NOAA Technical Memorandum NMFS

MAY 2005

CREATING A COMPREHENSIVE DAM DATASET FOR ASSESSING ANADROMOUS FISH PASSAGE IN CALIFORNIA

M. Goslin

NOAA-TM-NMFS-SWFSC-376

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

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CREATING A COMPREHENSIVE DAM DATASET FOR ASSESSING ANADROMOUS FISH PASSAGE IN CALIFORNIA

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Introduction

The listing of many West Coast salmon and steelhead runs as threatened or endangered species under the U.S. Endangered Species Act has focused attention on barriers to anadromous fish migration between stream and ocean habitats. Dams are one of the most significant and widespread barriers to fish passage. Having accurate information on dam locations and characteristics is critical to determining what areas of potential salmon or steelhead habitat have been blocked or restricted.

There are several existing dam datasets available for use in Geographic Information Systems (GIS), but initial use of these datasets revealed discrepancies in dam locations between the different datasets, suggesting inaccuracies in the data. Existing digital geographic dam data sources include the Army Corps of Engineers (ACOE) dataset (1508 dams in California), the California Department of Water Resources (CDWR) dataset (1427 dams in CA), the Federal Energy Regulatory Commission (FERC) dataset (518 dams in CA) and the U. S. Geological Survey's (USGS) geographic names information system list of dam locations (1466 dams in CA). While there is a great deal of overlap between these datasets, each includes dams that are unique to that dataset. The datasets also differ in the types of attribute information provided. The ACOE and CDWR data offer the most extensive list of dam attributes and are cross-referenced with dam national identification numbers. The FERC dataset focuses on license information rather than dam characteristics, and the USGS dataset offers locations only (Appendix A).

In order to assess which streams are reachable as fish habitat, we needed a dataset that synthesized the various dam datasets and located dams accurately relative to the 1:100K geographic coverage[1] of streams and rivers derived from the National Hydrographic Dataset (NHD) (USGS 2003) and edited by the California Department of Fish and Game and the Pacific States Marine Fisheries Commission (CDFG/PSMFC) (Christy and Haney 2003). Since the existing dam datasets had not been systematically referenced to the 1:100K stream coverage, we intended to adjust dam locations such that dams would sit precisely (“snap”) on the 1:100K stream coverage. Where possible, we intended to automate this process by using GIS commands that would adjust dam locations by finding the nearest location on the nearest stream in the hydrology.

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[1] A digital map that is the basic unit of vector data storage in ArcInfo GIS (ESRI 2002). Attributes associated with the geographic features (vector data) are stored in associated tables within the coverage.

Initial perusal of ACOE and CDWR dam data revealed several types of errors and potential problems that called for a systematic accuracy assessment before automatically adjusting dam locations. Most egregious, but least common, among errors were dams located in an entirely different river drainage than their true location. More common were dams located in the correct general area, but closest to a river in the hydrology different than the actual river on which the dam should be located. Given our intent to automate relocation of dams to the nearest point on the nearest river, this type of error would lead to placement on the incorrect river and inaccurate assessments of accessible salmon habitat. Dams that should be located on a large main-stem river might be relocated onto a smaller tributary, leading to overestimates of available habitat, or dams on small tributaries might be incorrectly relocated onto the larger main-stem river, leading to underestimates of available habitat. Also problematic: the datasets included dams that were offstream (storage basins, dams on canals) as well as dams that were located on streams too small to be represented in the 1:100K hydrography. Therefore, it was necessary to distinguish between dams that should indeed be relocated onto instream locations on the 1:100K hydrography and those that should not be snapped to the hydrography.

The goal of this project was to produce a synthesized, useable geographic dam dataset in a timely manner, balancing automated processes with more time-intensive manual checks. As a final product, we aimed to produce a clean geographic coverage in which dam locations were aligned properly relative to the 1:100K hydrology, such that available and blocked anadromous fish habitat could then be accurately assessed.

Methods

The creation of a synthesized dam dataset consisted of two phases. The first phase focused on checking and synthesizing the two primary dam datasets, ACOE and CDWR. In the second phase, dams unique to the USGS and FERC dam lists were identified and error-checked. Dams unique to USGS were appended to the new, synthesized dataset. Dams unique to FERC were kept in an independent dataset due to current restrictions on public release of FERC data. Both phases followed a systematic sequence of verification steps.

Since the dam datasets had not been systematically referenced relative to the 1:100K CDFG/PSMFC hydrography, it was necessary to assess and edit dam locations relative to this layer. Fundamental to this assessment and editing was the use of the

NEAR command in ArcINFO GIS (ESRI 2002)[2]. For each dam, the NEAR command could be used to find the coordinates of the nearest point on the nearest stream as well as the distance to and identity of the nearest stream. The distance to and identity of the nearest stream was used in the verification process. After verification was complete, nearest point information could then be used to relocate instream dams such that they would sit precisely on their respective rivers (a process called snapping). Where possible, this process was automated. However, visual checks against topographic maps and manual digitization of new locations were often required.

There were several goals in the verification process:

1. Differentiate between dams which should be snapped to the 1:100K hydrography and those which should not (offstream dams, dams on non-1:100K streams).
2. Remove extraneous records: duplicate records, “secondary” offstream dams (such as dikes around a reservoir), and dams outside the anadromous fish passage study area (Fig. 1).
3. Assess the accuracy of dam locations and correct locations where necessary. A dam location was considered “correct” if its snapped position (the nearest point on the nearest stream in the hydrography) was located on the correct stream, positioned correctly relative to that stream's tributaries and situated < 500 m from it true location[3].

Initially, our primary method for visual verification was to overlay and compare dam locations with 1:24K USGS-derived TOPO! maps (TOPO 2001) loaded as images in ArcMap GIS (a “topo check”). While considered authoritative, loading TOPO! map images proved to be time-consuming. Therefore, we devised a strategy to topo-check only those dams deemed likely in error and/or significant. An alternative, faster check (a “hydro check”) could be made by overlaying dam locations on the 1:100K hydrography, and verifying locations by the reservoir outlines represented in the hydrography. Some

[2] Disclaimer of Endorsement: Reference to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed in this document do not necessarily state or reflect those of NOAA or of the United States Government, and shall not be used for advertising or product endorsement purposes.

[3] “True” locations were considered those published on USGS 1:24K topographic maps

verification and classification of dams could also be completed on the basis of dam attributes and NEAR-generated statistics alone.

Phase I: Assessing ACOE and CDWR datasets

Step 1. Initial differentiation of offstream dams and elimination of unwanted records

Offstream dams were initially differentiated on the basis of their stream name or dam name in the dataset (Fig. 2). Dams with stream names such as "offstream" or "*River X* – os" were considered definitively offstream. Dams with names that included words such as "tank," "tailings" or "storage basin" and had a drainage attribute = 0 were also categorized as offstream. Offstream dams were retained but not snapped to the stream hydrography.

Duplicate records were eliminated in cases where identical dams appeared twice within a dataset – i.e. two records with the same dam name, stream name and owner but different National Identification Number (NID). In these cases, the record containing the most accurate location and/or attribute information was retained, and the deleted record's NID was noted in the comments field. Also eliminated were "secondary" offstream dams in cases where a "primary" dam was located instream. Secondary offstream dams included dikes around a primary dam's reservoir and auxiliary dams or powerhouses. Wastewater treatment plants were also eliminated.

Step 2. Check of dams likely in error

The dam checking process began by looking for "red flags" (Fig. 2). If a dam occurred in both datasets, but had a distance > 500 m between the two datasets' locations, it was considered likely in error and immediately checked against the 1:24K TOPO! maps. For most dams with locational discrepancies, one location sufficiently matched the TOPO! map and was retained, while the other dataset was simply wrong. In other cases, neither position was correct according to the TOPO! map, and it was necessary to manually digitize a new location. In a few cases, locational discrepancies were caused by a different ordering of NID numbers for the same series of 2-4 dams. In such cases, one sequence of NID numbers was deemed correct based upon which ordering best fit the geographic sequence of surrounding dams.

After finishing the check of dams with between-dataset discrepancies, another red flag was given attention. Using a California county layer and a series of ArcInfo GIS

commands (starting with the spatial reselect command in ArcPlot), the county in which each dam was digitally located in the geographic coverage was compared with the county attribute information listed in its associated table. All dams with discrepancies between the listed and actual digital county location were checked against the TOPO! maps and moved to correct locations when in error.

Step 3. Verification and differentiation of all remaining dams

After visually checking all the dams with "red flags," remaining dams were systematically verified using dam attributes and output from the ArcInfo NEAR command as criteria for further steps. Distance to the nearest stream in the 1:100K hydrography was evaluated, and the name of the nearest stream in the hydrography was compared with that listed for the dam in the dataset. The next appropriate analysis step was determined on the basis of these results (Fig. 2).

Dams could be verified in three different ways – with "topo checks" against the 1:24K TOPO! maps, with "hydro checks" against the 1:100K hydrography or with attribute verification only. Topo checks were conducted as a first step if certain attributes suggested potential for error (e.g. a mismatch in listed and nearest stream name) or indicated importance (e.g. large drainage area). Otherwise, dams were hydro-checked as a first step, and topo-checked only if the hydro check raised questions about the dam's locational accuracy. In some cases, dams were considered sufficiently verified (without hydro- or topo-checking) if the nearest and listed stream names matched, and the distance to nearest stream was small.

Certain drainage area values or nearest/listed stream name combinations facilitated verification. For example, dams with listed drainage areas of 0 were considered likely offstream. A hydro check showing the dam point near a reservoir outline not contiguous with any stream was considered verification of the dam's location and status as an offstream dam. Another special case was that of dams which had listed stream names of "trib- *River X,*" where "*River X*" matched the name of the nearest stream. This situation usually occurred when a dam exists on a stream not represented in the 1:100K hydrography (a non-1:100K dam), making the mainstem river the nearest represented stream. In these matching "trib-*River X*" cases, location and classification as a non-1:100K dam were considered verified if the hydro check revealed a reservoir not contiguous with any represented stream or, in the absence of a reservoir outline, there were no unnamed tributaries nearby that might alternatively be the "trib-*River X*" stream.

After checking was complete, dams were relocated (snapped) to the nearest stream, if there was some evidence that they were located on a stream in the 1:100K hydrography. Instream dams were relocated automatically to the nearest stream locations yielded by the NEAR command, unless a hydro or topo check had indicated that such a move would result in an inaccurate location (e.g. on the wrong stream or incorrectly positioned relative to tributaries). If automatic snapping would result in improper location, the dam was manually digitized to a proper instream location.

If there was evidence that a dam was offstream or on a non-1:100K stream, it was retained, but not snapped to a stream location. Most offstream or non-1:100K dams were simply retained in their original location. However, if such a dam was misaligned relative to surrounding streams (e.g. on the west side of a stream instead of the east) or located > 1000 m from its "true" location, the dam was manually digitized to an acceptable location.

Step 4. Web-investigation of selected dams not apparent on the TOPO! maps

Twelve dams were checked using web resources. Most were dams that were not represented on the TOPO! maps even though they had large storage or reservoir areas. These "invisible" dams, often proposed or built after the publication of the TOPO! maps, were verified using maps, narrative descriptions or photos found on the web-sites of engineering contractors, county planning agencies, recreational agencies or environmental advocates.

Step 5. Unification of attribute data

A selection of attributes from the two datasets was used in the new master dam coverage (Appendix B). Many of the attributes were found in both datasets but sometimes values differed between datasets or were missing. In cases where attribute values were missing from one dataset, values were supplied from the dataset with the available attribute data. Otherwise, attribute data was supplied by the dataset that had provided the "best" location for a given dam. Some attributes (such as DAM_TYPE) existed in both datasets but had different code sets. In such cases, one dataset's coding scheme was used, and values obtained from the other dataset were translated. For example, in the case of DAM_TYPE, the two-letter ACOE codes were used (e.g. "RE" for earthen dam), and any dam for which attribute information was supplied from the

CDWR dataset had its four-letter code (e.g. "ERTH" for earthen dam) changed to the ACOE code for that type ("RE").

New attributes were also created which reflected information determined while processing the data. In particular, dams were categorized into "offcodes" which indicated whether a dam was judged to be instream on 1:100K streams, instream on streams not in the 1:100K hydrography, offstream or of uncertain status.

Phase II: Assessing and appending unique USGS and FERC data

After constructing a master dam coverage from the ACOE and CDWR datasets, we evaluated dams that were found only in the FERC or USGS datasets. Neither the FERC nor USGS data included the dam attributes that had been used to structure the ACOE/CDWR dam verification process. Therefore, the verification process was simplified (Fig. 3).

The first step in assessing the USGS and FERC data was identifying dams that were unique to these datasets and not already included in the master dam coverage built from the ACOE/CDWR data. Since neither dataset contained the national dam identifier (NID) used in the ACOE and CDWR datasets, USGS and FERC dam names were compared with the ACOE/CDWR dam names. Dams were discarded after automated comparisons, if names matched exactly and distance between the datasets' digital locations was small. However, since names for identical dams were often similar but not exactly matching, it was often necessary to visually compare similarly named dams by overlaying the different GIS dam layers in ArcMap. The FERC dataset also included multiple records – e.g. for powerhouses and auxiliaries associated with a dam – for what would typically be a single dam record in the ACOE or CDWR dataset. None of these secondary dam structures was retained. The USGS dam list also included many dams labeled "historic" in the dam name. These were retained but given a distinct classification in the HISTORIC attribute (Appendix B).

While neither data set had a stream name attribute that could be checked against the nearest stream in the hydrography, dam names sometimes contained an element that referred to the stream on which it was located, e.g. "*River X* diversion dam." A dam was deemed sufficiently verified without further checking, if its name contained a stream name element that matched the nearest stream in the hydrography and its location was a short distance (< 200 m) from the nearest stream in the hydrography. In the absence of matching name elements, dams were either topo-checked as a first step or hydro-checked and then topo-checked if necessary (Figure 3).

The FERC dataset contained many small diversion dams, most of which were not represented by dam symbols on the TOPO! maps nor did they have significant reservoirs that would outlined in the hydrography. These “non-apparent” dams were retained and considered verified if there was evidence of other structures that might be associated with a diversion dam (canals, aqueducts, tunnels, siphons, flumes, gauging stations) intersecting or proximate to the stream, or if an element in the dam name matched the nearest stream name.

FERC and USGS dams were relocated (snapped) to the nearest stream, if there was some evidence that they were located on a stream in the 1:100K hydrography (matching stream name with stream element in dam name, reservoir outline in hydrography, dam symbol or associated structure on the TOPO! map). Dams were retained, but not snapped to the hydrography if there was some evidence that they were offstream or on non-1:100K streams. A dam was removed if there were none of these indicators of its existence.

Results

The final master dam dataset contains 1612 dams, including 1323 from the ACOE and CDWR datasets which were then appended with 113 dams unique to the USGS data and 176 unique to the FERC dataset. Of those dams derived from ACOE/CDWR datasets, 1191 were shared by both datasets, 68 were unique to ACOE and 64 were unique to CDWR.

In developing the master dam dataset from the ACOE/CDWR datasets, many dams were eliminated from the original datasets. After first excluding dams outside our study area boundaries, 35 records were eliminated because they appeared to be duplicates of existing dams with differing NID identifiers, and 76 dams were eliminated that were dikes around a reservoir or offstream auxiliaries secondary to a primary instream dam. Finally, 14 dams were eliminated because their digital locations conflicted with their attribute information, and they could not be found on the TOPO! maps.

While a majority of dams were snapped to locations aligned with the 1:100K stream hydrography (67% of 1612), many dams were not relocated, being deemed offstream or on non-1:100K streams (Table 1).

A majority of dams were visually checked against the 1:24K TOPO! maps (66%), but where possible, other methods of verification were used (Table 2).

Among the various datasets, the ACOE dataset included the most locational discrepancies (the largest percentage of dams with large distances between original and

corrected locations), while the USGS and FERC datasets had the fewest discrepancies (Table 3). However, the differences between the USGS/FERC datasets and the ACOE/CDWR datasets may be misleading, since only a small subset of USGS and FERC dams were verified – only those which were not already found in the ACOE and CDWR datasets. The advantage of using two datasets (ACOE and CDWR) with many shared dams and a shared national identifier was that it allowed us to target dams with likely errors, i.e. those with large distances between dams with same national identifier. Often, a dam from one of the datasets had an acceptable location that could be automatically snapped to an instream location, and the other, invalid location could simply be ignored (142 instream cases, see Table 4). Nevertheless, many dams required manual digitization of new locations (12%). These included dams that were within an acceptable distance (< 500 m) of their "true" instream location, but were most proximate to the wrong stream or incorrectly positioned relative to tributaries (68 instream cases), demonstrating the importance of careful verification (Table 4).

The synthesized dam coverage created in this process will make possible the determination of where barriers to anadromous fish migration exist, where habitat remains available and where habitat has been lost. By synthesizing data from several different sources, the new coverage offers a comprehensive dataset of dams for the fish passage study area within California. Error-checking revealed a sizeable proportion of dams with locational errors among the two primary datasets (ACOE and CDWR). As a result of this intensive verification, the synthesized dam coverage can be used with a confidence not possible with the original datasets. The new dam dataset can enable the accurate assessment of the impact of barriers to fish migration, because dams that occur on streams represented in the 1:100K hydrography have been differentiated from those that do not, and all appropriate dams have been snapped to adjusted locations coincident with the hydrography.

Data Distribution

For information about obtaining the data, please contact Dr. Peter Adams, 831-420-3923, Peter.Adams@noaa.gov

Currently there are no plans to update the database further, however, should a user come across any errors or issues with the dataset, please contact us.

Literature Cited

Christy, T. and E. Haney. 2003. 1:100K hydrography (Version 2003.6). Pacific States Marine Fisheries Council and California Department of Fish and Game. http://www.calfish.org/.

ESRI. 2002. Environmental Systems Research Institute. ArcGIS 8.3 software. Redlands, CA.

TOPO. 2001. Topo software version 2.6.8. National Geographic Holdings. http://maps.nationalgeographic.com/topo

USGS. 2003. National hydrography dataset. U. S. Department of Interior, U. S. Geological Survey. http://nhd.usgs.gov/.

Table 1. Dam placement categories: number of dams moved to instream locations on the 1:100 K hydrography (snapped) relative to number of dams not snapped to the hydrography.

Dam Placement Category	ACOE/CDWR	USGS	FERC
Instream	868	63	146
Non-1:100K stream, not snapped to hydrography	207	25	6
Offstream, not snapped to hydrography	241	21	15
Status uncertain, not snapped to hydrography	7	4	9
Total	**1323**	**113**	**176**

Table 2. Dam verification: number of dams by type of verification.

Verification Type	ACOE/CDWR	USGS	FERC
Topo check[1]	840	95	128
Hydro check[2]	348	18	0
Stream name match only[3]	64	0	48
Not verified[4]	71	0	0
Total	**1323**	**113**	**176**

[1]Visually checked against 1:24K TOPO! maps.
[2]Visually checked against 1:100K hydrography; includes dams with matching stream names that were hydro-checked for additional verification.
[3]Stream name attribute in dam dataset matched name of nearest stream in the 1:100K hydrography, and distance to nearest stream was < 500 m, considered sufficiently verified and not visually checked against TOPO! maps or hydrography.
[4]Not verified using any of the above methods; only contains dams categorized as offstream (based on stream name containing “offstream”).

Table 3. Dam discrepancies by dataset: percent of instream dams by distance from final instream location.[1]

	ACOE	CDWR	USGS	FERC
> 5000 m	6.6 %	1.7 %	0.0 %	0.7 %
1000-5000 m	14.1 %	3.9 %	0.0 %	0.7 %
500-1000 m	9.2 %	6.8 %	3.2 %	2.1 %
100-500 m, mismatched[2]	4.2 %	5.8 %	3.2 %	2.7 %
< 100 m, mismatched[2]	0.7 %	0.6 %	3.2 %	1.4 %
100-500 m, OK	21.8 %	25.3 %	7.9 %	8.2 %
< 100 m, OK	43.4 %	55.9 %	82.5 %	84.2 %
Total number moved instream	**835**	**823**	**63**	**146**

[1]The percentages in this table are based only on those dams snapped to locations on the 1:100K hydrography. Distances are from the dam location in the original database to the final, corrected instream location. ACOE and CDWR statistics are shown separately here, since dams shared by both databases had differing original positions between the two databases.

[2]These dams had distances of < 500 m from their "true" location on the 1:100K hydrography (which would generally be considered acceptable), but they were closest to an incorrect stream or were positioned incorrectly relative to tributaries entering that stream. Automatic snapping to nearest stream would have resulted in error.

Table 4. Number of dams by validity category and method of locational adjustment.

	ACOE/CDWR	USGS	FERC
Instream dams			
Both[1] > 500 m: Digitized	91	1	5
Both or one[2] < 500 m, but mismatched[3]: Digitized	58	4	6
One < 500 m, OK: Snapped one[4], other invalid	142		
Both < 500 m, OK: Snapped	577	58	135
Verified offstream and non-1:100K stream dams			
Both > 1000 m: Digitized	14	4	0
Both or one < 1000 m, but misaligned[5]: Digitized	8	0	2
One < 1000 m, OK: Retained one, other invalid	22		
Both < 1000 m, OK: Retained location	293	42	28
Other offstream and non-1:100K dams			
Retained, but distance from "true" location unclear	118	4	0
Total	**1323**	**113**	**176**

Distances are from initial locations to final, accepted locations

[1]"Both" applies to dams that occurred in both ACOE and CDWR dataset and indicates that the dam had the same status in both datasets. Since dams included in the FERC and USGS datasets were unique to that dataset, inclusion in this category means that the unique dam found only in that dataset had this status.
[2]"One" applies to dams that occurred in both ACOE and CDWR datasets, and indicates that one dam among the two datasets had this status, but the other did not (distance was greater). In the case of FERC and USGS dams, the unique dam found in that dataset had this status.
[3]"Mismatched" indicates that the dam was closest to the wrong stream or positioned incorrectly relative to tributaries coming into the stream.
[4]"Snapped" indicates acceptable status for automated relocation to nearest point on nearest 1:100K hydrography stream.
[5] "Misaligned" offstream and non-1:100K stream dams were those which were positioned incorrectly relative to surrounding streams, e.g., positioned on the west side of a stream rather than the east.

Figure 1. Outline of anadromous fish passage study area within California for which dam locations were assessed. Study area encompassed all rivers that empty into the ocean within California.

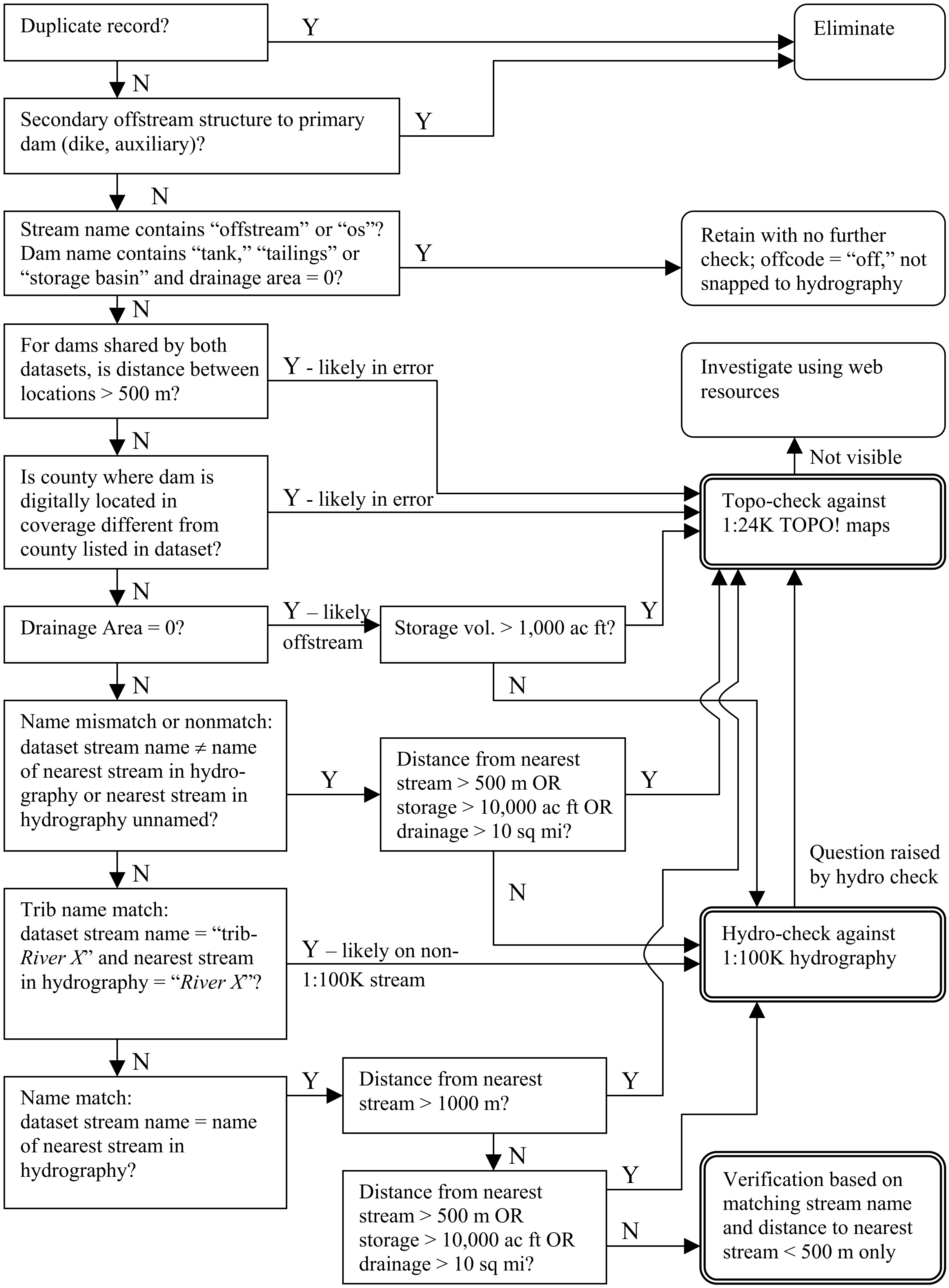

Figure 2. Flow chart of verification procedure ACOE and CDWR dams.

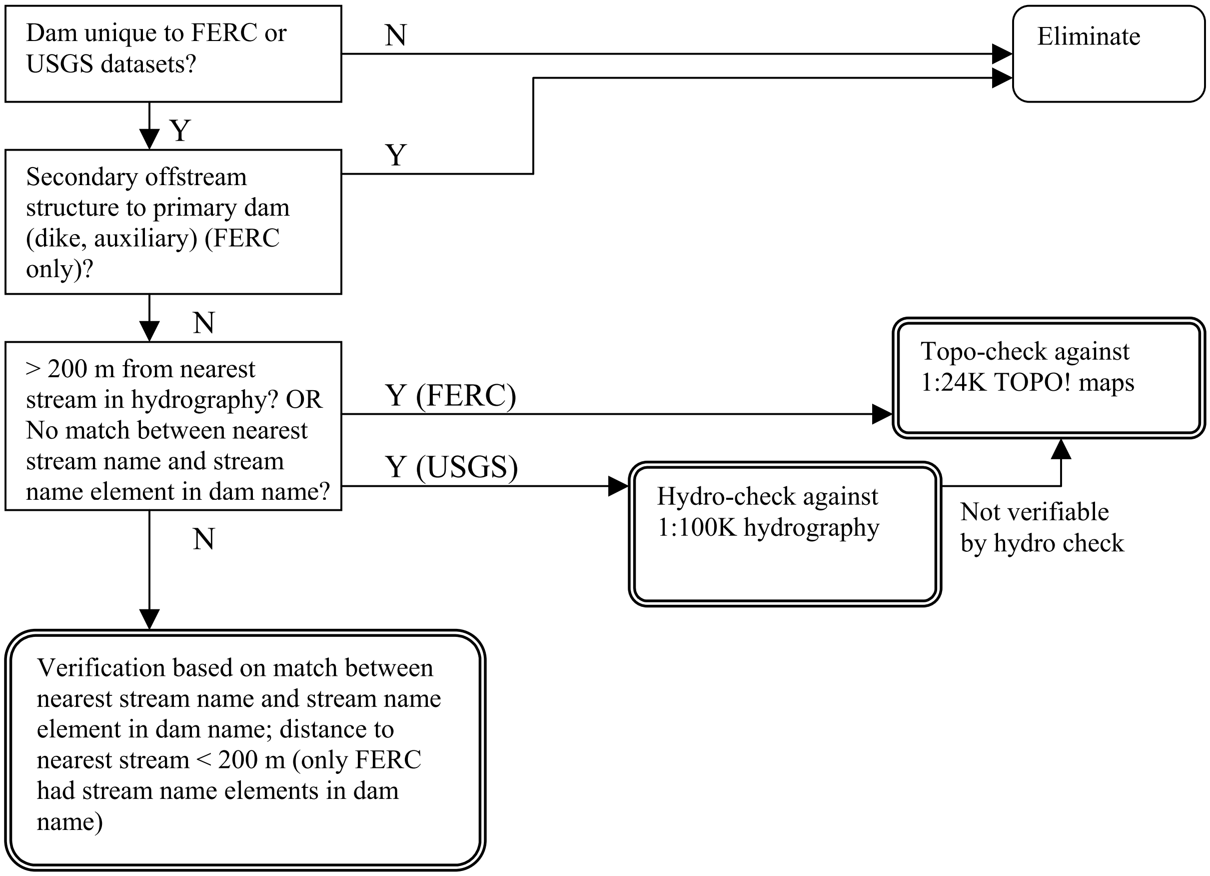

Figure 3. Flow chart of verification procedure for FERC and USGS dams.

Appendix A: Summary of datasets.

California Department of Water Resources (CDWR)

Date: 1997 (Caltrans update)

Includes: All dams within the jurisdiction of the State of California. Jurisdictional Dams are defined as "artificial barriers, together with appurtenant works, which are 25 feet or more in height or have an impounding capacity of 50 acre-feet or more. Any artificial barrier not in excess of 6 feet in height, regardless of storage capacity, or that has a storage capacity not in excess of 15 acre-feet, regardless of height, is not considered jurisdictional." (DWR Bulletin 17-93).

Attributes in dataset include: Dam name, CDWR dam number, owner, county, stream, section, town, range, benchmark, NID (National Identification Number), latitude, longitude, dam type, storage capacity, drainage area, crest elevation, length, paracode, height, freeboard, operating freeboard, width, volume of dam, year built.

Data prepared by: California Department of Fish and Game, Inland Fisheries Division GIS Staff from a database file provided by Floyd Brooks, CA Department of Water Resources, Division of Safety of Dams.

Number of dams in California included in original coverage: 1427

Army Corps of Engineers (ACOE)

Date: 1996

Includes: Criteria for inclusion is not clear from metadata. This dataset was a clip (to California) from the National Inventory of Dams (NID) obtained within the U.S. EPA BASINS v. 2.0 system of GIS coverages. The National Inventory of Dams was originally developed by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency to track dam related problem areas. The National Inventory of Dams was authorized by a variety of legislation from Congress, including the National Dam Inspection Act (P.L. 92-367) of 1972, the Water Resources Development Act of 1986 (P.L 99-662), and the Water Resources Development Act of 1996 (P.L. 104-303) which made the inventory an ongoing process.

Attributes in dataset include: NID (National Identification Number), state, dam name, other name, hazard, EAP, state name, congressional district, county, nearest downstream city, distance to nearest city, river, primary purpose, NID dam type, year completed, NID height, NID storage, length, max

discharge, owner, owner type, state regulating agency, federal regulating agency, nonfederal dam code, section township, purpose (multiple), dam type, height, hydraulic height, structural height, normal storage, max storage, surface area (reservoir), drainage area, spillway type, spillway width, number of locks, lock length, lock width, volume, inspection date, phase I inspection indicator, federal agency constructing, federal agency designing, federal agency funding, federal agency inspecting, federal agency operating, federal other, federal agency owning, federal agency regulating, federal agency supplying data code, date at which data supplied, agency supplying data, federal agency id number for dam, longitude, latitude, FIPS state code, FIPS county code

Prepared by: U.S. Environmental Protection Agency/Office of Water/OS Federal Emergency Management Agency, 500 C St., Washington, DC 20472 202-646-2801.

Number of dams in California included in original coverage: 1508

Federal Energy Regulatory Commission (FERC)

Date: 2002

Includes: All federally licensed hydropower dams in the state of California licensed by FERC.

Attributes in dataset include: FERC dam number, dam name, code for license/exemption, longitude, latitude, storage capacity, powerhouse id number, powerhouse name, installed power capacity (kW), id link, project id number, project name, authorized power capacity, type (exemption/ license), name of exemptee or licensee, co-exemptee/licensee, date license/exemption issued, expiration date, contact name, primary address of contact, secondary address, city for contact, state for contact, zip for contact, phone for contact

Prepared by: FERC, obtained from John.Paquin@ferc.gov by Steve Edmundson of NOAA.

Number of dams in California included in original coverage: 518

Additional Note: Citing the events of Sept 11, 2001, NOAA Fisheries has been instructed not to distribute this data.

US Geological Survey's (USGS) Geographic Names Information System (GNIS)

Date: 2000

Includes: All dams that are federally recognized geographic feature names.
Attributes include: None except name, identifying GNIS number and location
(latitude, longitude, county, state).

Prepared by: Obtained from the USGS GNIS web page by M. Goslin.

Number of dams in California included in original data set: 1466

Appendix B: Dam attributes in unified dataset.

Attribute	Source	Definition
NID	ACOE, CDWR	National Inventory of Dams identification number for the dam
NAME	ACOE, CDWR, USGS	Dam Name
OTHER_NAME	ACOE, CDWR	Other name by which dam may be known
DWR_ID	CDWR	California Dept of Water Resources ID number
COUNTY	ACOE, CDWR	County in which dam is located
CITY	ACOE	Name of nearest downstream city
RIVER	ACOE, CDWR	Official name of the river or stream on which the dam is built; if the stream is unnamed, it is identified as a tributary to the named stream
PPURP	ACOE	Primary purpose for which the reservoir/dam is used
PURP	ACOE	Codes for indicating the purposes for which the reservoir/dam is used. Codes are concatenated if the dam has multiple purposes.
YEAR_BLT	ACOE, CDWR	Year in which original main dam construction was completed
HISTORIC	USGS	Indicator if dam is no longer in existence (a historic dam)
YEAR_OUT	SCL[1]	Year in which dam removed, if removed
OWNER	ACOE, CDWR	Owner
OWN_TYPE	ACOE	Type of owner
DAM_TYPE	ACOE, CDWR	Code indicating the type of dam (i.e. construction type such as rockfill, concrete etc.)
HEIGHT	ACOE, CDWR	Dam height in feet
STORAGE	ACOE, CDWR	Normal storage in acre-feet
RESAREA	ACOE	Surface area of reservoir in acres of the impoundment at its normal retention level
DRAINAGE	ACOE, CDWR	Basin/ drainage area in square miles, defined as the area that drains to a particular point on a river (to the dam location)
DAM_LENGTH	ACOE, CDWR	Length of dam
DISCHARGE	ACOE	Number of cubic feet per second that the spillway is capable of discharging
SPILL_TYPE	ACOE	Type of spillway: controlled or uncontrolled
SPILL_WIDTH	ACOE	Width of the spillway in feet
ST_AGENCY	ACOE	Primary state agency with regulatory authority over dam
FED_AGENCY	ACOE	Federal agency/agencies with involvement in the dam
NONFED	ACOE	Term indicating whether the dam is non-federal

[1] SCL indicates "Santa Cruz Laboratory," attribute created by author and filled with data from our analysis or SCL information gathering.

FED_OP	ACOE	Code identifying which federal agency is involved in operating dam
FED_REG	ACOE	Code identifying which federal agency is involved in regulating dam
NHD_STREAM	SCL	Name of stream in 1:100K hydrography (derived from National Hydrographic Dataset) to which dam is snapped
D_NHD_STREAM_I	SCL	Initial distance to nearest 1:100K hydrography stream before any corrections or snapping
D_NHD_STREAM_F	SCL	Distance to nearest 1:100K hydrography stream (for both instream and offstream dams) after snapping all instream dams to hydrography. Theoretically, this should be non-zero for offstream dams and zero for instream dams, but in practice, the distance was usually <.1m for snapped instream dams as calculated by ArcINFO.
CHECK	SCL	Codes indicating method by which dam was verified
OFFCODE	SCL	Code indicating whether dam was instream, offstream, on stream not represented in 1:100K hydrography or of uncertain status.
SOURCE	SCL	Original data source for dam
KEYSTONE	SCL	Numeric code indicating whether dam is the first impassable dam encountered (keystone)
COMMENTS	SCL	Comments
PAD_ID1	SCL	Passageid from Coastal Conservancy Fish Passage Assessment Database (PAD)
PAD_ID2	SCL	Second passageid from Coastal Conservancy Fish Passage Assessment Database (PAD) if dam occurs more than once in PAD
PAD_ID3	SCL	Third passageid from Coastal Conservancy Fish Passage Assessment Database (PAD) if dam occurs more than twice in PAD
PAD_PASS	PAD	Passage status imported from Coastal Conservancy Fish Passage Assessment Database (as of March 2004): Total, Partial, Temporal, Partial and Temporal, Total and Temporal, Not a Barrier, Unknown
PAD_COMMENTS	PAD	Selected comments imported from Coastal Conservancy Fish Passage Assessment Database
LLID	CDFG/PSMFC	Latitude longitude id of routed stream in CDFG/PSMFC 1:100K hydrography version 6
BEGFT	SCL	Measure in feet upstream along routed stream in CDFG/PSMFC 1:100K routed hydrography
X-COORD	SCL	UTM coordinate (E) after all adjustments/snapping
Y-COORD	SCL	UTM coordinate (N) after all adjustments/snapping

Erratum to NOAA Tech. Memo. NMFS-SWFSC-376.

The Passage Assessment Database (PAD, December 2004 version) referenced in Appendix B was produced by the California Coastal Conservancy, California Department of Fish and Game, and Pacific States Marine Fisheries Commission. PAD data is available online at http://www.calfish.org/.

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