

The Kings IGSM model is physically characterized by the following data groups:

- Subregion Definition;
- Model Grid;
- Nodal Coordinates; and
- Surface Hydrology Configuration.

4.1 SUBREGION DEFINITION

Water and land use management in the model area is represented in the Kings IGSM by subdividing the model area into 32 management areas called subregions (Figure 4-1). The Kings IGSM uses subregions to enable independent analysis of water budgets and hydrologic conditions for each management area. In addition, the subregions allow for the proper development of model input data, especially water supply and demand data, which are generally available in terms of water districts or irrigation districts. The Kings IGSM subregions represent urban areas sphere of influence, individual water districts, irrigation districts, or other organized and/or unorganized areas within the model. The names of the Kings IGSM model subregions, their representative areas, and criteria for selecting the boundaries of the subregion are presented in Table 4-1.

The general criteria used to configure the Kings IGSM subregions include:

- Boundaries of Water Agencies;
- Boundaries of Municipalities;
- Administrative Boundaries; and
- Principal Hydrologic and Hydrogeologic Features.

Specific criteria used to define the Kings IGSM subregions are:

- IRWMP Area;
- Urban Spheres-of-Influence; and
- City of Fresno Pressure Zones.

Specific criteria are described below.

4.1.1 IRWMP PLAN AREA

Kings IGSM subregions were configured to provide geographic coverage similar to administrative boundaries of members of the Upper Kings Basin IRWMP. FID and CID subregions were further divided into FID East and West and CID East and West where

Highway 99 crosses FID and CID, respectively. AID was divided into three subregions AID West, East, and North where the Kings County Line and the Union Pacific Railroad tracks cross AID.

4.1.2 URBAN SPHERES-OF-INFLUENCE AND PRESSURE ZONES

Kings IGSM subregions in the Fresno Metropolitan Area were configured using spheres-of-influence (SOI) boundaries of the Cities of Fresno, and Clovis. Fresno sphere-of-influence is further divided into eight subregions using boundaries of five pressure zones of municipal water distribution system in Fresno (Subregions 7, 8, 10,11, and 12), Pinedale County Water District (Subregion 9), Bakman Water Company (Subregion 13), and California State University of Fresno (Subregion 14). Figure 4-2 illustrates the Kings IGSM subregions in Fresno SOI and Clovis SOI.

4.2 MODEL GRID

A two-dimensional, finite element grid was developed for the entire model area, as shown in Figure 4-3. The model area is subdivided into a series of triangular and quadrilateral elements. The grid shape allows the model to reasonably reflect the physical features in the model area. The Kings IGSM model grid consists of 4,689 elements and 4,266 nodes. The model area covers approximately 1,627 square miles, with an average element size of about 222 acres and minimum and maximum sizes of 9 acres and 965 acres, respectively (Table 4-2). The subregions are defined by a collection of finite elements of the model grid, as shown in Figure 4-3. The model grid was developed using a finite element mesh generation software and in coordination with and review by the TAD Work Group.

The general features of the model grid are:

- Model boundary matches the hydrogeologic and hydrologic boundaries of the underlying Kings groundwater basin;
- Grid orientation follows regional groundwater flow streamlines;
- Grid orientation follows the course of significant streams;
- Model elements are smaller in the IRWMP Area;
- Model elements are smaller in the groundwater depression area in the western part of the model area; and
- Model elements are smaller in the urban areas (Figure 4-4).

The specific features of the model grid in the Fresno SOI (Figure 4-5) are:

- Subregion boundaries match the boundaries of:
 - Fresno pressure zones;

- Pinedale County Water District;
- Bakman Water Company; and
- Fresno State.
- Grid orientation follows the course of major canals in Fresno and Clovis area; and
- Model elements are smaller in Fresno SOI than the neighboring agricultural areas.

4.3 NODAL COORDINATES

The model uses the Universal Transverse Mercator (UTM) projection, Zone 11N coordinates, and North American Datum of 1983 for the x-y coordinates of the nodes. The list of connecting nodes for each element was developed by mesh generation software. Two independent sets of sequential numbers were used for nodes and elements identification. These node and element numbers are used in specifying model input data.

4.4 SURFACE HYDROLOGY CONFIGURATION

The Kings IGSM provides simulation of flows and stream-aquifer interaction for two major rivers and nine creeks. The rivers and creeks are:

- | | |
|---|--------------------|
| ■ Kings River between Pine Flat and Mendota Pool | ■ Fancher Creek |
| ■ San Joaquin River between Friant Dam and Mendota Pool | ■ Holland Creek |
| ■ Little Dry Creek | ■ Watoke Creek |
| ■ Dry Creek | ■ Wooten Creek |
| ■ Redbank Creek | ■ Sand Creek |
| | ■ Cottonwood Creek |

There are also fourteen major canals that are simulated in the Kings IGSM as part of the surface water flow system:

- | | |
|-----------------------|-------------------------|
| ■ Alta Canal | ■ Fresno Canal |
| ■ Consolidated Canal | ■ Mill Canal |
| ■ C-K Canal | ■ Dry Creek Canal |
| ■ Lone Tree Canal | ■ Fancher Creek Canal |
| ■ Fowler Switch Canal | ■ Herndon Canal |
| ■ Gould Canal | ■ Herndon-Brawley Canal |
| ■ Enterprise Canal | ■ Murphy Slough Canal |

The deliveries of eight additional canals (Crescent Canal, Grant Canal, A Ditch Canal, Island Canal, Summit Lake Canal, Liberty Canal, Stinson Canal, and James Canal) are included in the Kings IGSM, but the flows in these canals are not simulated. Since the surface water deliveries

to the south are not used in the model area, they are considered as exports from the model area. These are flows in and deliveries from the following facilities:

- Lakelands Canal,
- Peoples Canal,
- Last Chance Canal,
- Lemoore Canal, and
- South Fork of Kings River

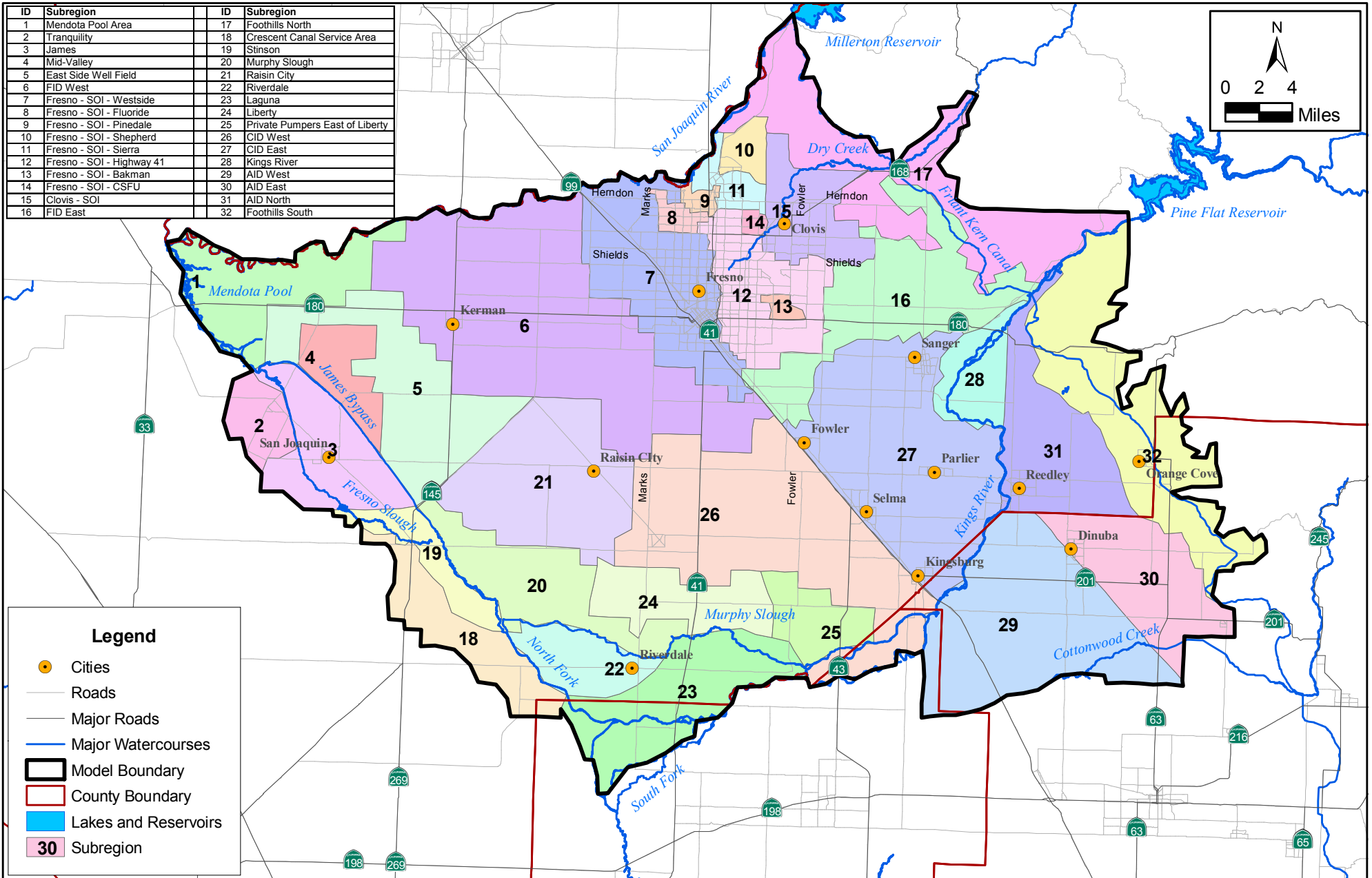
Figure 4-6 shows the location of the simulated rivers and creeks. The location of these physical features is based on GIS mapping available from the California Spatial Information Library (www.gis.ca.gov).

4.4.1 STREAM REACH CONFIGURATION

The surface water flow system is modeled by using 1-dimensional line elements along the stream courses. Each stream course simulated in the Kings IGSM is comprised of stream nodes, which correspond to groundwater nodes. A stream reach is defined by a series of sequential stream nodes. There are 78 stream reaches and 790 stream nodes that represent the stream courses listed above. The stream reaches are shown in Figure 4-6 and the names of the stream reaches are listed in Table 4-3.

The Kings IGSM uses stream reaches for streamflow accounting. Criteria commonly used for delineating stream reaches are locations of confluences, inflow locations, dam locations, outflow locations, subregions boundaries and/or administrative boundaries. Additional criteria can include the relative importance of the reach to a particular study, and stream reach gains or losses to local aquifer.

ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



Model Subregions

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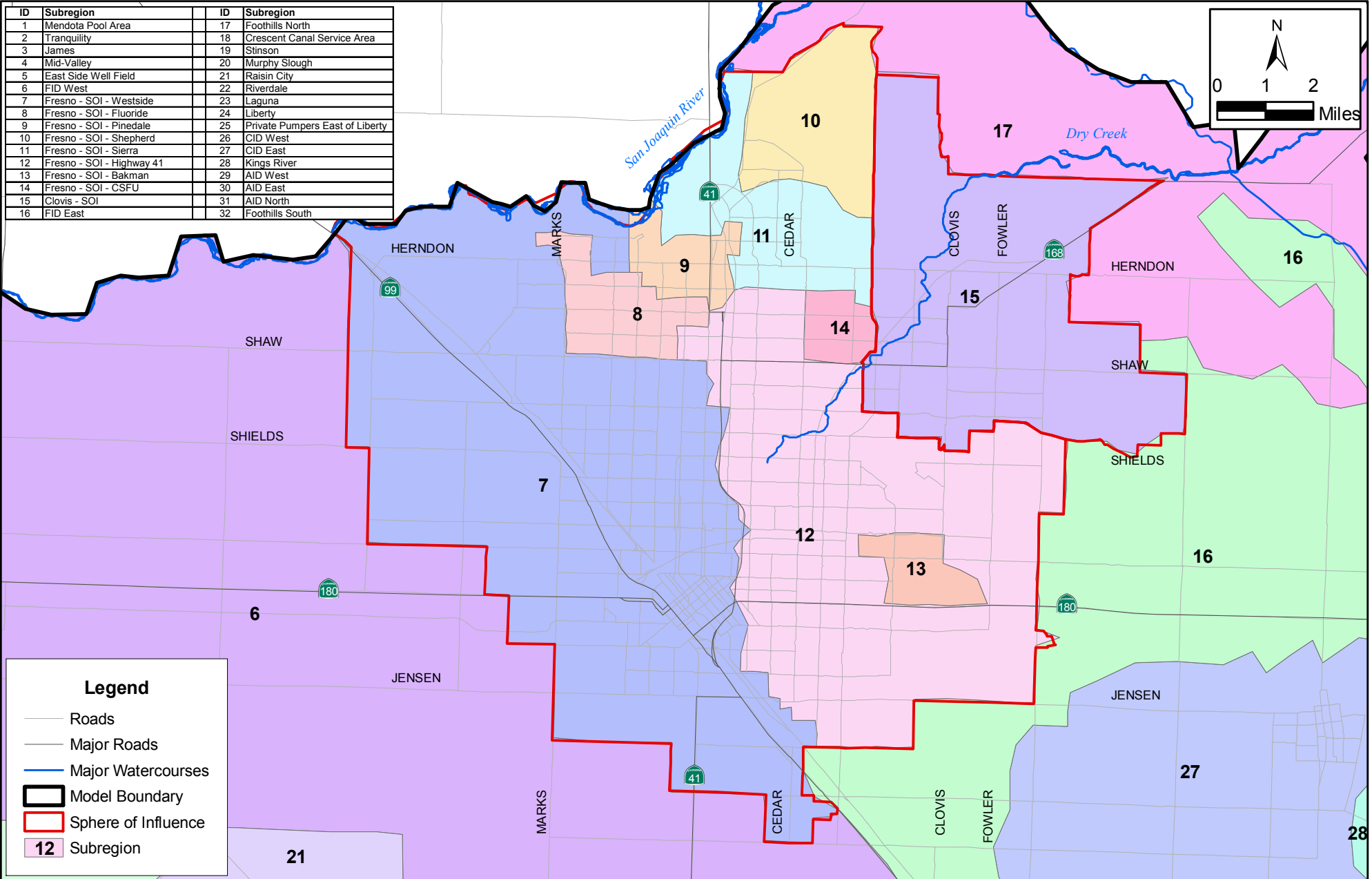
Figure 4-1



Table 4-1. Subregion Attributes

Subregion Number	Name	Criterion			Area	
		Sphere of Influence	IRWMP	District	Acres	Sq. Miles
1	Mendota Pool Area		No		33,239	52
2	Tranquility		No	Tranquility I.D.	10,431	16
3	James		No	James I.D.	28,196	44
4	Mid-Valley		No	Mid-Valley W.D.	13,483	21
5	East Side Well Field		No		44,193	69
6	FID West		Yes	Fresno I.D.	111,970	175
7	Fresno - SOI - Westside	City of Fresno	Yes		44,399	69
8	Fresno - SOI - Fluoride	City of Fresno	Yes		3,070	5
9	Fresno - SOI - Pinedale	City of Fresno	Yes	Pinedale W.D.	2,036	3
10	Fresno - SOI - Shepherd	City of Fresno	Yes		5,202	8
11	Fresno - SOI - Sierra	City of Fresno	Yes		6,229	10
12	Fresno - SOI - Highway 41	City of Fresno	Yes		27,869	44
13	Fresno - SOI - Bakman	City of Fresno	Yes	Bakman W.C.	1,651	3
14	Fresno - SOI - CSFU	City of Fresno	Yes		1,312	2
15	Clovis - SOI	City of Clovis	Yes		20,322	32
16	FID East		Yes	Fresno I.D.	48,167	75
17	Foothills North		No		59,406	93
18	Crescent Canal Service Area		No		23,230	36
19	Stinson		No	Stinson W.D.	12,155	19
20	Murphy Slough		No	Murphy Slough W.D.	30,870	48
21	Raisin City		Yes	Raisin City W.D.	49,502	77
22	Riverdale		No	Riverdale I.D.	15,966	25
23	Laguna		No	Laguna I.D.	38,629	60
24	Liberty		No	Liberty W.D.	21,499	34
25	Private Pumpers East of Liberty		No		13,875	22
26	CID West		Yes	Consolidated I.D.	86,963	136
27	CID East		Yes	Consolidated I.D.	76,202	119
28	Kings River		Yes	Kings River W.D.	14,676	23
29	AID West		Yes	Alta I.D.	67,425	105
30	AID East		Yes	Alta I.D.	32,728	51
31	AID North		Yes	Alta I.D.	34,733	54
32	Foothills South		No		62,075	97

ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



Model Subregions in Fresno and Clovis

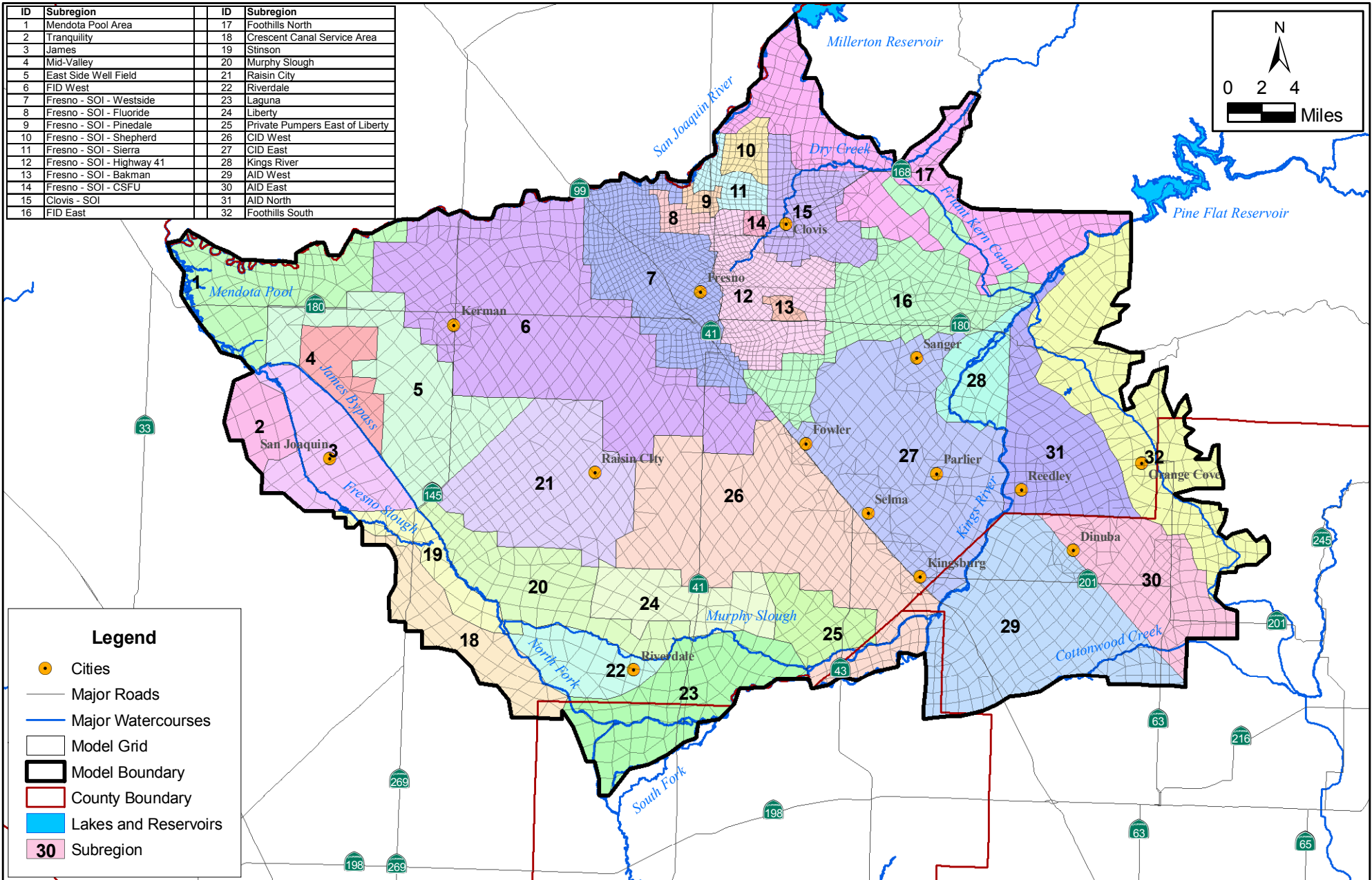
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Figure 4-2



ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



Model Grid

Kings IGSM Model Development and Calibration

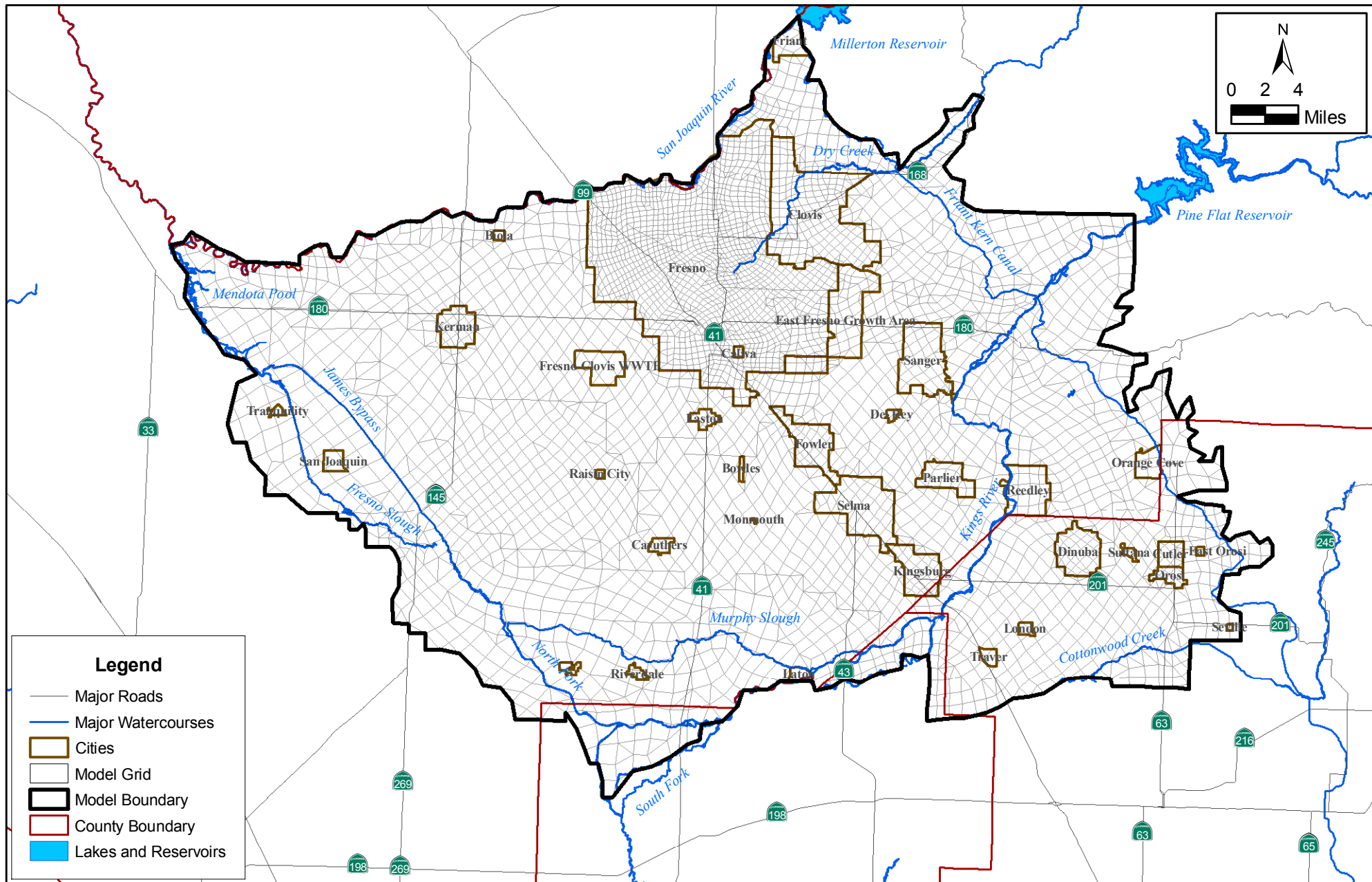
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Figure 4-3



Table 4-2. Kings IGSM Grid Statistics

Statistic	Area						Total Model Area
	AID	CID	FID	Clovis SOI	Fresno SOI	Others	
# of Nodes	482	581	657	220	1,395	1,335	4,266
# of Elements	495	604	639	197	1,447	1,307	4,689
# of Layers	3	3	3	3	3	3	3
Min. Element Size (acres)	24	24	17	13	9	28	9
Max. Element Size (acres)	543	713	654	181	191	965	965
Average Element Size (acres)	272	270	251	103	63	361	222
Total Area (sq. miles)	211	255	250	32	143	737	1,628



Model Grid Refinement for Urban Areas

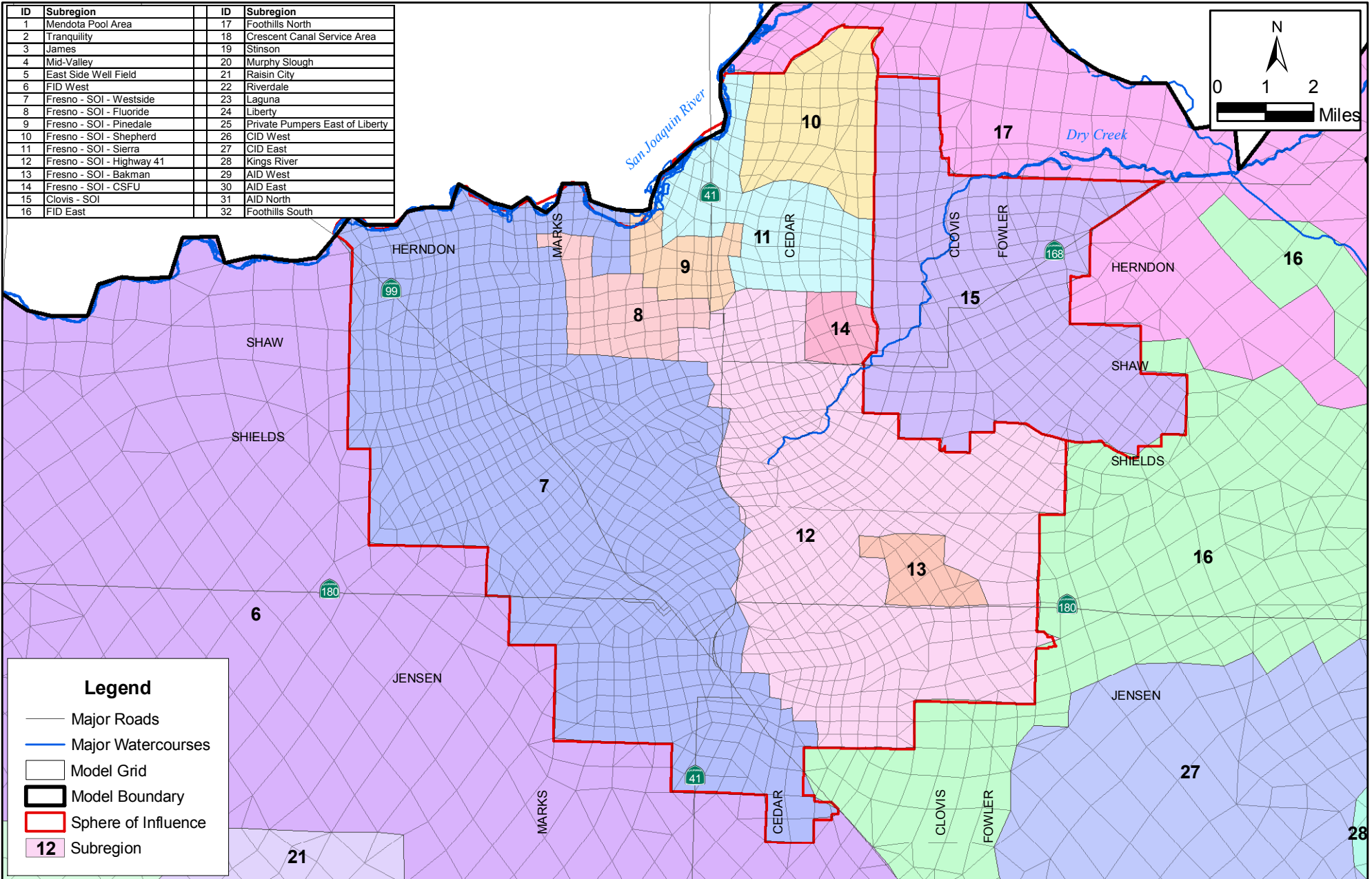
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Figure 4-4



ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



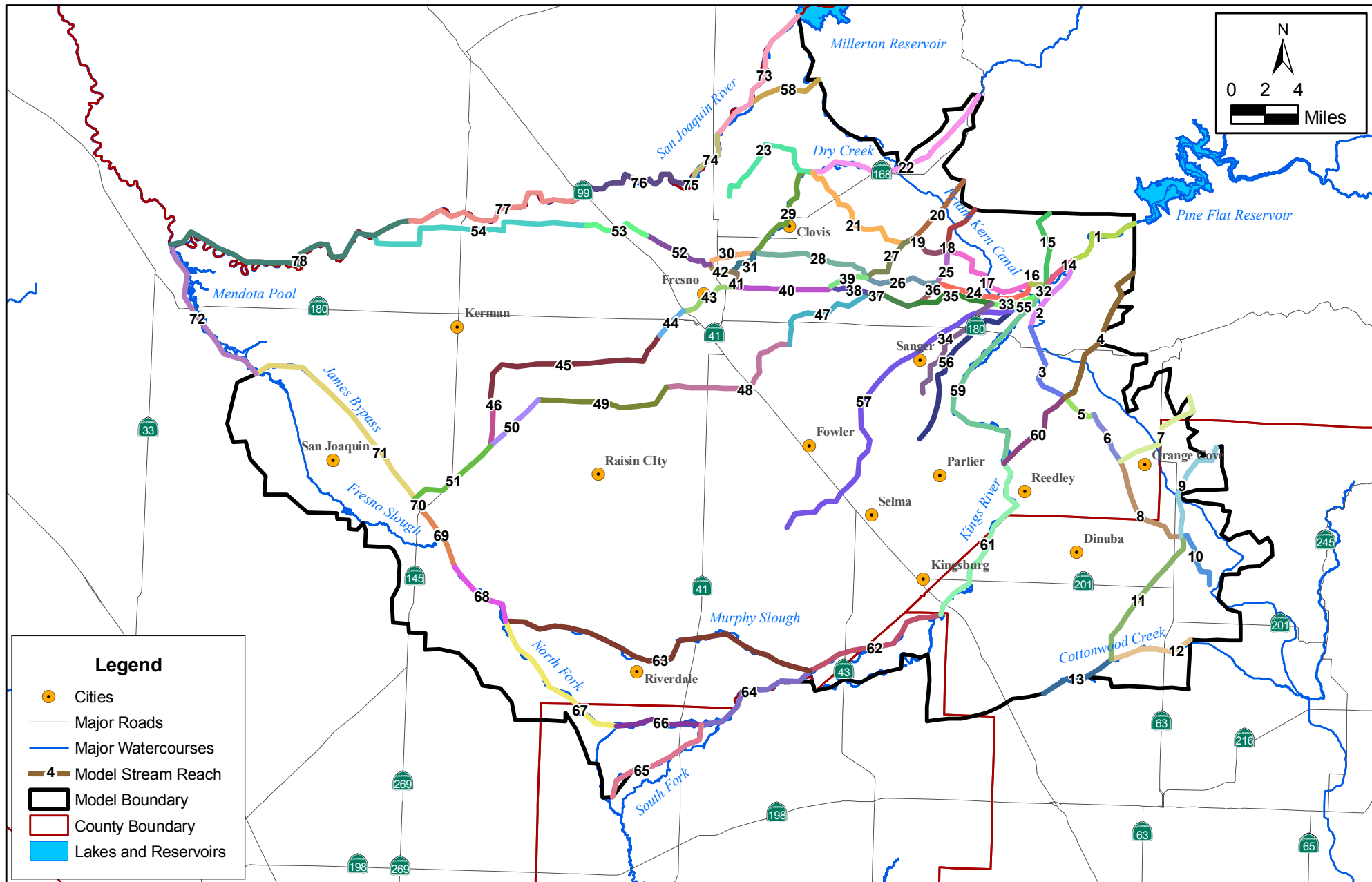
Model Grid Refinement for Fresno SOI

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Figure 4-5





Legend

- Cities
- Major Roads
- Major Watercourses
- Model Stream Reach
- ▭ Model Boundary
- ▭ County Boundary
- ▭ Lakes and Reservoirs

Model Surface Water System

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Figure 4-6



Table 4-3. Kings IGSM Stream Reaches

Stream Reach	Name	Begin	End	Segment Length (miles)
Kings River Reaches				
1	Kings River	Pine Flat	Alta Weir	4.8
14	Kings River	Alta Weir	Gould Weir	2.3
32	Kings River	Gould Weir	Fresno Weir	0.7
59	Kings River	Fresno Weir	Watoke Creek Confluence	14.3
61	Kings River	Watoke Creek Confluence	Peoples Weir	11.3
62	Kings River (Cole Slough)	Peoples Weir	Murphy Slough Weir	8.9
63	Murphy Slough	Murphy Slough Weir	North Fork Kings River near Stinson Weir	20.0
64	Kings River	Murphy Slough Weir	Island Weir	7.9
65	South Fork Kings River	Island Weir	Southern Model Boundary	7.5
66	North Fork Kings River	Island Weir	Crescent Weir	5.2
67	North Fork Kings River	Crescent Weir	Stinson Weir	9.6
68	North Fork Kings River	Stinson Weir	Conjeo Ave	4.8
69	North Fork Kings River	Conjeo Ave	James Weir	4.0
70	James Bypass	James Weir	McMulin Grade	0.7
71	James Bypass	McMulin Grade	Mendota Pool	13.3
72	Mendota Pool	James Bypass	San Joaquin River	9.9
Total Length (not including reach 63 & 65)				97.7
San Joaquin River Reaches				
58	Little Dry Creek	Foothills Model Boundary	San Joaquin River	4.6
73	San Joaquin River	Friant Dam	Madera County 10th Ave	9.1
74	San Joaquin River	Madera County 10th Ave	Madera County Road 40 1/2	3.4
75	San Joaquin River	Madera County Road 40 1/2	Madera County Road 40	0.6
76	San Joaquin River	Madera County Road 40	Hwy 99	7.9
77	San Joaquin River	Hwy 99	Madera County Road 24	12.4
78	San Joaquin River	Madera County Road 24	Kings River Confluence	17.3
Total Length (not including reach 58)				50.8
AID Reaches				
2	76 Channel	Kings River	Alta Canal Headgate	5.0
3	Alta Canal	Alta Canal Headgate	Watoke Creek	5.3
4	Watoke Creek	Foothills Model Boundary	Alta Canal	9.1
5	Alta Canal	Watoke Creek	Alta East Branch Canal	2.2
6	Alta East Branch Canal	Alta Canal	Wooten Creek	3.3

Stream Reach	Name	Begin	End	Segment Length (miles)
7	Wooten Creek	Foothills Model Boundary	Alta Canal	6.6
8	Alta East Branch Canal	Wooten Creek	Sand Creek	6.4
9	Sand Creek	Foothills Model Boundary	Alta East Branch Canal	6.6
10	Alta East Branch Canal	Sand Creek	End of Canal	4.0
11	Sand Creek	Alta East Branch Canal	Cottonwood Creek	8.9
12	Cottonwood Creek	Foothills Model Boundary	Sand Creek Confluence	5.0
13	Cottonwood Creek	Sand Creek Confluence	Southern Model Boundary	4.6
60	Watoke Creek	Alta Canal	Kings River	5.6
CID Reaches				
34	Lone Tree Canal	Fresno Canal	End of Canal	7.3
55	Consolidated Canal	Fresno Weir	C&K Canal and Fowler Swich Headgates	1.9
56	C&K Canal	C&K Canal and Fowler Swich Headgates	End of Canal	10.4
57	Fowler Swich	C&K Canal and Fowler Swich Headgates	End of Canal	21.3
FID Reaches				
15	Holland Creek	Foothills Model Boundary	Kings River	4.8
16	Gould Canal	Gould Weir	Enterprise Canal Headgate	1.0
17	Enterprise Canal	Enterprise Canal Headgate	Fancher Creek	6.4
18	Fancher Creek	Foothills Model Boundary	Enterprise Canal	3.2
19	Enterprise Canal	Fancher Creek	Redbank Creek	2.4
20	Redbank Creek	Foothills Model Boundary	Enterprise Canal	4.5
21	Enterprise Canal	Redbank Creek	Dry Creek	8.6
22	Dry Creek	Foothills Model Boundary	Enterprise Canal	12.2
23	Enterprise Canal	Dry Creek	End of Canal	8.0
24	Gould Canal	Enterprise Canal Headgate	Fancher Creek	6.1
25	Fancher Creek	Enterprise Canal	Gould Canal	2.1
26	Gould Canal	Fancher Creek	Redbank Creek	4.4
27	Redbank Creek	Enterprise Canal	Gould Canal	4.1
28	Gould Canal	Redbank Creek	Dry Creek	7.2
29	Dry Creek	Enterprise Canal	Gould Canal	6.7
30	Gould Canal	Dry Creek	End of Canal	2.9
31	Gould Extension	Gould Canal	Herdon Canal	2.0

Stream Reach	Name	Begin	End	Segment Length (miles)
33	Fresno Canal	Fresno Weir	Lone Tree Canal	2.9
35	Fresno Canal	Lone Tree Canal	Fancher Creek	4.6
36	Fancher Creek	Gould Canal	Fresno Canal	1.6
37	Fresno Canal	Fancher Creek	Fancher Creek and Mill Canal Headgates	3.1
38	Mill Canal	Fancher Creek and Mill Canal Headgates	Redbank Creek Confluence	2.4
39	Redbank Creek	Gould Canal	Mill Canal	2.3
40	Mill Canal	Redbank Creek Confluence	Dry Creek and Herndon Canal Headgates	5.7
41	Herndon Canal	Dry Creek and Herndon Canal Headgates	Gould Extension Confluence	1.2
42	Herndon Canal	Gould Extension Confluence	Gould Canal Confluence	1.4
43	Lower Dry Creek	Dry Creek and Herndon Canal Headgates	Lower Dry Creek and Houghton Headgates	3.6
44	Lower Dry Creek	Lower Dry Creek and Houghton Headgates	Marks Ave	2.1
45	Lower Dry Creek	Marks Ave	American Ave	12.5
46	Lower Dry Creek	American Ave	McMulin Grade	2.8
47	Fancher Creek	Fancher Creek and Mill Canal Headgates	Central Canal	6.7
48	Central Canal	Fancher Creek	Central Wasteway	9.2
49	Central Wasteway	Central Canal	McMulin Grade	8.3
50	McMulin Grade	Central Wasteway	Lower Dry Creek Confluence	3.9
51	McMulin Grade	Lower Dry Creek Confluence	Kings River	5.8
52	Herndon Canal	Gould Canal Confluence	Herndon Headgate at Brawley	4.4
53	Herndon Canal	Herndon Headgate at Brawley	Garfield Ave	4.0
54	Herndon Canal	Garfield Ave	San Joaquin River	14.4

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