TECHNICAL SERVICE CENTER
DENVER, COLORADO

TECHNICAL MEMORANDUM No. 8260-96-03

RIPARIAN VEGETATION MAPPING OF THE LOWER COLORADO RIVER FROM THE DAVIS DAM TO THE INTERNATIONAL BORDER

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U.S. Department of the Interior
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June 20, 1996

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INTRODUCTION

The riparian vegetation of the lower Colorado River from Davis Dam to the U.S.-Mexico border varies in wildlife habitat quality depending on vegetation type. In order to gauge the change in relative quality of wildlife habitat along the river over time it is necessary to inventory the vegetation type changes every few years. Reclamation has conducted three previous mapping efforts starting in 1976. The analysis of vegetation change over an 18 year period shows the effects of various human disturbances including the effects of controlled river flow on the riparian corridor.

Vegetation changes in a highly dynamic area such as riparian corridors can be quite dramatic. Along the lower Colorado River changes have arisen from natural events such as successions of species development, fires, floods, and droughts. Change also ovbiously occurs due to human impacts such as removal of vegetation, river channelization and diversion, and the introduction and spread of non-native species. Gauging these disturbances is difficult without multi-temporal "looks" at the river.

The purpose of this study is to remap the riparian vegetation type, vegetation structural type, and backwaters so that a more current inventory of wildlife habitat is available. Using these data, vegetation trends can be determined and linked to management issues such as water allocation and timing of releases.

Scope of Study

The study area extends from Davis Dam to the U.S.-Mexico border, about 450 kilometers or 273 miles (Figure 1). The photography covered an area approximately 2500 feet on either side of the river. This coverage was considerably wider than the extent of riparian vegetation in most locations, considerably less in others. Previous studies mapped a greater extent of the riparian corridor, presumably due to better photographic coverage.

As part of the mapping, marsh areas, sandbars, river channels and backwaters are included as well as riparian vegetation. The impact of the mapped data on wildlife habitat is not included in this study.

The study was designed to be a replication of previous efforts, not an update of them. In other words, the previous maps were not to be used as a base upon which changes were superimposed, but rather the entire mapping effort was redone from the beginning as if previous data were nonexistent. No reference was made to previous data for polygon shape or data attributes. This was done in order to prevent previous classification from influencing the current interpretation.

The minimum map unit is nominally 5 acres, but a number of smaller parcels are included, particularly of important vegetation classes such as marsh. The marsh categories frequently are mapped to smaller than one acre parcels. Additional areas not mapped in previous efforts but included in this report are long thin strips of vegetation. These areas were excluded in previous efforts because they typically fell beneath the minimum mapping unit. These areas were included in this effort for a number of reasons. Collectively, the large numbers of these areas may be significant. In addition, many of these areas fall along the lake margins and may provide important habitat between the water and the drier upland areas. The high ratio of polygon boundary length to polygon area may also be significant as indicators of ecotonal areas. Ecotones are typically higher in species diversity than non-ecotonal areas (Odum 1971).

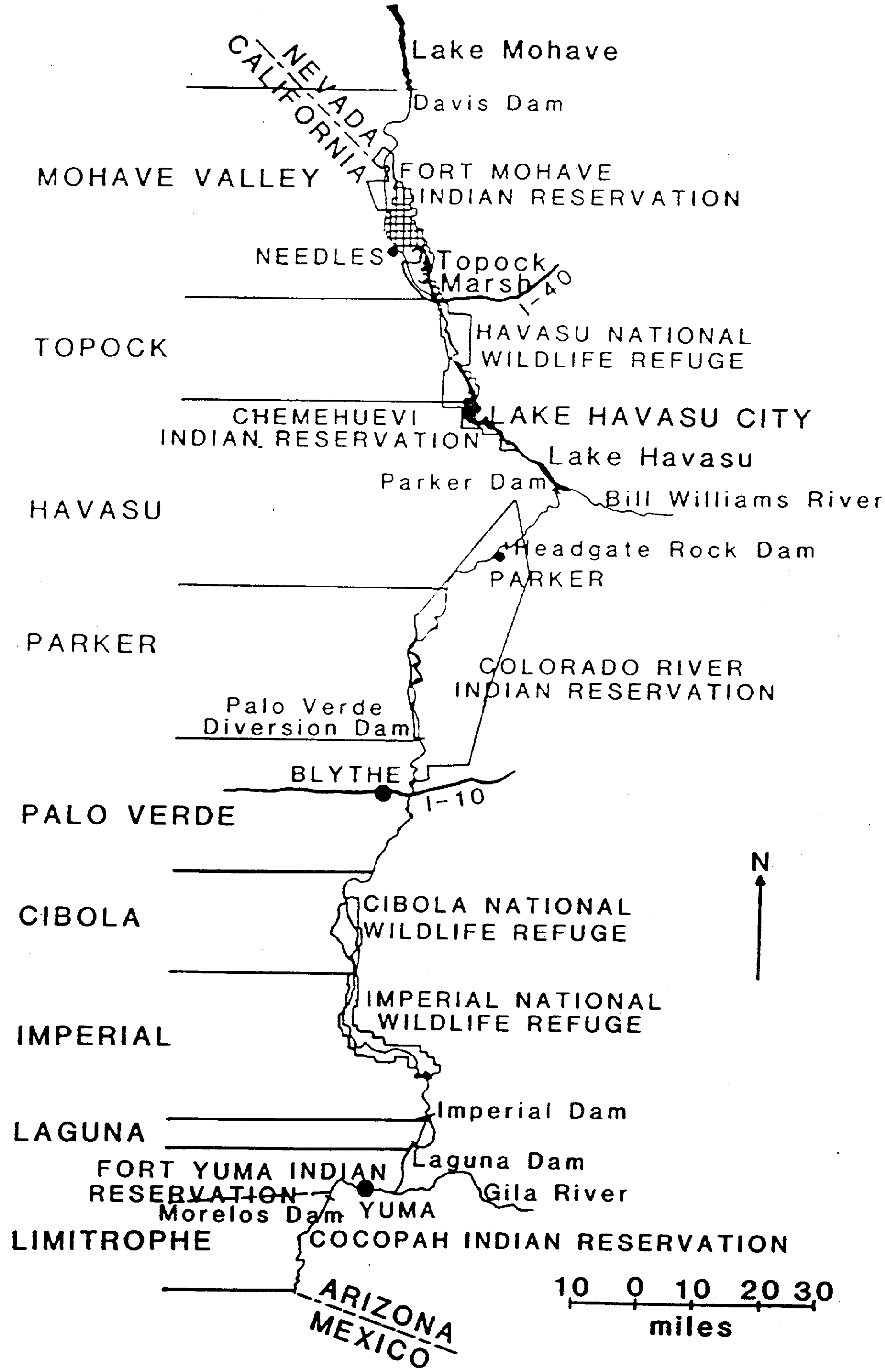

Figure 1. Map of the lower Colorado River. Management units are identified. (Ohmart et al. 1988)

PREVIOUS STUDIES

Studies of the riparian corridor along the lower Colorado river began in 1976 with studies by Anderson and Ohmart (1976). This 1976 effort was the initial mapping of vegetation along the lower portion of the Colorado River. This mapping effort was repeated using 1981-1982 photography (Anderson and Ohmart 1984) and again in 1986 (Younker and Anderson). All of these efforts used the same classification system used in the first study.

The minimum mapping unit in the 1976 study was approximately 50 acres, although the scale and type (color infrared, natural color, or black & white) of the aerial photography used in the delineation was not mentioned. The maps published in this report are not very detailed since they are at a scale of about 1" to a mile (1:63,360). Considerable changes between this vegetation map series and current vegetation distributions exist, as might be expected over 20 years of floods, fires, development, etc. No accuracy assessment was provided.

The 1984 study used aerial photography of unknown type and scale dated winter 1981-1982. There is much more emphasis and documentation in this study on studying vegetation on the ground. Numerous transects were laid out to measure vegetation density and height on the ground instead of just interpreting vegetation characteristics from aerial photography. Extensive data analysis was performed on the collected data, which is beyond the scope of the current study.

The 1986 study used 1:6,000 aerial photographs to update the 1984 Anderson and Ohmart report. All classification was done visually; no measurements of the type made in the previous study were made. Acreage of each polygon was annotated on the maps for the first time.

These studies are discussed at length in Younker and Anderson (1986) and Ohmart et al. (1988). Please refer to them for additional information.

STUDY AREA

The mapping for this project began at the Davis Dam and continued south to the U.S.-Mexico border at San Luis. The portion of Mexico where the Colorado River forms the international boundary between the two countries was also included. Still other areas included: the Havasu National Wildlife Refuge, portions of the Cibola National Wildlife Refuge, the Imperial National Wildlife Refuge, and the delta of the Bill Williams River as it enters Lake Havasu. The study area was divided into several management units/divisions. Figure 1 details the study area and the management units.

MAPPING METHODS

Prior to the initiation of the mapping effort, discussions were conducted with Glen Gould and, later, John Swett, of the Boulder City Lower Colorado River District concerning the final product. After discussions about content, extent of photointerpretation, concerns about the classification system, and map products, we began the mapping effort.

An initial overview of the project area was conducted by helicopter. We observed the entire project area at low level. During this flight we were briefed about ongoing projects, peculiarities of the area, and familiarized ourselves with accessibility to different areas.

Field Reconnaissance

During initial field reconnaissance, Tables 1, 2, and 3, and Figures 2 and 3 were used to familiarize the photointerpreters with the vegetation species and structure types. Previous mapping efforts restricted the minimum mapping unit to 10 hectares (25 acres) for all classes. We duplicated this procedure, occasionally mapping to smaller units with the exception of the marsh categories. All marsh categories were delineated using a minimum mapping unit of 1 acre.

In addition to the initial reconnaissance by helicopter, additional ground visits to the field familiarized photointerpreters with class signatures such as tone, texture, color, pattern, etc. Sites visited in the field were noted on the photographs. These sites received an additional designation in the GIS database as field verified.

Aerial Photo Interpretation

Photointerpreters involved in the riparian mapping used a variety of resources to make accurate classification determinations. These included: 1:6,000 scale color aerial photography acquired on June 13, 1994; field photographs; ground truthing; and accuracy assessments. After the work had begun, we discovered that we lacked photography for some off river areas. These areas were portions of Havasu and Cibola National Wildlife Refuges. In order to include these areas in this inventory, we obtained existing color infrared photography at a scale of 1:15,840. The Cibola National Wildlife refuge was photographed June 29, 1995 and Havasu National Wildlife refuge was photographed March 7, 1995. Both dates were close enough to the 1:6,000 scale photography to be included in the same database. However, because the Havasu National Wildlife Refuge photography was obtained in March, much of the vegetation was phenologically different from the other two sets. This introduced additional photointerpretive ambiguity.

Photointerpretive Techniques

Photointerpretation was performed directly on mylars overlaying each aerial print using a light table, stereoscope, and 10-power hand lens. Feature recognition was based on size, color, shape, shadows, topographic location, and field observations.

Mylar overlays were attached to all photographs. Each photograph was delineated with polygons representing a single vegetation class. The photointerpretive line work and classification on each photograph were matched with the photointerpretation on both previous and subsequent photographs. Care was taken to insure uniformity of classification and linework. We used two photointerpreters to complete this task. All work was reviewed by David Salas to insure uniformity of interpretation.

Typically, only the center portions of aerial photos are interpreted to prevent the introduction of image and relief displacement. This technique is used when overlapping stereo pairs are available. However, the photo acquisition for this project was primarily one-dimensionals, i.e. linear. Therefore, photographic overlap only existed, for the most part, along the river corridor in one direction. With a few exceptions, no sidelapping photography was available. Therefore, where no sidelap or overlap existed, we decided to interpret each photograph to its edge.

Table 1. Vegetative Communities and Criteria Used in Classification Lower Colorado River, 1996 (Younker and Andersen, 1986).

COMMUNITY	CRITERIA
Cottonwood-Willow (CW)	*Salix gooddingii* and *Populus fremontii* (the latter in extremely low densities) constituting at least 10% of total trees.
Salt cedar (SC)	*Tamarix chinensis* constituting 80-100% of total trees.
Salt cedar-Honey mesquite (SH)	*Prosopis glandulosa* constituting at least 10% of total trees; rarely found to constitute greater than 40% of total trees.
Salt cedar-Screwbean mesquite (SM)	*Prosopis pubescens* constituting at least 20% of the total trees.
Honey mesquite (HM)	*Prosopis glandulosa* constituting 90-100% of total vegetation in area.
Arrowweed (AW)	*Tessaria sericea* constituting 90-100% of total vegetation in area.
Atriplex (ATX)	*Atriplex lentiformis, A. canescens* and/or *A. polycarpa* constituting 90-100% of total vegetation in area.
Marsh (MA)	Predominately cattail/bulrush (*Typha/Scirpus*) and carrizo (*Phragmites*).
Creosote (CR)	*Larrea divaricata* constituting 90-100% of total vegetation in area.

Table 2. Marsh Types and Criteria Used in Classification. Lower Colorado River, 1996. (Anderson and Ohmart, 1984b).

Type	Criteria
1	Nearly 100 percent cattail/bulrush, small amounts of *Phragmites* and open water.
2	Nearly 75 percent cattail/bulrush, many trees and grasses interspersed.
3	About 25 to 50 percent cattail/bulrush, some *Phragmites*, open water. Some trees and grass.
4	About 35 to 50 percent cattail/bulrush, many trees and grasses interspersed.
5	About 50 to 75 percent cattail/bulrush, few trees and grasses interspersed.
6	Nearly 100 percent *Phragmites*, little open water.
7	Open marsh (75 percent water), adjacent to sparse marsh vegetation; includes sandbars and mudflats when Colorado River is low.

Table 3. User's Guide to Classifying Vegetation by Dominant Tree or Shrub Species Present.

This key can be used to classify about 95% of the riparian vegetation found along the lower Colorado River. By applying the same general principles used to construct the key and a little imagination, rare vegetation types can also be classified. (Anderson and Ohmart 1984a)

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1. A. Stand in which virtually 100% of the trees present are of 1 species or virtually 100% arrowweed. . . . . Go to 2
   B. Trees within stand of clearly mixed species. The different species may occur as mixed individuals or as small clumps. Go to 3

2. A. Stand in which trees are composed of nearly 100% of some species (may be occasional, widely scatter individuals of 1 or more species). Many large stands have arrowweed in patches encompassing 2 ha (5 a) or more. Honey mesquite stands in addition to, or instead of, arrowweed may have quail bush, four-winged salt bush, wolfberry, or inkweed.
   Salt-Cedar I-IV or Honey Mesquite III-VI
   B. Stand composed of nearly 100% arrowweed, may be an occasional tree or widely scattered clump of some
   other shrub. Arrowweed

3. A. Stand of vegetation is structural Type I and trees are primarily salt cedar, cottonwood and/or willow with an occasional widely scattered screwbean or honey mesquite tree or clumps of trees. Arrowweed or some other shrub may occur in relatively widely scattered clumps.
   Salt Cedar-Cottonwood/Willow Mix
   B. Vegetation not structural Type I . . . . Go to 4

4. A. Stand of vegetation is structural Type II of III . . . . Go to 5
   B. Stand not structural Type II or III . . . . Go to 6

5. A. Stand in which trees are salt cedar with large numbers of cottonwood and/or willow present; may be widely scattered individuals or clumps of screwbean or honey mesquite. Salt Cedar-Cottonwood/Willow Mix
   B. Stand in which trees are mainly salt cedar and screwbean mesquite; may be an occasional, widely scattered clump or individual cottonwood and/or willow or honey mesquite. Salt Cedar-Screwbean mesquite Mix

6. A. Stand of vegetation in structural Type IV . . . . Go to 7
   B. Stand not structural Type IV . . . . Go to 8

7. A. Stand composed mainly of salt cedar but with significant numbers of cottonwood and/or willow present; may be widely scattered individuals or clumps of screwbean or honey mesquite. Shrubs, mainly arrowweed, abundant and occurring in moderate to relatively large patches sometimes encompassing 2 ha (5 a) or more. Salt Cedar-Cottonwood/willow Mix
   B. Stand much as above but with screwbean mesquite or honey mesquite instead of cottonwood and/or willow.
   Salt Cedar-Screwbean Mesquite Mix or Salt Cedar-Honey Mesquite Mix

8. A. Stand of vegetation is structural Types V or VI .... Go to 9
   B. Stand not V or .... Go to 3

9. A. Stand composed mainly of salt cedar, but with significant numbers of cottonwood and/or willow occurring as scattered individuals or clumps. Arrowweed is usually abundant (occasionally some other shrub species such as quail bush also present) and occurring in patches encompassing several ha (a). Salt Cedar-Cottonwood/Willow Mix
   B. Stand composed primarily of salt cedar but with significant numbers of individuals or clumps of screwbean or honey mesquite. May be widely scattered individuals or clumps of screwbean or honey mesquite. Arrowweed present as in 9.A.
   Salt Cedar-Screwbean mesquite Mix or Salt Cedar-Honey Mesquite Mix

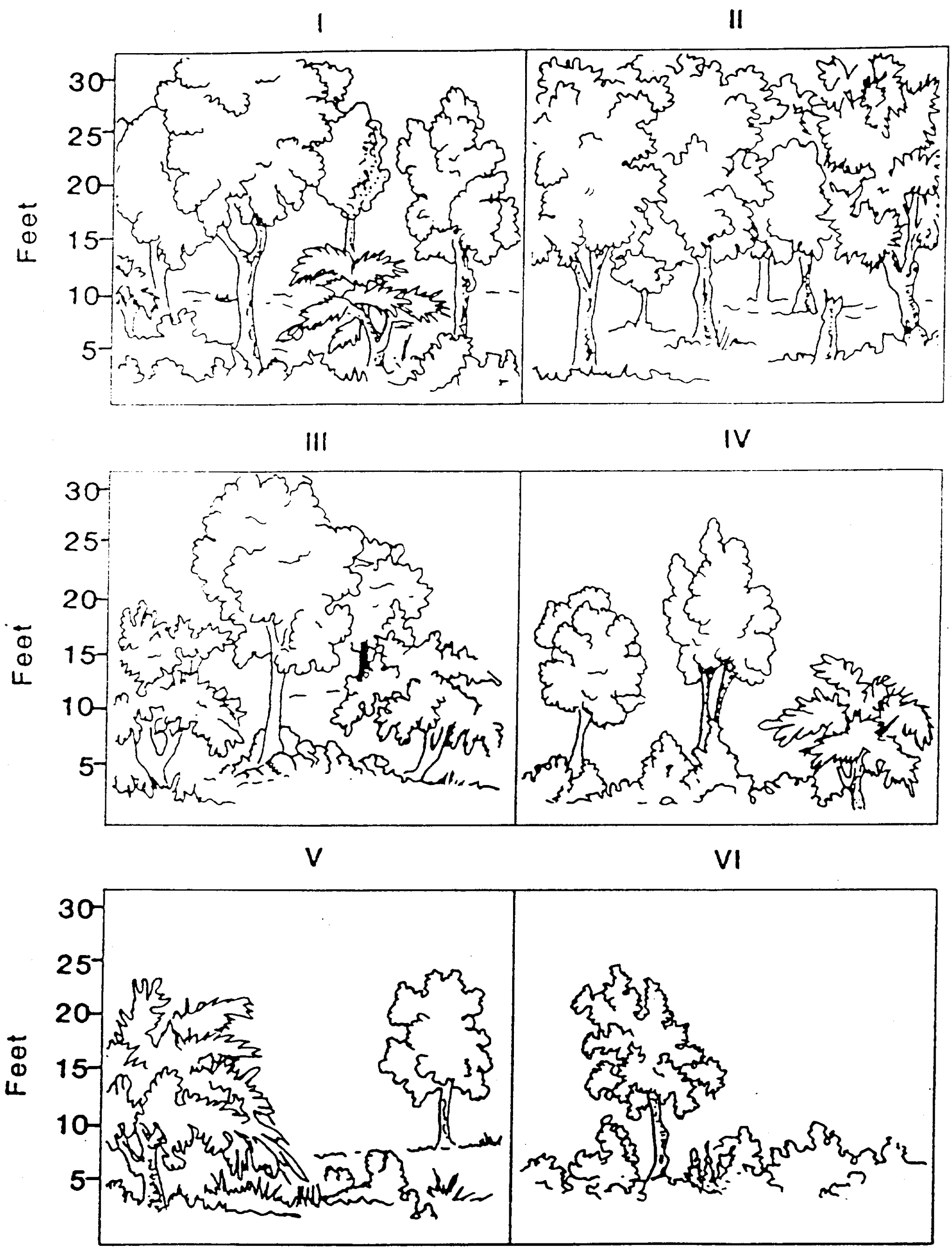


Figure 2. Examples of vertical configurations for the vegetation structural types defined in Figure 3. (Anderson and Ohmart 1984).

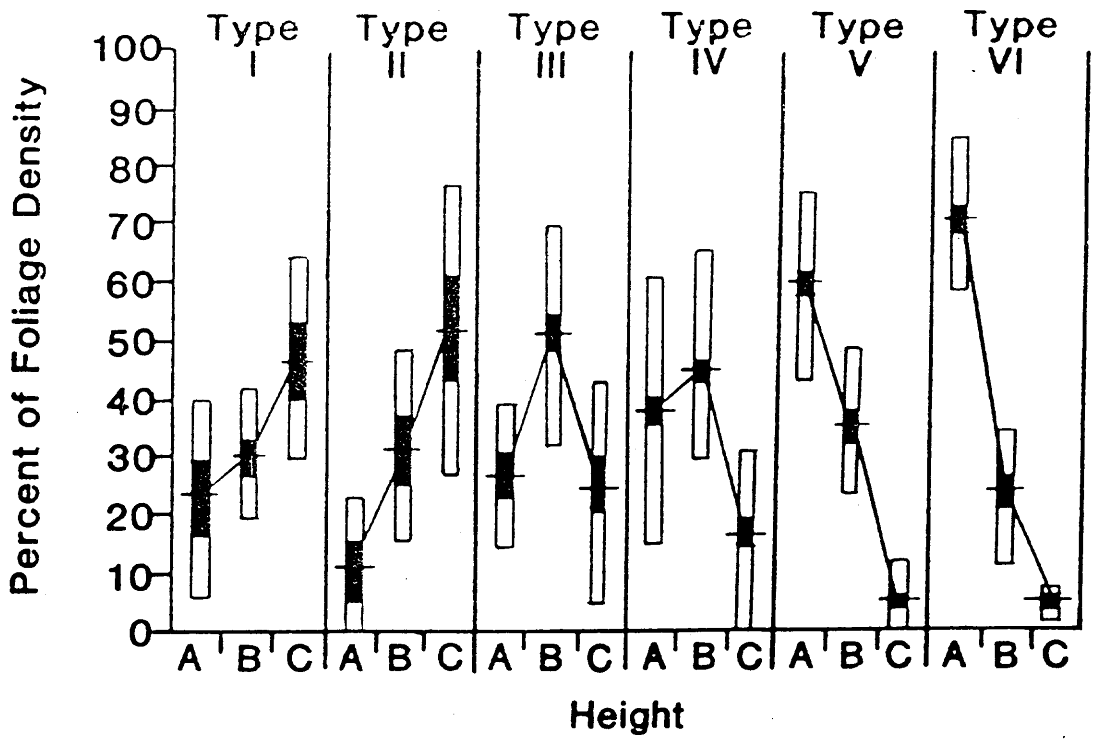


Figure 3. Proportional distribution of vertical layers of vegetation by structure type. From Anderson and Ohmart (1984b) (Figure 11-A) depicting the proportional distribution of the vegetation in 3 vertical layers. Data were taken only from subplots within various stands of vegetation which overall were classified as belonging to 1 vertical structural type (I-VI). Horizontal lines represent mean values; large rectangles represent ±1 standard deviation; small rectangles represent ±2 standard errors. A = 0.0-0.6 m (0-2ft); B = 0.6-4.5m (2-15ft); C = >4.5m (>15ft)

This allowed us to recover as much information as possible. If this technique had not been employed only a very narrow corridor along the river would have been mapped. The effects of image displacement are negligible due to the high quality of modern camera systems (Avery and Berlin, 1985). Relief displacement probably presented some inaccuracies, but given that the terrain is very flat in most divisions, this problem can be ignored, especially in lieu of the additional information gathered. The trade off was sufficiently high to warrant ignoring relief displacement. There was considerable relief in the Topock Gorge division. However, in this division riparian vegetation occurred only immediately adjacent to the river. Therefore, relief displacement was again ignored.

Photointerpretive Classes

The classification system for this project was originally developed by Anderson and Ohmart (1976). Discussions of the development and justification for this classification system are well discussed in Anderson and Ohmart (1976;1984), Ohmart, Anderson, and Hunter (1988), and Younker and Anderson (1986). Table 1 shows the floristic vegetation classification. Each vegetation class, with the exception of the marsh category, is further subdivided with a structure designation. Figures 2 and 3 describe and illustrate the separate structure types. The marsh category was further subdivided into separate floristic categories (Table 2). Figures 4a -4m show typical vegetation types and their classification along the lower Colorado River.

Cartography

The methodologies for transfer of photointerpretive information to digital data bases vary considerably. The particular technique used often depends on the quality and scale of the base maps available. Two separate techniques were attempted in this project.

We initially attempted to transfer the information from the photo mylars to a 1:24,000 scale USGS base map using a Salzman vertical projector. However, differences in scale between the photography and the base maps made this frustrating and fraught with inaccuracies. Adding to the problems of scale were the temporal differences between information on the photographs and the maps. Many of the base maps used have not been updated since the 1950's. Hence, many features on the ground were completely different from the what the maps indicated. In some cases the river itself was miles from its location 40 years ago.

Two mapping techniques were used depending on the availability of base map material. For sheets 3 through 21 we combined photointerpretive mylars from each flight line, redrafted them on to individual sheets, and transformed the redrafted sheets into state plane coordinates. For example, flight line 9 had twelve photographs. Each of the photointerpretive mylars attached to the photographs were joined end to end, abutting where photointerpretation ended on one and began on the next. This intermediate product was then overlaid with a single strip of mylar and the photointerpretation from the twelve mylars manually drafted to one sheet. This process was done on a light table. The redrafted sheet was then scanned into digital form using an Anatech Eagle 4080 ET scanner at a resolution of 200 dots per inch. The scanned information then had to

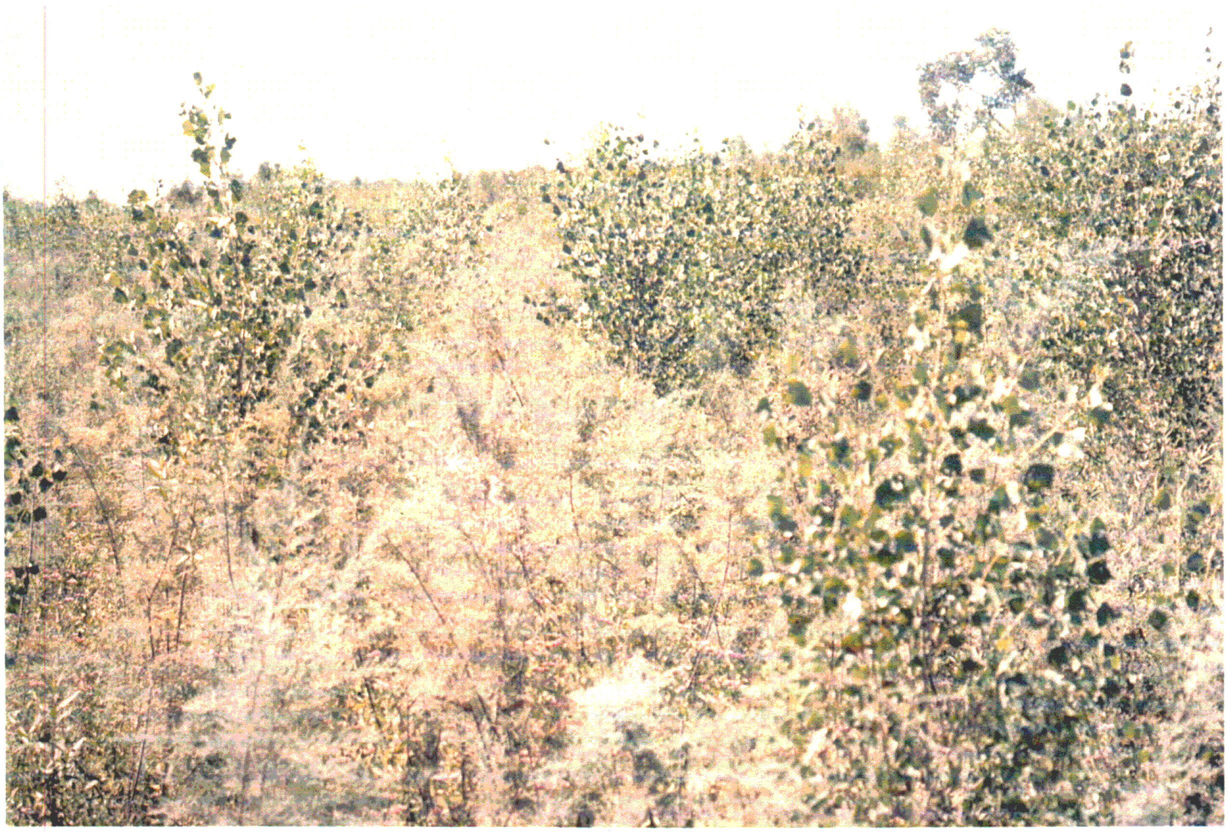


Figure 4a. Cottonwood Willow structure type VI. This site about 6 miles west of Yuma.

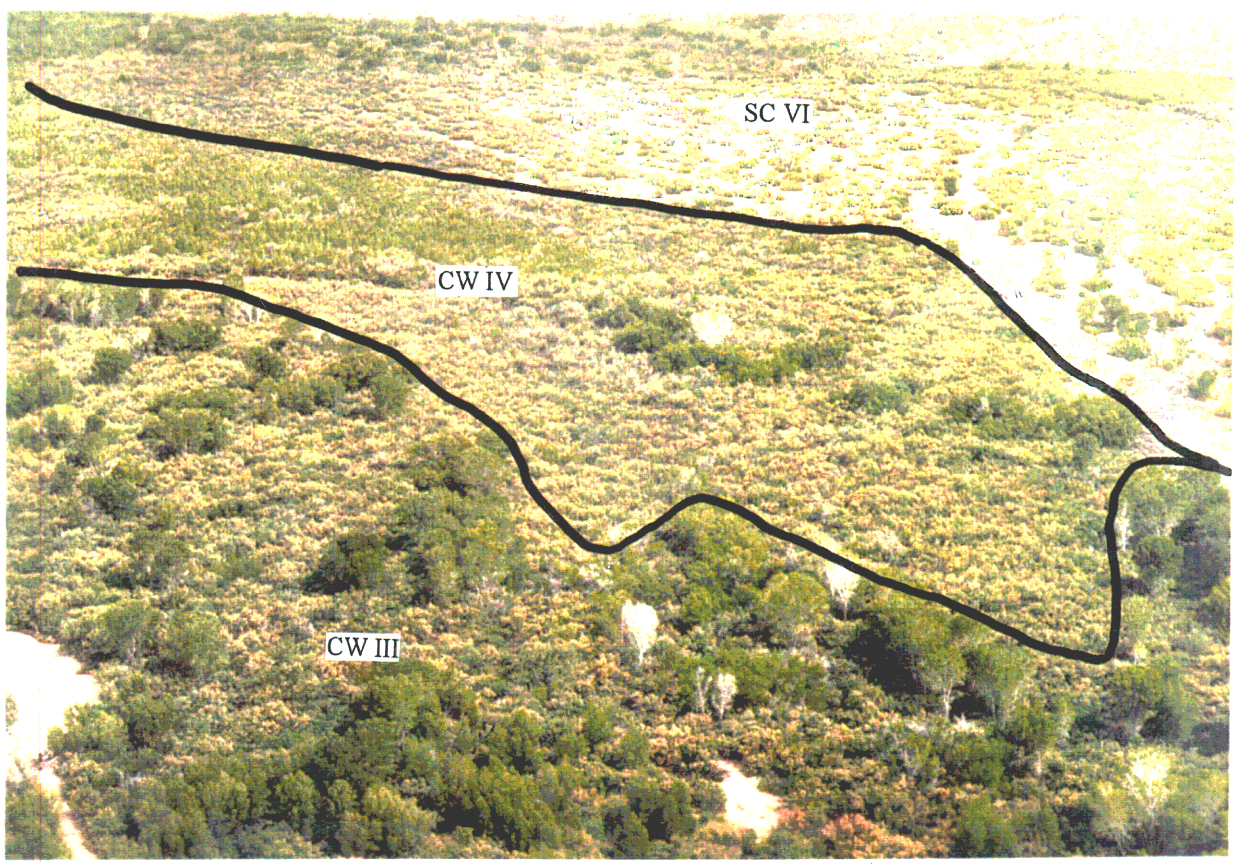


Figure 4b. Mosaic of Cottonwood Willow communities and Salt Cedar. This location near the confluence of the Bill Williams River and Lake Havasu.

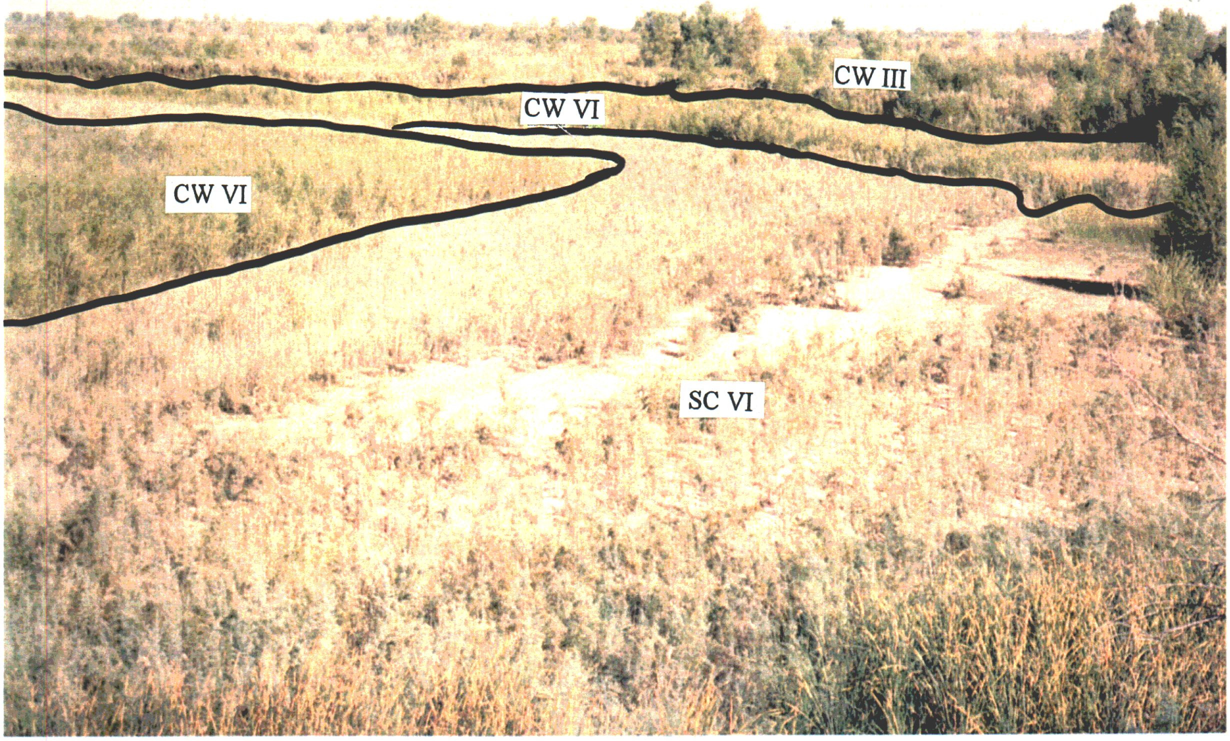


Figure 4c. Zonation of vegetation. CS III on bluff was classified as CW VI in 1986. CW VI are young willows established within the previous two years

Figure 4d. Marsh 1 category. This site of almost pure *Typha* is in Picacho State Park.

Figure 4e. Marsh type 6. Pure stand of *Phragmites* near the Mexican border.

Figure 4f. Marsh type 7. This site just north of the Morelos Dam. Opposite bank has two types of CW (VI and III). *Phragmites* on left side of frame.

Figure 4g. Backwater area in Topock Gorge. Wetland on left side of photograph is MA 4 and wetland toward the back is MA 1 with SC IV behind it.

Figure 4h. Wetland area leaving Topock Gorge and entering Lake Havasu. These wetlands are a combination of MA 1 and MA 4.

Figure 4i. Picacho State Park. Wetlands are a mosaic of *Typha* and *Phragmites* (MA 1 and MA 6).

Figure 4j. Dense Salt Cedar stand south of Yuma. This area is classified as SC IV.

Figure 4k. Salt Cedar stand in Yuma area. This area classified as SC V. Note gaps within the shrub layer.

Figure 4l. Salt Cedar Stand in river channel near Mexican border. This is young Salt Cedar no more than 2 - 3 years old. This area classified as SC VI.

Figure 4m. Salt Cedar - Screwbean mesquite stand south of Parker. This area classified as SM IV.

be converted from a TIFF (raster) format to a vector format using PROVEC software. The digital file was then transferred to a GIS system for transformation and editing.

The digital files then had to be transformed into Arizona state plane coordinates, west zone. For this we needed ground control points obtained from USGS maps. Typically this consisted of road intersections. However, due to the remoteness of much of the project area, ground control had to come from much less stable features such as distinct bends in tributaries or topographic features such as peaks and canyons. In addition to the USGS maps, we also obtained some ground control points from the 1986 (Younker and Anderson) vegetation maps that had more up-to-date ground control features. Evaluating the positional accuracy of these 1986 mapped features was not possible. In other words, the ground features such as roads, bridges, etc were more current than many USGS maps, yet their positional accuracy was unknown and may, in fact, have introduced additional positional error.

The second method we used was in areas where the photointerpretation extended into Mexico. These areas were not mapped on USGS topographic maps. For these areas we obtained 1:24,000 scale USGS orthophoto quads. Ground control points were selected from the orthophoto quads. Sheets 1 and 2 were compiled by scanning, vectorizing, and registering each individual photointerpretive mylar to ground control features on the orthophoto quads. Because of the abundance of ground control features the positional accuracy of map sheets 1 and 2 are greater than sheets 3 through 21.

Attributes for all polygons were transferred from either individual photointerpretive mylars or the redrafted sheets. Vegetation type and structure were attributed separately. In order to maintain topology we added two additional classes to the database which will not show up on the map key. These were the "water" and "undesignated" codes.

ACCURACY ASSESSMENT

Assumptions and Considerations

The accuracy assessment of a mapping effort such as this one is more than just a measurement of the proportion of correct classifications. There are a number of assumptions and considerations that should be identified. Only then can the user fully appreciate the usefulness of the final accuracy assessment.

Typically, errors are examined in terms of thematic accuracy and positional accuracy. Thematic accuracy assumes that there is no ambiguity between classes while positional accuracy assumes that any given point may be located in the field.

Although the classification system developed by Anderson and Ohmart (1986) is flexible, there are instances where class ambiguity may become a problem. This is particularly difficult when structure types grade from one to another. Most classes also require an estimation of percentage cover for a variety of different species. Although theoretically possible, this is a difficult parameter to estimate, even for experienced ecologists.

Positional accuracy most often considers the location of boundaries between classes. The delineation of boundaries can range from clearly unambiguous to wildly speculative. A boundary between an irrigated field and a Salt Cedar stand can be clearly delineated and easily found in the field. However, the delineation of boundaries between a SC VI and SC V are subjective as are boundaries between a SC IV (at least 80% *Tamarix chinensis*) and SH IV (at least 10% *Prosopis glandulosa* with the rest being *Tamarix chinensis*). These ecotonal areas are to be expected, but they introduce an element of uncertainty and speculation. Consequently, positional error is difficult to quantify. For the purposes of this mapping project we will not consider the positional accuracy. The modern cartographic methodologies discussed elsewhere will be assumed reliable enough to produce high quality maps.

A third, temporal factor, added uncertainty to the accuracy assessment. River corridors are highly dynamic areas. Change can occur quite rapidly. The photography was acquired in July 1994. The field reconnaissance was conducted during the summer and fall of 1995. Even in the short span of 12 to 14 months there was considerable change (compare Figures 5a and 5b). The accuracy assessment was conducted a year after the field reconnaissance. This was a full two years after photo acquisition. The effects of natural fires; human activities such as clearing and controlled burns; and new growth, combined to add additional difficulty to the accuracy assessment. During the actual assessment these factors were considered and taken into account when making classification judgements. If estimating what existed at the time of photo acquisition was impossible, then the site in question was dropped from consideration.

Sample Design and Data Collection Objectives

The sampling design used for this project addressed the following considerations (Stoms et al. 1994)

1. It should be scientifically sound. As such, the method should be repeatable, and the sampling design should permit the adequate representation of the population about which statistical inferences are to be drawn.

2. The methods used should be applicable to all subareas of a project. Although there may be some regional variation in the implementation of the accuracy assessment, these variations should still be based on the same theoretical foundation, such that the results of separate assessments are comparable.

3. The method should be feasible in view of both time and cost constraints.

Items 1 and 3 above may sometimes conflict. It was difficult to obtain statistically valid representations of the population that spans 240 river miles and over 80,000 acres without spending an exorbitant amount of time and money.

There are a number of sampling designs used for accuracy estimations. These include simple random sampling, stratified random sampling, systematic sampling, and two-stage sampling. All have their advantages and disadvantages (Taylor 1977). Because of the importance of determining accuracy for the less abundant but critically important marsh class we chose to use a stratified random sample.

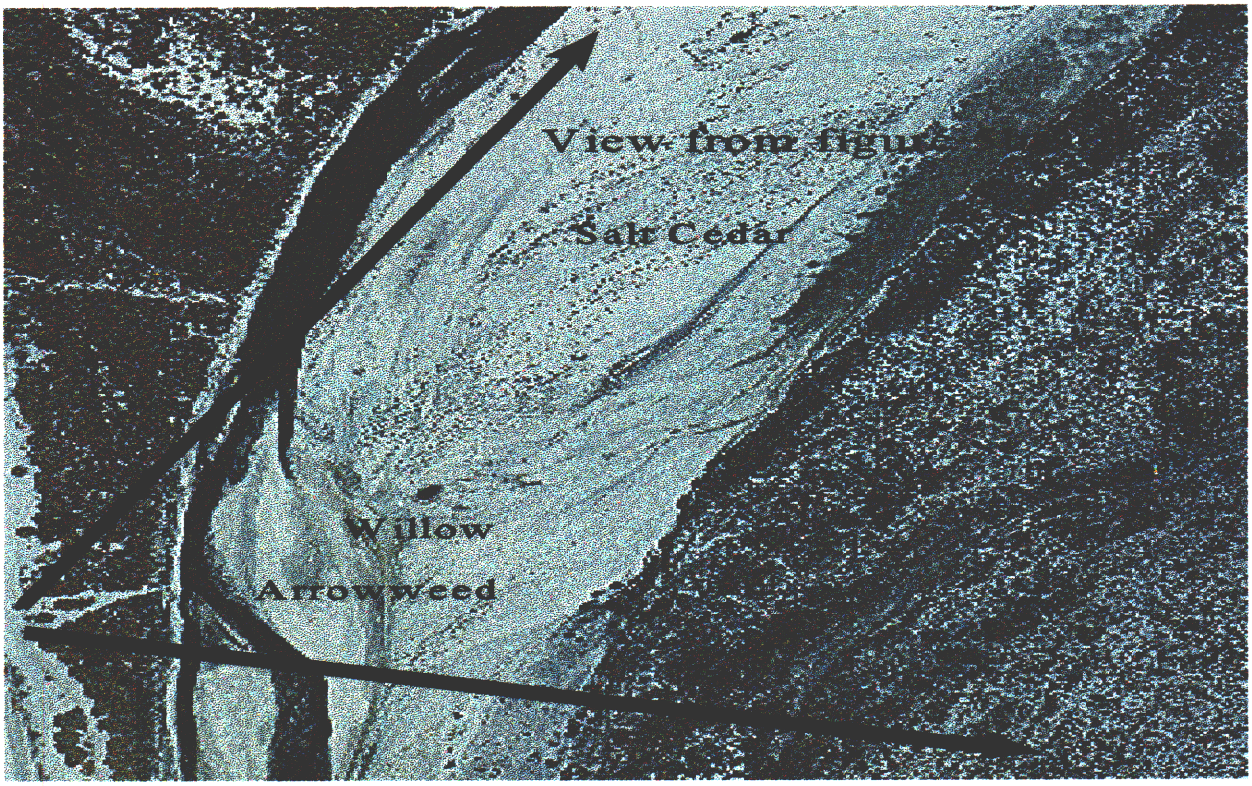


Figure 5a. Portion of aerial photograph 92-5. Light gray area appears lightly vegetated or bare. Compare to ground photograph in figure 5b.

Figure 5b. View of Colorado River 3 miles north of the Mexican border. This area is completely vegetated in September 1995. Compare to aerial photograph in figure 5a taken in June 1994.

Sampling Design

A random number generation program produced twenty x,y coordinate pairs, which were moved, copied and rotated through several iterations to include the entire project area. The points were given the vegetation type and structure attributes of their location. Number of points per type /class combination ranged from about 400 for common combinations to about 25 (one for every occurrence) for the least common combinations. The sample was stratified such that the less common marsh categories received a sufficient number of observations to make statistically valid statements. Points for water and undesignated categories were discarded. The selected locations were marked on the photointerpreted mylar overlays for field checking and interpretation. Actual observations were considerably fewer than those selected for observation due to time constraints.

Given the subjective and interpretive nature of vegetation mapping, we chose not to use overly stringent statistical parameters and selected confidence levels of 90%. This provided for acceptable statistical determination of vegetation class. However, accuracy was also determined separately for structure types. Obtaining a statistically valid sample size for both vegetation class and structure type was prohibitively expensive and in some cases, impossible. For example, some vegetation classes and structure type combinations such as SC I and CW I occur very rarely. Therefore, accuracy determinations for vegetation class will be much more precise than those for structure. It is possible to create a contingency table large enough to include all vegetation classes with every possible structure or type (marsh) but this becomes unwieldy and impractical.

Data Presentation and Interpretation

The accuracy of each class is presented in the form of an error matrix (also known as a contingency table). An error matrix will describe several statistical parameters regarding the accuracy of a mapping effort. The simplest descriptive statistic is the overall accuracy which is computed by dividing the total correct (i.e., the sum of the major diagonal) by the total number of observations. For example, in Table 4, we have the error matrix for the vegetation classes. The total number of observations for all classes is 132. The total number of correct observations is 116. The overall accuracy is then 116/132 = 0.88 or 88%. Using the formula for determining confidence intervals in a two tailed test (Formula 1) we then have an overall accuracy of 88% +/- 5%.

$$\hat{p} \pm z_{\alpha}\sqrt{\hat{p}(1-\hat{p})/n} \qquad (1)$$

In this formula $\hat{p}$ is the proportion correct, z_{α} comes from a table of the z-distribution at the 90% confidence interval for a two-sided test, (z_{α} = 1.645) and n is the sample size. Similarly, accuracies of individual categories can be determined. In this case, however, one has the choice of dividing the number of correct observations by either the total number of observations in the corresponding row or the corresponding column. Both are valid statistics but are interpreted differently. Dividing the number of correct observations by the sum of the column is really a measure of omission error and is also known as the "producer's accuracy". This statistic reveals how well a certain area can be classified. For example, in Table 4 the omission error for the Cottonwood/Willow class (CW) is 0 or 100% percent accurate. That is, all CW that was identified on the photographs as CW was correct. Another way of viewing this is to say that no actual CW was left out of this category (i.e. 0 omission error). This however does not reflect other classes that were mistakenly included into this category. If we look at the commission error (total number of correct observations divided by the sum of the row), we see a considerably different story. In the case of CW we have a commission error of 71% +/- 28%. This is also known as the "users accuracy" and reflects the probability that a polygon classified on the map actually represents that category on the ground. To sum this up, the producer of this map can say that 100% of the time an area that was CW was identified as such, yet a user of this map will find that only 71% of the time will an area visited that the map says is CW will actually be CW. A more detailed discussion of these statistics and considerations are reviewed in Congalton (1991).

The total number of observations for the accuracy assessment was unfortunately low. Time and cost constraints prohibited collecting sufficiently large sample for each and every class. Consequently, the confidence intervals are very large for some of the rarer classes such as Honey Mesquite, and Salt Cedar/Honey Mesquite.

Table 5a - 5d show the accuracy for structure types within each class. For structure types that were not observed the matrix will show ERR. No observations were made for the class SH consequently there is no associated error matrix for those structures. Table 6 shows the accuracy for the different vegetation types for the marsh class.

OBSERVED

	CW	SC	SH	SM	HM	AW	ATX	MA	CR	n	Total n	Fraction	Conf. Int.
CW	5	1		1						7		0.71	0.28
SC		13			1		1			15		0.87	0.14
SH		1	0							1		0.00	0.00
SM		1	2	19	3					25		0.76	0.14
HM				1	4					5		0.80	0.29
AW		1				19	2			22		0.86	0.12
ATX						1	12			13		0.92	0.12
MA								40		40		1.00	0.00
CR									4	4		1.00	0.00
n	5	17	2	21	8	20	15	40	4	116	132		
Total n										132			
Fraction	1.00	0.76	0.00	0.90	0.50	0.95	0.80	1.00	1.00			0.88	
Conf. Int.	0.00	0.17	0.00	0.11	0.29	0.08	0.17	0.00	0.00				0.05

Table 4. Error matrix for vegetation classes. CW - Cottonwood Willow, SC - Salt Cedar, SH - Salt Cedar/Honey Mesquite, SM - Salt Cedar/Screwbean Mesquite, HM - Honey Mesquite, AW - Arrowweed, ATX - Atriplex, MA - Marsh, CR - Creosote.

OBSERVED

	I	II	III	IV	V	VI	n	Total n	Fraction	Conf. Int.
I							0		ERR	ERR
II							0		ERR	ERR
III			3	1			4		0.75	0.36
IV							0		ERR	ERR
V							0		ERR	ERR
VI				1			1		0.00	0.00
n	0	0	3	2	0	0	3	5		
Total n							5			
Fraction	ERR	ERR	1.00	0.00	ERR	ERR			0.60	
Conf. Int.	ERR	ERR	0.00	0.00	ERR	ERR				0.47

Table 5a. Error matrix for Cottonwood-Willow vegetation class structure type.

OBSERVED

	I	II	III	IV	V	VI	n	Total n	Fraction	Conf. Int.
I							0		ERR	ERR
II							0		ERR	ERR
III							0		ERR	ERR
IV				4	1		5		0.80	0.29
V					6	1	7		0.86	0.22
VI					1		1		0.00	0.00
n	0	0	0	4	8	1	10	13		
Total n							13			
Fraction	ERR	ERR	ERR	1.00	0.75	0.00			0.77	
Conf. Int.	ERR	ERR	ERR	0.00	0.25	0.00				0.22

Table 5b. Error matrix for Salt Cedar vegetation class structure type.

OBSERVED

	I	II	III	IV	V	VI	n	Total n	Fraction	Conf. Int.
I							0		ERR	ERR
II							0		ERR	ERR
III							0		ERR	ERR
IV				8	4		12		0.67	0.27
V				3	2		5		0.40	0.43
VI						2	2		1.00	0.00
n	0	0	0	11	6	2	12	19		
Total n							19			
Fraction	ERR	ERR	ERR	0.73	0.33	1.00			0.63	
Conf. Int.	ERR	ERR	ERR	0.26	0.38	0.00				0.23

Table 5c. Error matrix for Salt Cedar - Screwbean Mesquite structure type

OBSERVED

	I	II	III	IV	V	VI	n	Total n	Fraction	Conf. Int.
I							0		ERR	ERR
II							0		ERR	ERR
III							0		ERR	ERR
IV				2		1	3		0.67	0.45
V				1			1		0.00	0.00
VI							0		ERR	ERR
n	0	0	0	3	0	1	2	4		
Total n							4			
Fraction	ERR	ERR	ERR	0.67	ERR	0.00			0.50	
Conf. Int.	ERR	ERR	ERR	0.45	ERR	0.00				0.58

Table 5d. Error matrix for Honey Mesquite vegetation class structure type

OBSERVED

	1	2	3	4	5	6	7	n	Total n	Fraction	Conf. Int.
1	9					1		10		0.90	0.16
2				1				1		0.00	0.00
3	4		2	2	1			9		0.22	0.23
4				4	1			5		0.80	0.29
5	1		6	2	1			10		0.10	0.16
6			1			5		6		0.83	0.25
7								0		ERR	ERR
n	14	0	9	9	3	6	0	21	41		
Total n								41			
Fraction	0.64	ERR	0.22	0.44	0.33	0.83	ERR			0.51	
Conf. Int.	0.21	ERR	0.23	0.27	0.45	0.25	ERR				0.18

Table 6. Error matrix for Marsh vegetation class types.

RESULTS

The acreage compilation for the 1994 mapping effort is detailed in Table 7. The table is divided into vegetation types and division. Total estimated acreages are included by vegetation class and by division. Included for comparative purposes are tables from Younker and Anderson (1986) that shows acreage figures for 1986 and 1981 (Tables 8 and 9), though a direct comparison of the numbers from one table to another is not possible given that the surveyed areas are different between 1994 and 1986, and probably also 1981. In order to provide some measure of comparison we have normalized the data of the total area surveyed by calculating the percentage and the total area surveyed for each class and structure. For example CWIII (Table 7) in the Mohave Division is 644 acres. We take (644/83051) 100 = 0.775 (Table 10). The resulting percentages are detailed in Tables 10, 11, and 12. Using the percent data we have subtracted the 1986 and 1981 amounts respectively from the 1994 data (Tables 13 and 14). The negative signs in each table indicate a percentage loss since the previous mapping effort. Backwaters are tallied in Table 15.

All acreage tallies were obtained using functions inherent to all GIS softwares and yield greater precision than antiquated electronic digital planimeters. A 3.5 inch diskette with these data in Quattro Pro format is included in Appendix A.

The maps for this projects are divided into the identical sheets as mapped in 1986. There are 21 sheets that extend from the Davis Dam to the Mexican border. These maps are included in Appendix B.

The final GIS database with all vegetation coverages and graphics files will be held by this office until it is requested by the client. All coverages include a metadata file describing the origin and processing of the data.

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0	0	32	0	2	0	0	0	0	34	68
CW II	26	0	0	26	0	90	6	3	0	0	151
CW III	644	0	335	8	3	64	278	38	318	145	1833
CW IV	100	7	0	184	8	47	84	61	258	169	918
CW V	62	0	0	16	0	0	24	6	6	38	152
CW VI	13	0	0	2	33	0	2	28	27	161	266
HM III	41	0	0	0	0	0	0	0	0	0	41
HM IV	125	0	0	7	0	0	11	3	3	0	149
HM V	0	0	0	16	85	32	60	0	0	0	193
HM VI	6	0	0	0	0	0	18	0	0	0	24
MA 1	1450	420	474	69	8	380	823	524	55	13	4216
MA 2	275	6	12	0	8	0	220	0	12	0	533
MA 3	164	30	59	321	19	71	922	249	76	2	1913
MA 4	215	652	9	300	98	195	936	91	27	0	2523
MA 5	84	95	16	13	5	26	65	9	1	0	314
MA 6	1	0	7	79	0	2	351	5	118	29	592
MA 7	420	8	7	69	22	30	74	31	126	144	931
SC I	278	0	0	0	0	0	0	0	12	0	290
SC II	6	0	2	2	0	0	47	5	9	16	87
SC III	67	13	0	0	27	23	67	15	40	15	267
SC IV	7230	105	82	1864	1632	4394	4081	1625	1279	1644	23936
SC V	3023	87	71	2722	868	2210	957	1195	300	1663	13096
SC VI	1372	16	85	1598	1111	322	517	552	239	1142	6954
SH III	4	0	0	0	10	0	53	0	0	0	67
SH IV	116	0	91	37	54	449	288	77	3	0	1115
SH V	0	0	15	19	0	708	260	25	0	0	1027
SH VI	0	0	3	0	0	128	0	0	0	0	131
SM I	3	0	0	0	0	0	0	0	0	0	3
SM II	14	0	0	0	0	0	0	1	0	0	15
SM III	500	0	0	0	1	0	0	0	7	0	508
SM IV	2100	129	326	2227	1372	878	905	556	264	14	8771
SM V	1267	26	138	799	645	428	182	160	53	44	3742
SM VI	300	0	31	376	589	65	9	195	0	0	1565
ATX VI	24	0	50	342	37	62	5	40	110	44	714
AW VI	657	0	126	2377	383	133	44	587	324	566	5197
CR V	0	106	223	0	0	0	151	113	153	3	749
IW VI	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0
TOTAL	20587	1700	2194	13473	7020	10737	11440	6194	3820	5886	83051

Table 7. 1994 acreages by Community and Division

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0	0	0	0	0	0	0	0	0	0	0
CW II	6	0	141	0	48	30	0	0	0	0	225
CW III	70	0	181	81	161	0	0	9	0	0	502
CW IV	734	0	262	164	273	142	73	85	0	0	1733
CW V	280	10	97	731	322	13	167	113	229	905	2867
CW VI	0	0	0	27	0	0	0	0	31	369	427
HM III	186	0	0	0	903	0	0	0	0	0	1089
HM IV	3417	0	147	242	4541	393	143	6	0	0	8889
HM V	964	0	0	311	0	365	23	20	0	0	1683
HM VI	0	0	0	20	0	0	0	0	0	0	20
MA 1	1211	511	537	93	75	60	2302	799	69	0	5657
MA 2	677	0	0	19	0	0	33	0	0	0	729
MA 3	226	162	0	92	72	48	1168	23	66	0	1857
MA 4	0	0	0	369	0	0	0	0	0	0	369
MA 5	24	340	0	63	6	0	10	0	0	0	443
MA 6	0	0	0	23	0	0	1143	30	561	0	1757
MA 7	0	0	0	0	0	0	267	13	226	1231	1737
SC I	173	0	0	0	0	0	0	17	38	82	310
SC II	0	0	0	9	0	0	0	0	0	0	9
SC III	0	0	4	0	0	0	0	7	0	0	11
SC IV	7744	137	498	2644	698	6992	1854	416	314	1084	22381
SC V	5189	135	153	3240	1465	2686	1193	1764	1381	354	17560
SC VI	1349	0	16	1669	58	288	0	892	420	74	4766
SH III	28	0	0	0	0	0	0	0	0	0	28
SH IV	1687	45	14	26	1324	2315	460	95	0	0	5966
SH V	1087	0	38	172	269	239	74	0	0	0	1879
SH VI	0	0	0	7	0	0	0	0	0	0	7
SM I	0	0	0	0	0	0	0	0	0	0	0
SM II	0	0	0	0	0	0	0	0	0	0	0
SM III	127	0	0	233	0	0	0	0	0	0	360
SM IV	3339	0	9	2968	1152	273	84	0	0	0	7825
SM V	2540	0	11	2036	1259	1063	0	78	80	0	7067
SM VI	240	0	0	0	0	0	0	0	0	0	240
ATX VI	623	0	16	320	11	7	0	0	254	0	1231
AW VI	2389	0	77	3194	424	91	57	1062	117	67	7478
CR V	0	0	0	0	0	0	0	0	426	0	426
IW VI	221		0	0	0	0	0	0	0	0	221
TOTAL	34531	1340	2201	18753	13061	15005	9051	5429	4212	4166	107749

Table 8. 1986 acreages by Community and Division (Younker and Anderson, 1986)

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0	0	0	0	0	0	0	0	0		0
CW II	0	0	114	26	8	15	0	0	0	0	163
CW III	27	0	47	0	142	132	110	18	116	0	592
CW IV	1328	5	388	1019	373	186	793	261	38	136	4527
CW V	0	0	399	632	66	40	22	214	288	39	1700
CW VI	500	0	0	0	75	63	0	0	234	67	939
HM III	315	0	0	0	913	0	0	0	0	0	1228
HM IV	3569	0	144	786	4150	377	25	0	0	0	9051
HM V	832	0	0	648	311	365	0	0	0	0	2156
HM VI	16	0	0	0	19	0	0	0	0	0	35
MA 1	635	0	59	8	0	48	2646	579	0	0	3975
MA 2	495	401	29	80	3	10	157	207	0	0	1382
MA 3	574	18	0	28	35	222	151	149	64	0	1241
MA 4	41	0	4	268	45	0	122	93	0	0	573
MA 5	544	215	0	69	0	9	178	78	0	0	1093
MA 6	0	0	0	0	0	0	122	0	514	0	636
MA 7	499	0	0	192	116	220	228	0	0	0	1255
SC I	131	0	0	0	0	0	0	0	199	0	330
SC II	0	0	0	0	101	0	0	0	0	0	101
SC III	338	62	8	0	0	17	0	0	0	0	425
SC IV	7855	211	383	1764	502	5914	3008	961	595	1317	22510
SC V	2944	6	127	2180	427	1735	629	1335	616	439	10438
SC VI	932	0	31	930	982	520	4	603	896	159	5057
SH III	0	0	0	0	0	138	66	0	0	0	204
SH IV	2420	54	89	223	1654	2023	686	0	0	0	7149
SH V	1180	0	0	127	251	1050	127	0	0	0	2735
SH VI	0	0	0	0	0	130	0	0	0		130
SM I	0	0	0	0	0	0	0	0	0		0
SM II	0	0	0	99	0	0	0	0	0	0	99
SM III	252	0	0	357	0	0	0	122	37	0	768
SM IV	3416	10	12	5281	1216	328	743	41	93	927	12067
SM V	2009	0	0	1141	860	484	0	332	170	242	5238
SM VI	1344	0	0	1019	220	483	0	0	142	0	3208
ATX VI	597	0	0	0	0	0	0	0	0	0	597
AW VI	1580	73	65	1173	506	20	87	595	154	0	4253
CR V	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0
IW VI	223	0	0	0	0	0	0	0	0		223
TOTAL	34596	1055	1899	18050	12975	14529	9904	5588	4156	3326	106078

Table 9. 1981 acreages by Community and Division (in Younker and Anderson 1986)

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0.000	0.000	0.039	0.000	0.002	0.000	0.000	0.000	0.000	0.041	0.082
CW II	0.031	0.000	0.000	0.031	0.000	0.108	0.007	0.004	0.000	0.000	0.182
CW III	0.775	0.000	0.403	0.010	0.004	0.077	0.335	0.046	0.383	0.175	2.207
CW IV	0.120	0.008	0.000	0.222	0.010	0.057	0.101	0.073	0.311	0.203	1.105
CW V	0.075	0.000	0.000	0.019	0.000	0.000	0.029	0.007	0.007	0.046	0.183
CW VI	0.016	0.000	0.000	0.002	0.040	0.000	0.002	0.034	0.033	0.194	0.320
HM III	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.049
HM IV	0.151	0.000	0.000	0.008	0.000	0.000	0.013	0.004	0.004	0.000	0.179
HM V	0.000	0.000	0.000	0.019	0.102	0.039	0.072	0.000	0.000	0.000	0.232
HM VI	0.007	0.000	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.029
MA 1	1.746	0.506	0.571	0.083	0.010	0.458	0.991	0.631	0.066	0.016	5.076
MA 2	0.331	0.007	0.014	0.000	0.010	0.000	0.265	0.000	0.014	0.000	0.642
MA 3	0.197	0.036	0.071	0.387	0.023	0.085	1.110	0.300	0.092	0.002	2.303
MA 4	0.259	0.785	0.011	0.361	0.118	0.235	1.127	0.110	0.033	0.000	3.038
MA 5	0.101	0.114	0.019	0.016	0.006	0.031	0.078	0.011	0.001	0.000	0.378
MA 6	0.001	0.000	0.008	0.095	0.000	0.002	0.423	0.006	0.142	0.035	0.713
MA 7	0.506	0.010	0.008	0.083	0.026	0.036	0.089	0.037	0.152	0.173	1.121
SC I	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.349
SC II	0.007	0.000	0.002	0.002	0.000	0.000	0.057	0.006	0.011	0.019	0.105
SC III	0.081	0.016	0.000	0.000	0.033	0.028	0.081	0.018	0.048	0.018	0.321
SC IV	8.705	0.126	0.099	2.244	1.965	5.291	4.914	1.957	1.540	1.980	28.821
SC V	3.640	0.105	0.085	3.278	1.045	2.661	1.152	1.439	0.361	2.002	15.769
SC VI	1.652	0.019	0.102	1.924	1.338	0.388	0.623	0.665	0.288	1.375	8.373
SH III	0.005	0.000	0.000	0.000	0.012	0.000	0.064	0.000	0.000	0.000	0.081
SH IV	0.140	0.000	0.110	0.045	0.065	0.541	0.347	0.093	0.004	0.000	1.343
SH V	0.000	0.000	0.018	0.023	0.000	0.852	0.313	0.030	0.000	0.000	1.237
SH VI	0.000	0.000	0.004	0.000	0.000	0.154	0.000	0.000	0.000	0.000	0.158
SM I	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
SM II	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.018
SM III	0.602	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.008	0.000	0.612
SM IV	2.529	0.155	0.393	2.681	1.652	1.057	1.090	0.669	0.318	0.017	10.561
SM V	1.526	0.031	0.166	0.962	0.777	0.515	0.219	0.193	0.064	0.053	4.506
SM VI	0.361	0.000	0.037	0.453	0.709	0.078	0.011	0.235	0.000	0.000	1.884
ATX VI	0.029	0.000	0.060	0.412	0.045	0.075	0.006	0.048	0.132	0.053	0.860
AW VI	0.791	0.000	0.152	2.862	0.461	0.160	0.053	0.707	0.390	0.682	6.258
CR V	0.000	0.128	0.269	0.000	0.000	0.000	0.182	0.136	0.184	0.004	0.902
IW VI	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
TOTAL	24.788	2.047	2.642	16.223	8.453	12.928	13.775	7.458	4.600	7.087	100.000

Table 10. Acreages of the 1994 survey by percentage of the total area surveyed.

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CW II	0.006	0.000	0.131	0.000	0.045	0.028	0.000	0.000	0.000	0.000	0.209
CW III	0.065	0.000	0.168	0.075	0.149	0.000	0.000	0.008	0.000	0.000	0.466
CW IV	0.681	0.000	0.243	0.152	0.253	0.132	0.068	0.079	0.000	0.000	1.608
CW V	0.260	0.009	0.090	0.678	0.299	0.012	0.155	0.105	0.213	0.840	2.661
CW VI	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.029	0.342	0.396
HM III	0.173	0.000	0.000	0.000	0.838	0.000	0.000	0.000	0.000	0.000	1.011
HM IV	3.171	0.000	0.136	0.225	4.214	0.365	0.133	0.006	0.000	0.000	8.250
HM V	0.895	0.000	0.000	0.289	0.000	0.339	0.021	0.019	0.000	0.000	1.562
HM VI	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.019
MA 1	1.124	0.474	0.498	0.086	0.070	0.056	2.136	0.742	0.064	0.000	5.250
MA 2	0.628	0.000	0.000	0.018	0.000	0.000	0.031	0.000	0.000	0.000	0.677
MA 3	0.210	0.150	0.000	0.085	0.067	0.045	1.084	0.021	0.061	0.000	1.723
MA 4	0.000	0.000	0.000	0.342	0.000	0.000	0.000	0.000	0.000	0.000	0.342
MA 5	0.022	0.316	0.000	0.058	0.006	0.000	0.009	0.000	0.000	0.000	0.411
MA 6	0.000	0.000	0.000	0.021	0.000	0.000	1.061	0.028	0.521	0.000	1.631
MA 7	0.000	0.000	0.000	0.000	0.000	0.000	0.248	0.012	0.210	1.142	1.612
SC I	0.161	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.035	0.076	0.288
SC II	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.008
SC III	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.010
SC IV	7.187	0.127	0.462	2.454	0.648	6.489	1.721	0.386	0.291	1.006	20.771
SC V	4.816	0.125	0.142	3.007	1.360	2.493	1.107	1.637	1.282	0.329	16.297
SC VI	1.252	0.000	0.015	1.549	0.054	0.267	0.000	0.828	0.390	0.069	4.423
SH III	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026
SH IV	1.566	0.042	0.013	0.024	1.229	2.149	0.427	0.088	0.000	0.000	5.537
SH V	1.009	0.000	0.035	0.160	0.250	0.222	0.069	0.000	0.000	0.000	1.744
SH VI	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.006
SM I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM III	0.118	0.000	0.000	0.216	0.000	0.000	0.000	0.000	0.000	0.000	0.334
SM IV	3.099	0.000	0.008	2.755	1.069	0.253	0.078	0.000	0.000	0.000	7.262
SM V	2.357	0.000	0.010	1.890	1.168	0.987	0.000	0.072	0.074	0.000	6.559
SM VI	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.223
ATX VI	0.578	0.000	0.015	0.297	0.010	0.006	0.000	0.000	0.236	0.000	1.142
AW VI	2.217	0.000	0.071	2.964	0.394	0.084	0.053	0.986	0.109	0.062	6.940
CR V	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.395	0.000	0.395
IW VI	0.205	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.205
TOTAL	32.048	1.244	2.043	17.404	12.122	13.926	8.400	5.039	3.909	3.866	100.000

Table 11. Acreages of the 1986 survey (Younker and Anderson 1986) by percentage of the total area surveyed.

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CW II	0.000	0.000	0.107	0.025	0.008	0.014	0.000	0.000	0.000	0.000	0.154
CW III	0.025	0.000	0.044	0.000	0.134	0.124	0.104	0.017	0.109	0.000	0.558
CW IV	1.252	0.005	0.366	0.961	0.352	0.175	0.748	0.246	0.036	0.128	4.268
CW V	0.000	0.000	0.376	0.596	0.062	0.038	0.021	0.202	0.271	0.037	1.603
CW VI	0.471	0.000	0.000	0.000	0.071	0.059	0.000	0.000	0.221	0.063	0.885
HM III	0.297	0.000	0.000	0.000	0.861	0.000	0.000	0.000	0.000	0.000	1.158
HM IV	3.365	0.000	0.136	0.741	3.912	0.355	0.024	0.000	0.000	0.000	8.532
HM V	0.784	0.000	0.000	0.611	0.293	0.344	0.000	0.000	0.000	0.000	2.032
HM VI	0.015	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.033
MA 1	0.599	0.000	0.056	0.008	0.000	0.045	2.494	0.546	0.000	0.000	3.747
MA 2	0.467	0.378	0.027	0.075	0.003	0.009	0.148	0.195	0.000	0.000	1.303
MA 3	0.541	0.017	0.000	0.026	0.033	0.209	0.142	0.140	0.060	0.000	1.170
MA 4	0.039	0.000	0.004	0.253	0.042	0.000	0.115	0.088	0.000	0.000	0.540
MA 5	0.513	0.203	0.000	0.065	0.000	0.008	0.168	0.074	0.000	0.000	1.030
MA 6	0.000	0.000	0.000	0.000	0.000	0.000	0.115	0.000	0.485	0.000	0.600
MA 7	0.470	0.000	0.000	0.181	0.109	0.207	0.215	0.000	0.000	0.000	1.183
SC I	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.188	0.000	0.311
SC II	0.000	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.000	0.000	0.095
SC III	0.319	0.058	0.008	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.401
SC IV	7.405	0.199	0.361	1.663	0.473	5.575	2.836	0.906	0.561	1.242	21.220
SC V	2.775	0.006	0.120	2.055	0.403	1.636	0.593	1.259	0.581	0.414	9.840
SC VI	0.879	0.000	0.029	0.877	0.926	0.490	0.004	0.568	0.845	0.150	4.767
SH III	0.000	0.000	0.000	0.000	0.000	0.130	0.062	0.000	0.000	0.000	0.192
SH IV	2.281	0.051	0.084	0.210	1.559	1.907	0.647	0.000	0.000	0.000	6.739
SH V	1.112	0.000	0.000	0.120	0.237	0.990	0.120	0.000	0.000	0.000	2.578
SH VI	0.000	0.000	0.000	0.000	0.000	0.123	0.000	0.000	0.000	0.000	0.123
SM I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM II	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.093
SM III	0.238	0.000	0.000	0.337	0.000	0.000	0.000	0.115	0.035	0.000	0.724
SM IV	3.220	0.009	0.011	4.978	1.146	0.309	0.700	0.039	0.088	0.874	11.376
SM V	1.894	0.000	0.000	1.076	0.811	0.456	0.000	0.313	0.160	0.228	4.938
SM VI	1.267	0.000	0.000	0.961	0.207	0.455	0.000	0.000	0.134	0.000	3.024
ATX VI	0.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.563
AW VI	1.489	0.069	0.061	1.106	0.477	0.019	0.082	0.561	0.145	0.000	4.009
CR V	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
IW VI	0.210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.210
TOTAL	32.614	0.995	1.790	17.016	12.232	13.697	9.337	5.268	3.918	3.135	100.000

Table 12. Acreages of the 1981 survey (Anderson and Ohmart 1984a - compiled by Younker and Anderson 1986) by percentage of the total area surveyed.

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0.000	0.000	0.039	0.000	0.002	0.000	0.000	0.000	0.000	0.041	0.082
CW II	0.026	0.000	-0.131	0.031	-0.045	0.081	0.007	0.004	0.000	0.000	-0.027
CW III	0.710	0.000	0.235	-0.066	-0.146	0.077	0.335	0.037	0.383	0.175	1.741
CW IV	-0.561	0.008	-0.243	0.069	-0.244	-0.075	0.033	-0.005	0.311	0.203	-0.503
CW V	-0.185	-0.009	-0.090	-0.659	-0.299	-0.012	-0.126	-0.098	-0.205	-0.794	-2.478
CW VI	0.016	0.000	0.000	-0.023	0.040	0.000	0.002	0.034	0.004	-0.149	-0.076
HM III	-0.123	0.000	0.000	0.000	-0.838	0.000	0.000	0.000	0.000	0.000	-0.961
HM IV	-3.021	0.000	-0.136	-0.216	-4.214	-0.365	-0.119	-0.002	0.004	0.000	-8.070
HM V	-0.895	0.000	0.000	-0.269	0.102	-0.300	0.051	-0.019	0.000	0.000	-1.330
HM VI	0.007	0.000	0.000	-0.019	0.000	0.000	0.022	0.000	0.000	0.000	0.010
MA 1	0.622	0.031	0.072	-0.003	-0.060	0.402	-1.145	-0.111	0.002	0.016	-0.174
MA 2	-0.297	0.007	0.014	-0.018	0.010	0.000	0.234	0.000	0.014	0.000	-0.035
MA 3	-0.012	-0.114	0.071	0.301	-0.044	0.041	0.026	0.278	0.030	0.002	0.580
MA 4	0.259	0.785	0.011	0.019	0.118	0.235	1.127	0.110	0.033	0.000	2.695
MA 5	0.079	-0.201	0.019	-0.043	0.000	0.031	0.069	0.011	0.001	0.000	-0.033
MA 6	0.001	0.000	0.008	0.074	0.000	0.002	-0.638	-0.022	-0.379	0.035	-0.918
MA 7	0.506	0.010	0.008	0.083	0.026	0.036	-0.159	0.025	-0.058	-0.969	-0.491
SC I	0.174	0.000	0.000	0.000	0.000	0.000	0.000	-0.016	-0.021	-0.076	0.061
SC II	0.007	0.000	0.002	-0.006	0.000	0.000	0.057	0.006	0.011	0.019	0.096
SC III	0.081	0.016	-0.004	0.000	0.033	0.028	0.081	0.012	0.048	0.018	0.311
SC IV	1.518	-0.001	-0.363	-0.209	1.317	-1.198	3.193	1.571	1.249	0.973	8.049
SC V	-1.176	-0.021	-0.057	0.271	-0.315	0.168	0.045	-0.198	-0.920	1.674	-0.529
SC VI	0.400	0.019	0.087	0.375	1.284	0.120	0.623	-0.163	-0.102	1.306	3.950
SH III	-0.021	0.000	0.000	0.000	0.012	0.000	0.064	0.000	0.000	0.000	0.055
SH IV	-1.426	-0.042	0.097	0.020	-1.164	-1.608	-0.080	0.005	0.004	0.000	-4.194
SH V	-1.009	0.000	-0.017	-0.137	-0.250	0.631	0.244	0.030	0.000	0.000	-0.507
SH VI	0.000	0.000	0.004	-0.006	0.000	0.154	0.000	0.000	0.000	0.000	0.151
SM I	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
SM II	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.018
SM III	0.484	0.000	0.000	-0.216	0.001	0.000	0.000	0.000	0.008	0.000	0.278
SM IV	-0.570	0.155	0.384	-0.073	0.583	0.804	1.012	0.669	0.318	0.017	3.299
SM V	-0.832	0.031	0.156	-0.928	-0.392	-0.471	0.219	0.120	-0.010	0.053	-2.053
SM VI	0.138	0.000	0.037	0.453	0.709	0.078	0.011	0.235	0.000	0.000	1.662
ATX VI	-0.549	0.000	0.045	0.115	0.034	0.068	0.006	0.048	-0.103	0.053	-0.283
AW VI	-1.426	0.000	0.080	-0.102	0.068	0.076	0.000	-0.279	0.282	0.619	-0.683
CR V	0.000	0.128	0.269	0.000	0.000	0.000	0.182	0.136	-0.211	0.004	0.506
IW VI	-0.205	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.205
TOTAL	-7.259	0.803	0.599	-1.182	-3.669	-0.998	5.375	2.420	0.690	3.221	0.000

Table 13. Changes in vegetation percent between 1986 and 1994.

Community Type	Mohave	Topock Gorge	Havasu	Parker	Palo Verde	Cibola	Imperial	Laguna	Yuma	Limatrophe	TOTAL
CW I	0.000	0.000	0.039	0.000	0.002	0.000	0.000	0.000	0.000	0.041	0.082
CW II	0.031	0.000	-0.107	0.007	-0.008	0.094	0.007	0.004	0.000	0.000	0.028
CW III	0.750	0.000	0.359	0.010	-0.130	-0.047	0.231	0.029	0.274	0.175	1.649
CW IV	-1.132	0.004	-0.366	-0.739	-0.342	-0.119	-0.646	-0.173	0.275	0.075	-3.162
CW V	0.075	0.000	-0.376	-0.577	-0.062	-0.038	0.008	-0.195	-0.264	0.009	-1.420
CW VI	-0.456	0.000	0.000	0.002	-0.031	-0.059	0.002	0.034	-0.188	0.131	-0.565
HM III	-0.248	0.000	0.000	0.000	-0.861	0.000	0.000	0.000	0.000	0.000	-1.108
HM IV	-3.214	0.000	-0.136	-0.733	-3.912	-0.355	-0.010	0.004	0.004	0.000	-8.353
HM V	-0.784	0.000	0.000	-0.592	-0.191	-0.306	0.072	0.000	0.000	0.000	-1.800
HM VI	-0.008	0.000	0.000	0.000	-0.018	0.000	0.022	0.000	0.000	0.000	-0.004
MA 1	1.147	0.506	0.515	0.076	0.010	0.412	-1.503	0.085	0.066	0.016	1.329
MA 2	-0.136	-0.371	-0.013	-0.075	0.007	-0.009	0.117	-0.195	0.014	0.000	-0.661
MA 3	-0.344	0.019	0.071	0.360	-0.010	-0.124	0.968	0.159	0.031	0.002	1.134
MA 4	0.220	0.785	0.007	0.109	0.076	0.235	1.012	0.022	0.033	0.000	2.498
MA 5	-0.412	-0.088	0.019	-0.049	0.006	0.023	-0.090	-0.063	0.001	0.000	-0.652
MA 6	0.001	0.000	0.008	0.095	0.000	0.002	0.308	0.006	-0.342	0.035	0.113
MA 7	0.035	0.010	0.008	-0.098	-0.083	-0.171	-0.126	0.037	0.152	0.173	-0.062
SC I	0.211	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.173	0.000	0.038
SC II	0.007	0.000	0.002	0.002	-0.095	0.000	0.057	0.006	0.011	0.019	0.010
SC III	-0.238	-0.043	-0.008	0.000	0.033	0.012	0.081	0.018	0.048	0.018	-0.079
SC IV	1.301	-0.072	-0.262	0.581	1.492	-0.284	2.078	1.051	0.979	0.738	7.601
SC V	0.865	0.099	-0.034	1.222	0.643	1.025	0.559	0.180	-0.219	1.589	5.929
SC VI	0.773	0.019	0.073	1.047	0.412	-0.102	0.619	0.096	-0.557	1.225	3.606
SH III	0.005	0.000	0.000	0.000	0.012	-0.130	0.002	0.000	0.000	0.000	-0.112
SH IV	-2.142	-0.051	0.026	-0.166	-1.494	-1.366	-0.300	0.093	0.004	0.000	-5.397
SH V	-1.112	0.000	0.018	-0.097	-0.237	-0.137	0.193	0.030	0.000	0.000	-1.342
SH VI	0.000	0.000	0.004	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.035
SM I	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
SM II	0.017	0.000	0.000	-0.093	0.000	0.000	0.000	0.001	0.000	0.000	-0.075
SM III	0.364	0.000	0.000	-0.337	0.001	0.000	0.000	-0.115	-0.026	0.000	-0.112
SM IV	-0.692	0.146	0.381	-2.297	0.506	0.748	0.389	0.631	0.230	-0.857	-0.815
SM V	-0.368	0.031	0.166	-0.114	-0.034	0.059	0.219	-0.120	-0.096	-0.175	-0.432
SM VI	-0.906	0.000	0.037	-0.508	0.502	-0.377	0.011	0.235	-0.134	0.000	-1.140
ATX VI	-0.534	0.000	0.060	0.412	0.045	0.075	0.006	0.048	0.132	0.053	0.297
AW VI	-0.698	-0.069	0.090	1.756	-0.016	0.141	-0.029	0.146	0.245	0.682	2.248
CR V	0.000	0.128	0.269	0.000	0.000	0.000	0.182	0.136	0.184	0.004	0.902
IW VI	-0.210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.210
TOTAL	-7.825	1.052	0.852	-0.793	-3.779	-0.768	4.438	2.190	0.682	3.952	0.000

Table 14. Changes in vegetation percent between 1981 and 1994.

DISCUSSION

Cartography

The mapped results for this project will be useful for the compilation of acreages. However, due to a lack of ground control over a wide portion of the project, positional accuracy will be somewhat less useful. Future mapping efforts should include the acquisition of ground control points using a Global Positioning System (GPS). A database containing these ground control points would greatly improve the registration of photography or satellite imagery.

Accuracy Assessment

The greatest difficulty in defining vegetation classes arose among the three mesquite classes. Honey Mesquite (HM); Salt Cedar - Honey Mesquite (SH); and Salt Cedar - Screwbean Mesquite (SM). Photographic signatures for the different mesquites were so similar that differentiation was problematic. Omission error for Salt cedar - Screwbean mesquite (SM) (90% correct) was low primarily because field work indicated that screwbean mesquite was the more predominant mesquite. Classifying this group as screwbean mesquite was then more of a reflection of ground observations (i.e. the probability of screwbean mesquite over honey mesquite) rather than photographic interpretation. Errors in the Salt Cedar class (SC) primarily owed to its confusion with the mesquite classes. The error in these cases came from estimating percentages of mesquite within salt cedar stands. Even the accuracy assessed observations are subject to visual interpretation. It is likely that estimations of mesquite percentage by visual observation will be no more accurate than estimations by photointerpretive observations. The errors observed in SC, SM, and SH reflect the fuzzy nature of the natural environment.

Estimations of the accuracy for the structure types was even more difficult because it required an even greater number of observations. Based on the limited number of observations that we obtained, it is apparent that photointerpreted structure types rarely varied over more than one structure type from that estimated during the field accuracy assessment. This observation accords Younker and Anderson (1986).

The marsh type classifications showed considerably more error. Most of the error was concentrated in marsh types 3, 4, and 5. These types all contained combinations of cattail/bulrush with trees and grasses. As with the SC class discussed above, much of this reported error was just as likely to come from the visual observation during the accuracy assessment as the photointerpretive observations. The highest accuracies were for types 1 and 6: essentially monotypic stands of either *Typha* or *Phragmites*.

Acreage Compilation

Comparisons of current vegetation coverage with previous efforts were problematic because the study area coverage was different for all mapping efforts. By converting the acreage totals to percentage one can get a better estimate of change. The source of the 1981 data is unclear. These data are not reported in Anderson and Ohmart (1984). In a later report Ohmart (1988) reported the total acres mapped, but they are not divided into divisions.

Vegetation Change

The relative amount of vegetation change is impossible to determine given that all percentages will sum to 100. However, the change in vegetation may still be examined by Division and vegetation class.

The greatest percentage loss since 1986 occurred in the Mohave Division showing a total relative loss of 7.259 %. Most of those losses occurred in the high resource value mesquite, marsh, and cottonwood-willow habitats. Another area of high relative loss occurred in the Palo Verde Division. This area showed a relative loss of 3.669 %. The losses occurred in the same classes as the Mohave Division. The greatest increase occurred in the Imperial, Laguna, and Limatrophe Divisions. Most of the increase in the Imperial Division came from salt cedar VI and IV with a small increase in salt cedar/screwbean mesquite IV. The Laguna Division showed an increase in salt cedar IV with a small increase in salt cedar/screwbean mesquite IV. The Limatrophe Division showed most of its increase in salt cedar V and VI.

An examination of the changes in Cottonwood-Willow since 1981 showed a very general trend from young type VI stands to older type II and III in many divisions. The Limitrophe Division showed the greatest increase in Cottonwood-Willow type VI. The channel in this division has the greatest potential for recruitment given the very wide flood plain. The higher numbers in cottonwood-willow VI probably reflects the creation of recruitment sites by high flows in 1992, 1993, and high survivorship, again due to high flows in 1994. One alarming trend does appear when one examines the total relative amounts of CW VI over the previous 13 years. The amount declined steadily. Cottonwood-willow structure types IV - VI all showed a decline with a large increase in structure type III.

Other areas that showed considerable decrease and increase were the mesquite classes. There was a large increase in salt cedar/screwbean mesquite IV (+3.299 %) with a concomitant decrease in honey mesquite IV (-8.070%) and salt cedar/honey mesquite IV (-4.194). This number should be interpreted carefully. During the accuracy assessment we found considerable error in distinguishing these classes from one another.

The largest percent increase came from salt cedar IV. This increase was obvious in nearly all divisions. This class was probably growing even faster than indicated here and often showed up as a component of other classes. For example, the marsh type 4 class was the only one to show any significant increase. Marsh type 4 is 35-75% cattail/bulrush with many trees and grasses interspersed. Most of the trees/shrubs observed in these areas were salt cedar.

The decline in most of the marsh categories may be even more serious than indicated by their statistics. We interpreted many very small marsh categories, some less than an acre in size. The previous mapping efforts did not record these small marshes. In spite of the inclusion of smaller marshes, decline is obvious.

The general trend since 1981 appears to be toward increasing populations of invasive species at the expense of the valueable wildlife habitat. The succession of cottonwoods toward older, decadent stands with less and less recruitment was also very obvious.

Overall trends for the vegetation classes are shown in Figure 6. The most obvious trend was the distinct increase in salt cedar and the decrease in cottonwood-willow habitats.

LOCATION	ACREAGE
Mohave	3767
Topock Gorge	239
Havasu	740
Parker	1364
Palo	160
Cibola	517
Imperial	2757
Laguna	585
Yuma	82
Limatrophe	14
TOTAL	10225

Table 15. Backwater acreages by division, lower Colorado River, 1994.

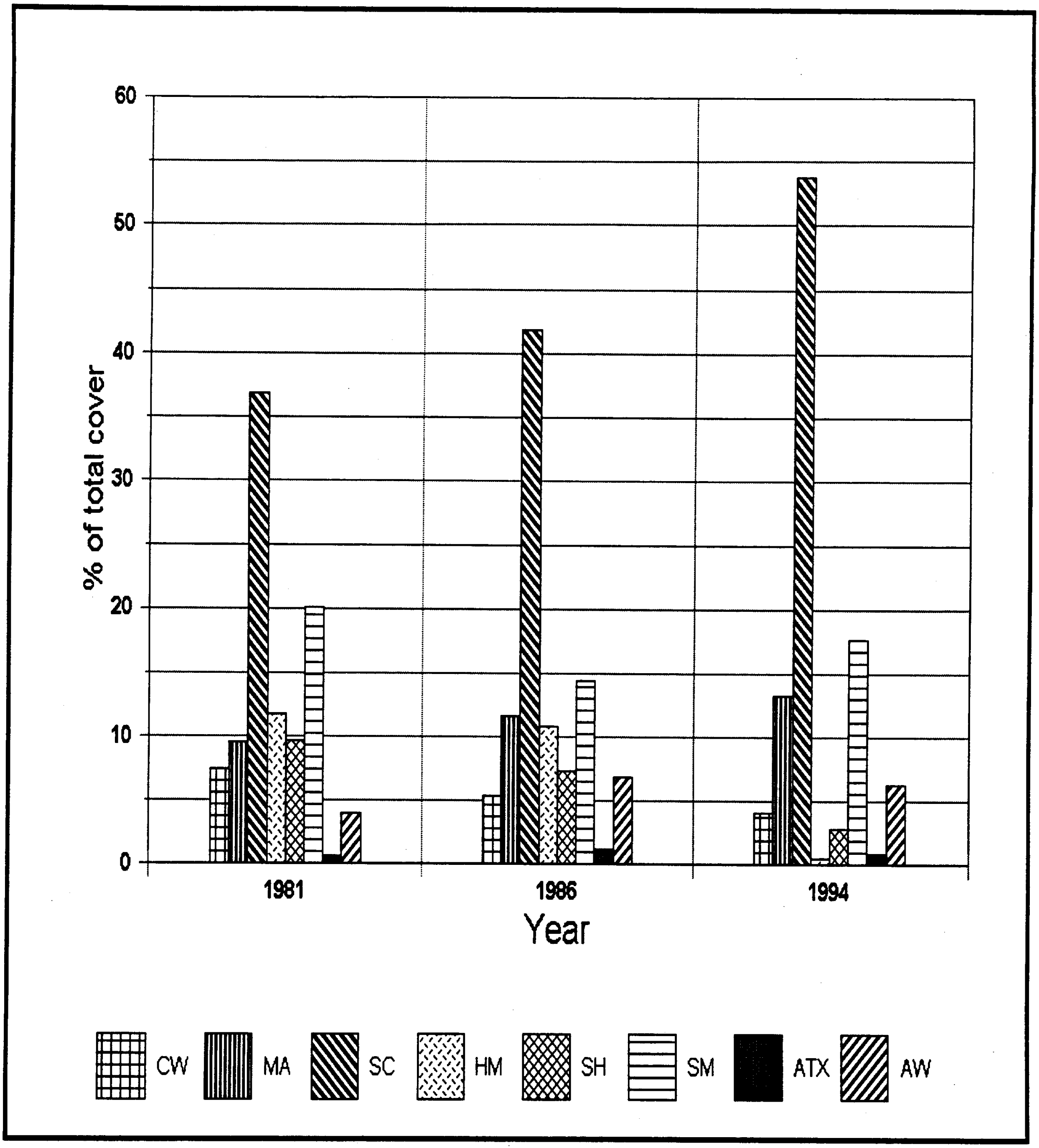


Figure 6. Changes in percent of total vegetation cover for 1981, 1986, and 1994 along the lower Colorado River. CW = Cottonwood-willow, MA = Marsh, SC = Salt Cedar, HM = Honey Mesquite, SH = Salt Cedar/Honey Mesquite, SM = Salt Cedar/Screwbean Mesquite, ATX = Atriplex, AW = Arrowweed.

LITERATURE CITED

Anderson, B.W. and R.D. Ohmart. 1976. Vegetation Type Maps of the Lower Colorado River from Davis Dam to the Southerly International Boundary. Bureau of Reclamation, Boulder City, Nevada. 4 pages and maps.

Anderson, B.W. and R.D. Ohmart. 1984a. Lower Colorado River riparian methods of quantifying vegetation communities to prepare type maps. Final Report U.S. Bur. Rec., Lower Colo. Reg., Boulder City, NV.

Anderson, B.W. and R.D. Ohmart. 1984b. Vegetation community Type Maps, Lower Colorado River. Bureau of Reclamation, Boulder City, Nevada. 59 pages and maps.

Anderson, B.W. and R.D. Ohmart. 1986. Vegetation. Pages 639-660 in A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart, eds. Inventory and monitoring of wildlife habitat. USDI Bur. Land Manage. Serv. Ctr., Denver, CO xviii + 858 pp.

Congalton, R.G. 1991. A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. Remote Sensing of the Environment. 37:35-46.

Odum, E.P. 1971. Fundamentals of Ecology. Pub. W.B. Saunders Co. 571 pp.

Ohmart, R.D., B.W. Anderson, and W.C. Hunter. 1988. The Ecology of the Lower Colorado River from Davis Dam to the Mexico-United States International Boundary: A community Profile. U.S. Fish Wildlife Service Biol. Rep. 85(7.19). 296 pp.

Stoms, D., Davis F., Cogan, C. and K. Cassidy. 1994. Assessing Vegetation /Land Cover Map Accuracy for Gap Analysis, *Draft Handbook*, University of California at Santa Barbara, Biogeography Laboratory.

Taylor, P.J. 1977. Quantitative Methods in Geography - An Introduction to Spatial Analysis. Boston: Houghten Mifflin company.

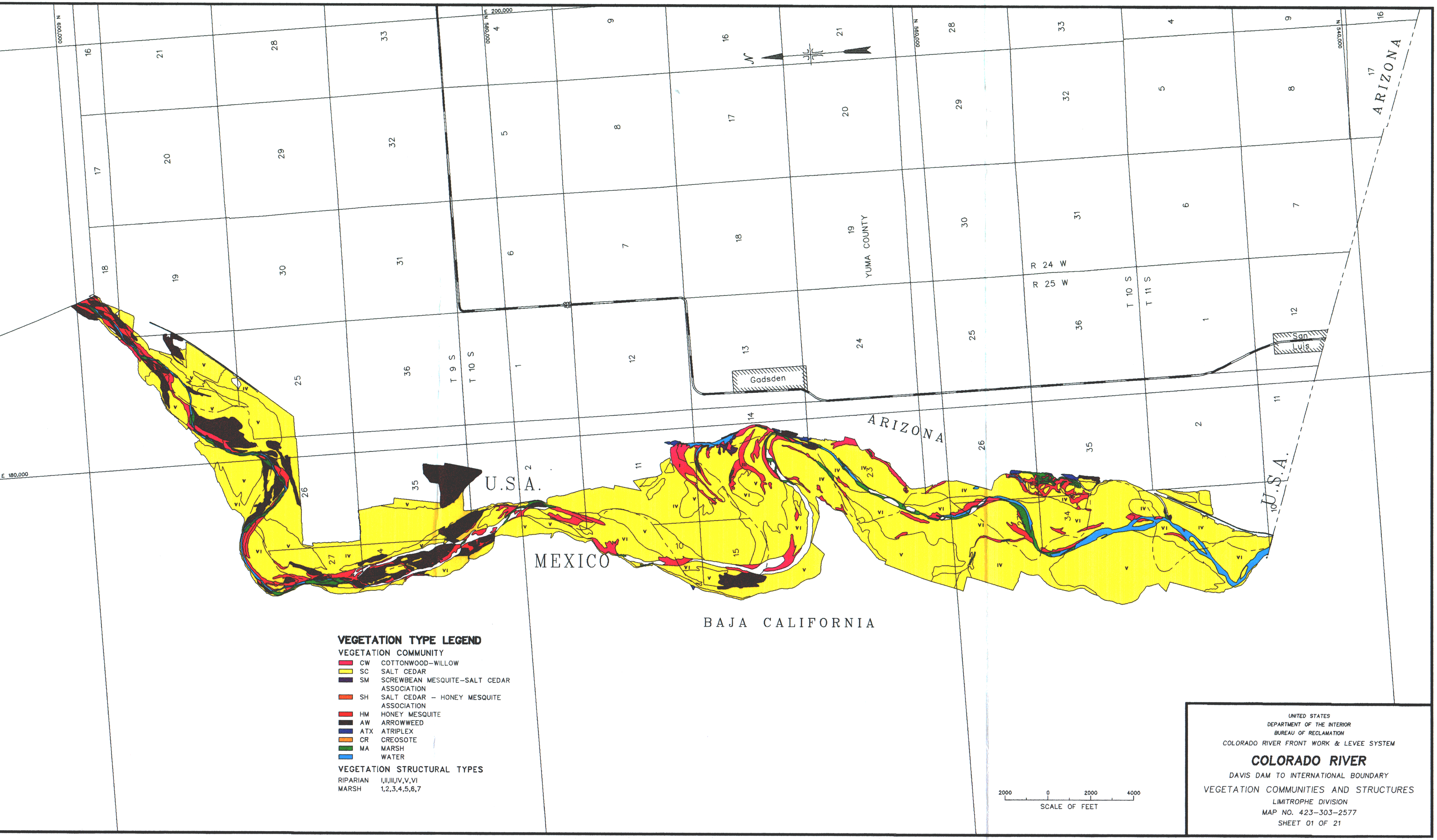
Younker, G.L. and C.W. Anderson. 1986. Mapping Methods and Vegetation Changes Along the Lower Colorado River Between Davis Dam and the Border with Mexico. Contract No. 6-CS-30-03800. 21 pages, appendices, and maps.

Appendix A

Data Disk

Appendix B

Vegetation Type Maps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San Luis
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R 25 W
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T 11 S
N 540,000
N 560,000
N 580,000
N 600,000
E 180,000
E 200,000
VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD-WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE-SALT CEDAR ASSOCIATION
SH SALT CEDAR - HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
2000 0 2000 4000
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
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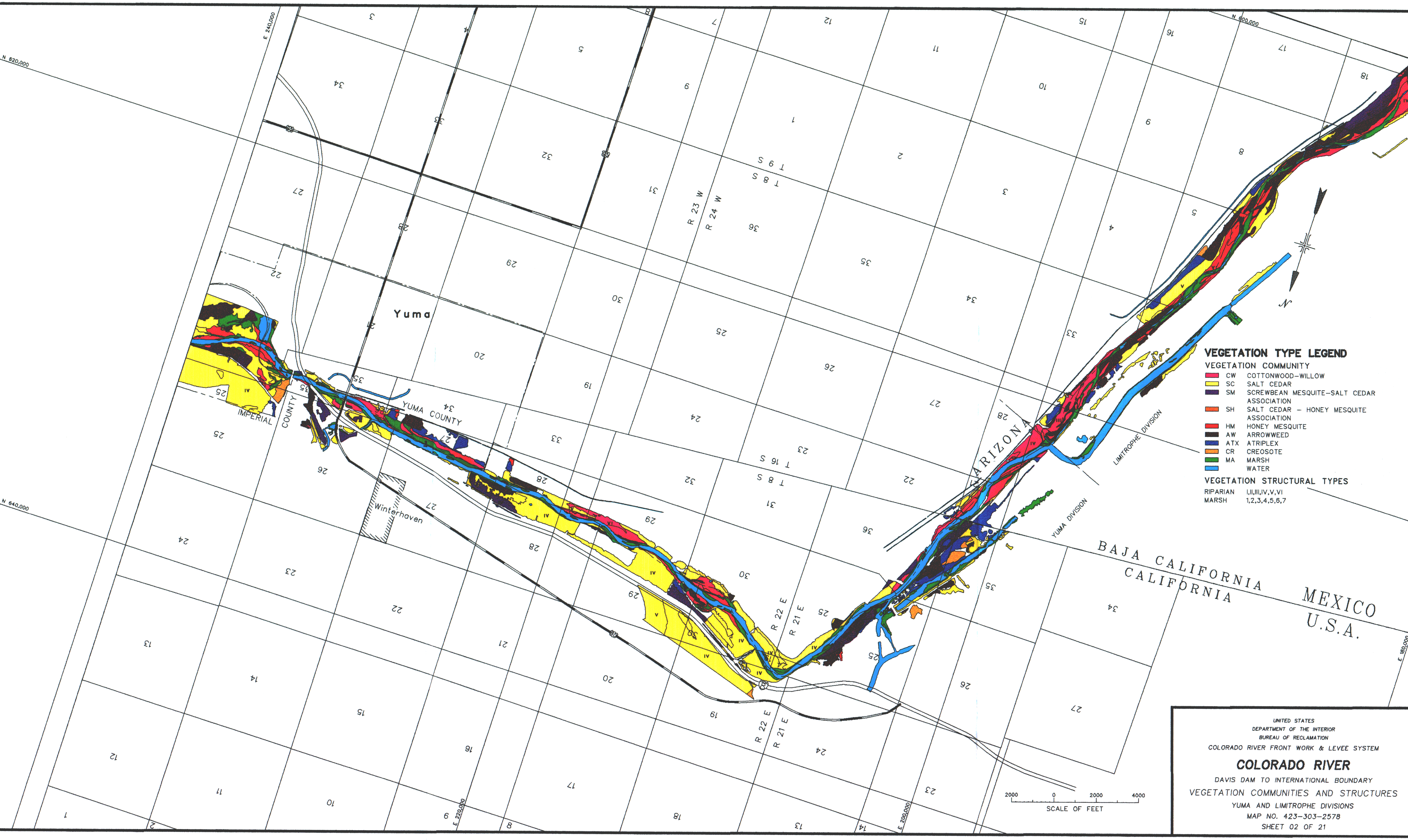
SHEET 01 OF 21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SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
ARIZONA
BAJA CALIFORNIA
CALIFORNIA
MEXICO
U.S.A.
LIMITROPHE DIVISION
YUMA DIVISION
Yuma
Winterhaven
YUMA COUNTY
IMPERIAL COUNTY
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T 9 S
T 16 S
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R 24 W
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E 200,000
E 220,000
E 240,000
SCALE OF FEET
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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
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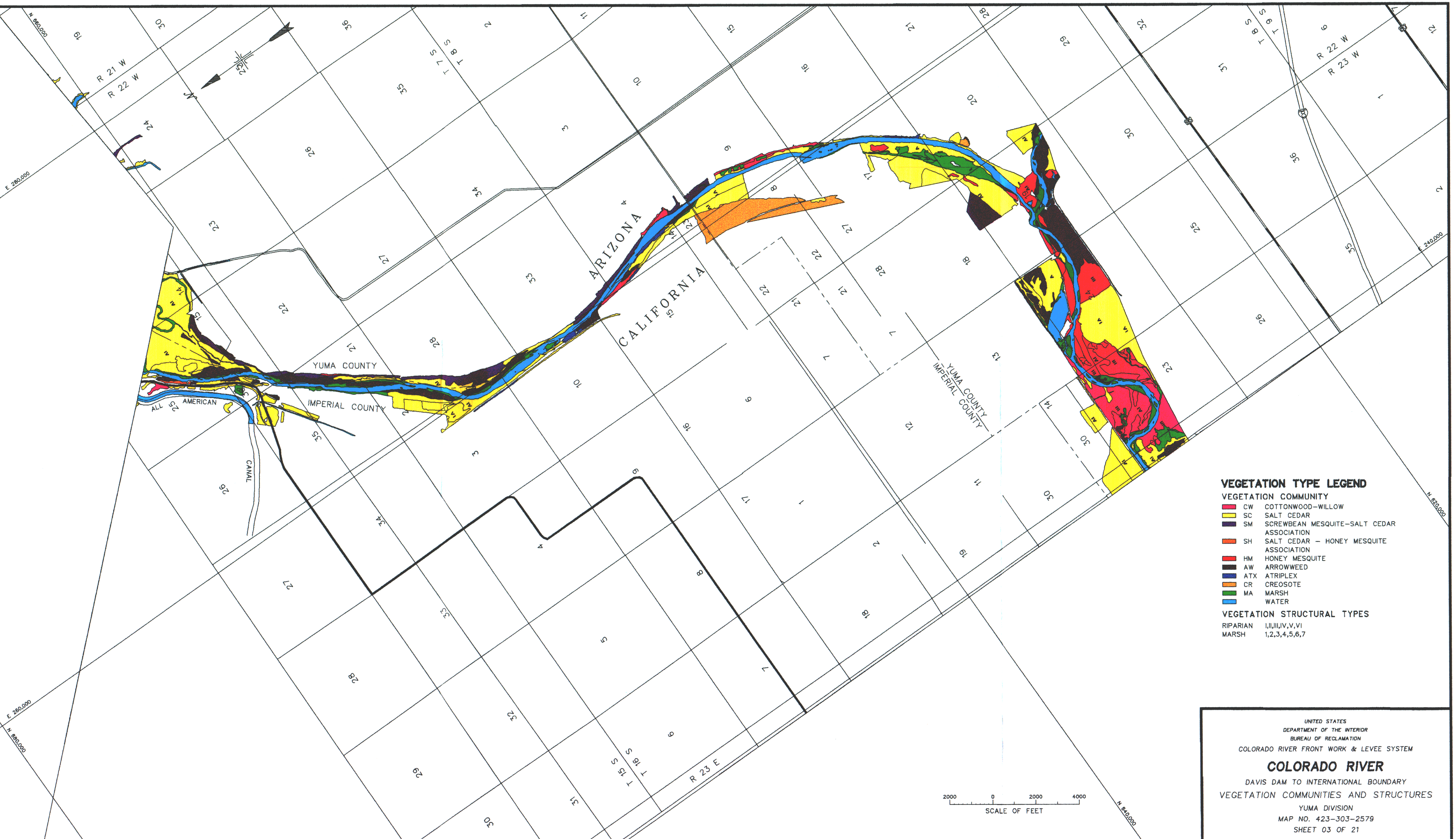
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T 15 S
T 16 S
E 280,000
E 260,000
E 240,000
N 660,000
N 640,000
N 620,000
N 680,000
VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD–WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
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SCALE OF FEET
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DEPARTMENT OF THE INTERIOR
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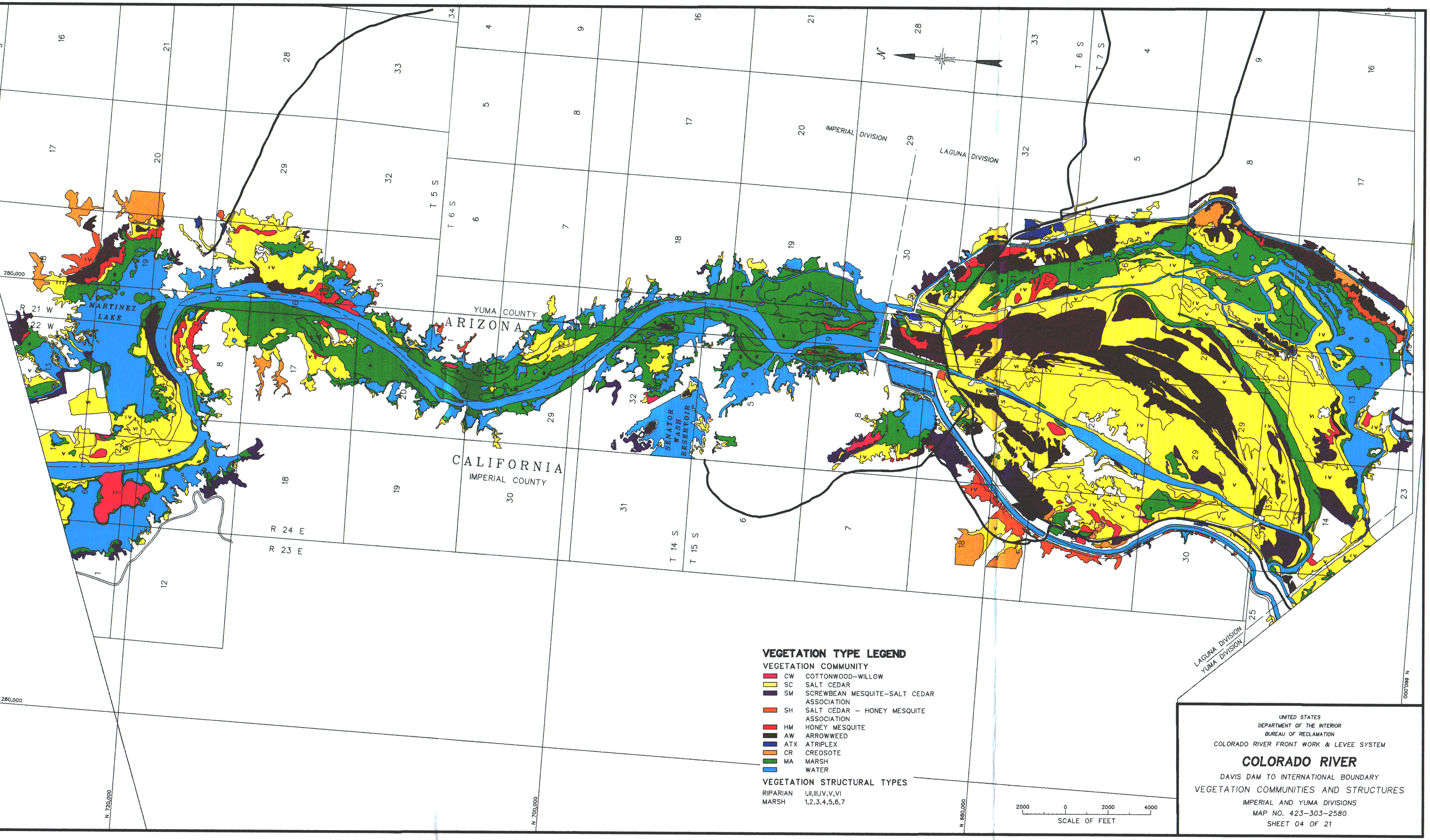

VEGETATION TYPE LEGEND

VEGETATION COMMUNITY

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SM	SCREWBEAN MESQUITE-SALT CEDAR ASSOCIATION
SH	SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM	HONEY MESQUITE
AW	ARROWWEED
ATX	ATRIPLEX
CR	CREOSOTE
MA	MARSH
	WATER

VEGETATION STRUCTURAL TYPES

RIPARIAN	I,II,III,IV,V,VI
MARSH	1,2,3,4,5,6,7

UNITED STATES
DEPARTMENT OF THE INTERIOR
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COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

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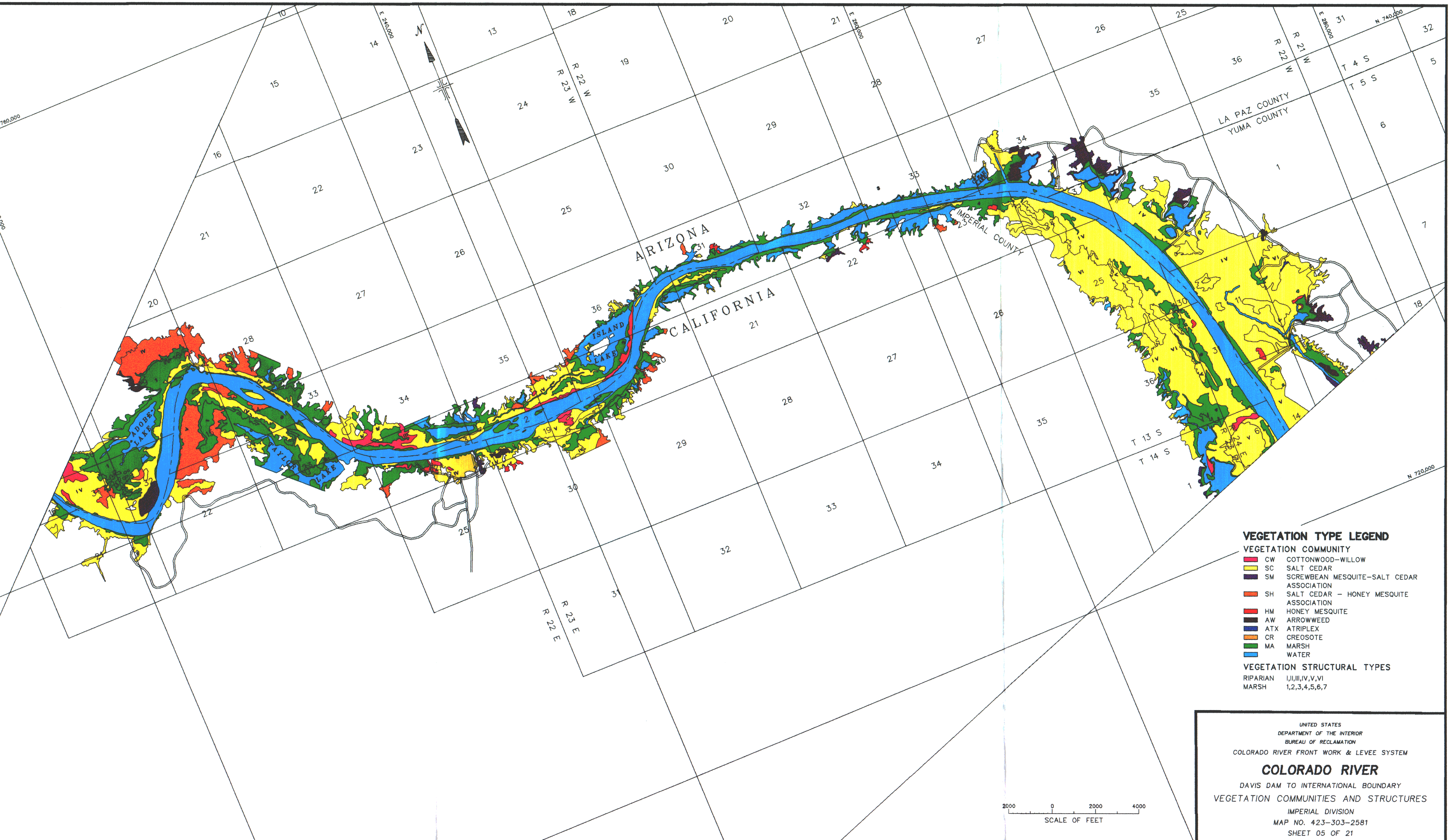
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CR CREOSOTE
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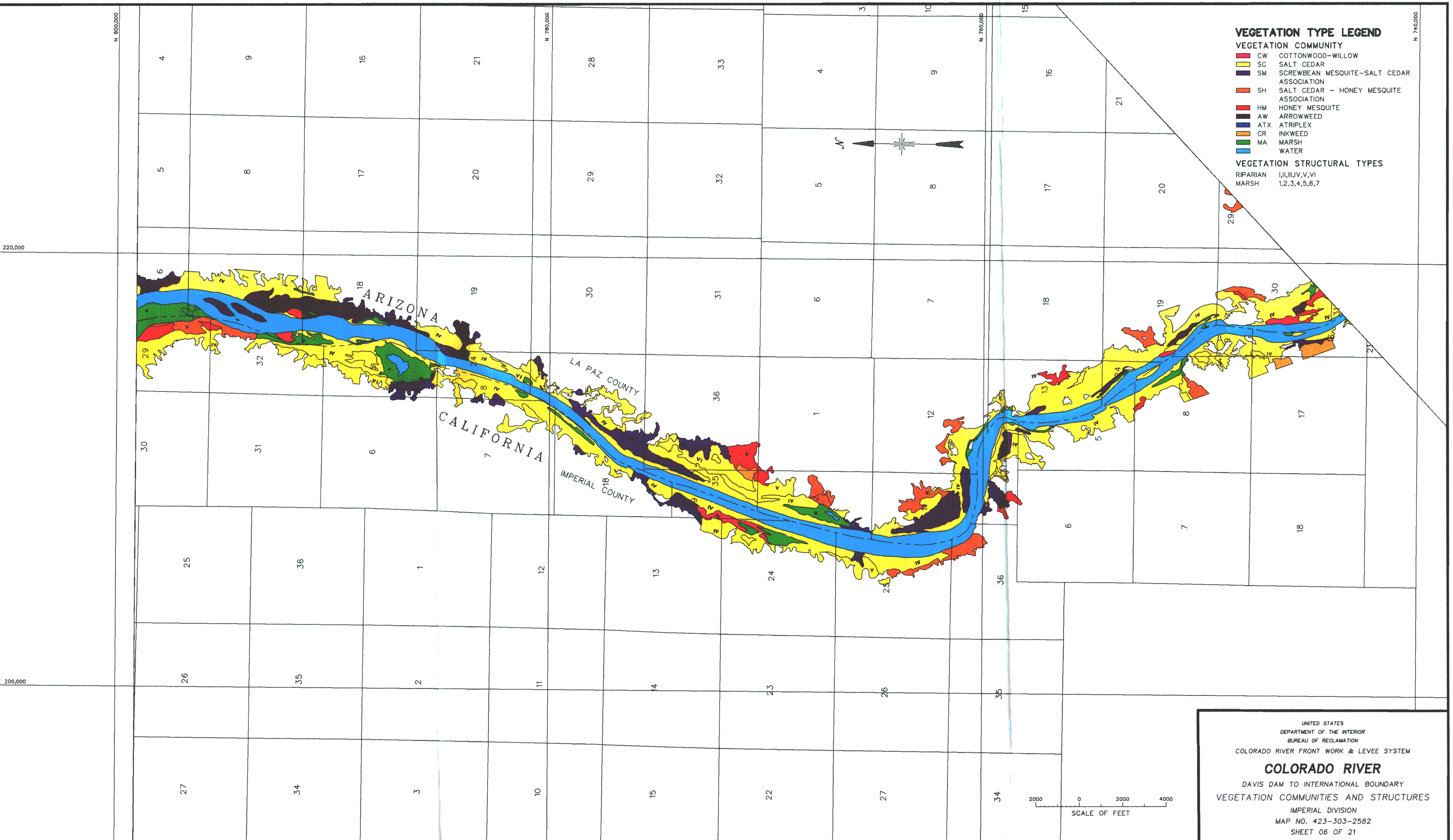
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ATX ATRIPLEX
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WATER
VEGETATION STRUCTURAL TYPES
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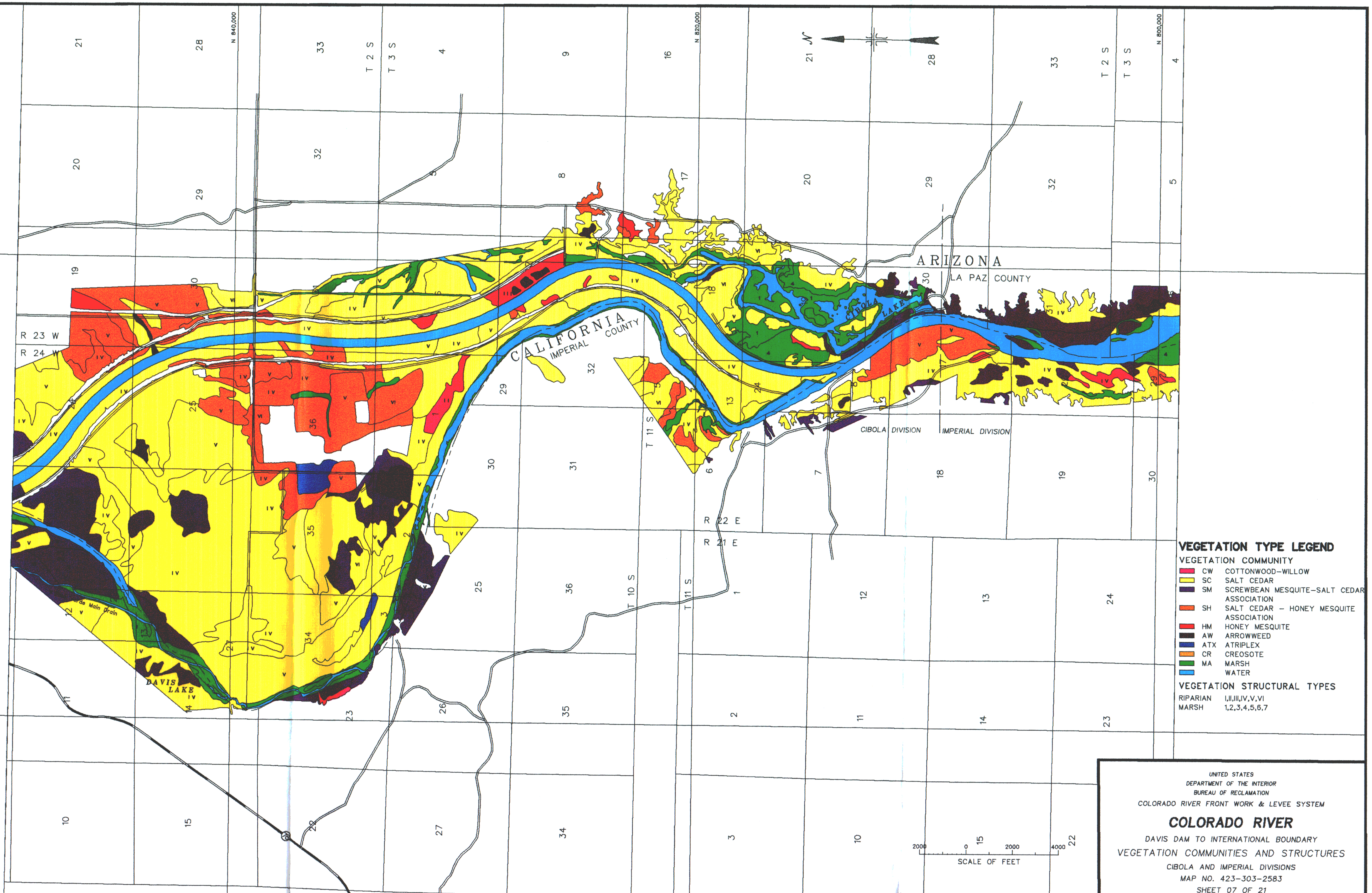

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COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

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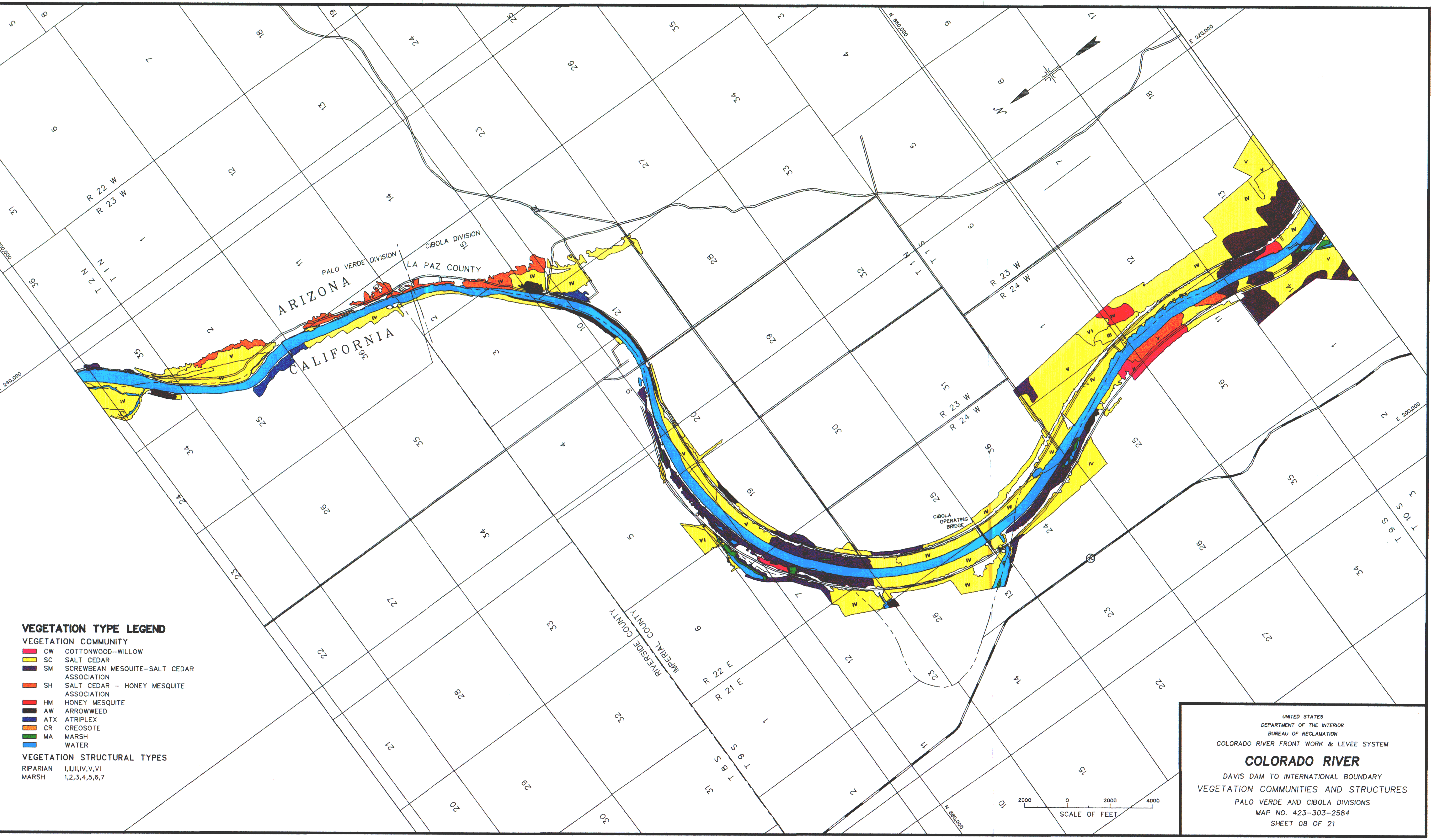

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AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
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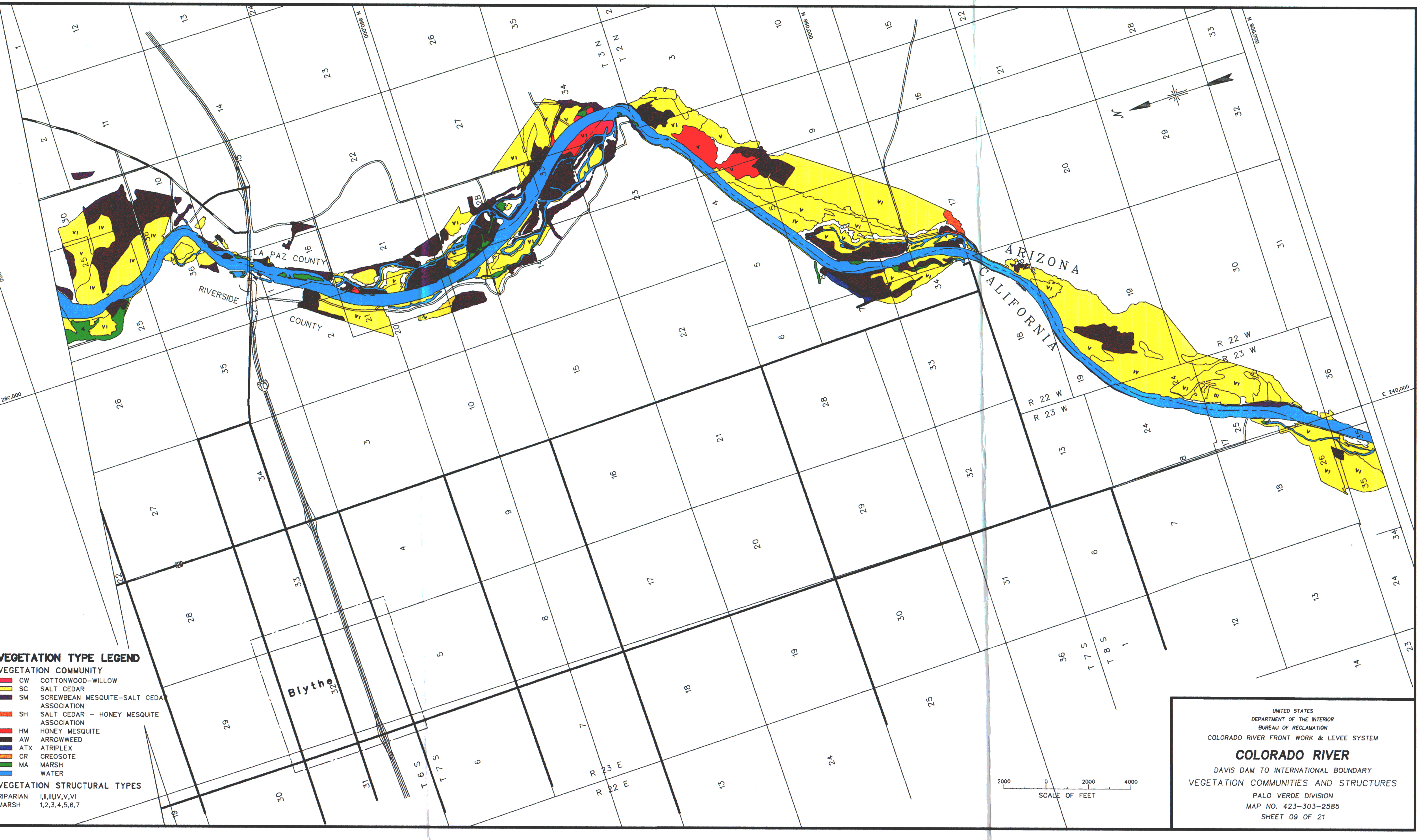
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ATX ATRIPLEX
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MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
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VEGETATION COMMUNITIES AND STRUCTURES
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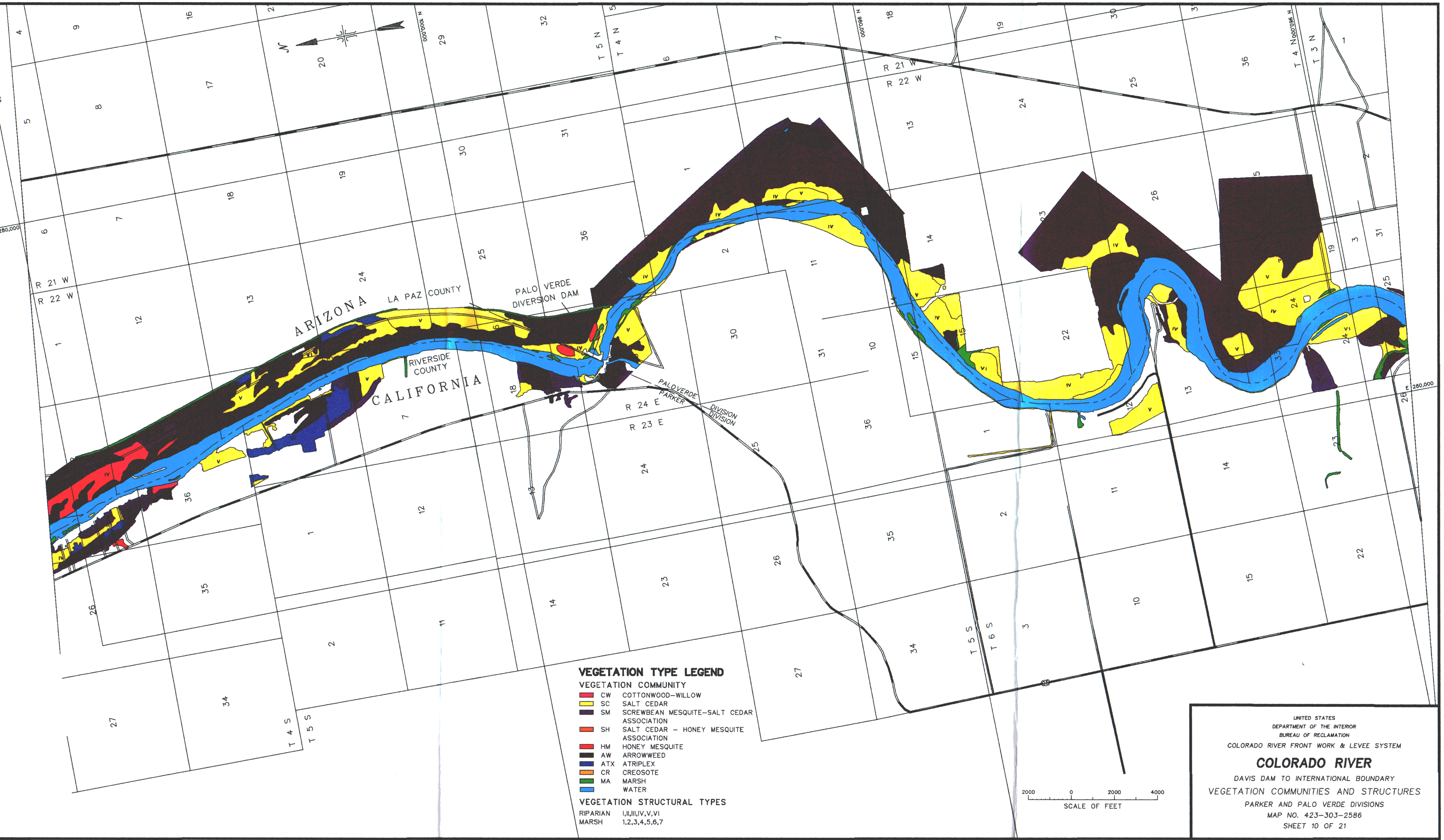
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SH SALT CEDAR - HONEY MESQUITE ASSOCIATION
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AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
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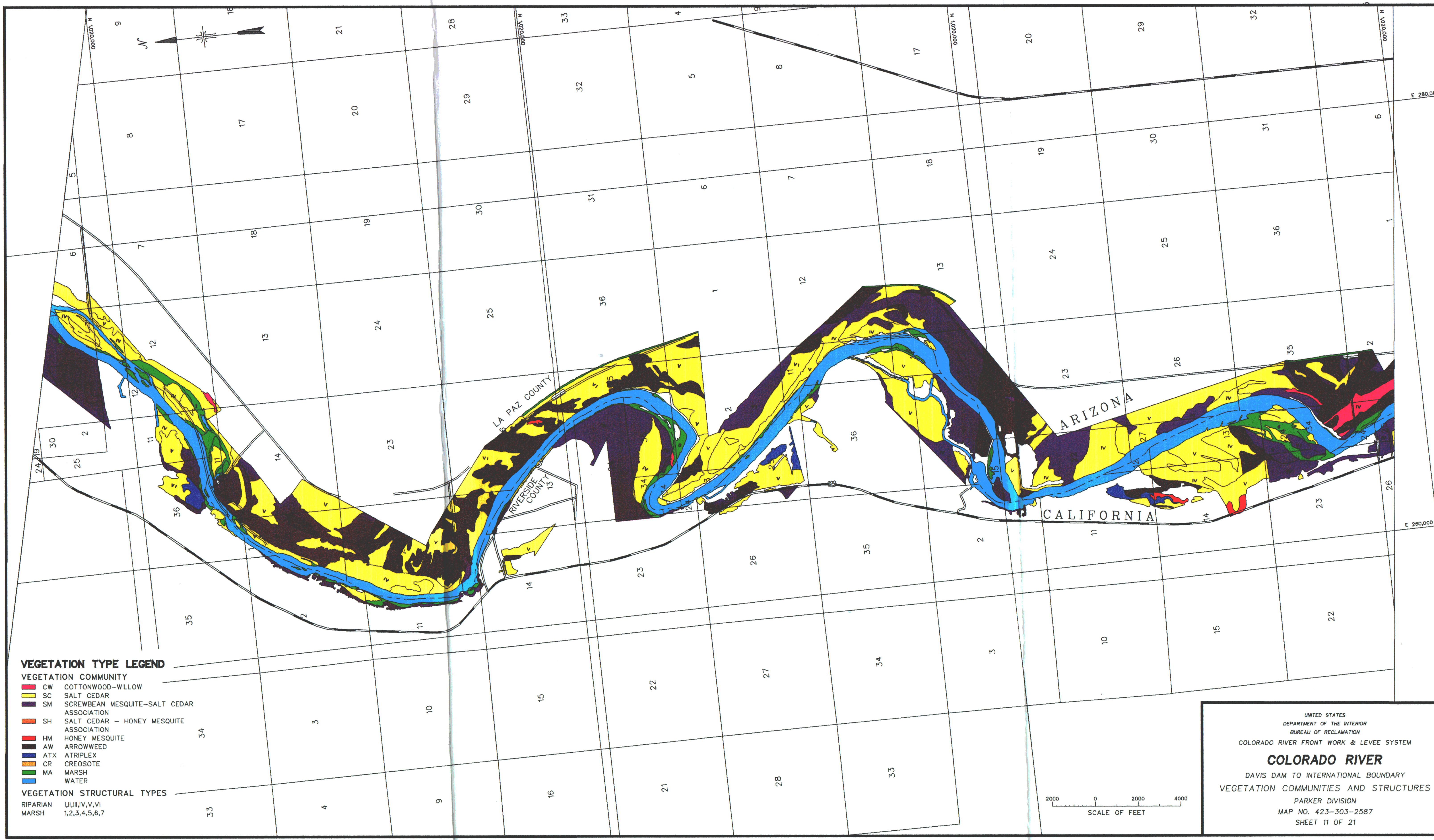

VEGETATION TYPE LEGEND
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SH SALT CEDAR - HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
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RIVERSIDE COUNTY
ARIZONA
CALIFORNIA
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E 260,000
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SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
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VEGETATION COMMUNITIES AND STRUCTURES
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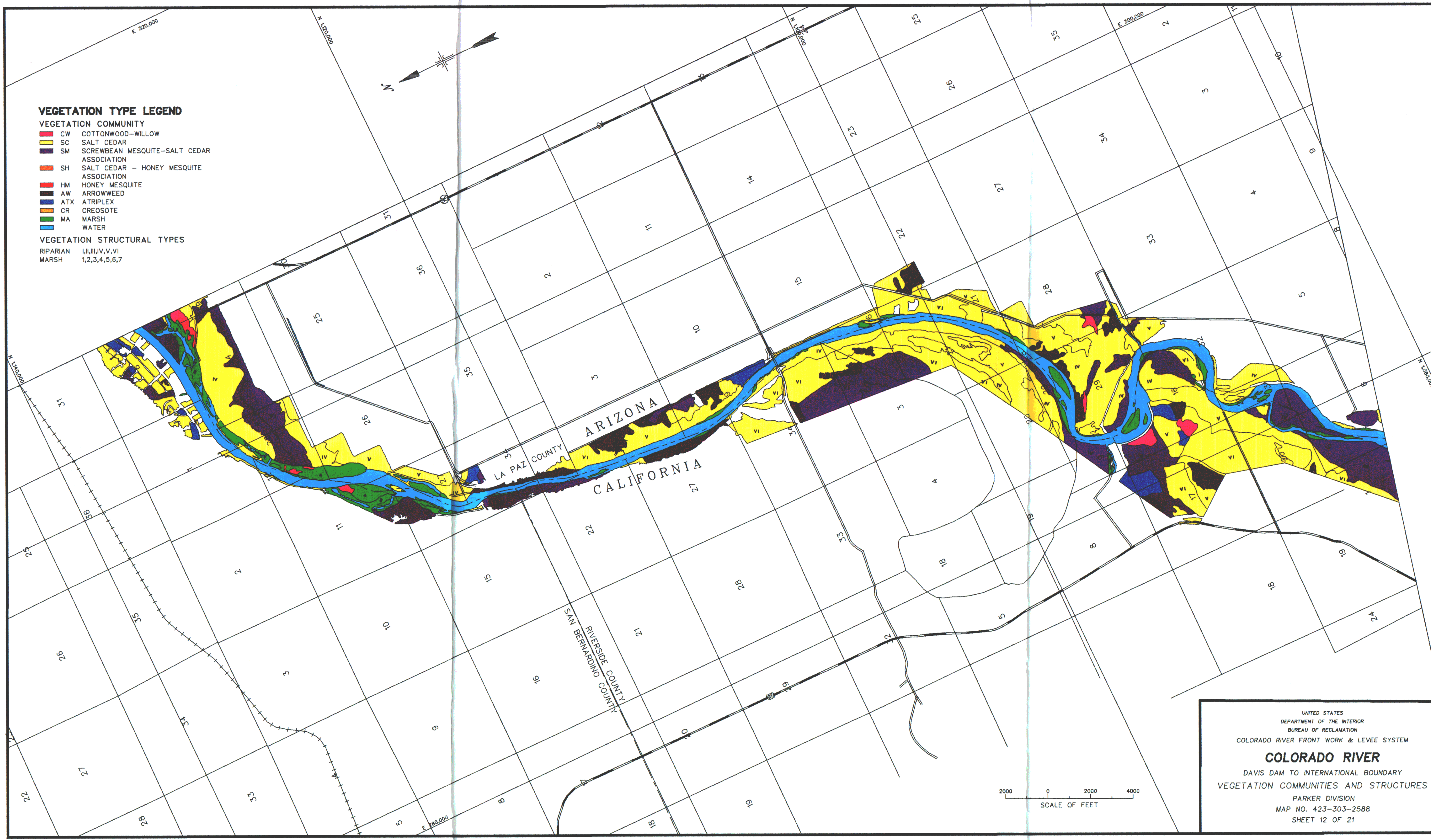
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HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
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CALIFORNIA
LA PAZ COUNTY
RIVERSIDE COUNTY
SAN BERNARDINO COUNTY
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SCALE OF FEET
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BUREAU OF RECLAMATION
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PARKER DIVISION
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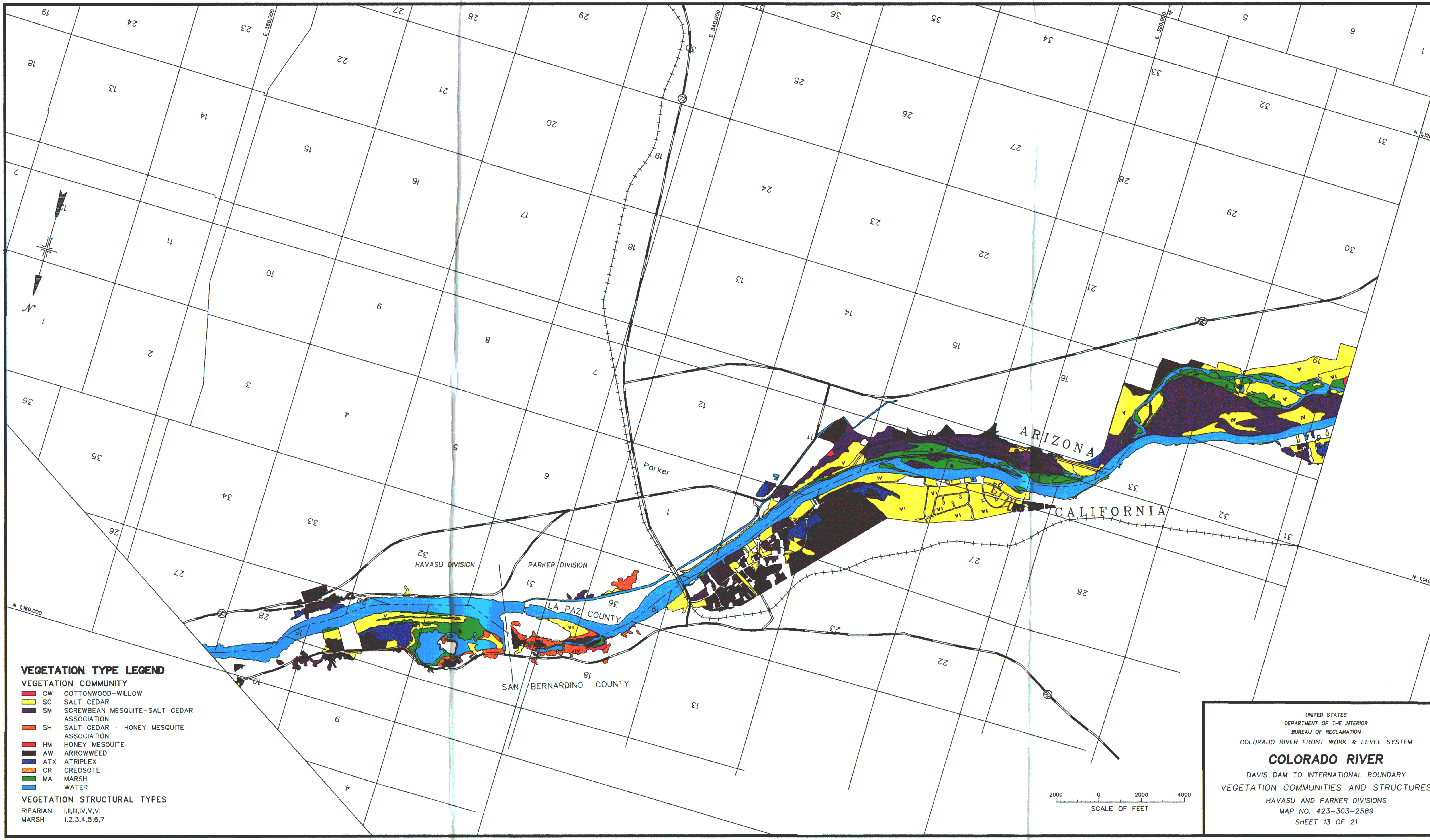

VEGETATION TYPE LEGEND

VEGETATION COMMUNITY

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SH	SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM	HONEY MESQUITE
AW	ARROWWEED
ATX	ATRIPLEX
CR	CREOSOTE
MA	MARSH
	WATER

VEGETATION STRUCTURAL TYPES

RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
HAVASU AND PARKER DIVISIONS
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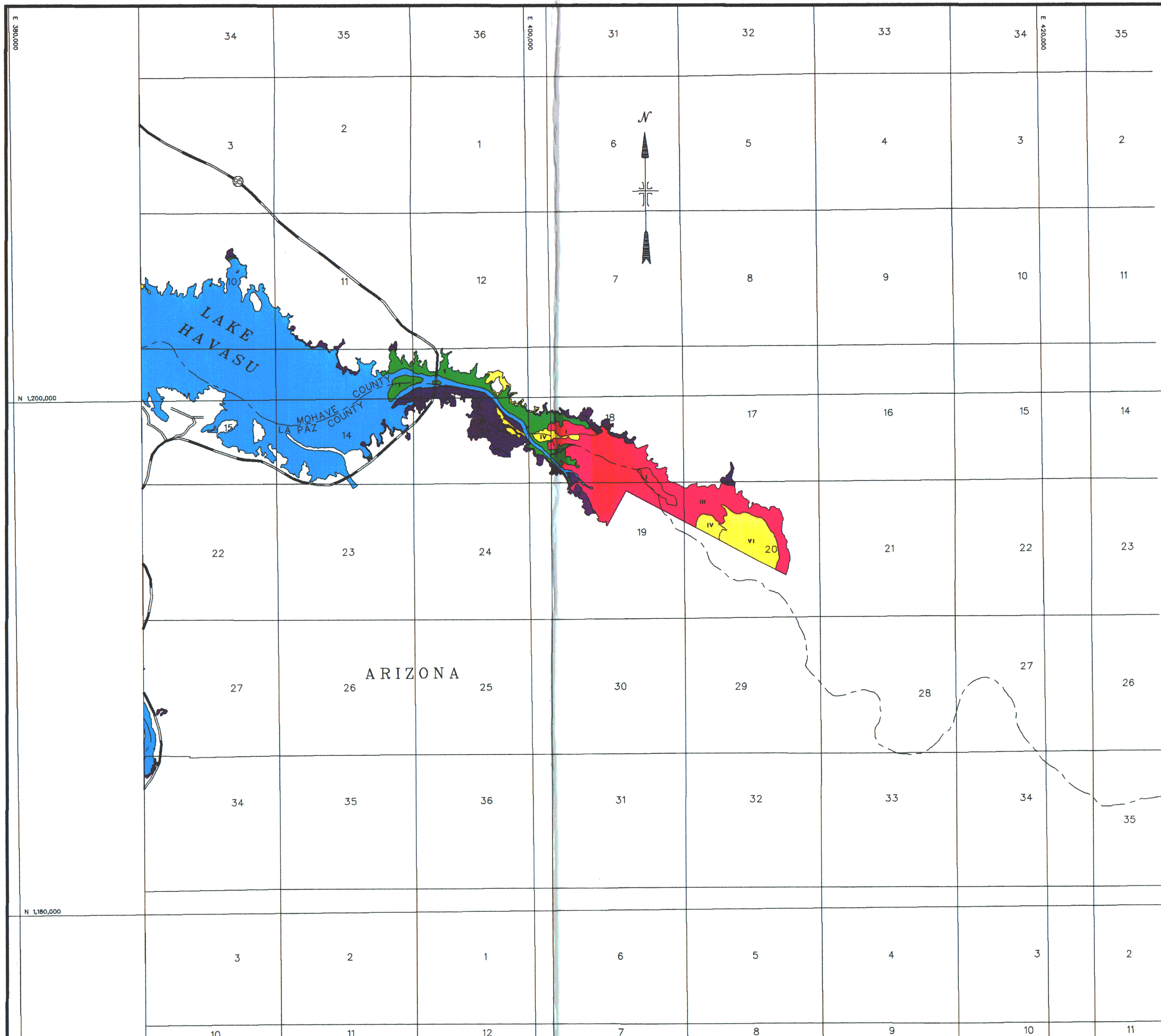
SHEET 13 OF 21



VEGETATION TYPE LEGEND

VEGETATION COMMUNITY

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- SM SCREWBEAN MESQUITE–SALT CEDA[R] ASSOCIATION
- SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
- HM HONEY MESQUITE
- AW ARROWWEED
- ATX ATRIPLEX
- CR CREOSOTE
- MA MARSH
- WATER

VEGETATION STRUCTURAL TYPES

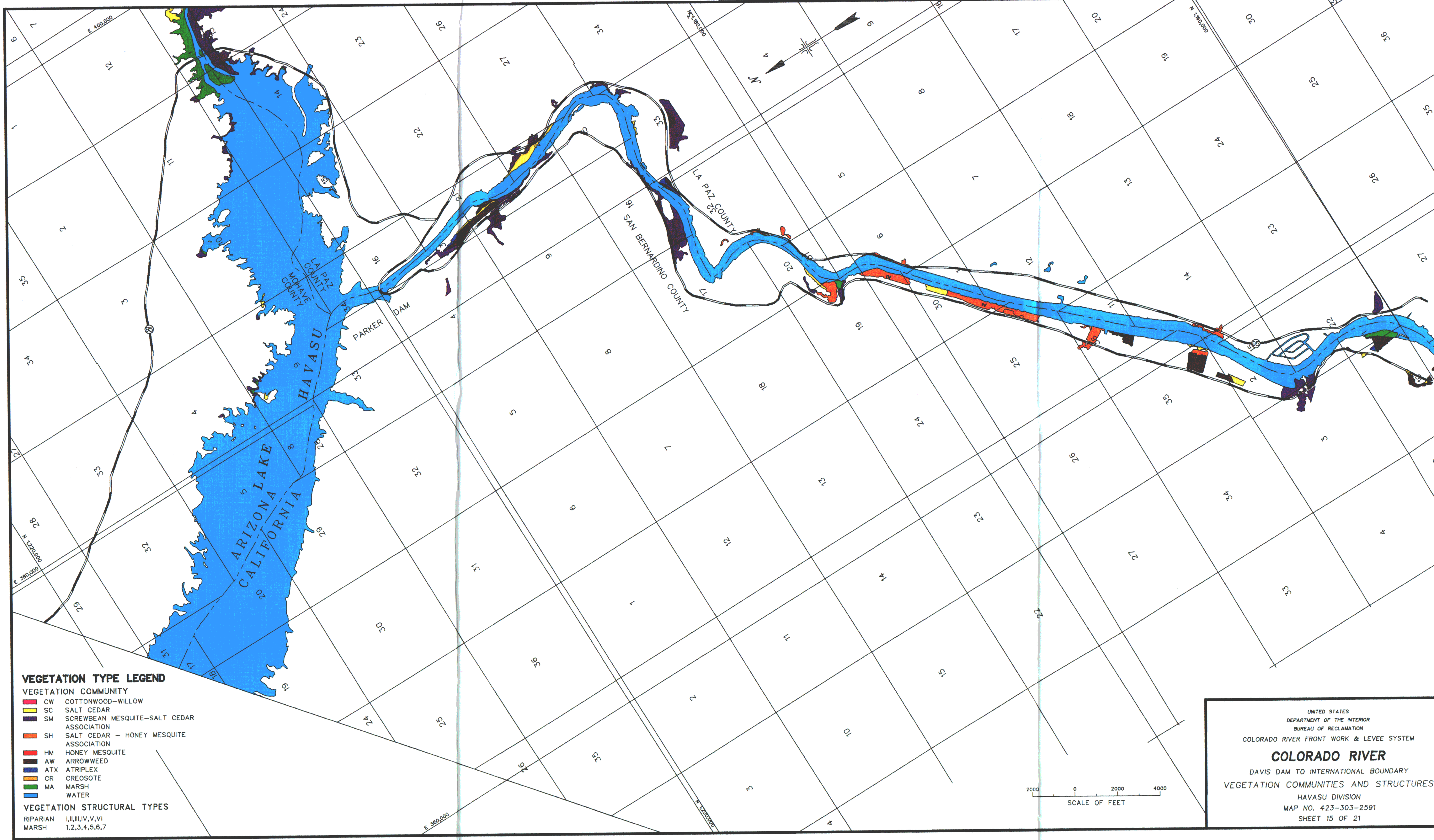
RIPARIAN	I,II,III,IV,V,VI
MARSH	1,2,3,4,5,6,7
WATER	1,2,3,4,5,6,7

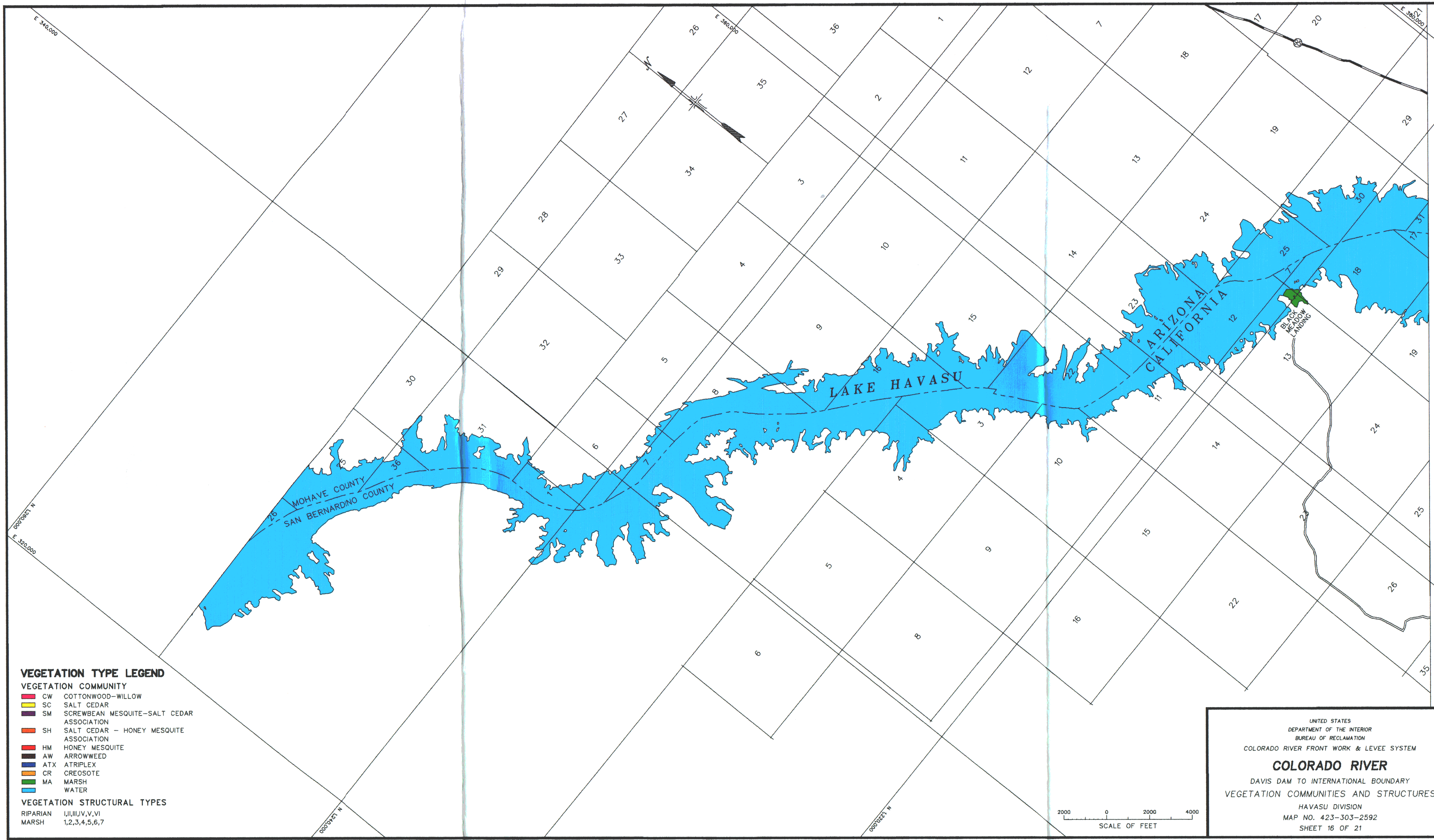
2000 0 2000 4000
SCALE OF FEET

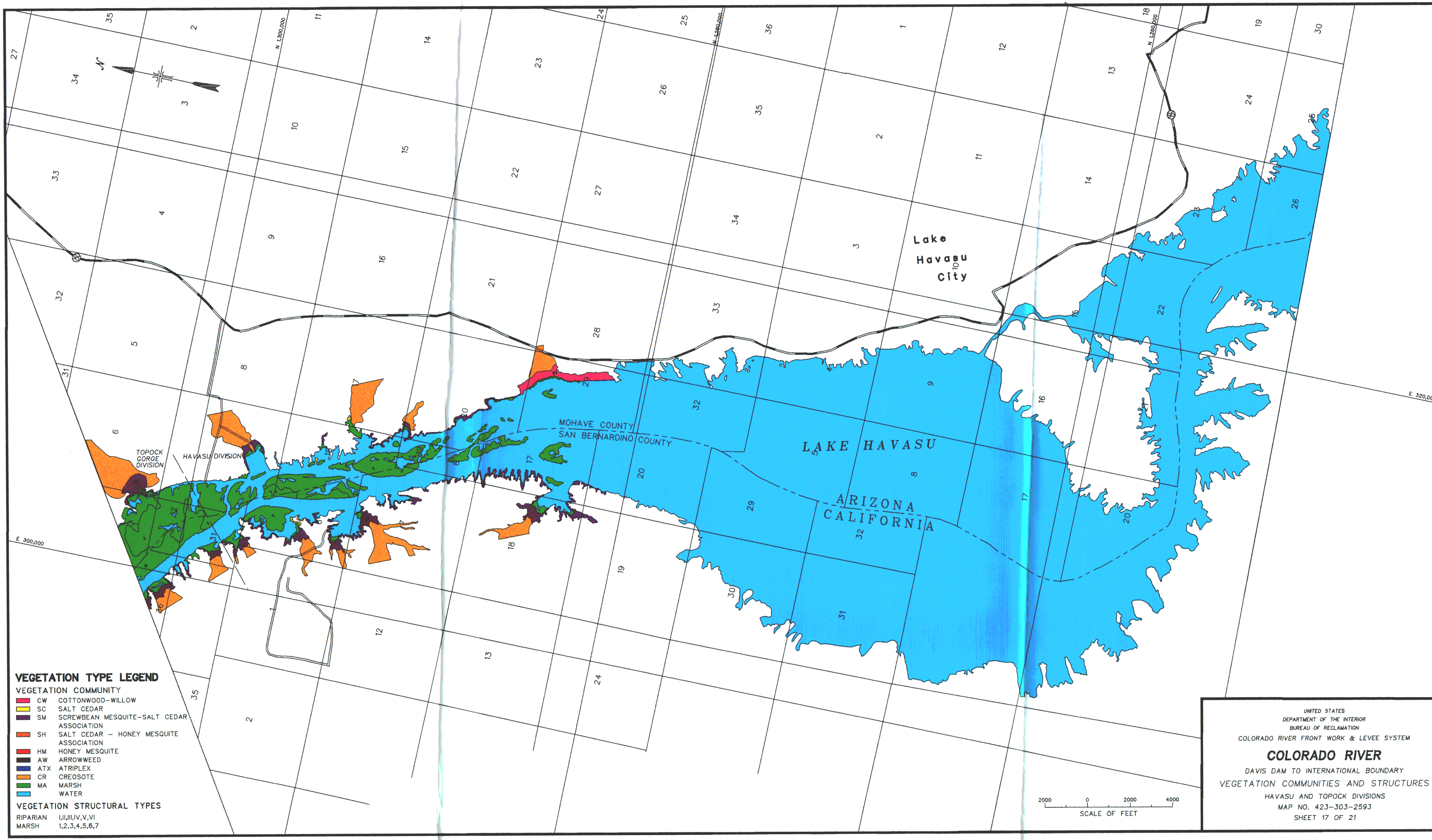
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

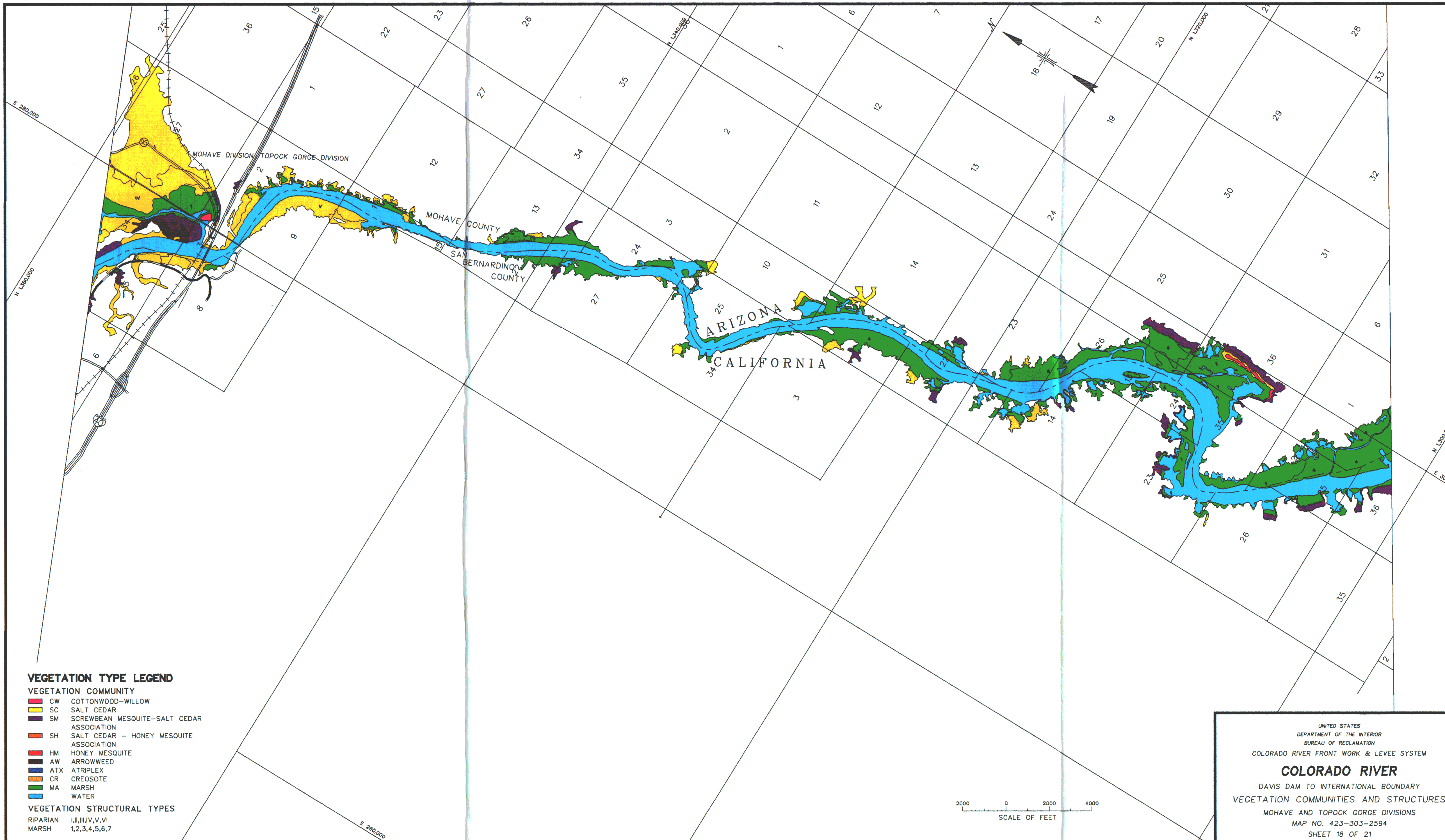
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTUR[AL TYPES]
HAVASU DIVISION
MAP NO. 423-303-2590
SHEET 14 OF 21


LAKE HAVASU
ARIZONA
CALIFORNIA
LA PAZ COUNTY
MOHAVE COUNTY
PARKER DAM
SAN BERNARDINO COUNTY
LA PAZ COUNTY
N
SCALE OF FEET
2000 0 2000 4000
VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD–WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
COLORADO RIVER
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
HAVASU DIVISION
MAP NO. 423-303-2591
SHEET 15 OF 21


VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD-WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE-SALT CEDAR ASSOCIATION
SH SALT CEDAR - HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
MOHAVE COUNTY
SAN BERNARDINO COUNTY
LAKE HAVASU
ARIZONA
CALIFORNIA
BLACK MEADOW LANDING
2000 0 2000 4000
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
COLORADO RIVER
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
HAVASU DIVISION
MAP NO. 423-303-2592
SHEET 16 OF 21



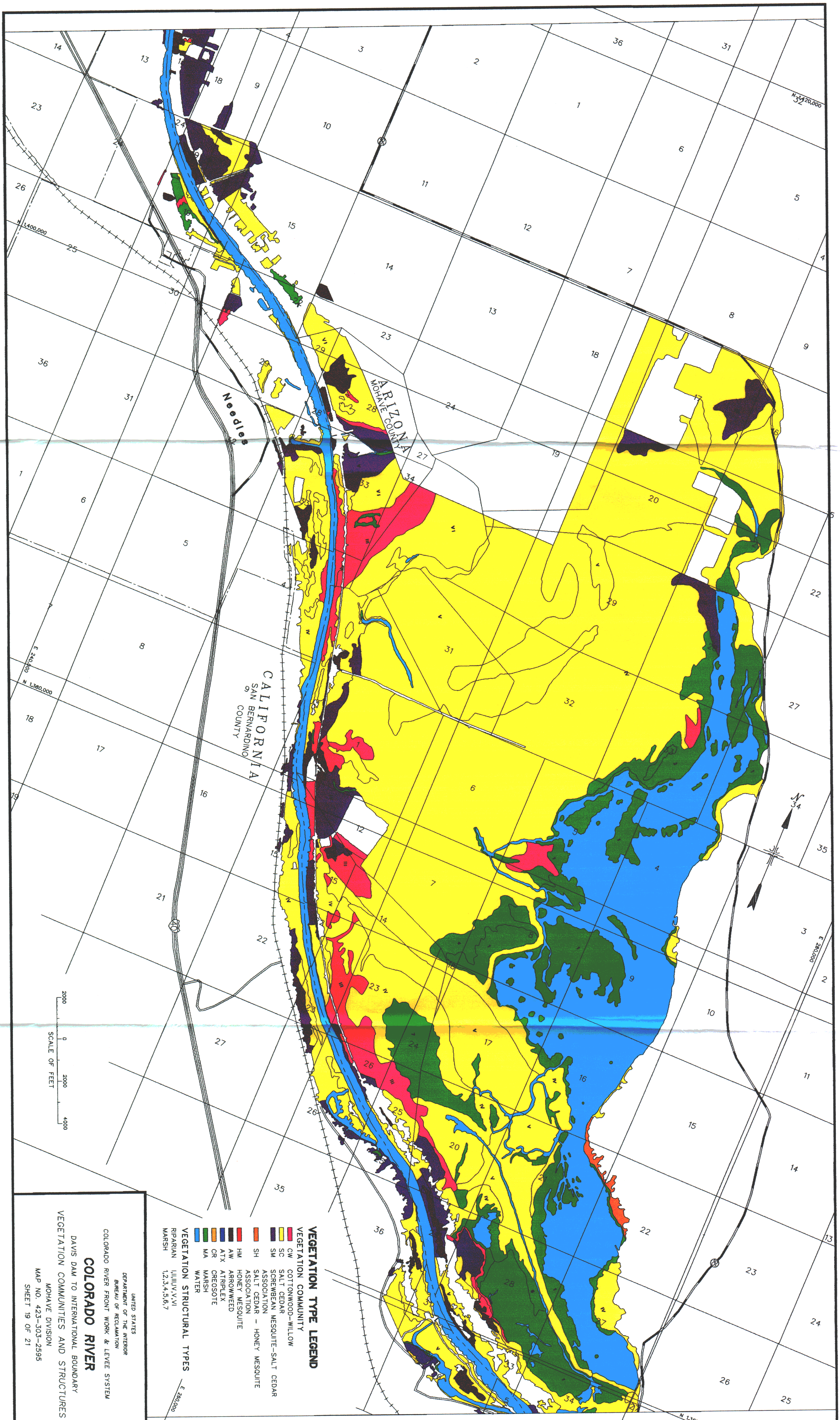
TOPOCK GORGE DIVISION
HAVASU DIVISION
MOHAVE COUNTY
SAN BERNARDINO COUNTY
LAKE HAVASU
ARIZONA
CALIFORNIA
Lake Havasu City
E 300,000
E 320,000
N 1,300,000
N 1,280,000
N 1,260,000
VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD–WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
2000 0 2000 4000
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
COLORADO RIVER
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
HAVASU AND TOPOCK DIVISIONS
MAP NO. 423-303-2593
SHEET 17 OF 21

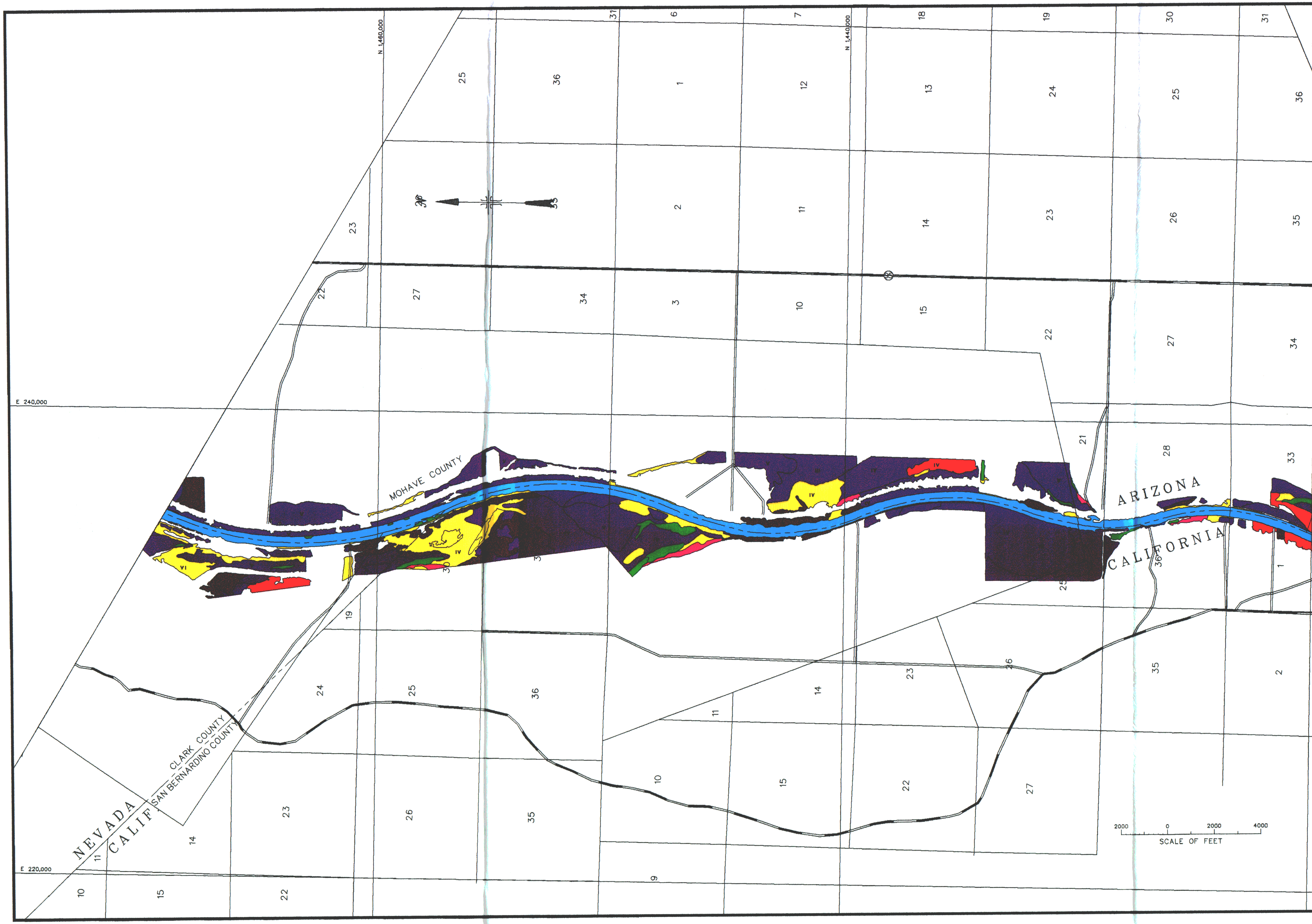


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
MOHAVE AND TOPOCK GORGE DIVISIONS
MAP NO. 423-303-2594
SHEET 18 OF 21


VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD–WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
COLORADO RIVER
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
MOHAVE DIVISION
MAP NO. 423–303–2595
SHEET 19 OF 21
ARIZONA
MOHAVE COUNTY
CALIFORNIA
SAN BERNARDINO COUNTY
Needles
SCALE OF FEET
2000 0 2000 4000
N
N 1,400,000
N 1,380,000
N 1,420,000
E 240,000
E 260,000
E 280,000



VEGETATION TYPE LEGEND

VEGETATION COMMUNITY

CW	COTTONWOOD–WILLOW
SC	SALT CEDAR
SM	SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH	SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM	HONEY MESQUITE
AW	ARROWWEED
ATX	ATRIPLEX
CR	CREOSOTE
MA	MARSH
	WATER

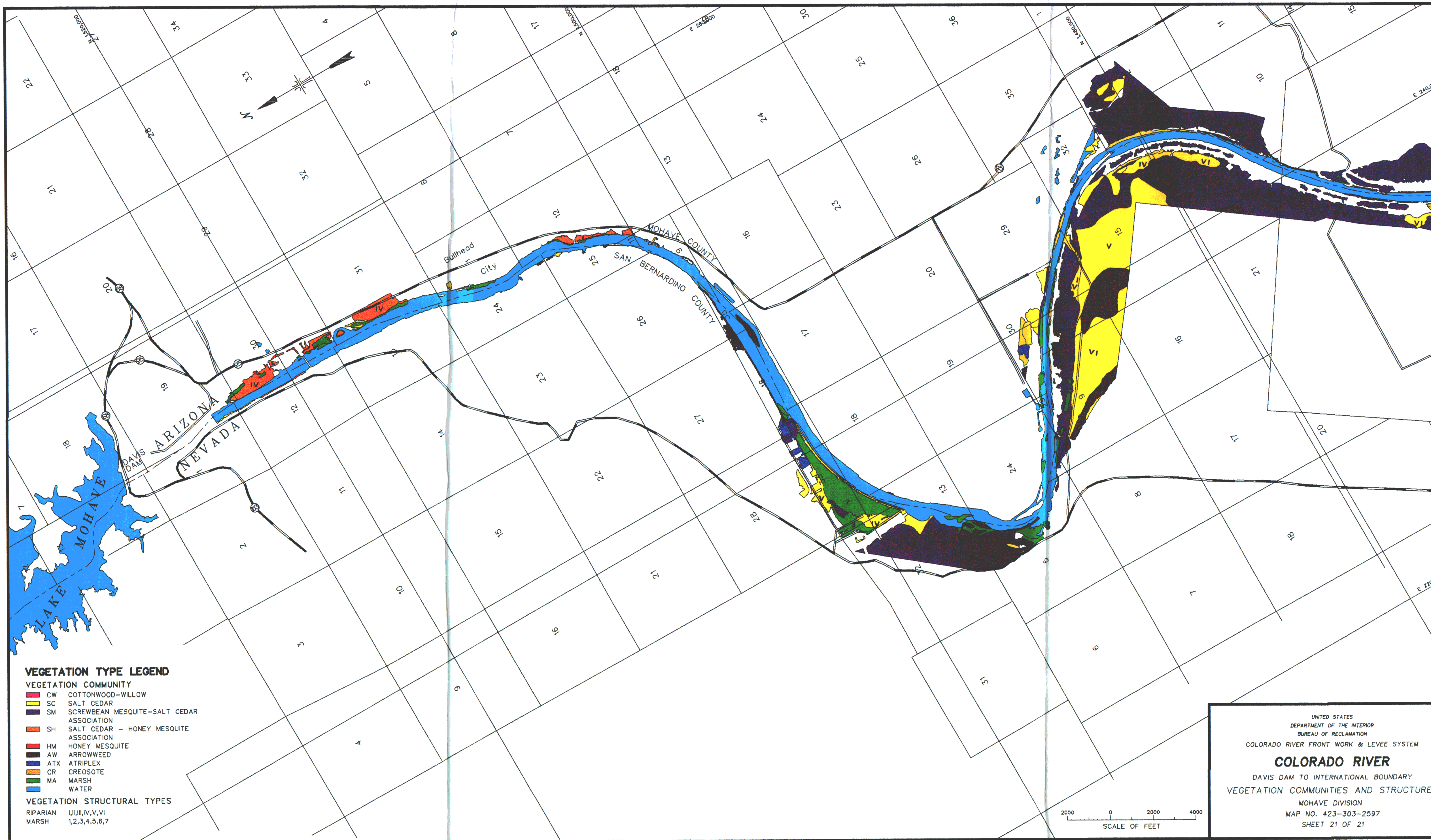
VEGETATION STRUCTURAL TYPES

RIPARIAN	I,II,III,IV,V,VI
MARSH	1,2,3,4,5,6,7

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM

COLORADO RIVER

DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
MOHAVE DIVISION
MAP NO. 423-303-2596
SHEET 20 OF 21


VEGETATION TYPE LEGEND
VEGETATION COMMUNITY
CW COTTONWOOD–WILLOW
SC SALT CEDAR
SM SCREWBEAN MESQUITE–SALT CEDAR ASSOCIATION
SH SALT CEDAR – HONEY MESQUITE ASSOCIATION
HM HONEY MESQUITE
AW ARROWWEED
ATX ATRIPLEX
CR CREOSOTE
MA MARSH
WATER
VEGETATION STRUCTURAL TYPES
RIPARIAN I,II,III,IV,V,VI
MARSH 1,2,3,4,5,6,7
LAKE MOHAVE
DAVIS DAM
ARIZONA
NEVADA
Bullhead City
MOHAVE COUNTY
SAN BERNARDINO COUNTY
2000 0 2000 4000
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK & LEVEE SYSTEM
COLORADO RIVER
DAVIS DAM TO INTERNATIONAL BOUNDARY
VEGETATION COMMUNITIES AND STRUCTURES
MOHAVE DIVISION
MAP NO. 423-303-2597
SHEET 21 OF 21