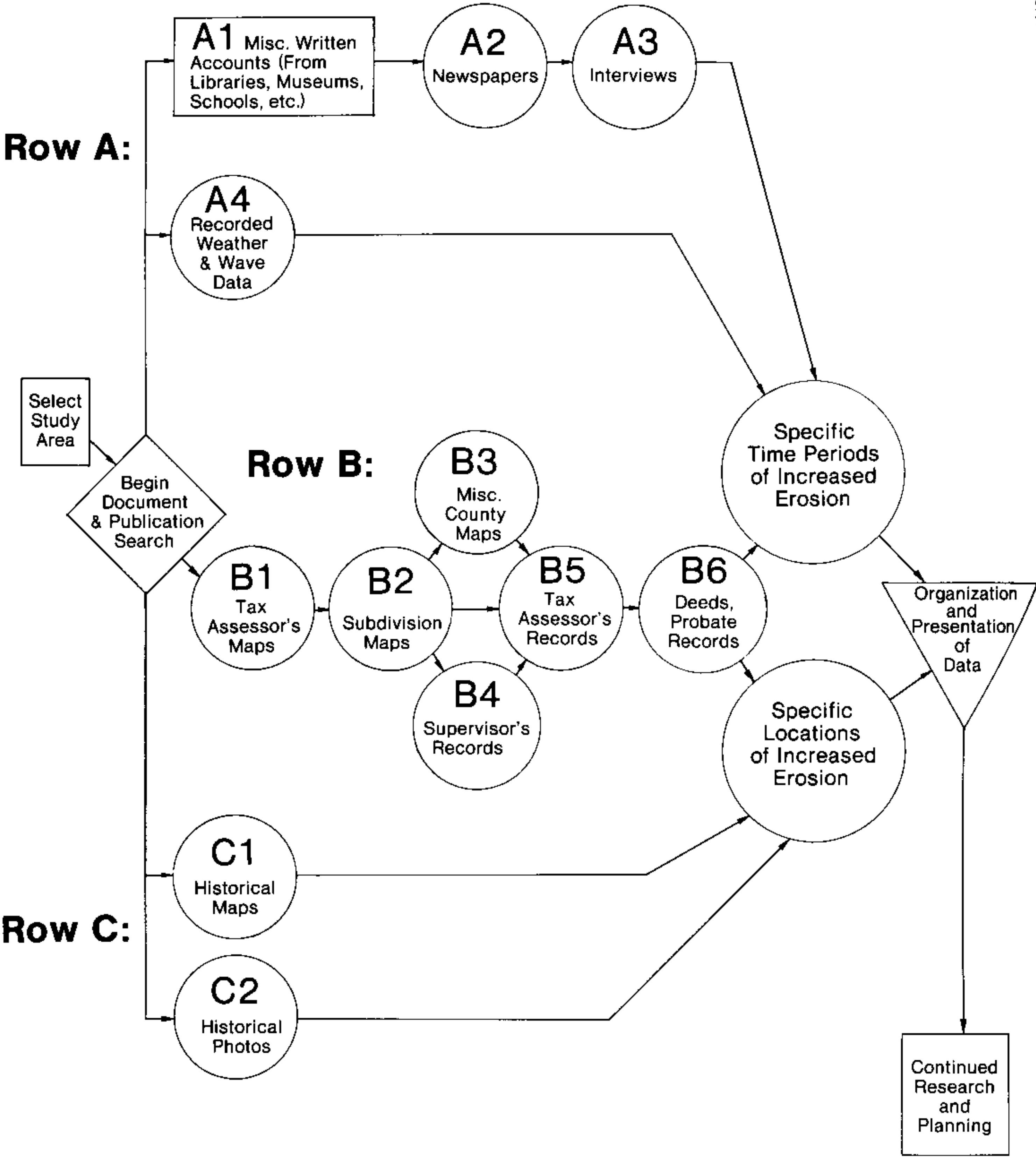


Figure 2. *Simplified flowchart for historical erosion research. Letters and numbers are referenced in the text.*

indicates that new sources will be found and obtained throughout the research process. Nonetheless, all those items that must be ordered by mail such as maps, photographs, or written publications, should be ordered as early as possible, because some may take months to arrive. In fact, a first step might be to send a letter to each relevant source listed in Appendix B, explaining the purpose and scope of the investigation and requesting information on that particular study area.

Row A

The top row of the flowchart (Row A) describes sources that can be used to document time periods when the greatest erosion is likely to have occurred in the past. After compiling a history of large storms and periods of unusually high waves, the researcher can determine the local significance of these extreme events, which are most likely to cause coastal changes. This history should extend backward as far as possible, so that both short- and long-term trends can be identified.

The sources listed in Row A will provide not only storm information, but also a general historical overview of the study area. Such background data is needed so that erosional events can be understood in a cultural context. For example, specific landholdings and titles can be traced by identifying the important families or individuals in a town's history. Evidence of past erosion, or other effects of storms can be obtained by interviewing the surviving members of these families, expecially if the landholdings are or were in coastal areas. Some individuals may even provide access to personal photograph collections, diaries, or memoirs. Finally, quantitative storm records, such as rainfall data, also can be collected and correlated with such oral and written accounts.

Row B

The sources listed in Rows B and C of the flowchart are primarily used to identify where erosion has occurred in the past, although some also may yield dates, which can be compared with the historical weather data from Row A. Local governmental sources (listed in Row B) are particularly useful for pinpointing the exact times and places of erosion-related damage to public or private property.

Row B begins with tax assessors' maps, because they are easy to obtain, they show both past and present property boundaries, and they can be researched in a relatively short time. From notations on each assessor's map, many other relevant county maps can be identified, including records of subdivision. These, in turn, can provide references to additional sources, such as road surveys, or county supervisors' records of road and property closings. Such county records, combined with notes on street, sidewalk, or utility repairs from the local departments of transportation, surveying, or public works, and from public utilities can yield site-specific and accurately dated information. Tax assessment record sheets and deeds can then be used to further verify any devaluation or loss of property that may have occurred.

Row C

Finally, Row C covers graphic information sources, some of which require careful, or even expert, interpretation to be useful. Both maps and photographs can provide visual evidence of coastal retreat, but are limited by their scale and accuracy. These sources are most often used to compare two or more representations of the same area on different dates, so as to identify any changes which may have occurred. For this reason, their chronological precision is usually limited to the length of time between consecutive maps or photos.

One common means of comparison for both maps and photos is to overlay the coastline from one source onto another of the same scale, but from a different time period. Direct, quantitative measurement of retreat from these sources is also possible, but both methods can be severely hampered by problems of scale or distortion. Any conclusions reached through such graphic sources should be verified through written records, whenever possible, because of the many uncertainties involved. For example, overlay comparisons based on matching map coordinates should be used with great care, since the coordinate grids may have shifted by tens or hundreds of feet as geodetic surveying techniques have become more sophisticated.

In addition to showing coastal retreat, pictorial sources can provide other information that may be useful to the historical researcher. Changes in all kinds of natural features, such as topography, vegetation, or drainage patterns can be documented in some cases. Man-made features, such as roads, railroads, structures, or cities, can be located and dated to some extent. Such coastal development will both affect and be affected by erosion over time. When combined, the information from Rows A, B, and C should indicate both where and when historical coastal erosion has occurred within the study area. More specialized and technical analyses can then be used to determine exactly how and why erosion is occurring, to project future erosional trends, and to effectively plan for them. These techniques are introduced in Parts II and III. The rest of Part I discusses in greater detail each element of the methodology listed on the flowchart.

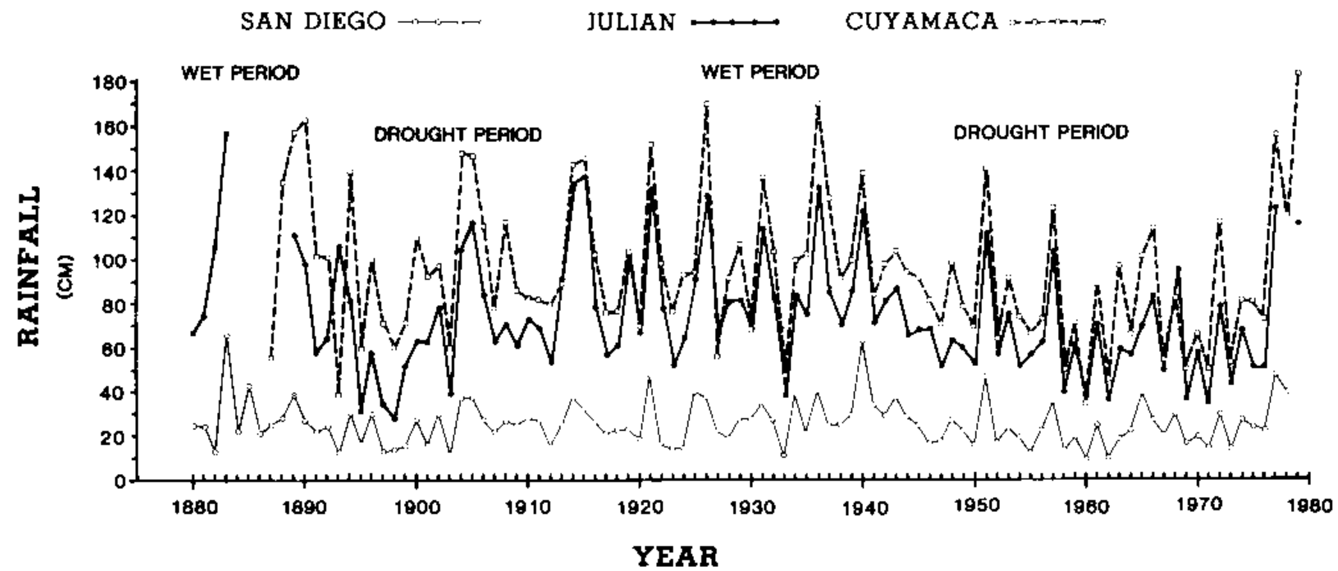


Figure 3. *Historical rainfall chart showing data for three San Diego-area stations from 1880 to 1980. (Illustration courtesy of Gerry Kuhn)*

Historical Weather Data (Row A)

Many of the important factors affecting erosion, such as large waves, runoff, and groundwater, are related to storms, either at sea or directly over the coastal watershed. For this reason, one of the first tasks of the researcher should be to compile a list of large storms and waves that affected the study region in the past. Once specific storms have been analyzed and dated, the research can begin to focus on discrete time periods during which erosion is most likely to have occurred. These periods may be as short as the several days during August of 1934, when huge waves--probably from a storm near New Zealand--caused loss of houses and beaches along many parts of the California coast. Or they may occur more frequently for a period of years, as during the period from 1884-1892, when four severe flood and storm years occurred in San Diego County, any one of which would be a catastrophe if it occurred today. Such a series of stormy years with above normal rainfall every year constitute a wet period. The greatest coastal changes appear to coincide with these wet periods, and provide the most conclusive evidence that coastal erosion does not proceed at an even, average rate. It should also be stressed that because weather is often geographically controlled, a wet period for one area may not necessarily apply to another.

Historical storm data is available from a wide variety of sources, but must be interpreted with care. Rainfall is perhaps the easiest data to obtain, but it may vary drastically, even between two recording stations in the same region. Figure 3 shows the rainfall recorded at three stations in San Diego County for the period between 1880 and 1980. A high total rainfall figure for a specific year does not necessarily indicate increased coastal erosion, but it is a contributing factor. However, the researcher should especially look for heavy rains recorded over a wide area, or of exceptional duration (weeks-months), such as occurred during the wet year of 1883-1884 (figure 4).

Even large floods do not always correlate with high rates of coastal erosion. They may cause shoreline accretion, or widening of some rivermouths or barrier beaches. However, if storm accounts coincide with reports of particularly large waves, then some cliff failures can be suspected. Flood descriptions are relatively easy to locate, but may be highly subjective. However, the researcher should not automatically reject spectacular accounts as being exaggerated, especially if they are backed up by rainfall or river-stage data. Some past storms may actually have been more severe than recent ones, particularly when long-term weather fluctuations are taken into account. For example, San Diego seems to have had a dry period from about 1947 until 1977 based upon tree ring and meteorological data. During this time, average wave height, rainfall, and coastal erosion were much lower than during the years from 1884 to 1946 (see figure 3). If the research turns up previously unknown historical flood information, it may even be necessary to re-evaluate estimations of "fifty- and one-hundred-year floods" and floodplains in some areas.

Miscellaneous Historical Sources (A-1)

Probably the best information on local storms can be obtained from a careful reading of regional histories or memoirs of individuals who have lived most of their lives in the study area. These, along with photos and other historical records, are often available from local libraries, schools, or private collections. They are useful not only for weather data, but as a cultural and historical context for the more detailed research that will follow. Such books may also contain references, in the text or bibliography, to other sources of historical information or lines of inquiry.

A wealth of local historical data often can be located through county or city libraries and historical societies. Both central and branch libraries commonly maintain indexed historical files or collections of newspaper clippings. An experienced librarian may be able to locate valuable materials and offer suggestions for further research. Similarly, the investigator should contact any local or regional historical societies, as they may provide access to documents and information, or know of older residents whose knowledge of the area of study might be useful.

Newspapers (A-2)

After investigating such general reference sources, several different directions could be taken, perhaps simultaneously, to confirm and supplement storm data. The first approach would be to use the specific dates of storms, gathered from local histories, as references to old newspaper accounts. This requires the scanning of old newspapers from the weeks or months during and after individual storms or rainy seasons. Little or no information may be available specifically on coastal bluff failures, especially in areas that were relatively uninha-

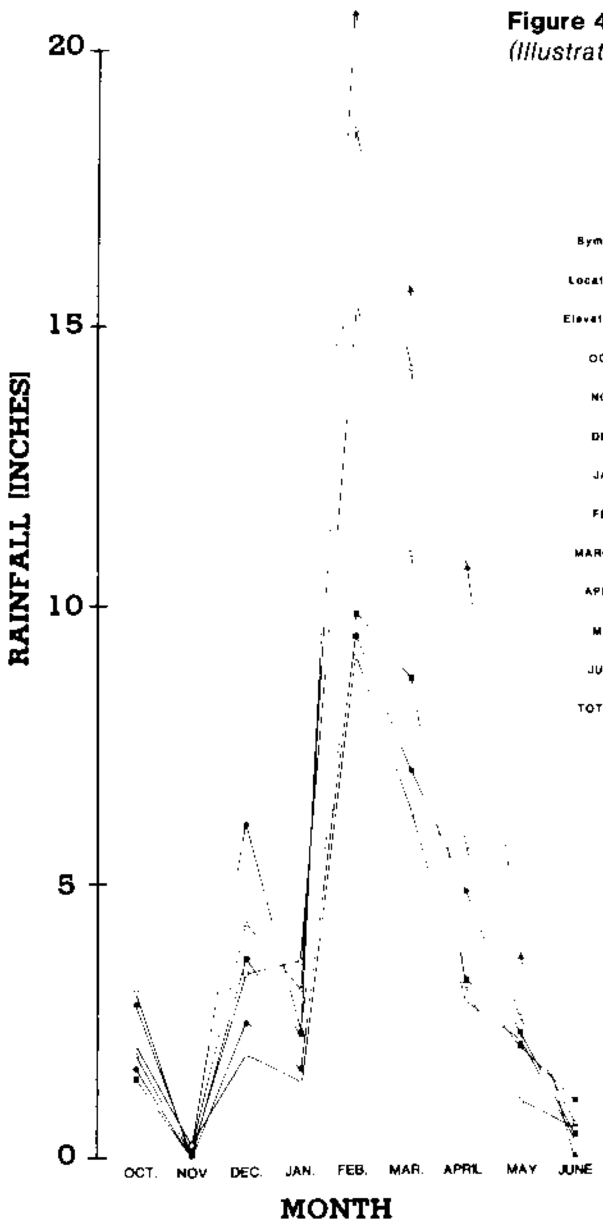


Figure 4. *Graph of rainfall recorded in San Diego County, 1883-1884. (Illustration courtesy of Gerry Kuhn)*

Symbol	. .	• •	- . .	■—■	-·-·-	▲ ◆
Location	San Diego	Poway	Fall Brook	Escondido	Valley Center	Julian
Elevation	96'	460'	700'	1020'	1400'	4200'
OCT	2 01	1 69	2 96	1 46	1.86	2 75
NOV	20	--	--	--	--	--
DEC.	1.82	2.40	3 32	3.66	4.22	6.00
JAN.	1 34	1 69	3 66	2 22	3.00	2.26
FEB	8.06	9.40	15 38	9.83	18 60	20 63
MARCH	8 23	8.96	10.90	6 88	14.20	15 63
APRIL	2 64	4 61	3.13	3 26	5.61	10 63
MAY	2 17	2 28	1.02	2 00	2 52	3 83
JUNE	.31	44	.52	1 05	61	--
TOTAL	26 97	29.46	40 77	32.07	50 61	61 52

RAINFALL 1883-1884

bited. However, descriptions and photos of rainfall, flood, or wave damage, along with references to previous storms, can be found. In fact, additional research of old county or city records may provide direct confirmation of reported damage to specific roads or structures.

Most existing newspapers have indexes to or collections of old editions. (The researcher might need to get special permission to examine these.) To make the search as complete as possible, it is useful to obtain, from a library or local governmental agency, a list of all newspapers that have served the study area. Some local papers may occasionally issue "historical editions" containing interesting features on past news events, including storms.

Interviews (A-3)

Personal interviews with long-term residents of the area are another source of information that can add considerable depth and insight to the sketchy accounts found in most printed material. Recollections of such individuals can bring the events of the past alive for the researcher and supply specific examples of past damages or changes that occurred. If any of these residents lived in coastal areas, or along the bluffs, it may be useful to interview them once again after additional historical data have been obtained.

Recorded Weather and Wave Data (A-4)

The second approach to completing a local weather history is more quantitative. Many governmental and private organizations record weather data such as rainfall and the effects of storms. Cities and counties often maintain lists of old floods and yearly rainfall figures in their departments of engineering, sanitation, or flood control. Local or regional water districts also generally document weather histories. *Rainfall and Streamflow in Southern California Since 1769* (Lynch, 1931) is an excellent example, printed by the Southern California Metropolitan Water District. This volume not only contains the results of painstaking historical research but also lists a complete bibliography for those interested in doing primary research at other locations.

Another general source of information, the California Department of Water Resources, maintains statewide and local offices that distribute publications on regional rainfall and flooding in various parts of the state. Finally, the federal government stores weather data relayed from local stations with the National Weather Service and the National Weather Records Center. The latter can provide a computer-produced list of all severe storms. All of these sources can be contacted at the addresses listed in Appendix B. Fortunately, if one agency does not have the necessary information, requests will often be referred to an appropriate office.

Information on past periods of large waves may be more difficult to obtain than weather data, but it certainly can be helpful in detecting apparently anomalous erosional episodes. Possible sources of information include local Coast Guard installations, lighthouses, harbor authorities, ship's logs (from the National Maritime Administration), the Army Corps of Engineers, and the National Weather Service. Because these are all federal agencies, their records are likely to be stored in the National Archives, either in Washington, D.C., or at the California regional branch, listed in Appendix B.

A useful book for locating such documents is the *Guide to the National Archives* (1974), which lists the location of every type of government record. Even though their locations are known, however, many such records are not adequately indexed or filed and it might be necessary to search through many collections of records to obtain specific information. This might not be practical, considering limitations of time and money. A more recent book, *Directory of Archives and Manuscripts in the United States*, is also available from the National Archives. It lists a variety of records by the state and city in which they are stored.

Another possible source of information on wave data is interviews with elderly sailors, fishermen, lifeguards, or others who have lived and worked by the sea. Their recollections can provide clues to exceptional past events.

Detailed local wave statistics are available from the California Department of Boating and Waterways (formerly Department of Navigation and Ocean Development), and from the Army Corps of Engineers. However, predictions by these agencies of maximum probable wave size and frequency might be based on data gathered over the last 24 to 29 years. They would be less useful, therefore, for historical research, which should cover at least 80 to 100 years.

More recently, surf and weather readings from ships' records dating back to 1854 have been collected and stored in a computer file by a private firm: Meteorology International, Incorporated. Although the ships' reports of wave size have not been considered completely accurate, historical wave sizes and directions can be approximately calculated for almost any coastal region, using recorded weather conditions. As reported in *Marine Environmental Data Bases and Their Analysis* (Cuming, 1978), this method is still in the experimental stage and uses a great deal of computer time for each location analyzed. If perfected, however, it could provide an excellent source for coastal planners in many areas.

Local Governmental Records (Row B)

Once a historical record of storms and other erosional episodes has been produced, the time periods identified can be used as reference points for other avenues of research. For example, the researcher can examine historical maps of surveys done before and after important storm periods for signs of coastal change. Unfortunately, most maps are somewhat ambiguous with respect to time, because the areas are not resurveyed very often. Written records or documents, on the other hand, often contain yearly or monthly evidence of coastal change if it affects property values or endangers publicly maintained roads and structures.

The following section of this manual provides an overview of the types of records listed in Row B of the flowchart and indicates how each could be used to develop a detailed history of coastal erosion. Most of these records cover only the time period during which a local government has been in existence. Therefore, records maintained on towns that have a longer history of

Table A

Steps to Use in Tracing Historical Damage to Public Roads or Utilities

	Type of Information	Source	Document Storage Location
1.	Locations of closed streets	Current assessor's maps	County/city assessor's office
2.	A county map index and copies of subdivision plat maps with all changes indicated by date and "S.R. number" (Supervisors Records)	Subdivision maps with compiled changes	County department of transportation (not available in all counties)
3.	*First*: minutes of final decision; *Second*: minutes of prior public hearings and closure petition	Clerk of board of supervisors' records	County clerk's office
4.	Original petition to close street with correspondence and reasons	Written records of road closings	County clerk recorder's office
5.	Notes of repairs necessary due to erosion at specific dates and locations	Records of road, sidewalk, or utility repairs	County department of transportation or public works
6.	Repairs needed to restore service in coastal areas	Records of special districts	Sewer, water, irrigation districts, gas and electric companies

Table B

Steps to Use in Tracing History of Lost or Devalued Private Property

	Type of Information	Source	Document Storage Location
1.	Locations of past and present property lines	Current assessor's maps	County/city assessor's office
2.	Property owners/former coastlines	Coastal road surveys	County department of transportation/ surveys, CalTrans
3.	Property owners and lot/block numbers	Original subdivision plats	Department of transportation recorder's office/department of surveying and maps
4.	Property values and devaluations, past owners	Old assessment records	County/city assessor's office
5.	Reasons for devaluation of property and dates of removal from tax rolls	Records of assessment appeal approvals	Records of board of supervisors/ assessment appeals board
6.	Past and present property ownership and proof of ownership of eroded parcels	Deeds and patents	Recorder's office, deed and patent books
7.	Records of property ownership at time of death/subsequent ownership	Probate court and coroner's records	County recorder/county coroner

organized government will be the most useful. These records, in general, can provide a great deal of information from as far back as 1850, when California became a state. Tables A and B list a series of detailed steps which may be used to investigate damage to public roads or utilities, and loss or devaluation of private property.

Table C

Suggestions for Researching Governmental Files

1. Obtain or compile a county, city, or state directory, listing what each office is supposed to do, and what records it might have. (Owen C. Coy's *Guide to County Archives*, printed in 1919, is excellent, though difficult to find; other guides may be obtained directly from the public relations offices of the governmental agencies or offices.)
2. If necessary, obtain official, signed permission to examine old files from an individual in the highest possible position of authority over records (i.e., a county supervisor).
3. Whenever possible, look for items in person. Many relevant items are discovered by chance--stored in basements, closets, or boxes, and forgotten for years. Thus, researchers must learn their way around important offices, and be able to get what is needed while causing as little disturbance as possible.
4. Even if people say records don't exist, keep looking or ask another person.
5. Get to know individuals in key departments personally: they may spot items that could prove useful to you in their daily work. Talk with older or retired employees who may know of files others have forgotten.
6. Many items will have to be tracked from one office to another. This can be frustrating, but perseverance will often prove fruitful.
7. Compile a summary or index of everything you discover that might turn out to be useful, even to someone else, so it can be found again, if necessary.
8. Find and use original copies of maps and records whenever possible, as information may be left out or distorted when originals are microfilmed or copies are made.
9. Start research on a broad scale both in terms of time period and geographical area. Then begin to focus on specific people, areas, important time periods, and so forth.
10. The most difficult part may be assembling all of the pieces of data that are collected into a coherent history of erosion; a cataloging or indexing system for the data may help to organize all of the material collected (see Part II).
11. Different city, county, and state governments may be organized differently than described in this manual. Some will be more or less difficult to research.

Because so much historical information is maintained in the files of local cities or counties, these are potentially the most important resources for the historical researcher. Researching these files requires a great deal of time because of the variable and complex governmental structures and filing methods which must be understood to locate and obtain information. Table C lists suggestions for researching such files.

Tax Assessor's Maps (B-1)

The county or city assessor's office is a good starting point for investigations into local records. Assessor's files are some of the most easily accessible, and contain two different sources of information. Record books (issued every year) and map books (issued every three to five years) contain information on every piece of property in the assessment district. Although current editions of the books are easy to locate, older records might be filed in forgotten locations. To find old assessor's maps, the easiest approach is to start with current ones, particularly since they can show whether previous maps were markedly different.

First, the study region should be located on an assessor's map book index, like the one shown in figure 5. The number listed there (for Solana Beach, No. 298) refers to the appropriate map book for that region. These books are available to the public at the assessor's office. From a second index in each book (not illustrated), the specific map(s) of coastal property can be identified. A sample map (Map 010) for the Solana Beach area is shown in figure 6.

On each piece of property shown in figure 6, the circled number (e.g.(9)) is the parcel number, and the uncircled number (e.g. 24) is the lot number. The numbers in ovals (e.g. (010)) are assessor's map numbers, and the circles divided in half (e.g. (263/33)) refer to adjacent book and map numbers. If the top half of the circle is empty, then the adjacent map is in the same book. References such as "sheet 2" identify additional pages, which usually show a portion of the same area in greater detail. All of these numbers are used in various ways to exactly specify a single taxable piece of real estate. For example, Las Brisas condominiums could be found in the current assessor's record book under: 298 (book no.) -- (010) (map no.) -- (54) (parcel no.).

Although book and map numbers usually do not change with time, individual parcels may be renumbered when lots are consolidated or split. The chart entitled "Changes" on figure 6 lists all such lot splits or consolidations that have occurred during the three to five years since the last map book was published. These tables can be used to trace general urbanization trends or

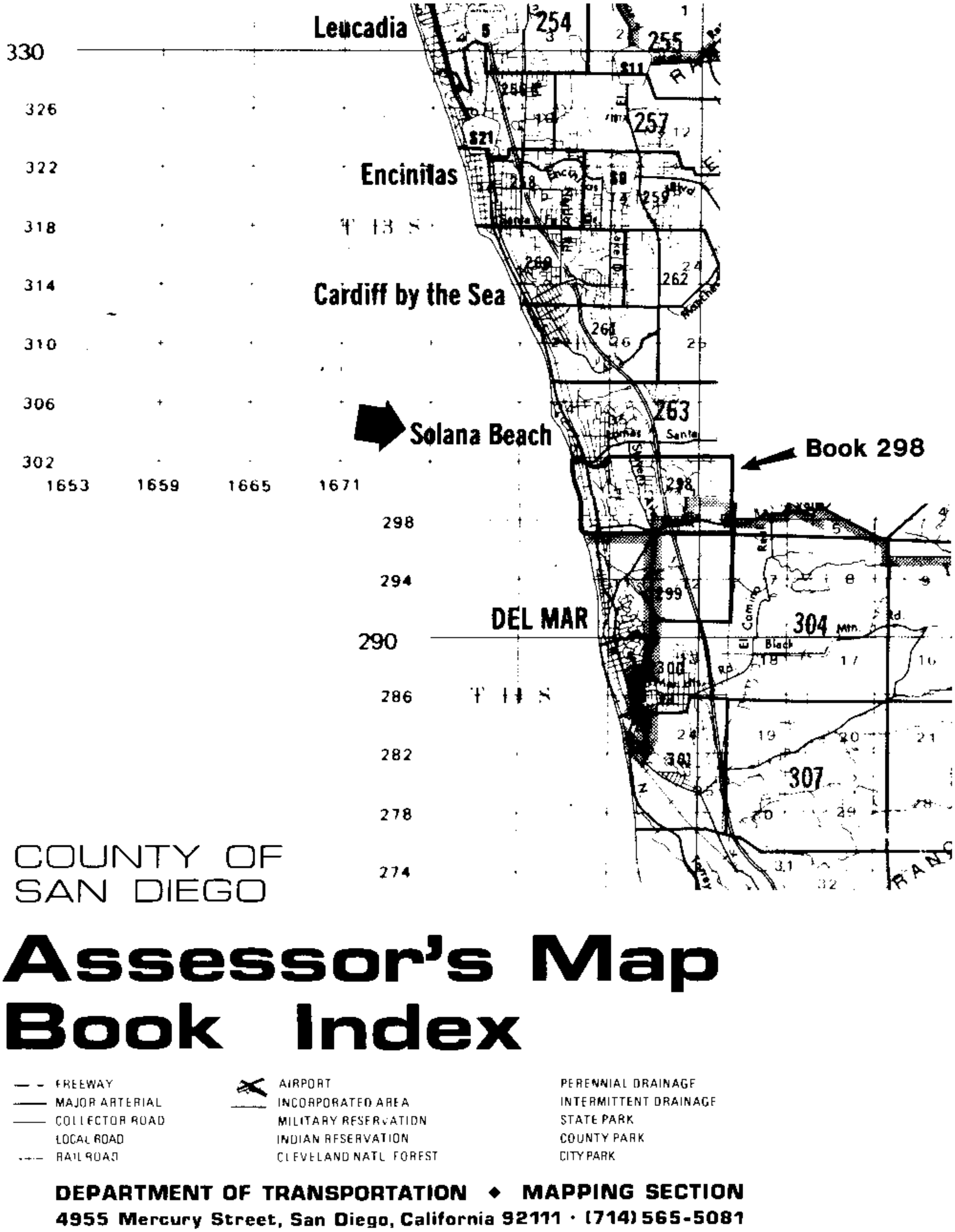


Figure 5. *Portion of an Assessor's Map Book Index with annotations showing appropriate Map Book number for central Solana Beach. (Illustration courtesy of San Diego County Assessor's Office)*

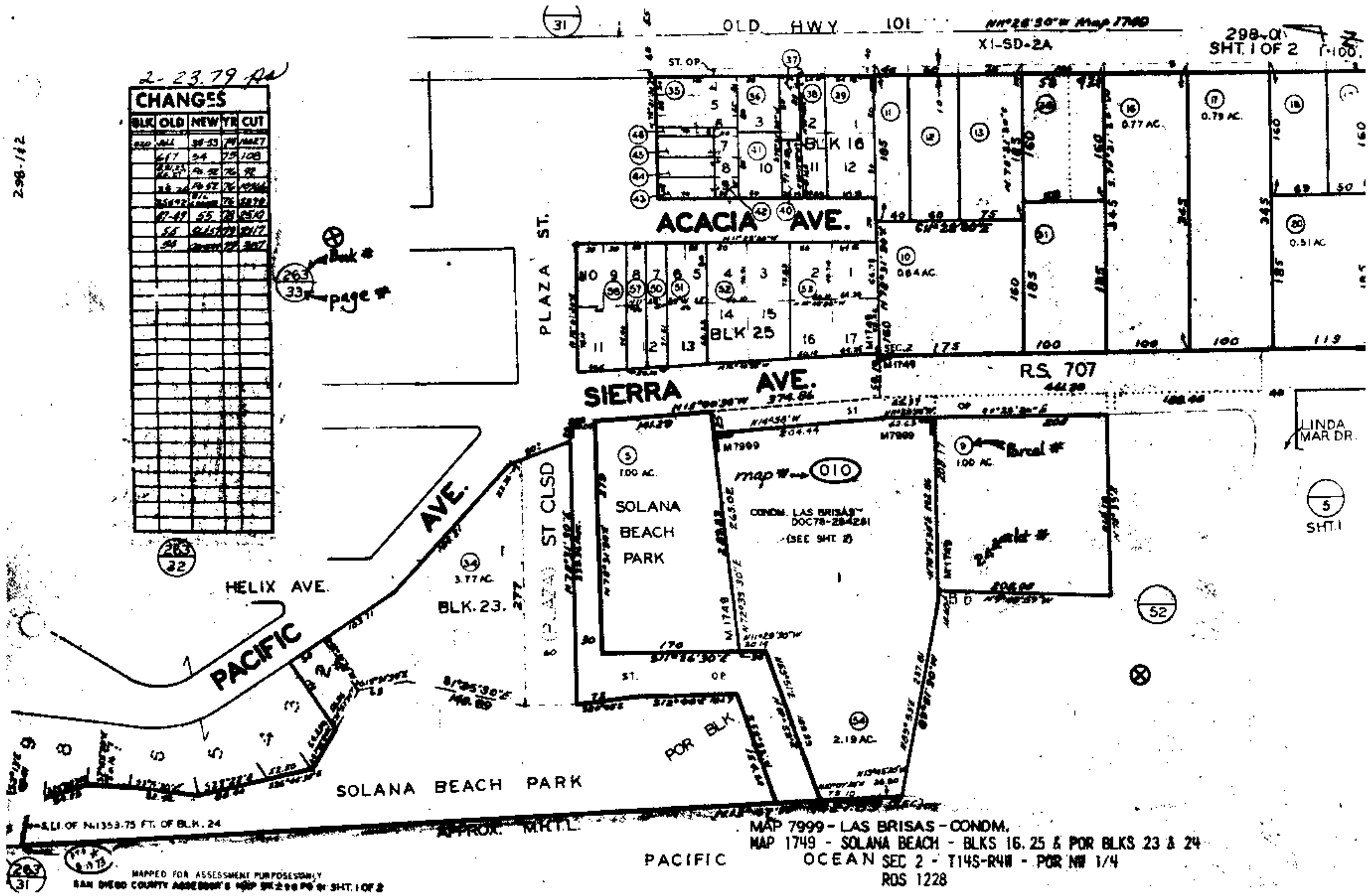


Figure 6. *Reduced copy of an assessor's map of central Solana Beach with annotations indicating map, parcel, lot numbers, and references to adjacent maps. (Illustration courtesy of San Diego County Assessor's Office)*

to gain information on a specific parcel. This is done by using the "Cut" number from the table to find the official records of the lot split. Such files can yield former taxpayer's names and other legal records of ownership.

Although a "coastline" is shown on most assessor's maps, it may represent a legal mean high tide line, a bluff edge, or some other property boundary, but is not always defined, especially on older maps. By tracing changes that have occurred over many years in the boundaries of specific parcels, however, past erosion may become evident. Over the same period, land-use changes, such as increasing densities of development, can also be observed.

Probably the most useful aspect of tax assessor's maps is that they show not only existing property boundaries, but also all boundary changes that have occurred in the past. For example, the current assessor's map for Encinitas (figure 7) shows existing parcels along the bluff top, but seaward of the mean high tide line (MHTL) is an older "coastline" and dotted lines that indicate parcels and roads that are presently under water. Needless to say, these submarine roads and lots are now closed, but they do appear on the original subdivision plat for Encinitas, referred to as San Diego County Subdivision "MAP 148" at the bottom of the figure. Furthermore, old assessor's records (figure 8) show that local residents actually purchased, owned and paid taxes on these now nonexistent parcels of land. In fact, by tracing the dates that various streets in the area were closed, the progressive erosion of these cliffs can be followed from the past to the present. Although most cases are not quite so obvious, old road or property closings are not uncommon in rapidly eroding areas which had had roads or subdivisions located near the bluff edges. Detailed records of the closings may be on file in the city or county clerk's office. These are discussed under "Supervisor's Records."

Another advantage of using assessor's maps is that all roads and parcels are precisely surveyed, and areas of lots are given. In some cases, the survey number of the road or parcel is also provided, and may be used to locate an original survey map or notes in local engineering, surveying, or transportation department records. Finally, the map numbers listed at the bottom of each page refer to the county map number for subdivision maps of parcels shown on that page. These can be used for comparison or correlation with assessor's maps. For example, Subdivision Map 7999 (Las Brisas) referred to at the bottom of the Solana Beach assessor's map, is reproduced in figure 9. Subdivision maps are the next items that should be acquired when researching local governmental files.

Subdivision Maps (B-2)

Both for entire towns, and for small parcels of land, subdivision maps can be key elements in narrowing down the search for information to specific individuals or sites. In particular, original township subdivision maps can provide much information concerning man-made features. Often, entire new towns were created with the filing of these maps. Large landholdings were divided and sold, either in entire blocks or as individual lots arranged around a predetermined street pattern. These parcels, in turn, were often resold and resubdivided by speculators, who sometimes changed streets or lots from the original map arrangement.

A portion of the original subdivision map for north Solana Beach is shown in figure 10, and a later resubdivision south of Plaza Street is shown in figure 9. Maps such as these are usually indexed and available at the county or city recorder's office, Department of Surveying and Mapping, or Department of Transportation. However, such files may be somewhat incomplete, especially with respect to old subdivision maps, which may be stored in other offices, forgotten or misplaced.

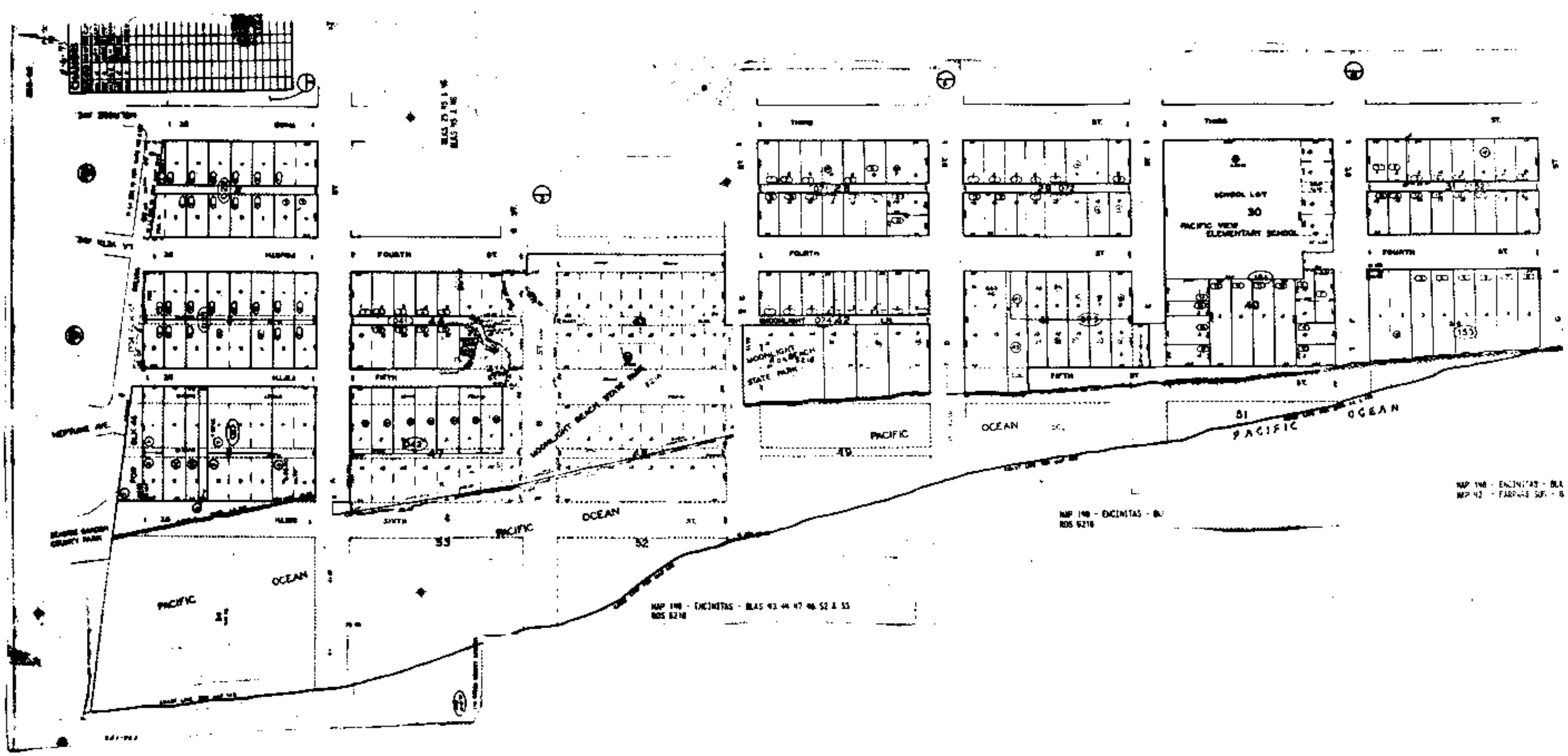
Subdivision maps vary in scale from 1:240 to 1:2,400, depending on the size of the property. They are legal documents, providing the exact location, size, and area of each numbered parcel, and of the project as a whole. All proposed and existing street and railroad rights-of-way are surveyed, with directions and dimensions given. If the property has the ocean as one boundary, an approximate mean high tide line is usually drawn. This line may or may not coincide with the legal boundary of the subdivision, or with the mean high tide line for the adjacent subdivision.

Locations of specific surveying monuments or markers on the property are also given on subdivision maps. They can provide useful references to older base maps or surveys, and thus yield additional information concerning changes in bluff configuration or property ownership. In some counties, roads which have been vacated for one reason or another may be shown by notations or shading on a special set of original subdivision maps held by the Department of Transportation. These can be correlated with similar information on the tax assessor's maps mentioned above.

The name of the licensed surveyor who drew up the subdivision map can be used to track down the original survey notes. These may describe bluff or lot conditions prior to development, but are often difficult to locate. They are often on file in local records, in the possession of the surveyor's family, or in another surveyor's personal collection.

A written record of the subdivision must accompany a subdivision map, including signed and dated approval by appropriate governmental

Figure 7. *Portion of an assessor's map of Encinitas, showing two separate "coastlines." The one furthest inland depicts the current mean high tide line. The other, further to the west, represents a coastline recorded on San Diego County Subdivision Map 148 in 1883. (See also figure 27.) Former city blocks are denoted by dotted lines. (Illustration courtesy of San Diego County Assessor's Office)*



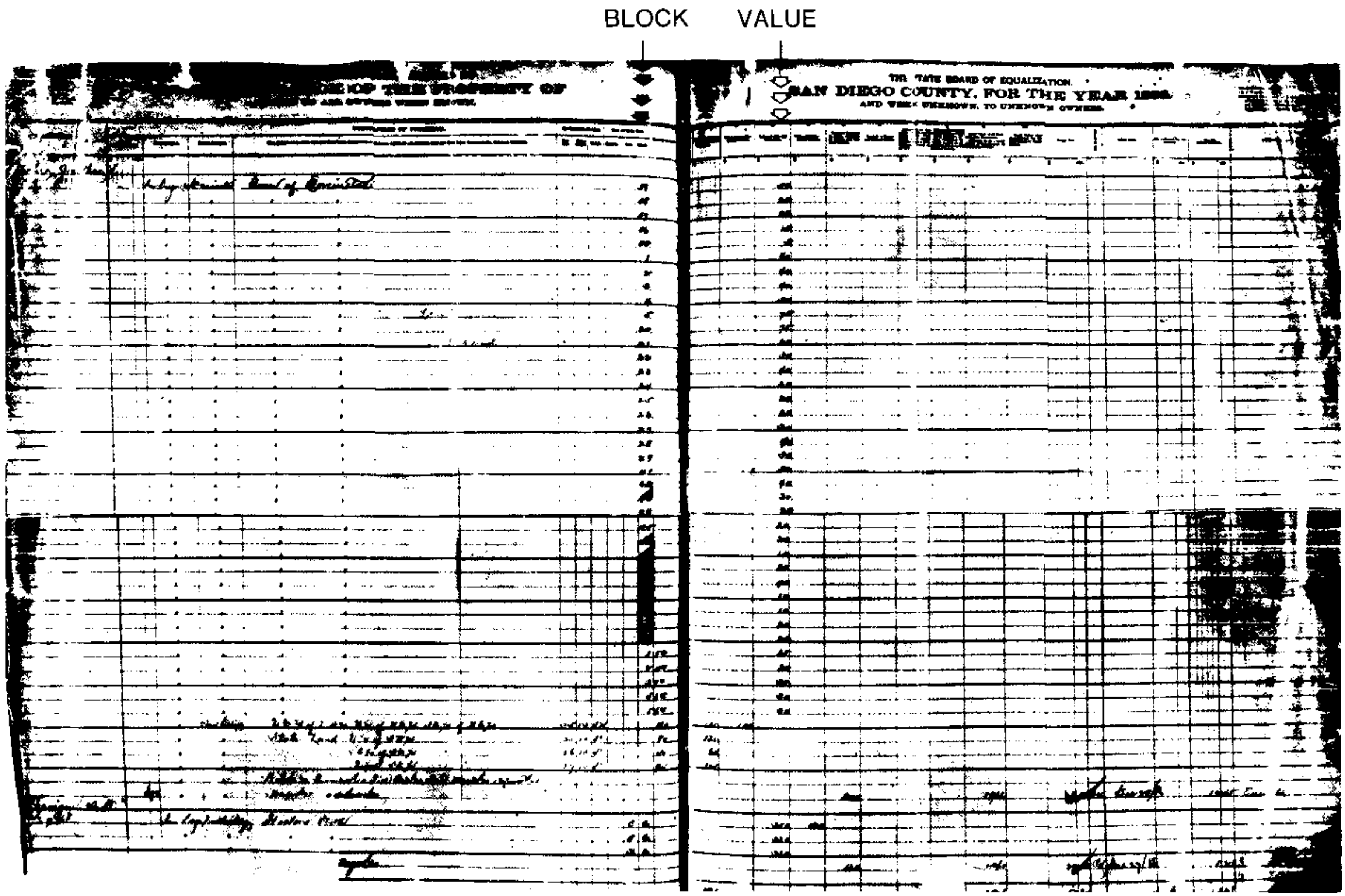


Figure 8. *A Tax Assessor's record sheet for John S. Pitcher listing information on real and personal property owned at Encinitas. Location and value of property are important columns. Shaded blocks (Blocks 48-54), shown underwater in figure 6, were owned by Pitcher and are assessed on this sheet. (Illustration courtesy of San Diego County Assessor's Office)*

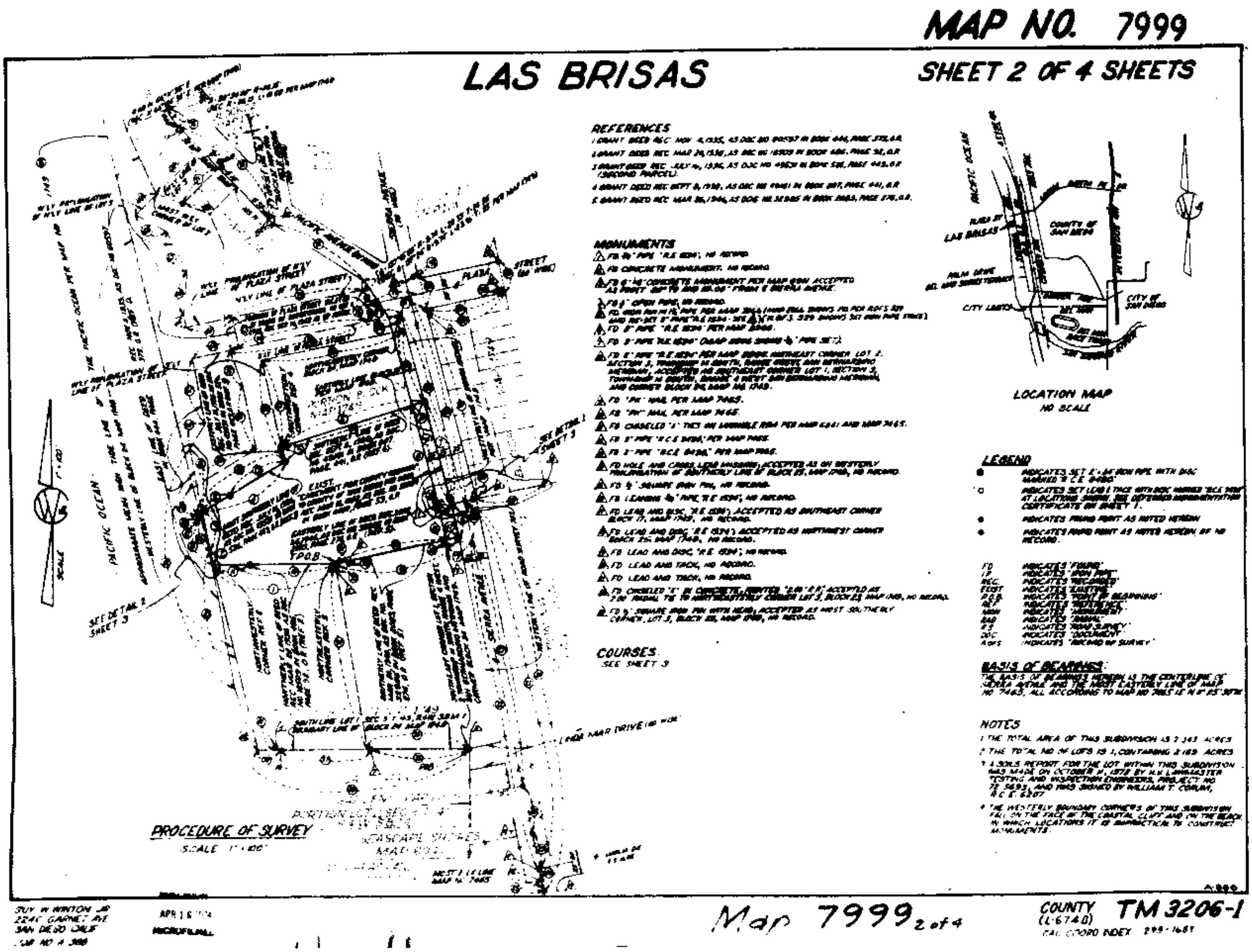


Figure 9. *Las Brisas Subdivision Map # 7999. Note detailed descriptions of survey monuments, references to earlier surveys, and list of abbreviations commonly found on such surveys. (Illustration courtesy of San Diego County Recorder's Office)*

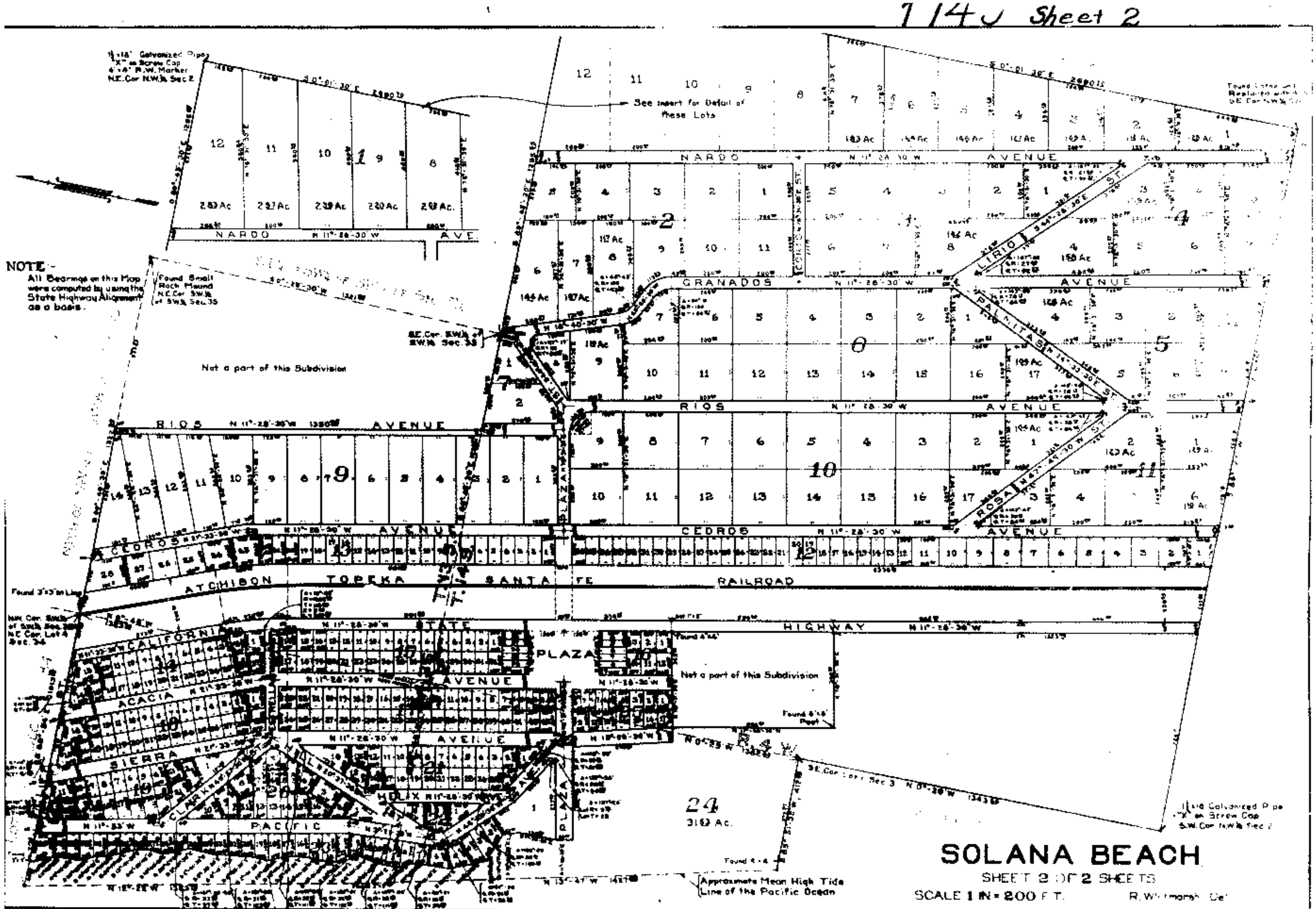
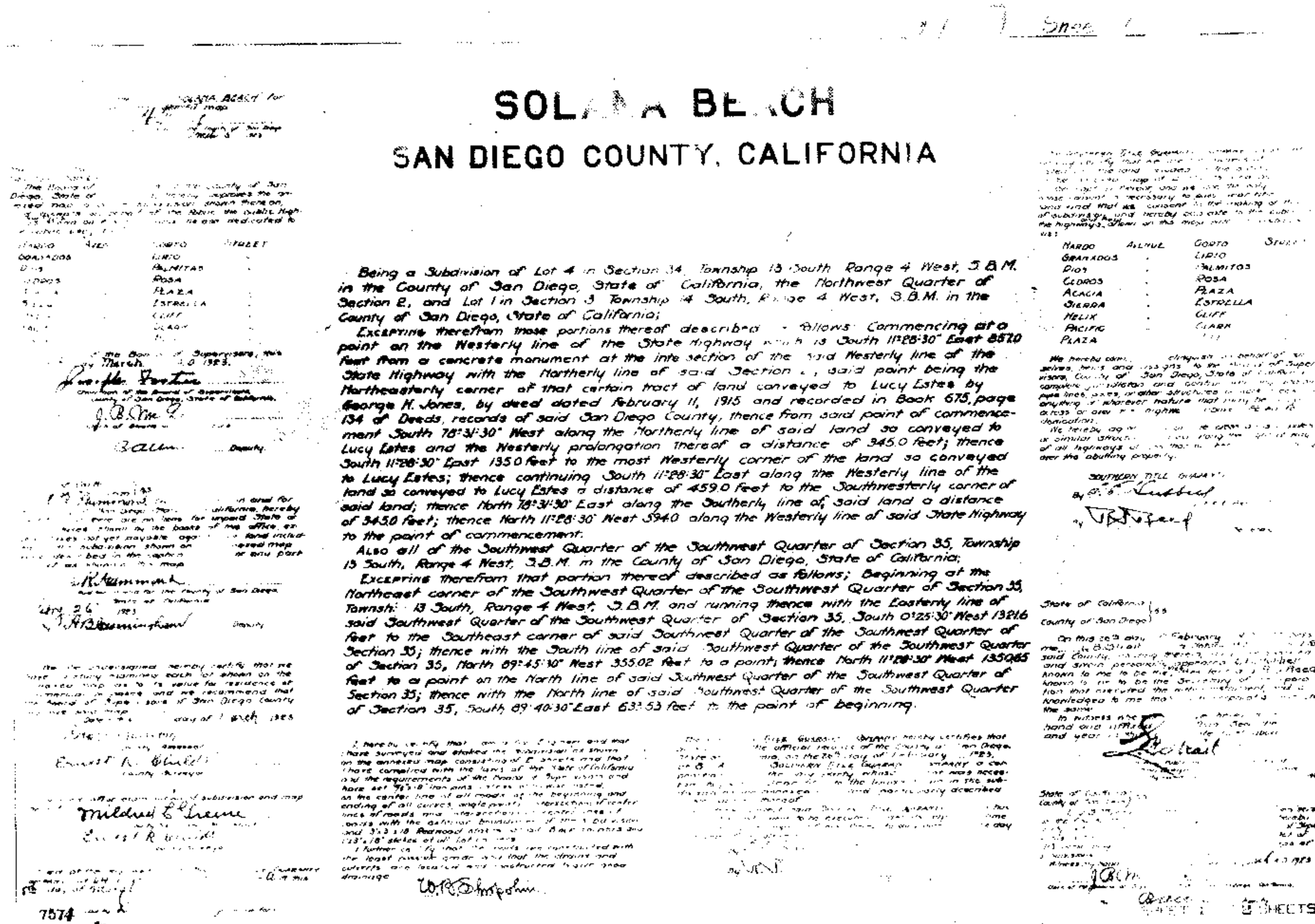


Figure 10. *Original subdivision plat of Solana Beach, 1923. (Illustration courtesy of San Diego County Recorder's Office)*



SOL[illegible]A BE[illegible]CH

SAN DIEGO COUNTY, CALIFORNIA

Being a Subdivision of Lot 4 in Section 34, Township 13 South, Range 4 West, S.B.M. in the County of San Diego, State of California, the Northwest Quarter of Section 2, and Lot 1 in Section 3, Township 14 South, Range 4 West, S.B.M. in the County of San Diego, State of California;

Excepting therefrom those portions thereof described as follows: Commencing at a point on the Westerly line of the State Highway which is South 11°28'30" East 857.0 feet from a concrete monument at the intersection of the said Westerly line of the State Highway with the Northerly line of said Section [illegible], said point being the Northeasterly corner of that certain tract of land conveyed to Lucy Estes by George H. Jones, by deed dated February 11, 1915 and recorded in Book 675, page 134 of Deeds, records of said San Diego County, thence from said point of commencement South 78°31'30" West along the Northerly line of said land so conveyed to Lucy Estes and the Westerly prolongation thereof a distance of 345.0 feet; thence South 11°28'30" East 135.0 feet to the most Westerly corner of the land so conveyed to Lucy Estes; thence continuing South 11°28'30" East along the Westerly line of the land so conveyed to Lucy Estes a distance of 459.0 feet to the Southwesterly corner of said land; thence North 78°31'30" East along the Southerly line of said land a distance of 345.0 feet; thence North 11°28'30" West 594.0 along the Westerly line of said State Highway to the point of commencement.

Also all of the Southwest Quarter of the Southwest Quarter of Section 35, Township 13 South, Range 4 West, S.B.M. in the County of San Diego, State of California;

Excepting therefrom that portion thereof described as follows; Beginning at the Northeast corner of the Southwest Quarter of the Southwest Quarter of Section 35, Township 13 South, Range 4 West, S.B.M. and running thence with the Easterly line of said Southwest Quarter of the Southwest Quarter of Section 35, South 0°25'30" West 1321.6 feet to the Southeast corner of said Southwest Quarter of the Southwest Quarter of Section 35; thence with the South line of said Southwest Quarter of the Southwest Quarter of Section 35, North 89°45'30" West 355.02 feet to a point; thence North 11°28'30" West 1350.65 feet to a point on the North line of said Southwest Quarter of the Southwest Quarter of Section 35; thence with the North line of said Southwest Quarter of the Southwest Quarter of Section 35, South 89°40'30" East 633.53 feet to the point of beginning.

Avenue	Street
Nardo	Gorto
Granados	Lirio
Dios	Palmitos
Cedros	Rosa
Acacia	Plaza
Sierra	Estrella
Helix	Cliff
Pacific	Clark
Plaza	

Southern Title Guaranty

State of California, County of San Diego } ss

7574

[illegible] SHEETS

Figure 11. *Subdivision record for Solana Beach. This sheet contains a detailed description of the property shown in figure 7, along with signature approval of various county offices. (Illustration courtesy of San Diego County Recorder's Office)*

agencies (figure 11). This record often appears on a separate sheet the same size as the map. It can yield information such as: exact boundary lines, streets to be deeded to the county or city, exact dates of approval, and who was doing the subdividing (not necessarily the same person whose name was on the tax rolls). In the case of a more in-depth investigation, each of the county or city agencies--such as auditor, surveyor, or board of supervisors--which gave its approval for the project can be researched. Thus, minutes or notes for the date of approval may be obtained. This may, however, yield a relatively small amount of information from a fairly lengthy search, and is not recommended for general investigations.

Direct measurements of bluff configuration from subdivision maps are usually very difficult because topographic information is seldom, if ever, provided. Nonetheless, subdivision maps, records, and surveys do provide a good source of information, particularly for man-made boundaries or structures. Furthermore, they often present new possibilities for research or correlation with other data.

Road Surveys and Other County Maps (B-3)

References on subdivision or assessor's maps may lead to several other sources, that occasionally do contain detailed information on bluff formations. Record-of-survey maps, for example, can be found through references such as "ROS 1228" on the Solana Beach assessor's map from figure 6. These maps often are compiled for areas to be subdivided, and contain much of the same information as subdivision maps. However, they may illustrate not only survey points, but also topographic contours, including the top and bottom of the bluffs. Later grading will change these measurements, but record-of-survey maps still can provide good, large-scale historical comparisons to present coastal conditions.

Such "before-and-after" comparisons can more easily be made with some modern subdivision, because developers now must file both subdivision maps and "tentative parcel maps" (TPMs or TMs) which usually show more detail. TPMs show the outlines of all proposed structures and roads as they relate to the topographic contours at each specific site (see figure 12).

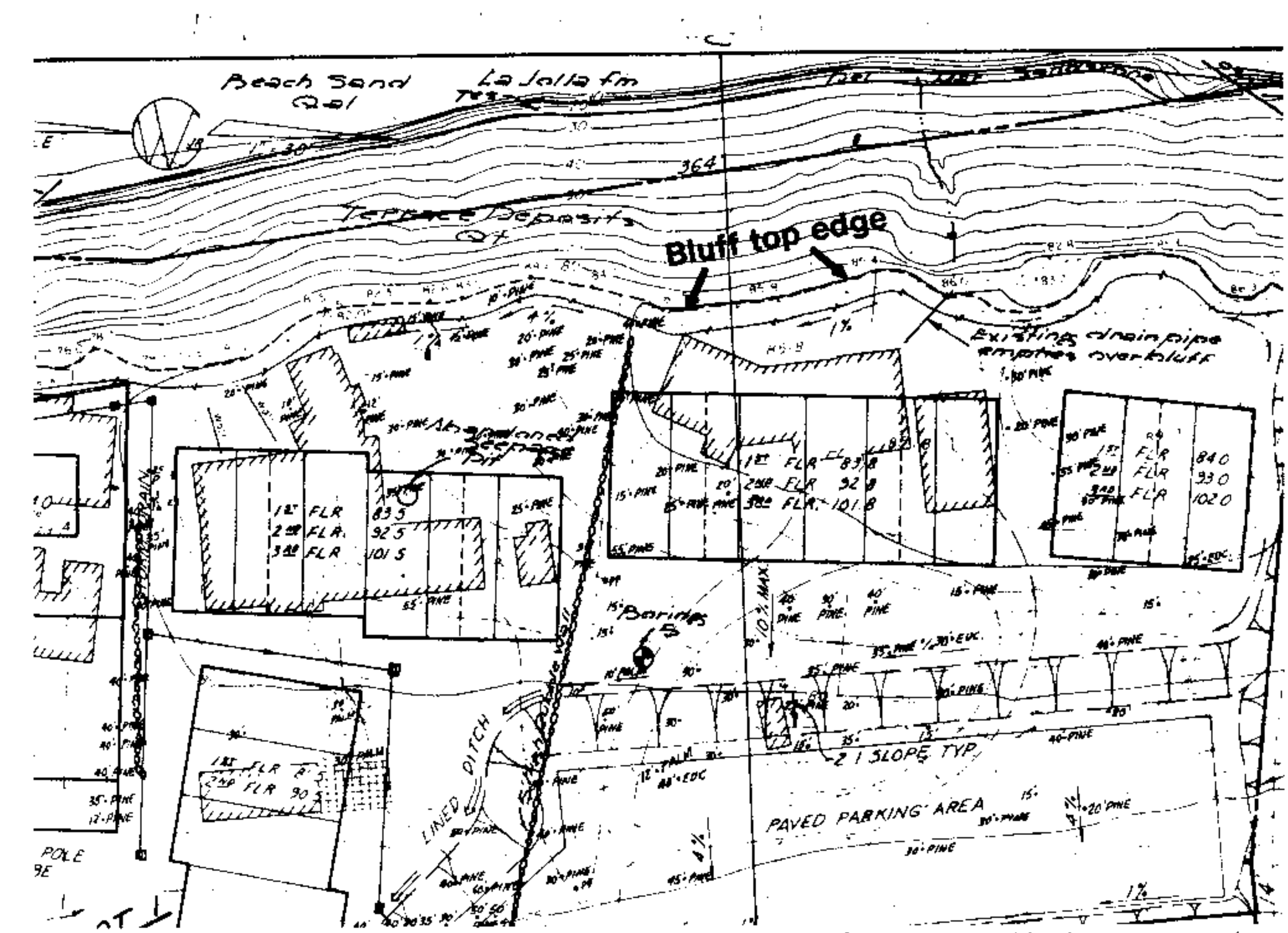


Figure 12. *Portion of a tentative map for a Solana Beach development. A recent map, this shows proposed building outlines and topographic contour lines along the bluff top edge, along with underlying rock formations. (Courtesy of San Diego County)*

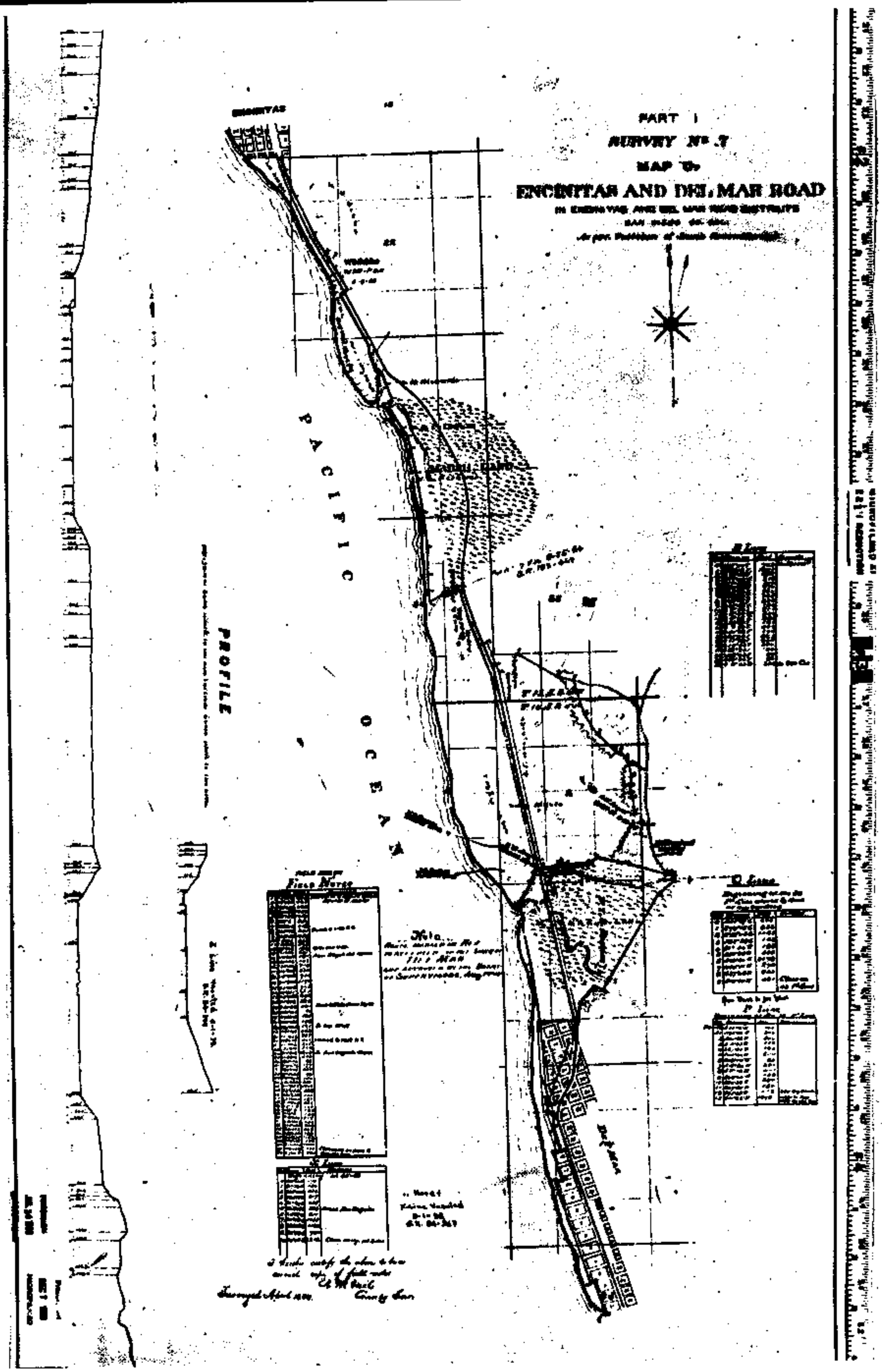


Figure 13. *An 1893 road survey of the coast from Del Mar to Encinitas showing hilly or marshy areas and proposed routes for a coastal road. Also includes field notes and topographic cross section. (Illustration courtesy of San Diego County Surveyor's Office, Department of Transportation)*

In some but not all cases, these contours will include the bluff edge, and an accurate mean high tide line. Both tentative maps and record-of-survey maps should be available from the county or city recorder's office, but older copies may be harder to find.

Another useful type of map is referred to by the letters "RS 707" on the Solana Beach assessor's map. This indicates a county road survey, which was used as a basis for later subdivision surveys in that area. Road surveys vary in content, and are covered in more detail below.

With each new road that is constructed, from a country lane to a federal highway, a preliminary survey of some kind is necessary. These are filed at the state, county, or city Department of Transportation, depending on which governmental body authorized construction of the road. Although old road surveys may be difficult to locate, they can be quite useful, especially if the road was built on or near a sea cliff. Some surveys, particularly newer ones, can be identified and located from references on assessor's or subdivision maps. As mentioned before, "RS 707" is shown on both figure 6 and figure 10, and refers to a moderately old road survey for Sierra Avenue.

Figure 13 shows the 1893 road survey for a proposed road from Encinitas to Del Mar, crossing the region that is now Solana Beach. As indicated by its low number, seven, this was one of the earliest San Diego county road surveys. Though the road was never constructed, the map contains a wealth of information concerning the coastal bluffs, lagoons, and general topography in the region of the proposed road routes in 1893. Man-made features such as railroad lines are also shown, and some property owners are listed along with references to appropriate volumes and pages in the Book of Deeds. Deed references can still be found under the same identifying numbers in the county recorder's office. The bearing and length of each road segment is given in the field notes, and specific remarks are made concerning the location and nature of houses, bluffs, "cobblestone dykes," river mouths, and other landmarks. Finally, this particular map includes a detailed topographic cross section for each alternative route, listing the exact depth of all river channels, altitude, cliffs, and beaches crossed. On some road survey maps, the distance from the road to the coastline or bluff top has been precisely surveyed, and can be used to determine distances of retreat.

State highway surveys can also yield much information, and may be obtained from local Department of Transportation records, CalTrans, or the California State Lands Commission. Although San Diego has few county roads which run directly along the ocean's edge, many other towns do have them (if the roads have not already been washed away). In such instances, old road surveys may prove to be extremely valuable.

Supervisor's Records (B-4)

Eventually, roads deteriorate to the point where they are no longer usable, and must either be repaired or removed. In unincorporated areas, this removal, "vacation," or "abandonment" must first be approved by the County Board of Supervisors. Such road closures are indicated on both assessor's and county Department of Transportation subdivision maps, and can be traced in several ways.

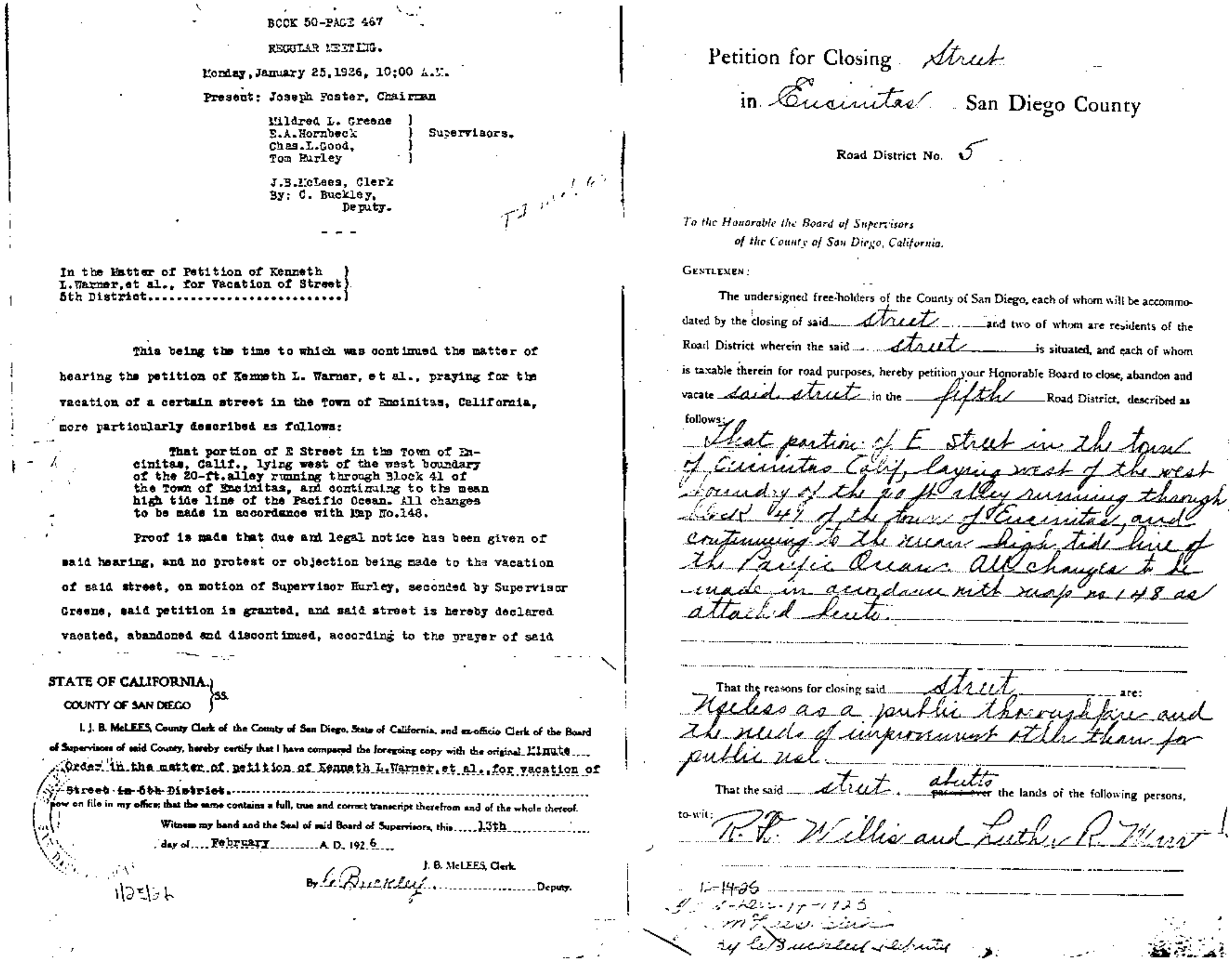
Subdivision maps held by the San Diego County Department of Transportation have been shaded or otherwise marked to indicate all roads, sewers, or other public utilities which have been installed, deleted, or closed in the past. For closures, a date is given, together with an S.R. (Supervisor's Records) number. The date and S.R. number can be traced to an "Official Street Closing" motion by the County Board of Supervisors, filed in the county clerk's or recorder's office (figure 14). The date given will indicate when the road was closed, but the records of the final decision may not tell why the closure was necessary.

To find out why the street was closed, the researcher must work backward in time, using the date of the meeting or public hearing from which the final decision was referred as a starting point. If the subject was considered at several meetings, each must be examined in turn, until the original petition for the alley, street or road closing is found (figure 14). This petition should provide a description of property adjacent to the street, and a listing of the problems--such as surface runoff, gullies, or undermining--which warranted closing that particular road. Incidentally, the closure of a portion of E Street referred to in figure 14 is also shown on the Encinitas assessor's map in figure 7.

In addition to minutes of supervisors' meetings, San Diego County also stores road closure records at the county clerk's office, in separate files for each road district in the county. Within each file are petitions, complaint letters, interoffice memos, announcements of public hearings, and records of approval or disapproval for each road vacation considered by the Board of Supervisors.

Similar files are available in county clerks' office records covering tax assessment appeals to the County Board of Equalization. These appeals were filed by homeowners who wished to have their property taxes lowered, because of devaluation of their land due to floods, fires, or coastal retreat. The appeals are organized by dates or property owners' names. Locating specific cases can take time, but a general search may be productive. In some counties,

Figure 14. *A Supervisors' motion (left) and original petition (right) for vacation of E Street in Encinitas, as shown in figure 7. (Illustration courtesy of San Diego County Clerk of the Board of Supervisors)*



BOOK 50-PAGE 467

REGULAR MEETING.

Monday, January 25, 1926, 10:00 A.M.

Present: Joseph Foster, Chairman

Mildred L. Greene, E.A. Hornbeck, Chas. L. Good, Tom Hurley — Supervisors.

J.B. McLees, Clerk
By: C. Buckley, Deputy.

In the Matter of Petition of Kenneth L. Warner, et al., for Vacation of Street, 5th District.

This being the time to which was continued the matter of hearing the petition of Kenneth L. Warner, et al., praying for the vacation of a certain street in the Town of Encinitas, California, more particularly described as follows:

That portion of E Street in the Town of Encinitas, Calif., lying west of the west boundary of the 20-ft. alley running through Block 41 of the Town of Encinitas, and continuing to the mean high tide line of the Pacific Ocean. All changes to be made in accordance with Map No. 148.

Proof is made that due and legal notice has been given of said hearing, and no protest or objection being made to the vacation of said street, on motion of Supervisor Hurley, seconded by Supervisor Greene, said petition is granted, and said street is hereby declared vacated, abandoned and discontinued, according to the prayer of said

STATE OF CALIFORNIA, COUNTY OF SAN DIEGO } ss.

I, J. B. McLEES, County Clerk of the County of San Diego, State of California, and ex-officio Clerk of the Board of Supervisors of said County, hereby certify that I have compared the foregoing copy with the original Minute Order in the matter of petition of Kenneth L. Warner, et al., for vacation of Street ~~in 5th District~~, now on file in my office; that the same contains a full, true and correct transcript therefrom and of the whole thereof.

Witness my hand and the Seal of said Board of Supervisors, this 13th day of February A. D. 1926

J. B. McLEES, Clerk.
By C. Buckley, Deputy.

Petition for Closing Street
in Encinitas San Diego County

Road District No. 5

To the Honorable the Board of Supervisors of the County of San Diego, California.

GENTLEMEN:

The undersigned free-holders of the County of San Diego, each of whom will be accommodated by the closing of said street and two of whom are residents of the Road District wherein the said street is situated, and each of whom is taxable therein for road purposes, hereby petition your Honorable Board to close, abandon and vacate said street in the fifth Road District, described as follows:

That portion of E street in the town of Encinitas Calif, laying west of the west boundary of the 20 ft alley running through Block 41 of the town of Encinitas, and continuing to the mean high tide line of the Pacific Ocean. All changes to be made in accordance with map no 148 as attached hereto.

That the reasons for closing said street are: Useless as a public thoroughfare and the need of improvement other than for public use.

That the said street abutts ~~passes over~~ the lands of the following persons, to-wit: R. R. Willis and Luther R.

recent appeals may be stored by a separate assessment appeals board, which has replaced the Board of Supervisors in this function.

Board of Supervisors' meeting minutes--especially those recorded during flood or storm years--can also yield other information. In some cases, yearly abstracts of the minutes may be available. These briefly list all actions taken by the board, along with dates and the names of individuals or parties involved. Within each year, the motions are arranged by subject, and in chronological order. Thus, unless specific dates are known, a "random search" will be necessary. This is a bit tedious, but it can yield useful information. For example, a preliminary search of old minutes of the San Diego County Board of Supervisors for the "wet" years around 1889-1891 revealed actions concerning road and bridge repairs, flood relief funds, and numerous road closures, some in coastal areas. Theoretically, all actions performed by the county departments of surveying and mapping or public works should be covered in supervisors' records. But, if time is available, the old files of these departments can be searched for more detailed records of past repairs to coastal streets, sidewalks, etc.

Once periods of coastal damage have been narrowed down sufficiently, the records of other county or city agencies should also be investigated. For example, sewer districts, water districts, irrigation districts, and public utilities may have old records of repairs and surveys on file. Such agencies may even have their own maps of coastal and inland areas showing water, gas, sewer, or electrical lines, and possibly locations of past repairs.

Tax Assessor's Records (B-5)

If a region is found for which old maps or records indicate that private property has retreated a large distance inland, this region should be researched as extensively as possible. Tax records provide one of the best methods for quantitatively proving that: (1) the land did exist and someone paid taxes on it, and (2) the land subsequently eroded, decreased in value, or was removed from the tax rolls. Some of these devaluations may be recorded in the assessment appeals files discussed above.

Current tax assessor's records can be located through computer-based indexes of individual owners' names, or through the book, map, and parcel numbers obtained from assessor's maps. Older records, again, may be more difficult to find, because specific individuals' taxes were recorded in an almost random order, at least in San Diego County. Indexes for each year do exist, but are not always accurate.

Because of this, an entire year's records may have to be examined to find a few specific individuals or lots. In addition, people who paid their taxes late were not listed in the main rolls, but in a "Delinquent Payments" section at the end of the main list. The researcher should therefore determine beforehand which years are most likely to show evidence of erosion, and, if possible, the specific block and lot numbers of coastal property that may have been affected.

The assessor's record sheets themselves list information concerning the exact location, owner, and legal description of property, its assessed value, improvements, and sometimes even the owner's personal belongings. The 1886 tax sheet shown in figure 8 lists property owned by John Pitcher in the Encinitas area, most of which he later subdivided and sold. Some of the parcels shown, such as Blocks 48-54, have since eroded away, as indicated on the assessor's map in figure 7. Others decreased in value as indicated on later record sheets. Each assessor's record contains the following categories: (1) name of owner; (2) road district; (3) school district; (4) description of property (includes town name if land was in a town; or section, township, and range numbers if it was not) along with personal possessions in some cases; (5) lot and block numbers for subdivided areas; (6) number of acres (not always given), (7) value of real estate and improvements (these are the values plotted in figure 15); (8) value of personal property (not always given); (9) various

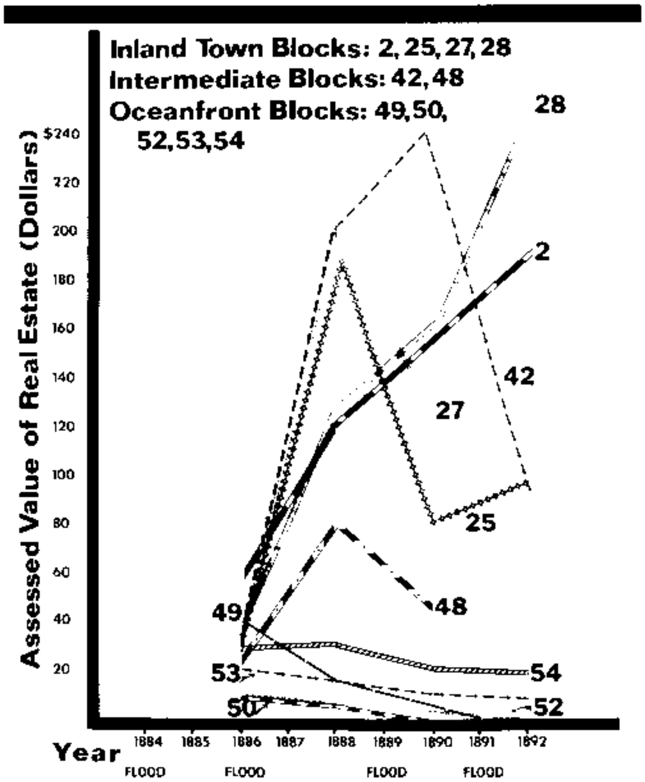


Figure 15. *Graph of property values, 1886-95, for blocks in the 1883 Encinitas Subdivision. As the Seaward property was devalued and removed from the tax rolls following wet and stormy years, the landward blocks and lots increased in value. (Illustration courtesy of Gerry Kuhn)*

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United States of America---State of California.

To all to whom these Presents shall come, Greeting:

Whereas, *Under the provisions of the several Acts of the Congress of the United States, entitled "An Act to appropriate the proceeds of the sales of the public lands and to grant pre-emption rights," approved September fourth, eighteen hundred and forty-one, five hundred thousand acres of the public lands were granted to the State of California; and an Act entitled "An Act to provide for the survey of the public lands in California, the granting of pre-emption rights therein, and for other purposes," approved March third, eighteen hundred and fifty-three, ten sections of land were granted for the erection of public buildings, and seventy-two sections for a Seminary of learning; also, the sixteenth and thirty-sixth sections of each township in said State; also, an Act entitled "An Act donating public lands to the several States and Territories which may provide Colleges for the benefit of agriculture and the mechanic arts," approved July second, eighteen hundred and sixty-two, one hundred and fifty thousand acres of the public lands were also granted to said State; and, whereas, the Legislature of the State of California has provided for the sale and conveyance of said lands by statutes enacted from time to time: and, whereas, it appears by the certificate of the Register of the State Land Office, No.* 4909 *, issued in accordance with the provisions of law, bearing date the* 19th *day of* February *, 1883, that the tracts of* Sixteenth and Thirty Sixth Section School *land hereinafter described have been duly and properly located in accordance with law, and that* J. S. Pitcher is *entitled to receive a patent therefor;*

Now, Therefore, *the State of California hereby grants to the said* J. S. Pitcher *and to* his *heirs and assigns, forever, the said tracts of land, located as aforesaid, and which are known and described as follows, to wit:* Lots One Two Three and Four, The East half ½ of the North East Quarter ¼ and the North East Quarter ¼ of the South East Quarter ¼ of Section Sixteen (16) Township Thirteen (13) South, Range Four (4) West San Bernadino Meridian

containing Two Hundred and Forty *acres, together with all the privileges and appurtenances thereunto appertaining and belonging. To have and to hold the aforegranted premises to the said* J. S. Pitcher *and to* his *heirs and assigns, to* his *and their use and behoof, forever.*

In Testimony Whereof, *I,* George Stoneman *, Governor of the State of California, have caused these Letters to be made Patent, and the seal of the State of California to be hereunto affixed. Given under my hand at the City of Sacramento, this, the* Thirty Seventh [?] *day of* February *, in the year of our Lord one thousand eight hundred and eighty-* three.

Seal of State

George Stoneman
Governor of State.

Attest: Thos L. Thompson
Secretary of State.

Countersigned: W. C. S. Willey
Register of State Land Office.

Figure 16. *1883 patent from the United States of America--State of California to John S. Pitcher for the land at the present site of Encinitas, California. (Illustration courtesy State Lands Commission, State of California)*

deductions; (10) total property value (adding up all lots owned); (11) value after equalization by state; (12) total tax; (13) state poll tax; (14) date paid; (15) tax on school district; and (16) remarks (may include damages by fire or flood).

Once obtained, old assessor's records of the parcel(s) most affected by erosion should be examined year by year during and following the storm years when erosion is most likely to have occurred. If the erosion was severe, some parcels may actually have been dropped from the tax rolls. Data gathered from these records can also be used to construct a graph of real estate property values over time (figure 15). This graph can then be compared with a graph of the value of other lots in the same area that were not affected by erosion. If property values in other lots were generally increasing while the threatened parcels were rapidly and progressively declining in value, this information could be used as evidence of erosion. The years of declining values, or the dates of removal from the tax rolls should then be checked with street closings, assessment appeals, or other sources for possible time and place correlations.

County Deeds (B-6)

If additional proof is needed that dry land did exist in an area that is currently underwater, then the owner's name listed in the assessor's record books can be traced to the deed for the property. In addition, some road surveys, railroad surveys, and subdivision records give references to deeds. A book of deeds should be available in the county or city recorder's office, listing all legal transfers of property in chronological order. For each year, an annual index to the grantor (seller) and the grantee (buyer) should be available.

When California became a state in 1850, open land was primarily divided into three categories: Spanish ranchos, state lands, and federal lands. When federal lands were granted to an individual for subdividing or homesteading, the transaction was listed in a book of patents, which was the precursor to the county book of deeds. Figure 16 shows the patent for the present town of Encinitas, granted to J.S. Pitcher in 1883. Both the book of patents and a patent index should be available at the county or city recorder's office. However, when searching for a particular patent, it may be necessary to look through the records of an entire year, unless the patent number is already known.

Once the land was purchased by an individual, usually from the federal government, all further transactions were recorded in the county or city book of deeds. Researching ownership in these records is not difficult, once the filing system is understood. If even a single past owner is known, by looking up that person's name in the "grantee" index, the researcher can discover from whom the land was purchased, and by looking in the "grantor" index, to whom the property was sold.

This process can be continued for each consecutive owner, both backward in time to the original patent records, and forward to the present owner. In this way, an entire history of ownership for important coastal property can be compiled through grantor-grantee indexes. The grantor index, in particular, provides specific deed numbers which can be looked up in the book of deeds, mentioned above. Such deeds provide documentation both for the ownership history, and for existence of the land itself. Copies of deeds purchased at a recorder's office can be notarized to verify that the records copied are legally true and valid.

The deeds themselves list names, dates, and prices for each land deal which occurred, and also contain legal descriptions of the parcel(s) sold. Some deeds also provide references to subdivision maps or other legal surveys of the land.

Further proof of ownership can be obtained through probate court records (available from the county clerk's office under the name of the deceased property owner) or in coroner's office files. The latter also lists details concerning the circumstances of death, which can indicate natural disasters or provide other historical clues. These two sources list property that was included in the owner's will and are particularly useful in cases where a single person owned a large amount of coastal property.

Historical Maps and Photos (Row C)

This section covers Row C of the flowchart: general-purpose historical maps and photographs. These contain some information on property, roads, and structures, but are particularly useful for determining past coastlines and other natural landforms, as well as for identifying changes in these landforms over time. Maps and photographs are especially necessary for areas that have only recently been, or have yet to be, developed because such areas will not usually be covered as thoroughly by the local written records discussed above.

Finding and Interpreting Historical Maps (C-1)

A wide variety of old maps is applicable to the study of historic coastline change, ranging from the rough sketches made by Spanish missionaries to the precise and detailed charts of the United States Coast and Geodetic Survey (presently National Ocean Survey). Most of these are useful in one way or another if they cover the area in question.

The important factors to note on any map are accuracy, scale, and type of information presented. For example, many towns and subdivisions wishing to attract new residents, printed up advertising maps, which glowingly portrayed their area. Although these may have been detailed enough to show individual houses or roads, they were not always accurate, especially in showing distances or parcel sizes. Such pictorial maps can be of a useful scale and appear to cover great detail but they are often misleading and should always be checked against other, more reliable sources, such as subdivision maps.

Maps that show a grid of township or survey lines are usually more accurate, but even these should be used with caution, because survey baselines may have been relocated over the years. Although it is possible to correct for these changes using sophisticated equipment, the most useful reference points for comparing one map to another include measured survey markers, railroad tracks, and central lines of streets near the coast. Trees and resistant rock headlands or outcroppings can also be used. If two maps of the same scale are overlain and such features superimposed, then coastal changes can be more easily observed.

Map scale is particularly important because different scales are applicable to different types of planning analysis. For example, a 1:24,000 scale map might be useful for understanding regional coastline configurations or extremely large changes in a bluff line. Maps having a smaller scale than that (e.g. 1:40,000) are useful for place-names, rivers, or major roads, but not for detailed land use planning or research. A 1:10,000 scale (figure 17) permits some direct measurement of bluff retreat. For site-specific measurement, 1:60 to 1:800 scale maps would be best, but are seldom available, except where detailed studies have been made in the past. The 1:2,400 scale is a good compromise for mapping coastal retreat within a particular study area.

Table D

Total Potential Error at Various Map Scales*

Scale Ratio	Approx. feet/inch	Approx. conservative maximum error (in feet)**
1:125,000	10,417	417
1: 62,500	5,208	208
1: 40,000	3,333	133
1: 24,000	2,000	80
1: 20,000	1,667	67
1: 10,000	833	33
1: 5,000	417	17
1: 2,400	200	8
1: 800	66.7	2.7
1: 200	16.7	.7

*Adapted from *The Analysis of Historical Shoreline Changes*, by V. Goldsmith, et al. (1978).

**Addition of errors in map production to errors in interpretation by nonprofessional map reader:

USGS map making allowable error (.02") + potential

Map reader error (.02") = .04" or 1 mm combined potential error.

Table D gives a comparison between different map scales, and a conservative figure for minimum distances that can be accurately measured at a given scale. When two maps are overlain, their potential errors must be added. In searching out old maps, one will find that various scales and adjustments will have to be made. In general, if a map is enlarged, the same error factor should be used as at the original scale. Thus, as seen in Table D, even if a 1:40,000 scale map is enlarged to 1:10,000 the possible error in measurement would still be almost 133 feet. This means that if less retreat is taking place, then larger scale maps will be necessary to detect it.

Another less practical method of measuring historical coastal retreat is to document a changing distance between two points: one inland fixed reference point, and one point which accurately represents the bluff top at a given time. Although it is relatively easy to find inland reference points such as houses or roads, precise measurement of seaward points might be difficult because very few maps show a supposed "mean high tide line." Because of sand-level fluctuations and legal disputes, one person's mean high tide line may be 50 feet seaward of his next-door neighbor's. For this reason, it is probably a poor indicator of coastline retreat, except where very accurate maps are available, or where massive changes have occurred in beach size or cliff configuration.

There are several additional sources of error which apply to both maps and aerial photographs. First of all, the line on a map or photograph that appears to indicate a bluff may actually represent either the top of the bluff, the bottom, the mean high tide line, or some point in between. If distances are to be measured or compared, it is necessary that the same part of the bluff be used in all cases.

Another problem arises because of shrinking or distortion of images, either from photocopying or with deterioration of the original. Such distortion may occur just near map edges, or in various complex ways. As a common though seldom noticed example, some photocopying machines will cause 1/8 of an inch of "stretching" across

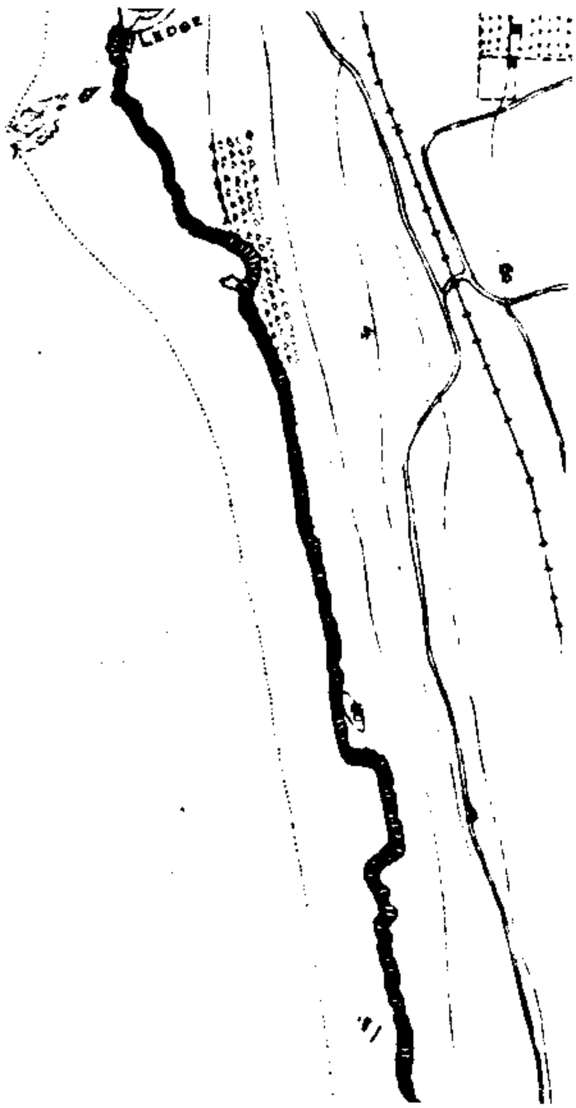


Figure 17a. *Portion of 1889 Coast and Geodetic Survey at 1:10,000 scale. Tops and bottoms of bluffs are shown, along with topographic contours. (Illustration courtesy of U. S. National Ocean Survey)*

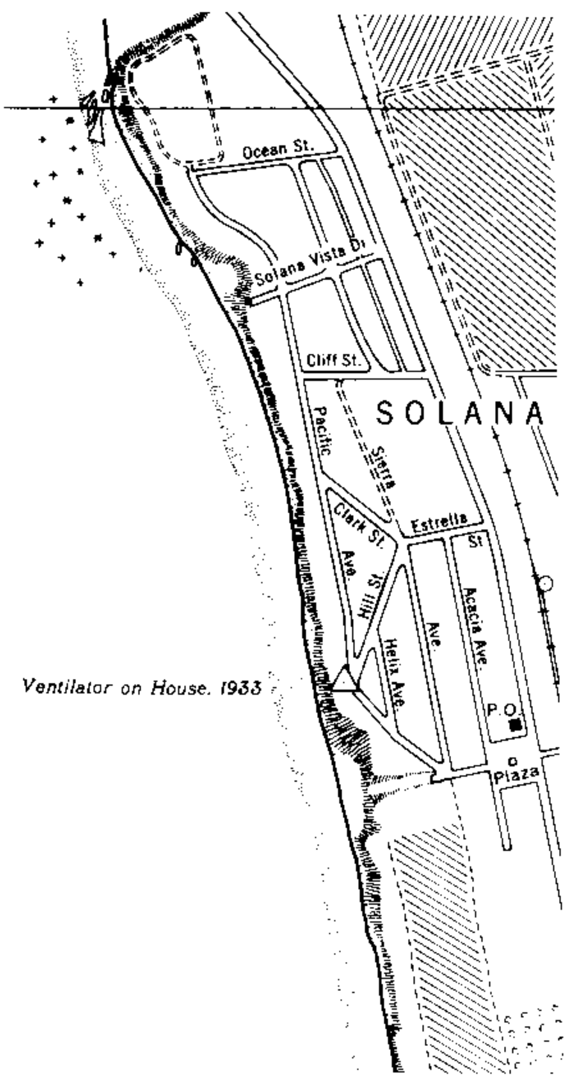


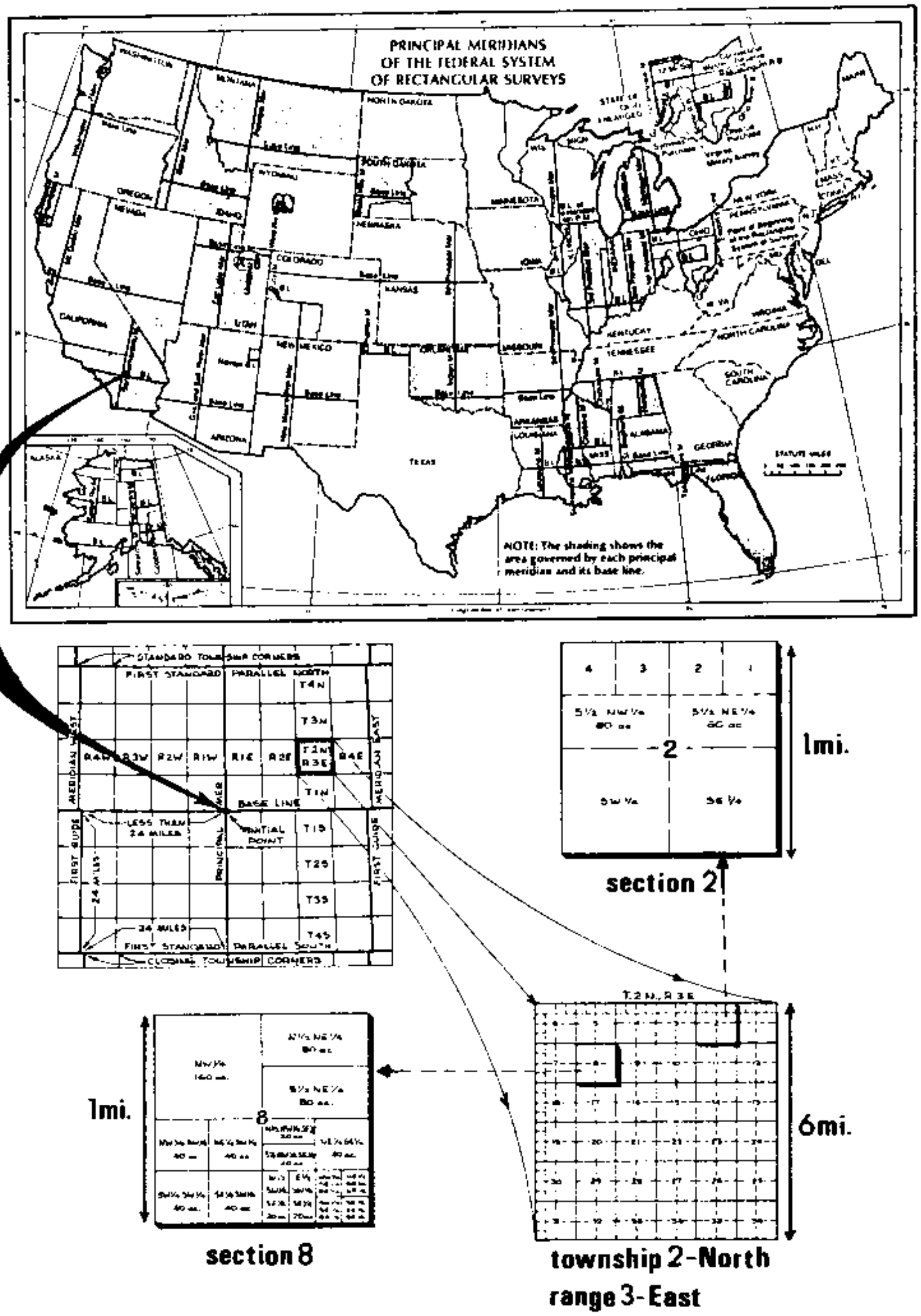
Figure 17b. *Portion of 1934 Coast and Geodetic Survey, same area and scale as in figure 17a, with some land-use and bluff-line changes visible. (Illustration courtesy of U. S. National Ocean Survey)*

an 8 ½" x 11" sheet of notebook paper because they enlarge the image slightly. This may not seem like much, but on a 1:24,000 scale map, it could cause a 250-foot error in measurements made from that copy. All of these pitfalls further emphasize the need to check and double-check any apparent evidence of erosion before definitive statements are made.

As a final word of caution, papers used for many maps are not dimensionally stable and may be subject to non-linear errors over the area of a single map. The indicated scale is approximate only. This imposes a distinct limitation on the accuracy of information that can be obtained by scaled measurements.

One extremely valuable reference for anyone using maps in planning or research is the *Coastal Mapping Handbook*, published by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS). Although it primarily describes current mapping practices and sources, the sections covering map making and interpretation could be very helpful for historical research. The Hand-

Figure 18. *A summary of the rectangular survey system in the U.S. (Illustration courtesy of Cazier, 1975; Bureau of Land Management, 1970)*



THE RECTANGULAR SURVEY SYSTEM

The U.S. rectangular system of surveys is a marvel of simplicity. Because of the system and the cadastral surveyors who transferred it from a plan on paper to regular lines upon the land, the swift and orderly settlement of a vast public domain became a reality.

Separate large pieces of the Public Domain are, in themselves, huge survey areas. There are 31 principal meridians and base lines in the contiguous United States and 5 in Alaska. At the intersection of these two lines is the initial point of each of the survey areas. Some of the principal meridians are numbered and the rest have proper names. The numbered ones go only to the Sixth Principal Meridan. Most of the other (named) meridians give a clue as to the area they govern: for example, the Boise Meridian, the New Mexico Principal Meridian, and the Humboldt Meridian. Townships are numbered north or south of the base line. A line or column of townships is called a range, and they are numbered east or west of the principal meridian.

At the beginning of the use of the rectangular system, no provision was made for the convergence of meridians or the limitation of accumulated error. At a later time standard parallels and guide meridians were included in the plan. Between the standard parallels the excess or deficiency of measurement caused by convergency and accumulated error in each township is placed in the sections lying against the north and west township boundaries. Each of the other sections theoretically contains 640 acres.

Each 6-mile-square township is divided into 1-mile-square sections numbered from 1 to 36. The section numbers run in opposite directions in alternate lines, beginning with section number 1 in the northeast corner of the township. These numbered sections may be further divided into aliquot parts, and thus described and identified. The southeast quarter of the southeast quarter of the southeast quarter of section 5, Township 2 North, Range 3 West, of the Boise Meridian, describes just one parcel of land. The description even tells the initiated how many acres are being described. The familiar BLM abbreviation for this particular 10 acres is SE¼SE¼SE¼ sec. 5, T. 2 N., R. 3 W., Boise Mer., Idaho.

book also lists hundreds of addresses of map sources, nation-wide. This book would be a useful addition to any planner's library.

Another excellent first source for old California maps is the Bancroft Library at the University of California, Berkeley. Fortunately, a large number of old maps and historical books there have recently been indexed in the *Guide to Library Research* (Davis, 1976). This text lists and describes hundreds of relevant books on California history, geography, and land use, as well as historical and current maps covering Spanish ranchos, cities, counties, and regions from one end of the state to the other. It also includes a helpful section on how to use the Berkeley library facilities and map room. This guide can be ordered by mail from the California State Lands Commission, but most charts and maps must remain in the library.

Other maps can be referenced through *A Guide to Obtaining Information from the U.S. Geological Survey* (USGS Circular No. 777), which can be ordered from the USGS Branch of Distribution, listed in Appendix B. This publication also emphasizes current sources, but older USGS papers, maps and aerial photos are available from the Branch of Distribution and from some regional offices of the Geological Survey. Descriptions of various sources, such as USGS libraries, offices, and related agencies are given in this guide, along with addresses and phone numbers.

Perhaps the most comprehensive source of old maps and photographs is the National Cartographic Information Center (NCIC). The NCIC is a clearinghouse for all federal agencies that deal with maps and photographs. It offers many valuable services to planners and researchers, including a comprehensive, computer-based index to nationwide aerial photography, and a collection of out-of-date USGS map reproductions. These and possibly other old maps can be obtained from either the western NCIC or NCIC headquarters. In association with the NCIC, the National Archives and the Geography and Map Division of the Library of Congress contain huge volumes of virtually untapped information.

Finally, the California State Lands Commission may have collections of historical maps, state highway surveys, federal land surveys, and many other useful items. This agency can be very helpful in guiding the historical researcher toward likely sources of old maps, photographs, and records. Addresses for all of the aforementioned state and federal agencies can be found in Appendix B.

The Rectangular Survey System

Many legal maps are based on the rectangular survey system, which has been applied throughout most of the western United States. In this system, land is divided into squares of equal area, so that the location of any piece of property may be precisely described by its position within one of these squares. As these survey lines provide the basis for most other legal and government maps, they should be understood by anyone researching historical maps. One historical guide to the cadastral surveys, which established these lines, is *Surveys and Surveyors of the Public Domain* by Lola Cazier. The diagram shown in figure 18 has been derived from her text, and from *Restoration of Lost or Obliterated Corners*, published by the U.S. Department of the Interior.

Specific Historical Maps

The following section gives descriptions and illustrated examples of some of the old maps that are most useful and easily accessible to the historical researcher. There are, of course, other types of maps which may be available from the general sources listed above, and the researcher may discover entirely new maps just by poking around in old books or files.

U.S. Cadastral Surveys: The rectangular coordinate system mentioned above was first established through a series of cadastral surveys during the second half of the nineteenth century, and these surveys provide a basis for all later maps that incorporate the rectangular survey grid. Cadastral survey maps are available from the Bureau of Land Management along with a pamphlet entitled *Land and Survey Records* (U.S. B.L.M., 1970) which describes how historical surveys are filed. These surveys cover almost all parts of the West, except for those Spanish ranchos which had not yet been subdivided at the time of the survey.

Figure 19 shows a reduced and modified copy of the U.S. cadastral survey for the coastline just south of Solana Beach, as it was in 1876. The original maps are generally not detailed enough to graphically show erosion, but they do show some topographic features, including a "sketched" coastline and an official surveyed one. The table of "meanders" lists the official coastal boundary lines, which do not necessarily match the actual coast. The length and direction of all township lines are described along with the area of each section. The notes of cadastral surveys contain descriptions of each section and all of the surveyed points which define it. They may also have valuable information in the form of "initiating documents" and "approval procedures," which provide an official explanation for survey or resurvey of a particular area. Resurveys do not change the original lines (which, accurate or not, are permanent legal boundaries), but can only attempt to verify what is already listed in the notes of the original.

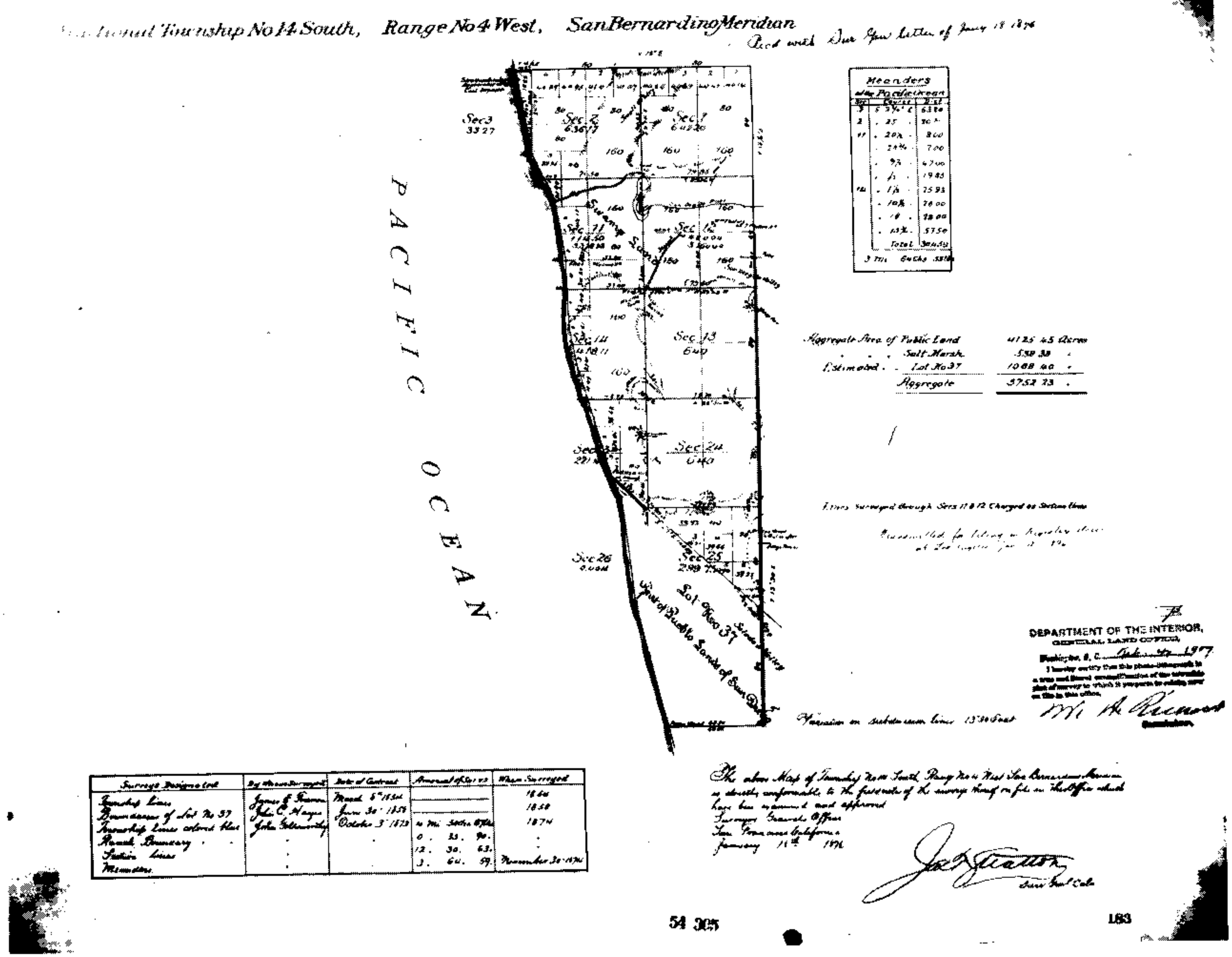


Figure 19. *A reduction of a cadastral survey plat showing original township and range lines for the Solana Beach Area in 1876, along with a few natural features and land ownership information. (Illustration courtesy of California State Lands Commission)*

Coast and Geodetic Surveys: Some of the most clearly and accurately drawn maps found during the historical research process are those of the U.S. Coast and Geodetic Survey. A general description of these and other resource materials, including information on ordering them, is available from the National Ocean Survey (address listed in Appendix B). The earliest of three index maps of the San Diego coastal area is shown in figure 20. From such index maps, selections can be made when ordering survey charts. The California State Lands Commission published *An Index to Historical Hydrographic and Topographic Charts of the California Coast* in October, 1979 as a guide to its holdings of U.S. Coast and Geodetic Survey maps.

Figure 17a shows a portion of survey chart T-1898 (dated 1889), which is underlined on the sample index map in figure 20. This section covers the Solana Beach area in 1889 (unnamed and uninhabited at the time), and includes a mean low water line as well as a highly accurate portrayal of the top and bottom of the bluffs. The railroad is also shown, and provides a reference line for comparing this map with others of different years. The triangular monuments and bench marks are also useful reference points, and may be referred to in the survey notes. A document describing *Rules for Representing Certain Topographical and Hydrological Features on the Maps and Charts of the U.S. Coast Survey* (1861) can be obtained from the U.S. Government Printing Office. The other Coast and Geodetic Survey map (figure 17b) shows the same region forty-five years later. Because these two maps are of the same scale, a visual comparison can bring out some interesting points. Note that many small headlands and indentations are shown on both maps, but that they vary slightly in outline, possibly due to erosion. A definite region of cliff retreat is evident near the cove in the lower-middle part of each map, although this may be due in part to hydraulic excavation which occurred in 1929 at the foot of Plaza Street. Also note that the mean low water line appears to have been further west at the time of the first survey. Even more visual evidence could be obtained from a simple overlay. Such evidence of erosion should always be confirmed by other maps or documents before definitive statements are made. Previous historical investigations have tended to rely rather heavily on such graphic sources, despite the many potential errors involved.

Field notes of the Coast and Geodetic Surveys are veritable grab bags of historical information. However, they vary considerably in the detail and type of information presented. Some surveys note factors such as average rainfall, "character of soil," coastline and beach formation, prominent rocks and ledges, lines of breakers, "shingle levees" (cobble beaches), bluff collapse, vegetation, settlements, and streamflow. Figure 21, from an 1889 survey of the area south of Solana Beach, illustrates the amount of detail available just under the headings of "Coastline Formation" and "Beach Formation." This description was transcribed from the original handwritten notes. Most later surveys had typewritten notes, but were not always as detailed as this one.

U.S. Geological Survey Topographic Maps: The U.S. Geological Survey (USGS) has been producing topographic and geologic maps since the late 1800s and maintains current 1:24,000 scale maps on file for virtually every coastal area. Each map covers a 10- by 15-mile area known as a quadrangle, or quad, which is named for a major city or landmark within its boundaries. Many quads have been surveyed more than once, but a new map is not necessarily printed for each new survey. Often, old maps are merely reprinted, with changes wrought by urbanization or erosion superimposed.

A portion of the Del Mar quadrangle topographic map is shown in figure 22. The index to USGS topographic maps of California is available from local offices of the USGS or from the Survey's Branch of Distribution (address in appendix B). Although these topographic maps are too small in scale for detailed analysis, they provide excellent coverage of larger landforms, such as lagoon openings or drainage patterns. Up-to-date topographic maps also provide good regional overviews, showing existing streets and landmarks at a useful scale for general purposes of orientation. They also present township and range lines well. Such recent maps can easily be ordered from any regional office of the USGS. In addition, older topographic maps of some areas are available dating as far back as 1891, and most of these can be ordered from the USGS at its Branch of Distribution. They might, however, be less useful because of their small scales (1:24,000 to 1:62,500).

Railroad Maps: Many towns along the Pacific coast have railroad lines--some of which predate the towns themselves--running near the oceanfront. Old track surveys for these lines often provide useful descriptions of the area immediately surrounding the railroad right-of-way. These surveys date as far back as 1853, and are of a variety of scales. Most railroad maps are proprietary documents of the railroad companies, but others are stored in the National Archives, California State Archives, and California State Lands Commission files. Some railroad maps include notations indicating where and when the tracks were damaged by flooding or landslides. Such maps--if they can be obtained--can be very helpful in predicting problem areas.

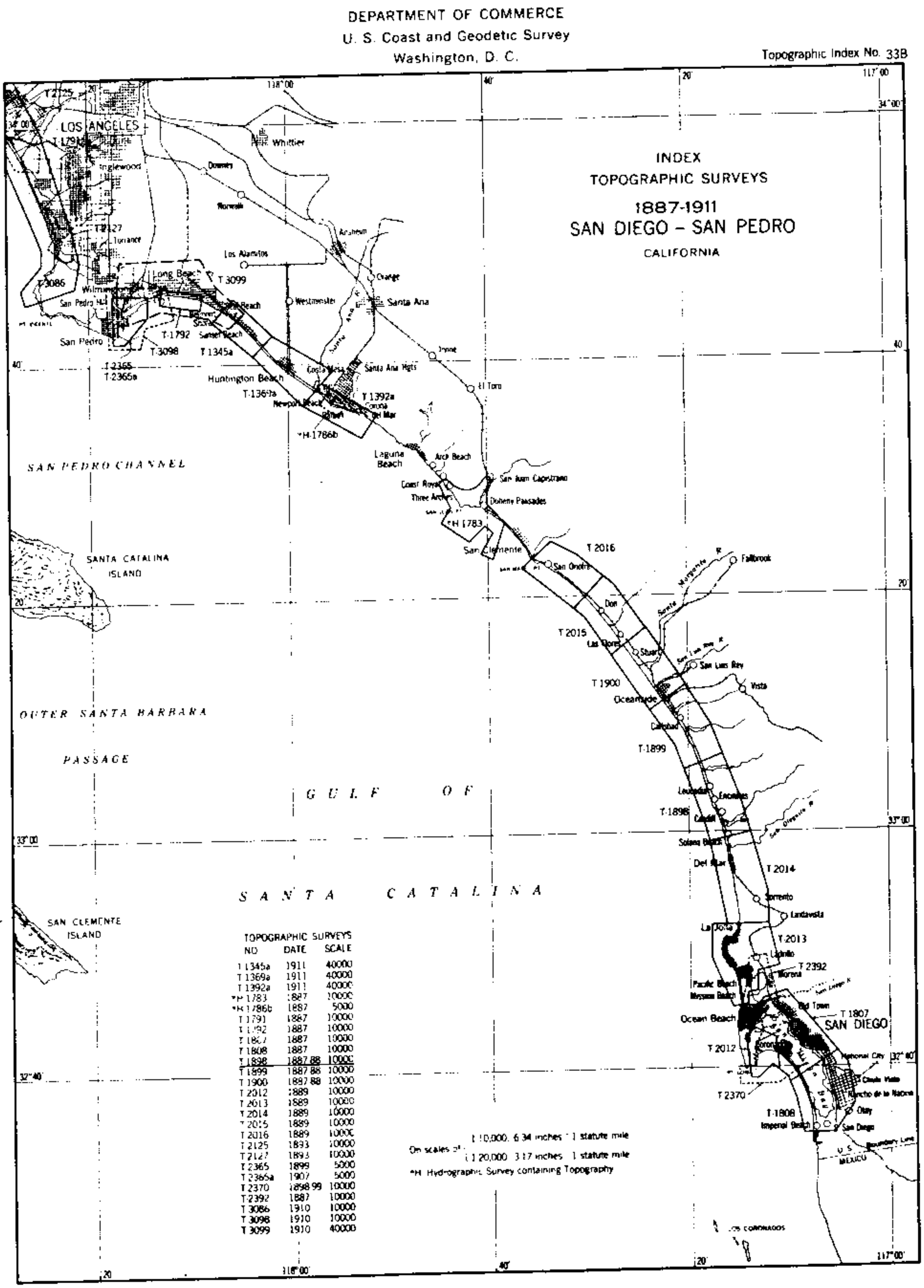


Figure 20. *U.S. Coast and Geodetic Survey index map of topographic surveys along the Southern California coast between 1887 and 1917. (Illustration courtesy of U. S. National Ocean Survey)*

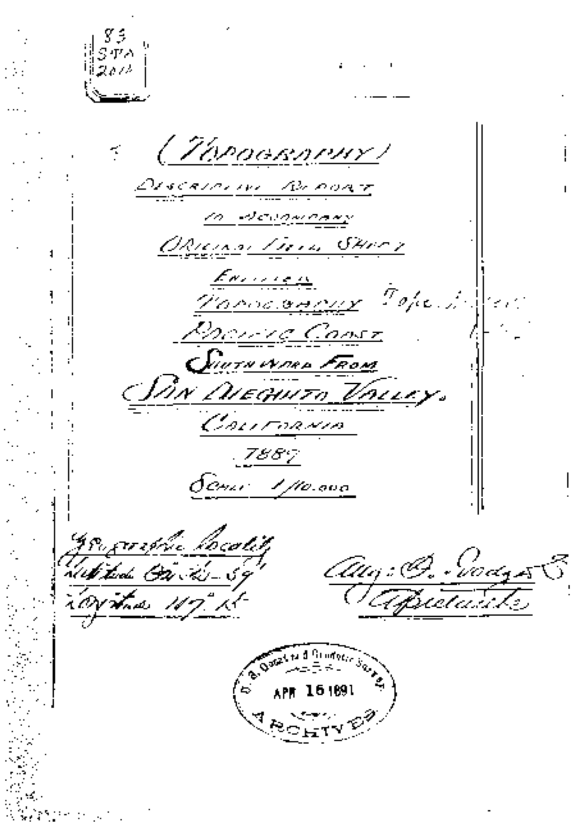


Figure 21. *Portion of a transcription of handwritten 1889 Coast and Geodetic Survey field notes for map 2014. (Courtesy of U. S. National Ocean Survey)*

Coastline Formation *Between . Center, as shown on the sheet & the opening into Soledad Valley, the coast is generally formed of precipitous bluffs, much broken and bearing evidence of "slide" during winter storms when the soil becomes saturated with water & top heavy.*

The opening into Soledad Valley is flanked by a very marked shingle levee.

It has been proposed to utilize this for street paving in San Diego, & the Rail Road siding at Soledad Beach was built for the purpose of transfering this material.

Between Soledad and San Dieguito Valleys the coastline is formed of clay bluffs tumbling down, but the recession consequent is slow owing to the mild climate and light character of storms.

The opening from the ocean to San Dieguito Valley is also flanked by a shingle levee, but it is not nearly so marked as the Soledad levee & sand predominates in the composition.

Beach Formation *Under a . Ball, shown on sheet, a sand beach commences but is broken at intervals by outcropping rocks, as far north as the "Mussel Rocks". From this latter point, there is an unbroken sand beach for forty or fifty miles or as far north as the valley of San Juan Capistrano & in former times this stretch of beach was used whenever specially fast time was to be made on the route Los Angeles, via Capistrano, to San Diego.*

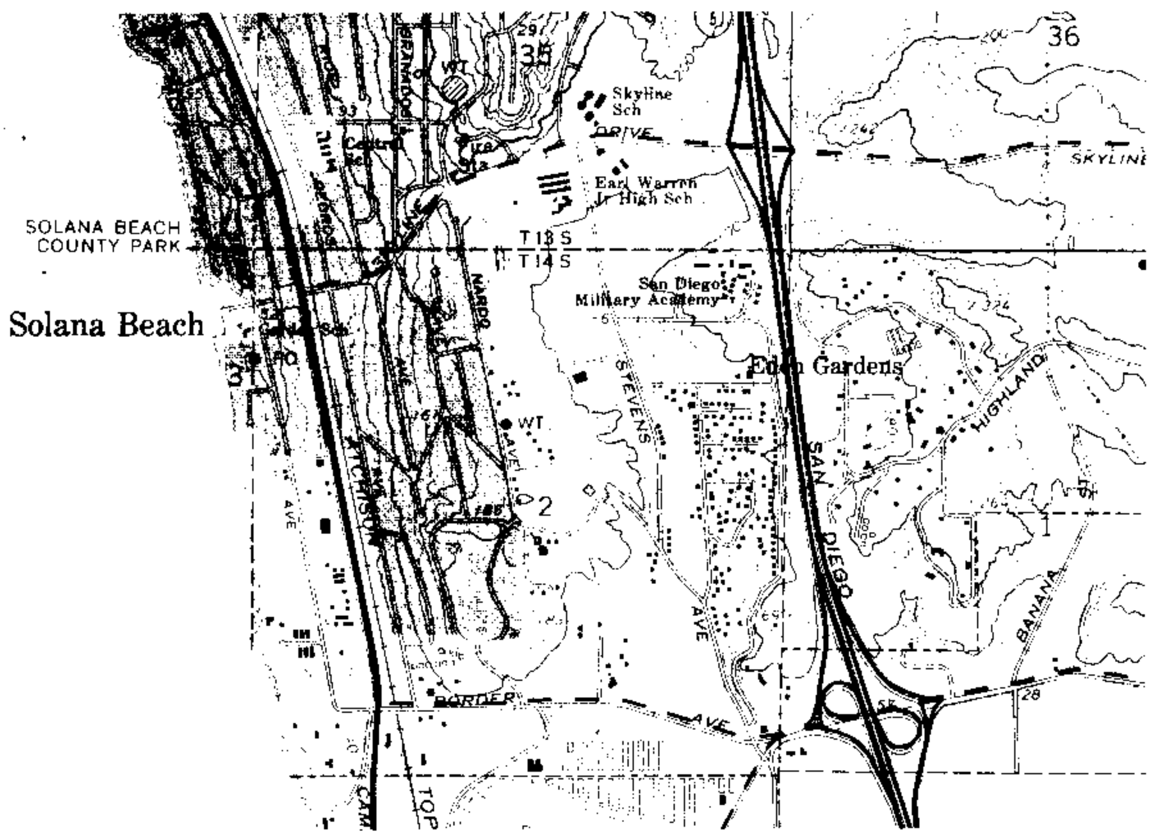
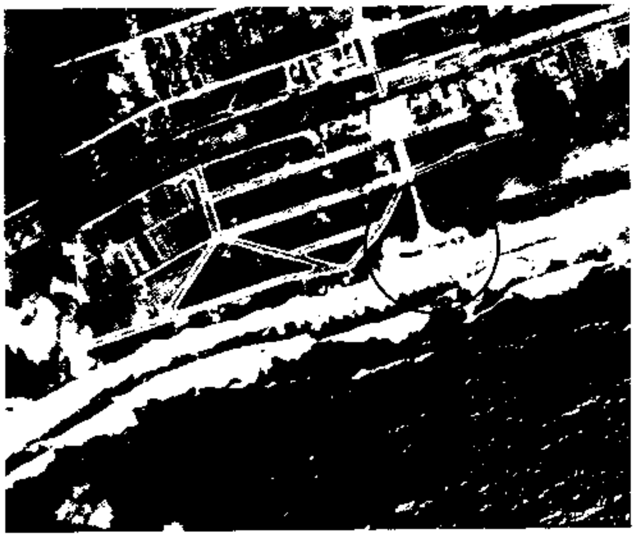
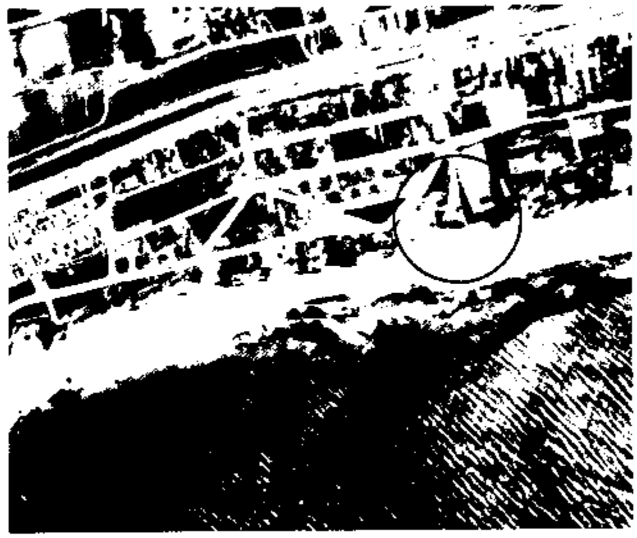


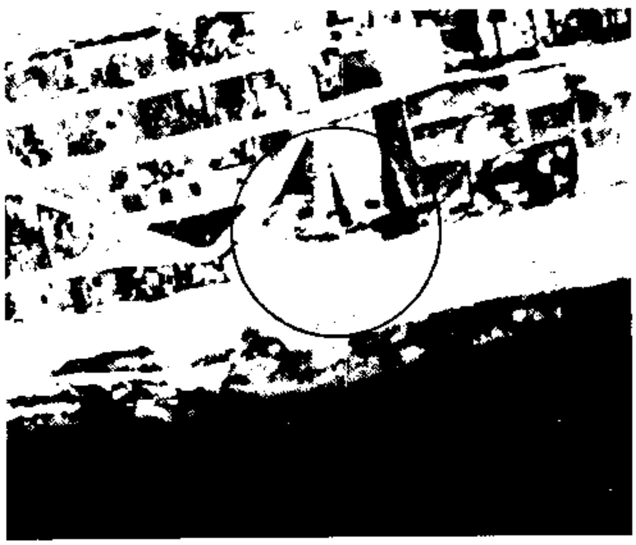
Figure 22. *Portion of a current USGS topographic map showing the Solana Beach area at 1:24,000 scale. (Illustration courtesy of U. S. Geological Survey)*



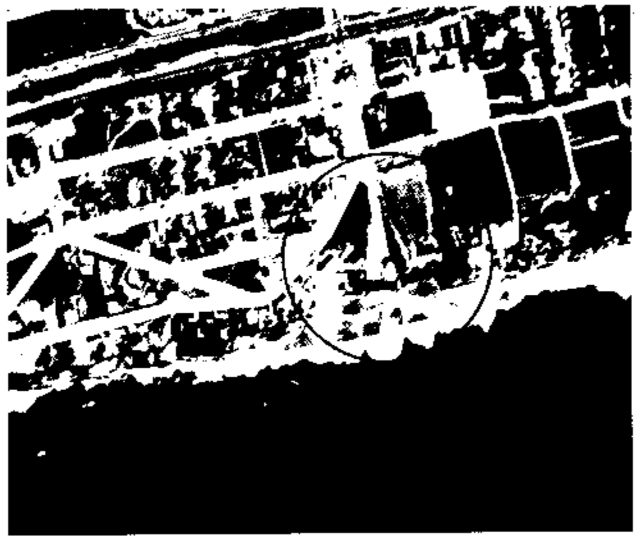
1929 San Diego County Tax Photo ~ 1:13,500 scale.



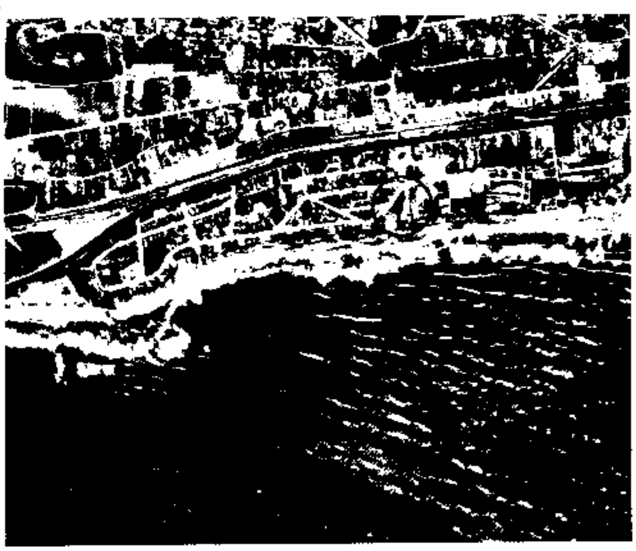
January 16, 1947 USGS ~ 1:13,500 scale.



1947 USDA ~ 1:8000 scale.



1949 USDA ~ 1:8000 scale.



1953 USDA ~ 1:25,000 scale.

1966 USGS ~ 1:28,600 scale.

Figure 23. *Six vertical aerial photos of Solana Beach taken between 1929 and 1963 at various scales. (Illustration courtesy of Gerry Kuhn)*

Historical Photographs (C-2)

Many old photographs are useful in tracing coastal erosion. They can generally be divided into two types: land-based, and aerial photos. Old photographs taken from land (and occasionally from offshore) vantage points are usually helpful in documenting coastal changes at very specific locations. If modern photographs are taken from exactly the same angle, and compared to older ones, dramatic changes can often be observed (see "Documenting Present-Day Erosion"). Some features, such as sand levels, will vary over brief time spans, but bluff angle and rock formation changes are slower or less frequent, and can be more easily documented through two or more historical photos.

Although land photos are probably the most common type of historical record dating to the mid-1800s, they are seldom catalogued, indexed, or available in large numbers from any one specific source. Because these sources range from the U.S. Geological Survey photo library to personal collections and souvenirs, all that can be suggested is a broad-based search of as many sources as possible.

Both land-based and aerial photos can yield an incredible amount of information if examined and re-examined, using magnification when necessary. Often details that are not noticed at first glance will become more obvious on the third or fourth viewing. Also, with land photos, the most useful information may be hidden in the background, behind the focal point of the photograph.

The usefulness of these, and of all photos, depends on their image quality and clarity. If photos (or maps) are to be copied, a 4" x 5" negative will give the best quality, but standard 35 mm film can be sufficient if the image is not going to be enlarged too greatly.

Because they do not usually contain identifying information, as do maps, photographs and negatives should always be labeled and filed carefully. A soft-tipped pen should be used to record background information such as the location, date, and source of the photograph on the back of each print, along with notations of particularly important features visible in the picture. In this way, ground-based views can be more easily compared with aerial photos or maps of the same time period, to ensure accuracy and to assist in interpretation.

Historical Aerial Photographs: Aerial photos of coastal areas may be available from as early as the 1920s, when they were often taken for tax or insurance records. The amount of information they yield depends on atmospheric clarity, lighting, and the quality of the photograph itself. Figure 23 shows photographs of the same section of Solana Beach at various scales, over a thirty-eight-year period. The circle on each photo covers the Plaza Street region shown on the assessor's and subdivision maps in figures 6 and 10. These photos show the wide range of scales and quality available from various sources. High-quality aerial photos can be even more useful than maps in understanding site-specific coastal retreat, because individual rock units can be observed and approximate distances of retreat measured.

In general, the same scales are useful for aerial photographs as for maps, but aerial photos often show much more detail, especially under magnification. However, they are likely to be less accurate for quantitative horizontal measurement than the best maps, because of uncertainties associated with distortion and angle of the camera. For this reason, larger-scale photographs (1:2,400 to 1:8,000 scale) may be preferred when direct measurements are to be made.

For accurate measurements, it is absolutely necessary that the aerial photographs be taken from as close to a vertical angle as possible. For example, aerial photos of one large building site near La Jolla appeared to show that the adjacent bluff had a fairly gentle slope, and offered some degree of stability. After the building was completed, however, it was discovered that portions of the cliff slope were actually close to vertical. The mistake occurred because aerial photographs of the site were not taken from a vertical angle but at a slight oblique angle toward the cliff face. This made the cliff look less steep than it really was.

This example illustrates an important difference between vertical and oblique aerial photographs. Vertical photos are taken with a camera pointed straight down at the earth's surface, and are sometimes optically corrected so that they give the same flat perspective as would a map of the area. Oblique photos merely present panoramas, and are not generally used for measurement purposes; however, they can show sufficent detail to document landform and cultural changes. Usually it is easy to distinguish oblique photos from vertical ones because in obliques some features appear closer than others, and the horizon may show. But this distinction is not always obvious at first glance.

Before any measurements can be made from aerial photos, the scale of the image must be determined. This is sometimes accomplished by measuring objects with known dimensions, such as roads or houses, but such measurements should be cross-checked with maps or surveys whenever possible. On oblique photos, a correction factor which depends on the angle from which the picture was taken must be applied when measuring horizontal distances. But even on vertical photos, there may be slight errors near the edges of the image if optical corrections have not been applied.

Interpreting Aerial Photos: Many types of qualitative information can be obtained through vertical and oblique aerial photos, but all interpretations should be field-checked whenever possible. This phase of the research may require the services of a trained interpreter, but it is certainly worthwhile for the researcher to consult the sources listed in the bibliography. These describe in greater detail the various methods of photointerpretation. Some of the more obvious features that can be identified are discussed briefly below.

Darker patches seen on black and white photos may indicate soil with a high water content, clay layers, dark vegetation, or just shadows. If a specific shade or texture of grey can be identified as a specific type of soil or vegetation through ground investigation, then it can sometimes be identified in other photos as well.

Many old landslides leave behind "scars" which may be visible on aerial photos, especially those taken before grading has occurred. These slides can be important because cliffs which have failed in the past are likely to fail again. The top of an old slide may appear strangely cracked, hummocky, or disrupted, even though vegetation has grown back over it (figure 24). Large broken rocks, or piles of dirt at the base of sea bluffs can provide evidence of recent sliding, but these remains may be broken down and washed away during periods of large waves.

If older photographs show large, steep gullies and ridges where rain has washed through weaker soils, then gullying may eventually pose a problem for development in these areas. Such extensive gullying indicates either relatively weak soils or heavy runoff concentrating in a particular location.

Occasionally, faults or other structural features can be observed on aerial photos, especially where such features intersect the shoreline. They can affect the type and severity

Figure 24. *1954 oblique photo of an old landslide located along the bluffs in northern San Diego County. Note ground cracks, hummocky topography and wave-eroded toe. (Photo courtesy of the U.S. Navy)*

of erosion at some specific locations. Inland extensions of faults can be traced through unusually linear landforms or changes in vegetation, which show well on aerial photographs. Unfortunately, structural features become harder to trace once an area has become urbanized. Older photos can be especially important for this reason.

Using a chronological sequence of aerial photographs at a useful scale (1:10,000 or greater), all of the features mentioned above can be identified at various time periods. Both human-induced changes, such as shifts in drainage patterns due to urbanization, and natural changes, such as seasonal fluctuations in beach width, may become obvious through a careful study of these photos.

Sources of Historical Photos: A general list of sources of old photographs ranging from private collections to federal agencies is given in Table E. The land-based photos are usually less expensive, but it takes more time to obtain them. The number of sources that can be explored is limited primarily by the amount of time available to the researcher.

Public sources such as libraries, museums, universities, and chambers of commerce are grab bags of unknown potential: some may have huge collections of old photos; others may have virtually nothing. Often the key to success is to find someone who can show you around the institution, or who can suggest a specific department or file to check. Although some public sources may lend photos without charge, the researcher should always be prepared to copy materials at the site if necessary. For most items, a carefully taken 35 mm photograph will provide sufficient copying quality, but xeroxing will not, especially if the material is to be published. Credit should always be given to the donor of the photo.

State and local agencies may have miscellaneous old photographs in storage, usually from aerial perspectives. For example, San Diego County authorized a series of air photos to be taken in 1928-1929 for tax purposes. Such collections may be kept in a recorder, clerk, or county surveyor's office or hidden away in forgotten corners. It is worthwhile to look for them. Local or regional title insurance or trust companies also keep historical photographs, either aerial or land-based. These groups may be more cooperative if they can be made aware of existing local coastal erosion problems, and of the financial ramifications of these problems for their business.

Files of old newspapers may contain only clippings or microfilm, but if original prints or negatives of old photos can be obtained from the newspaper office, new copies can be made. Such photographs often show the most dramatic effects of floods or landslides, and can help the researcher to understand how similar events could recur at the same location. For example, the January 2, 1941 *San Diego Union* carries a front-page photograph of a local train that was derailed in 1940, after its tracks were undermined by heavy rains and large surf. Although the tracks were subsequently moved away from the bluff edge, the same location was again endangered in 1978. This time, however, adequate warning was given, and the tracks were moved before the cliff actually failed. In this

Table E

Sources of Historical Photos*

State and Local Organizations:

Local Libraries and Museums (A,O,L)**

Local Schools and Colleges (A,O,L) (including school libraries)

UC Berkeley: Bancroft Library and Wave Research Lab

UC Los Angeles and Whittier College: Fairchild Aerial Photos

Local Governments--County, City offices (Recorder, Surveying, or Transportation) (A,O)

Federal Government:

Local Military Bases (A,O)

Army Corps of Engineers--Beach Erosion Board (A,O) and Coastal Engineering Research Center

NOAA (National Ocean Survey)--see Figure 21 (A,$)

Bureau of Land Management (A,O,$)

Department of Agriculture--Agricultural Stabilization and Conservation Service (A,$) and Soil Conservation Service (A,O,$)

U.S. Forest Service (Department of Agriculture) (A,$)

U.S. Geological Survey--Photographic Library and Regional Offices (A,O,L,$)

National Cartographic Information Center (NCIC) (A,O,$)

U.S. National Archives--Center for Cartographic and Architectural Archives and Regional Branches (A,O,L,$)

Private Sources:

Title and Trust Insurance Companies (O,L)

Newspapers' Files (L)

Local Aerial Photo Companies (A,O,$)

Statewide Aerial Photo Firms:
Cartwright Aerial Surveys, Inc.
Teledyne Geotronics
Murray-McCormick Aerial Surveys, Inc.

Southern California Aerial Photo Firms: (A,O,$)
Fairchild Air Surveys
Spence Air Photo

*Addresses of most sources are listed in Appendix B.

**Key:
A -- Aerial (vertical)
O -- Aerial (oblique)
L -- Land-based
$ -- Requires Payment

This status map shows photographed areas reported by the government agencies listed above and by several commercial firms. The photographic coverage considered most suitable for general use is shown.
For a more detailed explanation, refer to the text on the back of this map. Additional information on aerial photography may be obtained from the Map Information Office, U.S. Geological Survey, Washington, D.C. 20244.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATUS OF AERIAL PHOTOGRAPHY

JUNE 1973

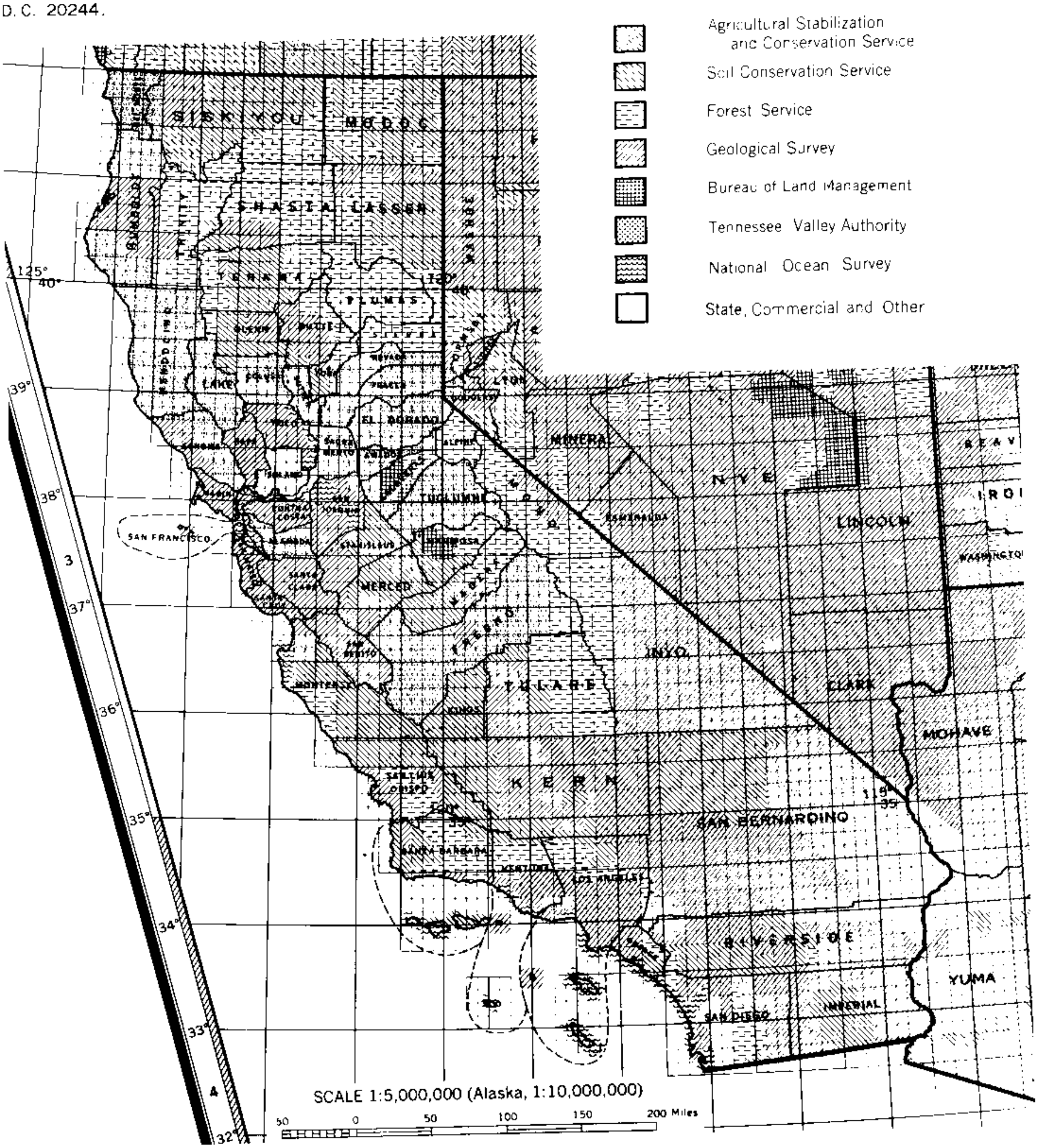


Figure 25. *1973 index to U.S. Geological Survey aerial photography in the state of California. (Illustration courtesy of USGS)*

example, knowledge of the precise location of a past slide area helped avert a second disaster at the same spot.

Obtaining historical aerial photographs may be an expensive part of coastal erosion research, as almost all sources charge for their services. Some public agencies will give discounts to publicly funded research projects, but photos from private businesses can be quite expensive. Fortunately, most sources have indexes available, and for a small-scale research project, only a few photos from each source are likely to be needed.

The U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service holds one or more sets of aerial photos for almost every part of the United States, dating as far back as 1928. An index to photographs of various sizes and scales is available from the USDA Aerial Photography Field Office (address in Appendix B). Although larger-scale photos are more expensive, they can also be more useful. For example, at 1:8,000 scale (the largest available from the USDA) such features as rock outcrops, sand dunes, sea caves, and smaller landslides can be located and identified. As with most sources of aerial photos, indexes and price quotations can be obtained by mail, thus saving the researcher a great deal of time.

One federal agency that, for a fee, supplies both aerial and ground photographs is the U.S. Geological Survey. The USGS has available numerous old aerial photographs from 1:12,000 to 1:66,000 scale, which can be ordered from the Menlo Park office of the USGS. Other oblique and land-based photographs, including illustrations from the past U.S. Geological Survey publications, are available from the USGS photo library. This library will supply, by mail, a list of all photos relevant to a specific area or subject requested.

In association with the USGS, the National Cartographic Information Center (NCIC) publishes a computer-based catalog of existing aerial photography and might have information on other sources of historical photos. Another index to aerial photography of a national scope, entitled *Status of Aerial Photography*, is available from the national office of the USGS. As shown in figure 25, this source indicates which agency or private firm to ask for aerial photos covering any part of the United States. These agencies include the Soil Conservation Service, Forest Service, Bureau of Land Management, and the National Ocean Survey, as well as local and private sources. Because this index was printed in 1973, some of the addresses have changed, but the photos should still be available from the same sources. Aerial photos in the National Archives are catalogued in Special List No. 25, available from the National Archives and Records Service. Also, aerial photographs used by the National Ocean Survey to produce Coast and Geodetic Survey maps are available from National Oceanographic and Atmospheric Administration. Addresses for all of these agencies are given in Appendix B.

Finally, individual military bases, or the Army Corps of Engineers may be able to supply photographs of certain areas. In particular, the Corps is likely to have photos of coastal areas near some of its projects, such as harbors, groins, or flood control channels.

A few of the larger private aerial photography firms that specialize in pictures of California are listed in Table E, but many others exist. Local firms may be found in the yellow pages of the local telephone book and through local airport authorities. Some of these private sources may be relatively expensive, but if they have low-altitude, large-scale photos, their products may be worth the extra cost.

Part 2

Suggestions for Additional Research

As described above, historical research can often fill a critical gap in the information base used by most jurisdictions when planning for coastal erosion. For the purposes of compiling a comprehensive planning document, however, historical information alone is not sufficient. It must be supplemented by a careful analysis of recent erosion, up to and including the current status of all parts of the study area. This final portion of the research might require more technical expertise than the historical element, but it is essential that the causes and locations of present-day erosion be considered before planning strategies are determined.

Researching Recent Erosion

The historical portion of this manual emphasizes a "long view" of erosion as it has been documented by the various surveyors and inhabitants of coastal areas during the past 100 to 150 years. This long view is necessary, but the information obtained is often scattered, imprecise and incomplete. Since World War II, however, a revolution in information processing has occurred. Tools such as satellites and computers have opened whole new research possibilities, with full potential yet to be realized. In addition to these technological resources and tools, new governmental agencies have been formed specifically to research and manage the coastal zone. Many of these can be helpful in tracing erosion over the last twenty years.

Some of the technological tools now available to the coastal researcher apply directly to the problem of coastal erosion. Computers, for example, can be used for wave hazard analysis, to model sand flow, to predict potentially dangerous high tides, or even to measure coastal retreat by using old maps. Satellites can provide wave and weather information, along with specialized photographs of many types, which can be useful for coastal research. Such photos are available to the public from various sources, including many of those listed in Appendix B. Further information on remote sensing applications can be obtained from sources listed in the bibliography.

Several different agencies that have been involved in coastal research or planning in California have useful information for filling in the most recent chapters of coastal history. The Army Corps of Engineers has designed structures for many parts of the coast and can provide wave or erosion information for those areas. It also conducted a National Shoreline Study in 1971. The official report of this study is still available from the National Technical Information Service (NTIS).

The California Department of Boating and Waterways (formerly DNOD), has extensively studied coastal erosion and published an excellent report entitled *Shoreline Erosion Along the California Coast.* This publication includes an atlas of 1:48,000 scale maps of erosion along the entire coast, such as the one shown in figure 26. Although these maps cannot be as site-specific as is necessary for detailed planning, they provide a good starting point for more intensive local erosion mapping.

Finally, the California state and regional coastal commissions represent another possible source of information, dating back to 1973. Because regional commissions issue permits for all construction in the coastal zone, their offices maintain files that document a variety of coastal projects, including construction of houses, apartments, sea walls, revetments, jetties, and even emergency sandbagging. From such records, especially those of emergency permits, the investigator can infer which protection methods did or did not work, and possibly get some idea of what, if anything, went wrong. Similarly, city or county records of conditional

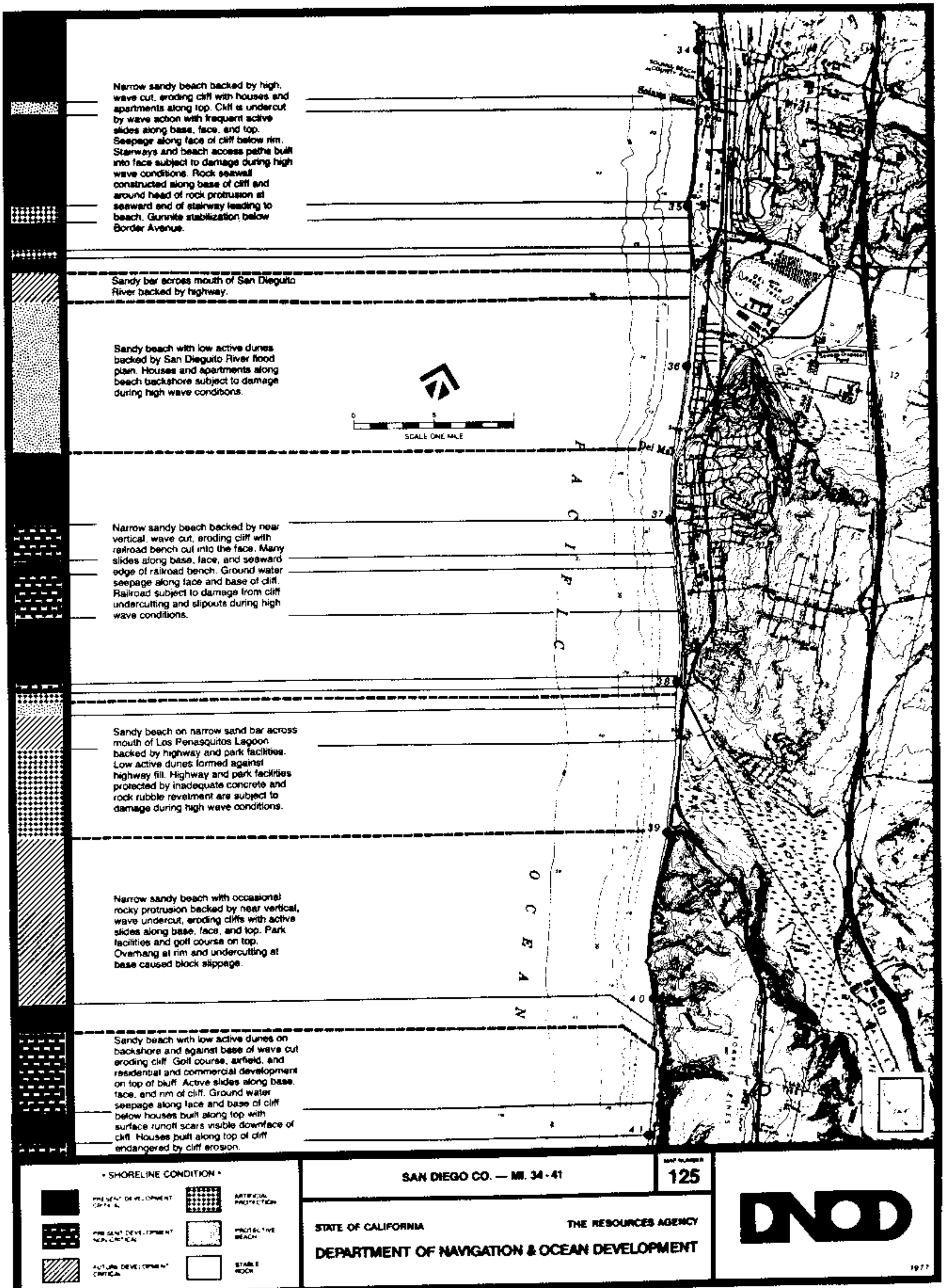


Figure 26. *Portion of a map indicating existing and potential risks from erosion or wave damage along the California coast. (Illustration courtesy of California Department of Navigation and Ocean Development, now California Department of Boating and Waterways)*

use permits or variances can provide insight into individual project histories.

Detailed geological information on individual sites is also included in some coastal commission project files, along with photographs, drawings, and other background information. Geological or soils investigations and Environmental Impact Reports stored in coastal commission or county files may provide additional information on some projects. These records can potentially indicate whether the rates of erosion at or near individual sites increased after construction occurred.

All this information is available to anyone willing to examine all permit applications along a given stretch of beach-front or bluff-top land. Such a systematic search and appraisal might even benefit the regional coastal commissions themselves, in their permits and appeals process.

Documenting Present-Day Erosion

Once the historical research has been conducted up to the present time, actual field studies should be undertaken to narrow down the causes of continuing erosion, but less technical approaches can be used as well.

For example, historical photographs carefully rephotographed from identical points of view can be of great help in identifying types and locations of erosion. Such photos should show the angle of the bluff face, the surface appearance of the bluff (including faults, springs, vegetation, sea caves, or cliff failures) and the shape and size of the beach. It may also be useful to take new photographs from vantage points which can be easily revisited after months or years have elapsed.

The contemporary physical location and condition of the shoreline and bluffs can be measured with respect to fixed reference points, such as trees, centerlines of streets, or survey monuments (such as the small brass discs set at property boundaries). Old subdivision boundaries should be resurveyed if their former distances from the cliff edge are known. Such measurements should be repeated every one to five years to monitor additional retreat at critical locations.

Organization of Research Data

Once the historical and contemporary research is complete, several different methods can be used to organize the collected data into a coherent and useful synthesis of regional coastal erosion. Organized data are useful as a basis

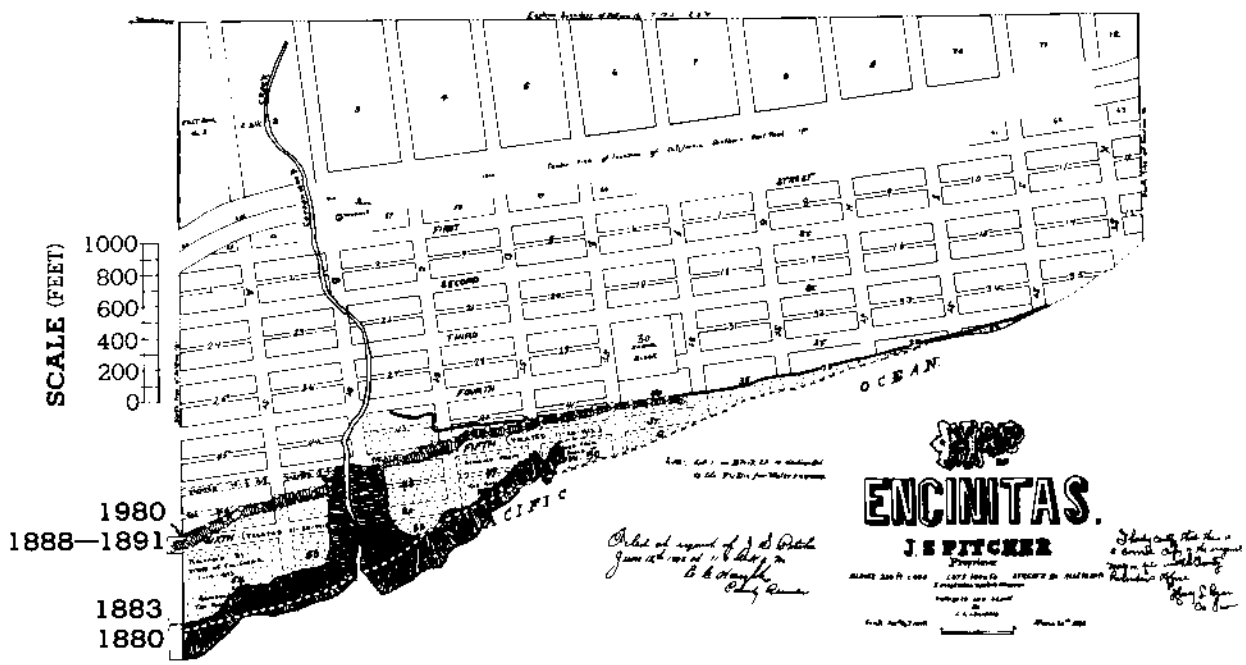


Figure 27. *Approximate coastal changes along Encinitas, California between 1880-1980. Compiled from 1880 California Southern Railroad Survey, 1883 Encinitas subdivision base map, 1888-1891 U.S. Coast and Geodetic Survey maps, and approximate 1980 bluff top line. (Illustration courtesy of Gerry Kuhn)*

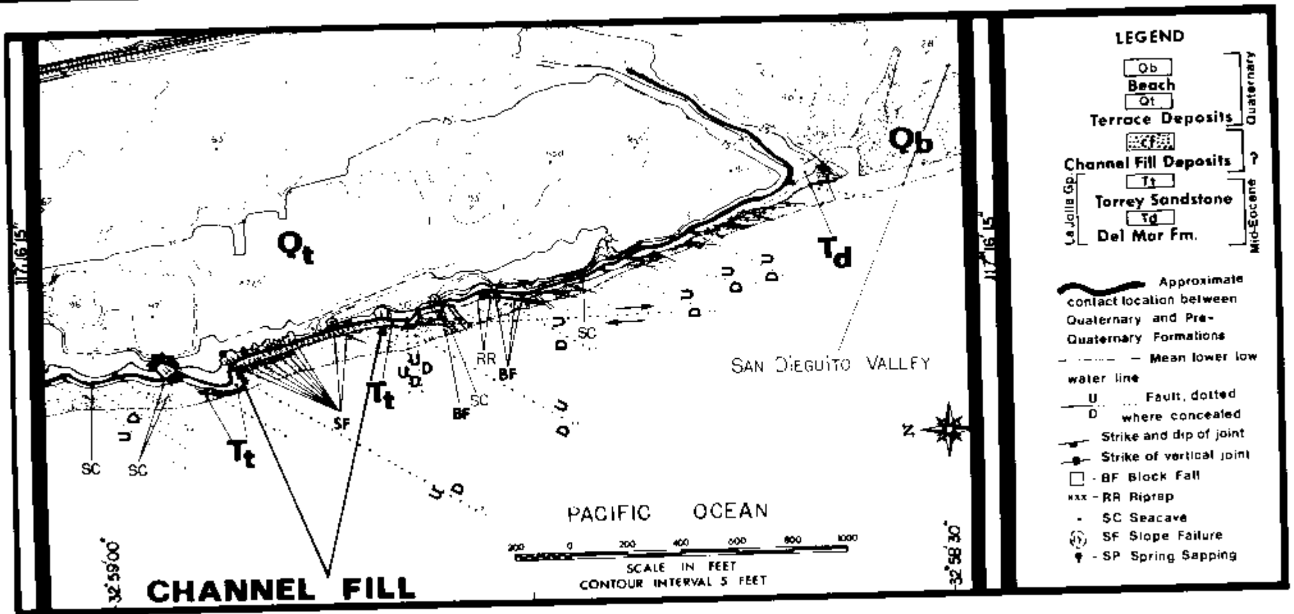


Figure 28. *Generalized geological map and erosional problems along a portion of south Solana Beach to north Del Mar, San Diego County. (Illustration courtesy of Gerry Kuhn)*

for public policymaking, and can be presented in a technical report for decision makers in local government, or in an easily understandable pamphlet for members of the general public, as discussed in Part III. Graphs of various sorts, photographic comparisons, erosional histories, and compilation maps can all be used to illustrate different aspects of the historical information which has been gathered.

Graphs and charts can be used to summarize data in a graphic manner for publication or interpretation. Graphs that trace changes over time are especially valuable for dealing with a series of historical events. Rainfall data, property values, or distances of retreat, for example, can be more easily understood in this form.

Selected land-based, oblique, and aerial photographs can provide visual documentation of historical and contemporary erosional hazards. Two or more photos of the same location taken at different times often show long-term landform or vegetation changes. Although they seldom provide quantitative data, such photographs can be especially useful for public education in the form of slide shows or brochures.

The third method of data organization is a written, summarized historical report on erosional events in the entire study area, or specific locations within that area. This report should consist of two interrelated elements. First, a list should be compiled showing the dates of all major storms, and listing any known information concerning wind velocity, rainfall, wave height and direction, and other pertinent data. Second, a similar list should be compiled to show the dates of significant shoreline changes, cliff failures, floods, and recorded damage to public or private property. By correlating events from both timelines, the researcher might be able to determine which natural conditions caused serious damage in the past, so they can be anticipated and planned for in the future.

A separate, comprehensive technical report should contain detailed written accounts of each historical event and provide a list of all known past references to that event for complete documentation. Some damages or erosion might only be datable to within a year, or even a decade, but these should also be included and might eventually be found to correlate with other more specifically datable events.

While the erosion history can be used to summarize when and under what conditions erosion has occurred, the compilation map can indicate the locations of past cliff failures, property damages, and shoreline changes. Such maps should be drafted to relatively large scales (i.e. 1:2,400 - 1:8,000) because knowledge of precise locations is very important in planning for coastal erosion. In areas of extensive coastal changes, such as Encinitas (figure 27), one or more past coastline configurations can be illustrated on these maps, especially where individual failures are not well documented. These coastlines can be derived from older maps and photographs, although the possible inaccuracy of such sources must be taken into consideration.

In addition to maps of erosion, large-scale geologic maps showing local faults, rock types, drainage patterns, soils, and other features can be of considerable use. Figure 28, for example, shows many structural features and some past

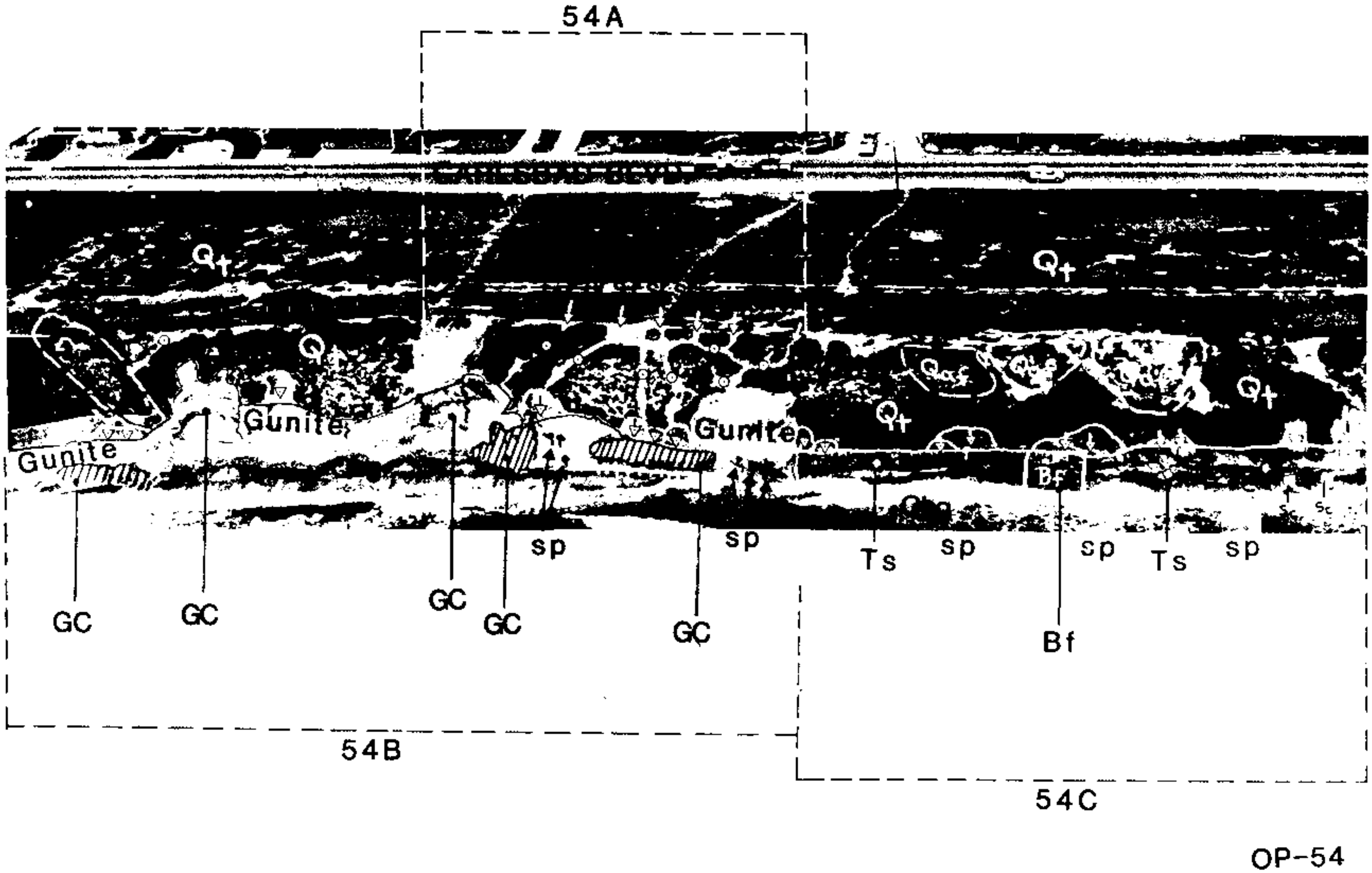


Figure 29. *1978 oblique aerial photo of south Carlsbad bluffs, illustrating site-specific conditions and hazards.*

Qbg - beach gravels	*Bf - blockfall*
Qaf - artificial fill site	*GC - gunite (concrete on cliff face) collapse site*
Qt - terrace deposits	*Sc - sea cave*
Cf - channel fill site	*sp - springs*
Ts - bedrock (Santiago Fm)	*sr - surface runoff site*

(Illustration Courtesy of Gerry Kuhn)

landslides (slope failures) in the extreme south end of Solana Beach. When such large-scale geological maps are overlain with a compilation map, specific geological structures or formations can be associated with regions of more or less rapid coastal retreat. Similarly, a series of very large-scale (at least 1:2,400) oblique aerial photographs of a study area can be used to pinpoint specific environmental or human elements that are contributing to erosion (see figure 29).

Part 3

Application of Historical Erosion Data in Coastal Planning

At this point, the researcher will have collected a great deal of information describing when and where different types of coastal erosion have occurred and are occurring. In addition, the historical research and continuing geologic investigation should indicate why certain locations are susceptible to one or more types of erosion. Once this historical and current information has been collected, organized, and analyzed, it may help answer some of the important questions commonly encountered when evaluating development proposals or planning for future ones.

One basic (but by no means simple) question concerns the amount of coastal erosion that can be expected at a specific site during the anticipated lifetime of a structure (say, 75 years). Oertel (1978) suggests using research data to estimate maximum distances of coastal retreat by assuming "worst possible" combinations of rainfall, storm surf, high tides, etc. This process is analogous to estimations of 75-year floodplains along rivers, except that coastal erosion is a cumulative process. He also emphasizes the need to consider such factors as dwindling beach sand supplies, urbanization, climatic changes, and rising sea levels, which could change the rate of erosion in the future. Because of the many uncertainties inherent in predicting erosion, distance estimates are not likely to be exact, but they can provide conservative, "round" numbers for planners to use. These uncertainties also underscore the need for periodic monitoring of critical areas, as described below.

From a regional planning perspective, it may be more helpful to use the large-scale compilation maps and create a coastal hazard overlay zone. The width of this zone would reflect the amount of anticipated erosion discussed above. Where coastal erosion appears to be rapid or increasing, the hazard zone should be wide, while in those coastal areas which appear stable, it might include only that part of the beach or cliff subject to inundation during maximum storm conditions. The zone would eventually have to be re-evaluated and possibly moved inland, as erosion removes its seaward edge.

Within this overlay zone, several different planning options and techniques are available to mitigate potential erosional damages. These options include protection of structures, regulation of land use, and issuance of permits for developments that meet specific "performance standards."

Protection of the shoreline and structures from waves or other erosional agents is a commonly proposed mitigation measure, especially where structures are already in place. From a planning perspective, however, it is much better to determine whether protection will be necessary before development takes place. Historical and contemporary erosion data may help answer questions such as what type of dangerous conditions can be expected, and whether previous protection measures were successful. If it is determined beforehand that protection will be necessary, that protection should be planned on a regional scale. Using an extensive data base, protective structures can be designed and built with safeguards, recognizing the specific geological and coastal factors contributing to erosion at particular sites. When planned regionally, but with consideration of site-specific factors, coastal protection has a much greater chance of success.

This fact is emphasized in *Man's Impact on the California Coastal Zone* (Inman, 1976), which provides some excellent examples of erosional problems and attempted solutions along the California coast. *Wave Damage Along the California Coast: Winter, 1977-78* (Howe, 1978) provides another set of case studies, indicating where and how protective structures failed during fairly severe storm conditions. Finally, the

Army Corps of Engineers' *Shore Protection Manual* (1975) exhaustively discusses the engineering factors which must be taken into account in designing revetments, sea walls, groins, and other shore protection devices. According to these and other sources, protection projects must be evaluated very carefully before construction, to ensure that offsite damages or long-term costs do not outweigh local, short-term benefits.

Where coastal protection appears to be impractical, or socially unacceptable, carefully formulated and implemented land use regulations or "performance standards" may be useful. In regions where extensive historical erosion has been documented, for example, the land might best be zoned for open-space or agricultural uses. Where very localized hazards exist, low-density zoning can allow more flexible siting of structures to avoid dangerous areas. Special incentives (such as "density bonuses" or "transferable development rights") might be necessary to facilitate acquisition or redevelopment where existing land uses are different from those deemed most appropriate for an area. These and other innovative planning approaches are discussed in *Coastal Natural Hazards Management* (Hildreth, 1980) and other planning literature listed in the bibliography.

"Performance standards" are regulations or building requirements designed to reduce or eliminate a specific type of erosional hazard. They cover such elements as: minimum setback distances and elevations, grading standards to protect bluffs and divert runoff; septic tanks, swimming pools, and other potential sources of underground water; building foundation reinforcement; coastal protection devices or other constructions which may affect the beach; and public viewshed and beach accessways. While some of these regulations may be widely applicable, others depend very much on the conditions at specific sites. A forty-foot setback, for example, may be adequate for one location, but virtually useless in areas where the cliffs have retreated seventy-five feet in a single slide. The historical research can indicate which hazards must be considered along certain parts of the study area.

Another important function of historical data for the local government is that it can provide "compelling scientific evidence" of coastal erosion. Such evidence may provide a strong legal basis for local coastal development regulations if they are contested in a legal suit. However, if the local government, for one reason or another, approves a development in a potentially hazardous location, it may be liable for any subsequent damages to that development. As local governments become aware of this liability, they might put more effort into controlling development in potentially dangerous areas. The legal history and ramifications of such cases are discussed further in Summerville (1978) and Hildreth (1980).

In conjunction with erosional hazard planning, it may be necessary to set up a coastal monitoring program, similar to the "documentation of erosion" program previously discussed. This would detect and investigate any new or unforeseen erosional problems as they develop. Such a program might simply produce an annual compilation of all new or imminent erosional problems that arise during a given year. Photographs of critical areas could be taken and investigations made into the causes of erosion at various sites. The effectiveness of various setbacks and protective measures could also be evaluated in this way. Coastal monitoring is especially important during wet years, to check the accuracy of the erosion estimates upon which the planning regulations are based.

Publication of Research and Planning Strategies

After the historical and contemporary research data have been organized, interpreted, and used in the formation of coastal erosion planning recommendations, both elements should be compiled into a single written report. This technical report should include all relevant data (e.g. erosional history, compilation maps, photos), analysis of that data, conclusions, and specific planning recommendations. It would be for use primarily by other researchers, and for governmental decision makers.

In addition to the detailed report, a simplified summary should also be written, explaining in non-technical terms the procedures, results, and conclusions of the study. This summary can be published either as a prologue to the main report, or as a separate document having illustrations and format designed for the general public. The latter case is preferable where financial resources permit, and where a large number of people may be affected (see Gutman, 1979).

Two other approaches could also be used to increase public awareness of coastal hazards. The first would be a brochure or a pamphlet for prospective or current coastal property owners, based on the regional and site-specific information gathered. This would explain the causes and extent of coastal problems in the study area, and provide references to the technical report and maps for those who wish to obtain information concerning specific portions of the coast.

A second and perhaps more effective approach would be to prepare a slide show or other presentation for the public to dramatize the issues at hand and explain the planning options available. Provided that human resources are available, this might turn out to be the least expensive method in terms of cost-per-person-reached.

Public awareness is a key to effective planning. Too many informative planning maps and documents are hidden in back offices and never seen by the people who live and work in the areas represented by those maps. A partial list of those who might be interested in the results of historical erosion research would include: public utilities, realtors, developers, titles and trust firms, insurance companies, lending agencies, consumer protection groups, architects, engineers, various public media, and prospective as well as present homeowners and tenants living in coastal areas.

Merely informing influential private firms and the general public of the potential dangers of building in specific areas may have a more profound effect than any regulatory actions. In fact, planning regulations by themselves may have little effect, unless they are supported by both the public and private sectors. Such support is best obtained through an increased awareness of the risks involved in building along coastal bluff tops or on beaches. Comprehensive historical research could provide much of the information needed not only to raise public awareness but also to devise and implement effective planning strategies.

Appendix A

A Summary of Coastal Research Sources

Source	Maps and Charts	Photographs	Written Records
Federal Government			
Department of Agriculture: U.S. Forest Service		Many aerial photos of national forests	
Department of Commerce (NOAA): National Ocean Survey (NOS)	Coast and Geodetic Surveys	Aerial photos used for mapping	Field notes and annual reports
National Weather Records Center	Daily weather maps, rainfall and temperature data	Satellite photos of storms	Computerized listing of severe storms, waves
Satellite Data Services		Landsat, Seasat, and other aerial photos	
Department of Defense: Army Corps of Engineers	Available at some locations	aerial, oblique	storm/wave/sand data, many publications
Coast Guard	some locations	possible	storm/wave information
Local Military Bases (all branches)	possible	aerial	
Defense Mapping Agency	possible	current aerial	
NASA		satellite and space shots	
Department of the Interior: Bureau of Land Management	cadastral surveys	aerial, oblique	cadastral survey notes and information
Bureau of Reclamation		aerial	
Office of Water Resources	rainfall and watershed maps		storm/rainfall data
U.S. Geological Survey	topographic maps and geological maps	aerial, oblique, land-based photos	annual reports and field notes, publications
EROS Data Center		satellite photos	
National Cartographic Information Center (NCIC)	indexes to old maps	aerial photo index (computerized)	
Miscellaneous Sources: U.S. National Archives	possible	aerial, oblique, land-based photos	records of federal agencies ship's logs
Library of Congress	possible	possible	possible
U.S. Government Printing Office			miscellaneous publications

California State Government			
Department of Boating and Waterways (formerly DNOD)	erosion maps of coast	possible	storm and wave data, sand transport studies
State Lands Commission	Railroad maps, Spanish land grants, cadastral surveys	possible indexes and photos	survey notes and documents
Department of Water Resources	rainfall and watershed maps	possible flood photos	rainfall and flood records
Department of Transportation (CalTrans)	state highway surveys	aerial survey photos	records of storm damage
University System and Libraries (Bancroft)	possible	aerial, oblique, land	histories, memoirs
State Archives	railroad and other maps	possible	court records and other state agency records
Local Cities and Counties (generalized)			
Recorder's Office	record of surveys, subdivision maps	possible	deeds, lease and mortgage books, survey records
Assessor's Office	tax district and assessor's maps	(in San Diego, aerial photos for tax purposes)	current and historical tax records, lot books
Auditor	subdivision maps, old lot books		tax collector's notes and records
Clerk of Board of Supervisors or City Council	possible, small scale	possible, ground and oblique	minutes of meetings, assessment appeals
Department of Public Works	maps of utilities or road routes		records of road, sidewalk, other repairs
Department of Transportation	compilation subdivision maps, road maps and surveys	possible, aerial	field notes of surveys (may be on sheets) possible records of repairs
Department of Surveying and Mapping	Possible, miscellaneous	aerial, oblique	survey notes
Coroner's Office			information on deceased
Public libraries and museums	possible	oblique, land, aerial	books, memoirs, newspapers, personal accounts
Local Schools and Colleges (including libraries)	possible	aerial, oblique, land	possible miscellaneous
Local/Regional Water Districts		possible land, aerial	rainfall and storm data
Public Utilities	maps of utilities connections	possible aerial	records of necessary repairs
Private Sources			
Railroads	route and track surveys		records of repairs, damage
Regional and local aerial photo companies		aerial, oblique	
Commercial map stores	mostly recent	aerial, oblique	
Newspapers		oblique, land-based	general history, floods and storms (may be indexed)
Individuals		land-based, personal collections	narratives, diaries, memoirs
Title and Trust Insurance		land-based and oblique	flood and erosion damages

Appendix B

Addresses of Information Sources

Federal Government

U.S. Department of Agriculture:

Agricultural Stabilization and Conservation Service
Western Lab
2505 Parley's Way
Salt Lake City, Utah 84109

Aerial Photo Field Office
Administrative Services Division
P.O. Box 30010
Salt Lake City, Utah 84125

Soil Conservation Service
Education and Publication Branch/Information Division
Federal Center Building
Hyattsville, Maryland 20781

Headquarters, California Region
U.S. Forest Service
630 Sansome Street
San Francisco, California 94111

U.S. Department of Commerce:

Chief, Coastal Mapping Division
National Ocean Survey/NOAA
6010 Executive Boulevard
Rockville, Maryland 20852
(aerial photos and maps)

National Weather Records Center
National Oceanic and Atmospheric Administration (NOAA)
Environmental Data Service
Federal Building
Asheville, North Carolina 28801

Satellite Data Services Division (SDSD)
NOAA/EDIS/NCC
Rm. 606 World Weather Building
Washington, DC 20233

U.S. Department of Defense:

Army Corps of Engineers
Coastal Engineering Research Center
256 Kingman Building
Fort Belvoir, Virginia 22060

Office of Information, Office of the Secretary
U.S. Air Force
The Pentagon
Washington, DC 20330

Public Affairs Division
Office of Public and International Affairs
U.S. Coast Guard
400 7th Street, SW
Washington, DC 20590

Oceanographic Unit
U.S. Coast Guard
Box 159 E
Washington Navy Yard Annex
Washington, DC

Research and Public Queries Office
Public Information Division, Office of Information
U.S. Navy
The Pentagon
Washington, DC 20350

Defense Mapping Agency Headquarters
U.S. Naval Observatory
Building 56
Washington, DC 20305

User Affairs Office, Office of Applications
National Aeronautics and Space Administration (NASA)
236 Federal Office Building
600 Independence Avenue, SW
Washington, DC 20546

U.S. Department of the Interior:

Bureau of Land Management (Cadastral Survey Division)
1129 20th Street, NW
Washington, DC 20240

Bureau of Land Management (California Division)
E-2841 Federal Office Building
2800 Cottage Way
Sacramento, California 95825

Bureau of Land Management
Denver Service Center (D500)
Building 50
Denver Federal Center
Denver, Colorado 80225

Chief, Publications and Photography Branch
General Services Division
Bureau of Reclamation
7442 Interior Building
18th and C Streets, NW
Washington, DC 20240

Manager, Water Resources Scientific Information Center
Office of Water Resources and Technology
Department of the Interior
Washington, DC 20240

U.S. Geological Survey:

Chief, Office of Research and Technical Standards
Topographic Division C3415
U.S. Geological Survey
M.S. 519 National Center
Reston, Virginia 22092

Branch of Distribution
U.S. Geological Survey
1200 Eads Street
Arlington, Virginia 22202

U.S. Geological Survey
Photographic Library
Box 25046 Federal Center
Stop 914
Denver, Colorado 80225

User Services Unit
EROS Data Center (EROS: Earth Resources Observation Satellite)
U.S. Geological Survey
Sioux Falls, South Dakota 57198

National Cartographic Information Center (NCIC) Headquarters
U.S. Geological Survey
507 National Center
Room 1-C-107
12201 Sunrise Valley Drive
Reston, Virginia 22092

Western National Cartographic Information Center
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

U.S. National Archives:

Center for Cartographic and Architectural Archives
National Archives and Records Service, Archives Building
Pennsylvania Avenue at 8th Street, NW
Washington, DC 20408

National Archives and Records Service
Federal Archives and Records Center
Archives Branch
24000 Avila Road
Laguna Niguel, California 92677

Miscellaneous Federal Sources:

Geography and Map Division
Library of Congress
845 Ricket Street
Alexandria, Virginia 22304

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

National Technical Information Service
Springfield, Virginia 22161

Aerial Surveys Branch
Highway Design Division
Room 3130A
400 7th Street, SW
Washington, DC 20590

California Government

California Department of Boating and Waterways (formerly Department of Navigation and Ocean Development--DNOD)
1416 9th Street, Room 1336
Sacramento, California 95814

California State Lands Commission
State Lands Division
1807 13th Street
Sacramento, California 95814

California Water Resources Control Board
Office of Public Affairs
2125 19th Street
Sacramento, California 95818

California Department of Transportation (CalTrans)
Division of Administrative Services
General and Technical Services Branch
1120 N Street
Sacramento, California 95814

California State Archives
1020 O Street
Sacramento, California 95814

Other:

Curator, Fairchild Aerial Photography Collection
Department of Geology, Whittier College
13615 Earlham Drive
Whittier, California 90608

Meteorology International, Inc.
2600 Garden Road, Suite 145
Monterey, California 93940

Selected Bibliography

Part I

General

California Department of Water Resources. *Land Use in California--an Index to Surveys Conducted by the California Department of Water Resources 1950-1970.* Bulletin No. 176, December, 1971.

California State Lands Commission. *An Index to Historical Hydrographic and Topographic Charts of the California Coast.* California State Lands Commission, October, 1979.
Indexes and background information on U.S. Coast and Geodetic Surveys available from the California State Lands Commission.

Cazier, Lola. *Surveys and Surveyors of the Public Domain, 1785-1975.* U.S. Government Printing Office, Superintendent of Documents No. 024-11-00083-6, 1975.
Historical and personalized approach to the role of surveyors in American growth and development.

Clark, Paul F., et al. *A Guide to Obtaining Information from the USGS.* U.S. Geological Survey, No. 777, 1978.
List of sources and applications of geological, topographic, and historical information from the USGS.

Coy, Owen. *Guide to County Archives.* California State Printing Office, California State Historical Survey Commission, Sacramento, 1919.
An old but extremely detailed catalogue of all known records of all California County governments in 1919.

Cuming, Michael J. and Caton, Francis G. "Marine Environmental Data Bases and Their Analysis," in: *Coastal Zone '78,* Volume III. American Society of Civil Engineers, New York, New York, 1978, pp. 1569-1588.
Semi-technical description of a method for computer storage and analysis of data from ships' weather logs since the mid-1800's.

Davis, Dick, and Crumb, D.D. *Guide to Library Research, University of California, Berkeley.* California Granted Lands and Area Projects Staff, California State Lands Commission, with supplementary listings, May 1976.
Catalogue of a variety of maps, documents and publications relating to California geography and land use, and stored in the Bancroft Library at Berkeley, California.

El-Ashry, Mohamed T. (ed.). *Air Photography and Coastal Problems.* Benchmark Papers in Geology series, Vol. 38, Dowden, Hutchison & Ross, Inc., Stroudsburg, Pennsylvania, 1977.
Collection of papers concerning the use of old and recent aerial photos for documenting coastal changes, both natural and human-induced.

Goldsmith, V., et al. "Analysis of Historical Shoreline Changes," in: *Coastal Zone, '78,* Vol. IV. American Society of Civil Engineers, New York, New York, 1978, pp. 2819-2836.
Description of methods for measuring coastal erosion or accretion, especially from old maps, using computer analysis.

Hayden, Bruce P., et al. "Erosion Rates: How Representative Are They?" *Shore and Beach,* April, 1979, pp. 25-30.
Technical study of East Coast erosion using maps and photos. Detailed description of techniques and potential errors involved.

Lynch, H.B. *Rainfall and Streamflow in Southern California Since 1769.* Southern California Metropolitan Water District, Los Angeles, August, 1931.
Historical collection of weather records over large area--may not represent conditions at specific locations, but good sources and bibliography.

Ray, R.G. *Aerial Photographs in Geologic Interpretation and Mapping.* U.S. Geological Survey Professional Paper 373 (fourth printing), 1972.
Technical manual for methods of identifyiing specific geological features on aerial photos; many photographic examples.

Sunamura, T., and Horikawa, K. "A Study Using Aerial Photographs of the Effect of Protective Structures on Coastal Cliff Erosion," *Coastal Engineering in Japan,* Vol. 15, 1972.
Technical summary of a quantitative investigation into relative rates of coastal retreat at protected and unprotected sites.

Thompson, Morris. *Maps for America: Cartographic Products of the U.S. Geological Survey and Others.* U.S. Geological Survey, Department of the Interior, Superintendent of Documents No. 024-001-03145-1, 1979.
Comprehensive basic description of the scales, purposes, interpretation and construction of various maps, especially those of the USGS.

U.S. Bureau of Land Management. *Land and Survey Records.* Department of the Interior, 1970.
Describes Bureau of Land Management holdings of original cadastral surveys and field notes; also covers the survey process itself.

U.S. Geological Survey. *Coastal Mapping Handbook.* Melvin Y. Ellis, ed. March, 1976.
Comprehensive introductory manual for coastal planners. Gives many reference sources and descriptions of various types of maps.

U.S. National Archives and Records Service, General Services Administration. *Guide to the National Archives of the United States.* Superintendent of Documents No. GS 4.6/2:N21, 1974.
Comprehensive catalogue of government records from all national agencies, past and present, stored in the National Archives.

U.S. Navy Hydrographic Office. *Manual of Coastal Delineation from Aerial Photographs.* Hydrographic Office Publication 592, 1947.
Old but informative manual of photointerpretation along coastlines.

Way, Douglas. *Terrain Analysis: A Guide to Site Selection Using Aerial Photographic Interpretation.* Dowden, Hutchison and Ross, Stroudsburg, Pennsylvania, 1973.
Semi-technical work describing aspects of photointerpretation relevant to land-use and individual site planning.

Part II

Contemporary Research and Planning

Amimoto, Perry Y. *Erosion and Sediment Control Handbook.* U.S. Environmental Protection Agency, Water Planning Division, EPA 440/3-78-003, 1978.
Manual describing techniques for controlling soil erosion, runoff and other problems with steep slopes.

Bowden, G. "Legal Battles on the California Coast: A Review of the Rules," *Coastal Zone Management Journal,* Vol. 2, No. 3, pp. 273-296, 1975.
A concise description of the legal issues surrounding coastal development regulations.

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Technical summary of relationship between coastal processes and planning, with references to ongoing and proposed research.

California State Coastal Commission. *Planning for an Eroding Shoreline,* San Francisco, 1978.
Contains detailed planning suggestions for regulation to mitigate erosional hazards under the California Coastal Act and through Local Coastal Plans.

Coates, Donald (ed.). *Environmental Geomorphology and Landscape Conservation,* Vol. II: *Urban Areas.* Benchmark Papers in Geology Series, Dowden, Hutchison and Ross, Inc., Stroudsburg, Pennsylvania, 1974.
A collection of papers describing planning for geological, hydrological, and other hazards.

Edge, Billy L. and Combe, Adrian J. "Low Cost Shore Protection" in: *Coastal Zone '78,* Vol. IV. American Society of Civil Engineers, New York, New York, pp. 2927-2947, 1978.
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Garofolo, Donald and Wobber, Frank J. "Monitoring Coastal Development Pressure," *Functional Photography.* July 1977, pp. 20-24, and September 1977, pp. 26-30.
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Gurman, Andrew, et al. *Nantucket Shoreline Survey.* MIT Sea Grant College Report, MITSG-79-9, Cambridge, Massachusetts, 1979.
Booklet describing methods and results of a historical shoreline study for the general public.

Hable, John S. and Armstrong, George A. (eds.). *Assessment and Atlas of Shoreline Erosion Along the California Coast.* California Department of Navigation and Ocean Development, 1977.
Generalized description and maps of landforms and erosion along the entire California coastline.

Heikoff, Joseph M. *The Politics of Shore Erosion: Westhampton Beach.* Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1976.
A case study of the problems and choices faced by a Long Island community. The political implications of planning alternatives are emphasized.

Hildreth, R.G. "Coastal Natural Hazards Management," *Oregon Law Review,* Vol. 50 March, 1980, pp. 201-242.
Description of the legal aspects of various approaches to coastal erosion planning and protection.

Hoexter, D.F., et al. "A Method for Evaluating the Relative Stability of Ground for Hillside Development," *Engineering Geology,* Vol. 12, 1978, pp. 319-336.
Semi-technical discussion of field mapping and investigation to determine hillside stability for planning purposes.

Howe, Steve. *Wave Damage Along the California Coast, 1977-1978.* California Coastal Commission, San Francisco, December, 1978.
Report of the public and private costs incurred during storm conditions, with planning suggestions for lessening future damages.

Jenks, Bonnie, et al. *Coastal Zone Bibliography* (2nd ed.). Sea Grant Publication No. 49, California Sea Grant College Program, Institute of Marine Resources, University of California, La Jolla, 1976.
Computerized list of references to coastal planning, resources management, and impact assessment.

Jensen, Paul A., et al. *Decisions for Delaware--Sea Grant Looks at Beach Management.* Sea Grant Publication DEL-SG-7-78, Delaware Sea Grant College Program, University of Delaware, Newark, 1978.
A discussion of Delaware's coastal processes, problems, and planning alternatives for the layman.

Kaufman, Wallace and Pilkey, Orrin. *The Beaches are Moving.* Anchor Press/Doubleday, Garden City, New York, 1979.
Easily readable description of erosion problems across the United States and various attempts to solve these. Advice to home buyers.

Kenny, Michael. "Sea Wall Attack," *Oceans.* Vol. 11, September, 1978, pp. 30-35.
Description of East Coast storms and damages. Discusses individual and governmental reactions to these problems.

Kuhn, G.G. *Coastal Zone Geology and Related Sea Cliff Erosion: San Dieguito River to San Elijo Lagoon, San Diego County.* S.D. County Integrated Planning Organization Contract No. 11596-0800E, prepared for S.D. County Board of Supervisors, 1977.
Technical report with photos and text describing relationships between geology and erosion in the Solana Beach area.

Leighton, F. Beach. "Origin and Control of Landslides in the Urban Environment of California," 24th International Geophysical Convention, Section B, pp. 89-96, 1972.
Describes methods of detecting potential or past slides, and avoiding future ones.

Leighton, F. Beach. *Urban Landslides: Targets for Land Use Planning in California.* Geological Society of America Special Paper 174, pp. 37-60, 1976.
Discusses land use planning approaches to landslide areas with an emphasis on collection of appropriate data.

Leopold, Luna B., et al. *A Procedure for Evaluating Environmental Impact.* Geological Survey Circular No. 645, U.S. Geological Survey, 1971.
Discusses geological hazards and impacts which should be considered in evaluating proposed projects.

Lintz, Joseph Jr. and Simonett, David. *Remote Sensing of Environment.* Addison-Wesley Publishing Company, Reading, Massachusetts, 1976.
Technical manual covering principles and applications of remote sensing using light, infrared, and microwave radiation.

McHarg, Ian. *Design with Nature.* Doubleday/Natural History Press, Garden City, New York, 1967.
A philosophical and pragmatic approach to land-use planning, using mapping of environmental conditions and hazards to create appropriate use zones.

Moore, Jon T. "Emergency Protection of Eroding Shores" in: *Coastal Zone '78*, Vol. IV. American Society of Civil Engineers, New York, New York, pp. 2897-2910, 1978. Using examples of successful and unsuccessful protection efforts in California, 1977-1978, discusses the need for better contingency planning for coastal hazards.

Morisawa, M. and King, C. A. "Monitoring the Coastal Environment," *Geology*. Vol. 2, No. 8, pp. 385-388, 1974.

Oertel, George F. "Data Requirements for Shore Protection Regulations" in: *Coastal Zone '78*, Vol. III. American Society of Civil Engineers, New York, New York, pp. 2057-2061, 1978.
Outlines a possible method for coastal erosion planning and the information necessary to tailor that method to a particular site.

Pilkey, Orrin H. "Let the Lighthouse Fall In," *The High School Journal*. October, 1974.
An elementary and entertaining discussion of shoreline problems and attempted solutions.

Robinson, G. D. and Spieker, Andrew (eds.). *Nature to be Commanded*. U.S. Geological Survey Professional Paper 950, 1978.
Describes applications of earth science maps to land and water management, using case studies across the United States; concisely written and clearly illustrated.

Sabins, Floyd F., Jr. *Remote Sensing: Principles and Interpretation*. W.H. Freeman and Company, San Francisco, 1978.
College-level textbook describing many remote sensing techniques and their applications.

Shepard, Francis P. "Photography Related to Investigation of Shore Processes," *Photogrammetric Engineering*. Vol. 16, No. 5, pp. 756-769, December, 1950.
Discussion of techniques and approaches to documenting a variety of ongoing coastal phenomena through land-based photographs.

Spangle, William, et al. *Earth Science Information in Land Use Planning*. U.S. Geological Survey Circular 721, 1976.
Discusses how planners can understand and use earth science information for hazard analysis and mitigation.

Summerville, Mary. "Government Tort Liability," *The Urban Lawyer*. Vol. 3, No. 3, pp. 376-395, Summer, 1978.
Discusses government liability in granting development permits or instituting coastal hazard mitigation measures.

U.S. Army Coastal Engineering Research Center, *Shore Protection Manual* (3 vols.). U.S. Corps of Engineers, Superintendent of Documents No. 008-022-00077-1, 1975.
A complete, technical description of the engineering and physical aspects of coastal protection.

U.S. Army Corps of Engineers. *Shore Management Guidelines*. Prepared by the Center for the Environment and Man, for the National Shoreline Study, Hartford, Connecticut, August, 1971.

U.S. Army Corps of Engineers. *National Shoreline Study--California Regional Inventory*. U.S. Army Corps Report to Congress, House Document 93-121, August, 1971.
One off a series of documents generally describing existing and proposed land uses, and erosional problem areas along all of the coasts of the United States.

White, Gilbert F., et al. *Natural Hazard Management in Coastal Areas*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, Washington, DC, 1976.
Catalogue and description of major coastal hazards (i.e. erosion, tsunami, hurricanes, etc.) with planning and study suggestions for each.

Williams, R.S. and Carter, W.D. (eds.). *ERTS-1 A New Window on our Planet*. U.S. Geological Survey Paper 929, Superintendent of Documents No. 024-001-02757-7.
Description, examples, and applications of photos taken by Earth Resources Technology Satellite 1 (ERTS-1). Many illustrations.

Part III

Physical Factors Affecting Erosion

Bascom, Willard. *Waves and Beaches*. Anchor Books, Garden City, New York, 1964.
Introduction to waves and coastal processes for the layman, with diagrams and illustrations.

California Department of Navigation and Ocean Development. *Shore Protection in California*, 1972.
Qualitative summary of coastal processes and different types of protective structures for the general reader.

Fisher, John S. and Dolan, Robert (eds.). *Beach Processes and Coastal Hydrodynamics*. Benchmark Papers in Geology series, Vol. 39. Dowden, Hutchison and Ross, Inc., Stroudsburg, Pennsylvania, 1977.
Collection of significant technical papers in the field.

Fox, William T. and Davis, Richard A. "Seasonal Variations in Beach Erosion and Sedimentation on the Oregon Coast," *Geological Society of America Bulletin*, Vol. 89, pp. 1541-1549, 1978.
Technical analysis of the seasonal variations in coastal processes due to type and intensity of weather patterns.

Ganus, William J. "Is Southern California Ready for a Wet Period?" *Environment Southwest*, Vol. 472, pp. 9-13, Winter, 1976.
Easily readable article explaining climatic cycles and the potential hazards of a future period of large storms in California.

Griggs, G.B. and Johnson, R.E. "Effects of the Santa Cruz Harbor on Coastal Processes of Northern Monterey Bay, California," *Environmental Geology*, Vol. 1, No. 5, pp. 299-312, 1976.
Detailed case study of the coastal changes resulting from installation of a small craft harbor.

Griggs, G. B. and Johnson, R. E. "Coastline Erosion: Santa Cruz County, California," *California Geology*, Vol. 32, No. 4, pp. 67-76, April, 1979.
Semi-technical case study of erosional processes and trends in the Santa Cruz area.

Hoose, Seena N. "Earthquake-Induced Ground Failure in Coastal Areas," in: *Coastal Zone '78*, Vol. III. American Society of Civil Engineers, New York, New York, pp. 1508-1529, 1978.
Documents coastal slides and slumps occurring after the major earthquakes in San Francisco and Alaska.

Inman, Douglas L. *A Summary Report of Man's Impact on the California Coastal Zone*. California Department of Navigation and Ocean Development, 1976.
A collection of case studies at six locations along the coast with assessment of coastal protection measures in light of specific environmental conditions.

Inman, Douglas L. and Brush, Birchard M. "The Coastal Challenge," *Science*, Vol. 181, pp. 20-32, July 6, 1973.
General introduction to physical coastal processes and human impacts on same.

Komar, Paul. *Beach Processes and Sedimentation*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976.
Textbook covering many types of coastal processes in a quantitative manner.

Kuhn, G. G. and Shepard, F. P. "Accelerated Beach-Cliff Erosion Related to Unusual Storms in Southern California," *California Geology*, Vol. 32, No. 3, pp. 58-59, 1979.
Description of historically documented severe storms and related coastal failures in southern California.

Leighton, F. Beach. "Landslides and Hillside Development" in: *Engineering Geology in Southern California*. Association of Engineering Geologists, Arcadia, California, October, 1966.
Simplified, but technically precise discussion of the causes, methods of identifying, and possible solutions to hillside stability problems.

McEwen, G. F. "Destructive High Waves Along the Southern California Coast," *Shore and Beach*, Vol. 3, No. 2, pp. 61-64, April, 1935.
Documents numerous incidents of high waves causing localized damage during 1934.

Moore, David G. "The Origin and Development of Sea Caves," *National Speleological Bulletin*, No. 16, pp. 71-76, December, 1954.
Discusses processes and geological conditions leading to the formation of sea caves along the southern California coast.

Munk, W.H. and Taylor, M. A. "Refraction of Ocean Waves: A Process Linking Underwater Topography to Beach Erosion," *Shore and Beach*, Vol. LV, No. 1, pp. 1-25, 1947.
A technical paper describing wave refraction diagrams and wave energy distribution in quantitative terms.

Norris, Robert M. "Sea Cliff Retreat Near Santa Barbara, California," *Mineral Information Service*, California Division of Mines and Geology, Vol. 21, No. 6, pp. 87-91, June 1968.
Case study describing methods of field investigation and various rates of retreat obtained at different locations.

Pestrong, Raymond. "Landslides--The Descent of Man," *California Geology*. Vol. 29, No. 7 pp. 147-151, July, 1976.
A good, basic summary of the types, causes, and social impacts of landslides.

Pipkin, Bernard W. and Ploessel, Michael. "Coastal Landslides in Southern California," (pamphlet). University of Southern California Sea Grant publication no. USC-SG-3-72, Los Angeles, 1972.
Pamphlet for homebuyers and the general public concerning coastal landslide hazards in Los Angeles County.

Shepard, Francis P. "Beach Cycles in Southern California." Technical Memorandum No. 20, Beach Erosion Board, Army Corps of Engineers, July, 1950.
Technical description and documentation of changing beach profiles at several sites in California.

Shepard, F. P. and Grant, U.S., IV. "Wave Erosion Along the Southern California Coast," *Geological Society of American Bulletin*, Vol. 58, pp. 919-926, October, 1947.
Discussion of physical processes, geological conditions and landforms associated with coastal erosion.

Shepard, Francis P. and Wayless, H. R. *Our Changing Coastlines*, McGraw-Hill Book Company, New York, 1971.
Comprehensive description and analysis of coastlines around the world; Chapter 10 covers California, generously illustrated.

Schuster, Robert L. and Krizek, Raymond J. (eds.). *Landslide Analysis and Control*. Transportation Research Board Special Report 176, National Academy of Sciences, Washington, DC, 1978.
Practical semi-technical approach to causes and types of hillside failures for planners and engineers.

Sorben, Donald R. and Sherrod, Kendall L. "Groundwater Occurance in the Urban Environment," in: *Geology of Southwestern San Diego County, California and Northwestern Baja California* (Gregory T. Farrand, ed.). San Diego Association of Geologists pp. 67-74, 1977.
Discusses several case studies in which watering of gardens appeared to lower the slope stability of certain subdivisions.

Sowers, G. B. and Sowers, G. F. *Introductory Soil Mechanics and Foundations*. MacMillan Publishing Company, New York, 1970.
College-level textbook on the physical properties of different soil types under various environmental conditions.

United States Weather Bureau. *Meteorology of Hydrologically Critical Storms in California*. Hydrometeorological Report No. 37, December, 1972.
Technical report describing the long and short-term atmospheric changes associated with large storms in California.

Wood, Fergus J. *The Strategic Role of Perigean Spring Tides*. U.S. Department of Commerce, National Oceanic and Atmospheric Association, National Ocean Survey, Superintendent of Documents No. 003-017-00420-1, 1976.
The comprehensive work in this field. Contains highly technical explanations and interesting, readable description of historical documentation of storms accompanied by extremely high (Perigean, Spring) tides.

Wylie, Francis E. *Tides and the Pull of the Moon*. The Stephen Greene Press, Brattleboro, Vermont, 1979.
Popularized, simplified explanations of tidal effects and their implications for human development.