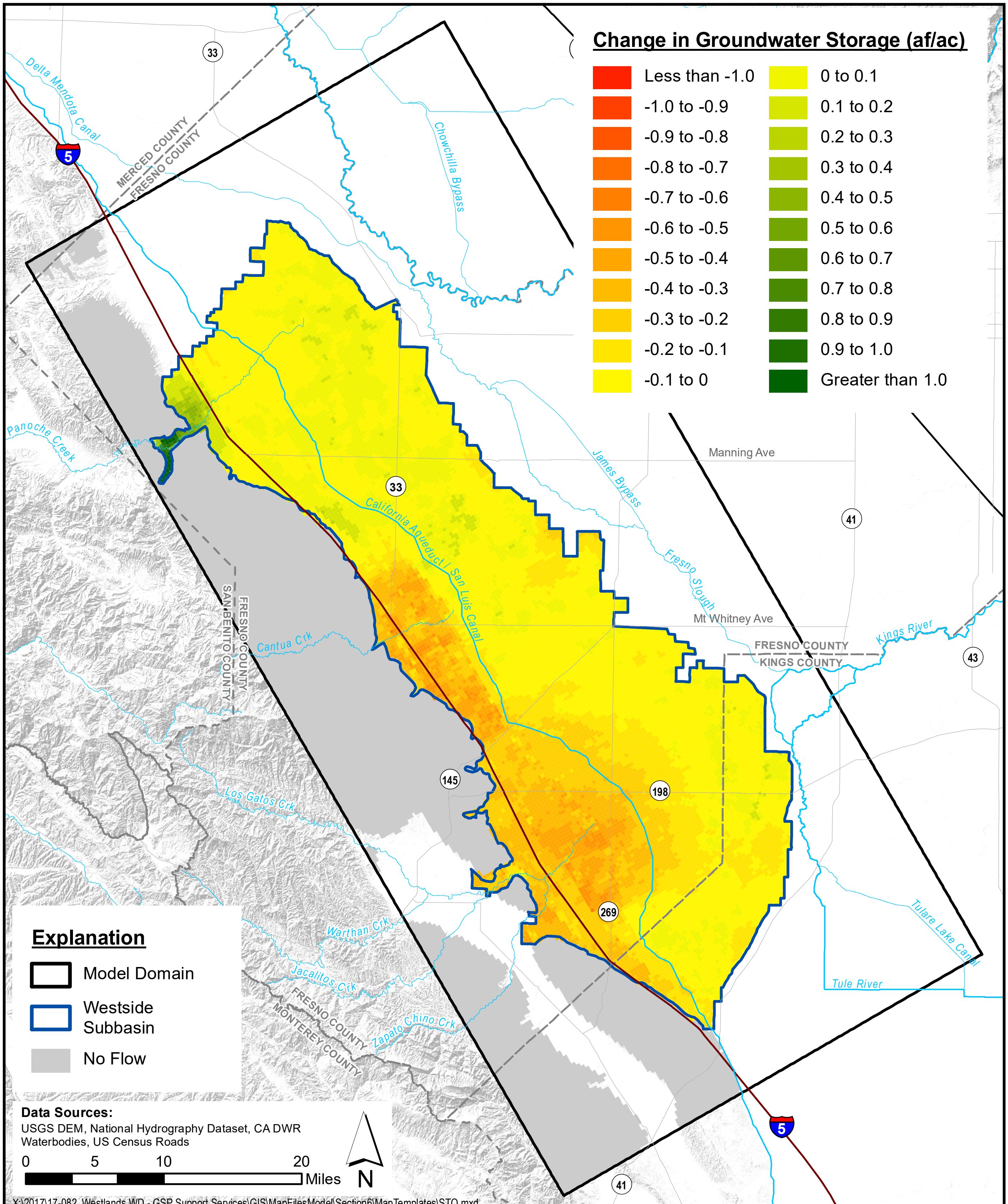

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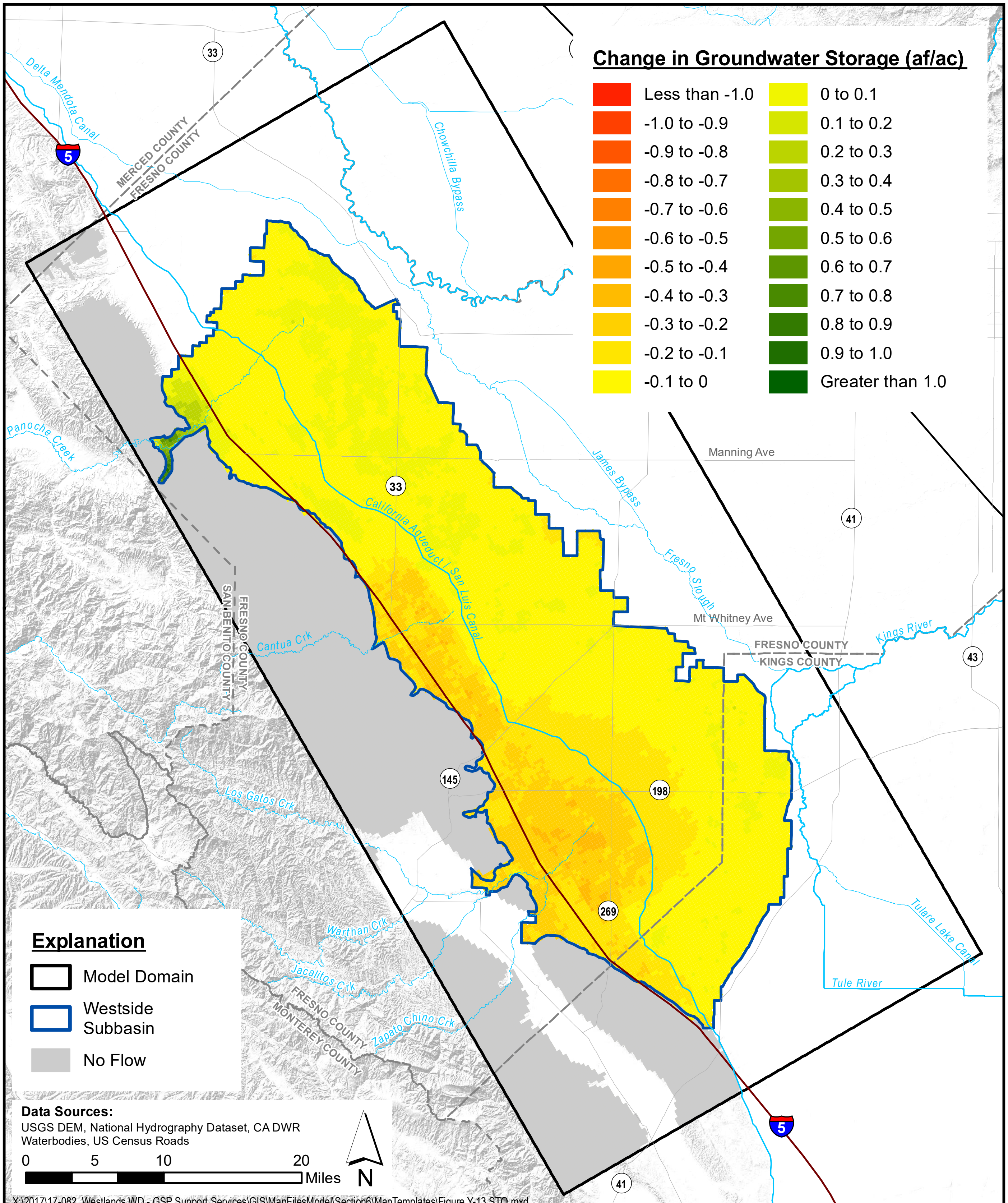
Simulated Change in Groundwater Storage
2030 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-87



Simulated Change in Groundwater Storage
2030 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

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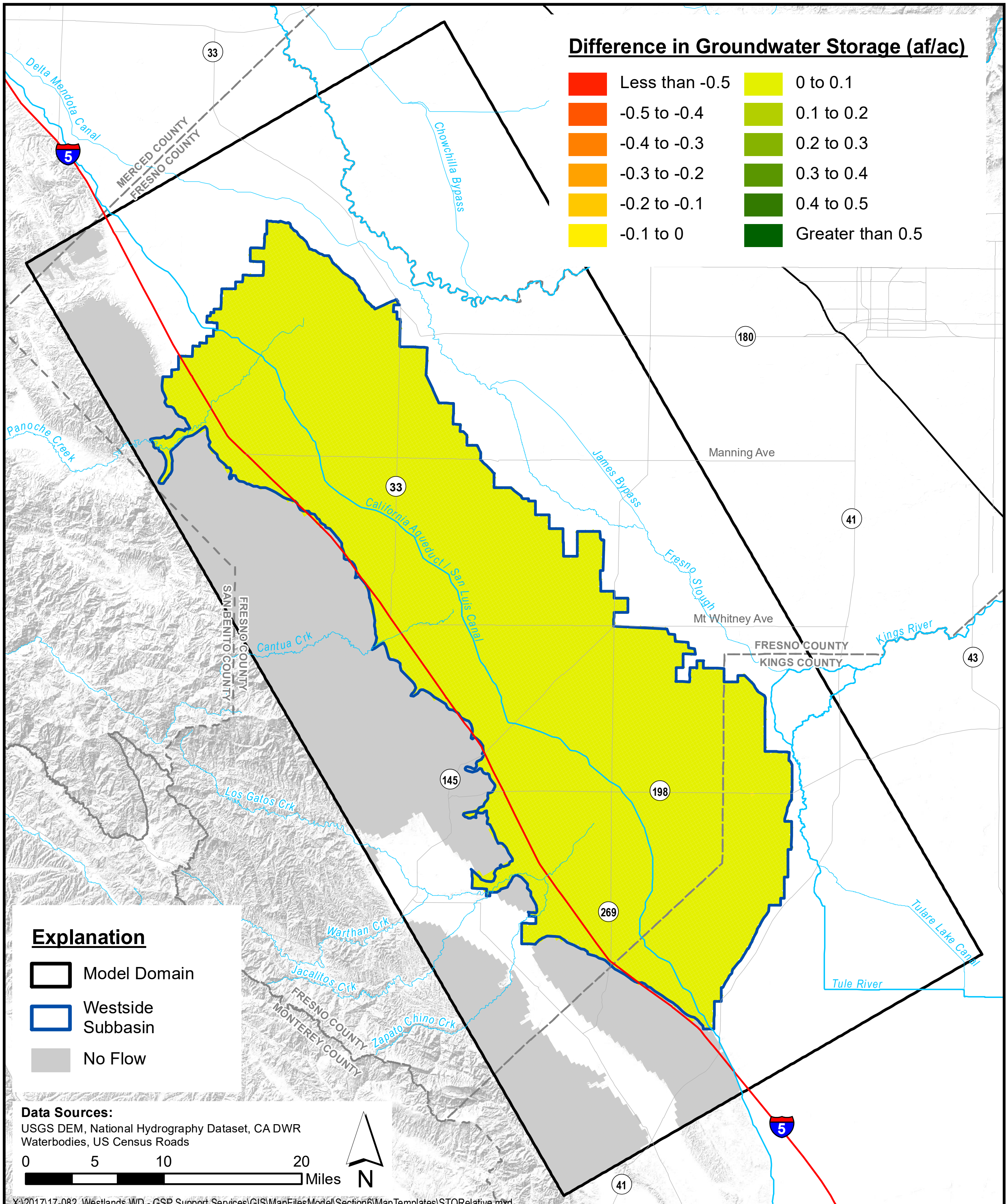
Figure F-88



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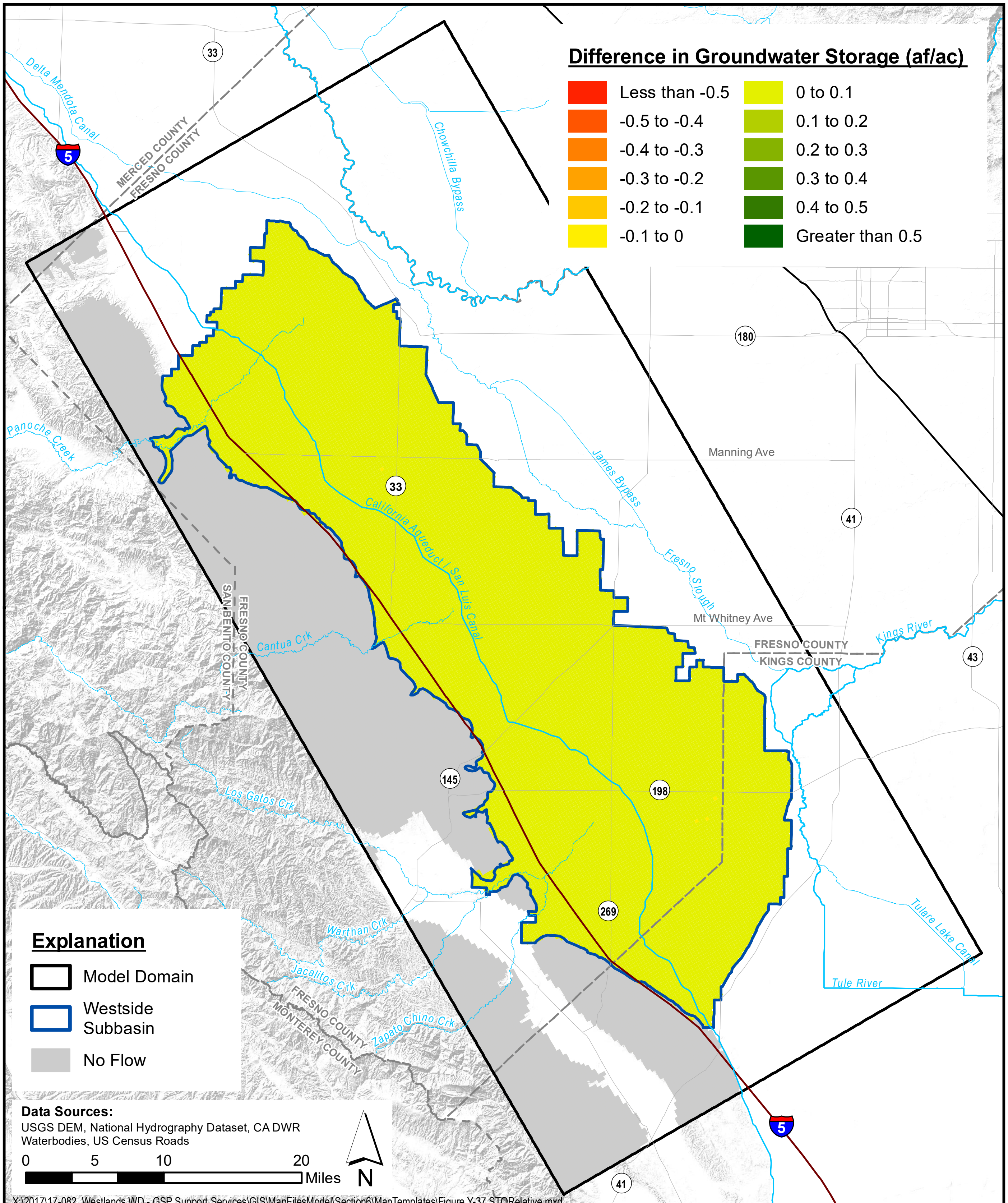
Project Impacts on Groundwater Storage 2030
Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-89



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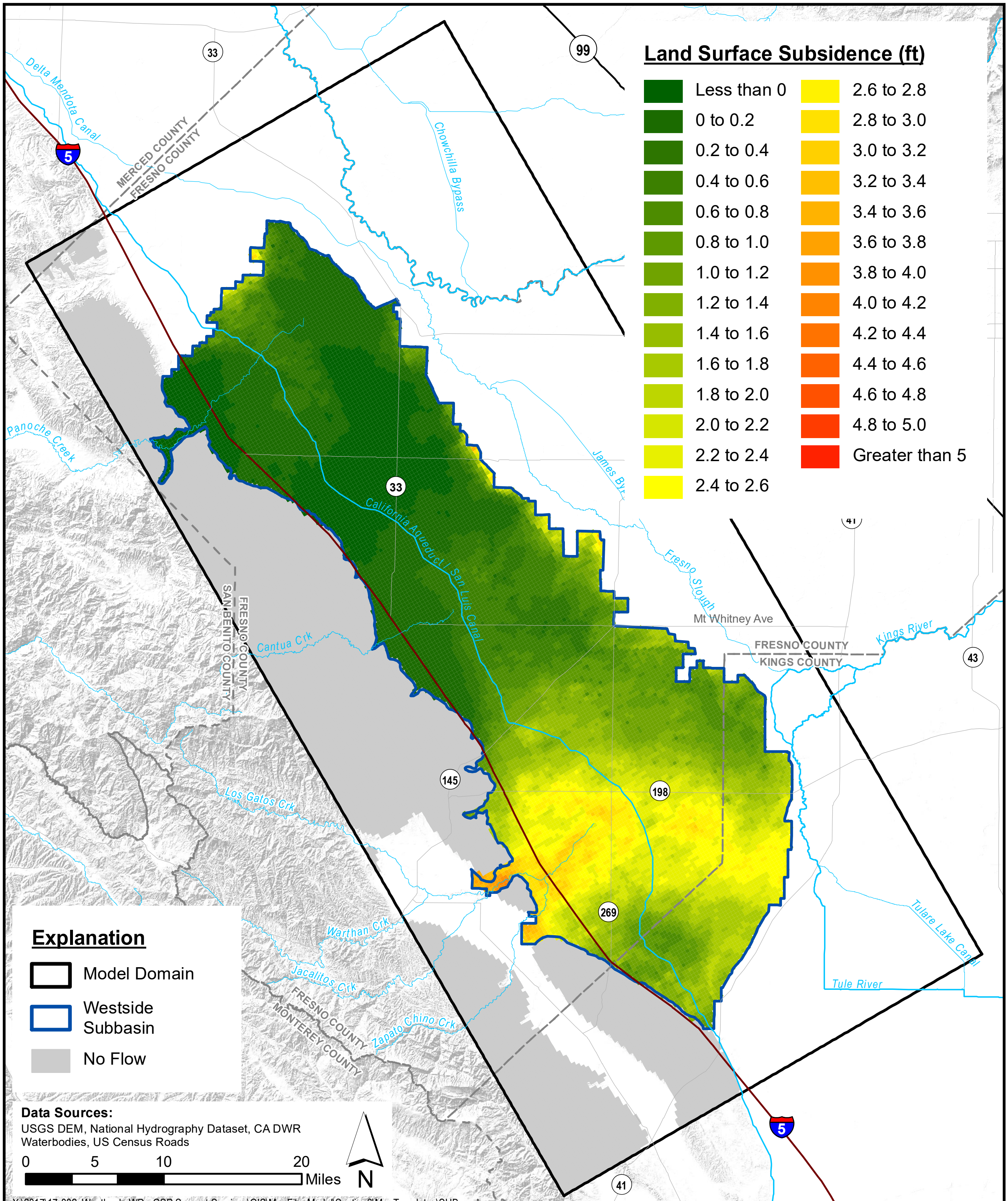
Project Impacts on Groundwater Storage
2030 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-90

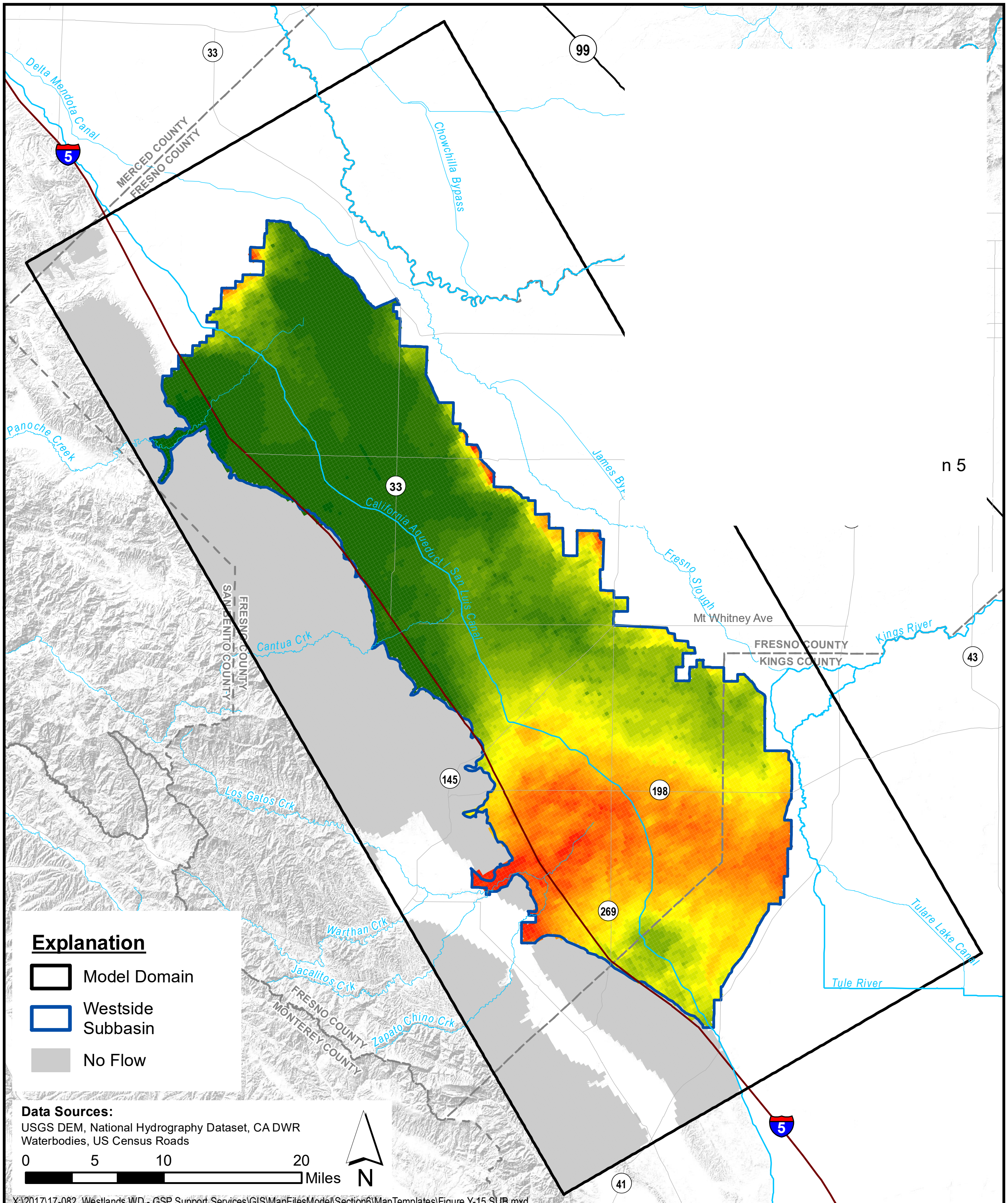


Luhdorff & Scalmanini Consulting Engineers

Simulated Land Surface Subsidence
2030 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-91



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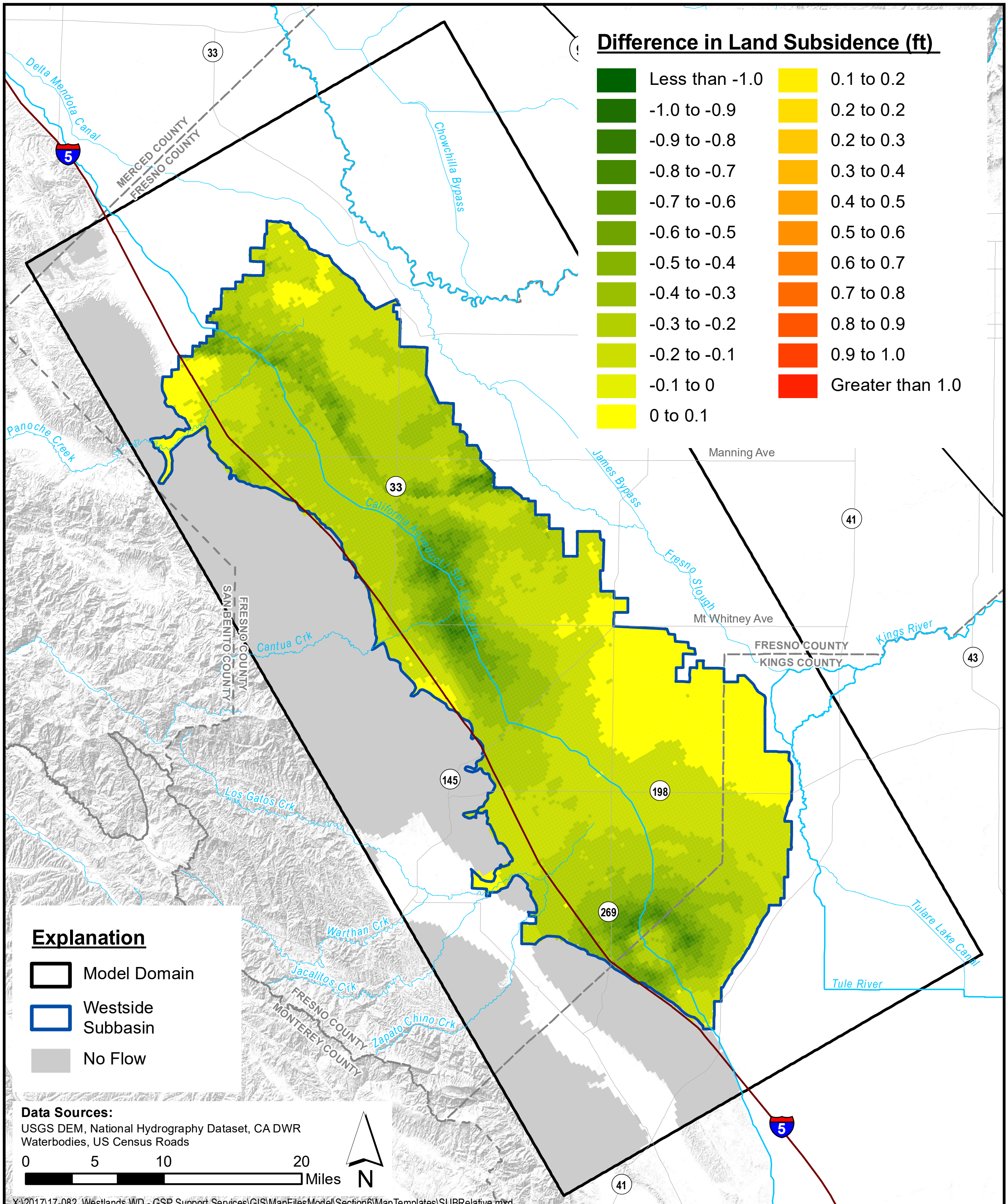
SGMA Sustainability Analyses
Westside Subbasin

e F-92

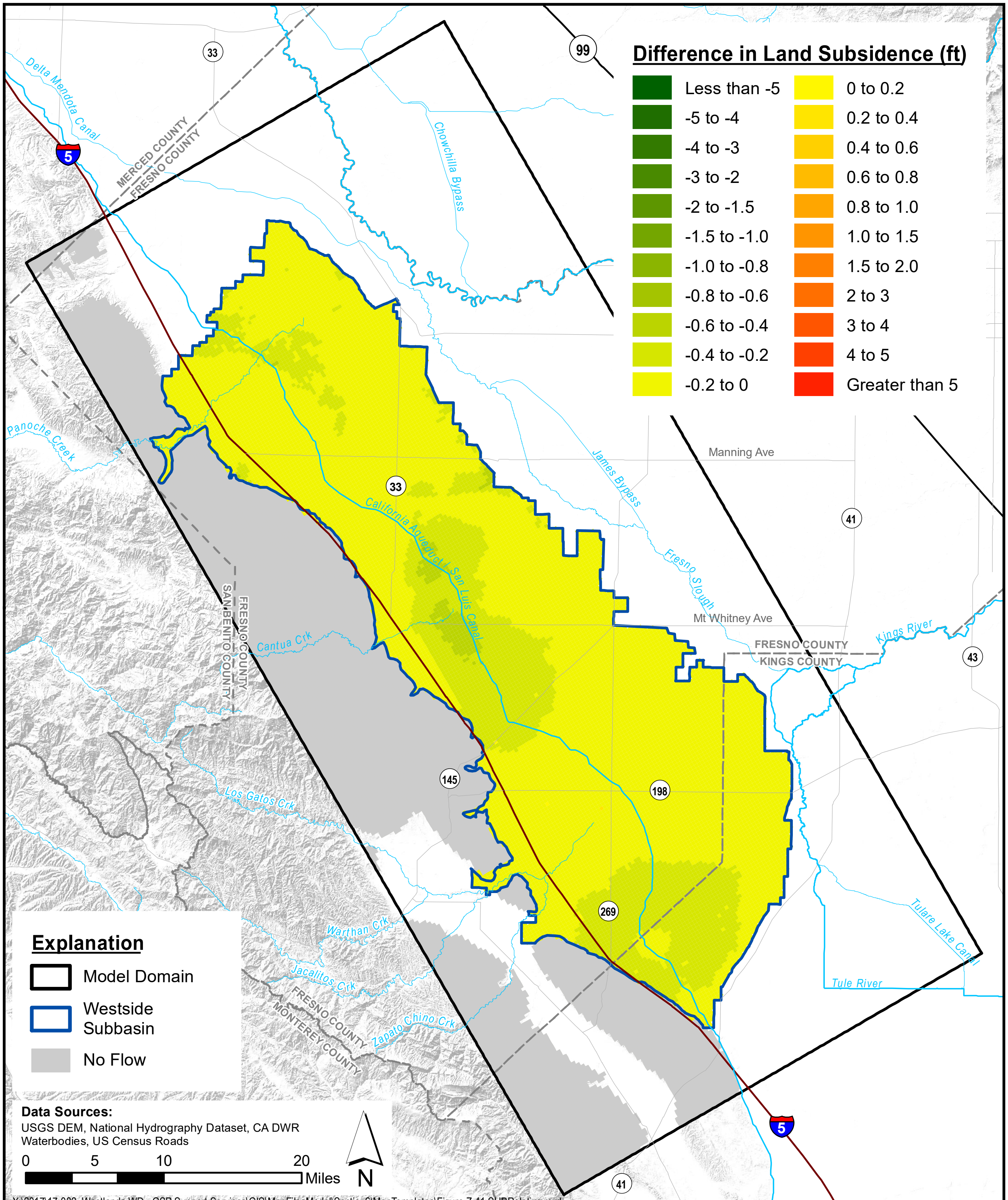


Luhdorff & Scalmanini Consulting Engineers

Project Impact on Land Surface Subsidence
2030 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-93



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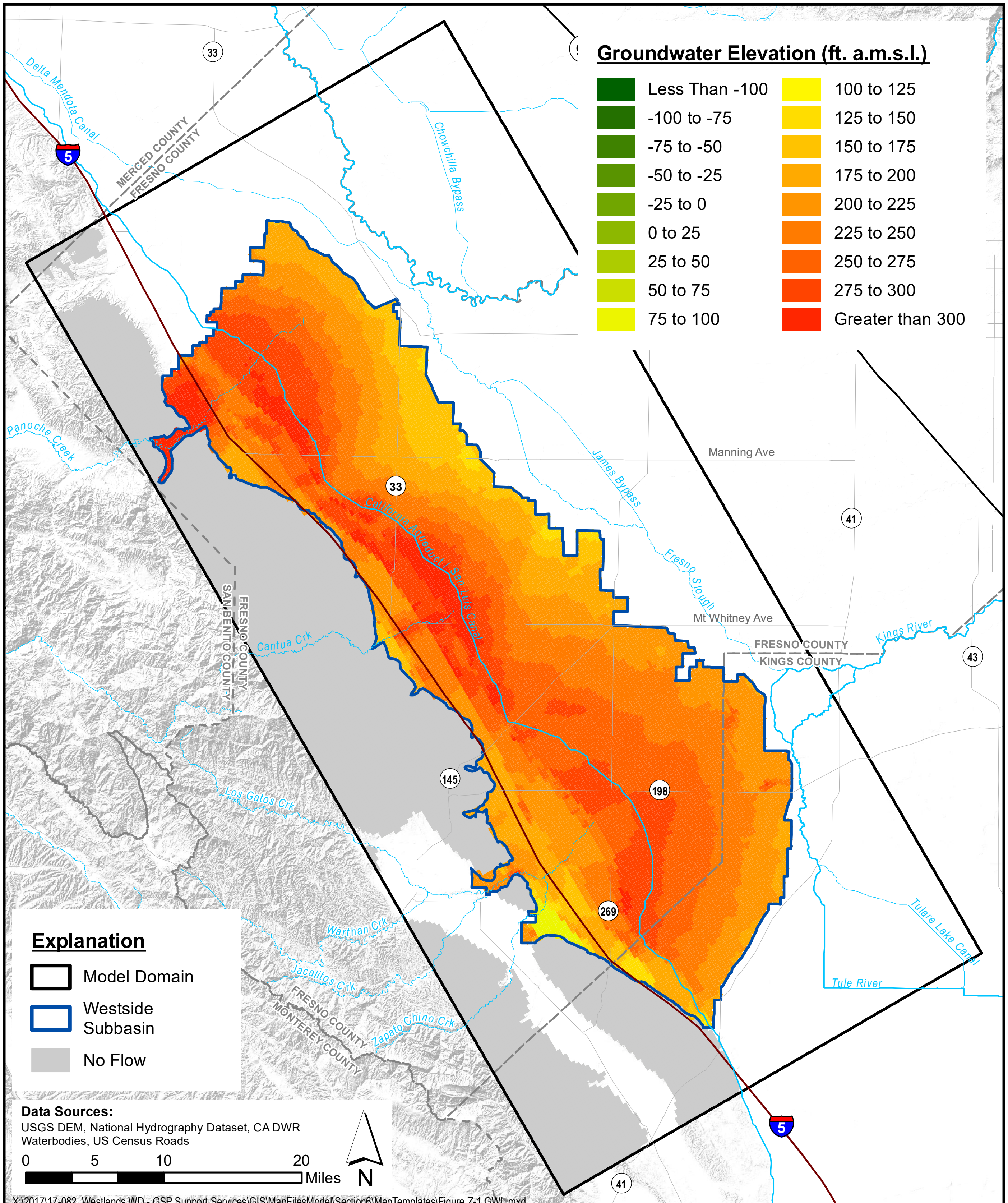
Project Impact on Land Subsidence
2030 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure F-94

Appendix G:

2070 Climate Change Model Projection Spatial Model Output



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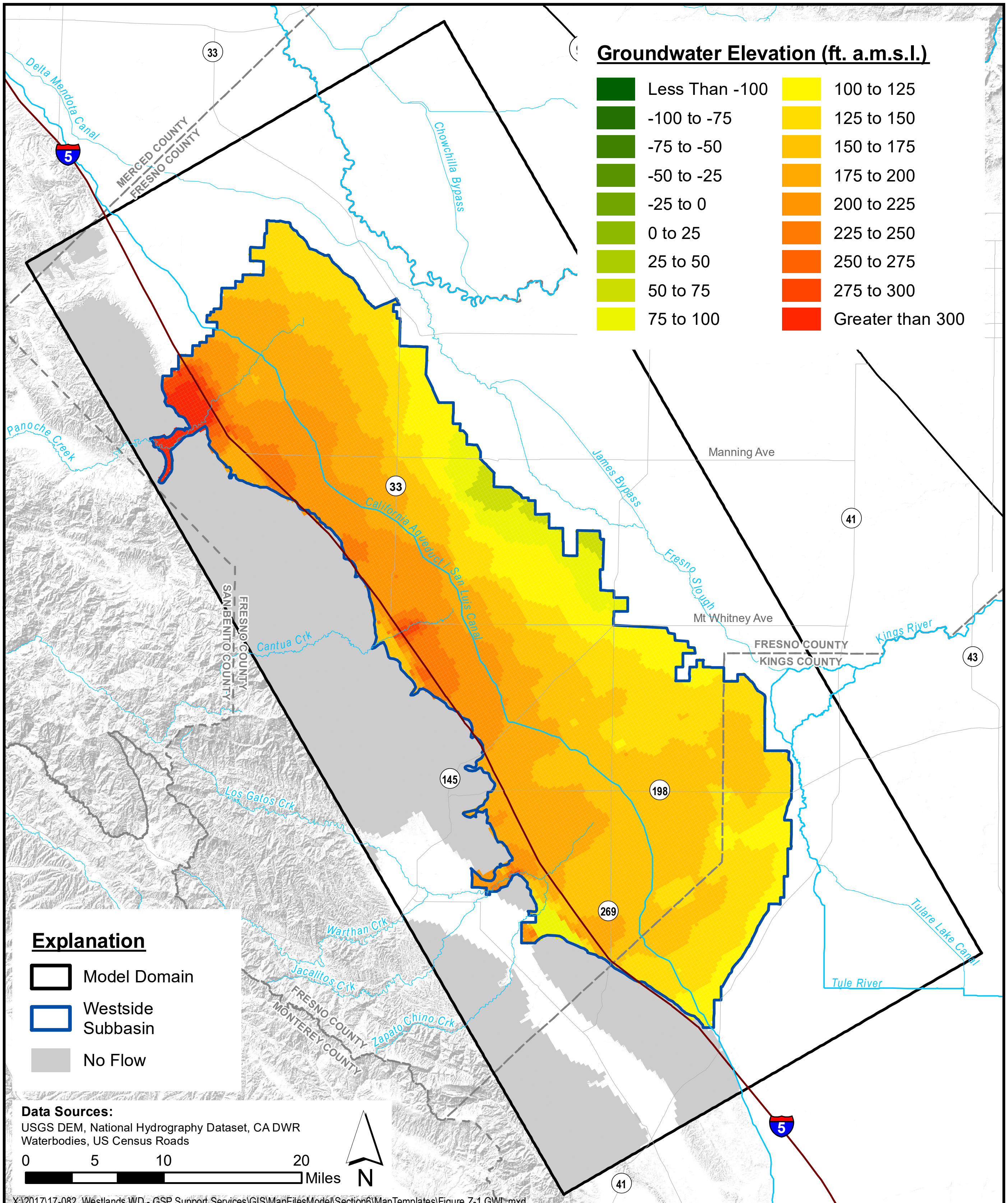
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - Baseline (January 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-1



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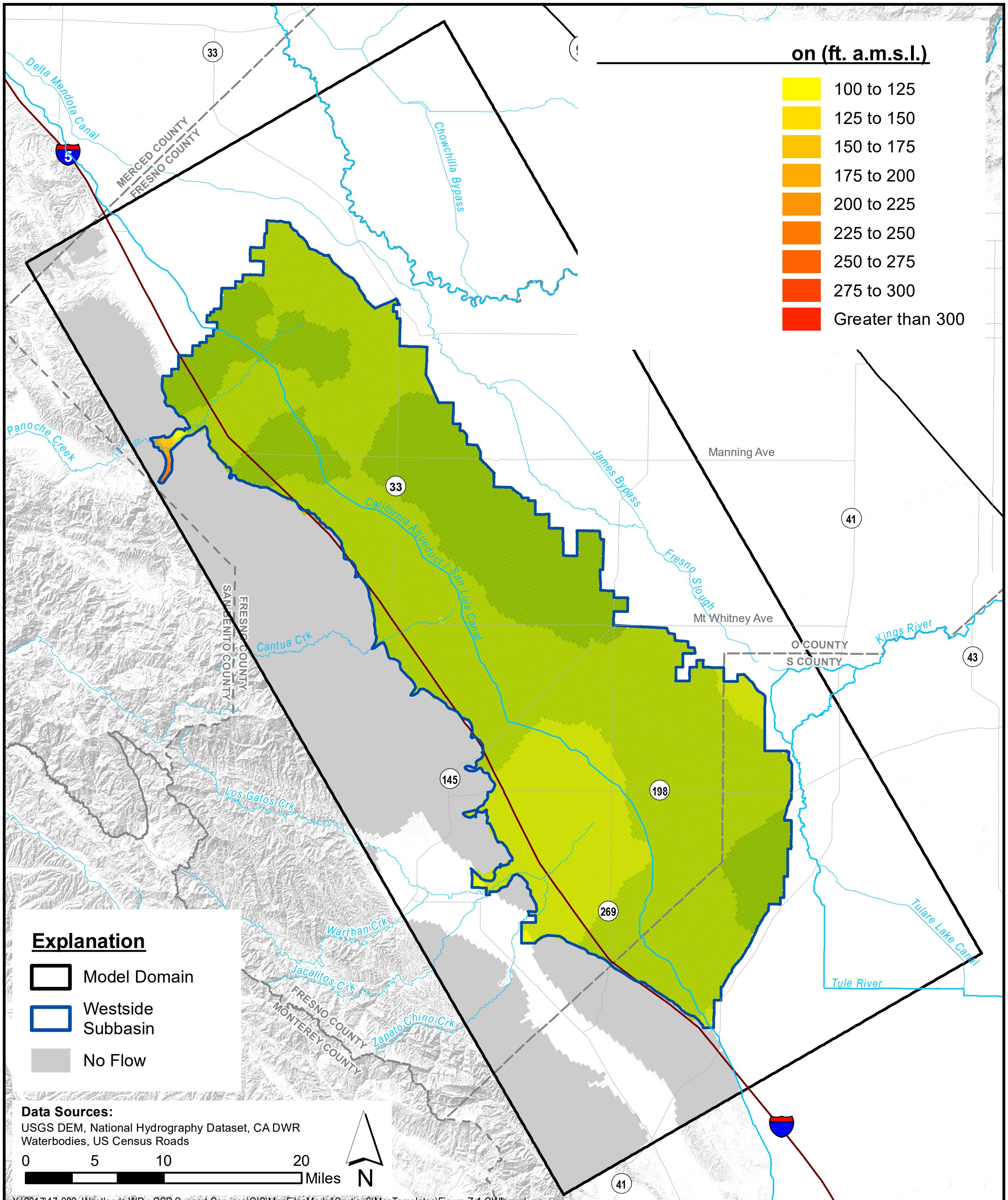
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - Baseline (January 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-2



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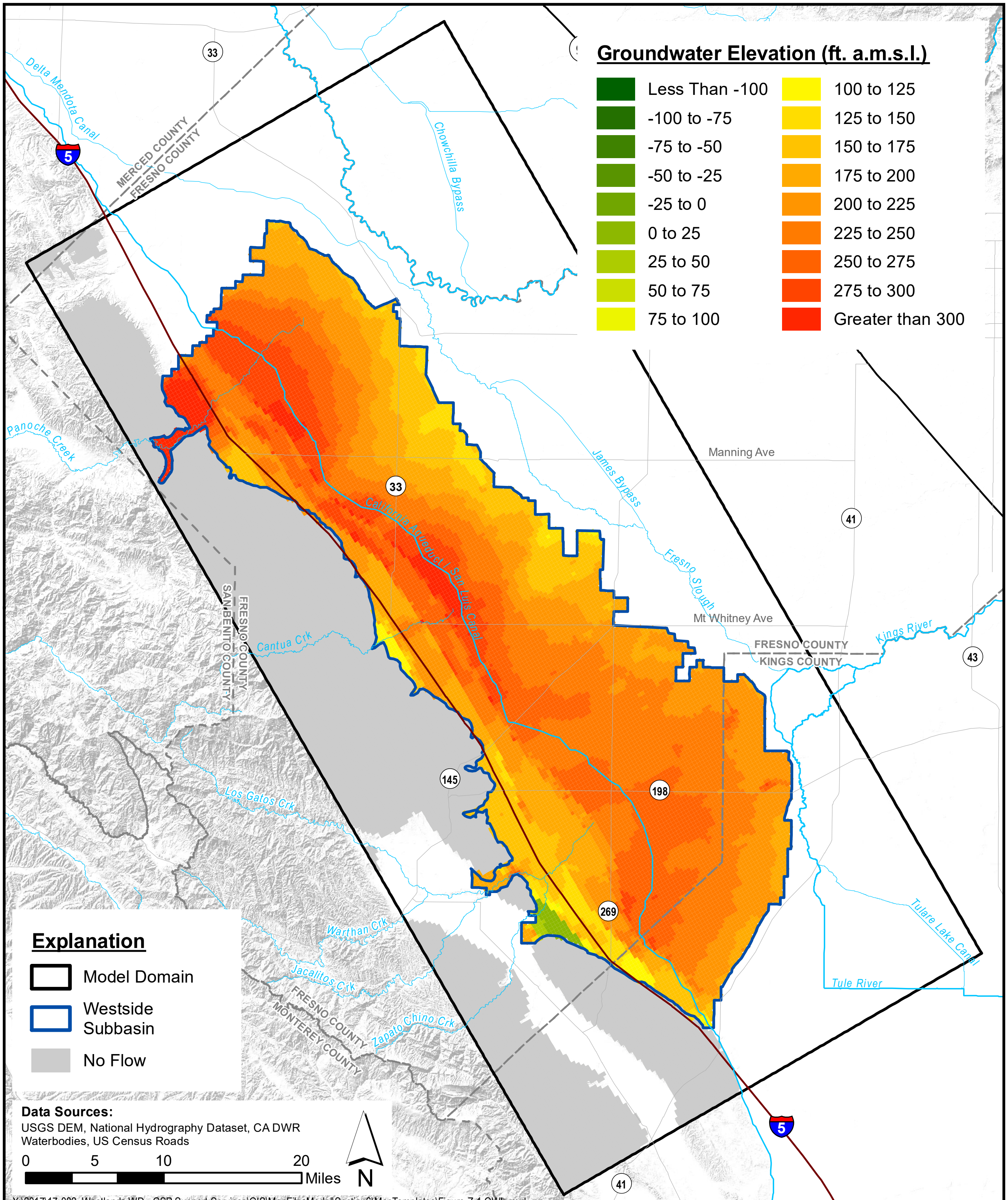
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - Baseline (January 2040)

Figure G-3

SGMA Sustainability Analyses
Westside Subbasin



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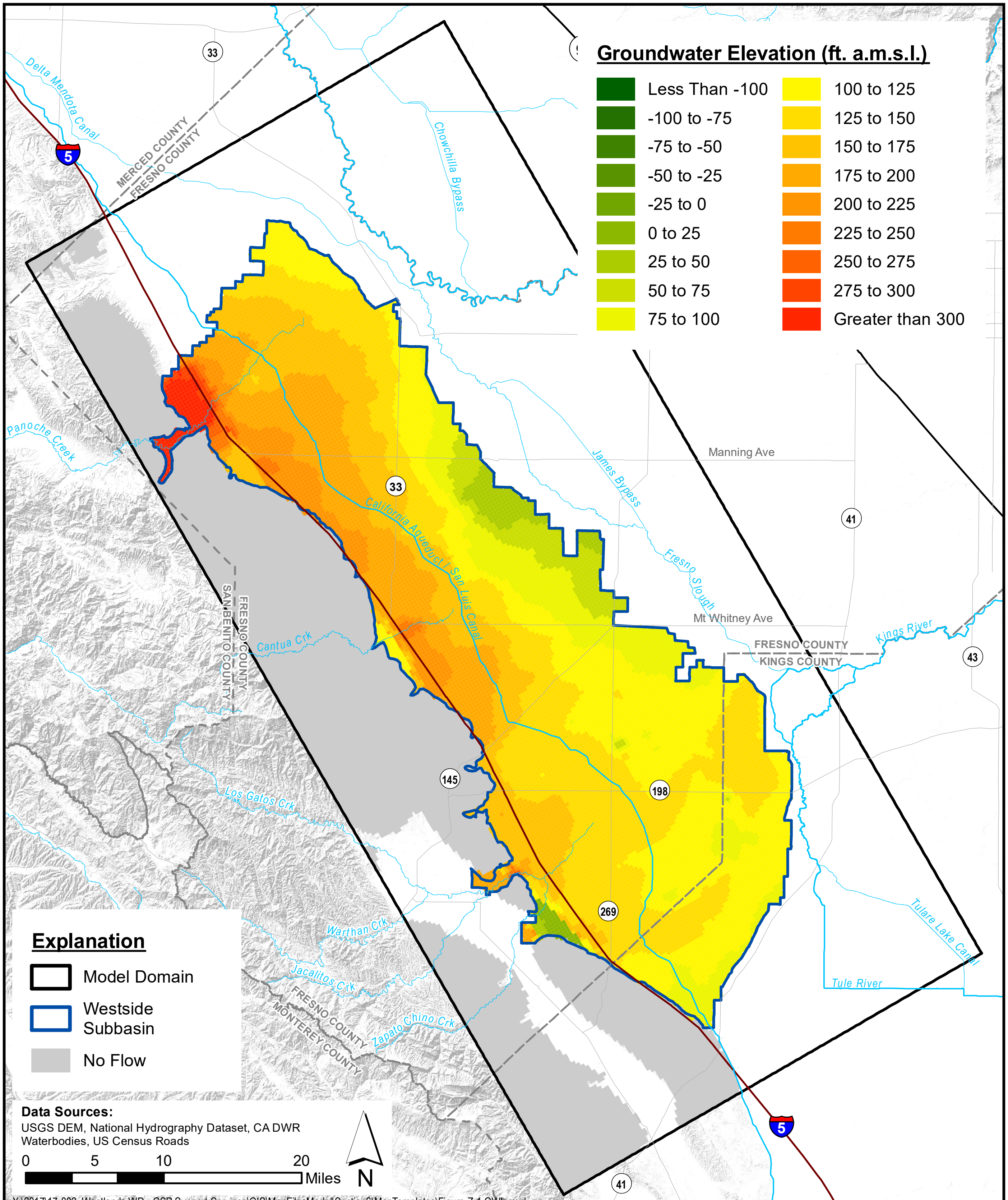
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - Baseline (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-4



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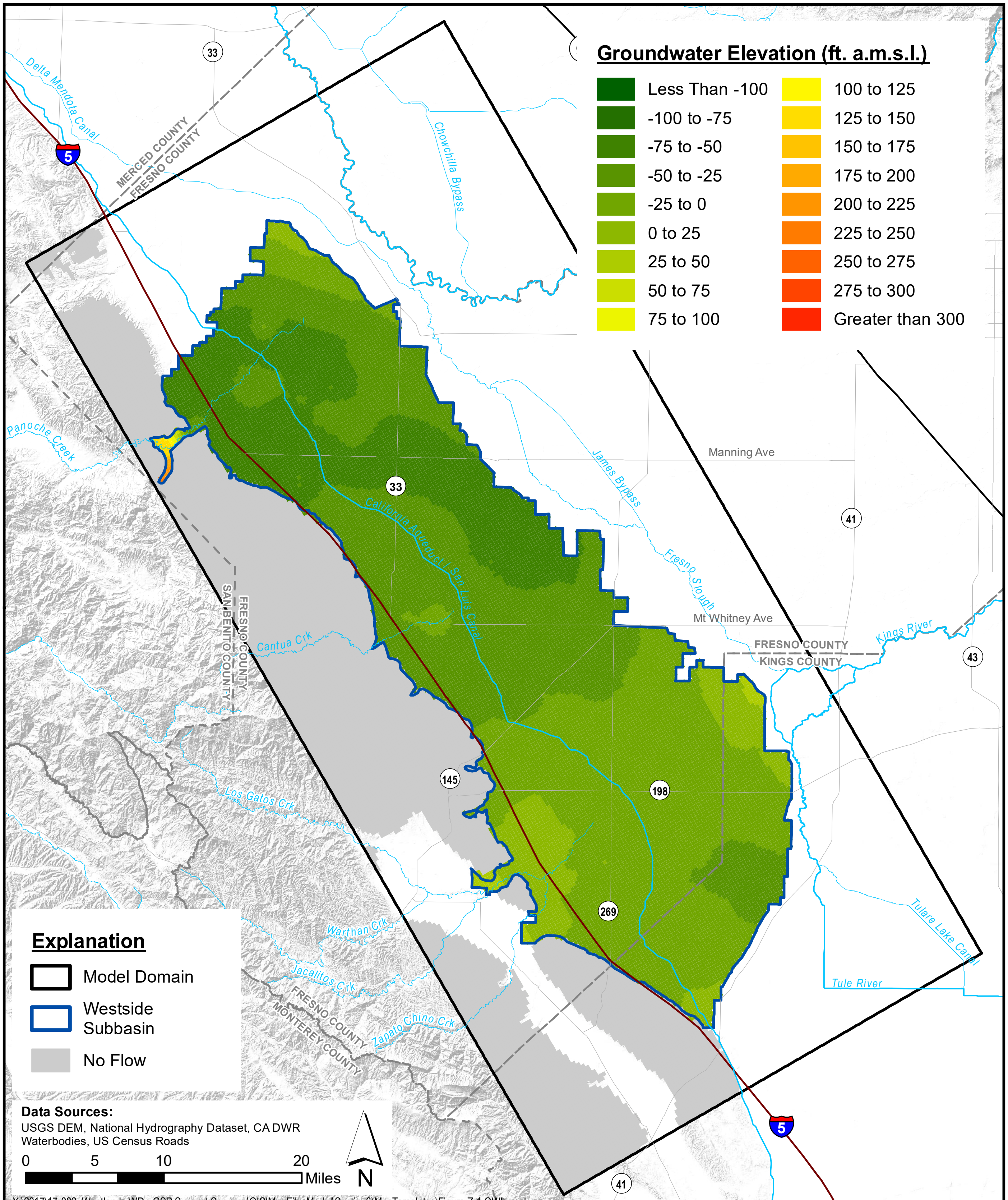
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - Baseline (January 2071)

Figure G-5

SGMA Sustainability Analyses
Westside Subbasin



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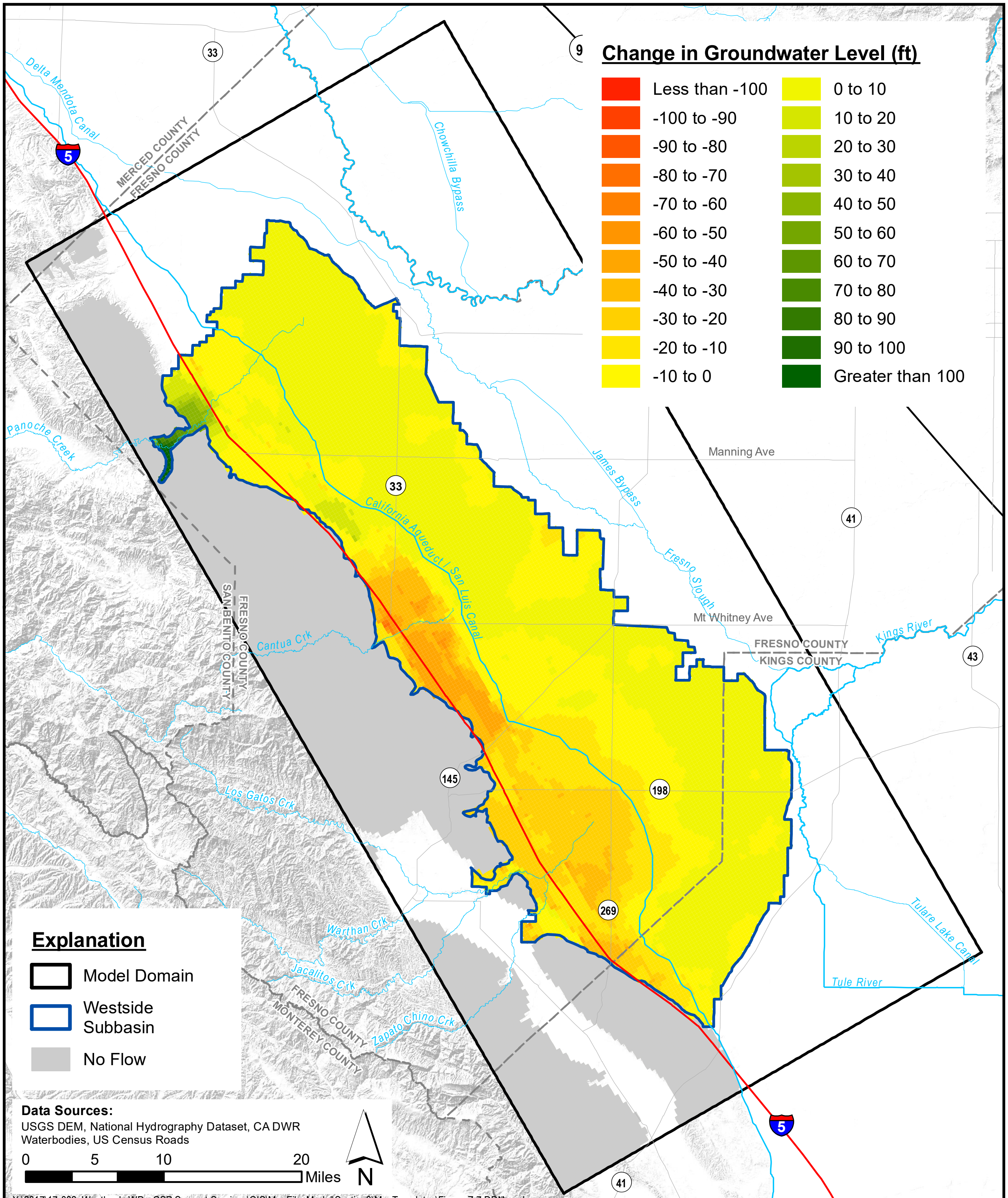
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - Baseline (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-6



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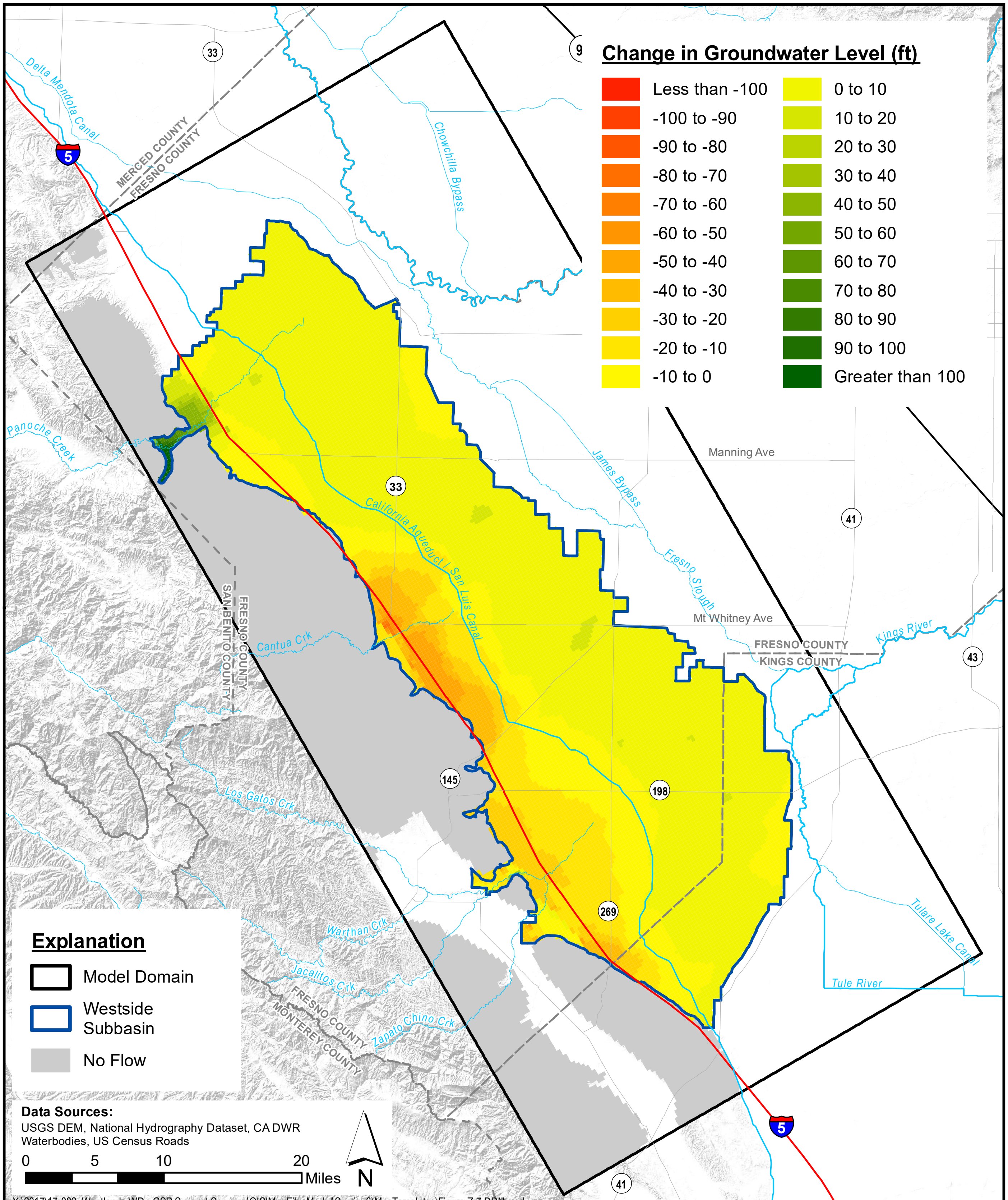
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - Baseline (2020 - 2040)

Figure G-7

SGMA Sustainability Analyses
Westside Subbasin



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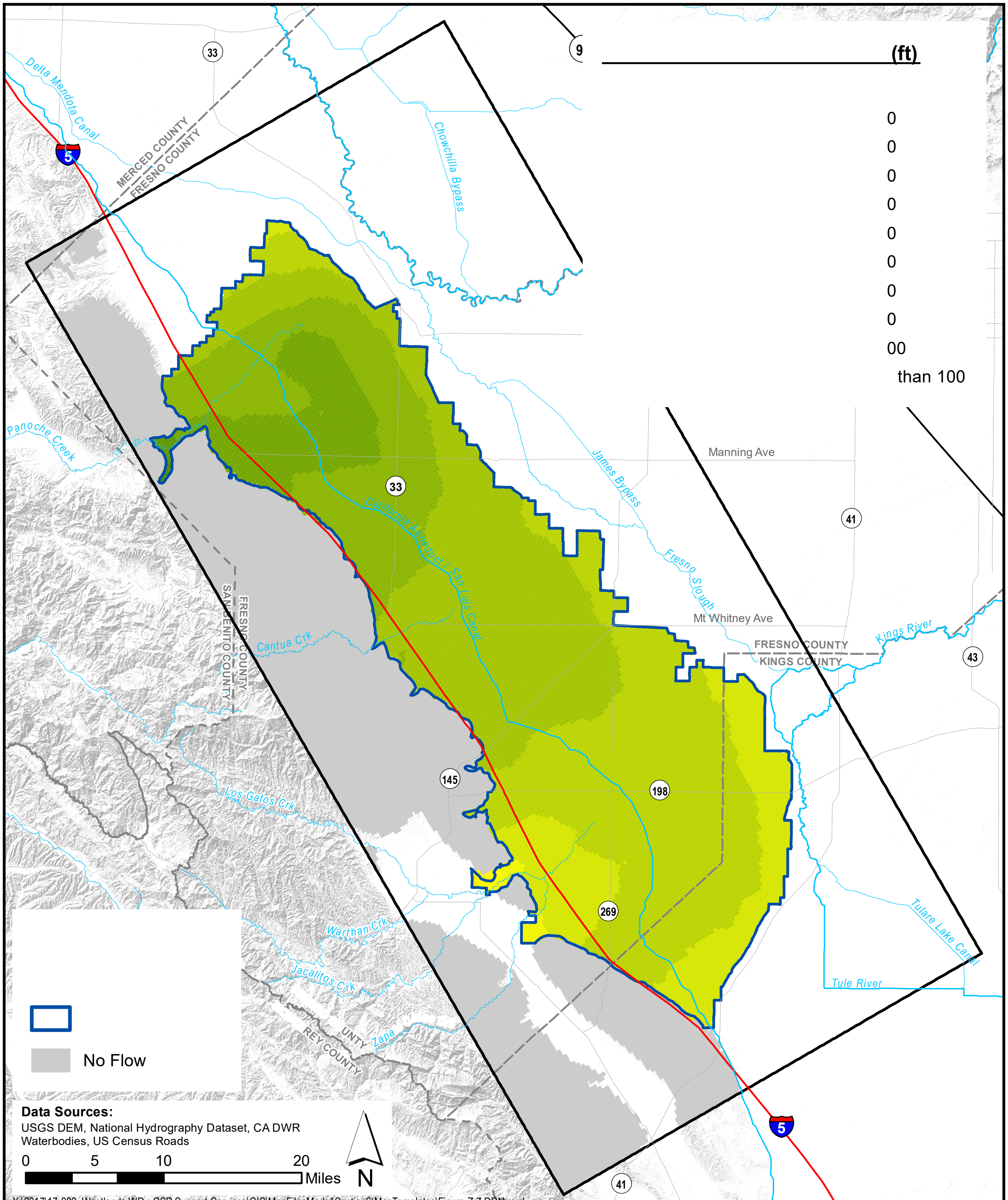
Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - Baseline (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-8



Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - Baseline (2020 - 2040)

Figure G-9

SGMA Sustainability Analyses
Westside Subbasin

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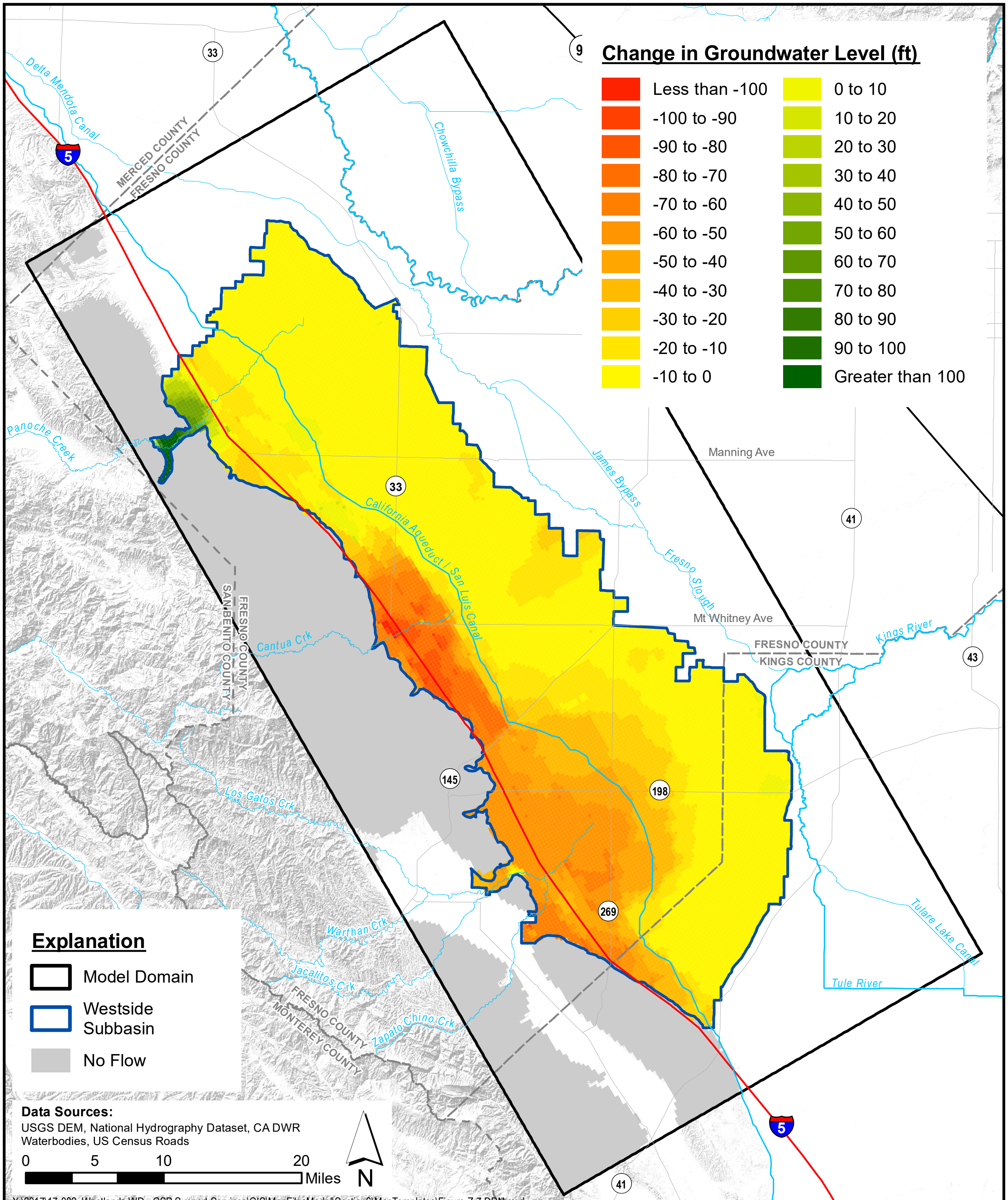

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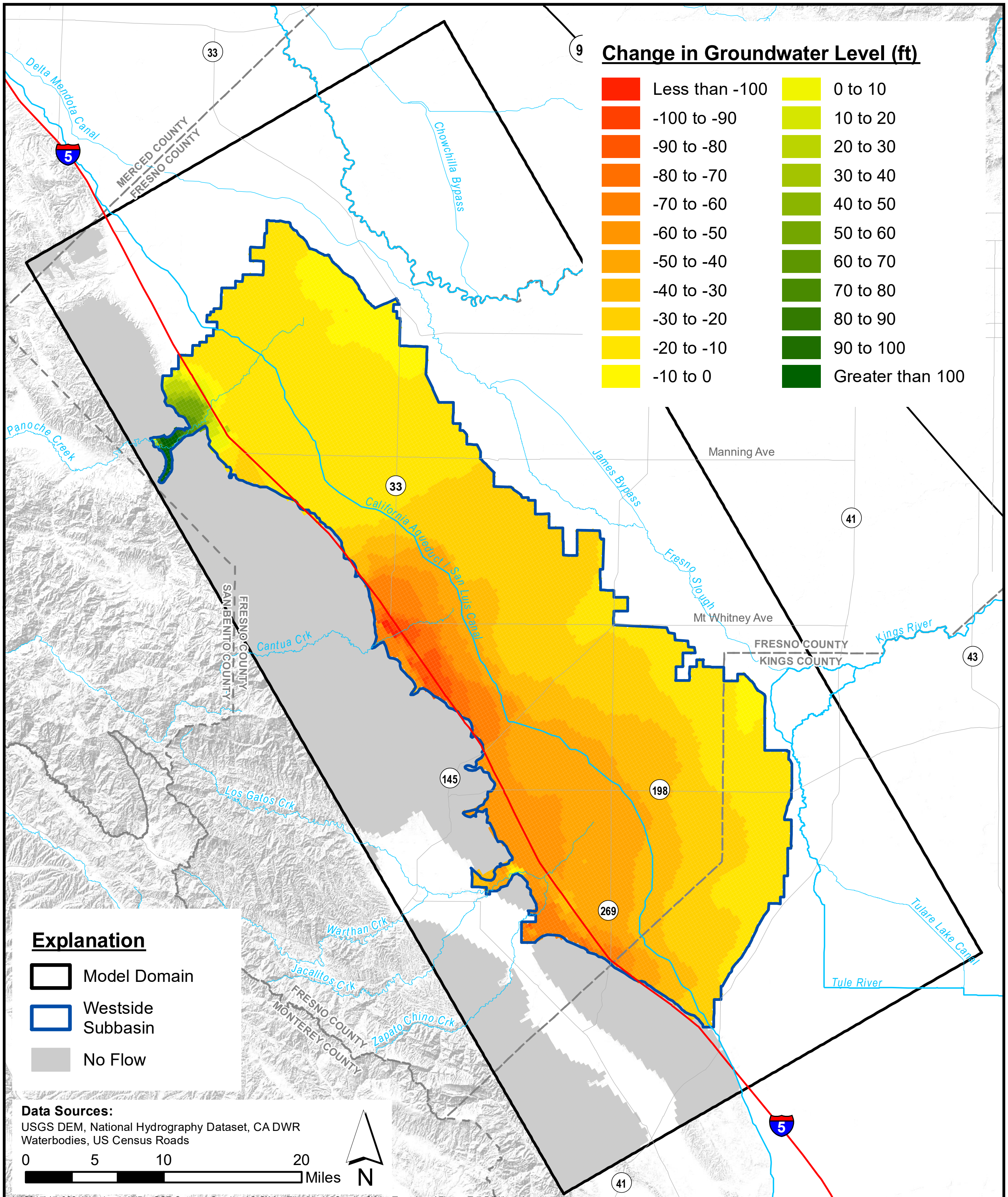
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - Baseline (2020 - 2070)

Figure G-10

SGMA Sustainability Analyses
Westside Subbasin



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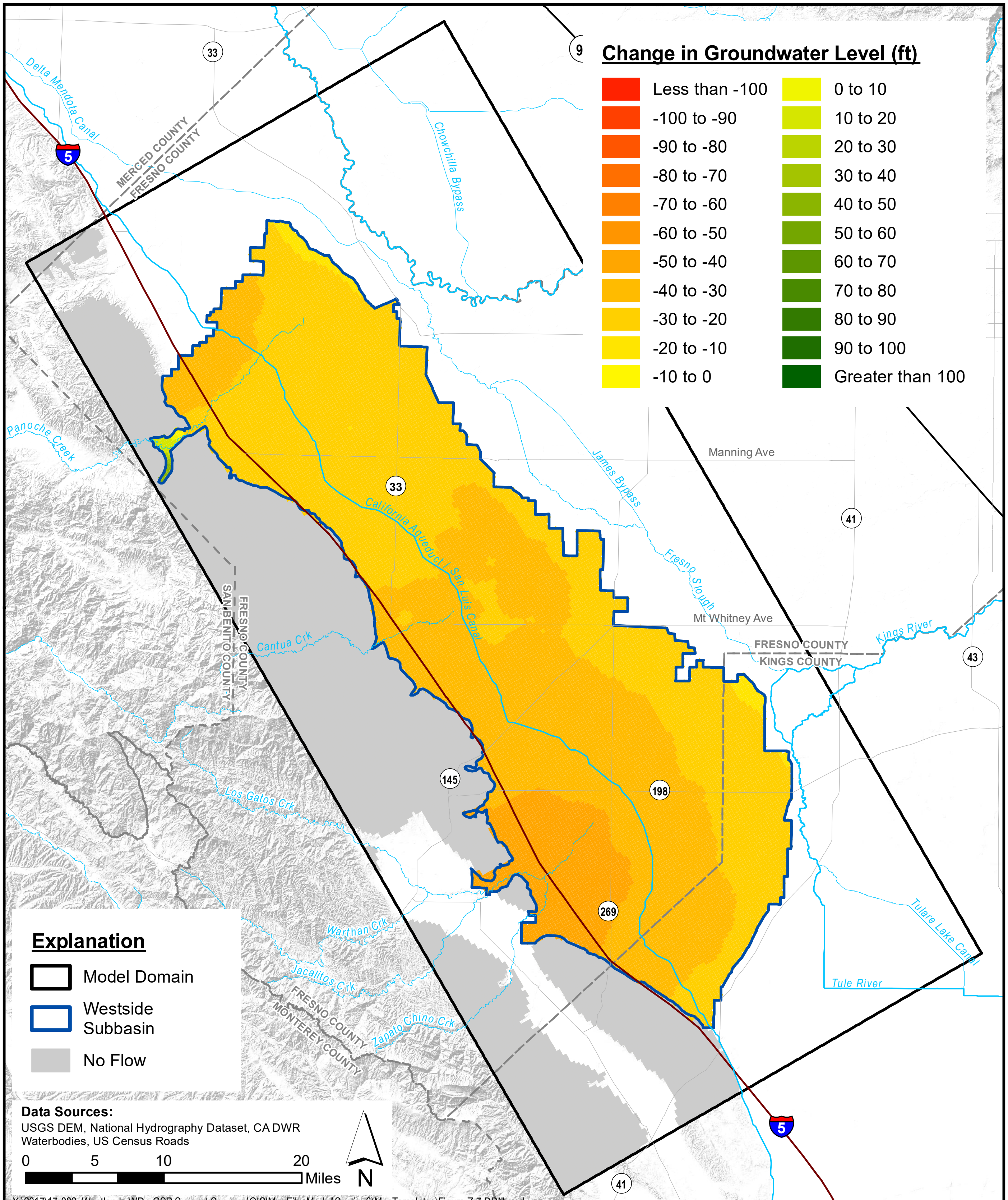
Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - Baseline (2020 - 2070)

Figure G-11

SGMA Sustainability Analyses
Westside Subbasin



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Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - Baseline (2020 - 2070)

Figure G-12

SGMA Sustainability Analyses
Westside Subbasin

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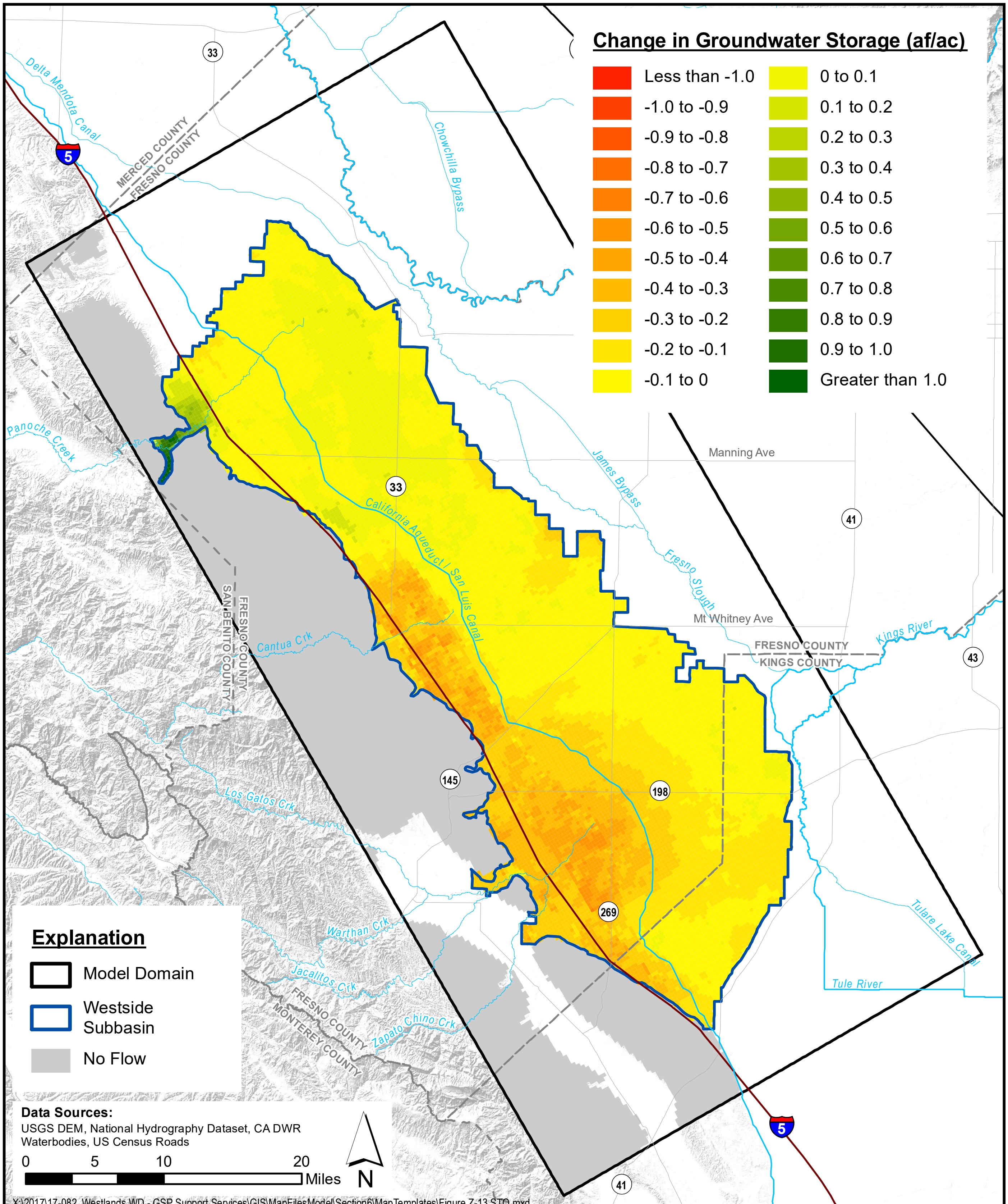

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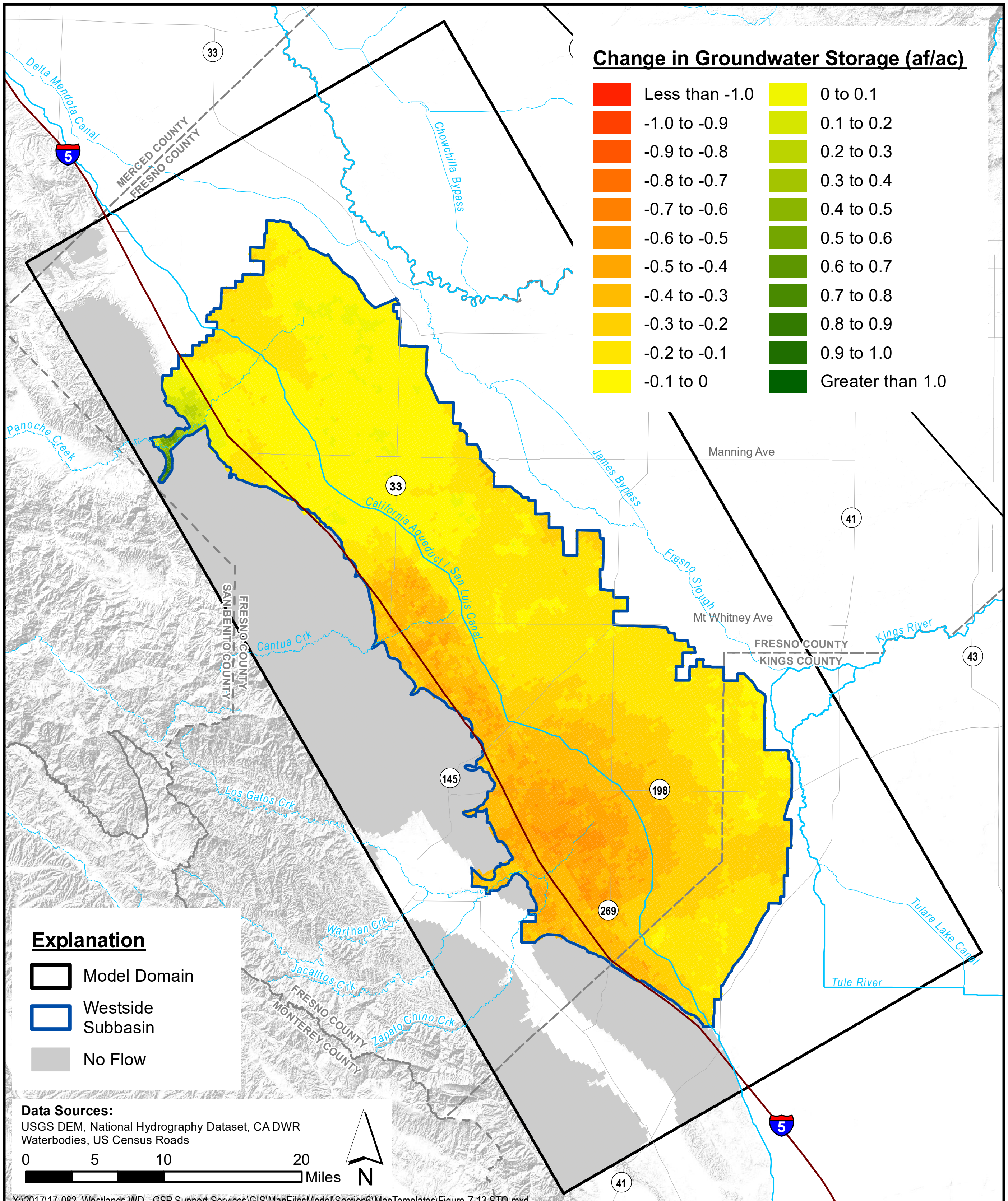
Simulated Change in Groundwater Storage
2070 Climate Change - Baseline (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-13



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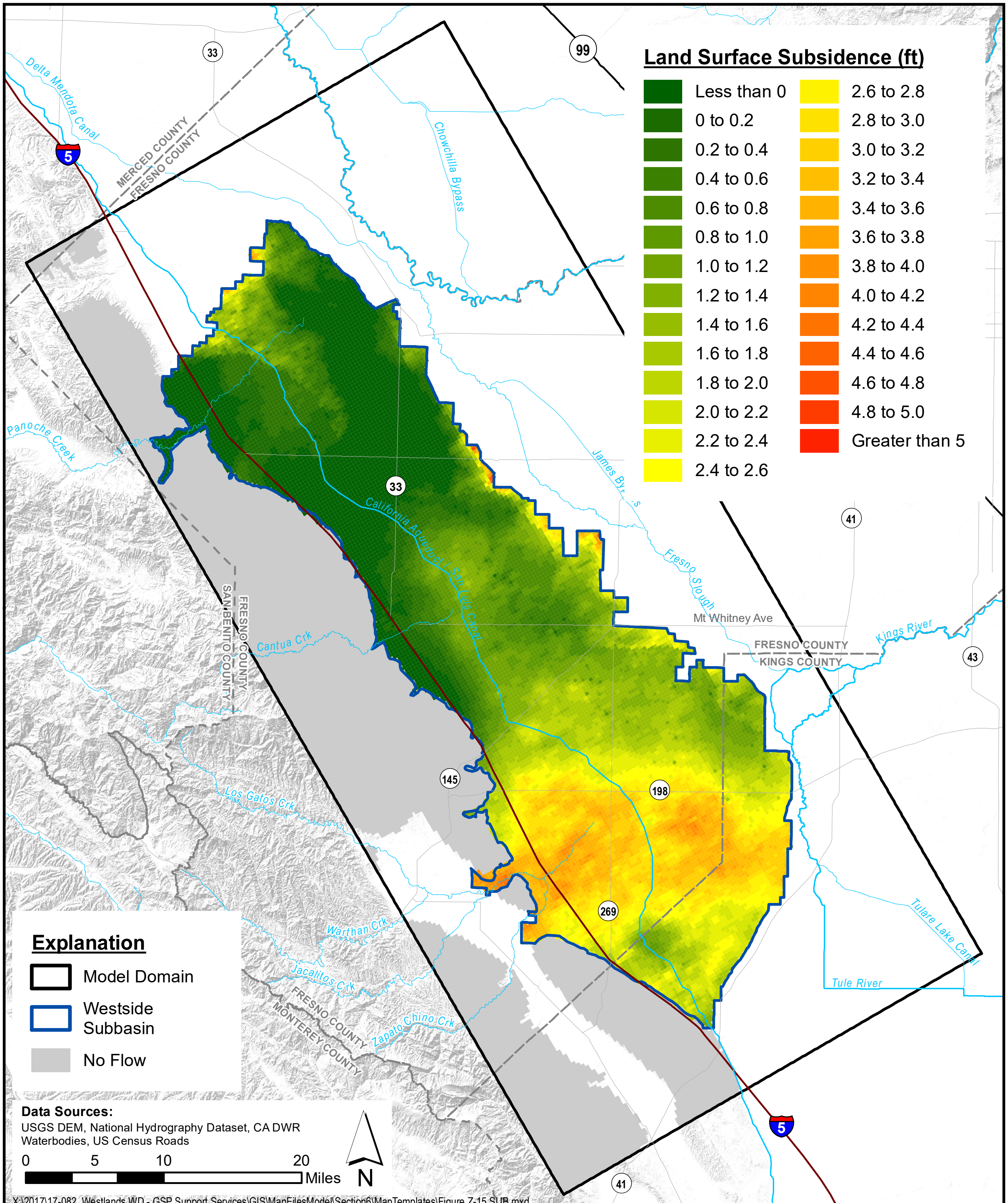
Simulated Change in Groundwater Storage
2070 Climate Change - Baseline (2020 - 2070)

Figure G-14

SGMA Sustainability Analyses
Westside Subbasin



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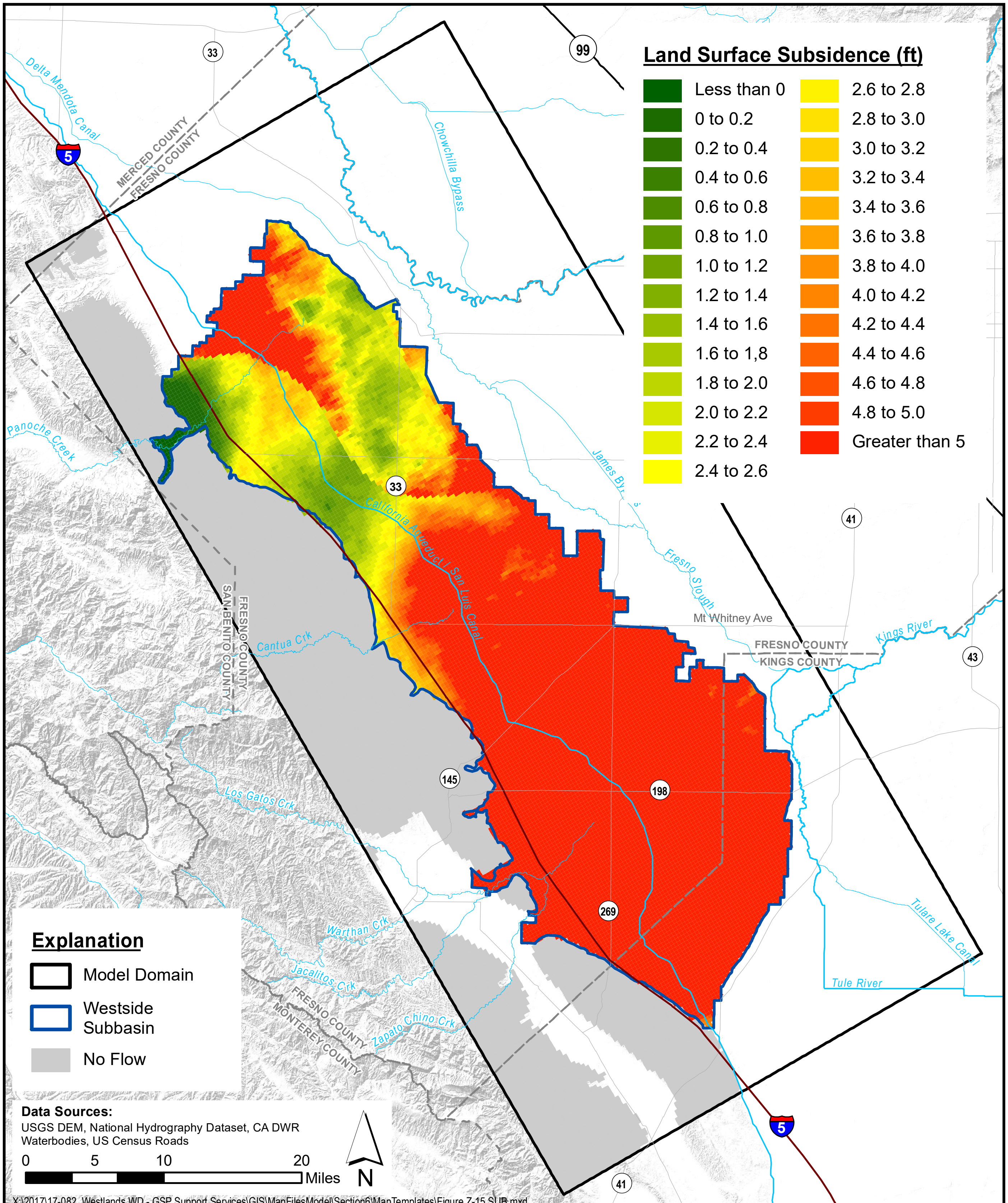
Simulated Land Surface Subsidence
2070 Climate Change - Baseline (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-15



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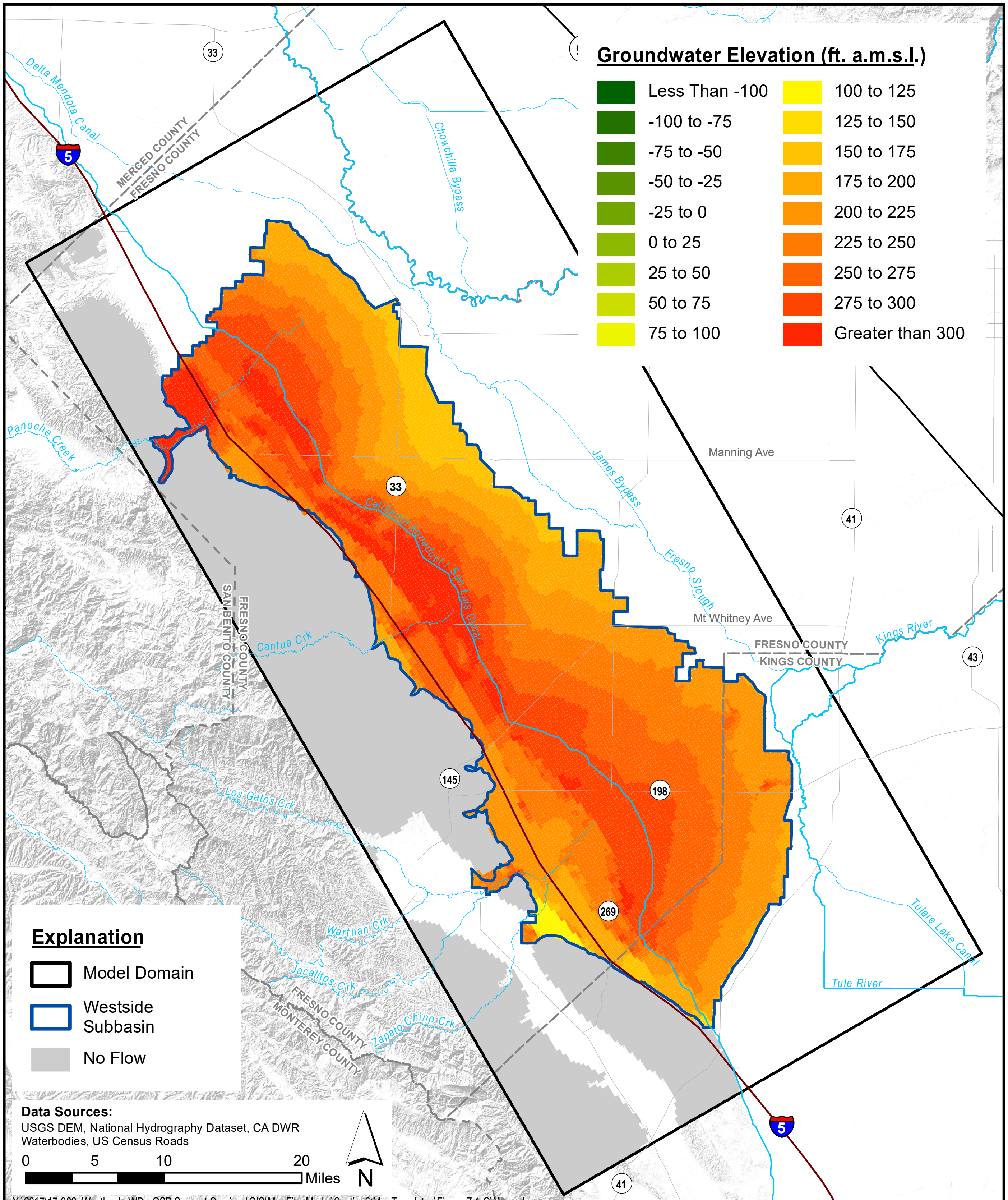
Simulated Land Surface Subsidence
2070 Climate Change - Baseline (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-16



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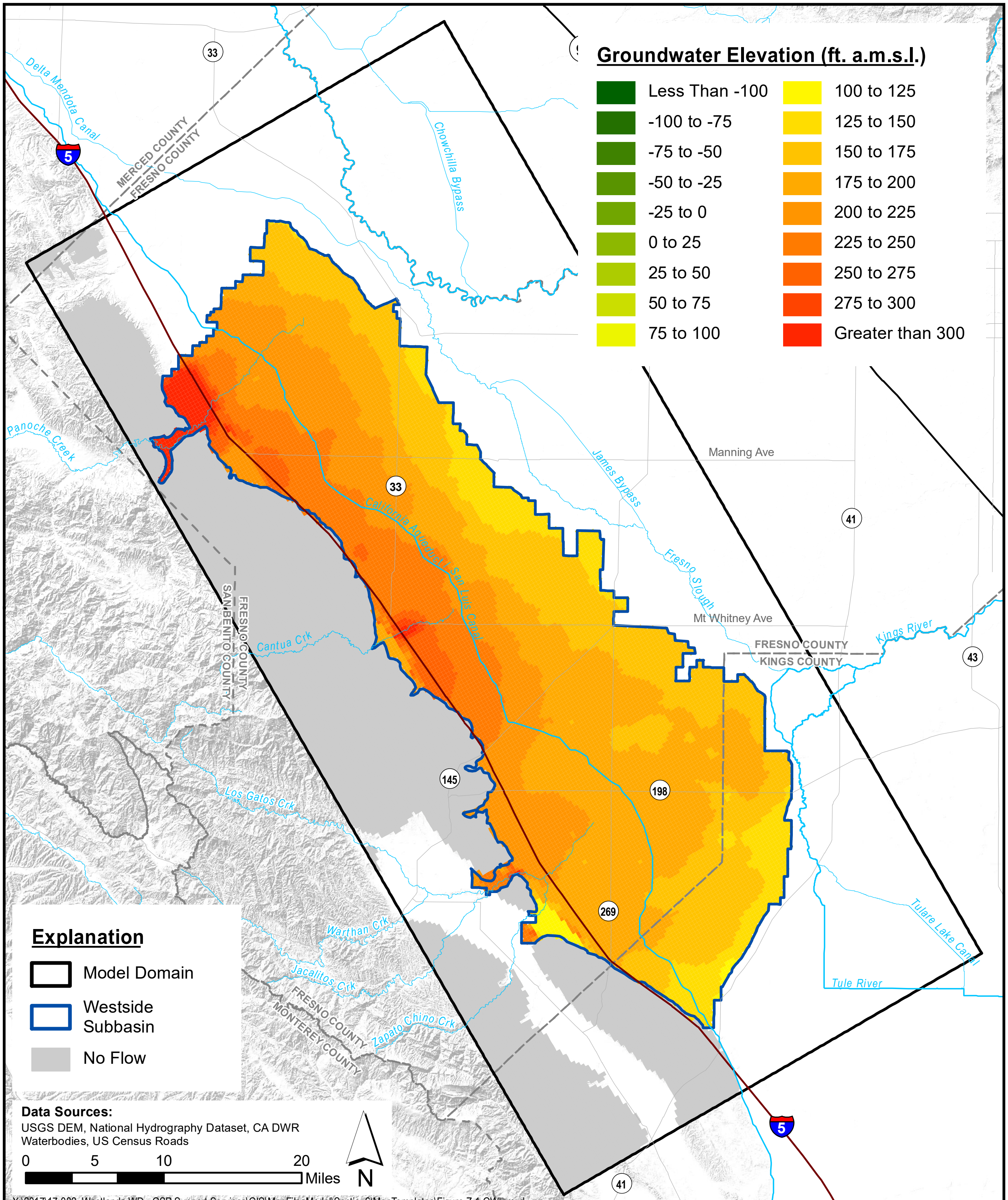
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.2 (January 2040)

Figure G-17

SGMA Sustainability Analyses
Westside Subbasin



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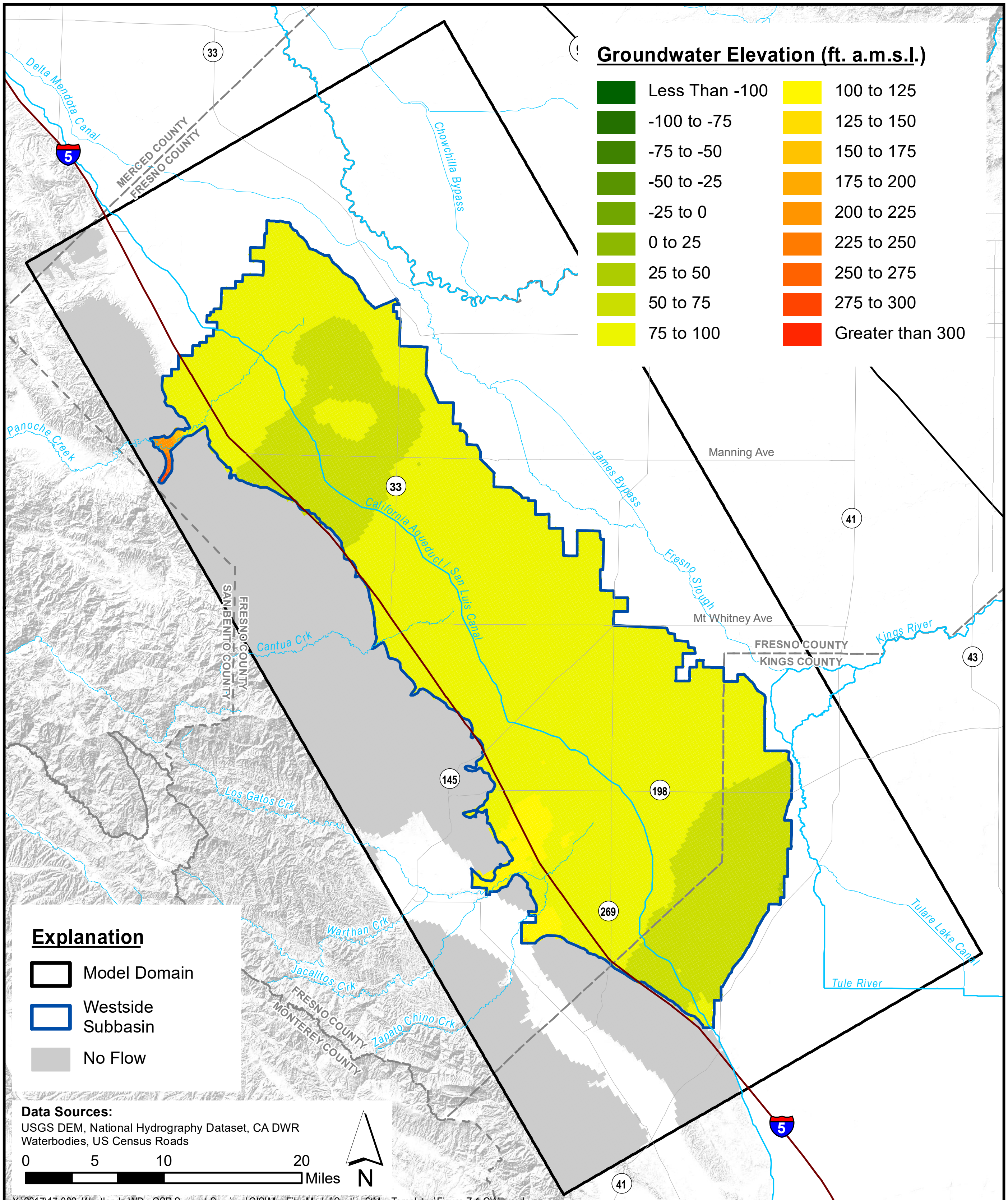
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.2 (January 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-18



Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.2 (January 2040)

Figure G-19

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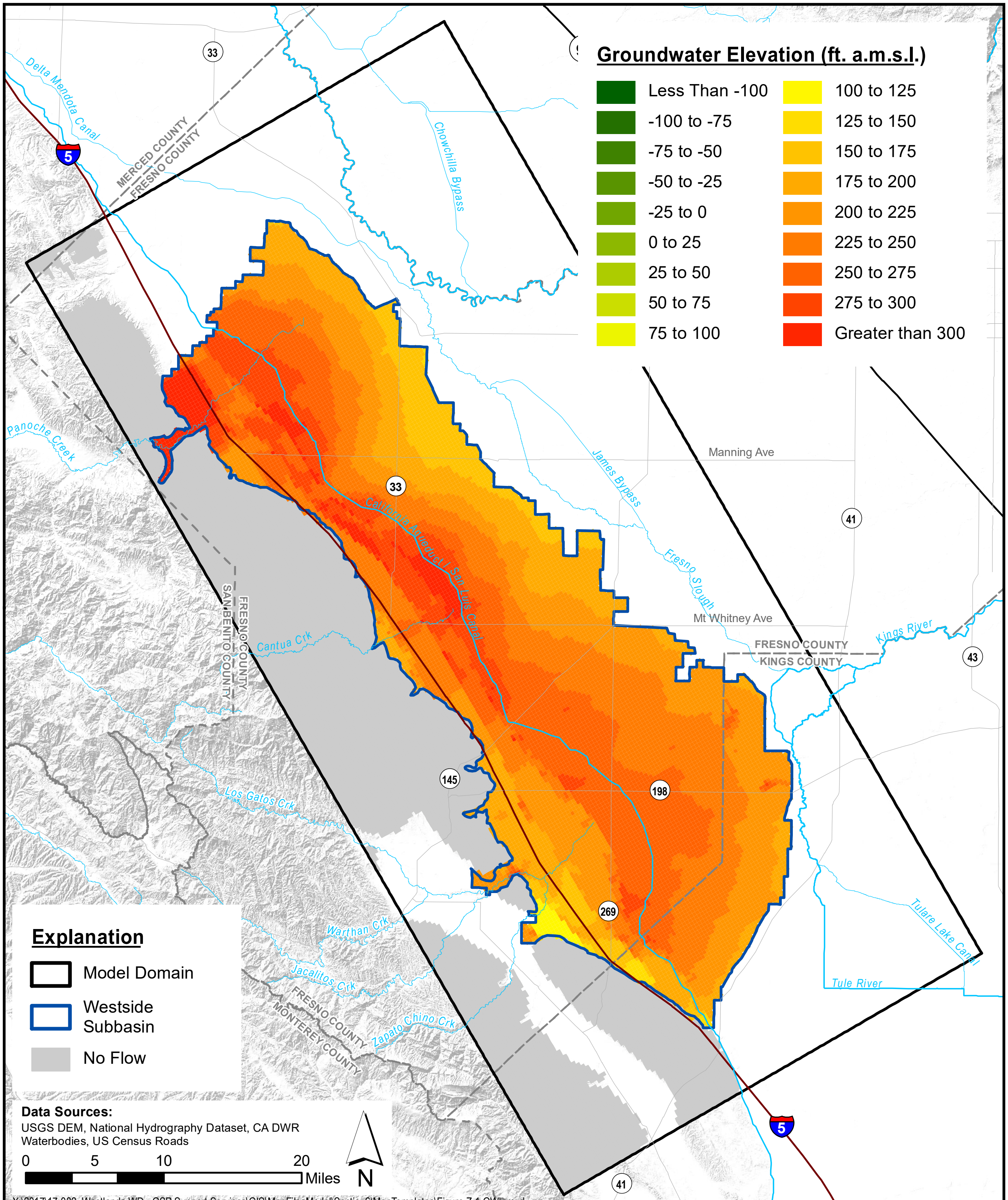
SGMA Sustainability Analyses
Westside Subbasin



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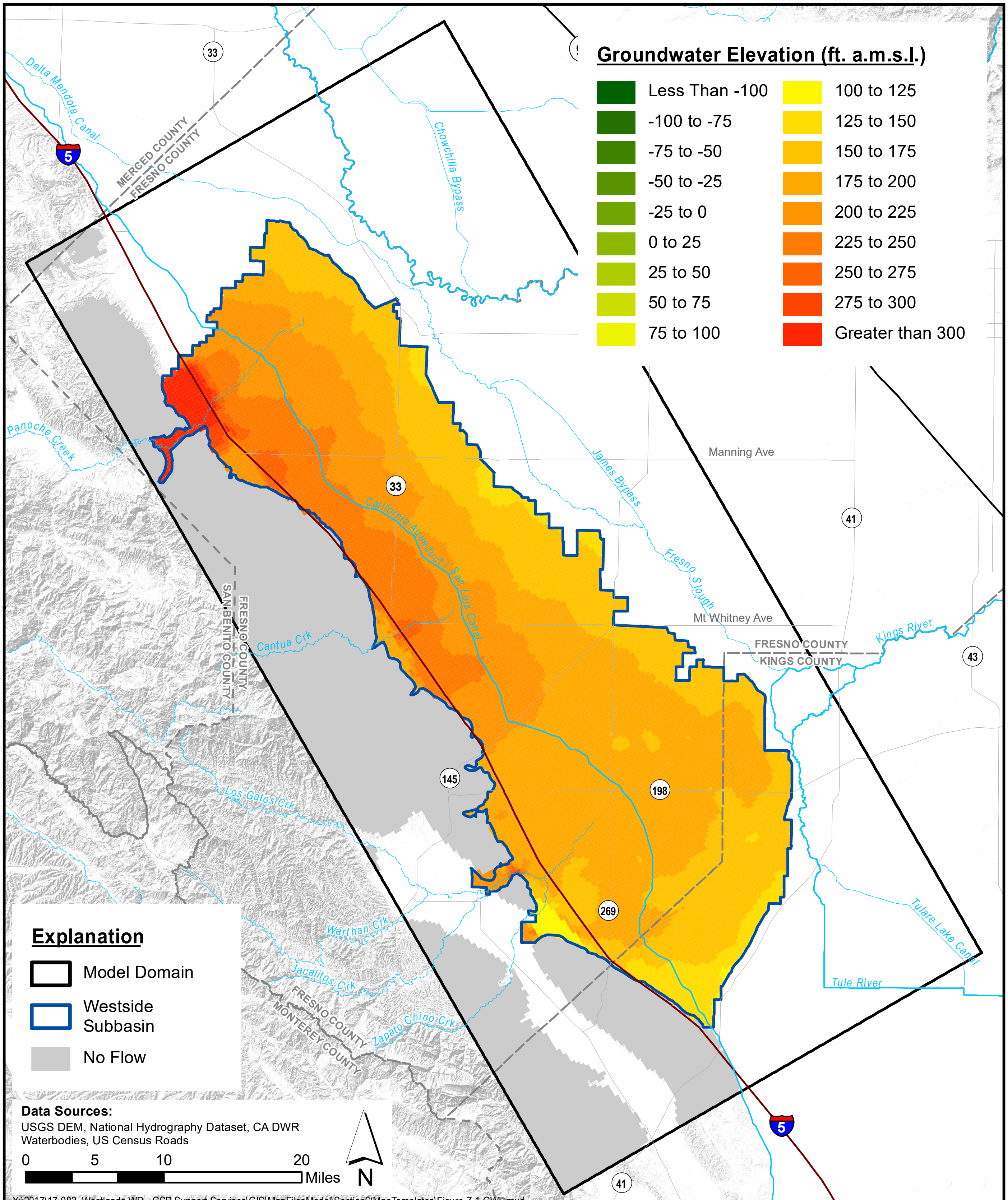
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.2 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-20



Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.2 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-21

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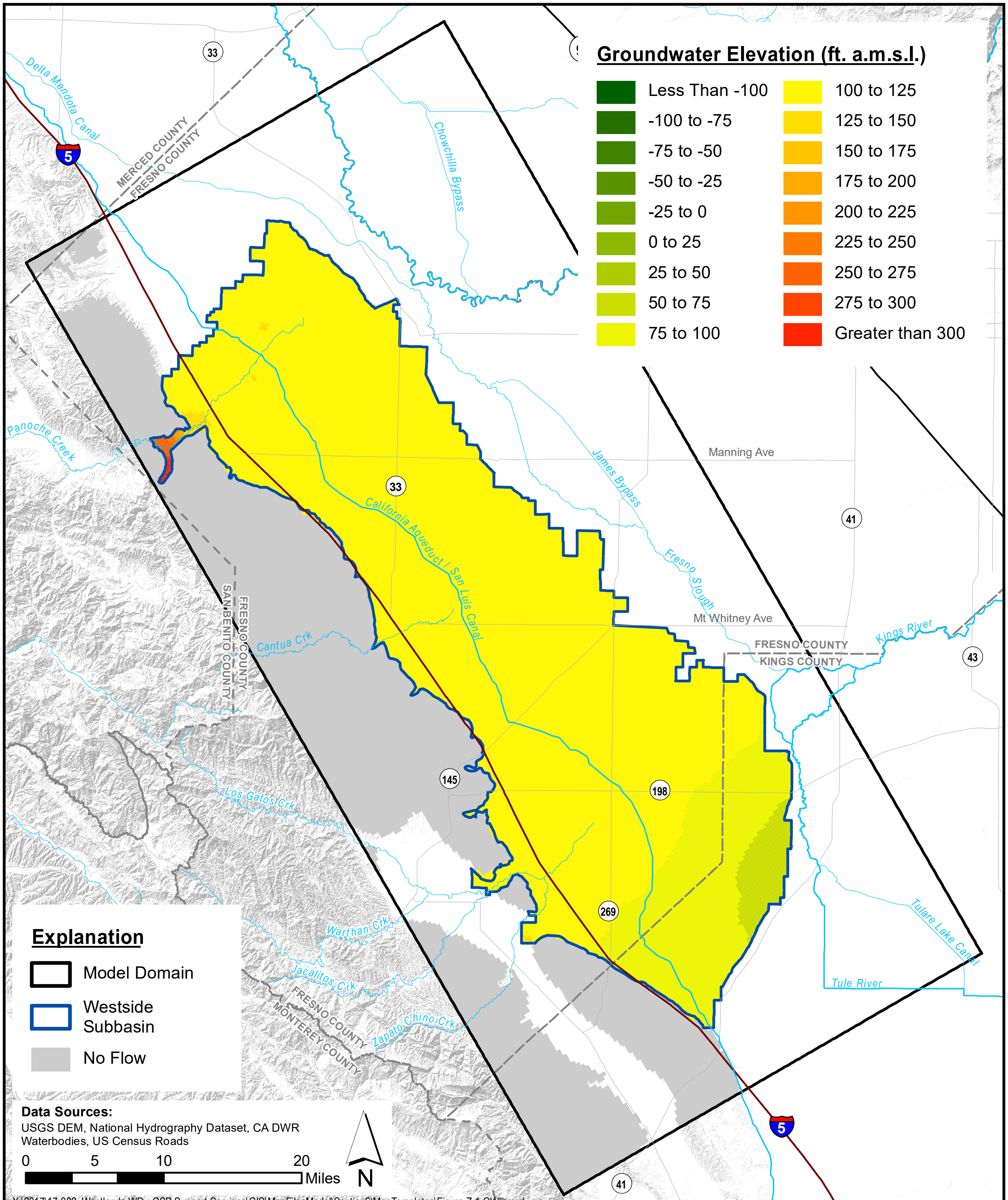

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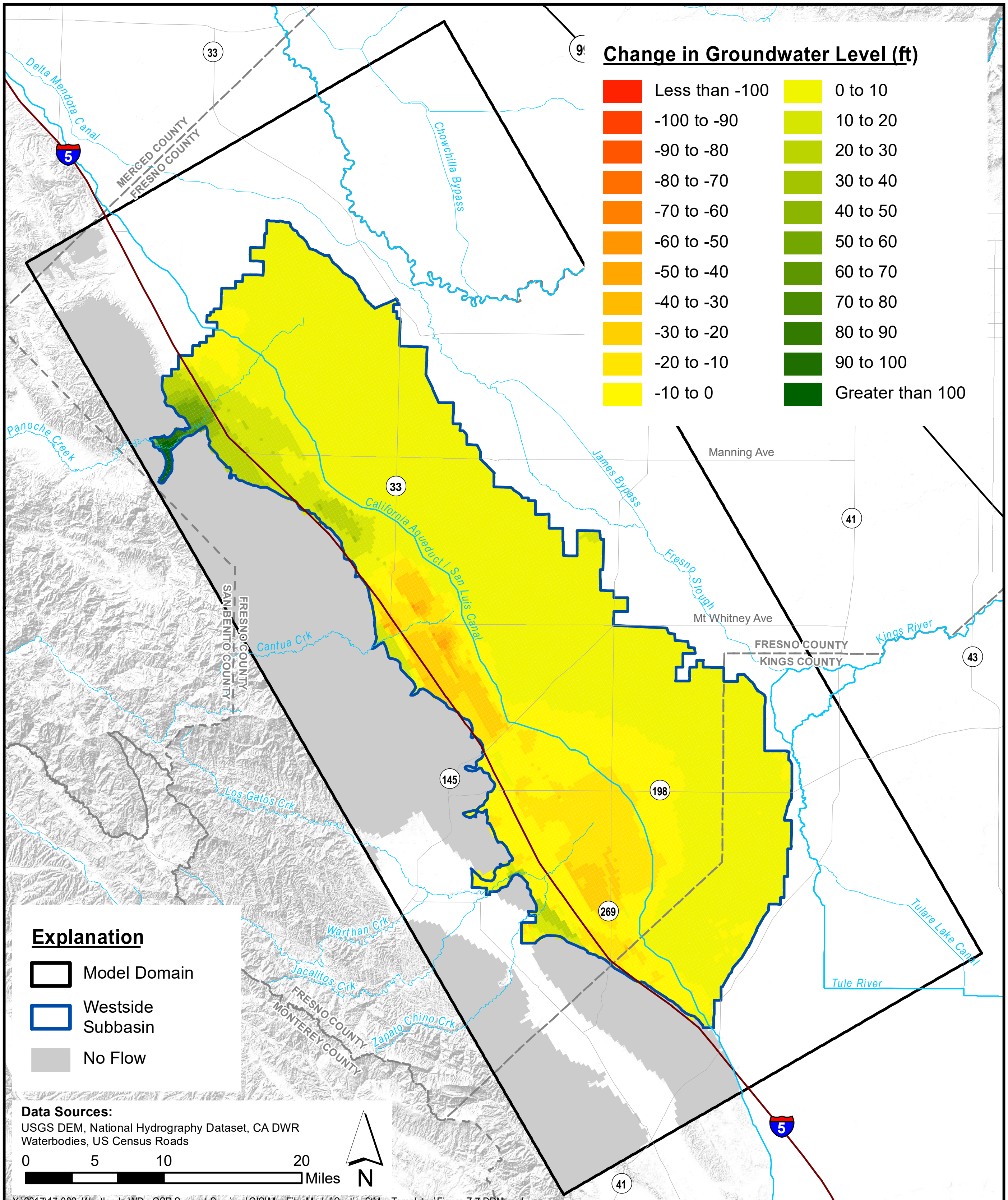
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.2 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-22



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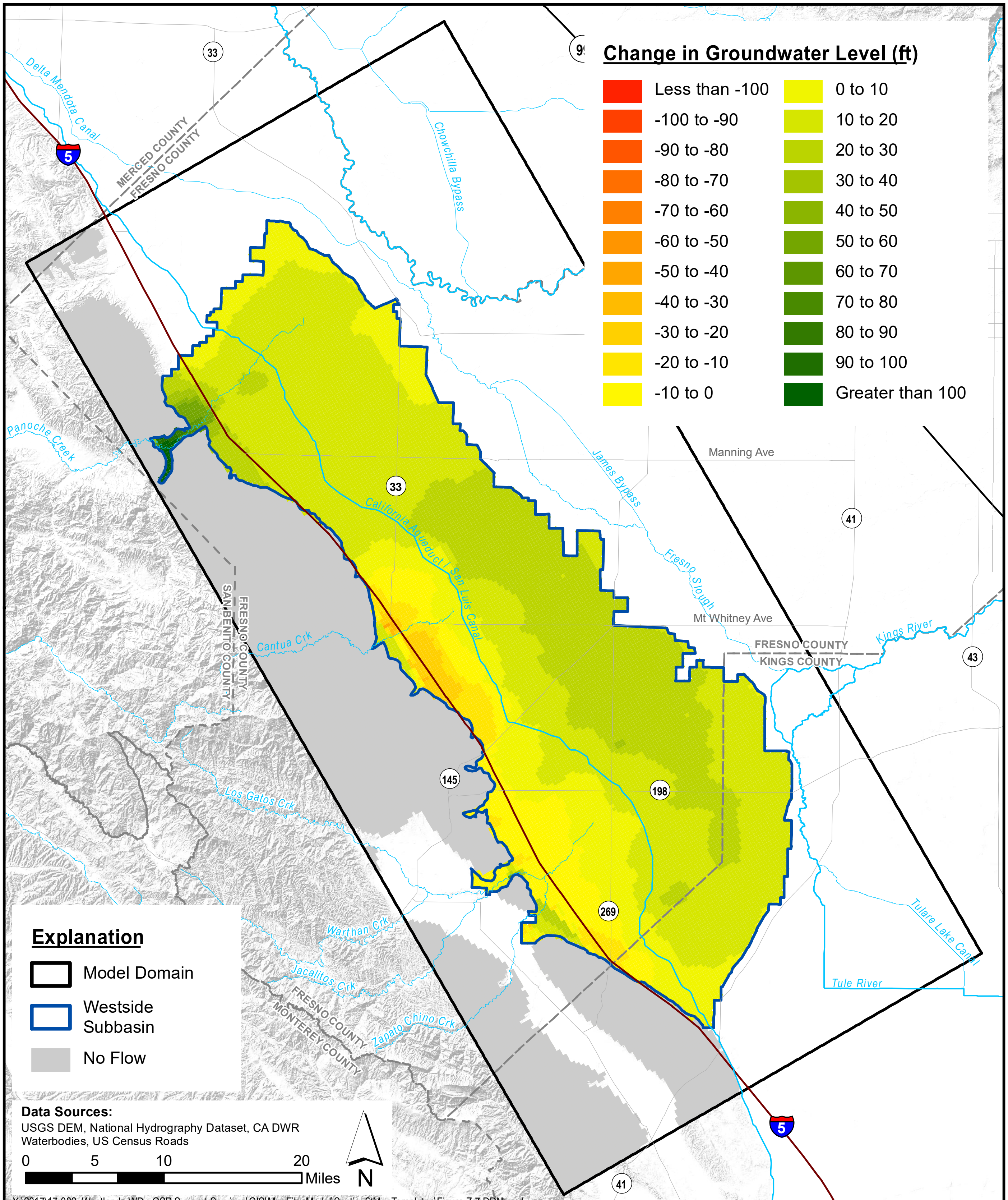
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.2 (2020 - 2040)

Figure G-23

SGMA Sustainability Analyses
Westside Subbasin



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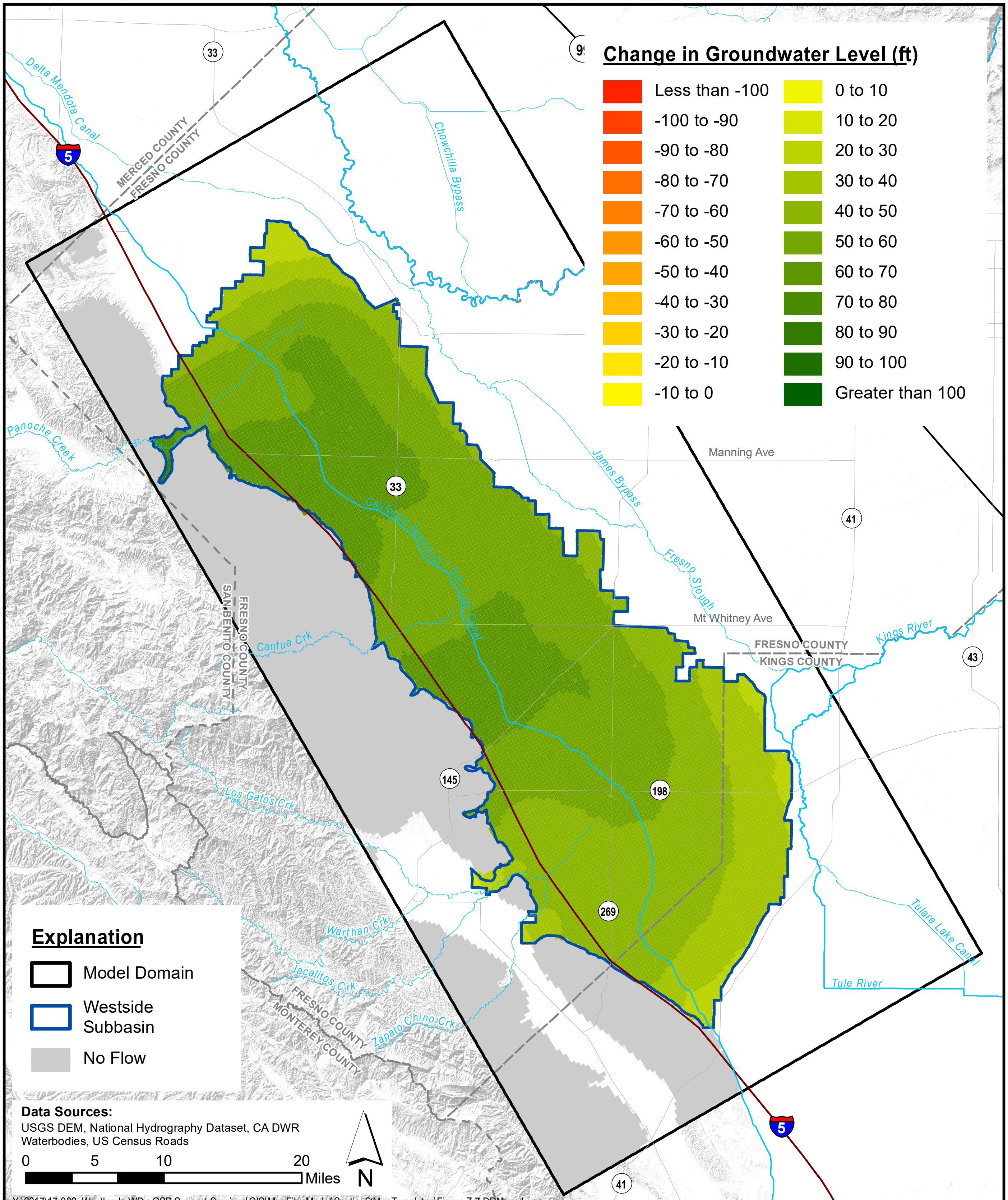
Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.2 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-24



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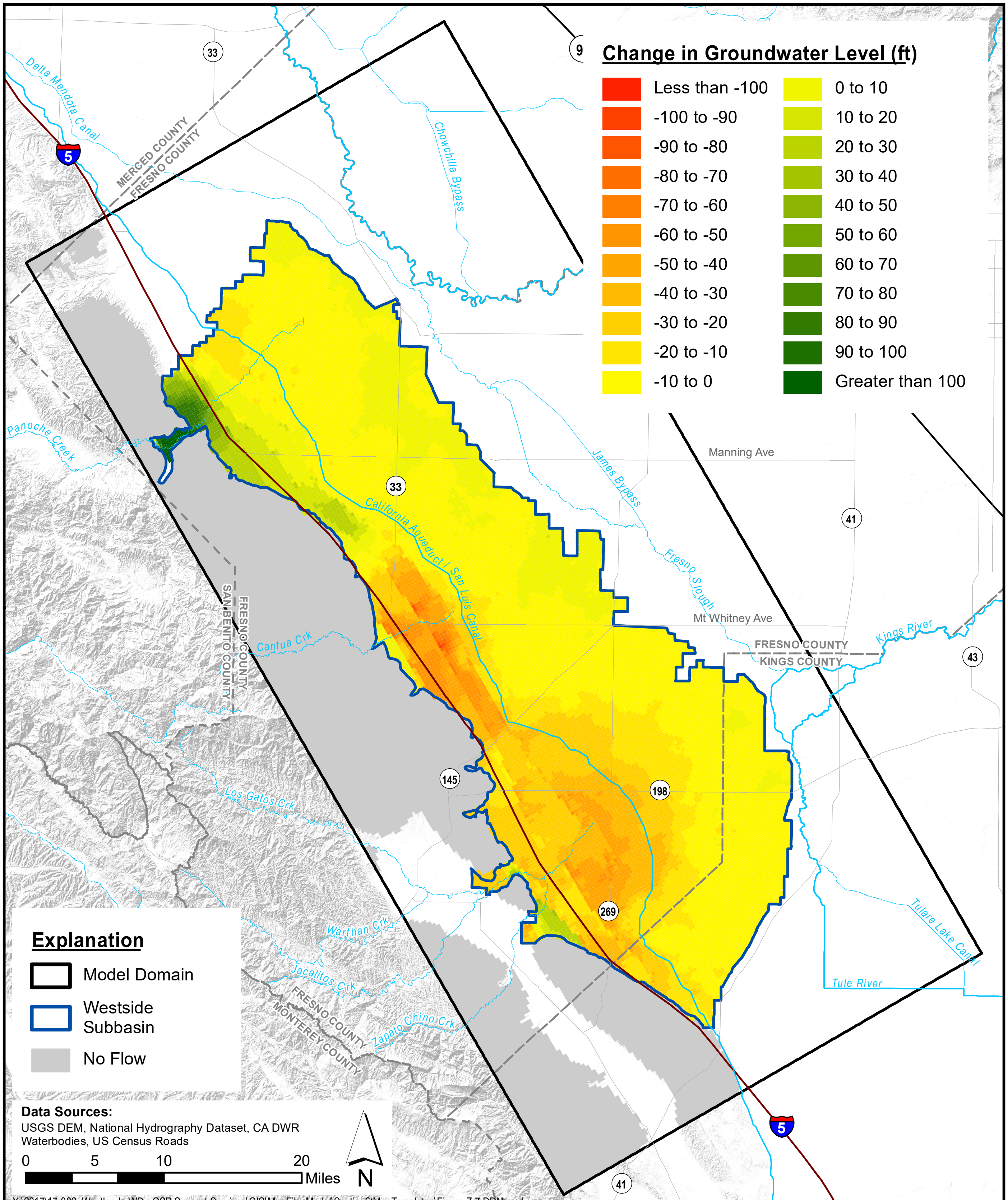
Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.2 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-25



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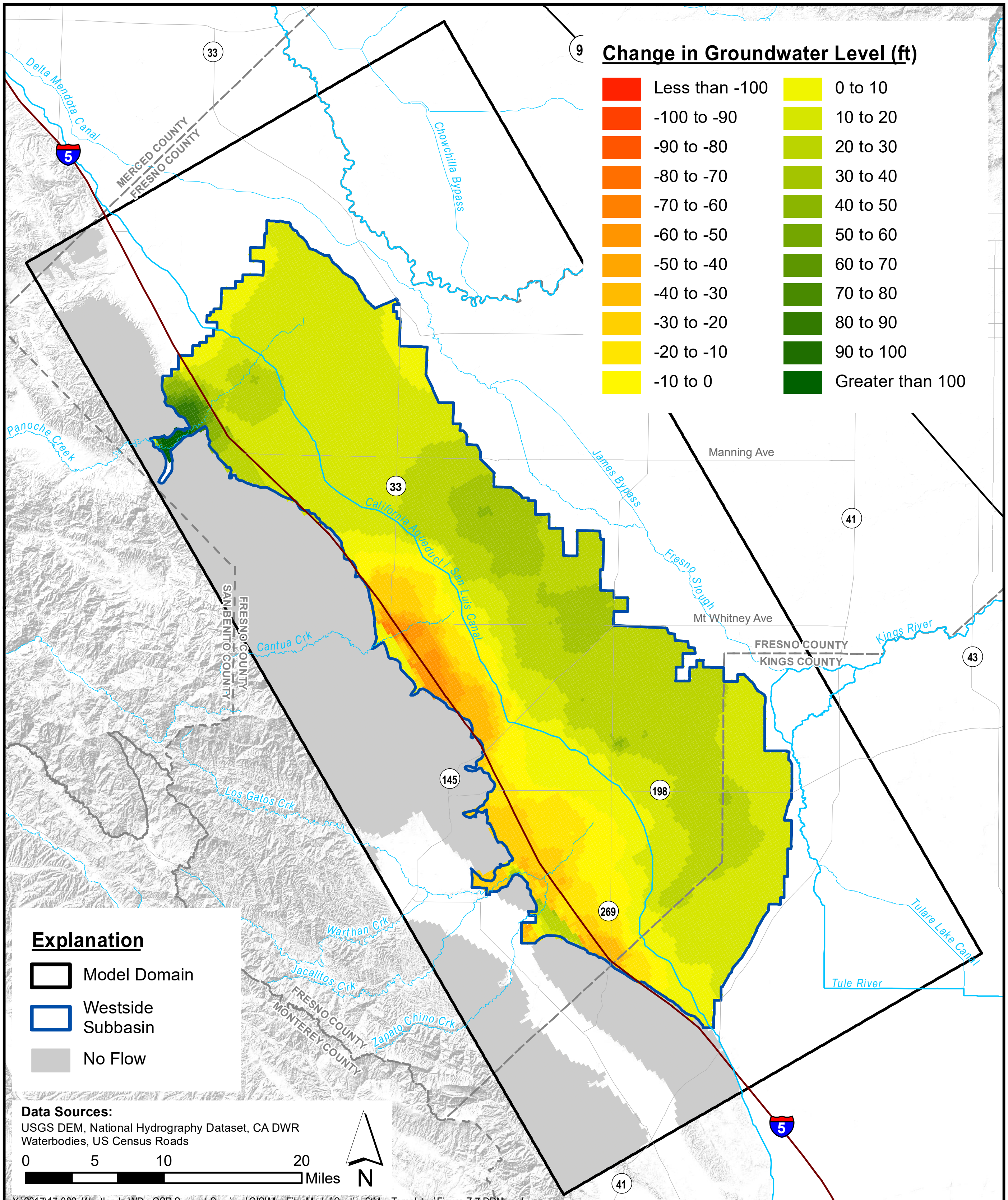
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.2 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-26



Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.2 (2020 - 2070)

Figure G-27

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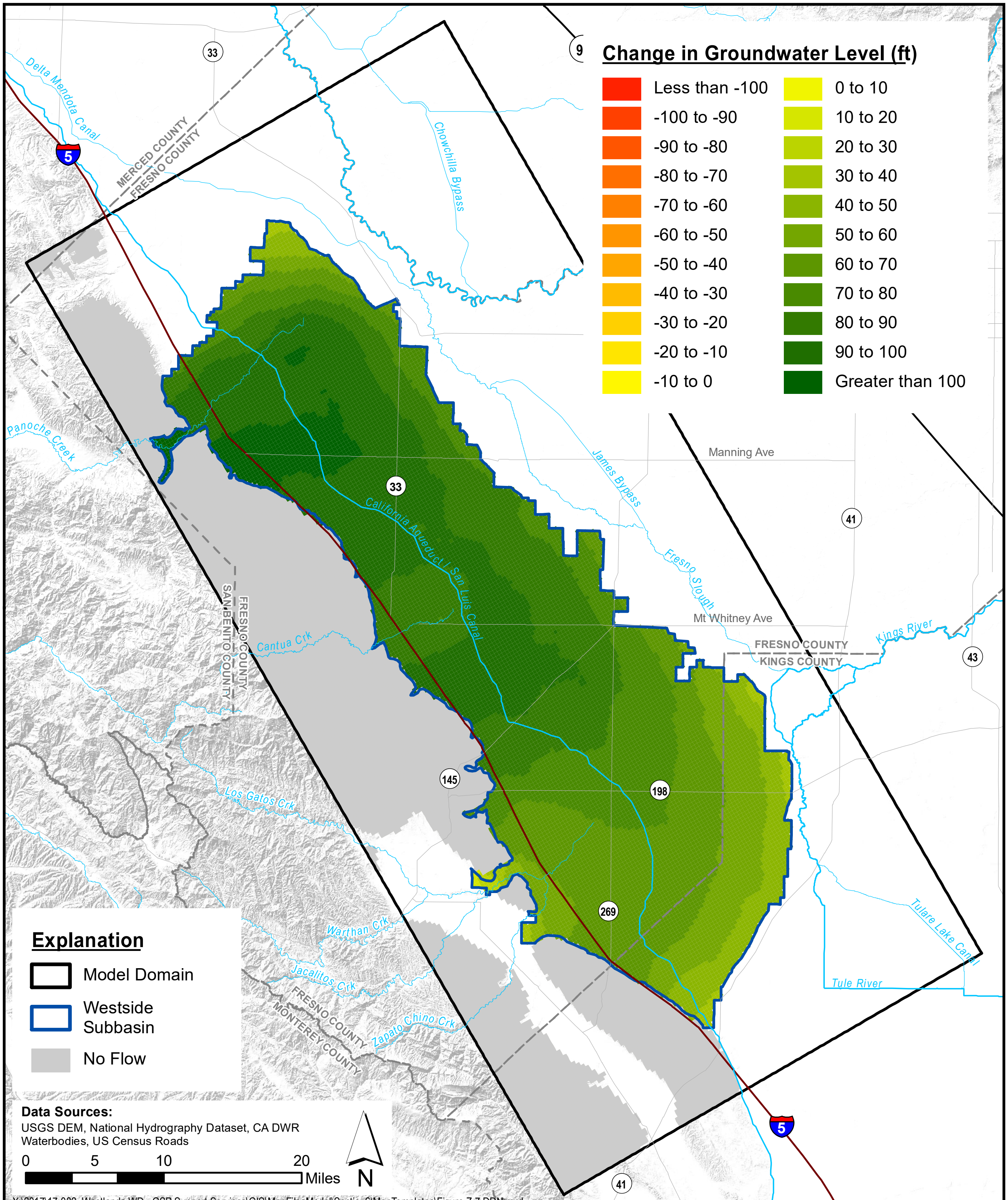
SGMA Sustainability Analyses
Westside Subbasin



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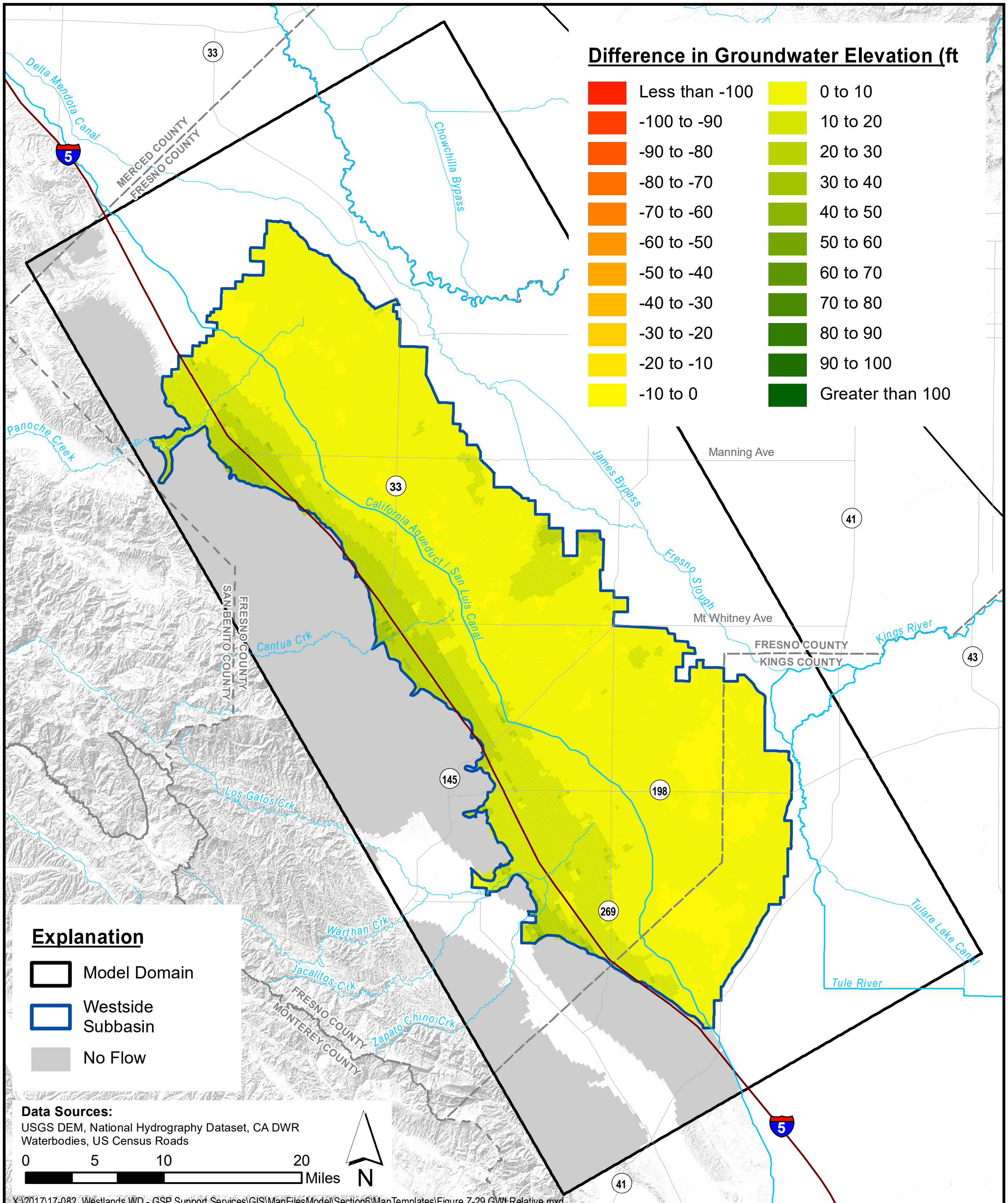
Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.2 (2020 - 2070)

Figure G-28

SGMA Sustainability Analyses
Westside Subbasin



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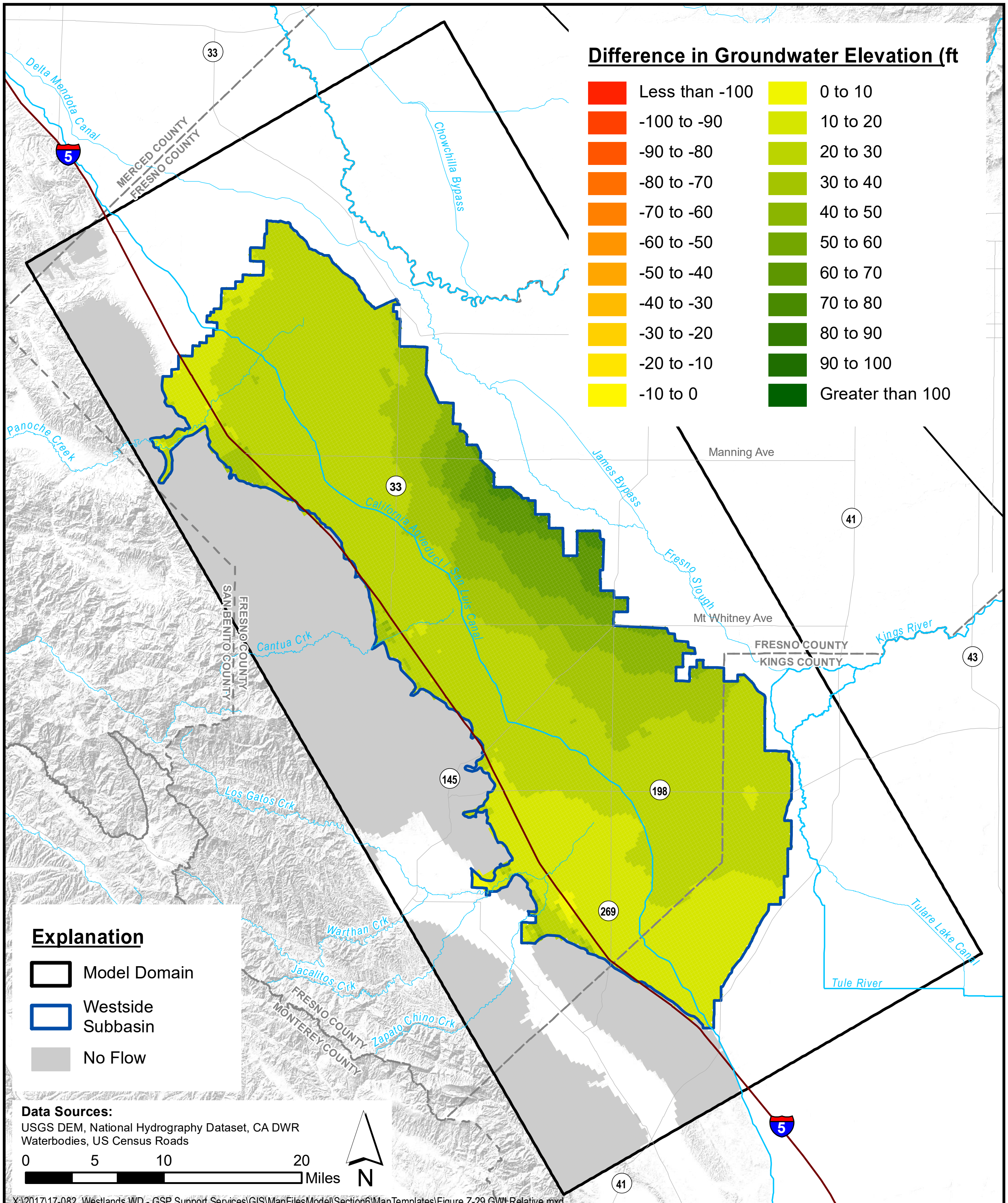
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 2 (2020 - 2040)

Figure G-29

SGMA Sustainability Analyses
Westside Subbasin



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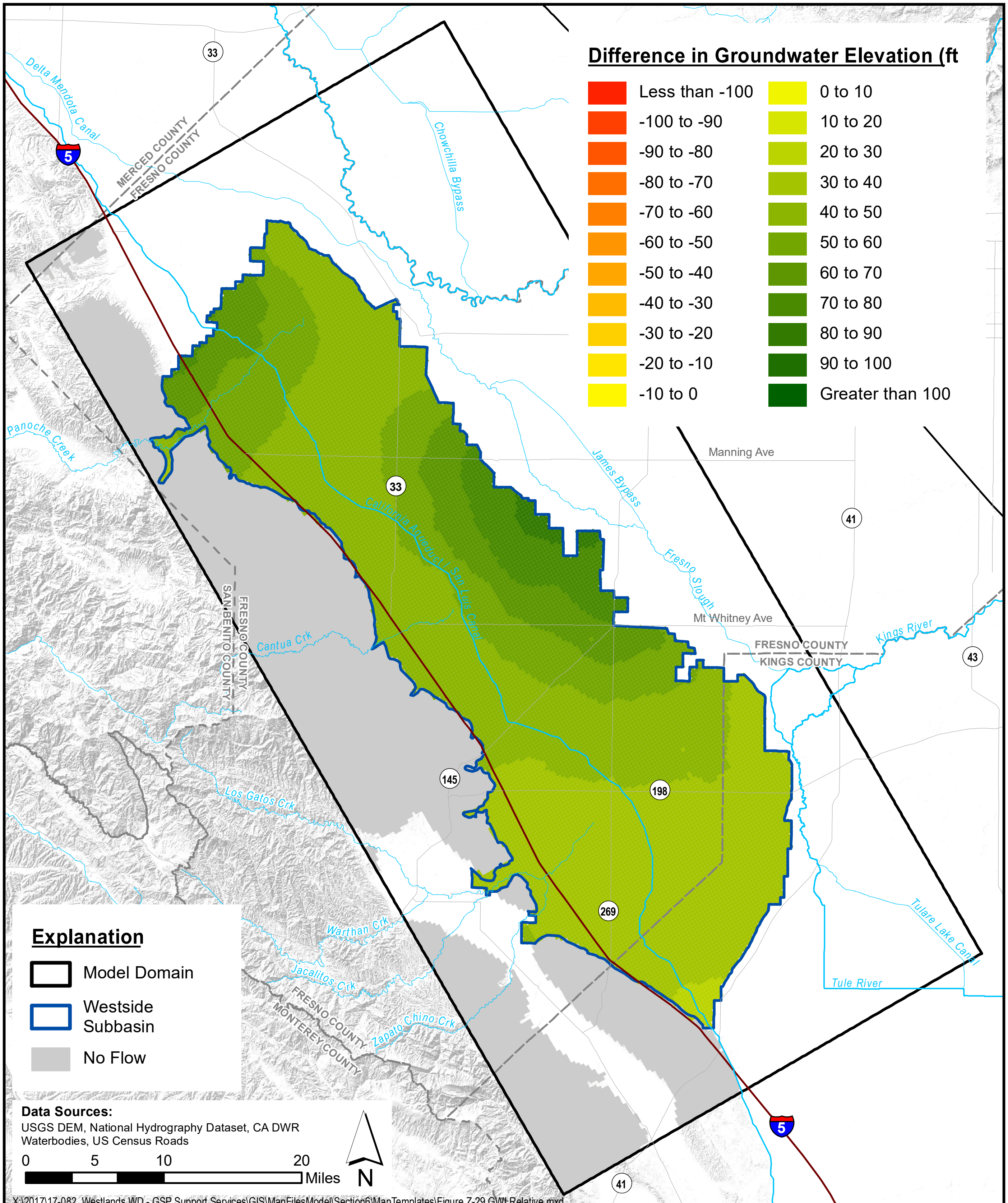
Project Impacts on Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No. 2 (2020 - 2040)

Figure G-30

SGMA Sustainability Analyses
Westside Subbasin



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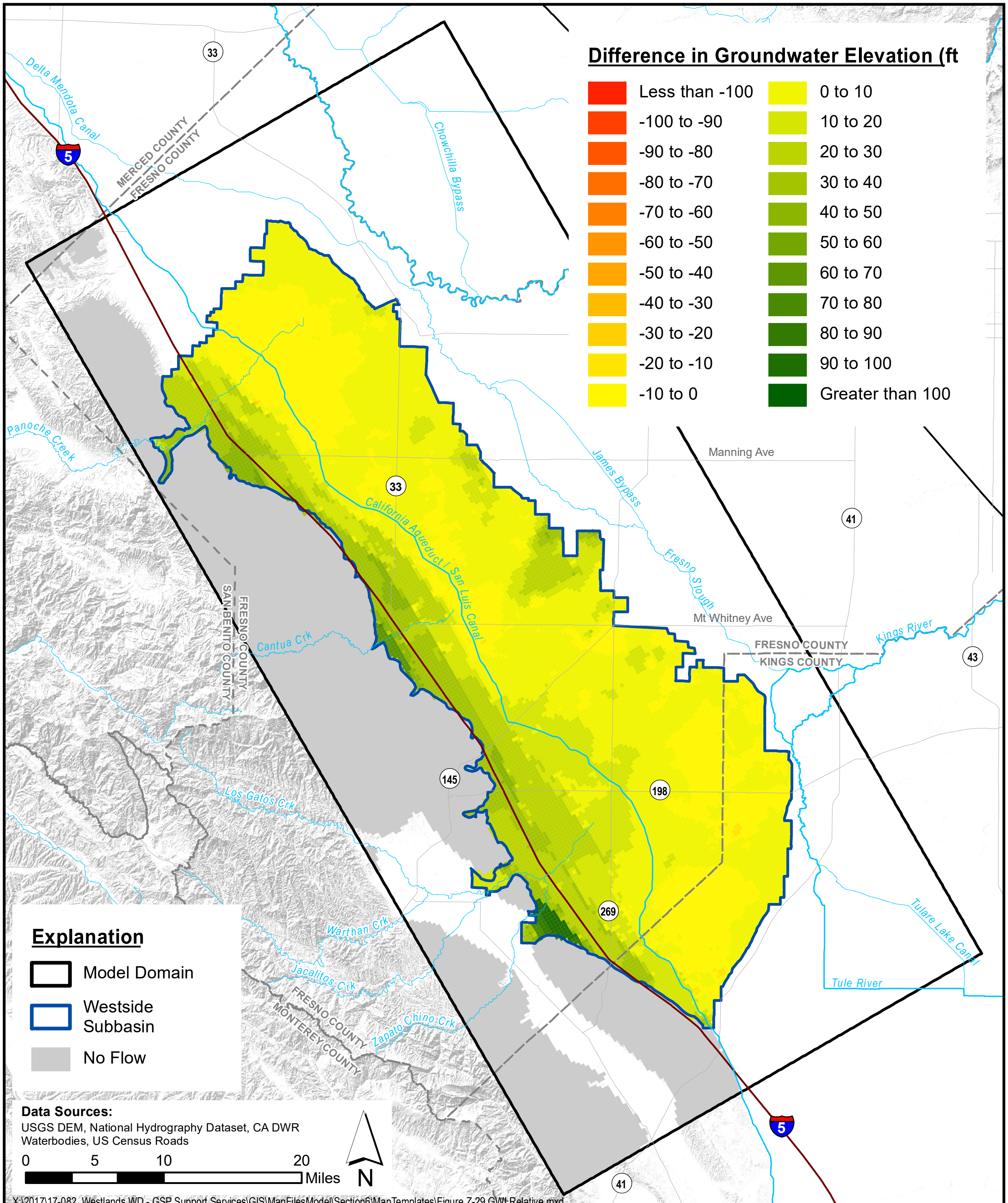
Project Impacts on Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 2 (2020 - 2040)

Figure G-31

SGMA Sustainability Analyses
Westside Subbasin



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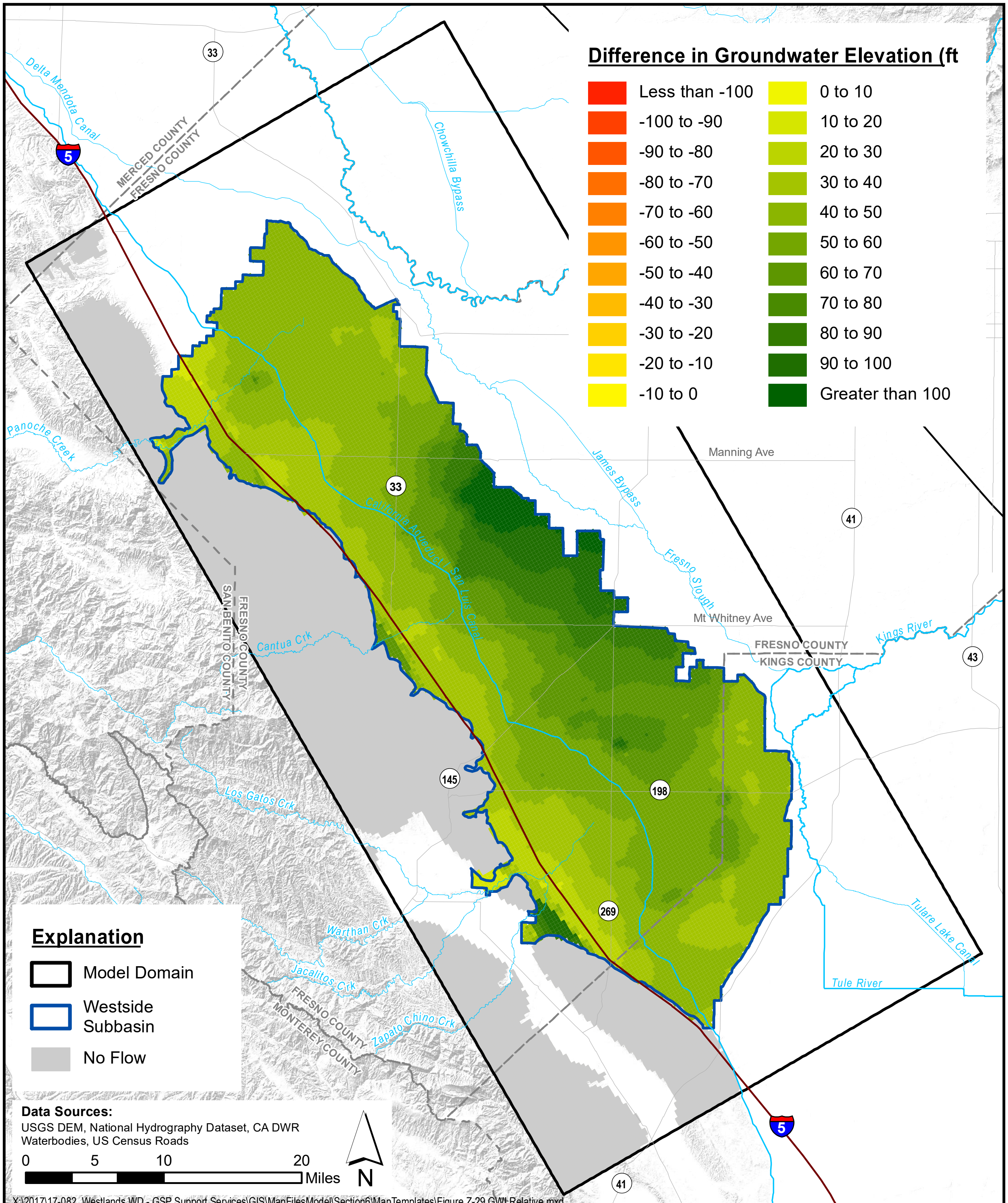
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 2 (2020 - 2070)

Figure G-32

SGMA Sustainability Analyses
Westside Subbasin



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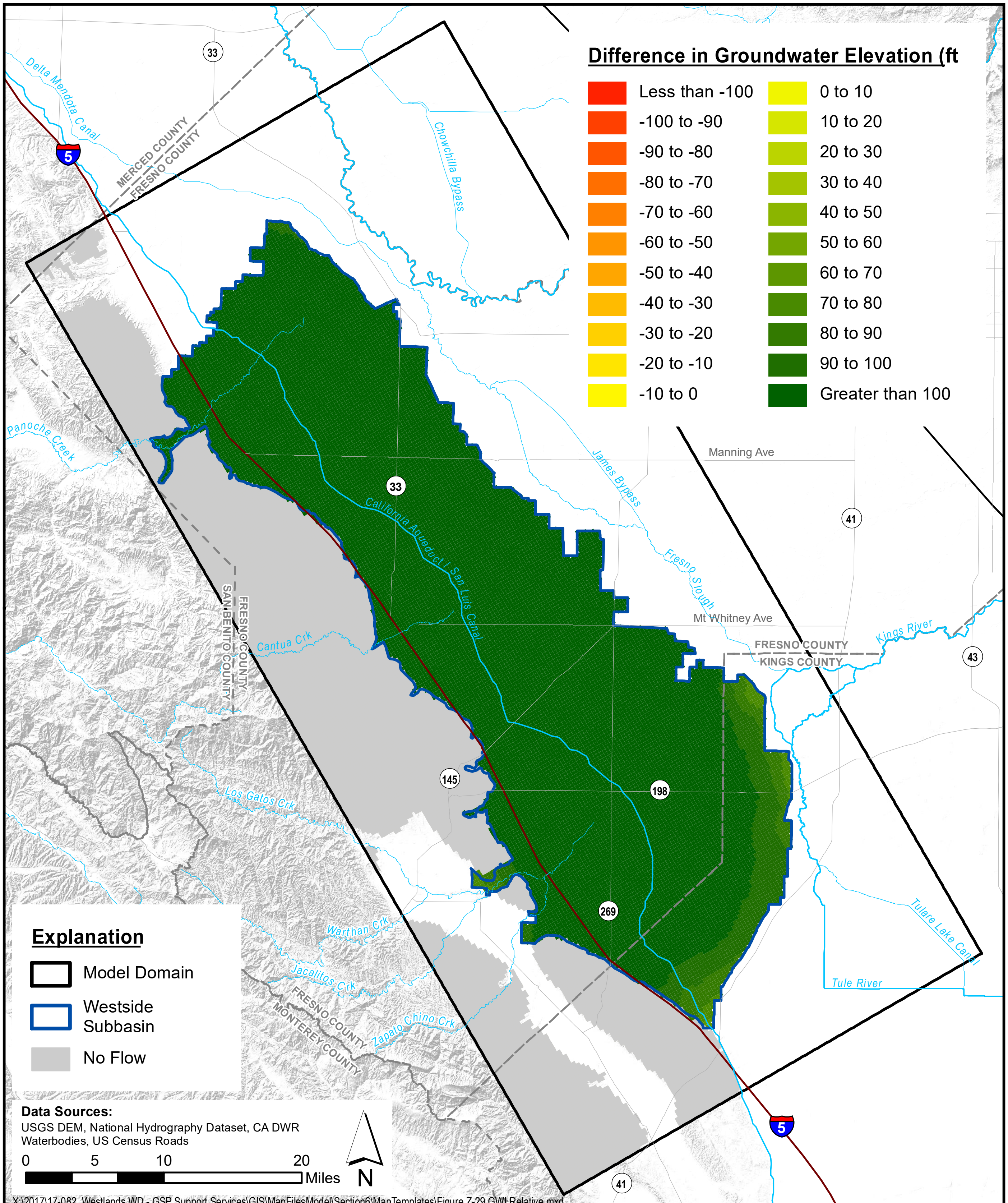
Project Impacts on Groundwater Elevation - Upper Aquifer 2070 Climate Change - PMA No. 2 (2020 - 2070)

Figure G-33

SGMA Sustainability Analyses
Westside Subbasin



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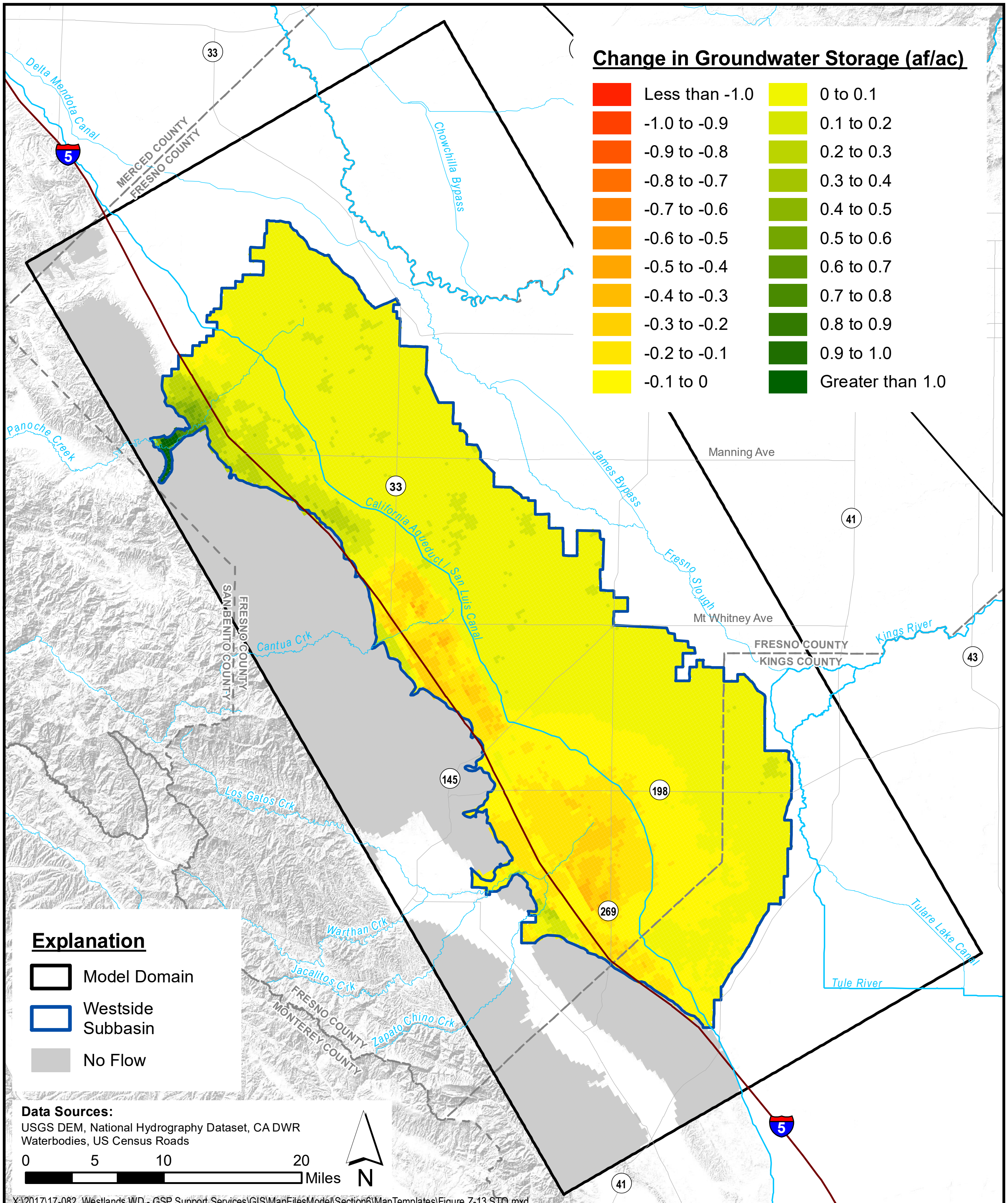
Project Impacts on Groundwater Elevation - Lower Aquifer 2070 Climate Change - PMA No. 2 (2020 - 2070)

Figure G-34

SGMA Sustainability Analyses
Westside Subbasin



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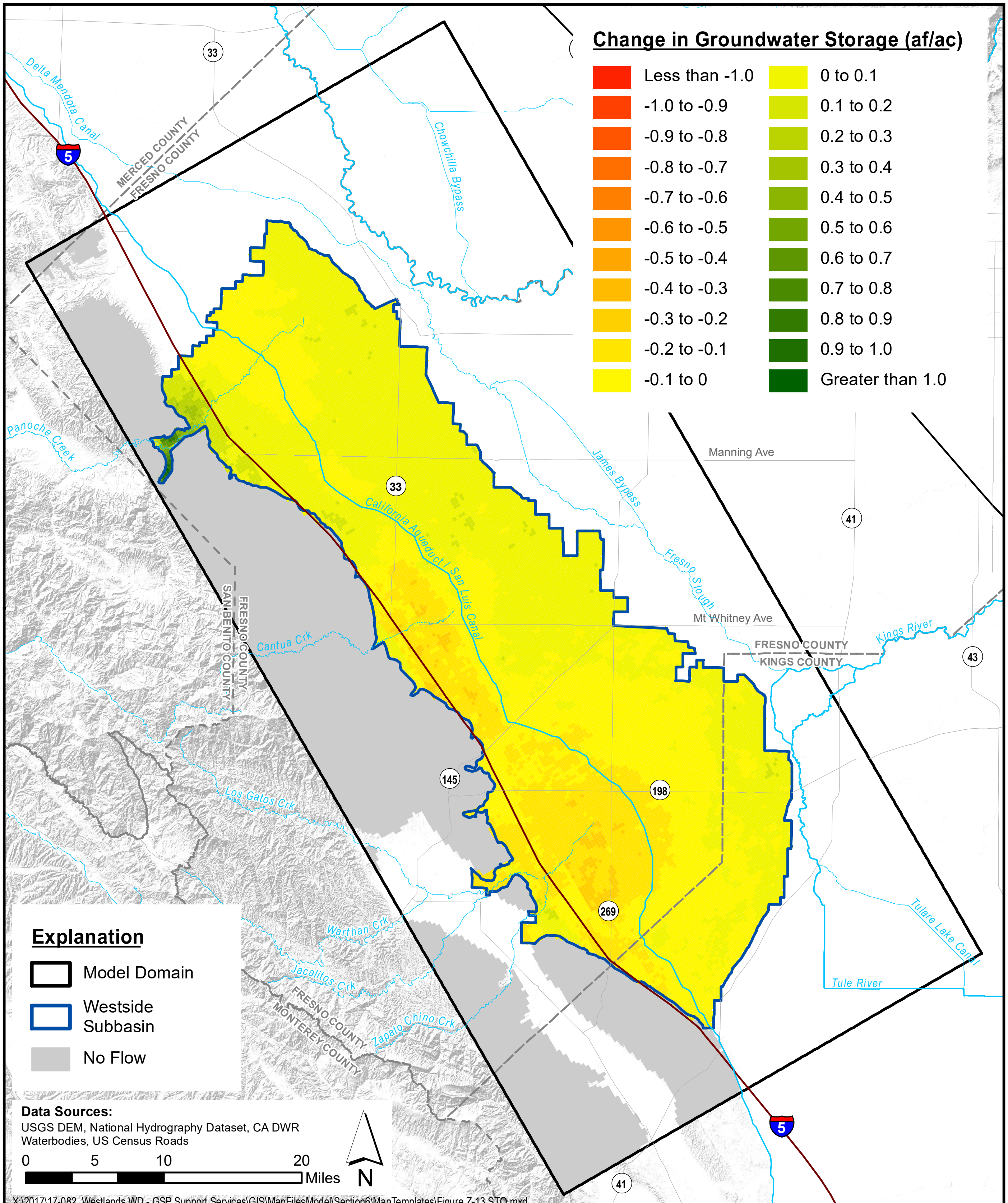
Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.2 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-35



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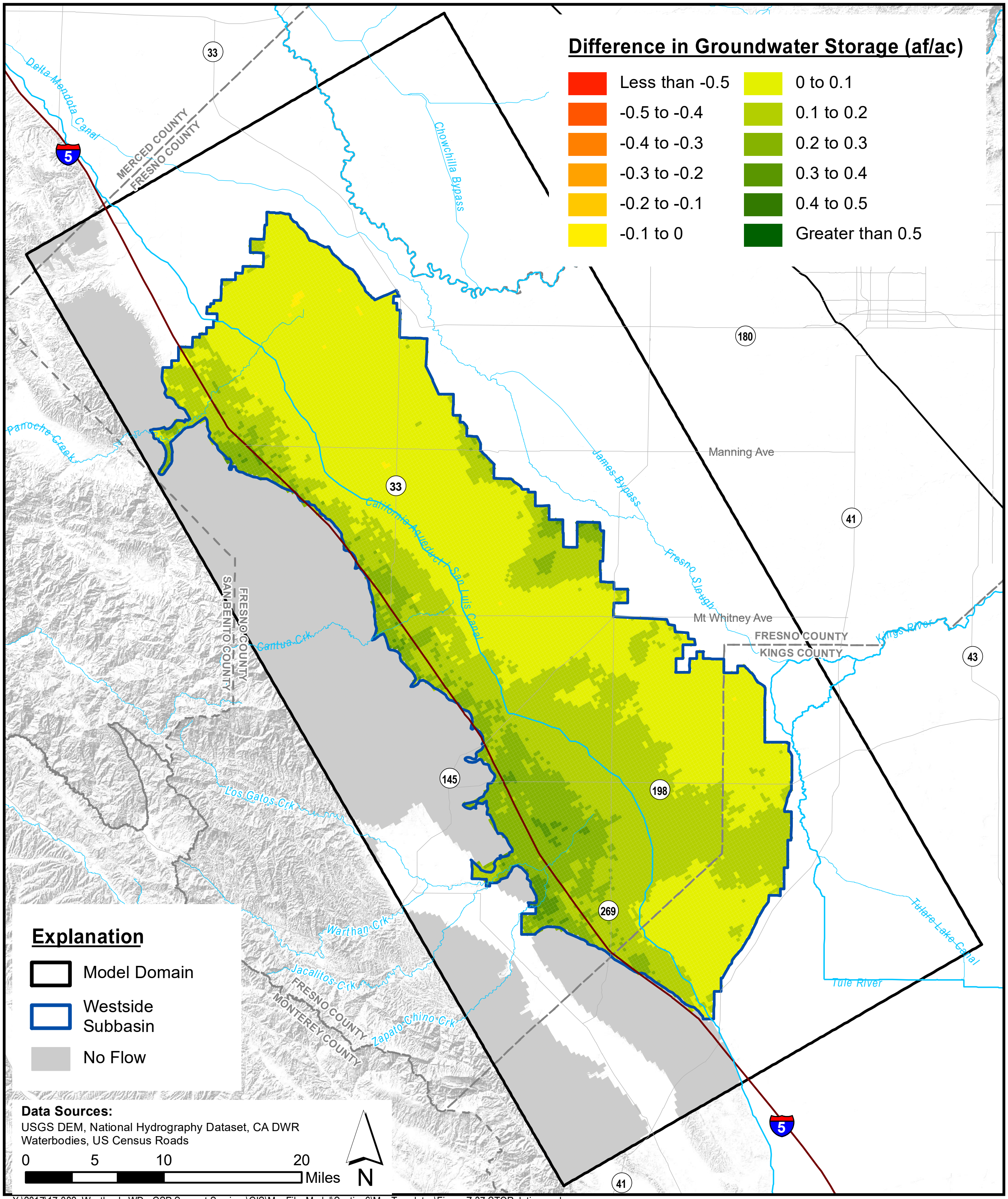
Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.2 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-36



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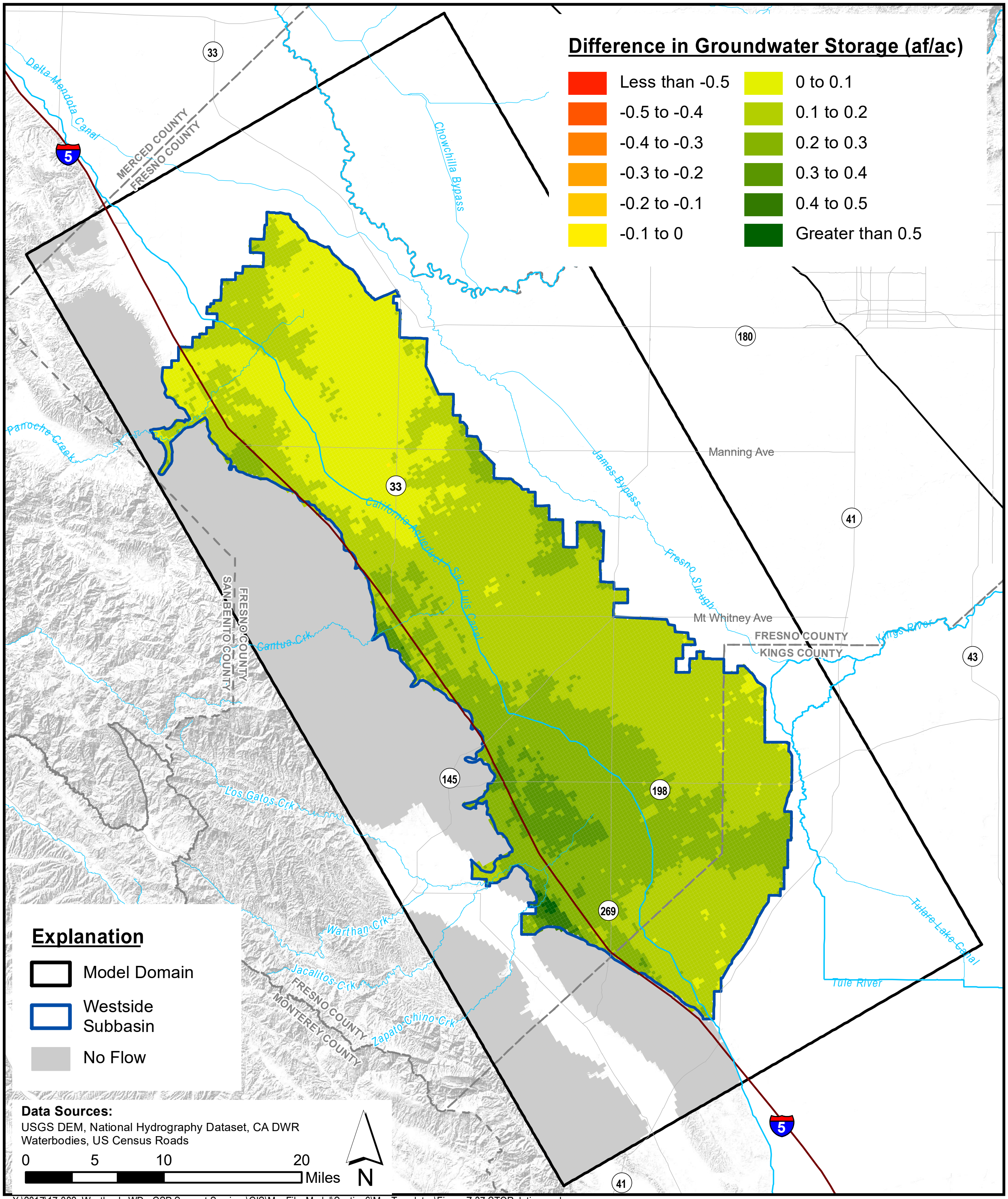
Project Impacts on Groundwater Storage
2070 Climate Change - PMA No. 2 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-37



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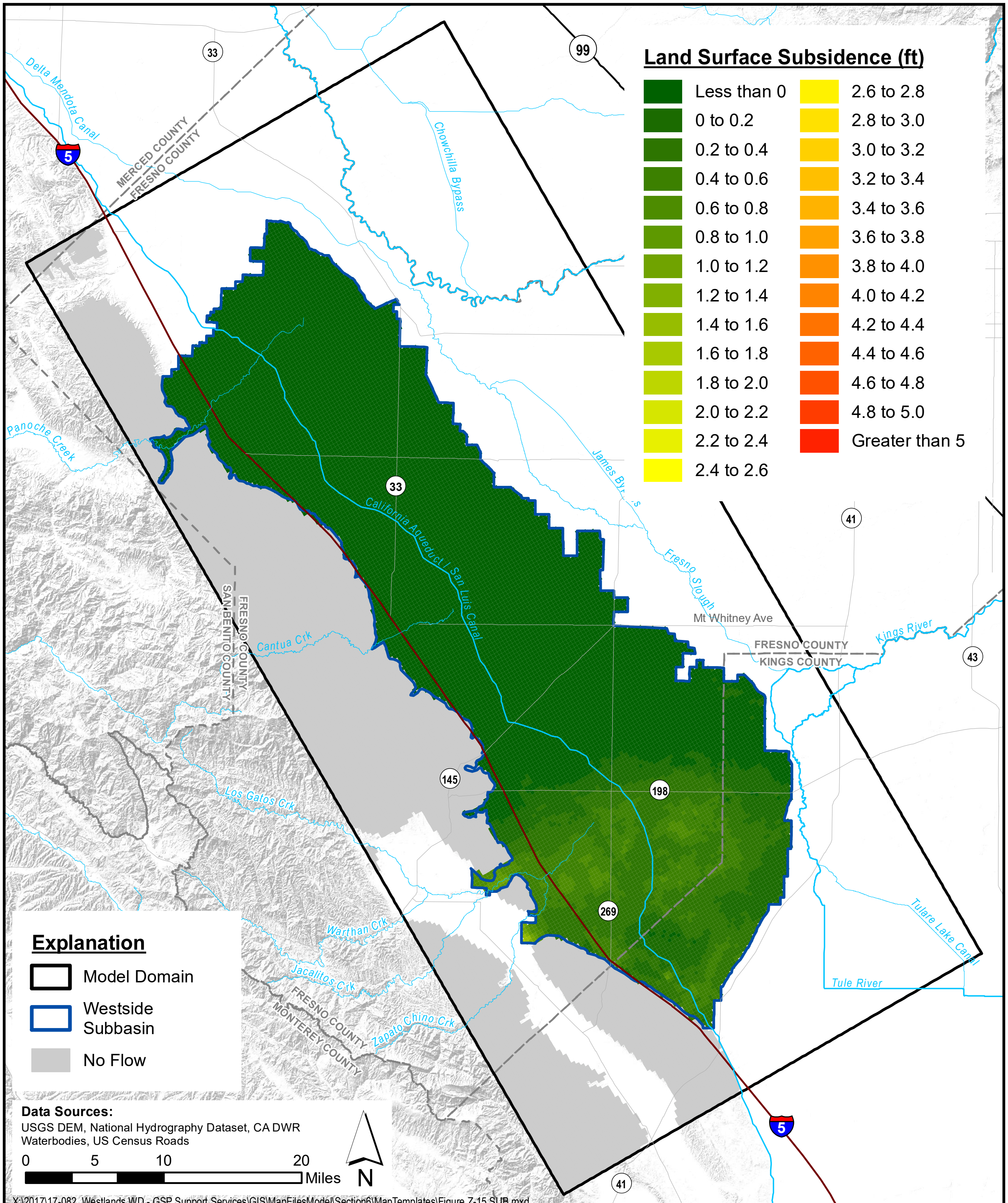
Project Impacts on Groundwater Storage
2070 Climate Change - PMA No. 2 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-38



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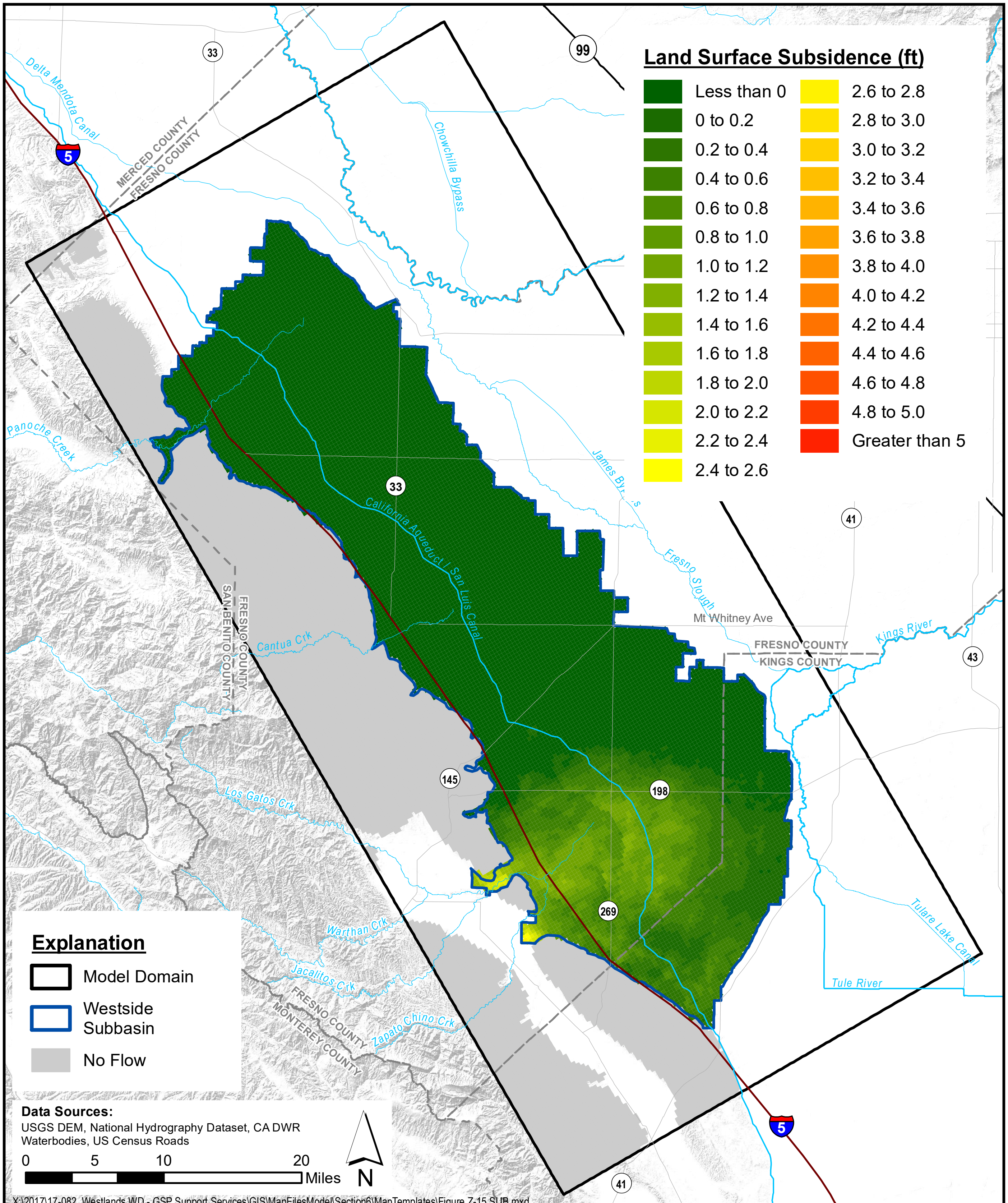
Simulated Land Surface Subsidence
2070 Climate Change - PMA No.2 (2020 - 2040)

Figure G-39

SGMA Sustainability Analyses
Westside Subbasin



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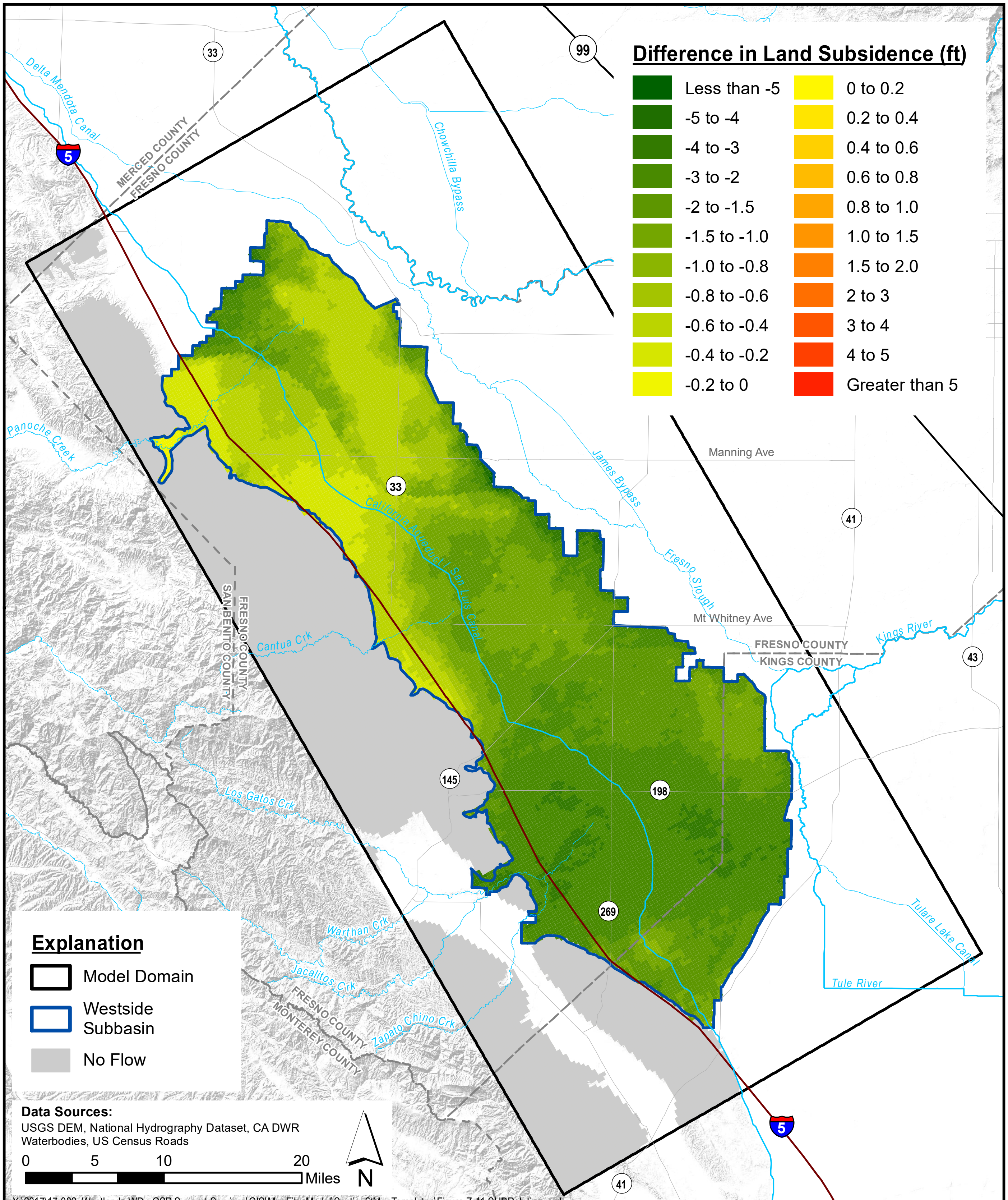
Simulated Land Surface Subsidence
2070 Climate Change - PMA No.2 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-40



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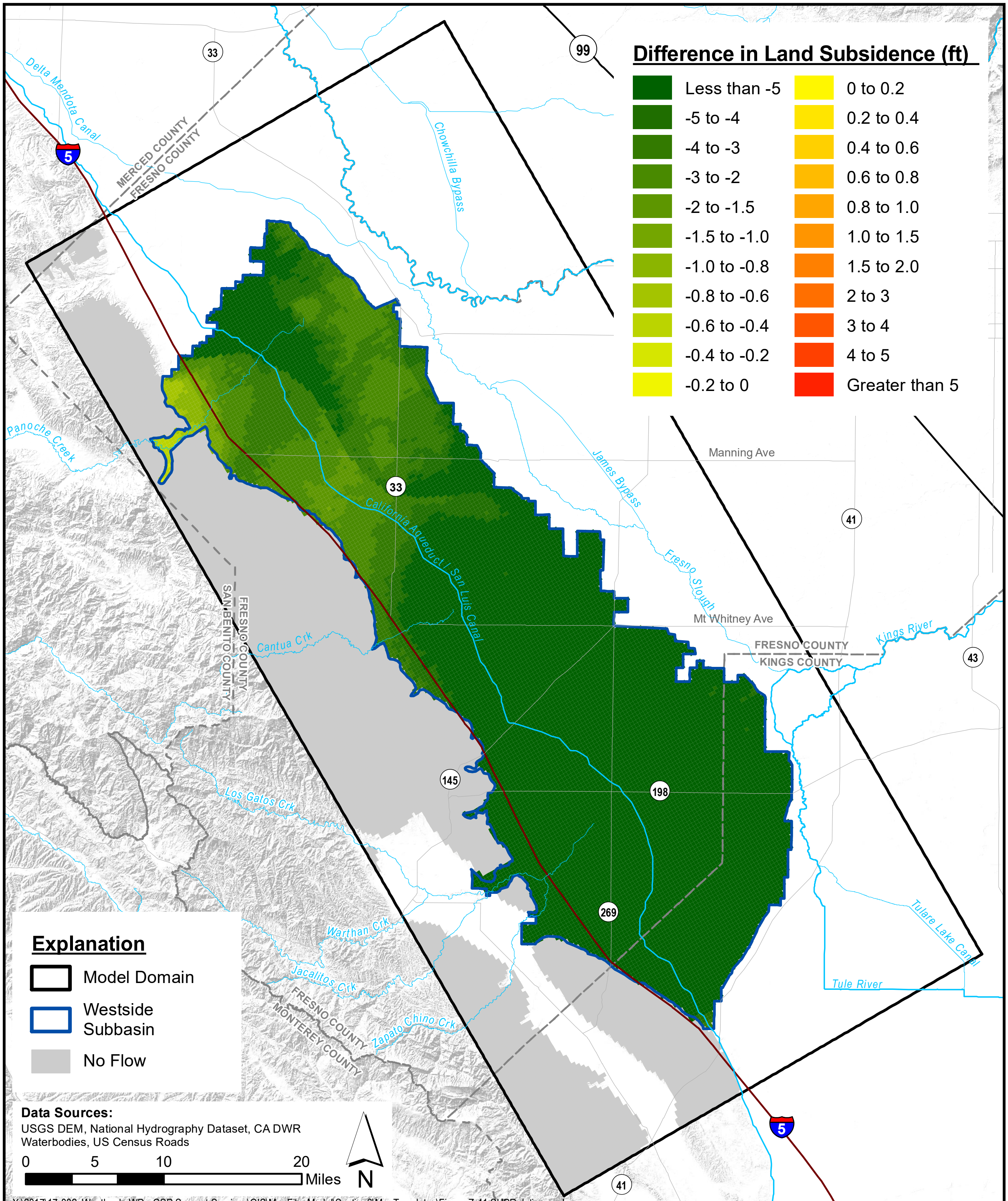
Project Impact on Land Subsidence
2070 Climate Change - PMA No. 2 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-41



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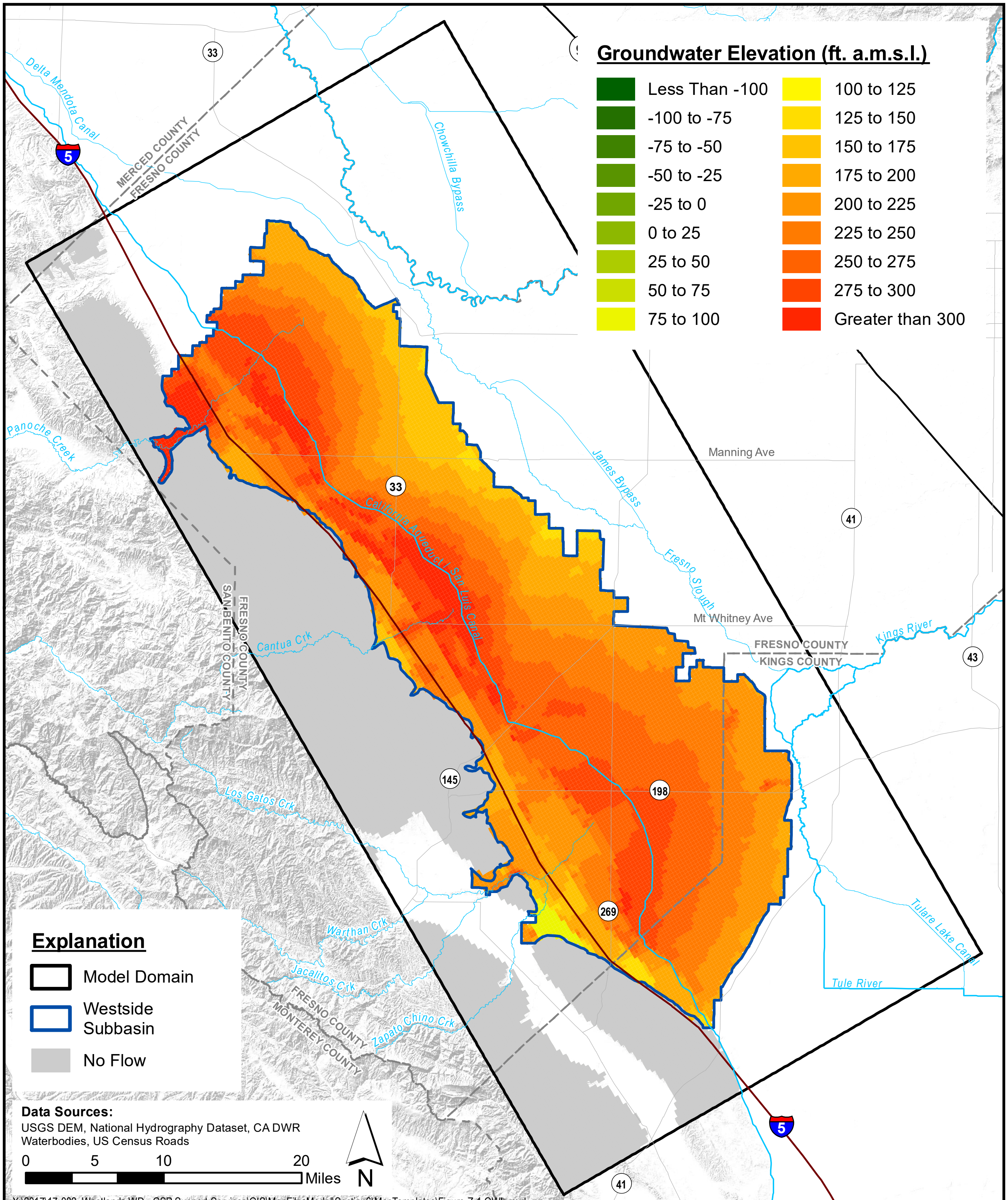
Project Impact on Land Subsidence
2070 Climate Change - PMA No. 2 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-42



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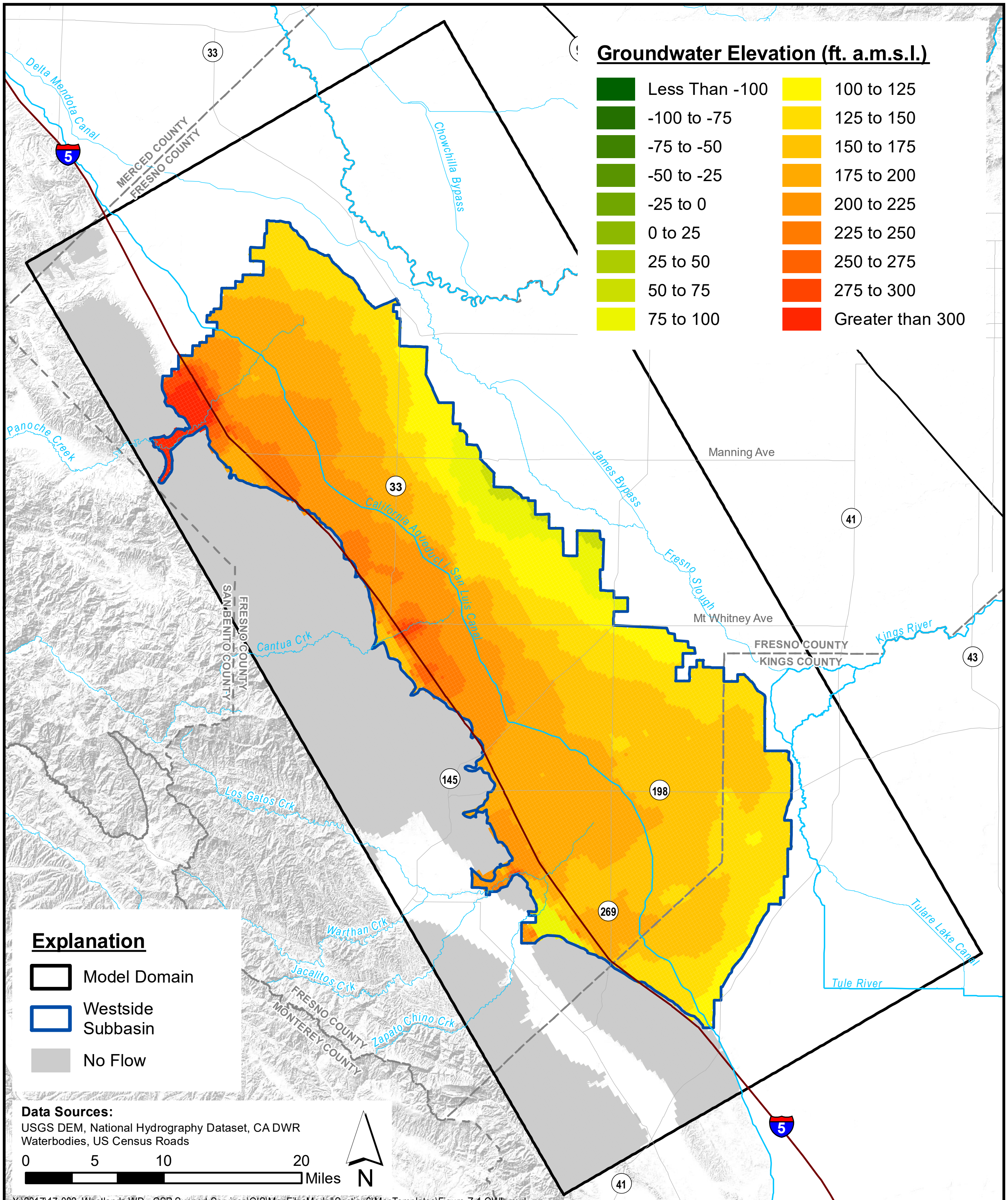
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.3 (January 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-43



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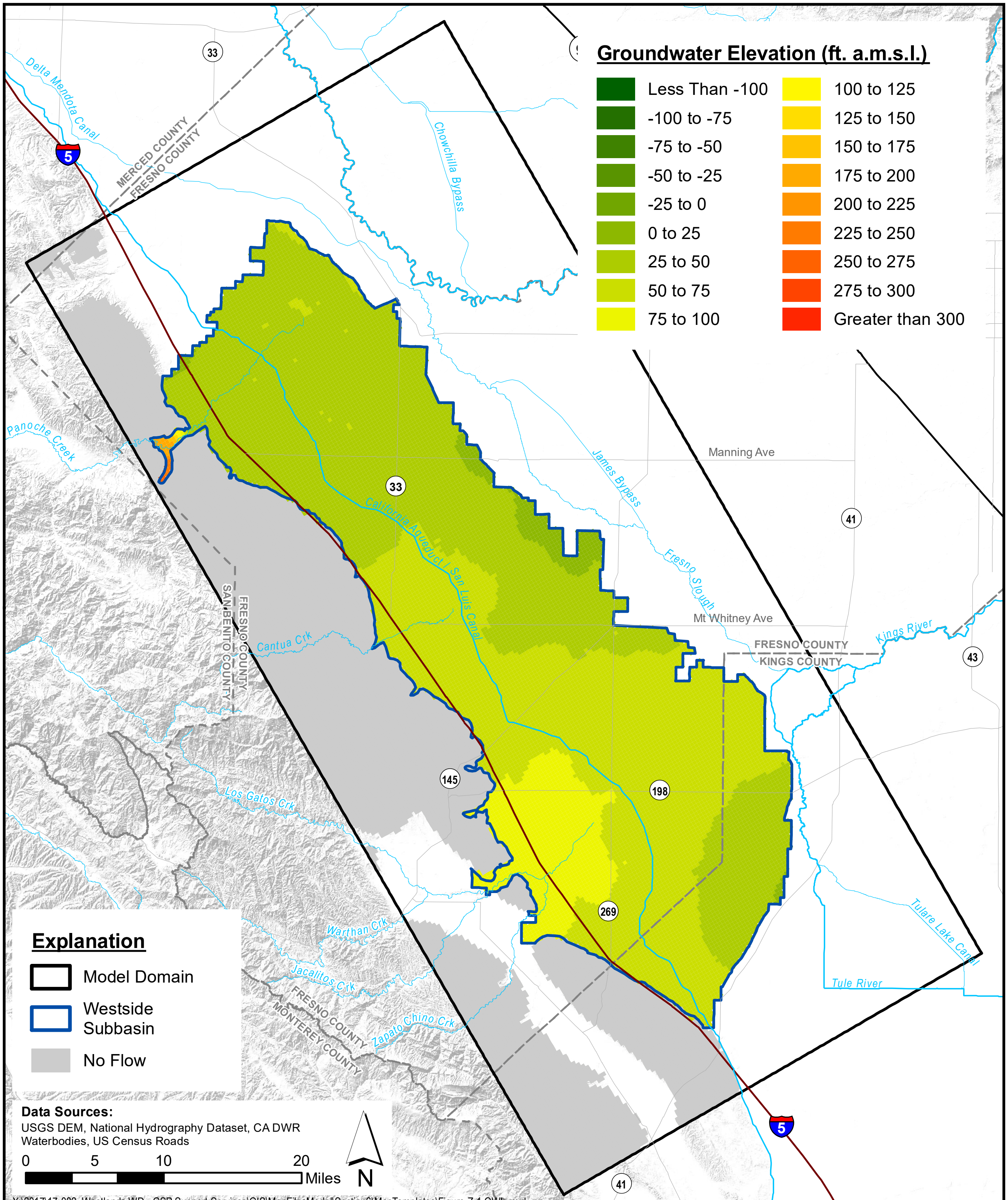
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.3 (January 2040)

Figure G-44

SGMA Sustainability Analyses
Westside Subbasin



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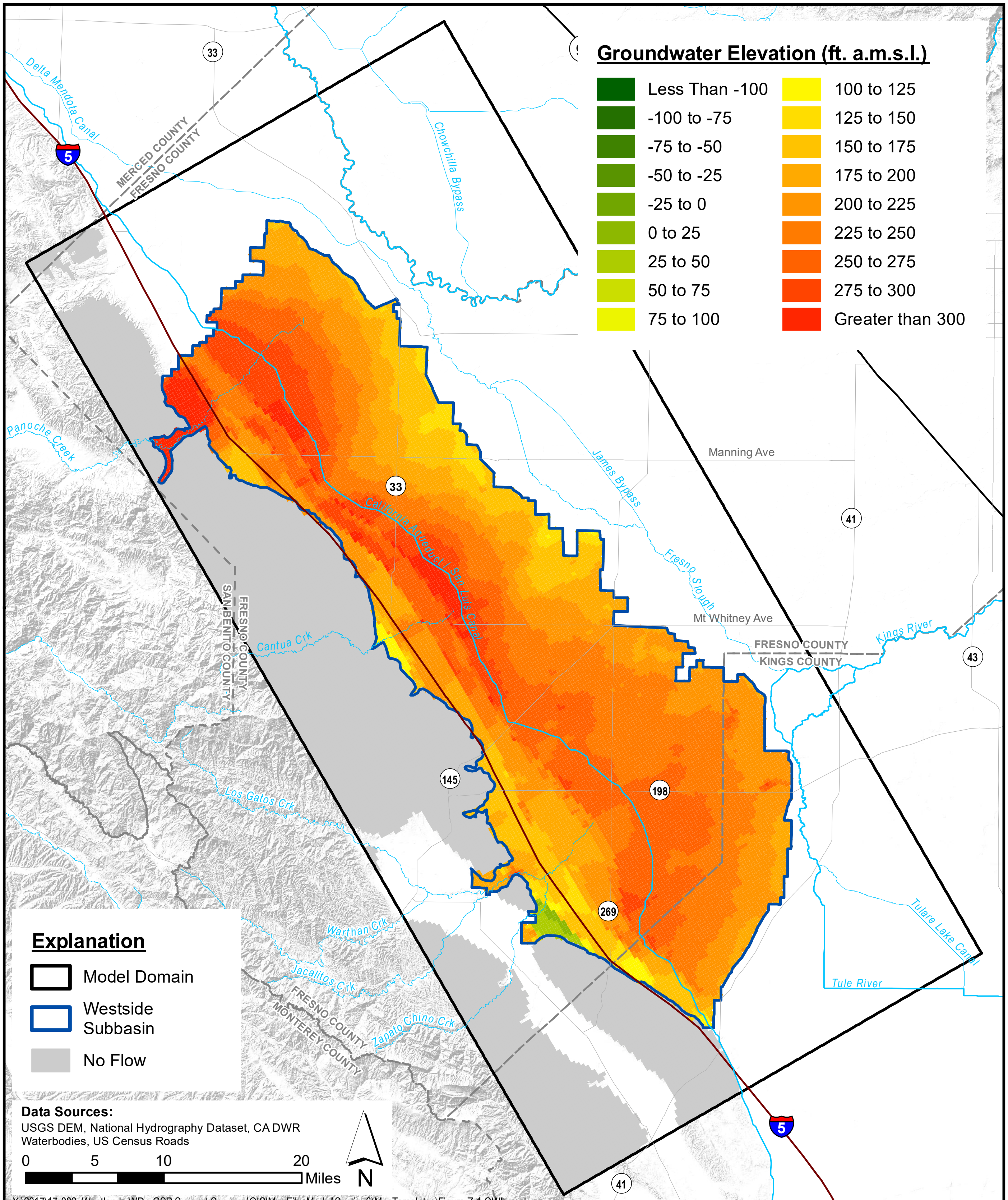
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.3 (January 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-45



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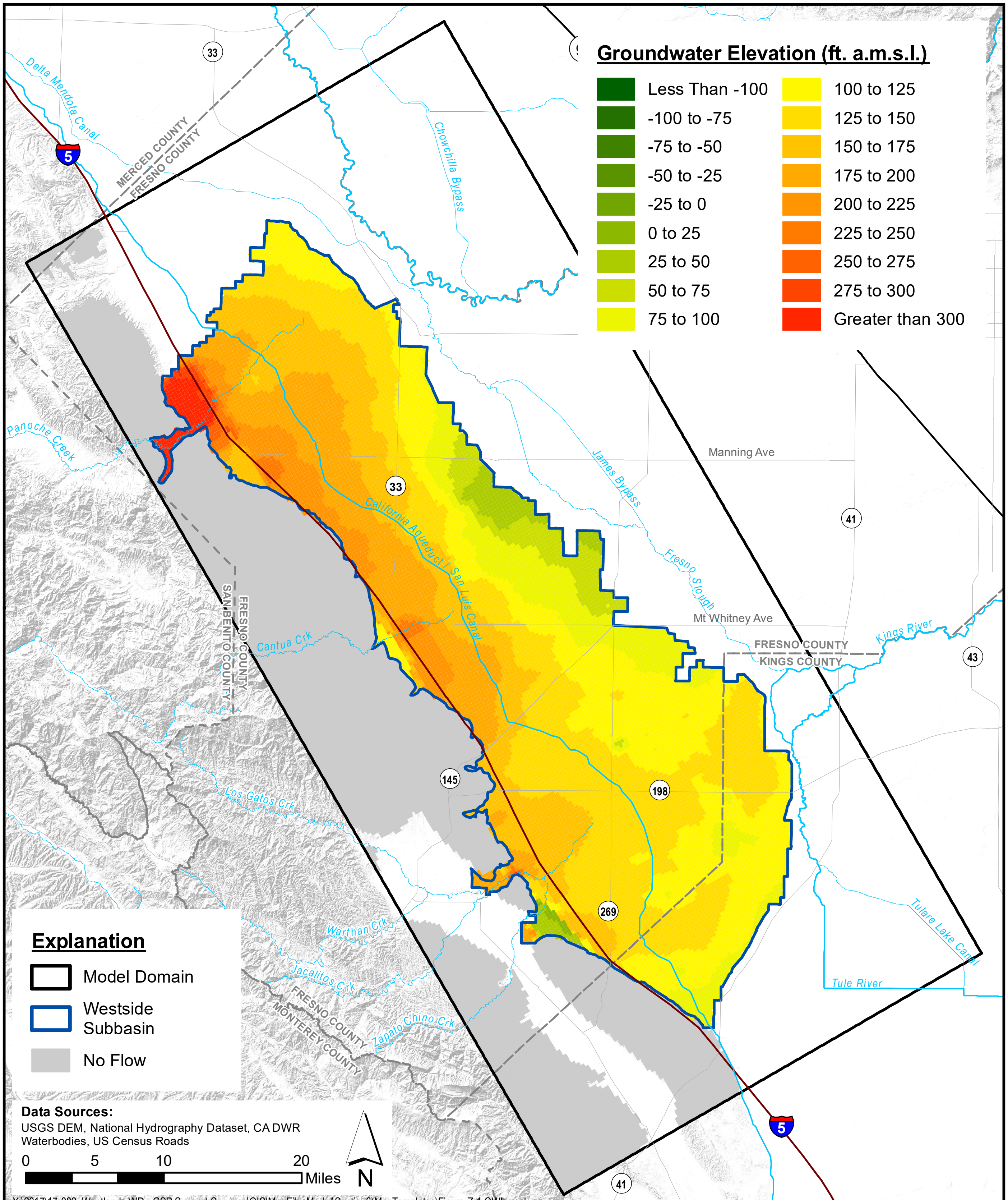
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.3 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-46



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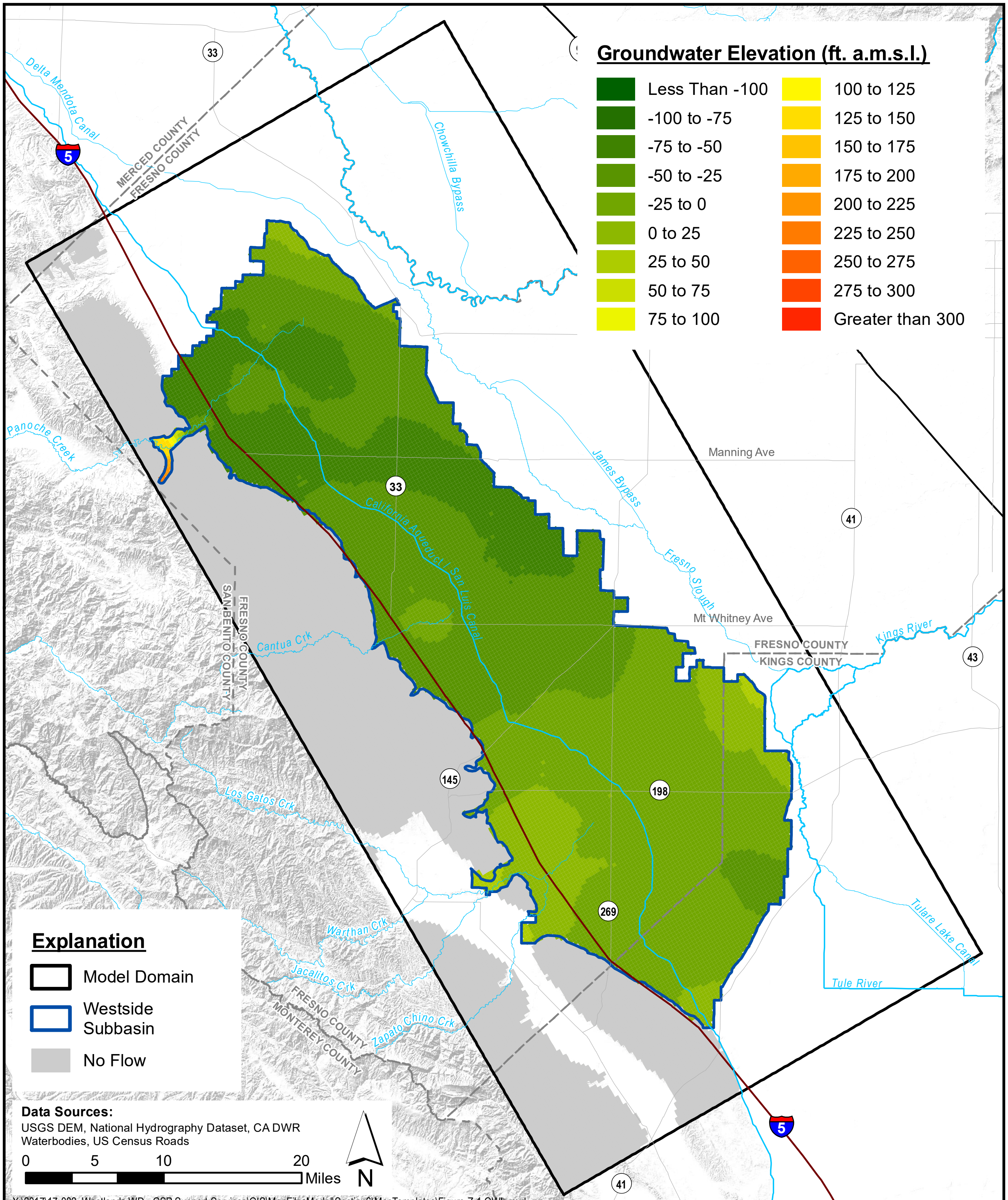
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.3 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-47



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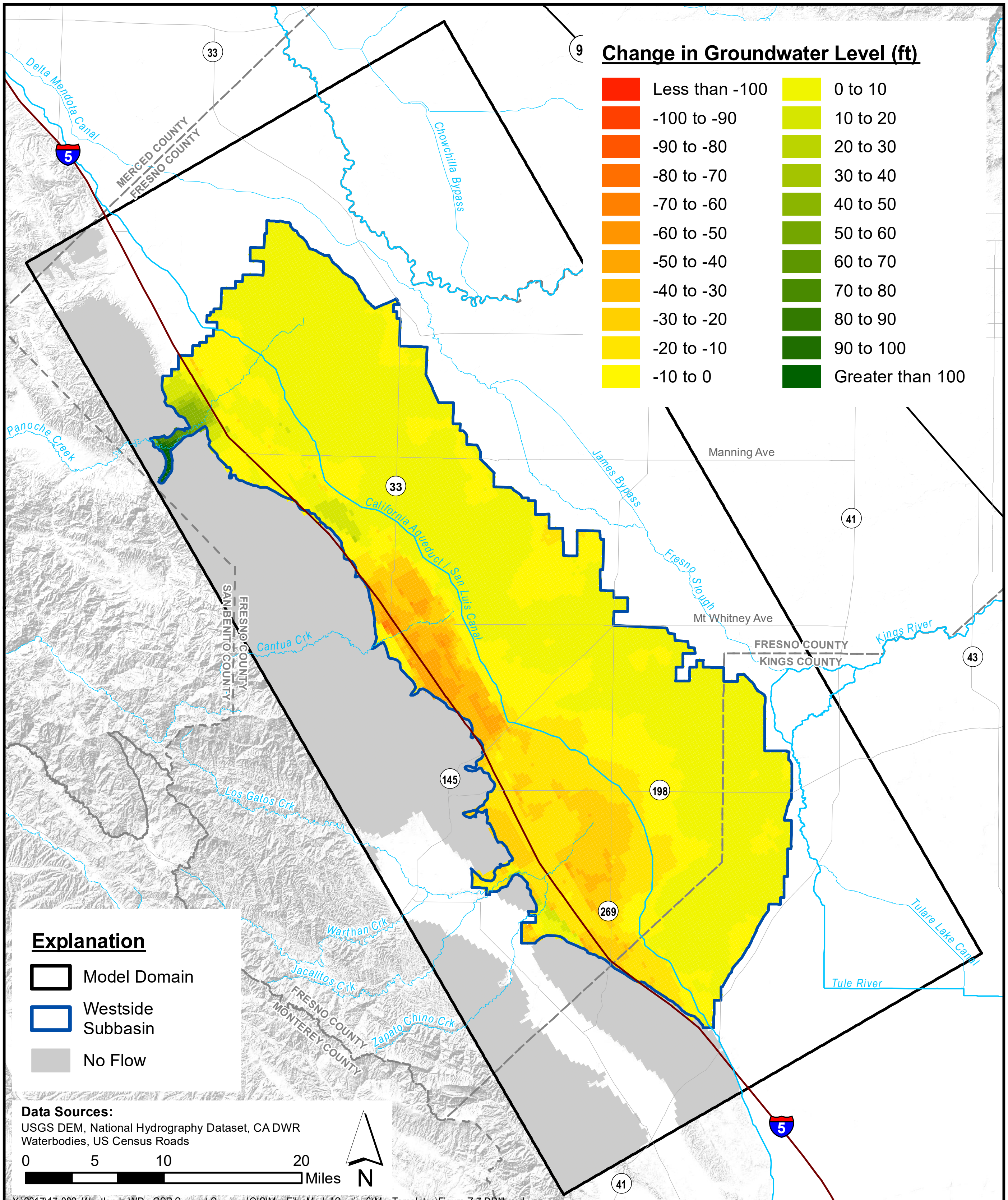
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.3 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-48



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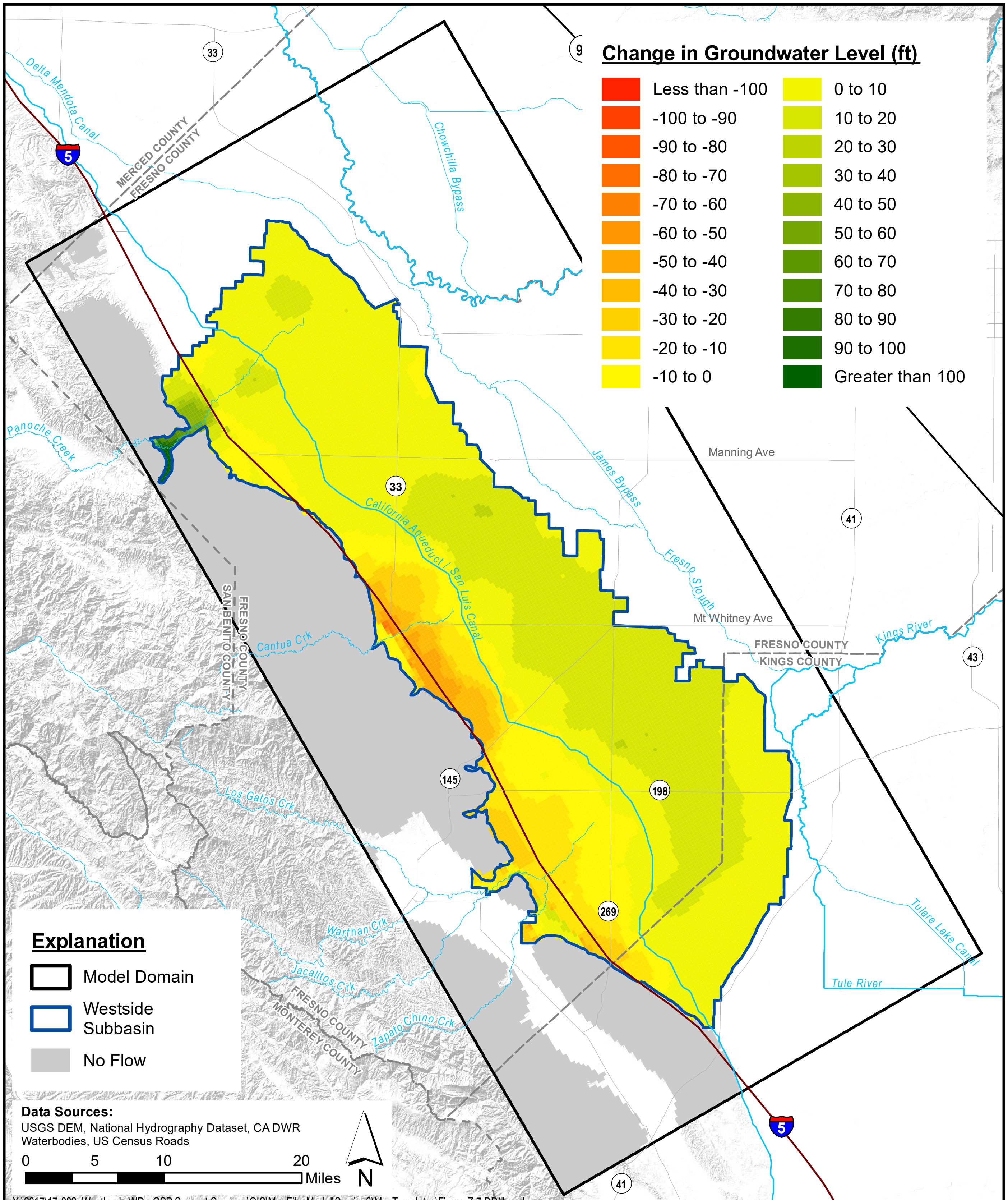
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 3 (2020 - 2040)

Figure G-49

SGMA Sustainability Analyses
Westside Subbasin



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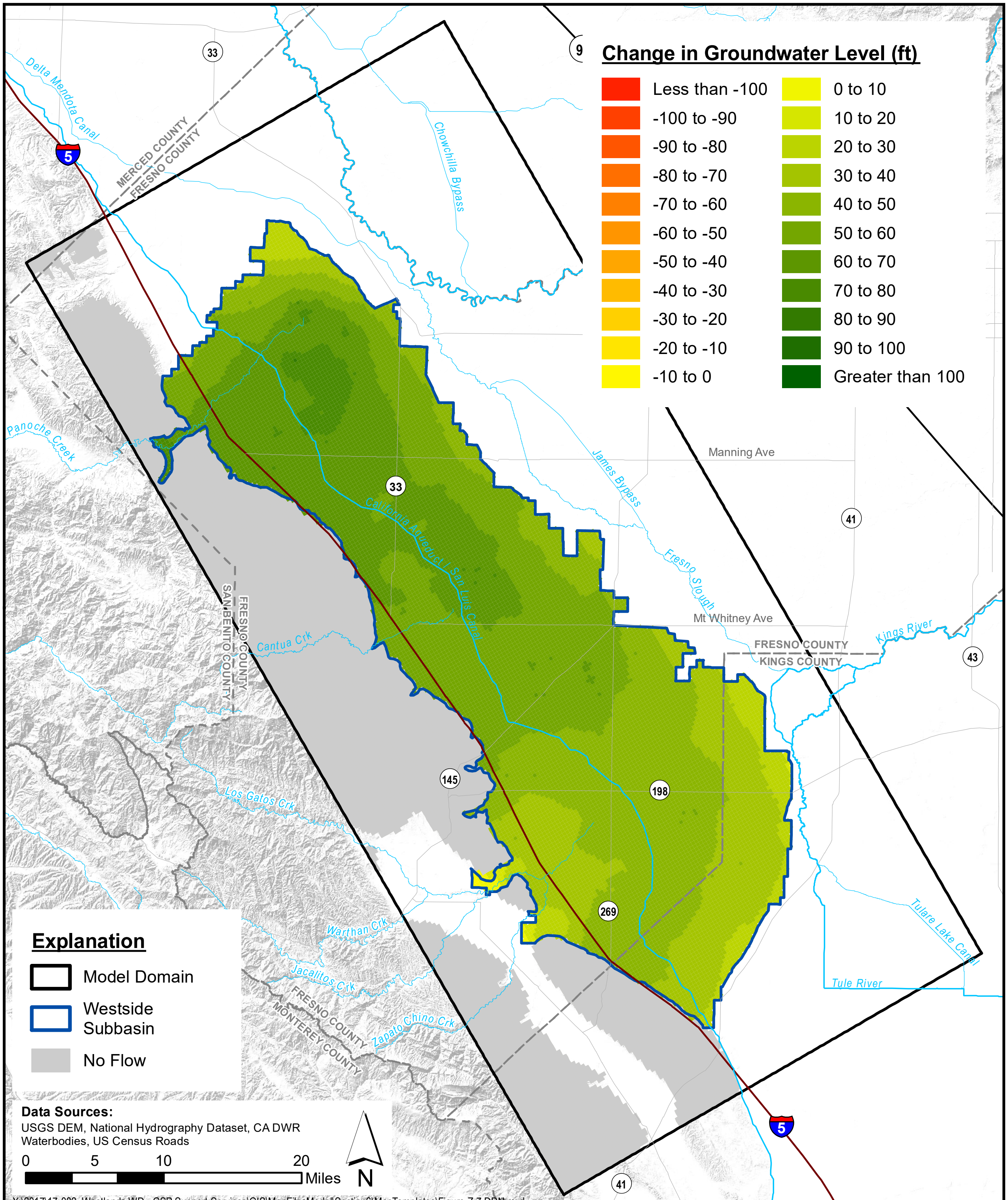
Simulated Change in Groundwater Elevation - Upper Aquifer 2070 Climate Change - PMA No. 3 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-50



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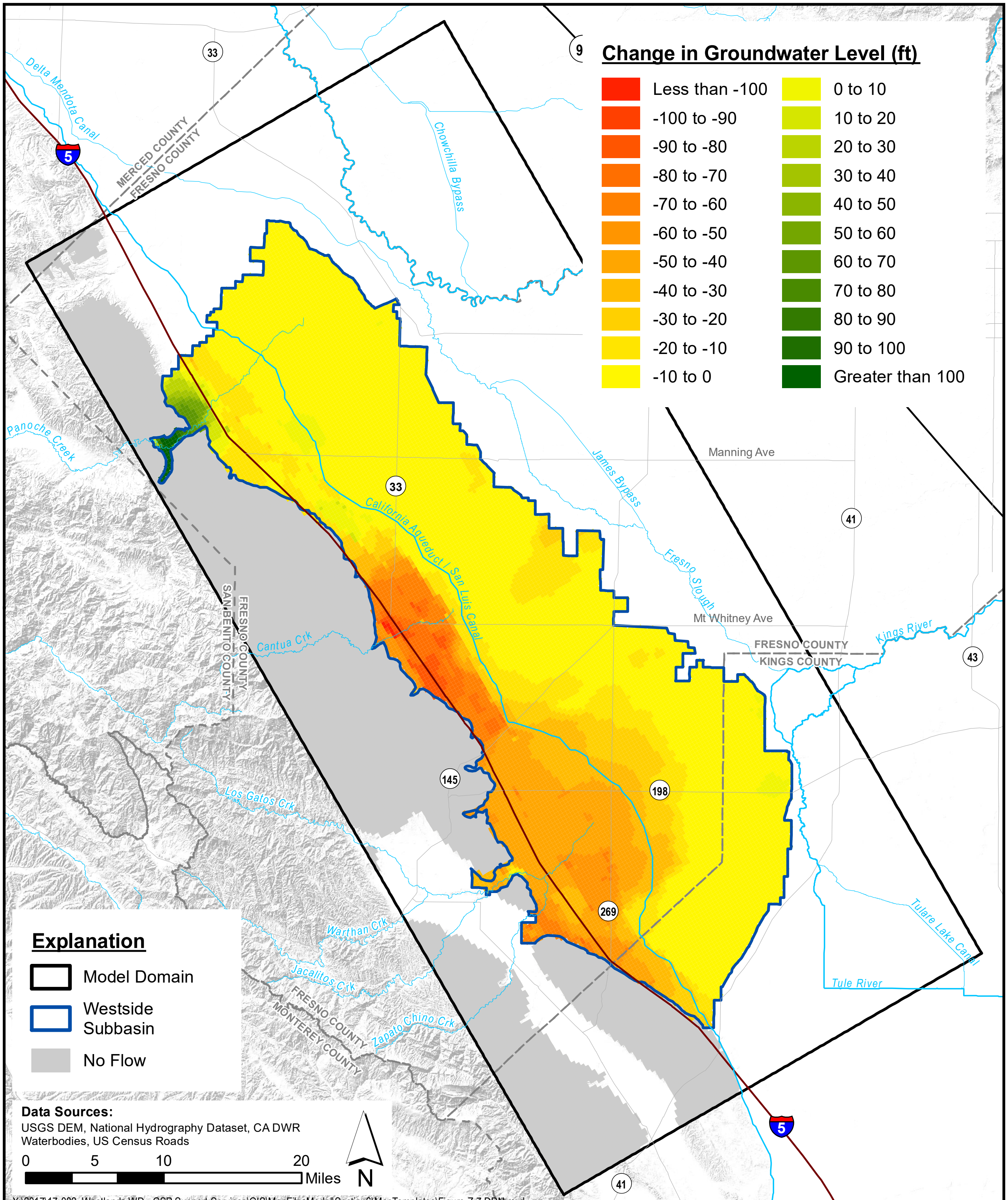
Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2040)

Figure G-51

SGMA Sustainability Analyses
Westside Subbasin



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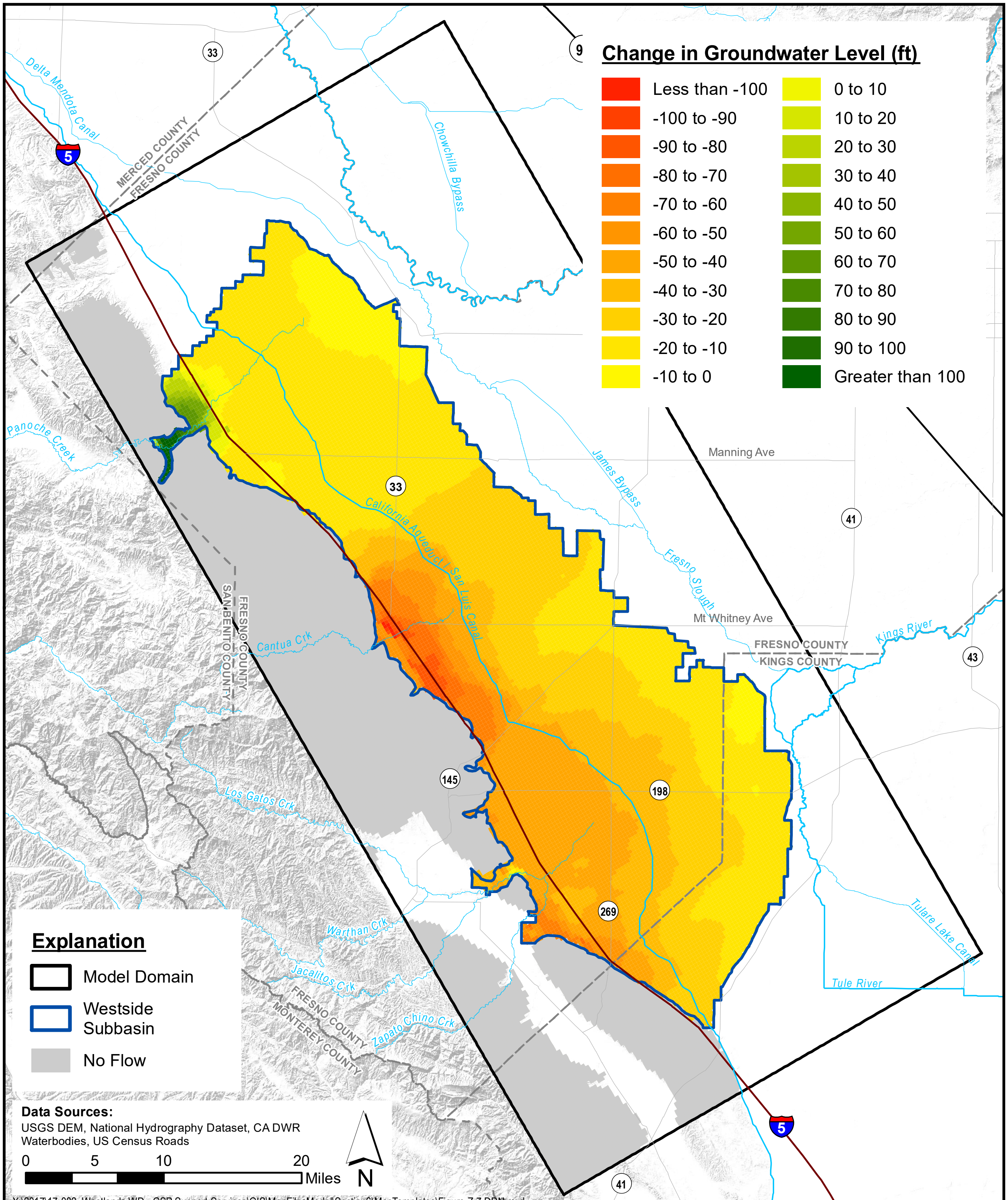
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-52

SGMA Sustainability Analyses
Westside Subbasin



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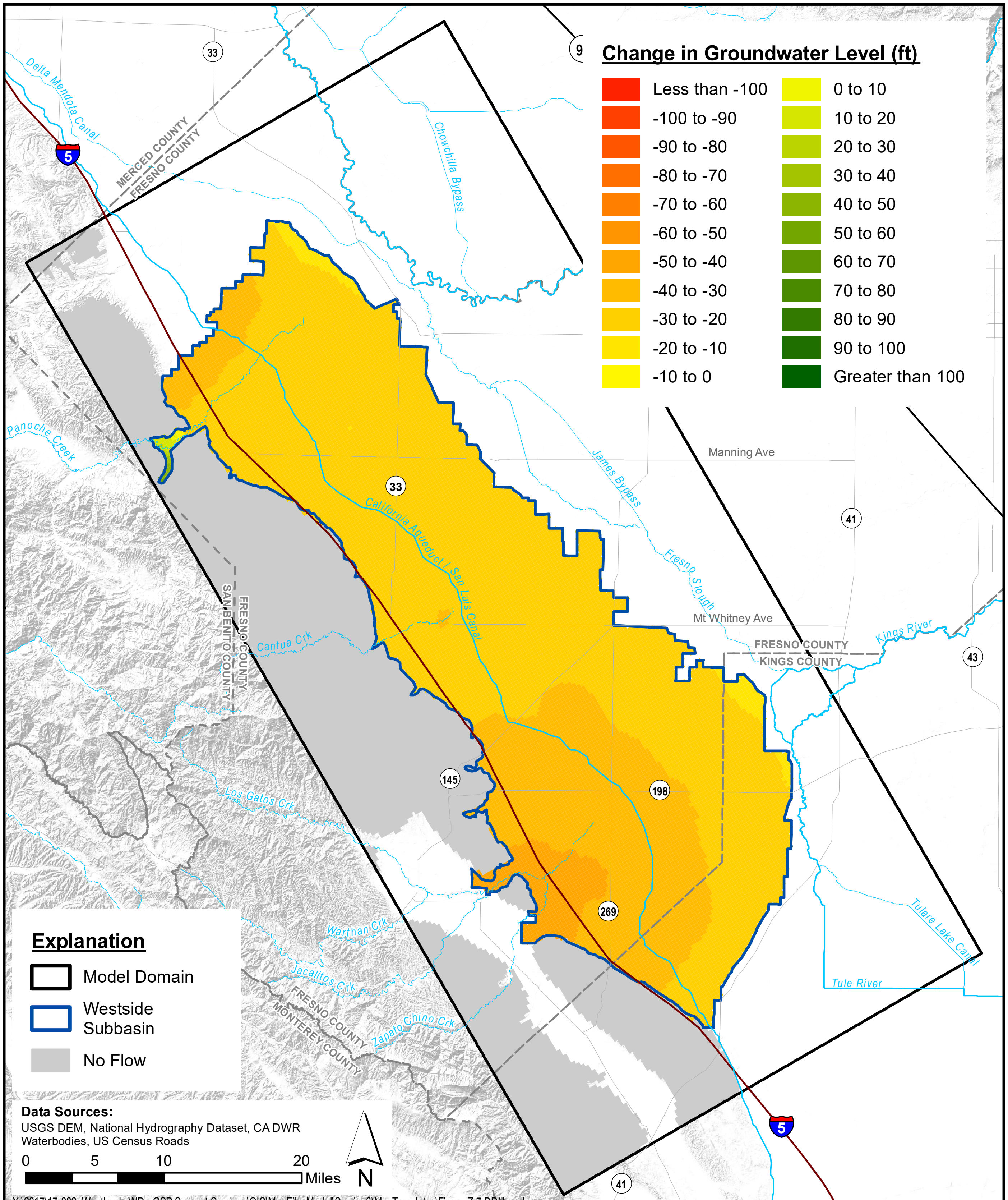
Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-53

SGMA Sustainability Analyses
Westside Subbasin



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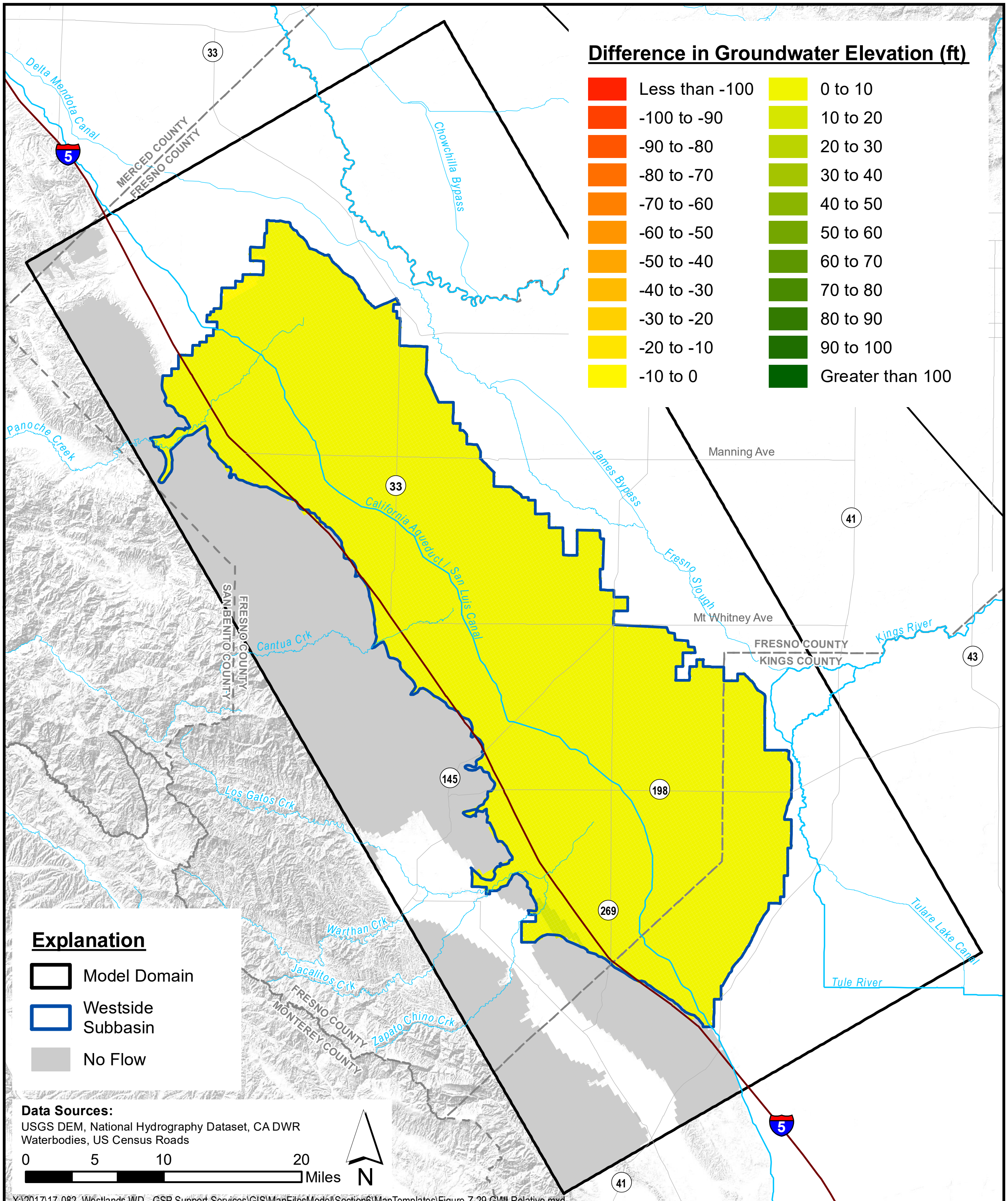
Consulting Engineers

Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-54

SGMA Sustainability Analyses
Westside Subbasin



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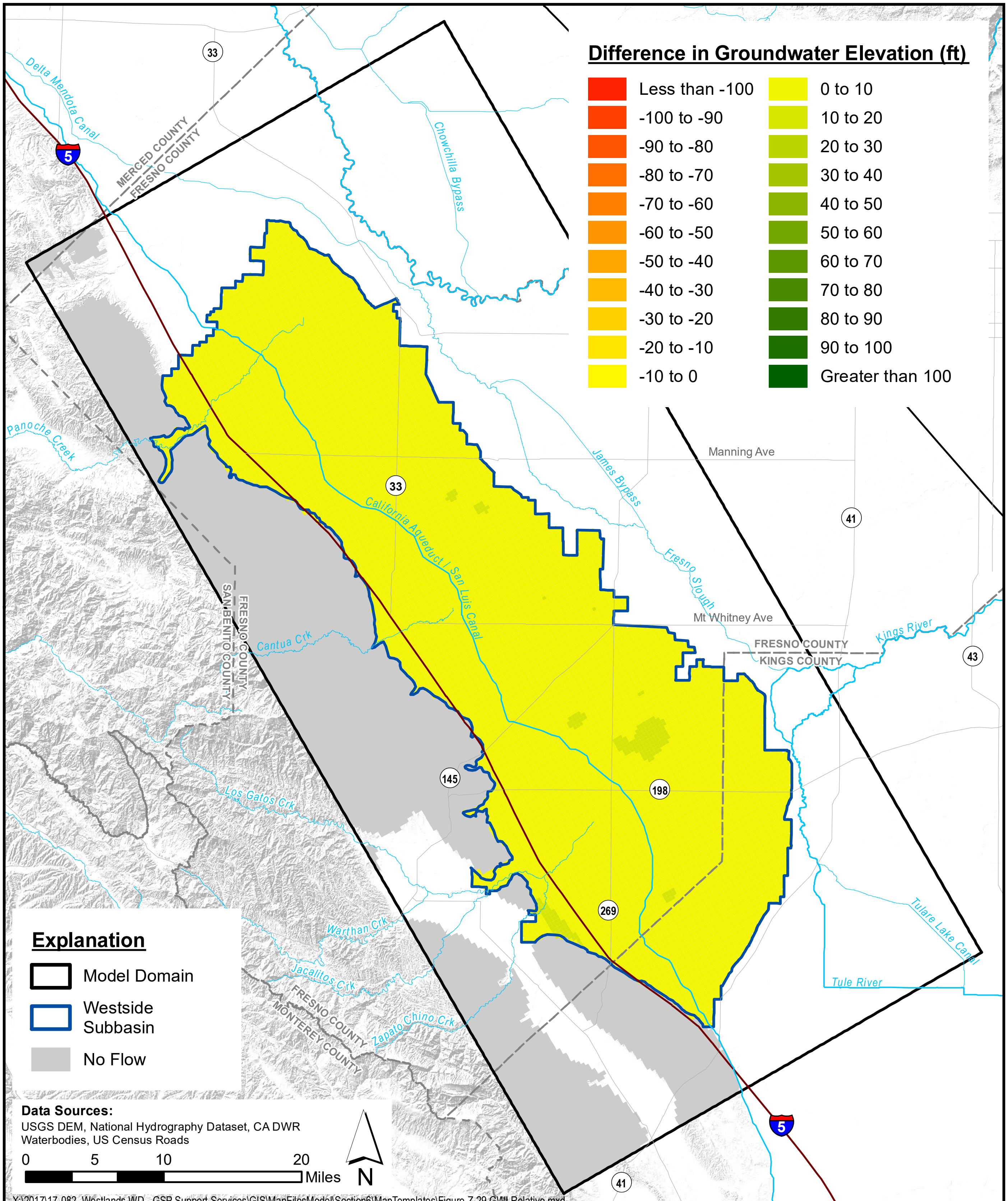
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 3 (2020 - 2040)

Figure G-55

SGMA Sustainability Analyses
Westside Subbasin



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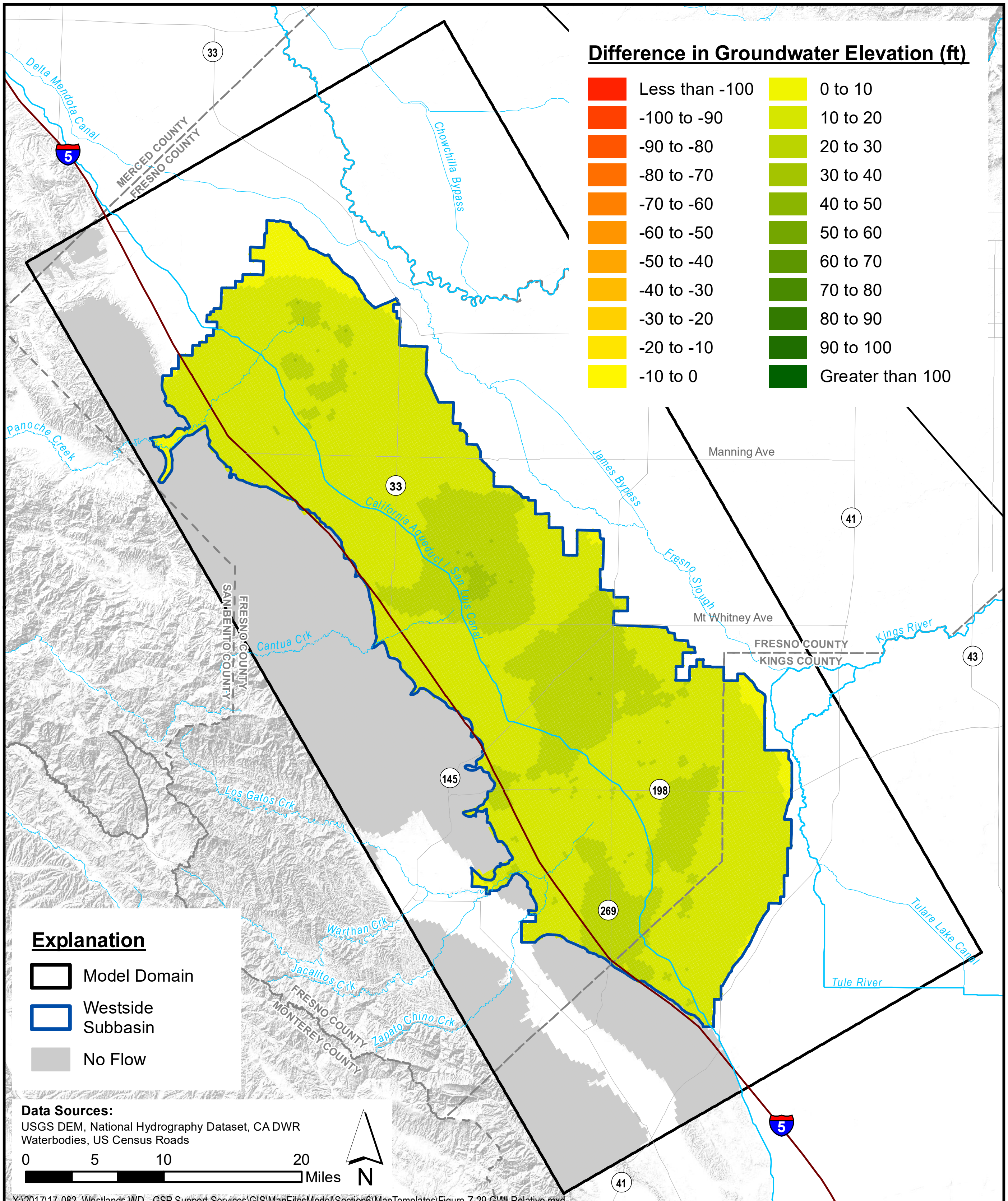
Project Impacts on Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2040)

Figure G-56

SGMA Sustainability Analyses
Westside Subbasin



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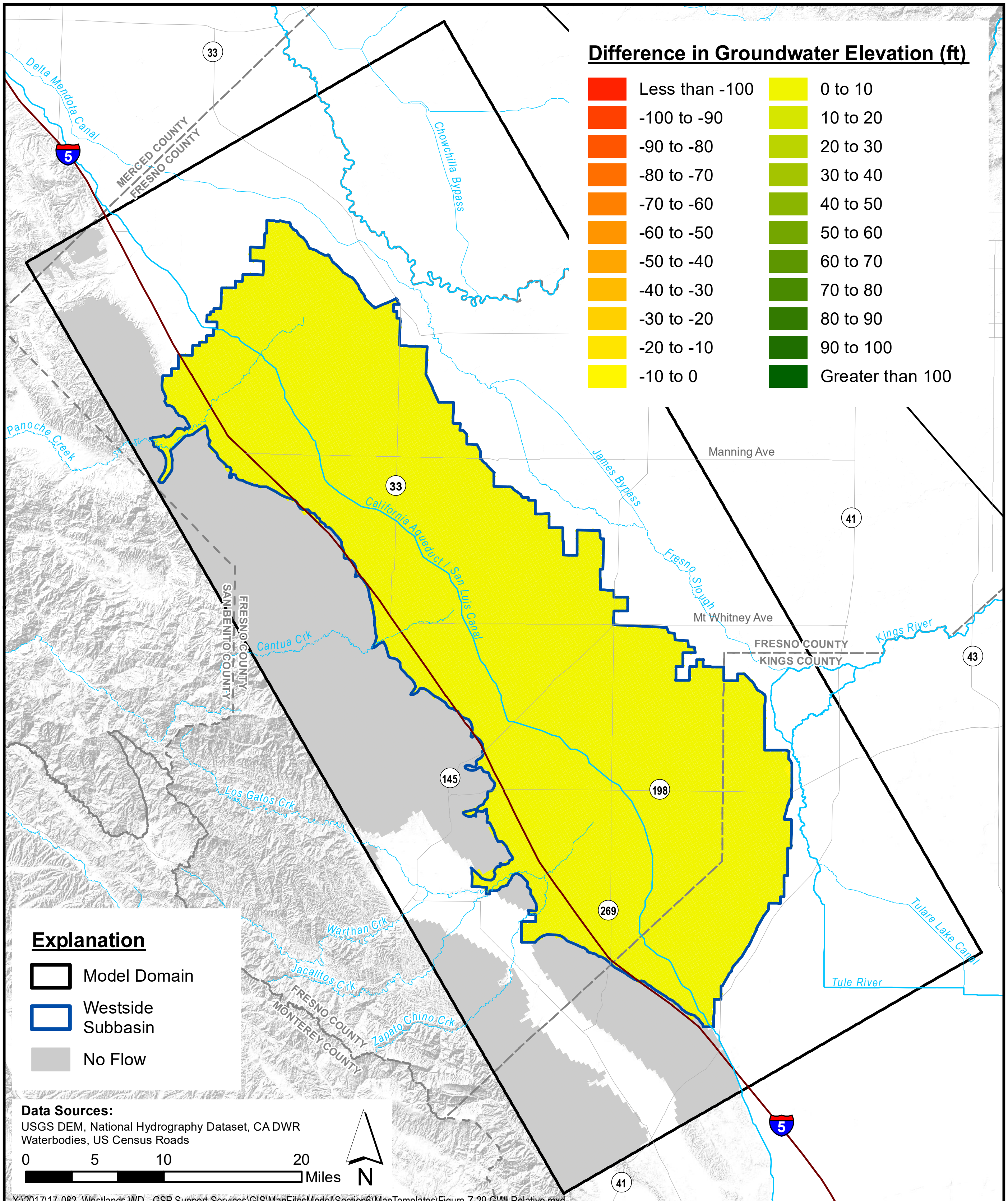
Project Impacts on Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2040)

Figure G-57

SGMA Sustainability Analyses
Westside Subbasin



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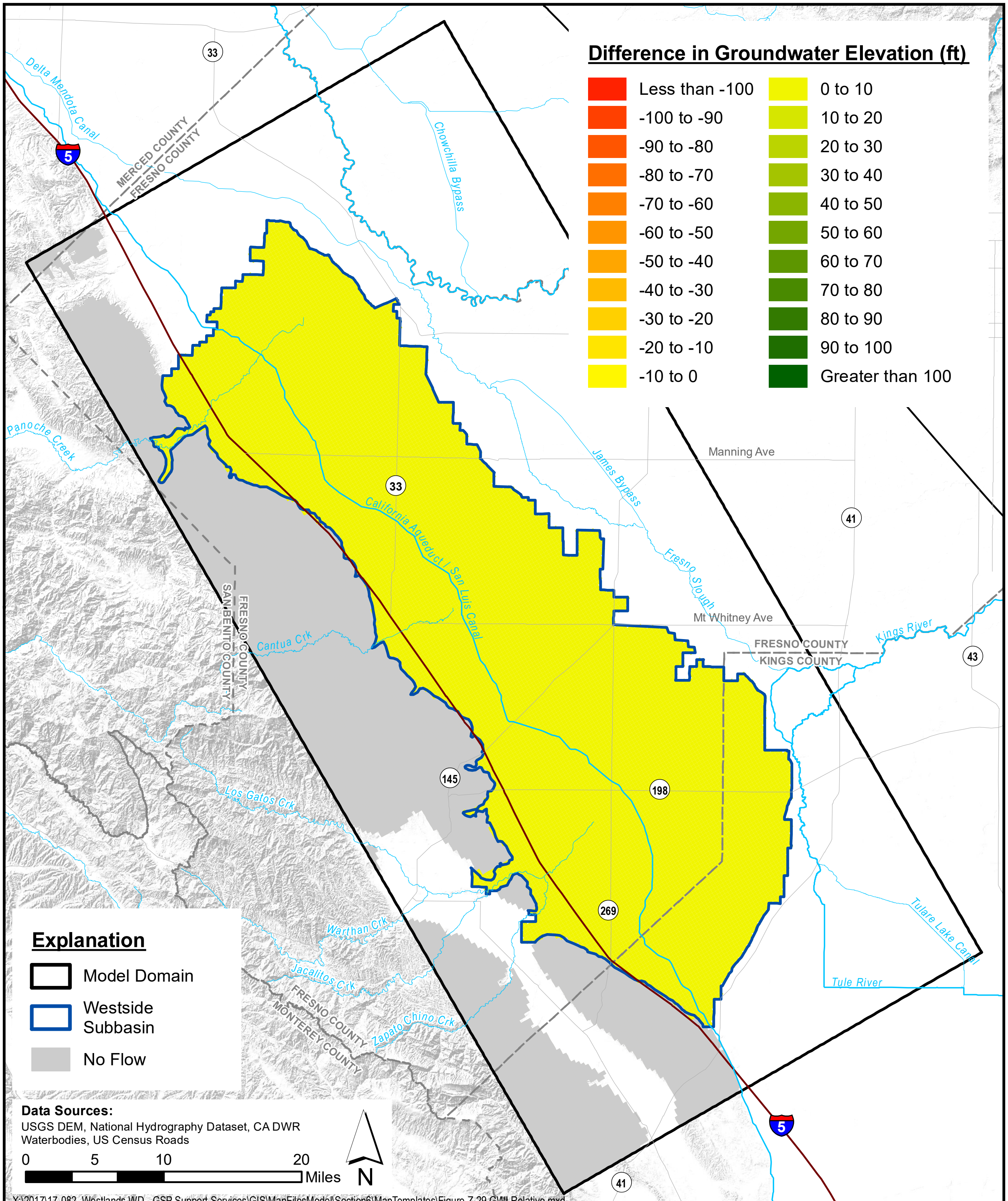
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-58

SGMA Sustainability Analyses
Westside Subbasin



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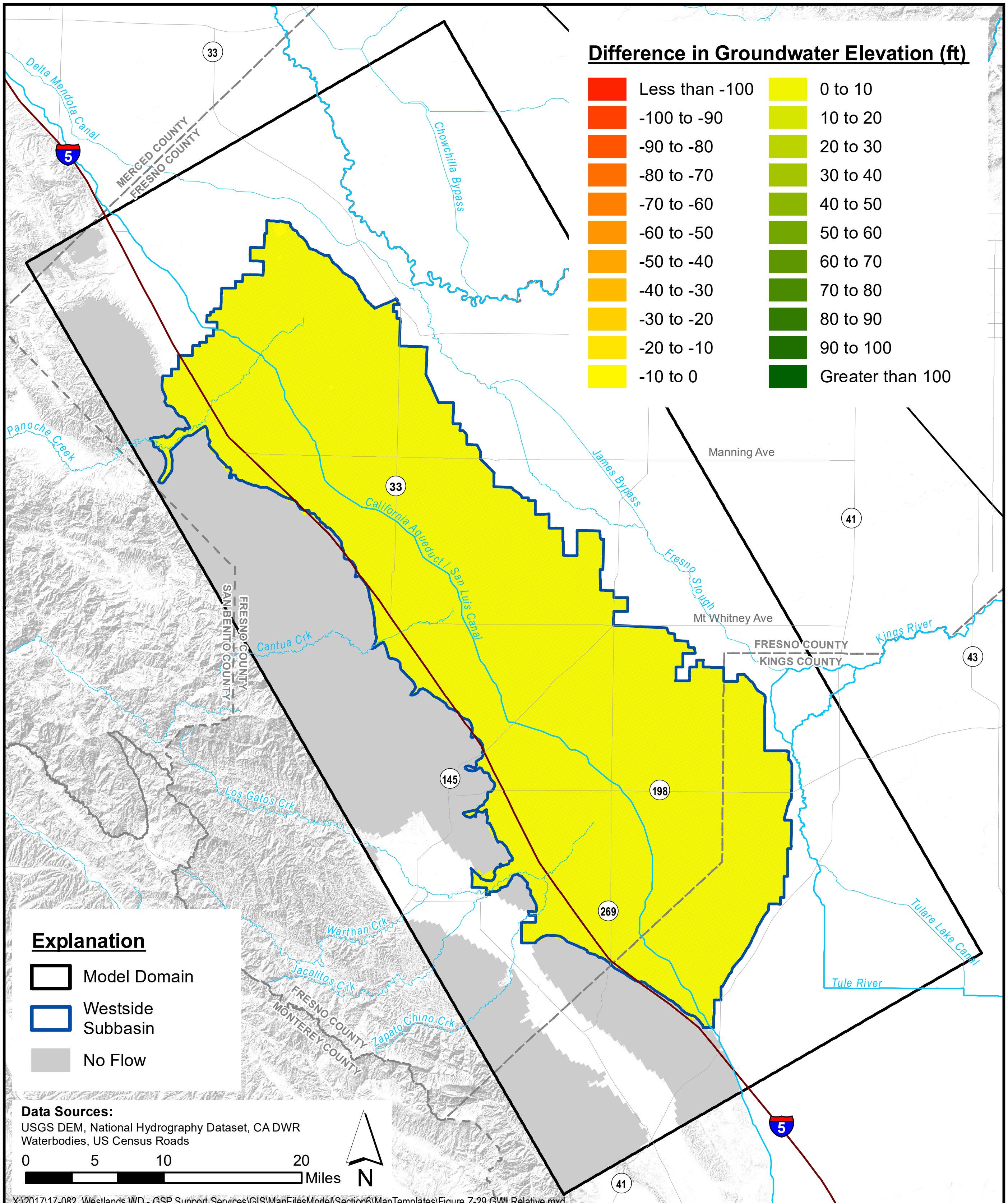
Project Impacts on Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-59

SGMA Sustainability Analyses
Westside Subbasin



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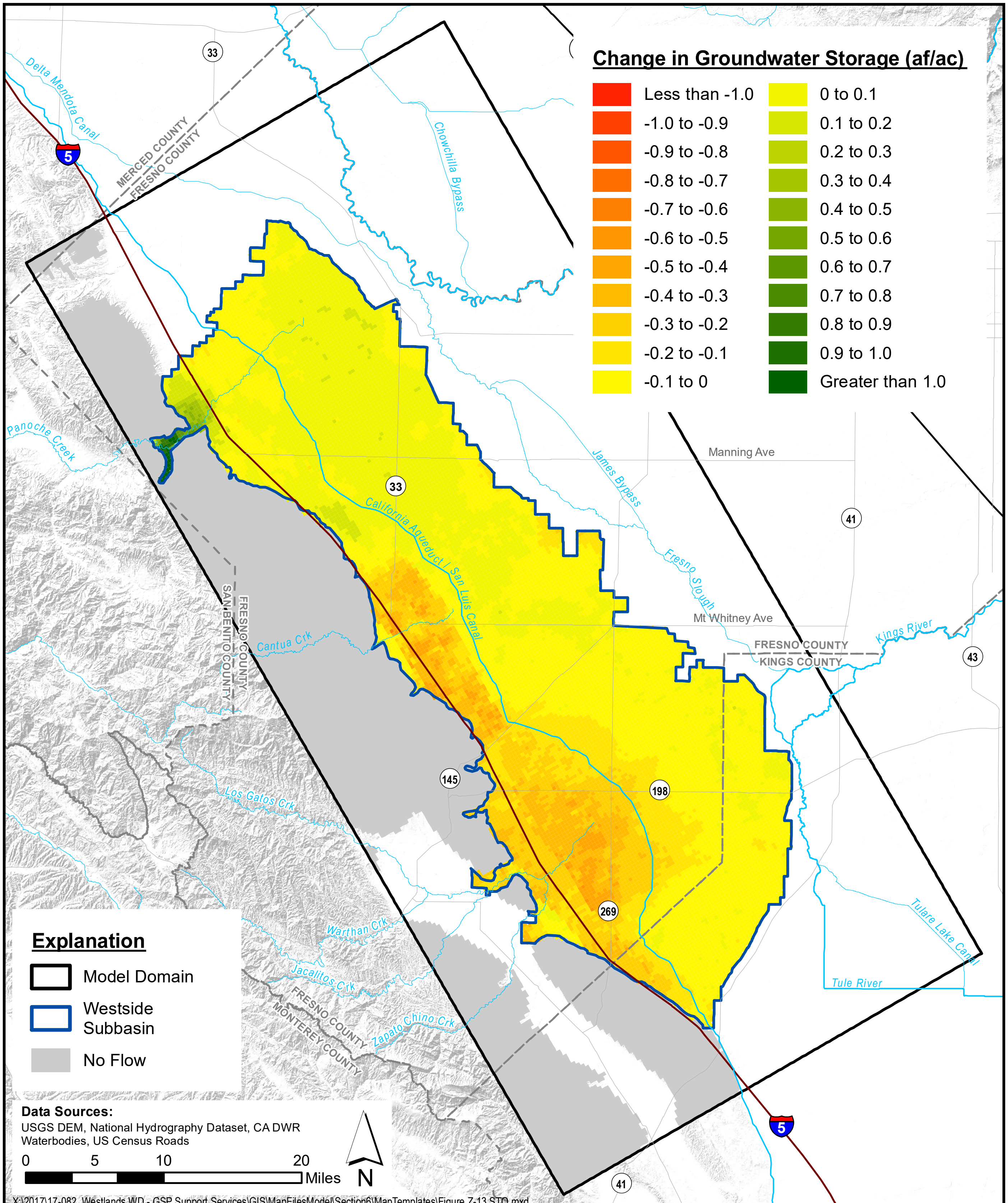
Project Impacts on Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 3 (2020 - 2070)

Figure G-60

SGMA Sustainability Analyses
Westside Subbasin



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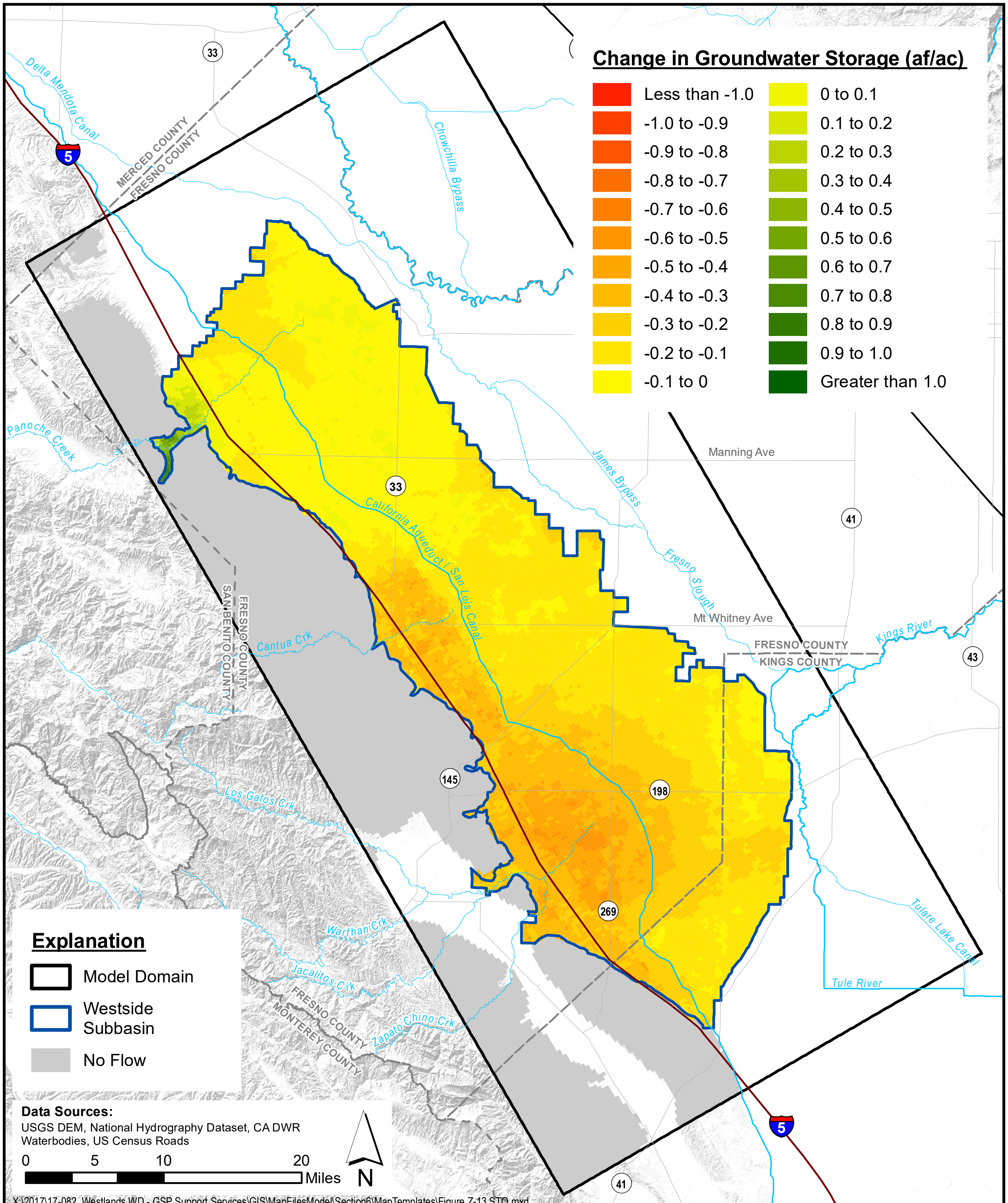
Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.3 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-61



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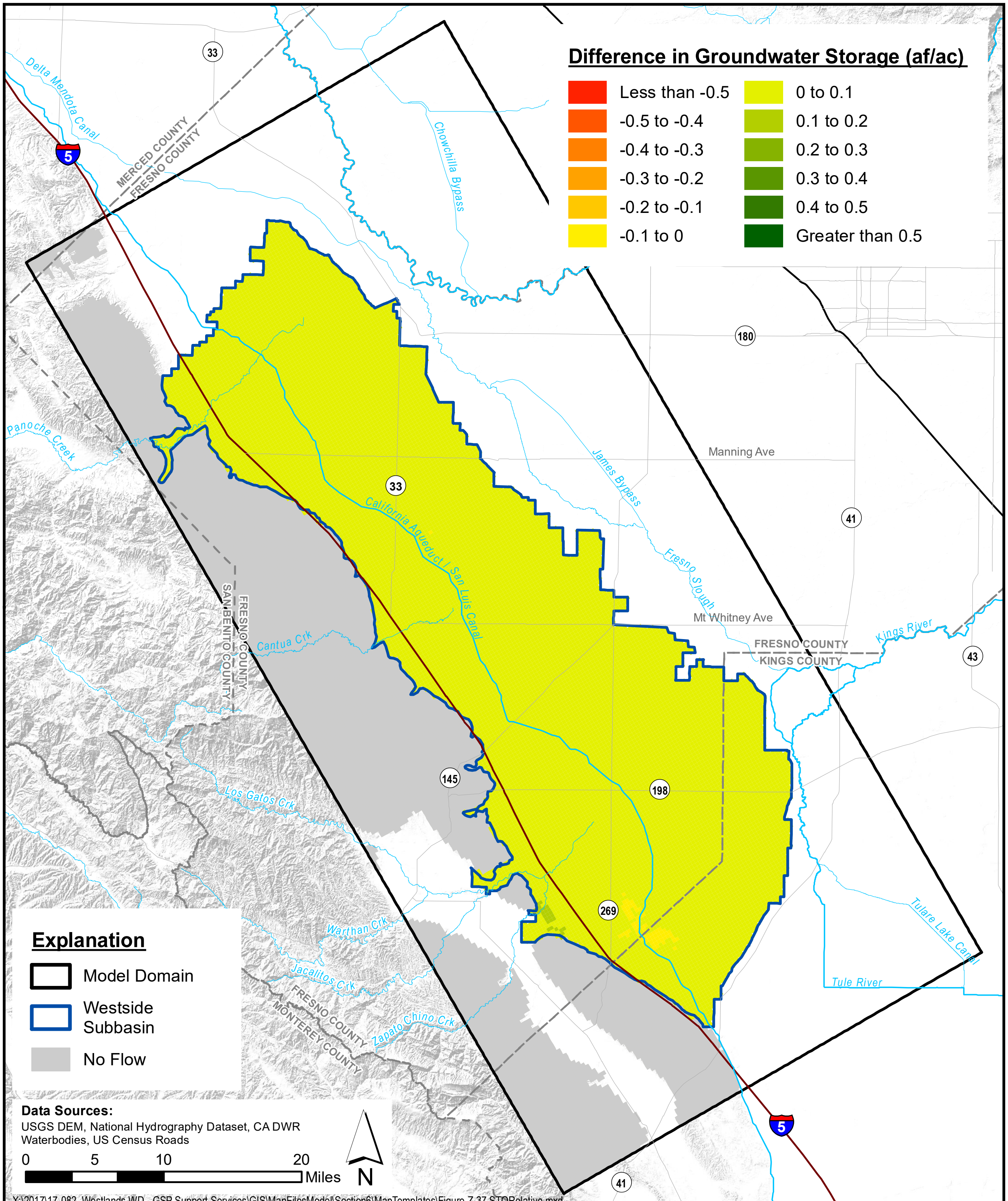
Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.3 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-62



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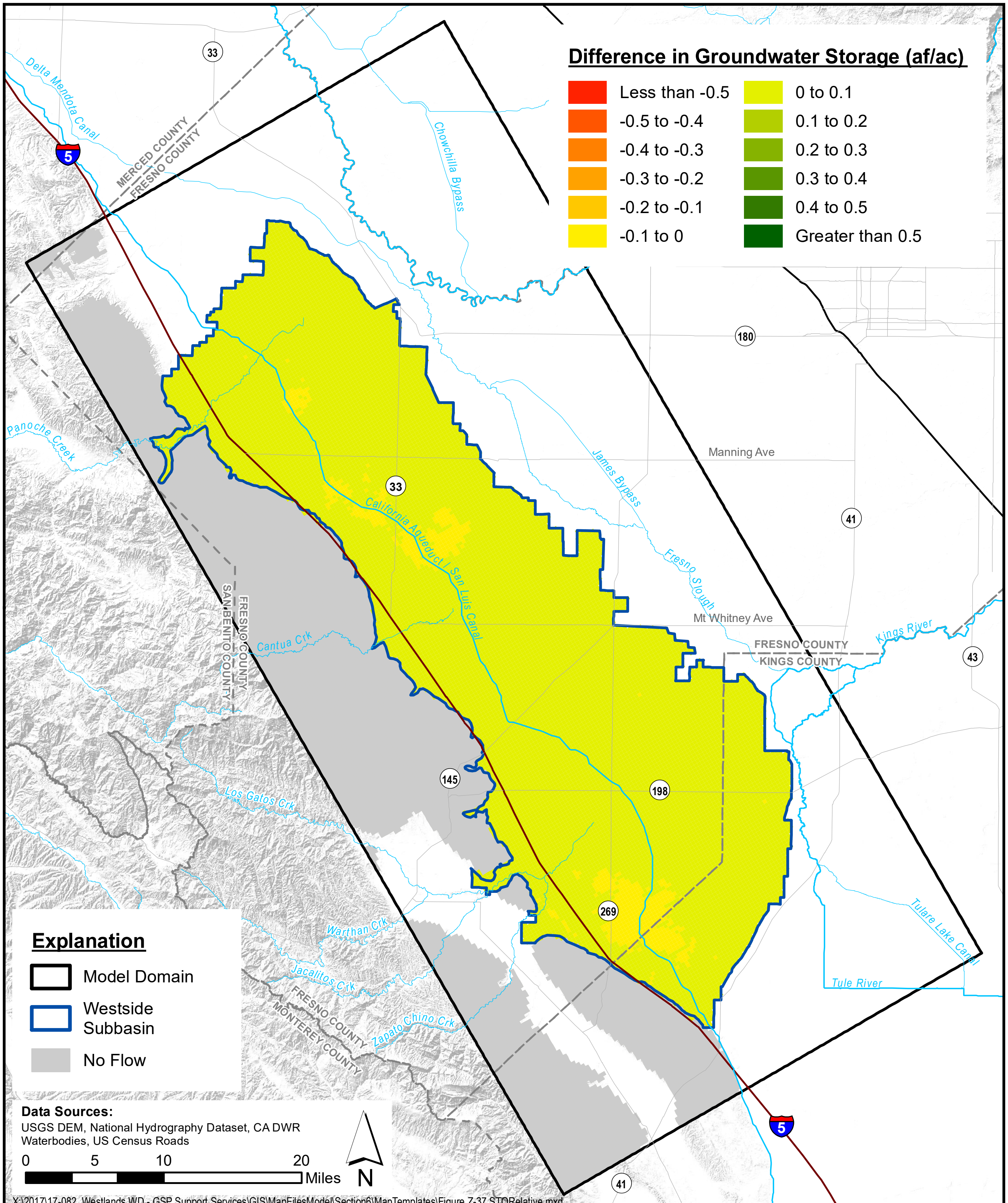
Project Impacts on Groundwater Storage
2070 Climate Change - PMA No. 3 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-63



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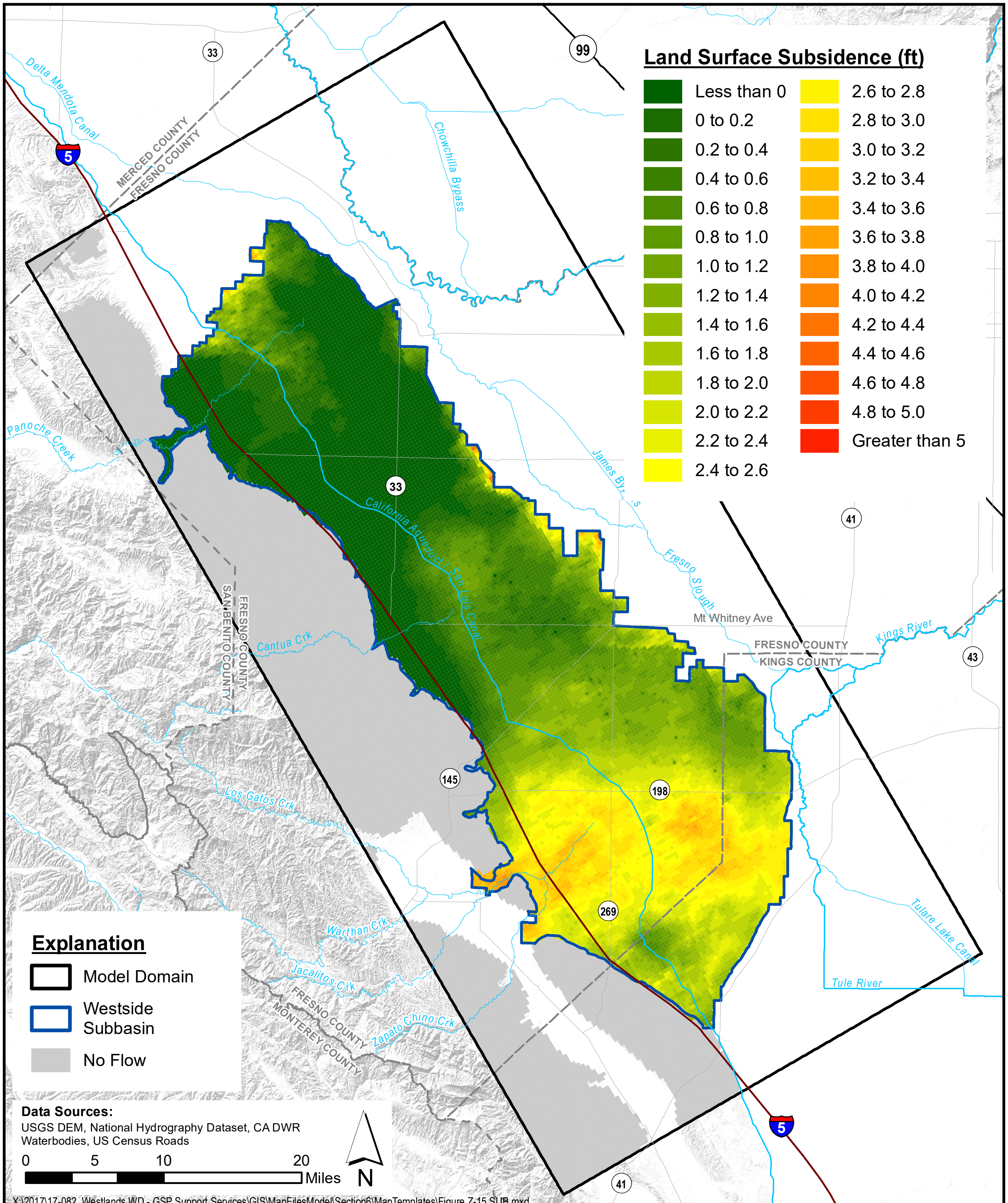
Project Impacts on Groundwater Storage
2070 Climate Change - PMA No. 3 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-64



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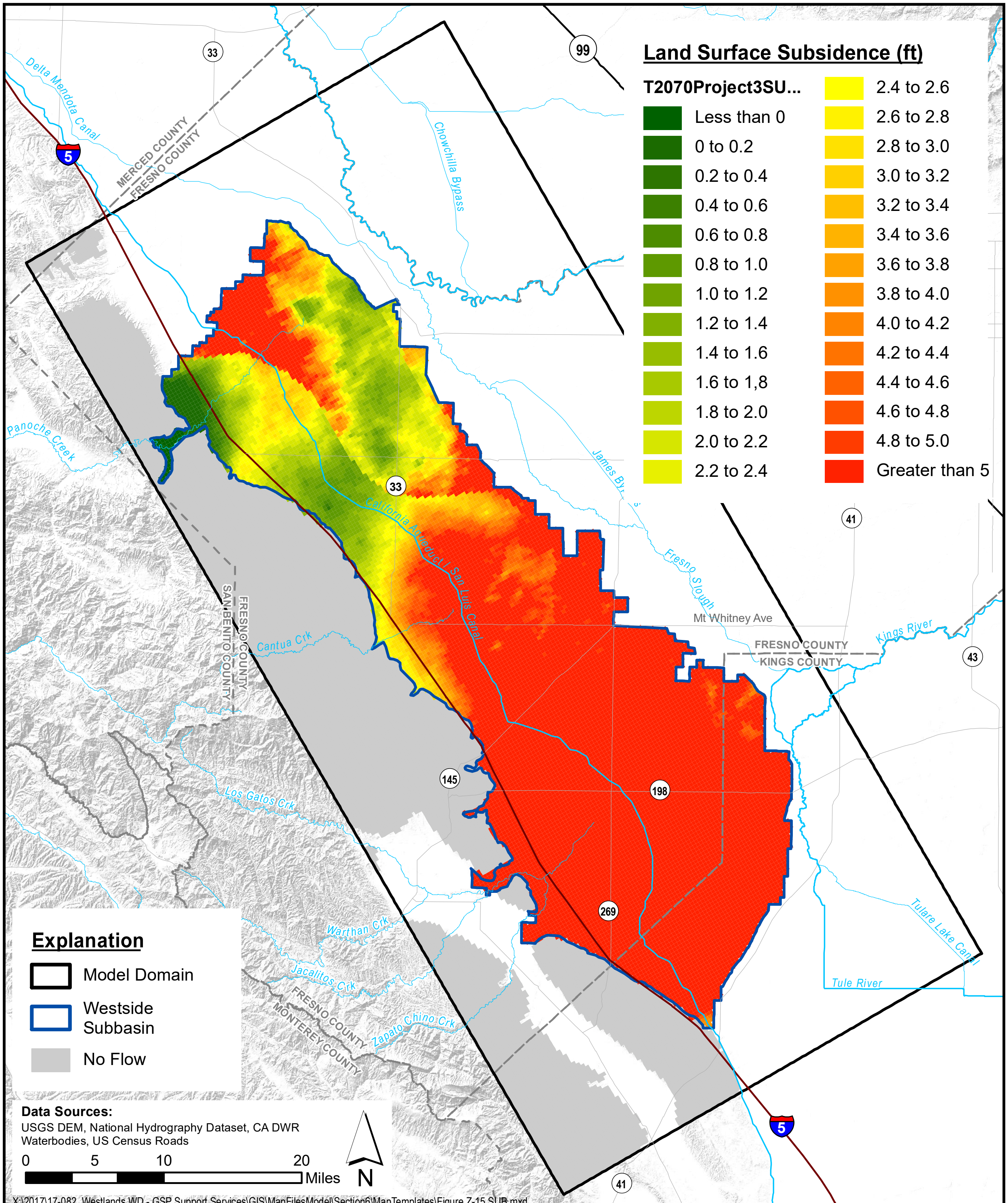
Simulated Land Surface Subsidence
2070 Climate Change - PMA No.3 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-65



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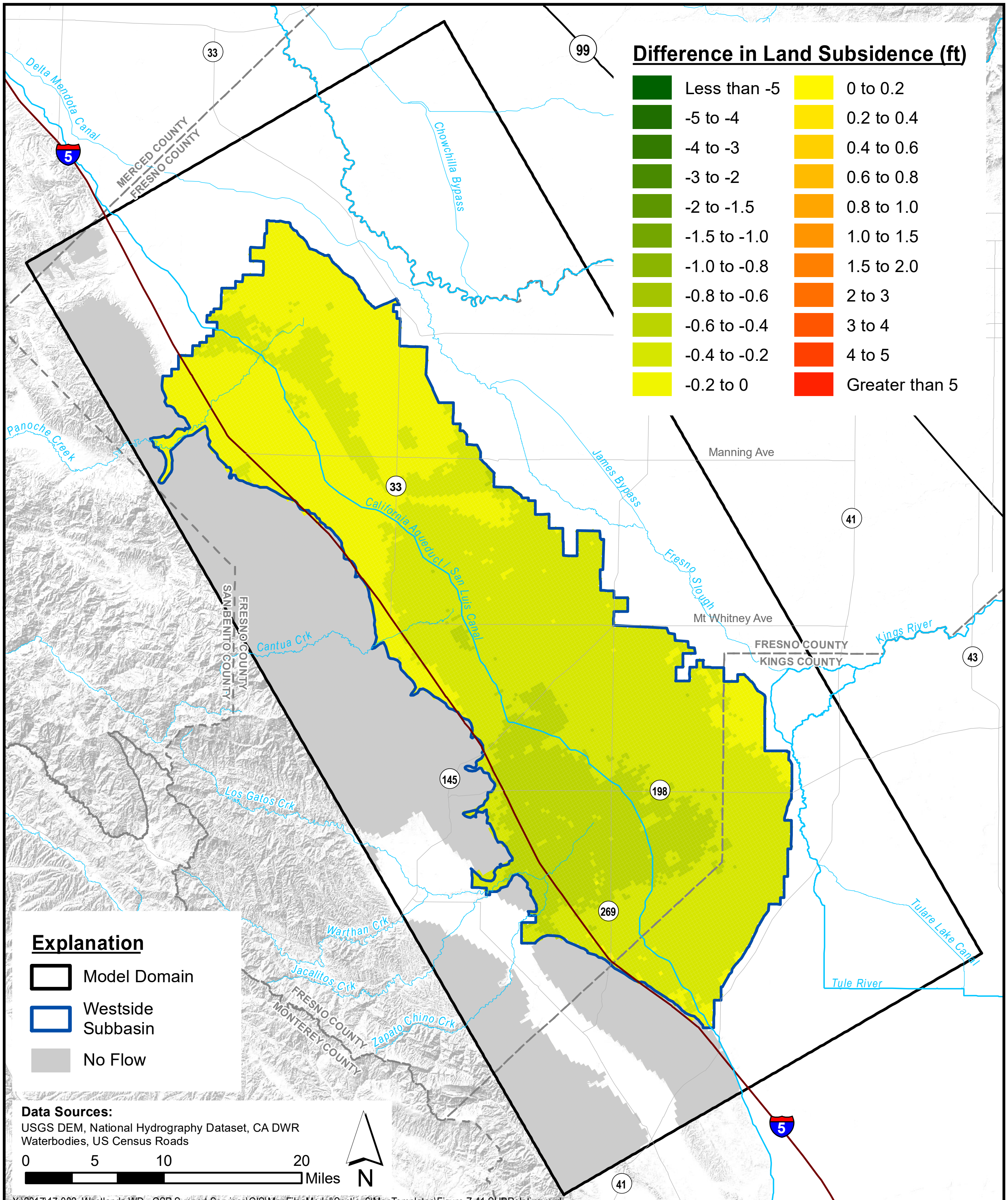
Simulated Land Surface Subsidence
2070 Climate Change - PMA No. 3 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-66



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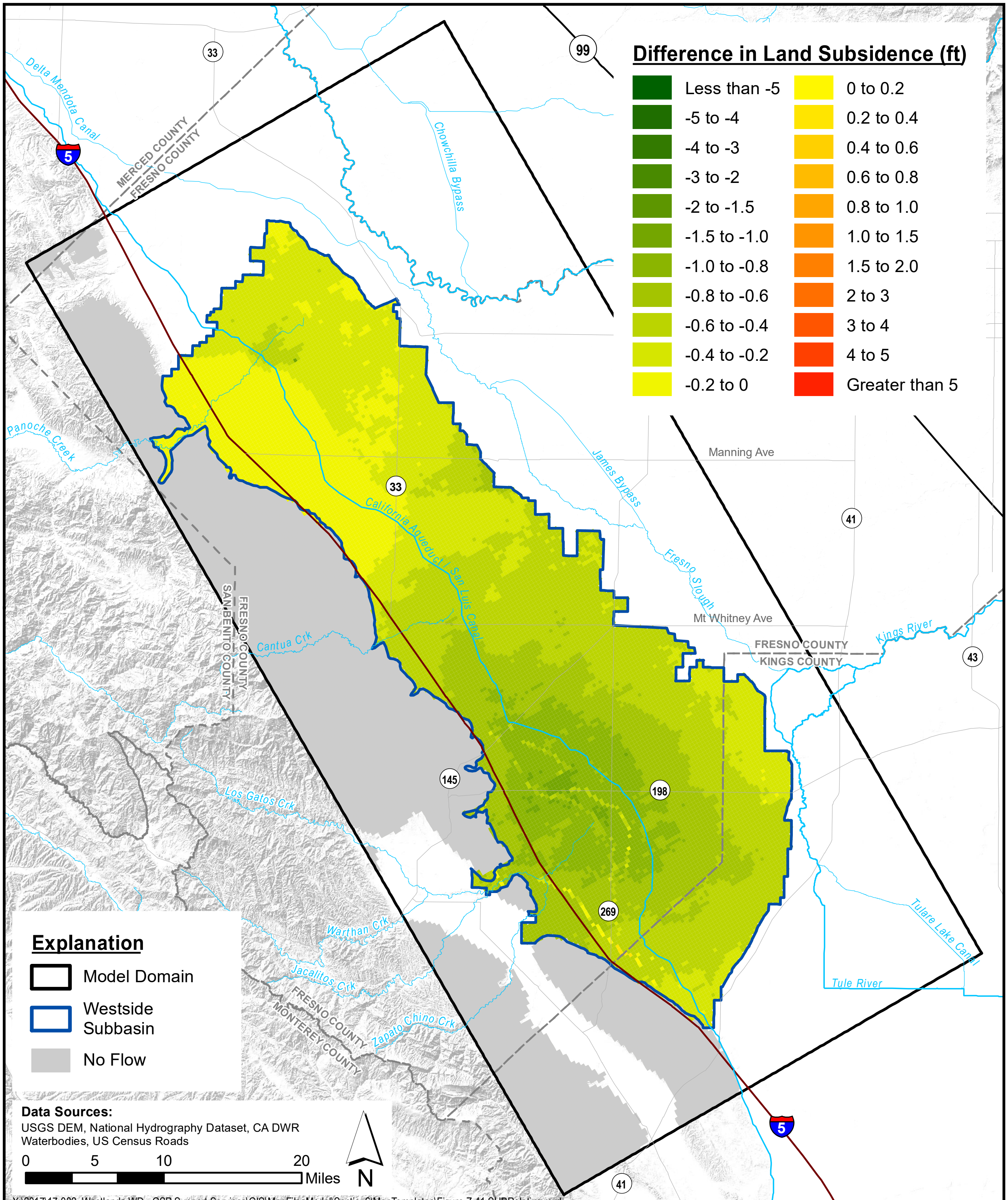
Consulting Engineers

Project Impact on Land Subsidence
2070 Climate Change - PMA No. 3 (2020 - 2040)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-67



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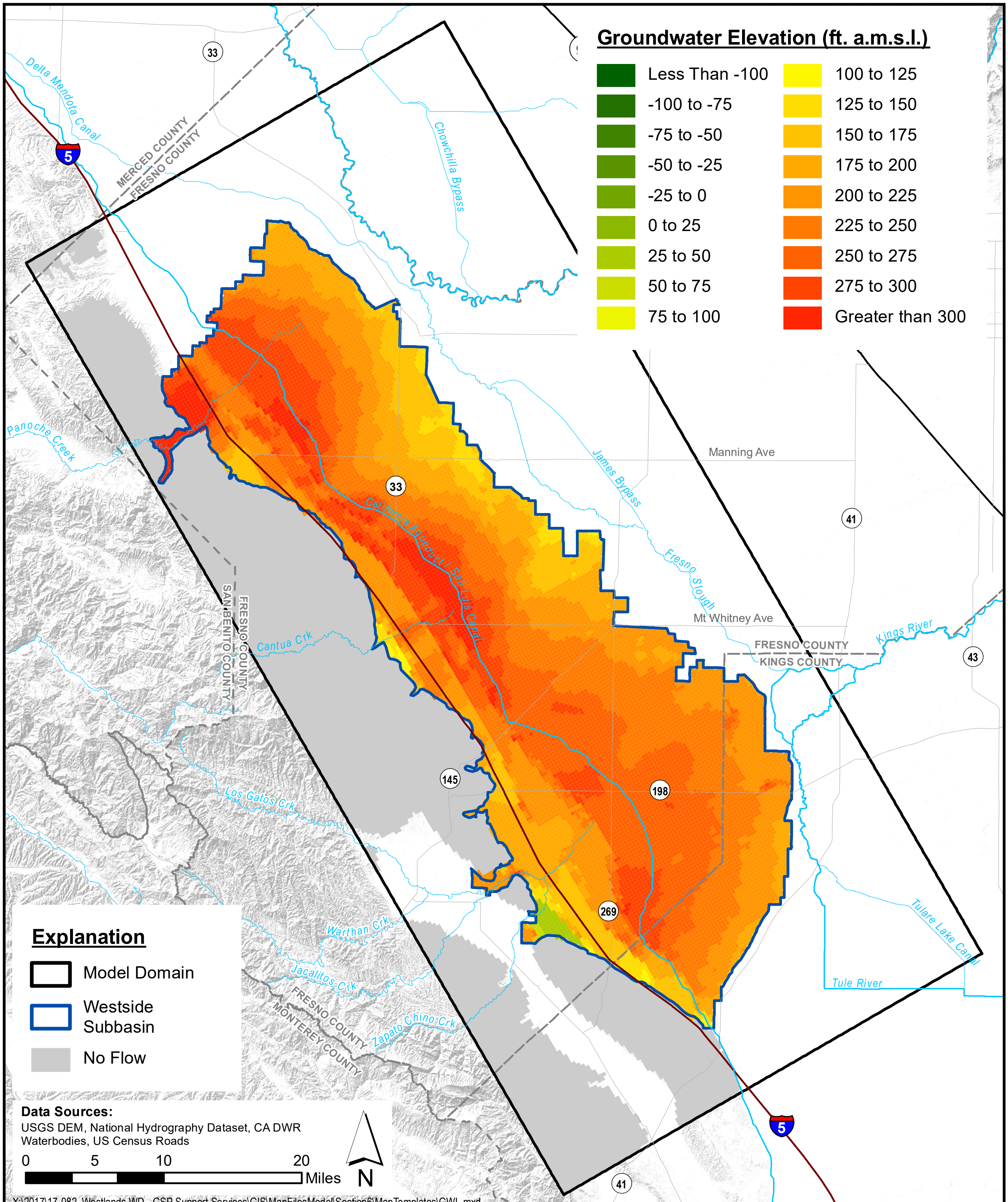
Project Impact on Land Subsidence
2070 Climate Change - PMA No. 3 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-68



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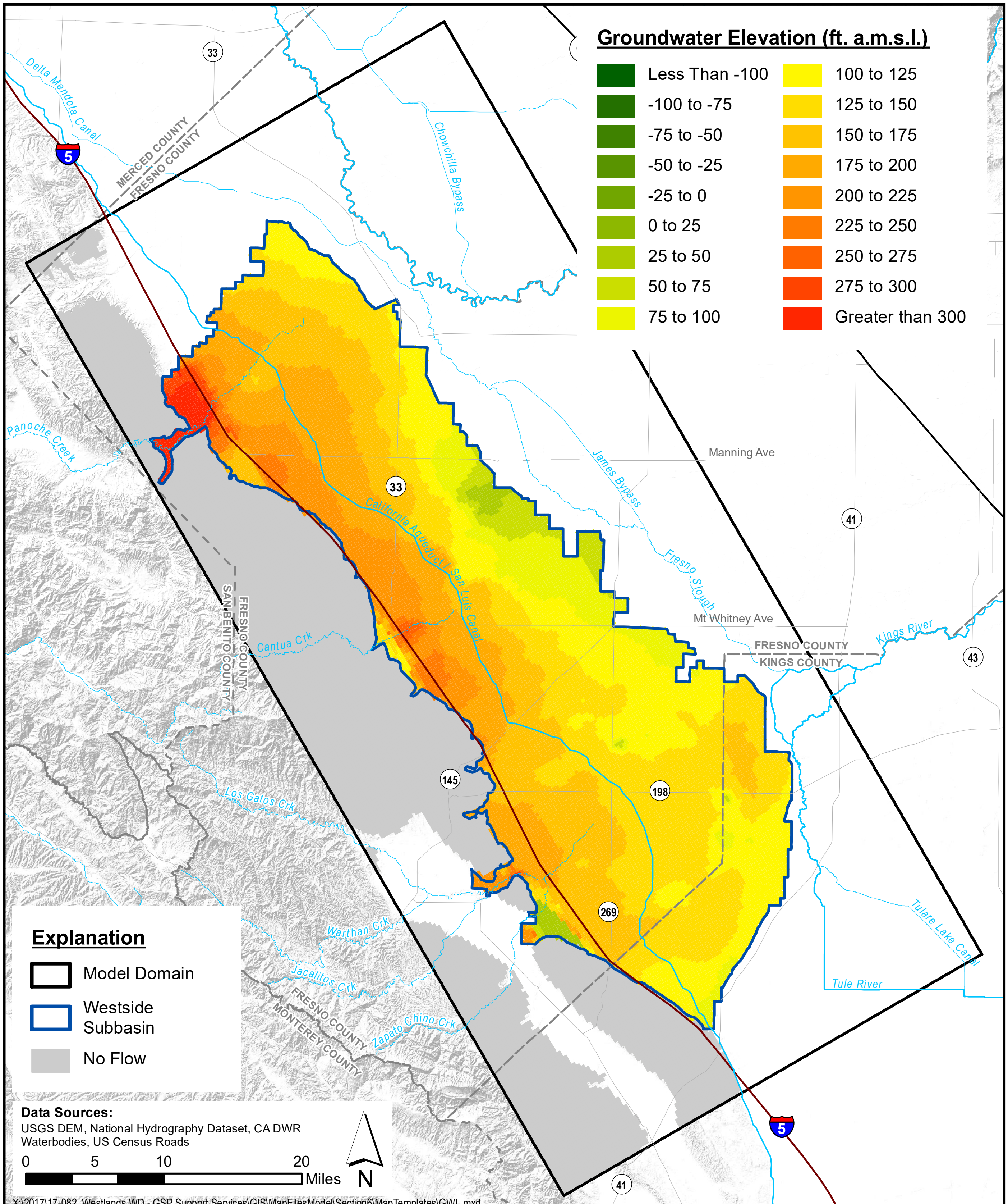
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.4 (March 2047)

Figure G-69

SGMA Sustainability Analyses
Westside Subbasin



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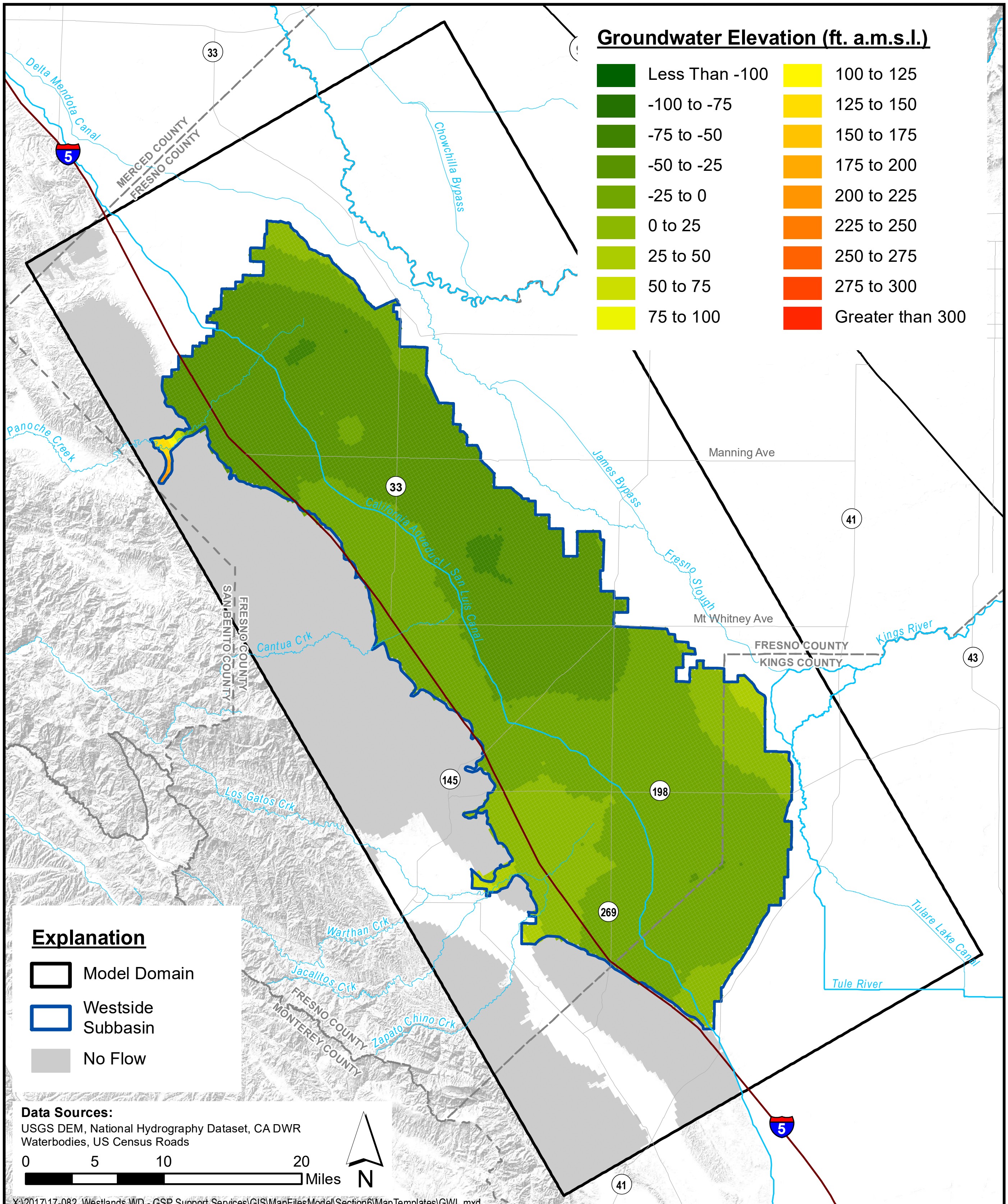
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.4 (March 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-70



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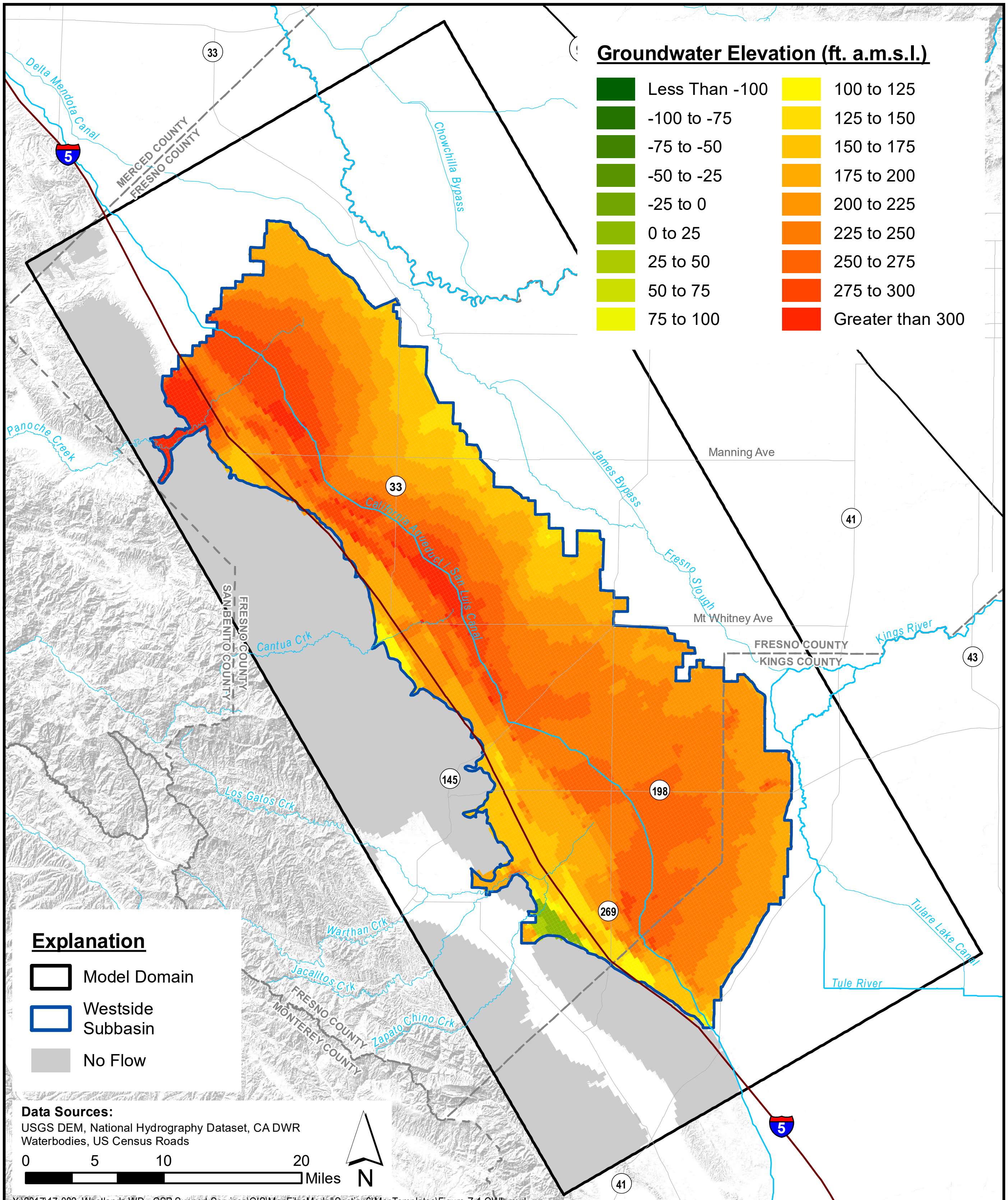
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.4 (March 2047)

Figure G-71

SGMA Sustainability Analyses
Westside Subbasin



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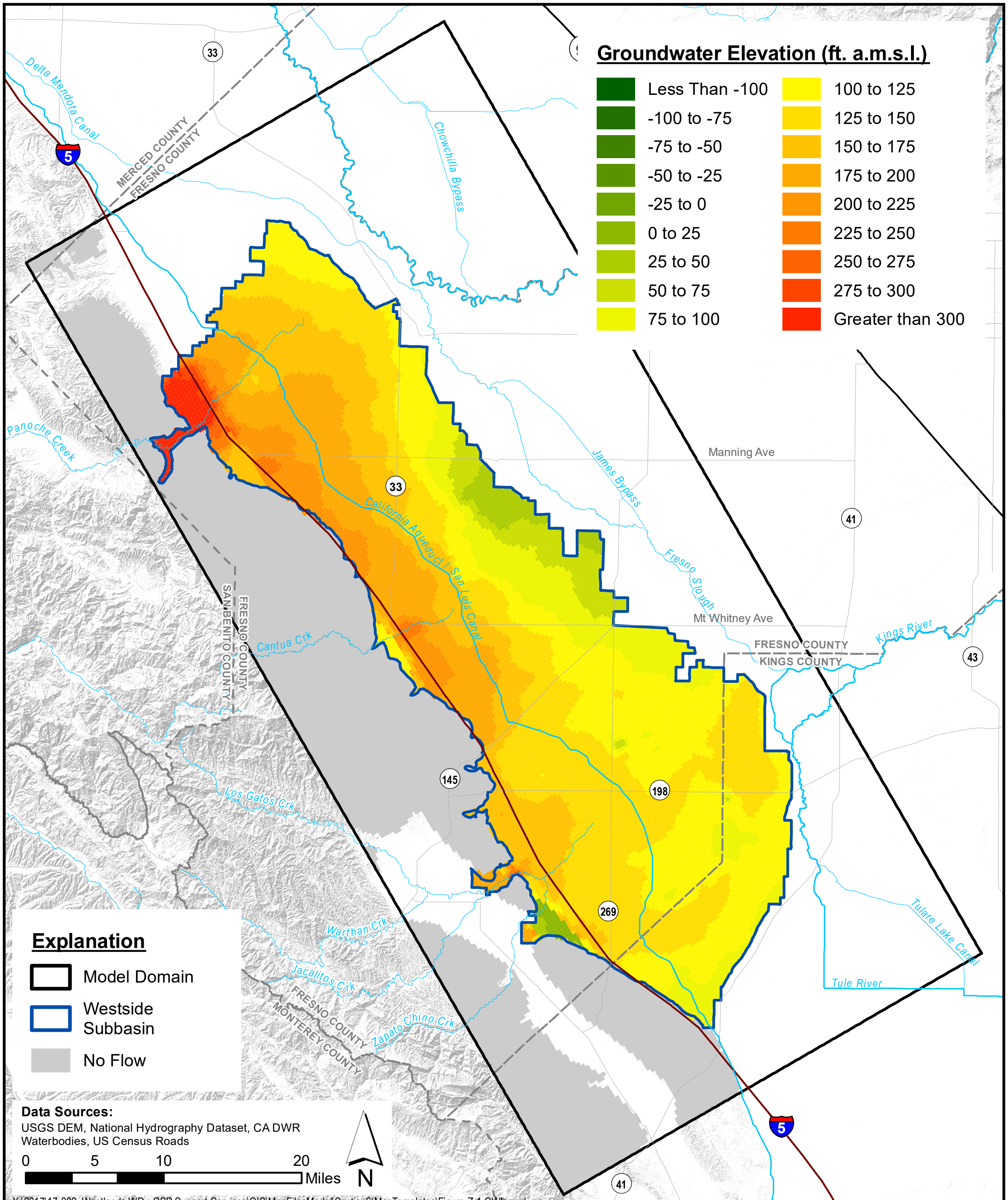
Simulated Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.4 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-72



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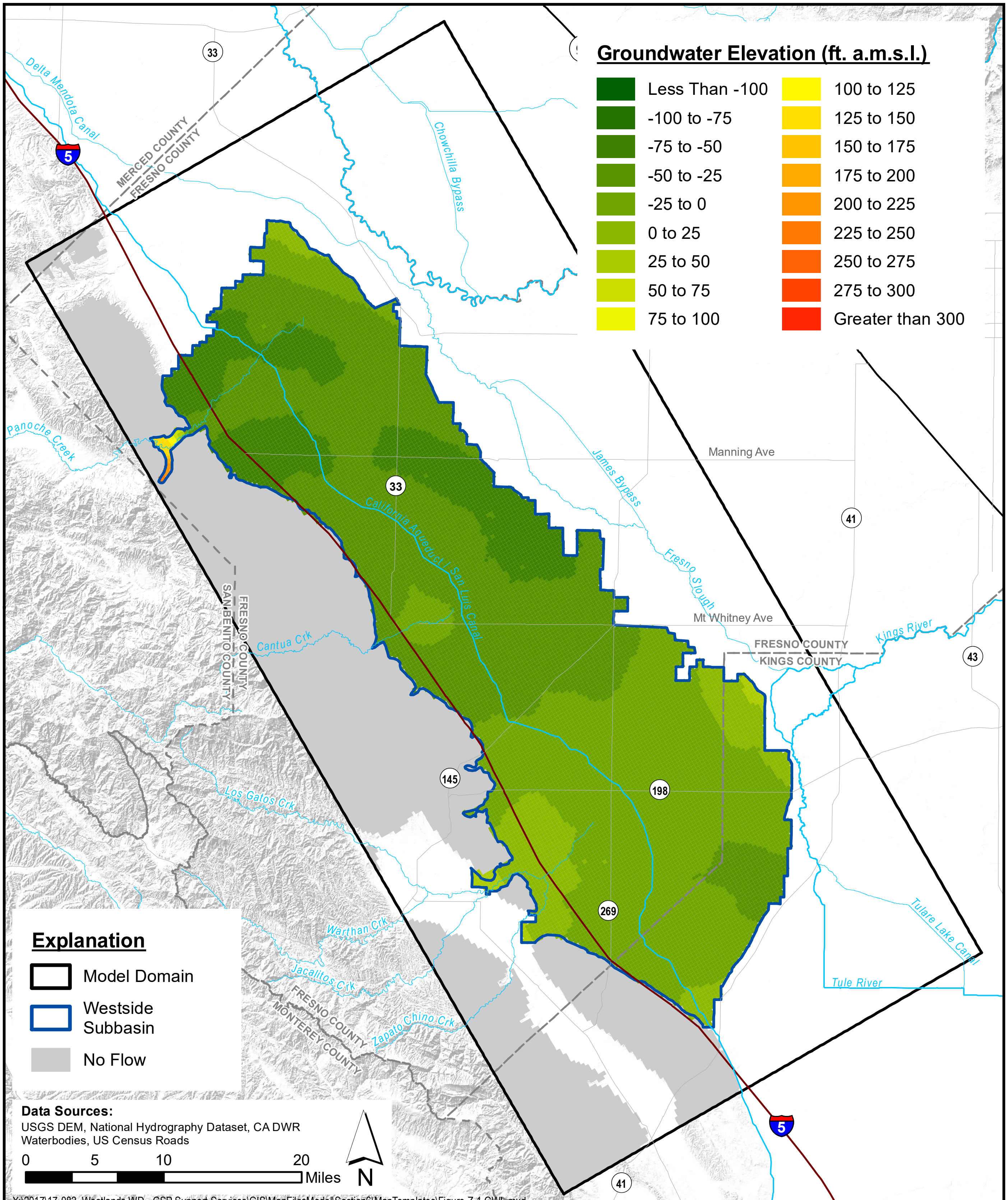
Simulated Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.4 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-73



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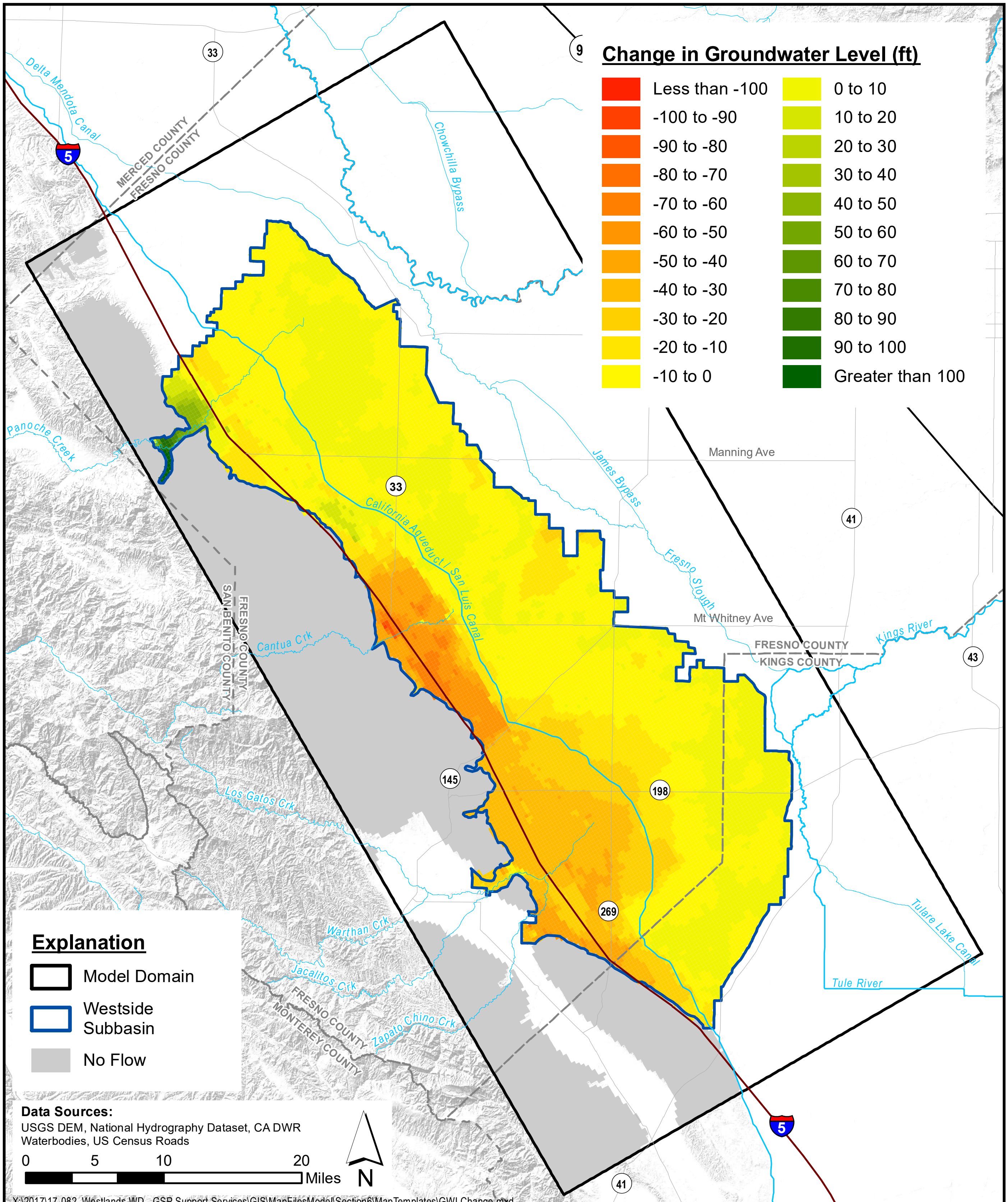
Simulated Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.4 (January 2071)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-74



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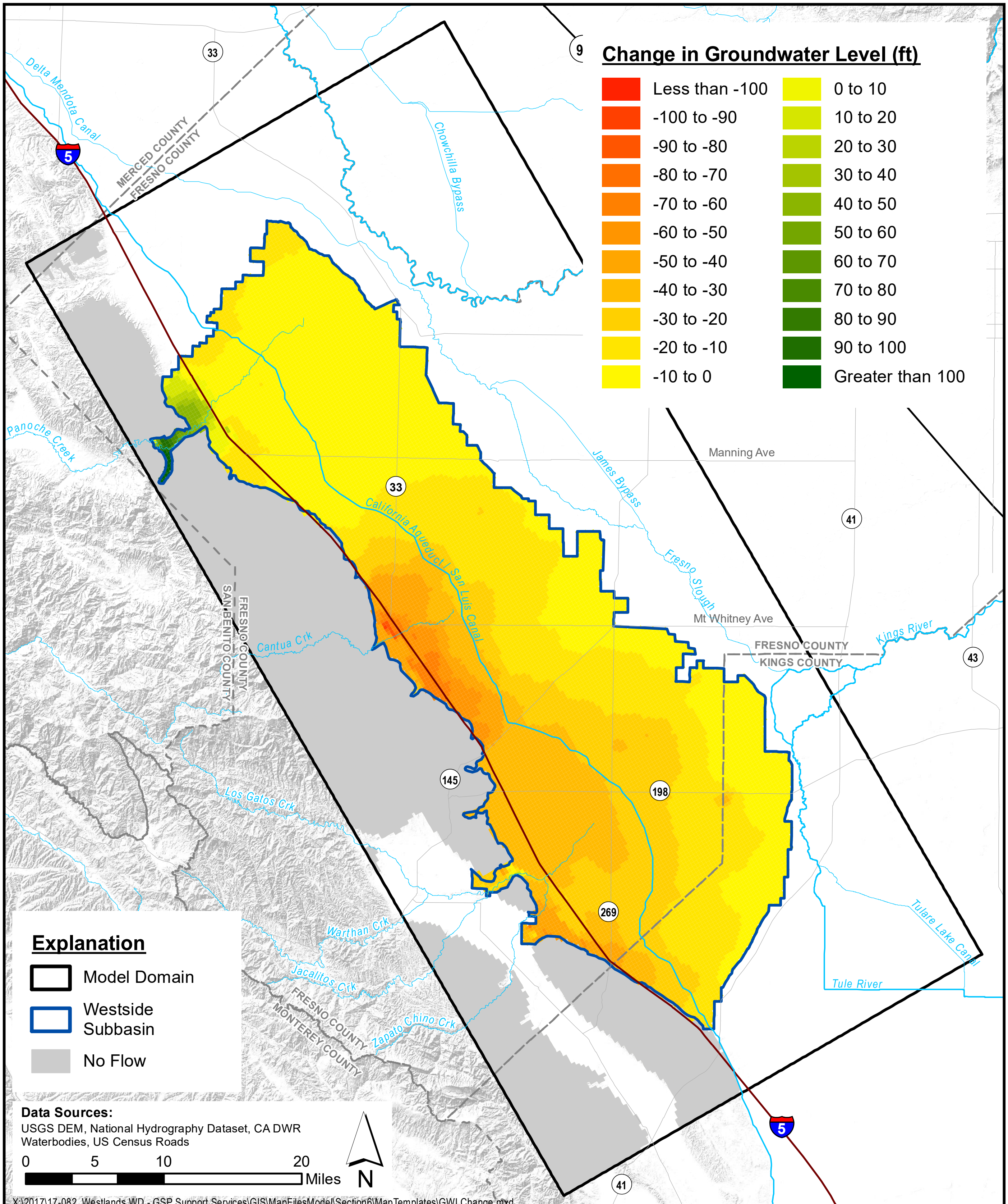
Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-75

SGMA Sustainability Analyses
Westside Subbasin



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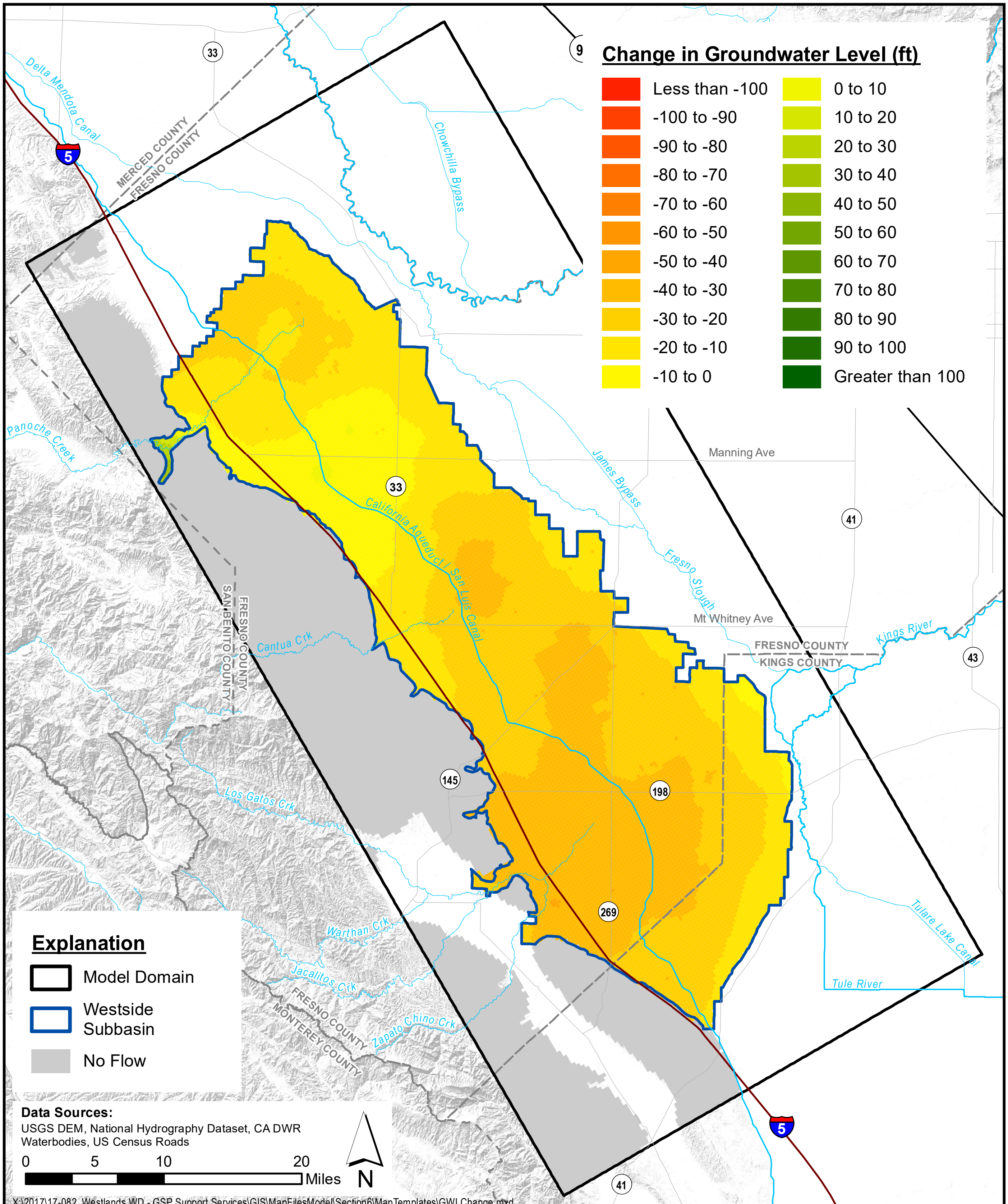
Simulated Change in Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-76

SGMA Sustainability Analyses
Westside Subbasin



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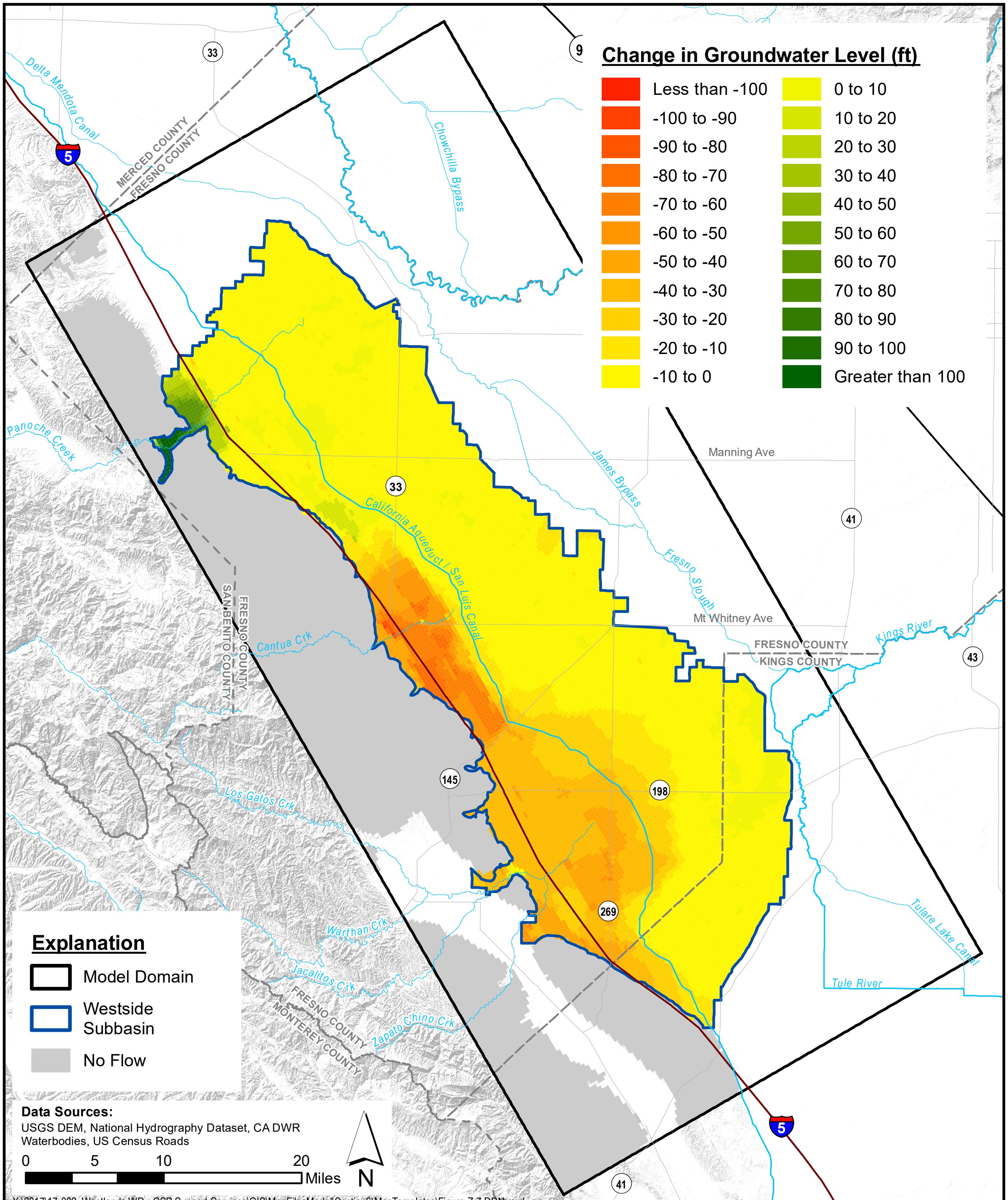
Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-77

SGMA Sustainability Analyses
Westside Subbasin



Simulated Change in Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.4 (2020 - 2070)

Figure G-78

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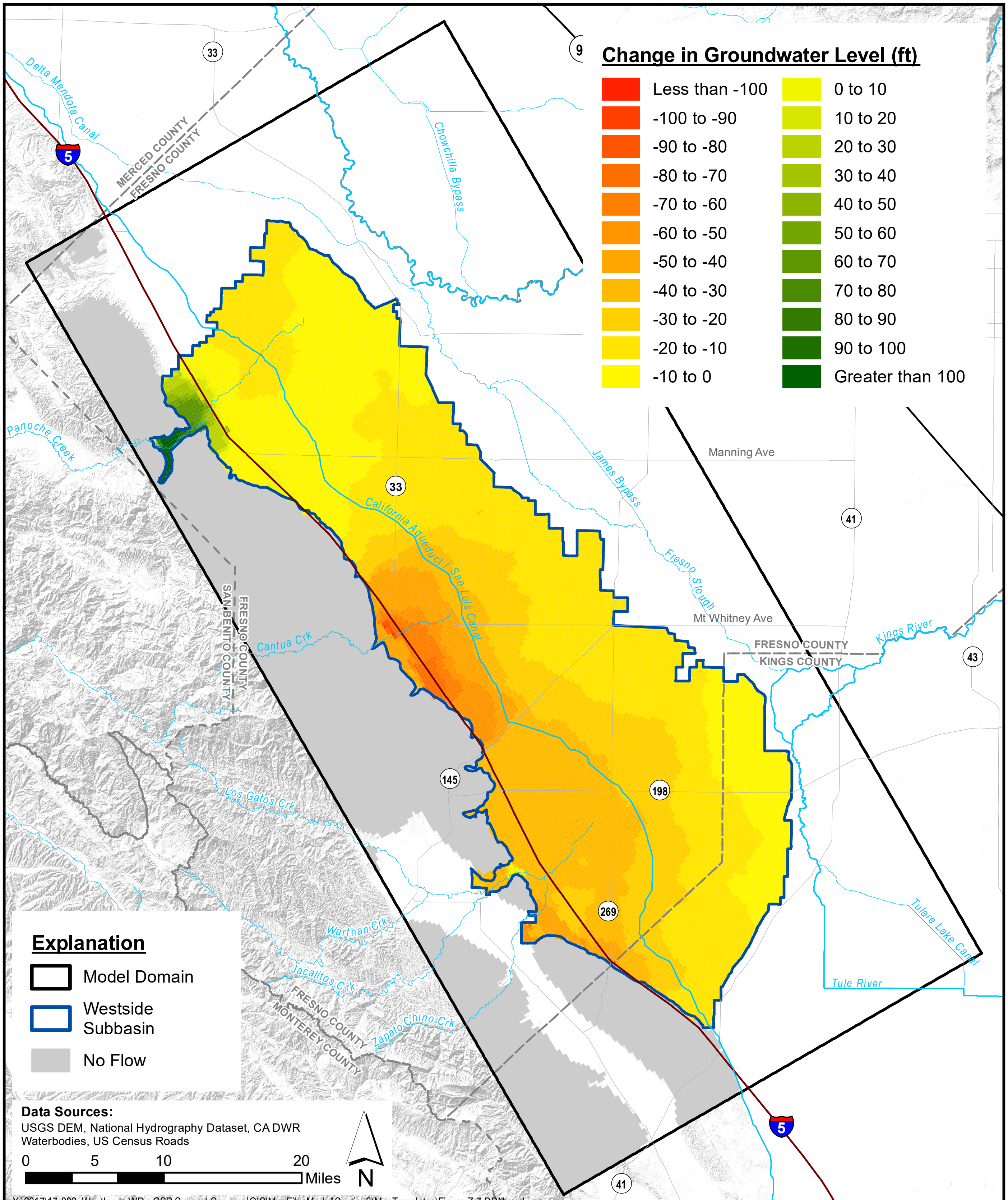
SGMA Sustainability Analyses
Westside Subbasin



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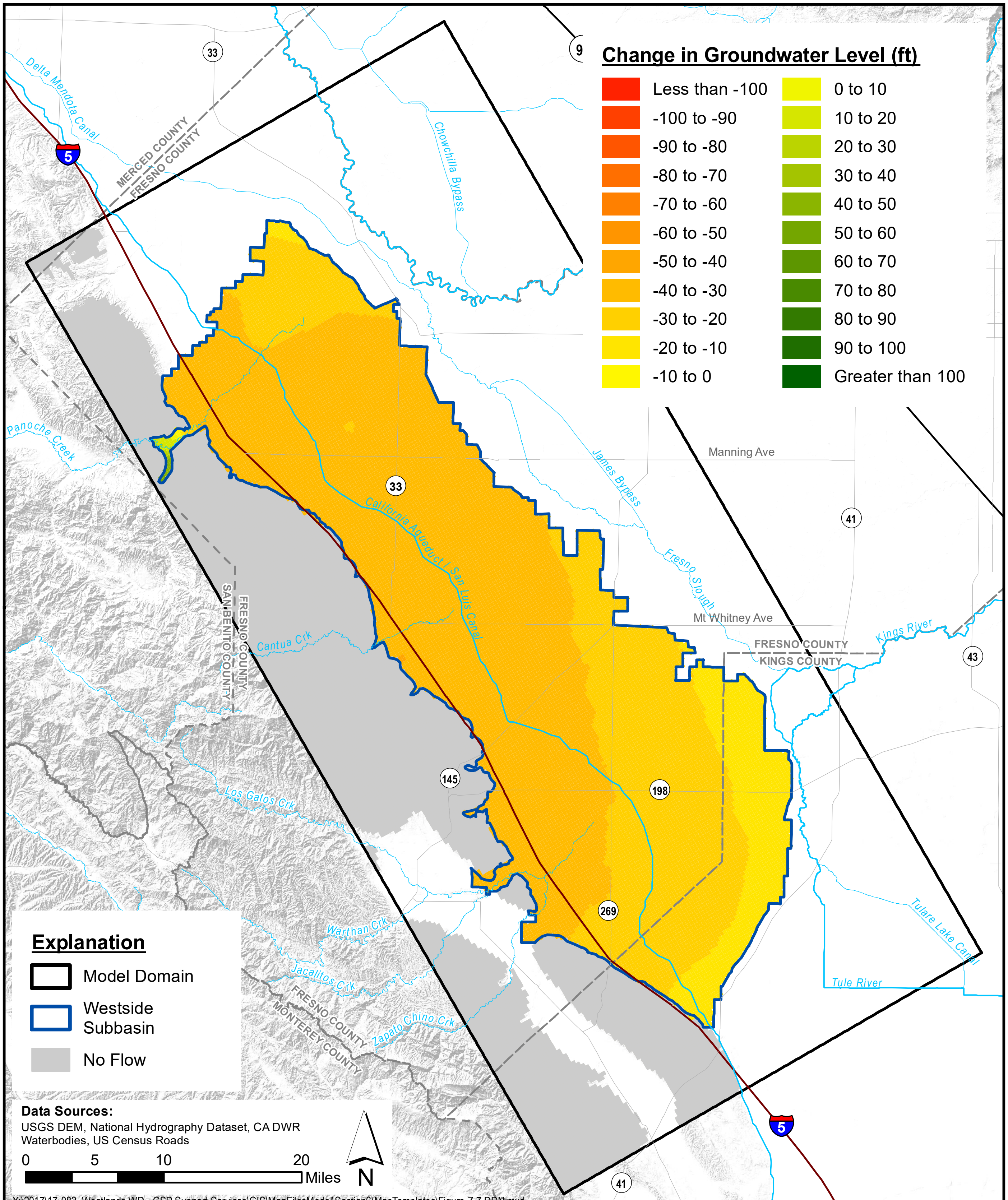
Simulated Change in Groundwater Elevation - Upper Aquifer 2070 Climate Change - PMA No.4 (2020 - 2070)

Figure G-79

SGMA Sustainability Analyses
Westside Subbasin



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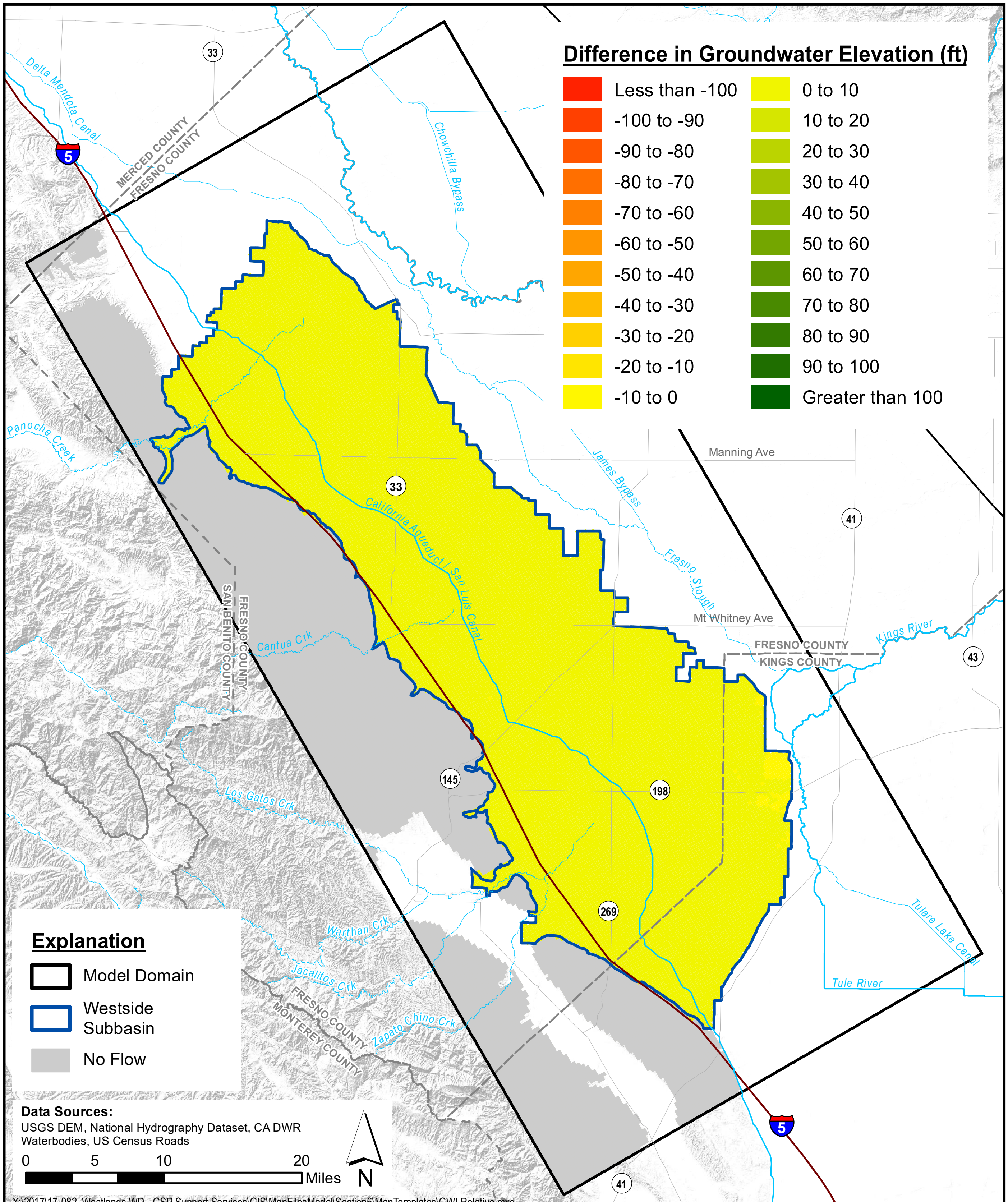
Simulated Change in Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No.4 (2020 - 2070)

Figure G-80

SGMA Sustainability Analyses
Westside Subbasin



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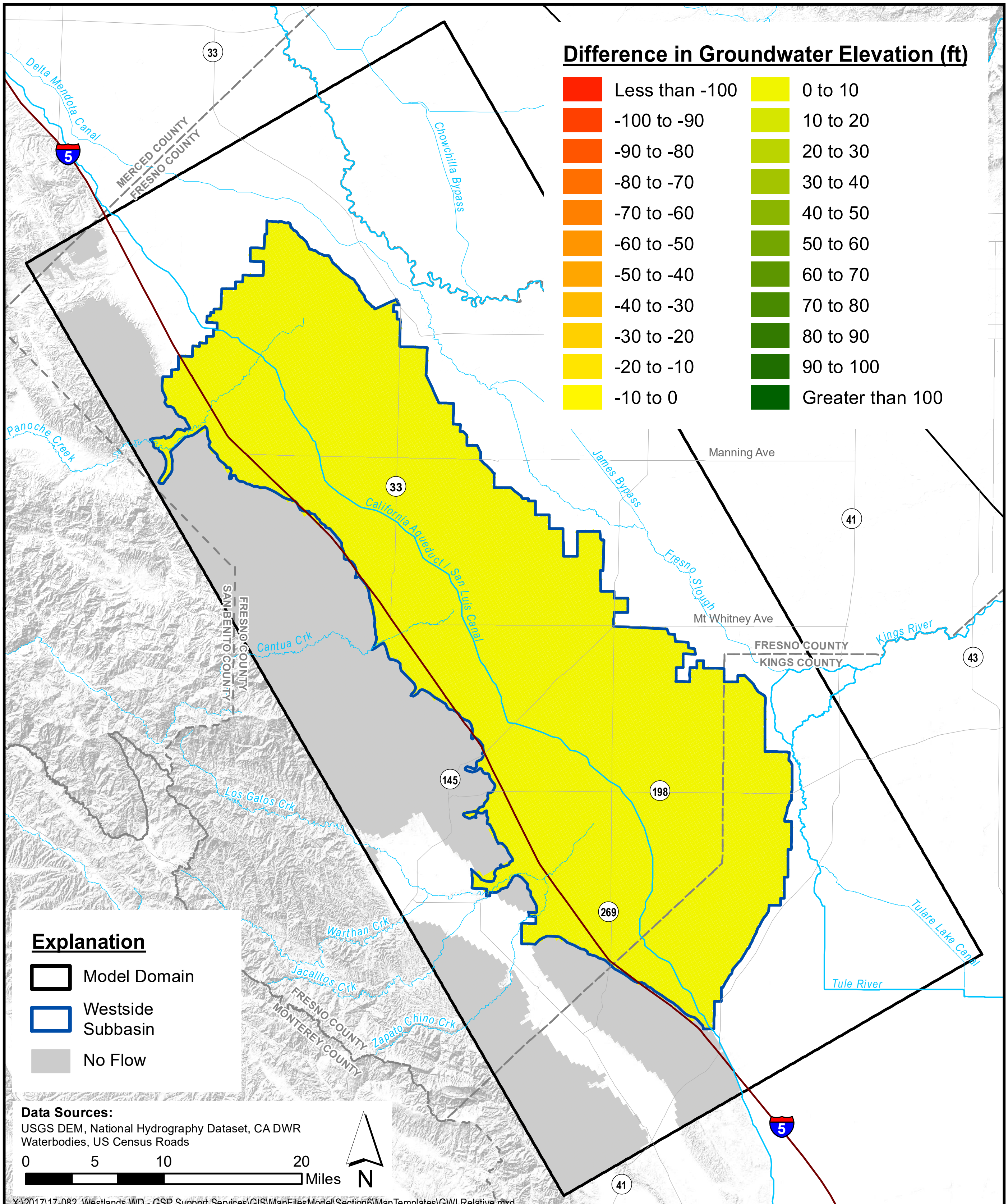
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-81

SGMA Sustainability Analyses
Westside Subbasin



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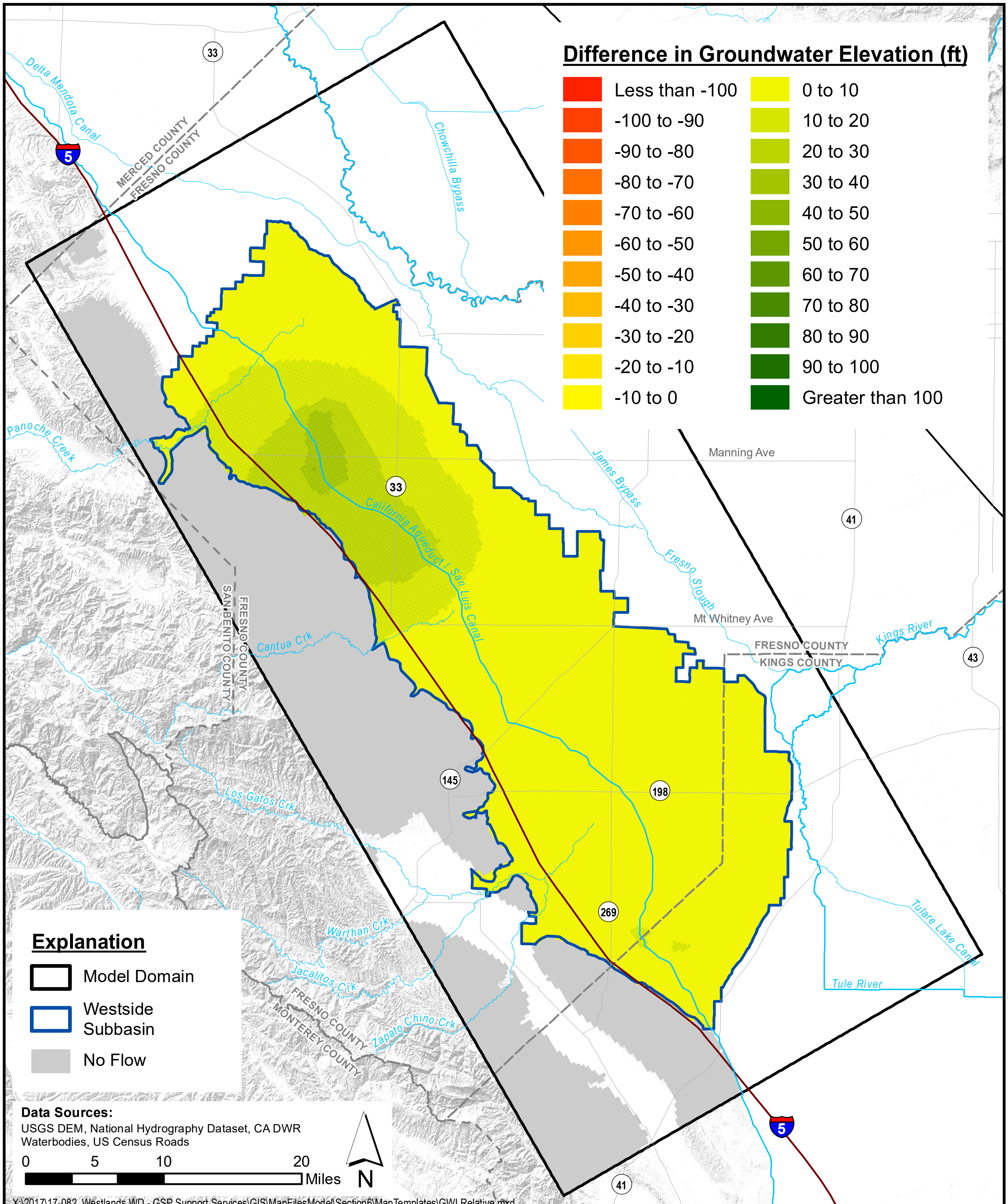
Project Impacts on Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-82

SGMA Sustainability Analyses
Westside Subbasin



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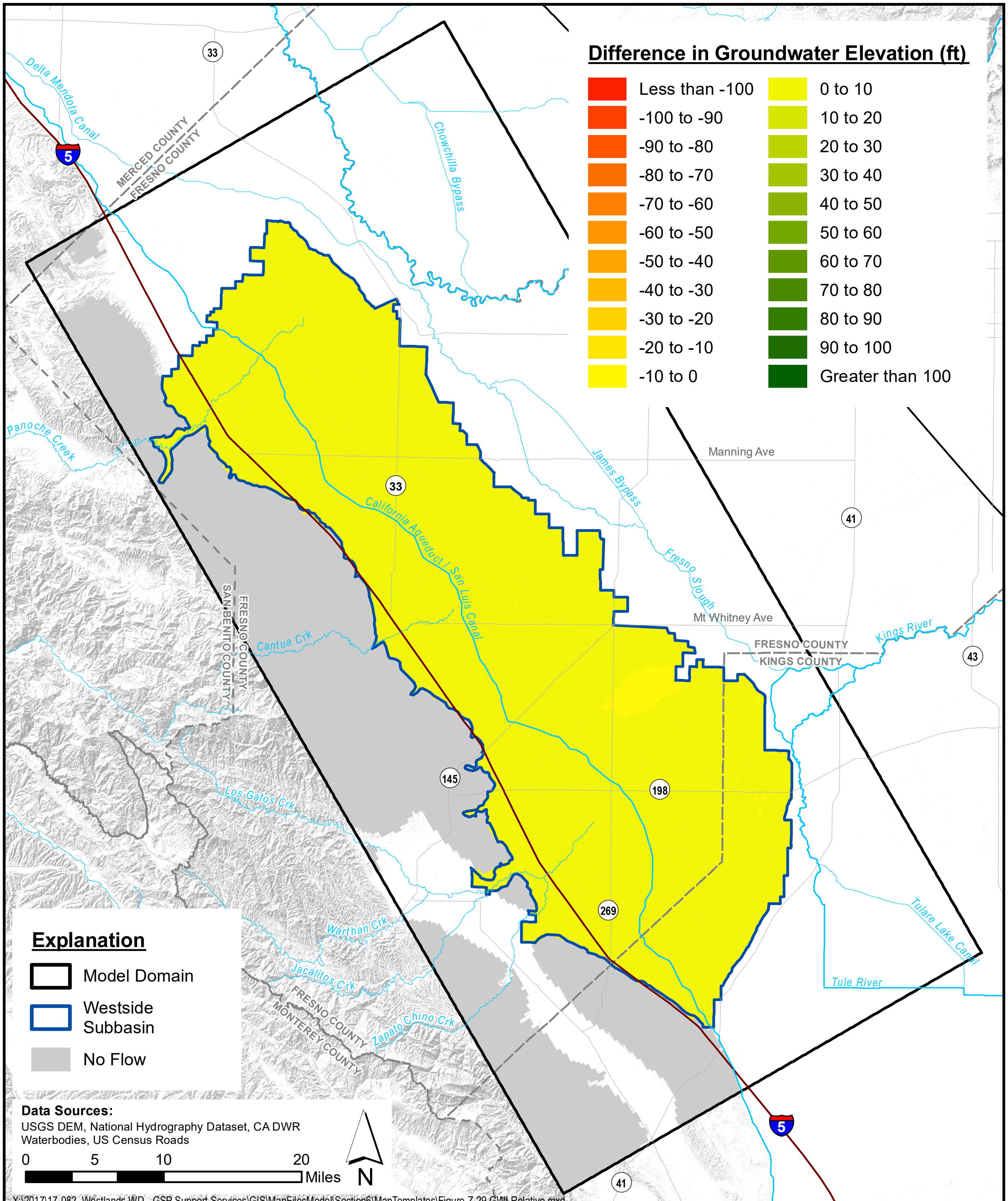
Project Impacts on Groundwater Elevation - Lower Aquifer 2070 Climate Change - PMA No.4 (2020 - 2047)

Figure G-83

SGMA Sustainability Analyses
Westside Subbasin



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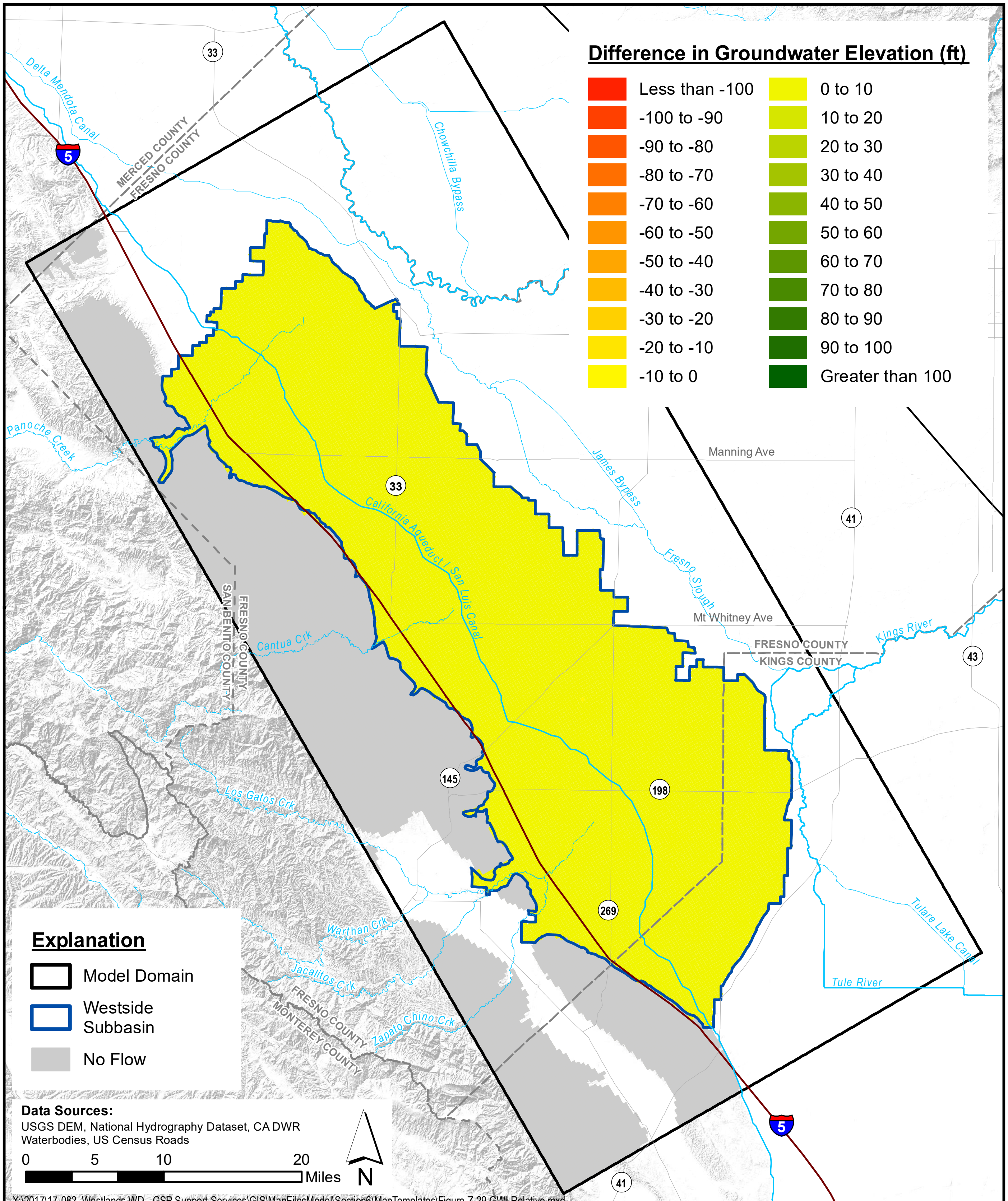
Project Impacts on Groundwater Elevation - Shallow Zone
2070 Climate Change - PMA No. 4 (2020 - 2070)

Figure G-84

SGMA Sustainability Analyses
Westside Subbasin



Project Impacts on Groundwater Elevation - Upper Aquifer
2070 Climate Change - PMA No. 4 (2020 - 2070)

Figure G-85

SGMA Sustainability Analyses
Westside Subbasin

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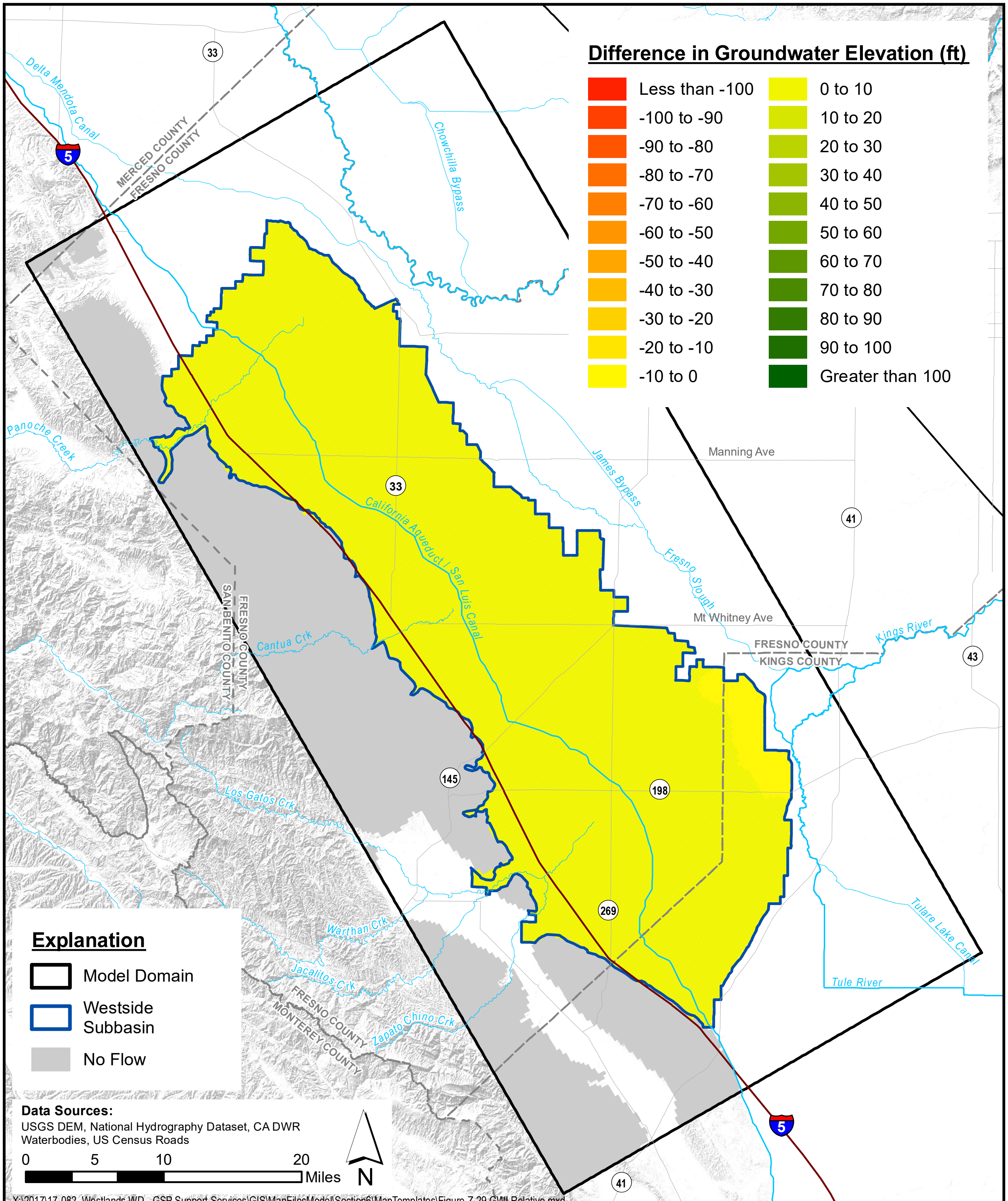

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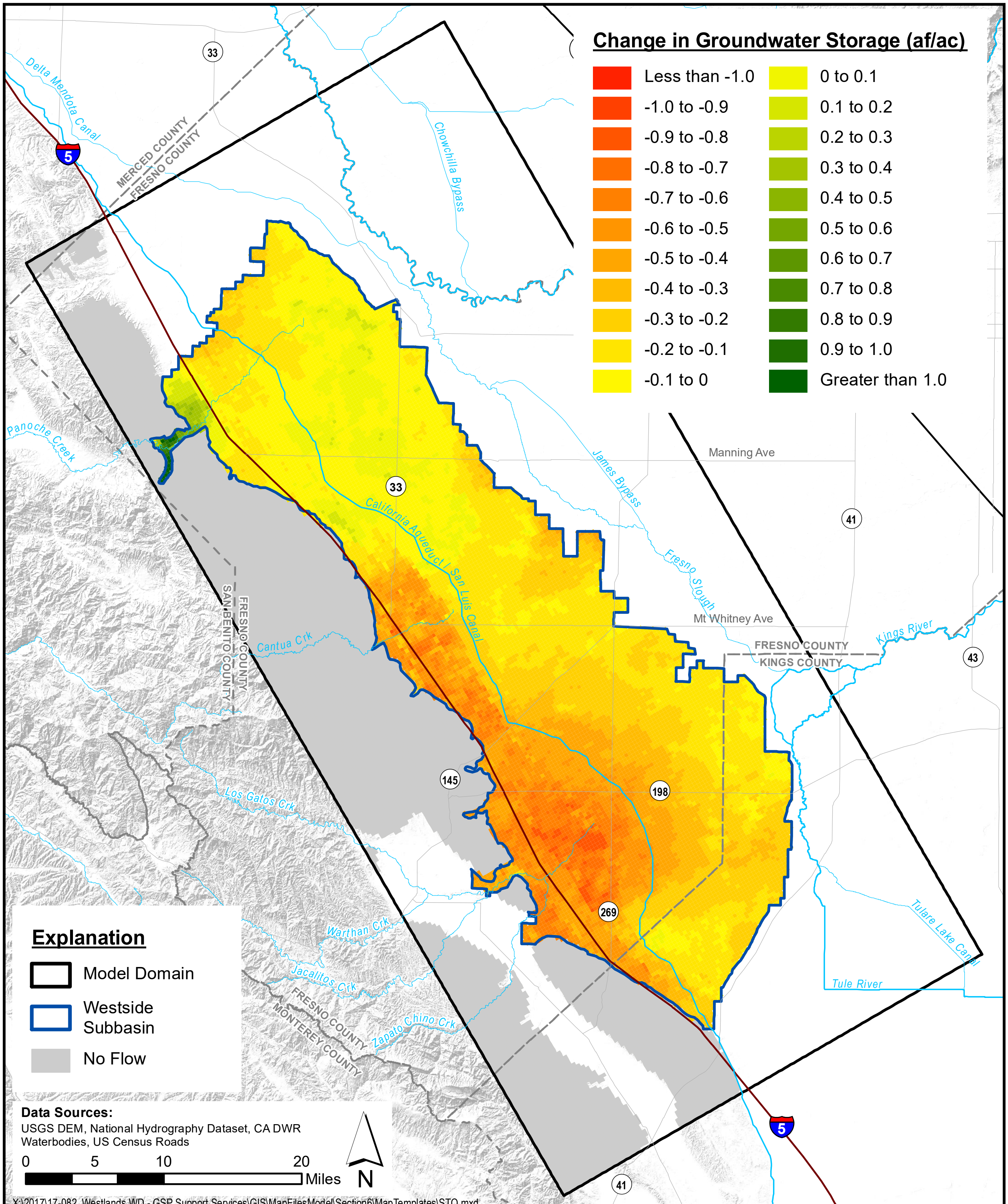
Project Impacts on Groundwater Elevation - Lower Aquifer
2070 Climate Change - PMA No. 4 (2020 - 2070)

Figure G-86

SGMA Sustainability Analyses
Westside Subbasin

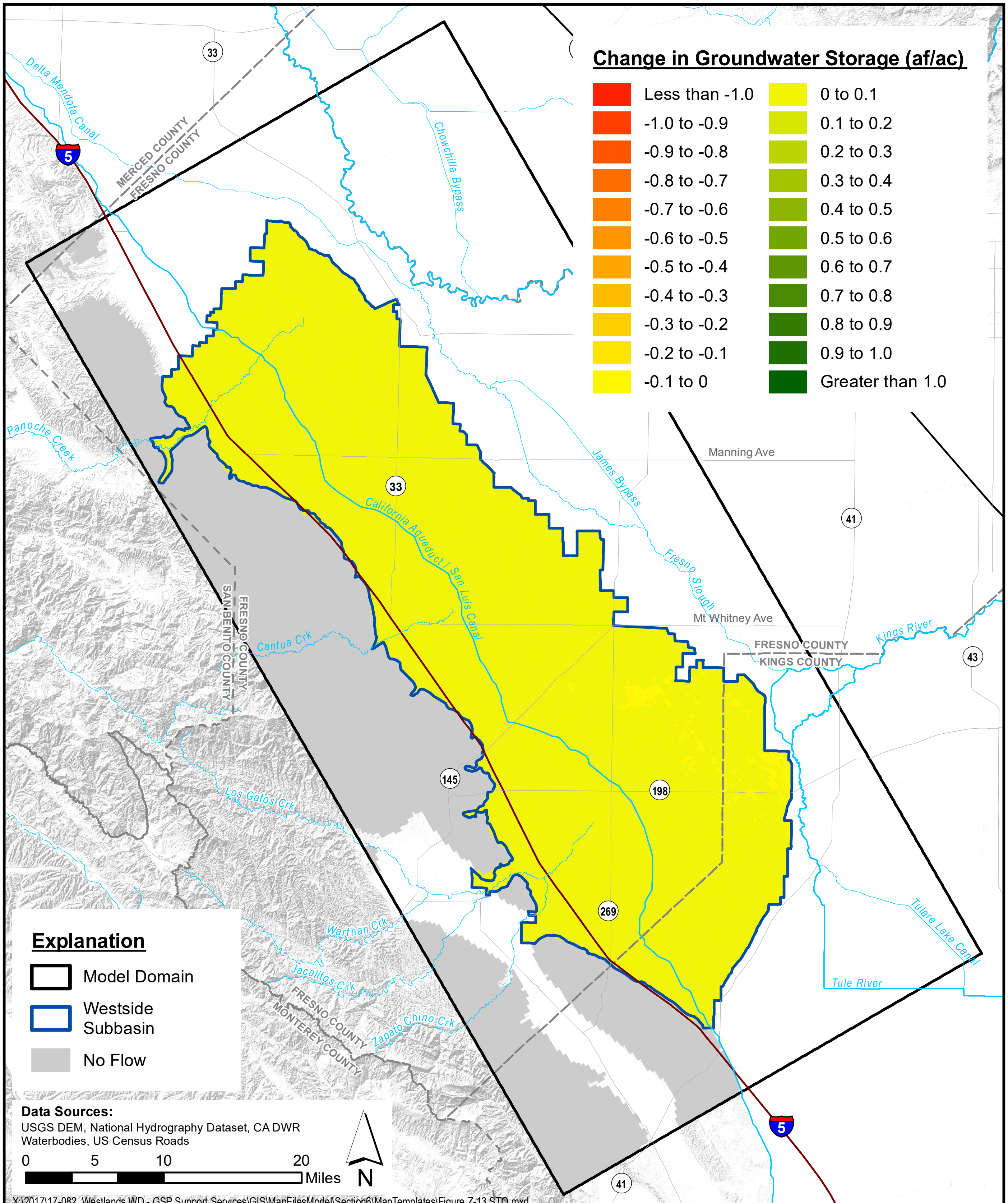


Luhdorff & Scalmanini
Consulting Engineers

Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-87

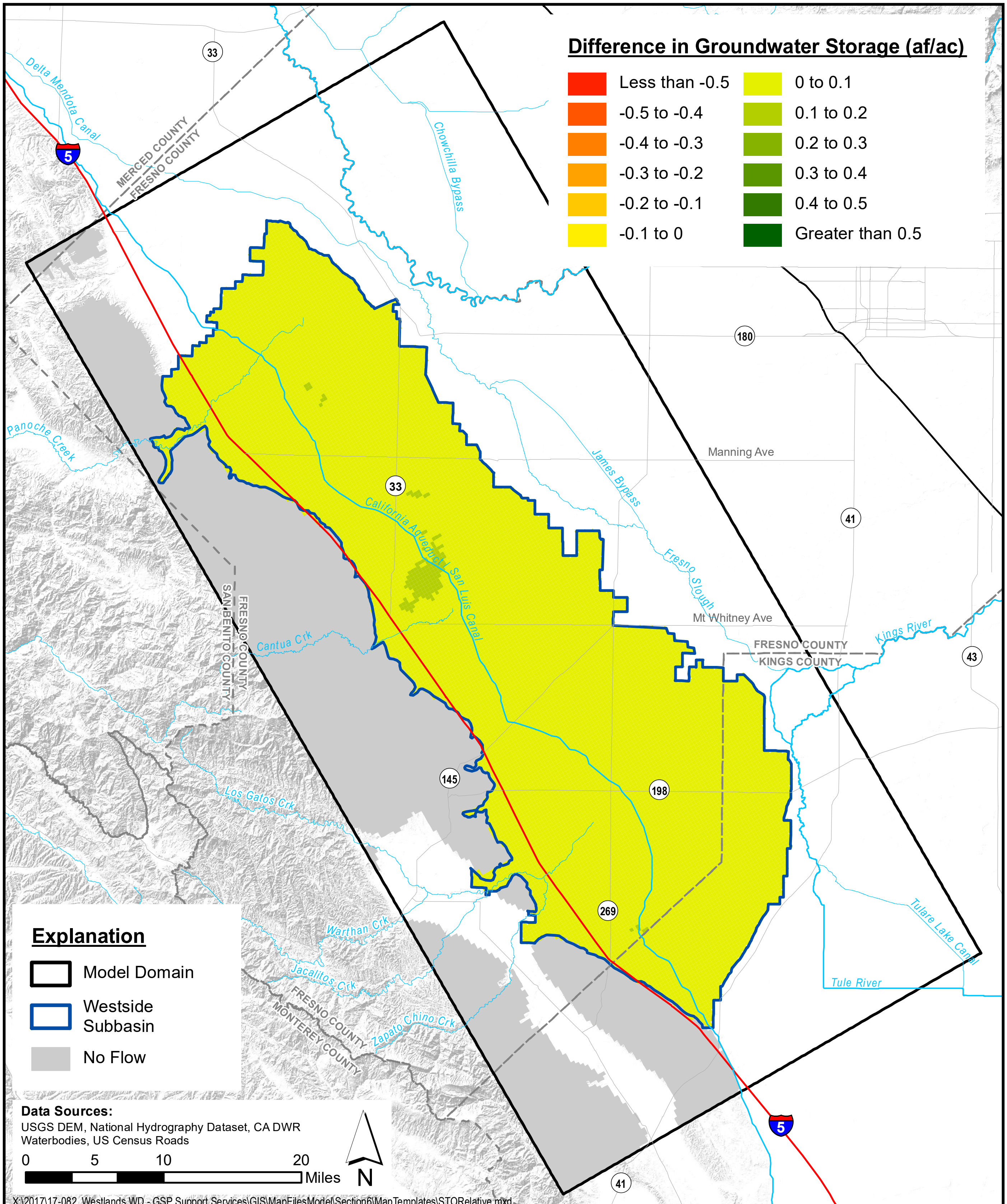


Simulated Change in Groundwater Storage
2070 Climate Change - PMA No.4 (2020 - 2070)

Luhdorff & Scalmanini
Consulting Engineers

Figure G-88

SGMA Sustainability Analyses
Westside Subbasin



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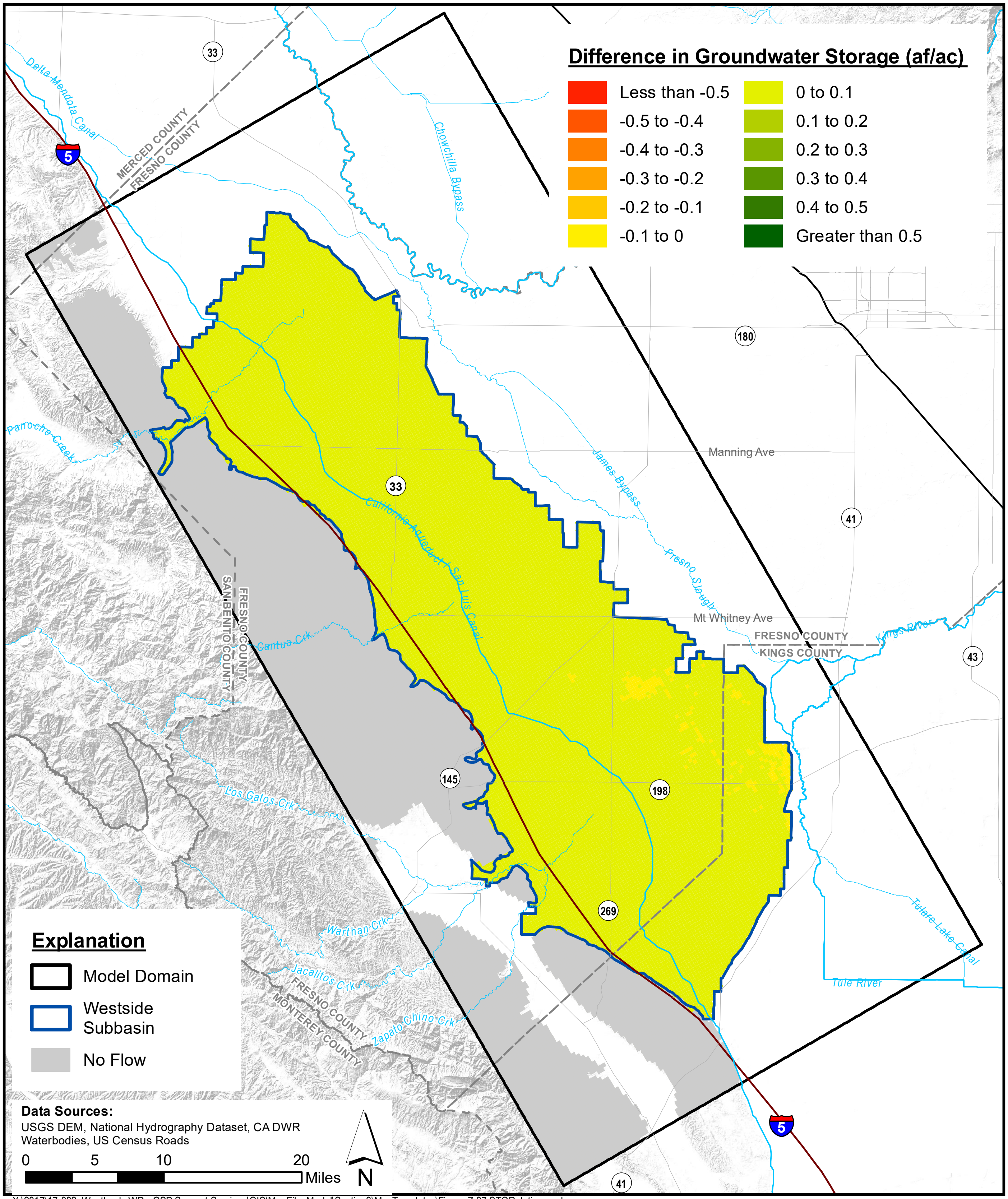
Luhdorff & Scalmanini
Consulting Engineers

Project Impacts on Groundwater Storage
2070 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-89



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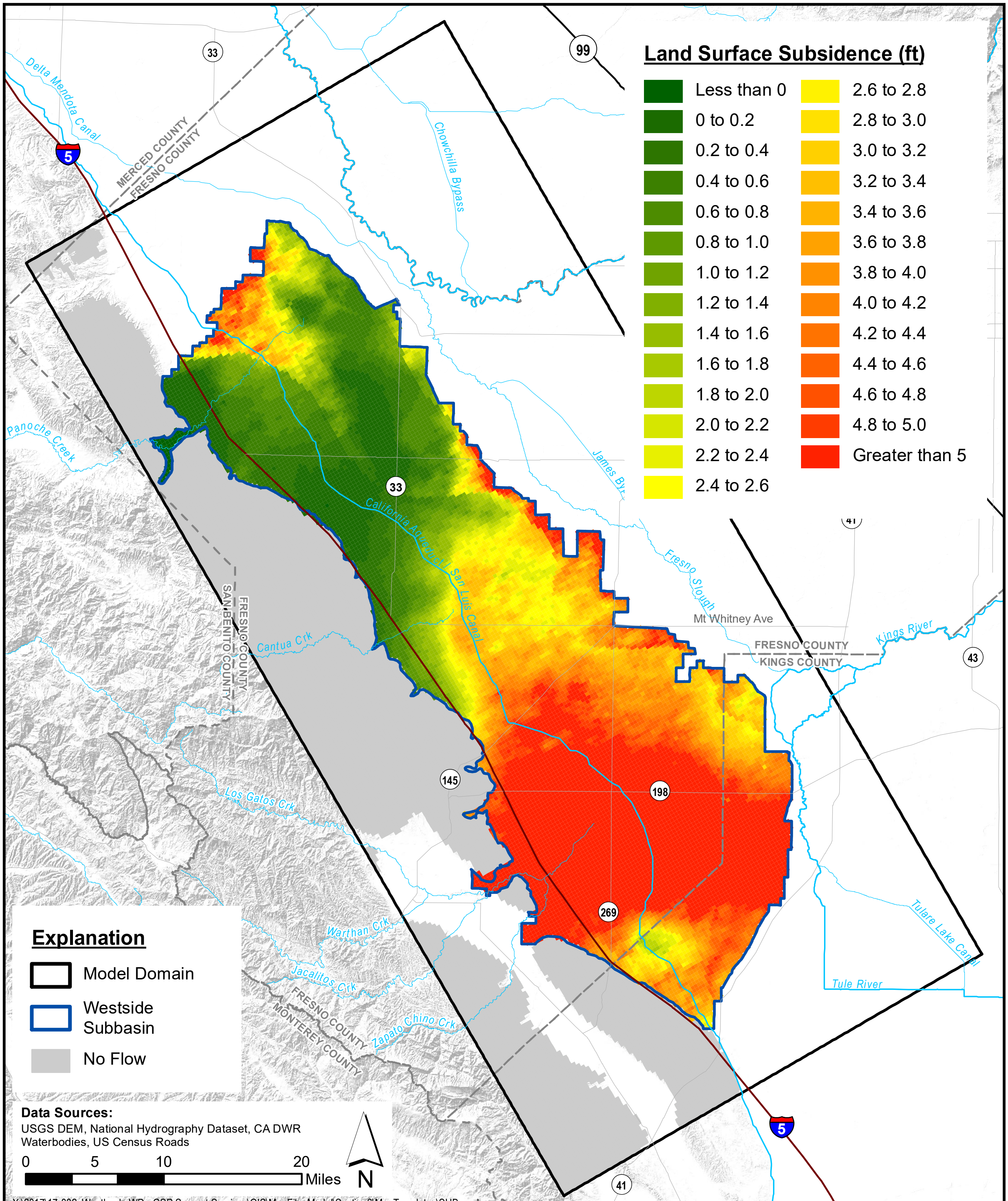
Luhdorff & Scalmanini
Consulting Engineers

Project Impacts on Groundwater Storage
2070 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-90



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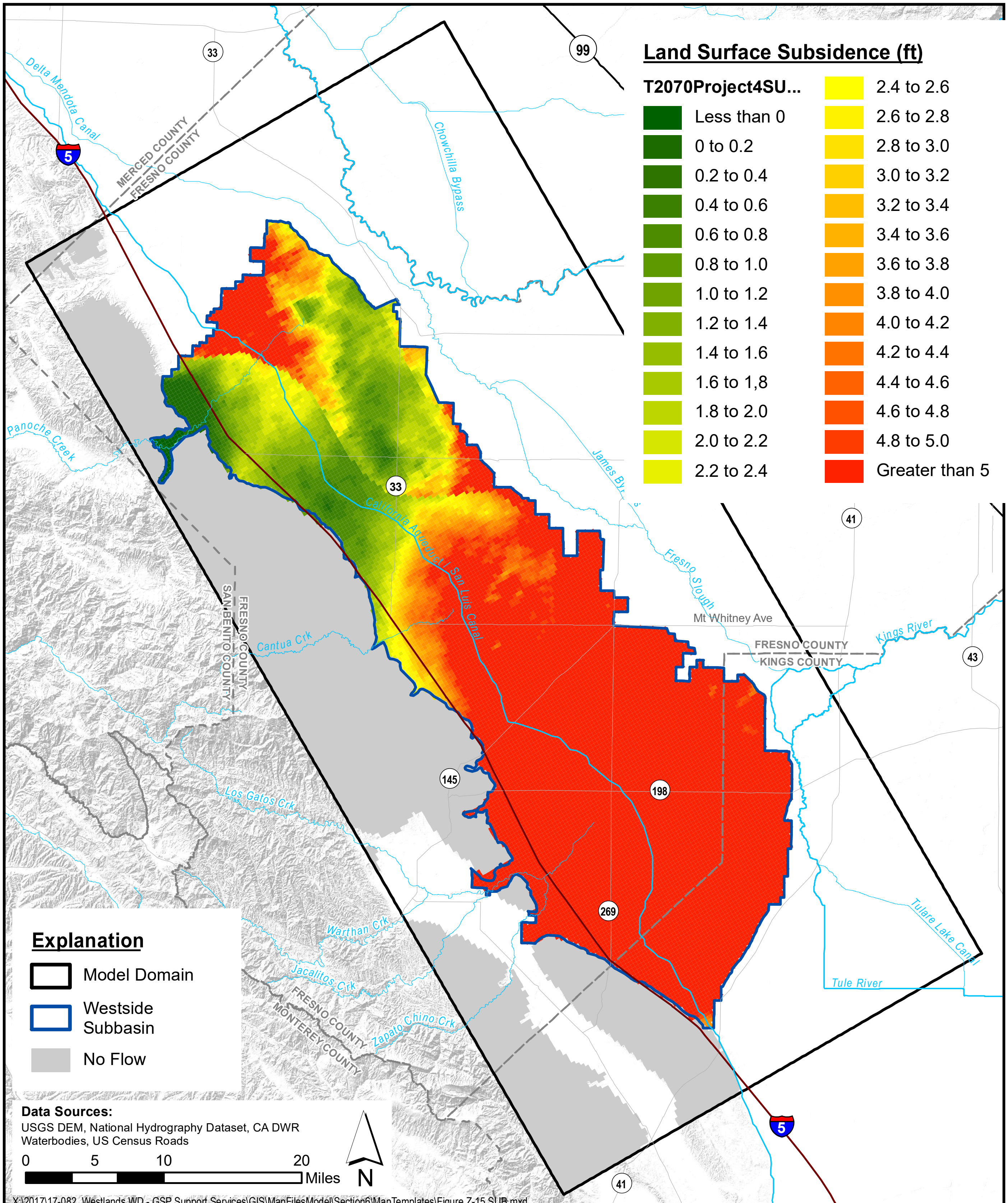
Luhdorff & Scalmanini Consulting Engineers

Simulated Land Surface Subsidence
2070 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-91



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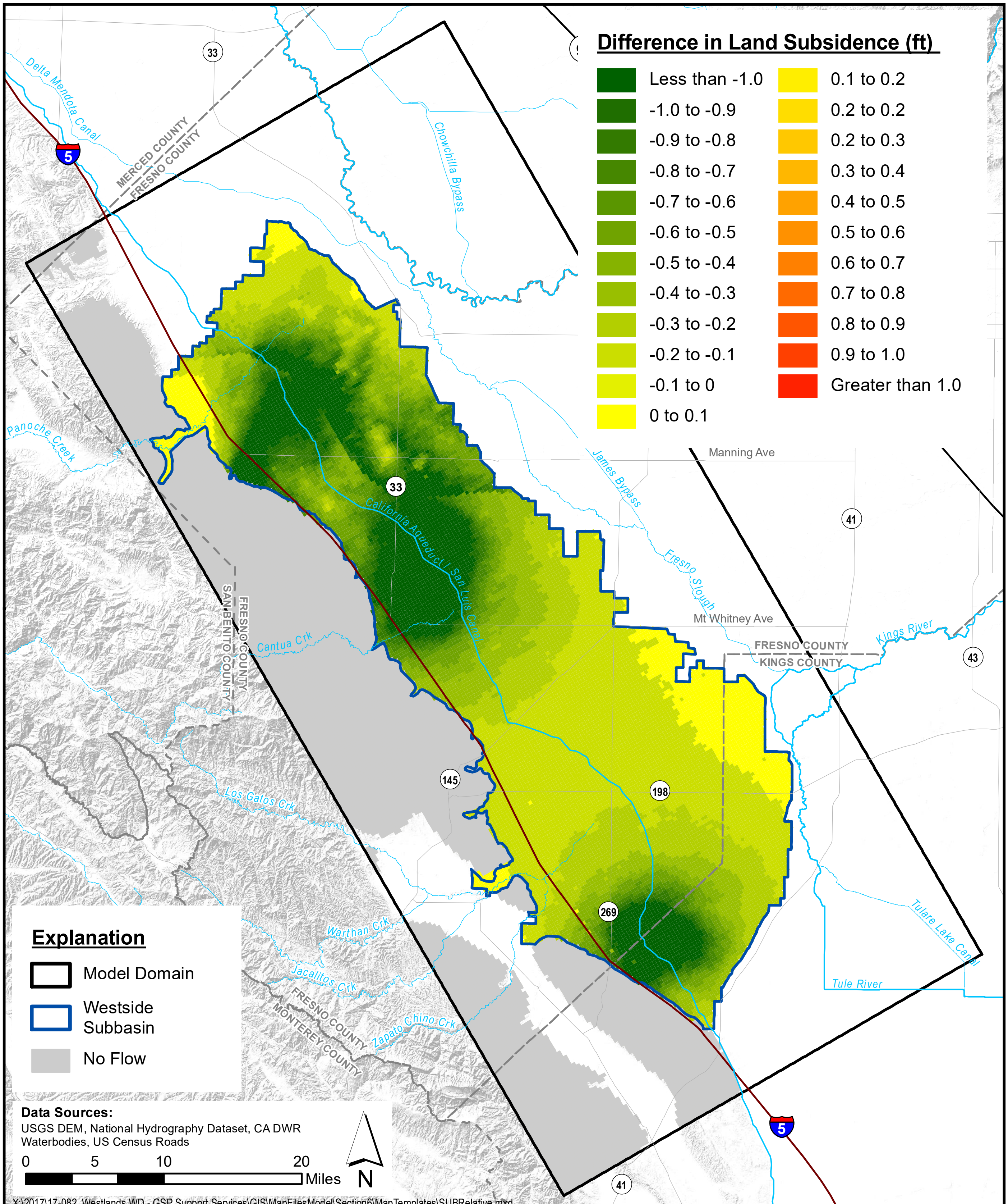
Simulated Land Surface Subsidence
2070 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-92



Data Sources:
USGS DEM, National Hydrography Dataset, CA DWR Waterbodies, US Census Roads

0 5 10 20 Miles

N

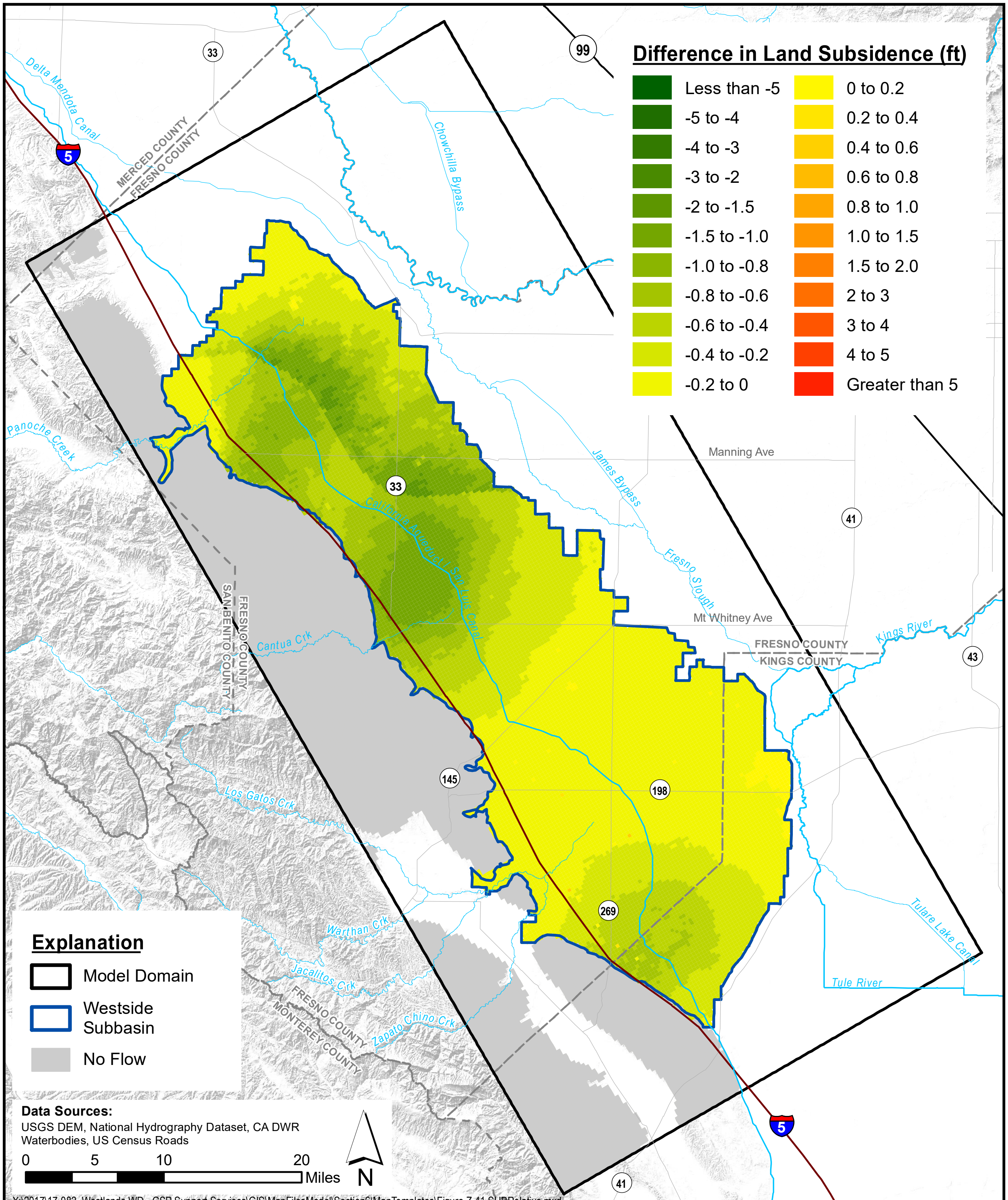
X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFilesModel\Section6\MapTemplates\SUBRelative.mxd

Luhdorff & Scalmanini Consulting Engineers

Project Impact on Land Surface Subsidence
2070 Climate Change - PMA No.4 (2020 - 2047)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-93



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Project Impact on Land Subsidence
2070 Climate Change - PMA No. 4 (2020 - 2070)

SGMA Sustainability Analyses
Westside Subbasin

Figure G-94

Appendix H:

Effect of Boundary Flows on GSP Implementation

APPENDIX H: EFFECT OF BOUNDARY FLOWS ON GSP IMPLEMENTATION

At the request of the Westside GSA, a model projection was developed to evaluate impacts of boundary flows on projected groundwater conditions of in the Westside Subbasin using the Westside Groundwater Model (WSGM). A review of several draft GSPs from adjacent groundwater subbasins indicates that GSAs in the Kings and Tulare Subbasins are providing for a continued decline in groundwater levels during the GSA implementation period from 2020 through 2040. The effect of these management decisions could have implications with respect to GSP implementation and Westlands Water District GSA's ability to achieve sustainability objectives outlined in the Westside Subbasin Draft GSP. This appendix describes modeling and analysis used to quantify potential impacts of continued decline in groundwater levels in adjacent subbasins on groundwater conditions within the Subbasin. Included in Appendix H is:

1. Development of Modified Model Inputs
2. Model Results
3. Conclusions

H.1 Development of Modified Model Inputs

Model inputs in the WSGM model projection from 2020 through 2070 were updated based on information provided in the Tulare Lake Subbasin GSP, North Fork Kings GSA GSP and McMullin Area GSA GSP. The primary modeling objective is to quantify how GSP implementation outlined in the GSPs could affect projected groundwater conditions in the Westside Subbasin. This was achieved through the development of two model scenarios which are compared to a baseline model scenario to evaluate impacts. These are hereafter referred to as Boundary Flow Scenario 1 and Boundary Flow Scenario 2.

H.1.1 Baseline

The PMA No. 2 – No Climate Change model scenario outlined in **Section 5.3.1** of the WSGM documentation (**Appendix I** of the GSP) serves as the comparative baseline used to evaluate changes made to the Boundary Flow Scenario 1 and Boundary Flow Scenario 2 models. Any changes described in **Section H.1.2** and **Section H.1.3** are made to this baseline scenario. The PMA No. 2 – No Climate Change was selected because it largely simulates sustainable groundwater conditions within the Westside Subbasin and incorporates the groundwater allocation framework which is anticipated to be fully implemented by 2030.

H.1.2 Boundary Flow Scenario 1 Assumptions

Boundary Flow Scenario 1 simulates the impact of GSAs in Kings and Tulare Lake Subbasins operating at their respective Minimum Threshold at the WSGM model boundary. Accordingly, this scenario incorporates a decline in the hydraulic head in general head boundary (GHB) cells at the edges of the WSGM model domain.

The PMA No. 2 – No Climate Change model projection assumes that average water levels at GHB cells do not substantially change over the 51-year projection as described in **Section 5.5.5.1** of the WSGM documentation (**Appendix I** of the GSP). For the purposes of Boundary Flow Scenario 1 model development, assigned water levels at the GHB in the Kings and Tulare Lake Subbasins decline between 2020 and 2040. The total decline is commensurate to the difference between starting groundwater levels and the Minimum Threshold (MT) in wells shown in Representative Monitoring Sites (RMS) included in each respective GSP. The decline in assigned hydraulic head was calculated for the water table or Shallow Zone (Aquifer Zone A), Upper Aquifer (Aquifer Zone B) and Lower Aquifer (Aquifer Zone C) for each GSA (**Table H-1**). The total amount of decline for each Aquifer Zone for each GSA was applied linearly such that the total decline was fully applied in 2040. Water levels assigned in the PMA No. 2 – No Climate Change and Boundary Flow Scenario 1 is shown for an example GHB cell in **Figure H-1**. In instances where a MT was not defined for an Aquifer Zone, it was assumed that the MO is current groundwater levels and the MT is the MO minus the Operational Flexibility (50 ft).

H.1.3 Boundary Flow Scenario 2 Assumptions

Boundary Flow Scenario 2 simulates the cumulative impact of Boundary Flow Scenario 1 in conjunction with land use changes applied only to James ID, McMullin Area GSA, North Fork Kings GSA, SouthFork/Mid Kings GSAs, Southwest Kings GSA and El Rico GSA. These GSAs correspond to MODFLOW One-Water Farms listed in **Table 3-1** of the WSGM documentation (**Appendix I** of the GSP). The PMA No. 2 – No Climate Change scenario incorporates annual changes to land use in these GSAs, which is intended to simulate sustainable groundwater conditions during the 51-year projection. For Boundary Flow Scenario Number 2, land use in these GSAs was fixed at the most current land use. This is the same land use assigned in the Baseline Model described in **Section 5.1.4.5** of the of the WSGM documentation (**Appendix I** of the GSP).

H.2 Model Results

A summary of impacts on water budgets, groundwater levels and subsidence are provided for the Boundary Flow Scenario 1 and Boundary Flow Scenario 2 model runs.

H.2.1 Boundary Flow Scenario 1 Results

Annual groundwater budgets summarized by water year are provided in **Table H-2** through **Table H-4**. A timeseries plot of the cumulative change in projected groundwater storage and cumulative net lateral subsurface inflow into the Westside Subbasin are shown for the Baseline (PMA No. 2 – No Climate Change) and Boundary Flow Scenario 1 in **Figures H-2** and **H-3**. In comparison with the Baseline, simulated groundwater storage is projected to decrease by over 58 TAFY between 2020 and 2070 in the Westside Subbasin. Similarly, net lateral subsurface inflow into the Subbasin is projected to decrease by 52 TAFY.

Projected differences in groundwater levels between the Baseline and the Boundary Flow Scenario 1 are shown for 2040 and 2070 in **Figures H-4** and **H-7**. Projected increase in land surface subsidence between the Baseline and the Boundary Flow Scenario 1 are shown for 2040 and 2070 in **Figures H-8** and **H-9**. The model simulates considerable impacts to groundwater levels and land surface subsidence concentrated predominantly in the southeastern portion of the Subbasin where boundary flows are most impacted.

H.2.2 Boundary Flow Scenario 1 Results

Annual groundwater budgets summarized by water year are provided in **Table H-5** through **Table H-7**. A timeseries plot of the cumulative change in projected groundwater storage and cumulative net lateral subsurface inflow into the Westside Subbasin are shown for the Baseline (PMA No. 2 – No Climate Change) and Boundary Flow Scenario 2 in **Figures H-10** and **H-11**. In comparison with the Baseline, simulated groundwater storage is projected to decrease by over 71 TAFY between 2020 and 2070 in the Westside Subbasin. Similarly, net lateral subsurface inflow into the Subbasin is projected to decrease by 88 TAFY.

Projected differences in groundwater levels between the Baseline and the Boundary Flow Scenario 2 are shown for 2040 and 2070 in **Figures H-12** through **H-15**. Projected increase in land surface subsidence between the Baseline and the Boundary Flow Scenario 2 are shown for 2040 and 2070 in **Figures H-16** and **H-17**. Impacts to groundwater levels and land surface subsidence concentrated predominantly in the southeastern portion of the Subbasin and are substantially greater than in Boundary Flow Scenario 1.

H.3 Conclusions

Modeling included in the Boundary Flow Scenario 1 and Boundary Flow Scenario 2 modeling scenarios show that water level declines in adjacent GSAs can have significant adverse impacts on groundwater storage, groundwater levels and land surface subsidence in the Westside Subbasin. Model results show greater impacts in the Boundary Flow Scenario 2 relative to Boundary Flow Scenario 1 due to the cumulative impact of assigning a relatively fixed water demand in Boundary Flow Scenario 2. Assumptions are likely conservative but are nonetheless demonstrative of how failure to implement effective management actions in adjacent GSAs can significantly impact the Westside GSAs ability to successfully meet sustainability objectives.

Table H-1: Measurable Objective, Minimum Threshold and Assigned Amount of Decline in Hydraulic Head at GHB by GSA and by Aquifer

GSA	Aquifer Zone	No. Well in Average	Average Starting Water Level[1]	Average Measurable Objective[2]	Average Minimum Threshold[2]	Operational Flexibility[3]	Water Level Decrease Over Implementation Period		
							ΔMO[4]	ΔMT[5]	ΔWSGM Model[6]
El Rico	A	1	216.1	197.3	147.3	50.0	18.8	68.8	68.8
El Rico	B	5	107.5	62.2	22.2	50.0	45.3	85.3	85.3
El Rico	C	20	31.2	-72.6	-124.7	50.0	103.8	155.9	155.9
Southfork Kings	A	5	197.4	192.2	142.2	50.0	5.2	55.2	55.2
Southfork Kings	B	13	93.2	0.2	-49.8	50.0	92.9	142.9	142.9
Southfork Kings	C	7	25.6	-80.7	-134.1	50.0	106.4	159.8	159.8
Southwest Kings	A	**NA**	**NA**	**NA**	**NA**	**50.0**	**NA**	**NA**	**50.0**
Southwest Kings	B	3	134.2	97.8	47.8	50.0	36.4	86.4	86.4
Southwest Kings	C	4	94.6	76.2	26.2	50.0	18.5	68.5	68.5
North Fork Kings	A	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**50.0**
North Fork Kings	B	22	38.0	-0.8	-52.7	51.8	38.9	90.7	90.7
North Fork Kings	C	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**50.0**
McMullin Area GSA	A	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**50.0**
McMullin Area GSA	B	23	28.5	5.1	-42.0	47.1	23.4	70.5	70.5
McMullin Area GSA	C	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**50.0**

1. Average of current water levels in GSA. Water Levels taken from NFK, TLSB and McMullin monitoring network wells in GSP (NFK & McMullin = 2020, TLSB = 2017)
2. Average Measureable Objective & Minimum Theshold from wells included in the monitoring network by GSA and Aquifer Zone
3. Difference between average Measurable Objective and average Minimum Threshold
4. Difference between Starting Water Level and the Measurable Objective
5. Difference between Starting Water Level and the Minimum Threshold
6. Proposed decrease in water level applied to WSGM model projection [equal to ΔMT]. Decline of 50 ft (Operational Flexibility) assigned in where no MT Defined

Table H-2: Boundary Flow Scenario 1 Projected Groundwater Budget

Water Year	Water Year Type	Net Deep Percolation (af)	Stream Leakage (af)	Lateral Subsurface Inflow (af)	Total Inflow (af)	Pumping (af)	Lateral Subsurface Outflow (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	483,000	15,000	211,000	709,000	137,000	132,000	270,000	429,000
2018	AN	294,000	12,000	163,000	469,000	270,000	104,000	375,000	87,000
2019	D	158,000	1,000	165,000	324,000	367,000	97,000	465,000	-141,000
2020	W	249,000	12,000	163,000	425,000	382,000	107,000	488,000	-65,000
2021	BN	367,000	1,000	161,000	528,000	359,000	110,000	469,000	55,000
2022	W	346,000	23,000	131,000	500,000	172,000	121,000	293,000	202,000
2023	D	271,000	10,000	151,000	432,000	590,000	141,000	731,000	-297,000
2024	W	547,000	32,000	157,000	737,000	147,000	123,000	270,000	458,000
2025	AN	194,000	5,000	116,000	315,000	280,000	118,000	399,000	-87,000
2026	BN	201,000	2,000	107,000	310,000	212,000	119,000	330,000	-28,000
2027	D	174,000	1,000	126,000	301,000	457,000	131,000	588,000	-285,000
2028	AN	474,000	13,000	141,000	628,000	269,000	115,000	384,000	231,000
2029	W	278,000	11,000	122,000	412,000	270,000	116,000	386,000	15,000
2030	W	225,000	11,000	112,000	348,000	272,000	121,000	393,000	-54,000
2031	C	203,000	8,000	99,000	309,000	205,000	124,000	329,000	-28,000
2032	C	150,000	0	141,000	291,000	582,000	137,000	719,000	-428,000
2033	W	578,000	21,000	145,000	745,000	226,000	134,000	360,000	367,000
2034	AN	235,000	4,000	123,000	362,000	338,000	135,000	473,000	-118,000
2035	W	357,000	21,000	114,000	492,000	191,000	133,000	324,000	159,000
2036	D	225,000	1,000	97,000	323,000	259,000	140,000	400,000	-87,000
2037	W	298,000	22,000	91,000	411,000	171,000	181,000	352,000	57,000
2038	W	426,000	22,000	79,000	526,000	159,000	174,000	333,000	189,000
2039	AN	200,000	4,000	82,000	286,000	247,000	160,000	407,000	-133,000
2040	D	177,000	1,000	87,000	264,000	234,000	155,000	389,000	-134,000
2041	W	248,000	30,000	87,000	365,000	216,000	155,000	371,000	-19,000
2042	C	155,000	6,000	125,000	285,000	461,000	144,000	605,000	-322,000
2043	C	167,000	2,000	170,000	339,000	552,000	137,000	689,000	-353,000
2044	C	214,000	0	169,000	383,000	363,000	138,000	501,000	-127,000
2045	C	184,000	1,000	189,000	373,000	598,000	140,000	738,000	-361,000
2046	C	274,000	5,000	178,000	457,000	403,000	154,000	557,000	-110,000
2047	C	332,000	8,000	170,000	510,000	529,000	172,000	701,000	-197,000
2048	W	564,000	30,000	156,000	750,000	199,000	164,000	362,000	367,000
2049	C	233,000	3,000	145,000	380,000	448,000	169,000	617,000	-244,000
2050	W	557,000	31,000	137,000	725,000	176,000	183,000	359,000	354,000
2051	W	316,000	10,000	104,000	429,000	158,000	215,000	374,000	48,000
2052	W	425,000	17,000	123,000	565,000	452,000	198,000	650,000	-107,000
2053	W	489,000	32,000	128,000	649,000	156,000	184,000	340,000	298,000
2054	AN	249,000	6,000	115,000	369,000	282,000	177,000	460,000	-108,000
2055	AN	235,000	5,000	116,000	356,000	221,000	168,000	390,000	-53,000
2056	D	168,000	10,000	146,000	324,000	497,000	160,000	658,000	-343,000
2057	D	194,000	1,000	144,000	339,000	272,000	160,000	431,000	-105,000
2058	BN	302,000	3,000	131,000	436,000	321,000	165,000	486,000	-60,000
2059	D	338,000	1,000	141,000	480,000	408,000	176,000	584,000	-119,000
2060	W	390,000	25,000	149,000	564,000	308,000	168,000	476,000	68,000
2061	W	359,000	12,000	130,000	501,000	171,000	172,000	343,000	152,000
2062	C	138,000	0	124,000	262,000	330,000	161,000	492,000	-233,000
2063	C	253,000	6,000	171,000	430,000	592,000	156,000	748,000	-326,000
2064	BN	178,000	0	183,000	362,000	474,000	162,000	636,000	-283,000
2065	AN	394,000	12,000	173,000	578,000	424,000	174,000	598,000	-33,000
2066	W	410,000	23,000	165,000	598,000	266,000	161,000	426,000	147,000
2067	D	222,000	1,000	146,000	369,000	250,000	155,000	405,000	-51,000
2068	C	176,000	0	172,000	348,000	519,000	156,000	674,000	-330,000
2069	C	117,000	0	151,000	268,000	224,000	162,000	386,000	-127,000
2070	C	158,000	0	104,000	262,000	129,000	177,000	306,000	-52,000
Average (2020 - 2040)		294,000	11,000	121,000	426,000	287,000	133,000	420,000	-1,000
Average (2020 - 2070)		287,000	10,000	135,000	431,000	322,000	152,000	474,000	-52,000

Table H-3: Boundary Flow Scenario 1 Projected Upper Aquifer Groundwater Budget

Water Year	Water Year Type	Net Deep Percolation (af)	Stream Leakage (af)	Lateral Subsurface Inflow (af)	Total Inflow (af)	Groundwater Pumping (af)	Lateral Subsurface Outflow (af)	Vertical Flow[1] (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	483,000	15,000	32,000	576,000	50,000	80,000	188,000	317,000	201,000
2018	AN	294,000	12,000	28,000	334,000	96,000	65,000	142,000	302,000	24,000
2019	D	158,000	1,000	29,000	189,000	124,000	61,000	133,000	317,000	-131,000
2020	W	249,000	12,000	27,000	288,000	128,000	67,000	135,000	330,000	-43,000
2021	BN	367,000	1,000	27,000	394,000	122,000	70,000	139,000	331,000	61,000
2022	W	346,000	23,000	25,000	394,000	59,000	74,000	155,000	288,000	100,000
2023	D	271,000	10,000	26,000	307,000	179,000	90,000	127,000	395,000	-84,000
2024	W	547,000	32,000	28,000	607,000	52,000	77,000	174,000	303,000	294,000
2025	AN	194,000	5,000	24,000	223,000	98,000	73,000	136,000	307,000	-88,000
2026	BN	201,000	2,000	22,000	226,000	75,000	74,000	139,000	288,000	-68,000
2027	D	174,000	1,000	24,000	199,000	146,000	82,000	127,000	355,000	-154,000
2028	AN	474,000	13,000	25,000	512,000	96,000	75,000	147,000	318,000	186,000
2029	W	278,000	11,000	24,000	313,000	95,000	73,000	142,000	310,000	-3,000
2030	W	225,000	11,000	23,000	259,000	95,000	76,000	138,000	309,000	-55,000
2031	C	203,000	8,000	22,000	232,000	72,000	77,000	141,000	291,000	-65,000
2032	C	150,000	0	25,000	175,000	177,000	86,000	131,000	394,000	-216,000
2033	W	578,000	21,000	25,000	624,000	81,000	88,000	160,000	330,000	287,000
2034	AN	235,000	4,000	24,000	263,000	115,000	86,000	140,000	341,000	-82,000
2035	W	357,000	21,000	23,000	401,000	66,000	82,000	160,000	308,000	86,000
2036	D	225,000	1,000	22,000	248,000	91,000	84,000	138,000	313,000	-71,000
2037	W	298,000	22,000	24,000	344,000	57,000	106,000	150,000	314,000	27,000
2038	W	426,000	22,000	24,000	471,000	52,000	97,000	148,000	298,000	168,000
2039	AN	200,000	4,000	22,000	226,000	85,000	90,000	135,000	310,000	-90,000
2040	D	177,000	1,000	22,000	199,000	82,000	89,000	140,000	311,000	-117,000
2041	W	248,000	30,000	22,000	300,000	76,000	87,000	142,000	305,000	-11,000
2042	C	155,000	6,000	26,000	186,000	147,000	78,000	136,000	361,000	-176,000
2043	C	167,000	2,000	29,000	198,000	174,000	74,000	151,000	398,000	-200,000
2044	C	214,000	0	25,000	239,000	125,000	76,000	159,000	360,000	-126,000
2045	C	184,000	1,000	31,000	216,000	188,000	74,000	149,000	411,000	-190,000
2046	C	274,000	5,000	25,000	304,000	136,000	87,000	158,000	382,000	-80,000
2047	C	332,000	8,000	26,000	366,000	169,000	100,000	150,000	419,000	-53,000
2048	W	564,000	30,000	25,000	620,000	71,000	90,000	173,000	334,000	272,000
2049	C	233,000	3,000	25,000	261,000	144,000	94,000	146,000	384,000	-128,000
2050	W	557,000	31,000	25,000	613,000	61,000	98,000	175,000	334,000	269,000
2051	W	316,000	10,000	25,000	351,000	54,000	117,000	162,000	333,000	13,000
2052	W	425,000	17,000	26,000	469,000	143,000	109,000	140,000	391,000	70,000
2053	W	489,000	32,000	26,000	546,000	53,000	99,000	181,000	333,000	206,000
2054	AN	249,000	6,000	25,000	279,000	97,000	96,000	151,000	344,000	-74,000
2055	AN	235,000	5,000	24,000	265,000	78,000	91,000	158,000	327,000	-73,000
2056	D	168,000	10,000	28,000	207,000	155,000	83,000	146,000	384,000	-182,000
2057	D	194,000	1,000	25,000	219,000	97,000	84,000	163,000	344,000	-131,000
2058	BN	302,000	3,000	25,000	330,000	110,000	88,000	152,000	350,000	-27,000
2059	D	338,000	1,000	25,000	364,000	134,000	97,000	151,000	382,000	-24,000
2060	W	390,000	25,000	26,000	442,000	107,000	91,000	160,000	358,000	74,000
2061	W	359,000	12,000	26,000	397,000	58,000	90,000	174,000	322,000	67,000
2062	C	138,000	0	25,000	163,000	110,000	86,000	144,000	340,000	-183,000
2063	C	253,000	6,000	32,000	291,000	183,000	78,000	145,000	406,000	-117,000
2064	BN	178,000	0	28,000	206,000	156,000	83,000	159,000	397,000	-192,000
2065	AN	394,000	12,000	27,000	432,000	140,000	95,000	157,000	393,000	35,000
2066	W	410,000	23,000	27,000	461,000	95,000	85,000	165,000	345,000	104,000
2067	D	222,000	1,000	25,000	248,000	88,000	84,000	157,000	329,000	-92,000
2068	C	176,000	0	31,000	207,000	163,000	77,000	145,000	385,000	-181,000
2069	C	117,000	0	24,000	141,000	82,000	83,000	165,000	329,000	-193,000
2070	C	158,000	0	22,000	180,000	50,000	90,000	153,000	293,000	-120,000
Average (2020 - 2040)		294,000	11,000	24,000	329,000	96,000	82,000	143,000	321,000	4,000
Average (2020 - 2070)		287,000	10,000	25,000	322,000	107,000	86,000	150,000	344,000	-27,000

1. Vertical flow to Lower Aquifer. Sum of flow through Corcoran clay and intraborehole flow

Table H-4: Boundary Flow Scenario 1 Projected Lower Aquifer Groundwater Budget

Water Year	Water Year Type	Lateral Subsurface Inflow (af)	Vertical Flow[1] (af)	Total Inflow (af)	Groundwater Pumping (af)	Lateral Subsurface Outflow (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	178,000	188,000	366,000	87,000	52,000	140,000	228,000
2018	AN	135,000	142,000	277,000	175,000	40,000	214,000	63,000
2019	D	136,000	133,000	269,000	244,000	37,000	281,000	-10,000
2020	W	137,000	135,000	272,000	253,000	40,000	293,000	-23,000
2021	BN	134,000	139,000	273,000	237,000	40,000	277,000	-5,000
2022	W	106,000	155,000	261,000	113,000	47,000	160,000	102,000
2023	D	125,000	127,000	252,000	411,000	51,000	462,000	-214,000
2024	W	130,000	174,000	304,000	96,000	46,000	142,000	164,000
2025	AN	92,000	136,000	228,000	183,000	45,000	228,000	1,000
2026	BN	84,000	139,000	223,000	136,000	45,000	181,000	40,000
2027	D	102,000	127,000	229,000	312,000	48,000	360,000	-132,000
2028	AN	116,000	147,000	263,000	173,000	41,000	213,000	46,000
2029	W	98,000	142,000	240,000	175,000	43,000	218,000	18,000
2030	W	89,000	138,000	227,000	177,000	44,000	221,000	1,000
2031	C	77,000	141,000	218,000	132,000	47,000	179,000	37,000
2032	C	116,000	131,000	246,000	404,000	51,000	455,000	-212,000
2033	W	120,000	160,000	281,000	145,000	46,000	191,000	80,000
2034	AN	99,000	140,000	239,000	223,000	49,000	272,000	-36,000
2035	W	91,000	160,000	251,000	125,000	51,000	176,000	72,000
2036	D	74,000	138,000	213,000	169,000	56,000	225,000	-16,000
2037	W	67,000	150,000	217,000	113,000	75,000	188,000	29,000
2038	W	55,000	148,000	203,000	106,000	77,000	183,000	20,000
2039	AN	60,000	135,000	195,000	162,000	70,000	232,000	-43,000
2040	D	65,000	140,000	205,000	152,000	66,000	218,000	-17,000
2041	W	65,000	142,000	207,000	140,000	68,000	208,000	-8,000
2042	C	99,000	136,000	235,000	314,000	66,000	380,000	-146,000
2043	C	141,000	151,000	291,000	378,000	63,000	441,000	-153,000
2044	C	144,000	159,000	303,000	237,000	63,000	300,000	-2,000
2045	C	157,000	149,000	306,000	409,000	66,000	476,000	-171,000
2046	C	152,000	158,000	311,000	266,000	68,000	334,000	-30,000
2047	C	144,000	150,000	294,000	360,000	72,000	432,000	-145,000
2048	W	131,000	173,000	304,000	128,000	73,000	202,000	95,000
2049	C	120,000	146,000	266,000	303,000	76,000	379,000	-117,000
2050	W	112,000	175,000	286,000	115,000	84,000	199,000	85,000
2051	W	79,000	162,000	241,000	105,000	98,000	203,000	35,000
2052	W	96,000	140,000	236,000	309,000	90,000	399,000	-177,000
2053	W	102,000	181,000	283,000	103,000	85,000	188,000	92,000
2054	AN	90,000	151,000	241,000	185,000	82,000	267,000	-34,000
2055	AN	91,000	158,000	249,000	143,000	77,000	220,000	20,000
2056	D	117,000	146,000	264,000	342,000	77,000	419,000	-160,000
2057	D	119,000	163,000	282,000	175,000	75,000	250,000	27,000
2058	BN	106,000	152,000	258,000	211,000	77,000	287,000	-32,000
2059	D	116,000	151,000	267,000	274,000	79,000	354,000	-96,000
2060	W	123,000	160,000	283,000	201,000	77,000	278,000	-7,000
2061	W	105,000	174,000	279,000	113,000	82,000	195,000	85,000
2062	C	99,000	144,000	244,000	221,000	75,000	296,000	-51,000
2063	C	138,000	145,000	284,000	409,000	78,000	487,000	-210,000
2064	BN	155,000	159,000	314,000	318,000	79,000	397,000	-91,000
2065	AN	147,000	157,000	304,000	283,000	80,000	363,000	-67,000
2066	W	137,000	165,000	302,000	171,000	76,000	246,000	43,000
2067	D	121,000	157,000	278,000	162,000	71,000	233,000	41,000
2068	C	141,000	145,000	286,000	356,000	78,000	434,000	-149,000
2069	C	126,000	165,000	291,000	142,000	79,000	221,000	67,000
2070	C	82,000	153,000	235,000	79,000	87,000	166,000	68,000
Average (2020 - 2040)		97,000	143,000	240,000	190,000	51,000	242,000	-4,000
Average (2020 - 2070)		110,000	150,000	260,000	215,000	66,000	281,000	-25,000

1. Vertical flow from Upper Aquifer. Sum of flow through Corcoran clay and intraborehole flow

Table H-5: Boundary Flow Scenario 2 Projected Groundwater Budget

Water Year	Water Year Type	Net Deep Percolation (af)	Stream Leakage (af)	Lateral Subsurface Inflow (af)	Total Inflow (af)	Pumping (af)	Lateral Subsurface Outflow (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	483,000	15,000	211,000	709,000	137,000	154,000	291,000	407,000
2018	AN	297,000	12,000	162,000	471,000	272,000	149,000	421,000	43,000
2019	D	164,000	1,000	164,000	330,000	370,000	169,000	538,000	-209,000
2020	W	257,000	12,000	178,000	447,000	386,000	166,000	552,000	-106,000
2021	BN	379,000	1,000	179,000	559,000	367,000	161,000	528,000	27,000
2022	W	361,000	23,000	153,000	536,000	173,000	146,000	318,000	212,000
2023	D	284,000	10,000	167,000	461,000	599,000	166,000	765,000	-301,000
2024	W	566,000	32,000	171,000	769,000	149,000	142,000	291,000	469,000
2025	AN	208,000	5,000	127,000	340,000	289,000	170,000	459,000	-119,000
2026	BN	216,000	2,000	126,000	344,000	220,000	187,000	406,000	-68,000
2027	D	188,000	1,000	149,000	338,000	465,000	188,000	653,000	-313,000
2028	AN	491,000	13,000	163,000	667,000	282,000	156,000	439,000	219,000
2029	W	298,000	11,000	142,000	451,000	286,000	168,000	454,000	-8,000
2030	W	242,000	11,000	136,000	389,000	287,000	179,000	465,000	-80,000
2031	C	220,000	8,000	126,000	353,000	217,000	189,000	406,000	-57,000
2032	C	166,000	0	158,000	324,000	591,000	192,000	783,000	-456,000
2033	W	598,000	21,000	165,000	785,000	245,000	163,000	408,000	366,000
2034	AN	255,000	4,000	143,000	403,000	354,000	185,000	540,000	-137,000
2035	W	376,000	21,000	137,000	533,000	199,000	179,000	378,000	148,000
2036	D	244,000	1,000	119,000	363,000	277,000	198,000	475,000	-114,000
2037	W	315,000	22,000	110,000	448,000	172,000	189,000	360,000	83,000
2038	W	448,000	22,000	91,000	561,000	160,000	189,000	349,000	206,000
2039	AN	219,000	4,000	96,000	319,000	267,000	217,000	484,000	-166,000
2040	D	194,000	1,000	108,000	303,000	249,000	221,000	470,000	-168,000
2041	W	263,000	30,000	110,000	403,000	234,000	213,000	447,000	-47,000
2042	C	170,000	6,000	137,000	313,000	473,000	215,000	688,000	-371,000
2043	C	179,000	2,000	177,000	358,000	562,000	212,000	774,000	-415,000
2044	C	225,000	0	183,000	408,000	373,000	217,000	590,000	-186,000
2045	C	194,000	1,000	190,000	386,000	607,000	222,000	829,000	-436,000
2046	C	285,000	5,000	190,000	480,000	413,000	223,000	636,000	-159,000
2047	C	343,000	8,000	184,000	535,000	541,000	223,000	764,000	-231,000
2048	W	584,000	30,000	169,000	784,000	219,000	205,000	424,000	349,000
2049	C	249,000	3,000	158,000	410,000	466,000	218,000	684,000	-272,000
2050	W	582,000	31,000	151,000	764,000	185,000	211,000	396,000	361,000
2051	W	338,000	10,000	117,000	464,000	162,000	229,000	392,000	67,000
2052	W	449,000	17,000	134,000	601,000	485,000	228,000	713,000	-113,000
2053	W	509,000	32,000	140,000	681,000	158,000	194,000	352,000	318,000
2054	AN	266,000	6,000	126,000	398,000	310,000	214,000	523,000	-125,000
2055	AN	251,000	5,000	131,000	387,000	244,000	225,000	469,000	-87,000
2056	D	185,000	10,000	154,000	349,000	513,000	230,000	743,000	-394,000
2057	D	208,000	1,000	161,000	370,000	286,000	236,000	522,000	-155,000
2058	BN	315,000	3,000	151,000	469,000	338,000	221,000	559,000	-91,000
2059	D	355,000	1,000	160,000	516,000	433,000	222,000	655,000	-140,000
2060	W	410,000	25,000	166,000	601,000	336,000	211,000	547,000	49,000
2061	W	378,000	12,000	147,000	537,000	173,000	201,000	374,000	156,000
2062	C	156,000	0	139,000	295,000	346,000	228,000	574,000	-271,000
2063	C	269,000	6,000	174,000	449,000	608,000	236,000	843,000	-392,000
2064	BN	190,000	0	191,000	381,000	486,000	234,000	720,000	-341,000
2065	AN	407,000	12,000	187,000	605,000	442,000	214,000	656,000	-53,000
2066	W	428,000	23,000	178,000	629,000	292,000	200,000	492,000	129,000
2067	D	238,000	1,000	163,000	401,000	272,000	212,000	483,000	-84,000
2068	C	192,000	0	177,000	369,000	533,000	235,000	768,000	-394,000
2069	C	128,000	0	171,000	299,000	229,000	255,000	483,000	-188,000
2070	C	169,000	0	134,000	302,000	136,000	266,000	401,000	-103,000
Average (2020 - 2040)		311,000	11,000	140,000	462,000	297,000	179,000	475,000	-17,000
Average (2020 - 2070)		303,000	10,000	151,000	463,000	335,000	204,000	539,000	-78,000

Table H-6: Boundary Flow Scenario 2 Projected Upper Aquifer Groundwater Budget

Water Year	Water Year Type	Net Deep Percolation (af)	Stream Leakage (af)	Lateral Subsurface Inflow (af)	Total Inflow (af)	Groundwater Pumping (af)	Lateral Subsurface Outflow (af)	Vertical Flow[1] (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	483,000	15,000	34,000	576,000	50,000	98,000	186,000	333,000	188,000
2018	AN	297,000	12,000	31,000	340,000	95,000	101,000	137,000	333,000	1,000
2019	D	164,000	1,000	31,000	196,000	120,000	116,000	128,000	364,000	-167,000
2020	W	257,000	12,000	32,000	302,000	127,000	113,000	133,000	374,000	-72,000
2021	BN	379,000	1,000	33,000	413,000	123,000	111,000	139,000	373,000	37,000
2022	W	361,000	23,000	30,000	414,000	59,000	95,000	158,000	313,000	93,000
2023	D	284,000	10,000	31,000	325,000	182,000	111,000	129,000	423,000	-92,000
2024	W	566,000	32,000	31,000	628,000	52,000	93,000	176,000	321,000	297,000
2025	AN	208,000	5,000	28,000	242,000	99,000	113,000	133,000	346,000	-106,000
2026	BN	216,000	2,000	29,000	248,000	77,000	125,000	134,000	336,000	-92,000
2027	D	188,000	1,000	30,000	220,000	146,000	128,000	126,000	401,000	-176,000
2028	AN	491,000	13,000	31,000	535,000	100,000	108,000	148,000	356,000	172,000
2029	W	298,000	11,000	30,000	339,000	100,000	115,000	140,000	355,000	-19,000
2030	W	242,000	11,000	30,000	283,000	99,000	123,000	136,000	358,000	-76,000
2031	C	220,000	8,000	30,000	257,000	76,000	128,000	138,000	342,000	-88,000
2032	C	166,000	0	31,000	197,000	181,000	131,000	131,000	443,000	-239,000
2033	W	598,000	21,000	30,000	650,000	88,000	110,000	159,000	357,000	286,000
2034	AN	255,000	4,000	30,000	289,000	120,000	125,000	139,000	384,000	-94,000
2035	W	376,000	21,000	29,000	426,000	69,000	119,000	154,000	342,000	78,000
2036	D	244,000	1,000	29,000	274,000	96,000	130,000	135,000	361,000	-88,000
2037	W	315,000	22,000	28,000	365,000	58,000	117,000	152,000	327,000	33,000
2038	W	448,000	22,000	26,000	496,000	55,000	111,000	150,000	316,000	176,000
2039	AN	219,000	4,000	28,000	252,000	92,000	135,000	131,000	358,000	-105,000
2040	D	194,000	1,000	30,000	224,000	87,000	140,000	135,000	361,000	-136,000
2041	W	263,000	30,000	30,000	323,000	83,000	133,000	137,000	353,000	-31,000
2042	C	170,000	6,000	31,000	206,000	151,000	134,000	134,000	420,000	-208,000
2043	C	179,000	2,000	32,000	213,000	175,000	134,000	145,000	455,000	-235,000
2044	C	225,000	0	32,000	257,000	126,000	136,000	152,000	415,000	-156,000
2045	C	194,000	1,000	32,000	228,000	187,000	138,000	141,000	466,000	-231,000
2046	C	285,000	5,000	32,000	322,000	138,000	138,000	150,000	426,000	-102,000
2047	C	343,000	8,000	32,000	383,000	171,000	137,000	144,000	452,000	-66,000
2048	W	584,000	30,000	31,000	645,000	79,000	122,000	167,000	368,000	270,000
2049	C	249,000	3,000	31,000	283,000	150,000	131,000	145,000	426,000	-139,000
2050	W	582,000	31,000	30,000	643,000	65,000	121,000	173,000	359,000	278,000
2051	W	338,000	10,000	28,000	376,000	56,000	129,000	162,000	347,000	24,000
2052	W	449,000	17,000	30,000	497,000	154,000	131,000	141,000	426,000	76,000
2053	W	509,000	32,000	30,000	570,000	55,000	108,000	182,000	345,000	219,000
2054	AN	266,000	6,000	29,000	301,000	108,000	124,000	150,000	382,000	-80,000
2055	AN	251,000	5,000	31,000	287,000	87,000	134,000	155,000	377,000	-90,000
2056	D	185,000	10,000	33,000	227,000	160,000	138,000	144,000	442,000	-209,000
2057	D	208,000	1,000	32,000	241,000	101,000	142,000	158,000	400,000	-157,000
2058	BN	315,000	3,000	32,000	350,000	116,000	132,000	150,000	398,000	-47,000
2059	D	355,000	1,000	32,000	387,000	142,000	132,000	150,000	424,000	-33,000
2060	W	410,000	25,000	32,000	467,000	116,000	125,000	159,000	400,000	67,000
2061	W	378,000	12,000	31,000	421,000	60,000	115,000	173,000	348,000	67,000
2062	C	156,000	0	31,000	187,000	116,000	137,000	142,000	394,000	-202,000
2063	C	269,000	6,000	34,000	309,000	184,000	141,000	142,000	467,000	-150,000
2064	BN	190,000	0	34,000	224,000	156,000	139,000	153,000	449,000	-219,000
2065	AN	407,000	12,000	33,000	452,000	145,000	126,000	154,000	425,000	29,000
2066	W	428,000	23,000	33,000	484,000	104,000	117,000	163,000	384,000	98,000
2067	D	238,000	1,000	32,000	271,000	96,000	128,000	154,000	378,000	-109,000
2068	C	192,000	0	33,000	225,000	166,000	140,000	142,000	447,000	-214,000
2069	C	128,000	0	33,000	161,000	82,000	151,000	157,000	390,000	-226,000
2070	C	169,000	0	32,000	201,000	52,000	154,000	147,000	354,000	-155,000
Average (2020 - 2040)		311,000	11,000	30,000	351,000	99,000	118,000	142,000	359,000	-10,000
Average (2020 - 2070)		303,000	10,000	31,000	344,000	111,000	126,000	148,000	386,000	-42,000

1. Vertical flow to Lower Aquifer. Sum of flow through Corcoran clay and intraborehole flow

Table H-7: Boundary Flow Scenario 2 Projected Lower Aquifer Groundwater Budget

Water Year	Water Year Type	Lateral Subsurface Inflow (af)	Vertical Flow[1] (af)	Total Inflow (af)	Groundwater Pumping (af)	Lateral Subsurface Outflow (af)	Total Outflow (af)	Change In Groundwater Storage (af)
2017	W	177,000	186,000	362,000	88,000	56,000	144,000	219,000
2018	AN	131,000	137,000	268,000	177,000	48,000	225,000	43,000
2019	D	133,000	128,000	261,000	250,000	52,000	302,000	-42,000
2020	W	145,000	133,000	278,000	259,000	52,000	312,000	-34,000
2021	BN	147,000	139,000	286,000	244,000	51,000	294,000	-9,000
2022	W	122,000	158,000	281,000	113,000	50,000	164,000	119,000
2023	D	136,000	129,000	265,000	417,000	55,000	472,000	-210,000
2024	W	141,000	176,000	317,000	96,000	50,000	146,000	172,000
2025	AN	99,000	133,000	232,000	189,000	56,000	246,000	-13,000
2026	BN	97,000	134,000	231,000	143,000	61,000	204,000	24,000
2027	D	118,000	126,000	244,000	318,000	60,000	379,000	-136,000
2028	AN	132,000	148,000	280,000	182,000	48,000	230,000	48,000
2029	W	112,000	140,000	252,000	187,000	52,000	239,000	11,000
2030	W	106,000	136,000	242,000	188,000	56,000	244,000	-4,000
2031	C	96,000	138,000	234,000	141,000	61,000	202,000	31,000
2032	C	127,000	131,000	258,000	410,000	61,000	471,000	-216,000
2033	W	135,000	159,000	294,000	157,000	53,000	210,000	80,000
2034	AN	113,000	139,000	253,000	235,000	60,000	295,000	-43,000
2035	W	107,000	154,000	261,000	130,000	60,000	190,000	69,000
2036	D	89,000	135,000	225,000	181,000	68,000	249,000	-25,000
2037	W	82,000	152,000	235,000	113,000	72,000	186,000	49,000
2038	W	65,000	150,000	215,000	106,000	78,000	184,000	31,000
2039	AN	67,000	131,000	198,000	174,000	82,000	257,000	-61,000
2040	D	78,000	135,000	213,000	162,000	81,000	244,000	-32,000
2041	W	80,000	137,000	218,000	151,000	80,000	231,000	-16,000
2042	C	106,000	134,000	241,000	322,000	80,000	402,000	-163,000
2043	C	145,000	145,000	290,000	386,000	78,000	465,000	-180,000
2044	C	151,000	152,000	303,000	246,000	81,000	328,000	-30,000
2045	C	158,000	141,000	299,000	420,000	84,000	504,000	-205,000
2046	C	158,000	150,000	308,000	275,000	84,000	359,000	-57,000
2047	C	152,000	144,000	296,000	370,000	86,000	456,000	-165,000
2048	W	138,000	167,000	306,000	140,000	83,000	223,000	79,000
2049	C	127,000	145,000	272,000	316,000	87,000	403,000	-133,000
2050	W	121,000	173,000	294,000	120,000	90,000	210,000	83,000
2051	W	88,000	162,000	251,000	106,000	100,000	207,000	43,000
2052	W	104,000	141,000	245,000	330,000	97,000	427,000	-189,000
2053	W	111,000	182,000	293,000	103,000	86,000	189,000	99,000
2054	AN	97,000	150,000	247,000	202,000	89,000	292,000	-45,000
2055	AN	100,000	155,000	255,000	157,000	90,000	247,000	3,000
2056	D	122,000	144,000	266,000	353,000	92,000	445,000	-185,000
2057	D	129,000	158,000	286,000	185,000	94,000	279,000	2,000
2058	BN	119,000	150,000	269,000	222,000	90,000	312,000	-45,000
2059	D	128,000	150,000	279,000	291,000	90,000	381,000	-107,000
2060	W	134,000	159,000	293,000	220,000	87,000	306,000	-17,000
2061	W	116,000	173,000	288,000	113,000	86,000	199,000	89,000
2062	C	108,000	142,000	250,000	230,000	91,000	321,000	-69,000
2063	C	140,000	142,000	282,000	424,000	95,000	518,000	-242,000
2064	BN	157,000	153,000	310,000	330,000	95,000	425,000	-122,000
2065	AN	154,000	154,000	308,000	296,000	88,000	385,000	-82,000
2066	W	145,000	163,000	308,000	188,000	83,000	271,000	31,000
2067	D	131,000	154,000	285,000	176,000	83,000	259,000	26,000
2068	C	144,000	142,000	286,000	367,000	95,000	462,000	-180,000
2069	C	138,000	157,000	295,000	146,000	104,000	250,000	39,000
2070	C	101,000	147,000	249,000	83,000	112,000	195,000	53,000
Average (2020 - 2040)		110,000	142,000	252,000	197,000	61,000	258,000	-7,000
Average (2020 - 2070)		120,000	148,000	268,000	224,000	77,000	301,000	-36,000

1. Vertical flow from Upper Aquifer. Sum of flow through Corcoran clay and intraborehole flow

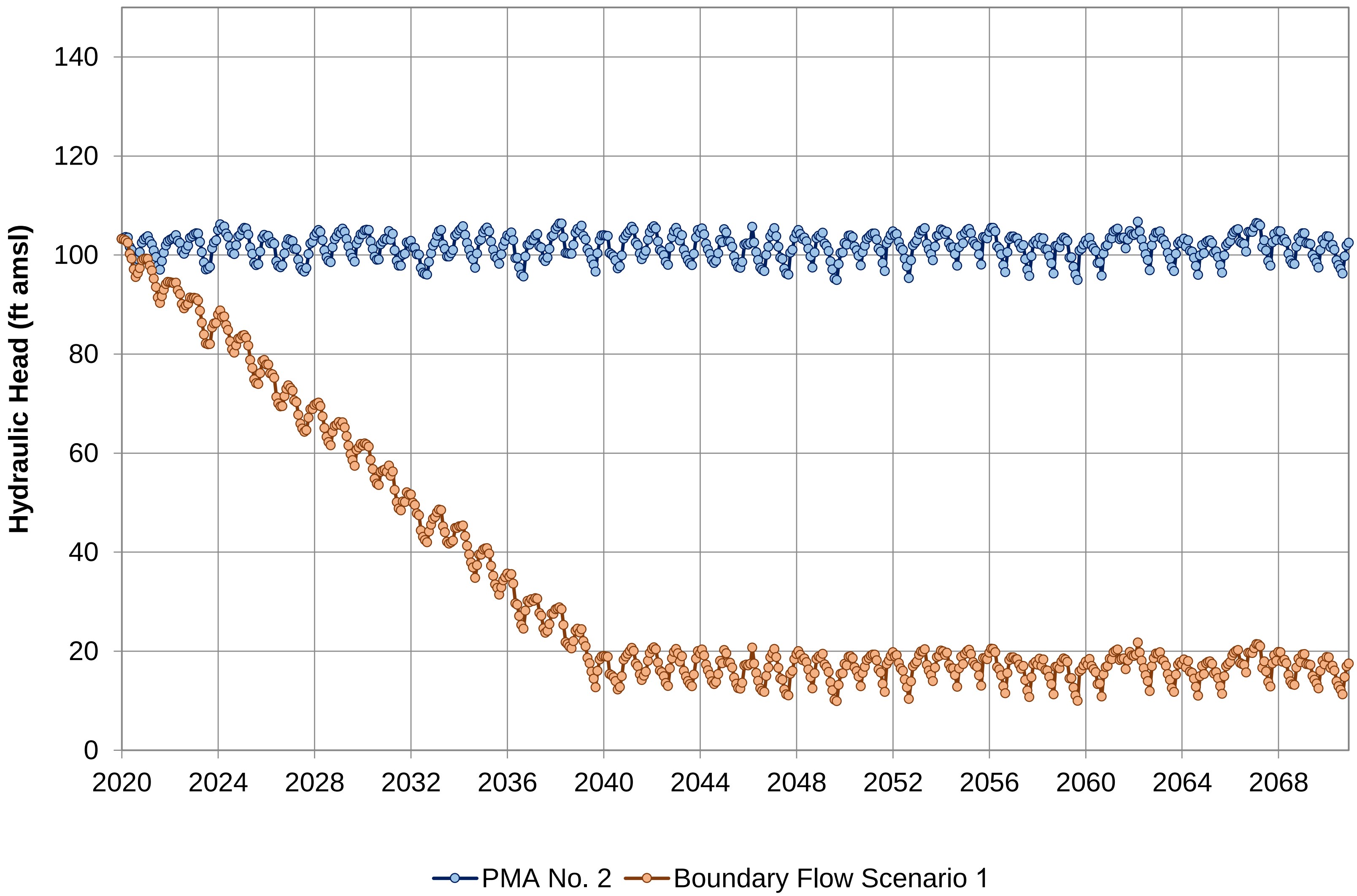

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Figure H-1
Assigned Hydraulic Head at Example GHB Node in Layer 8 (2020-2070)
PMA No.2 vs Boundary Flow Scenario 1

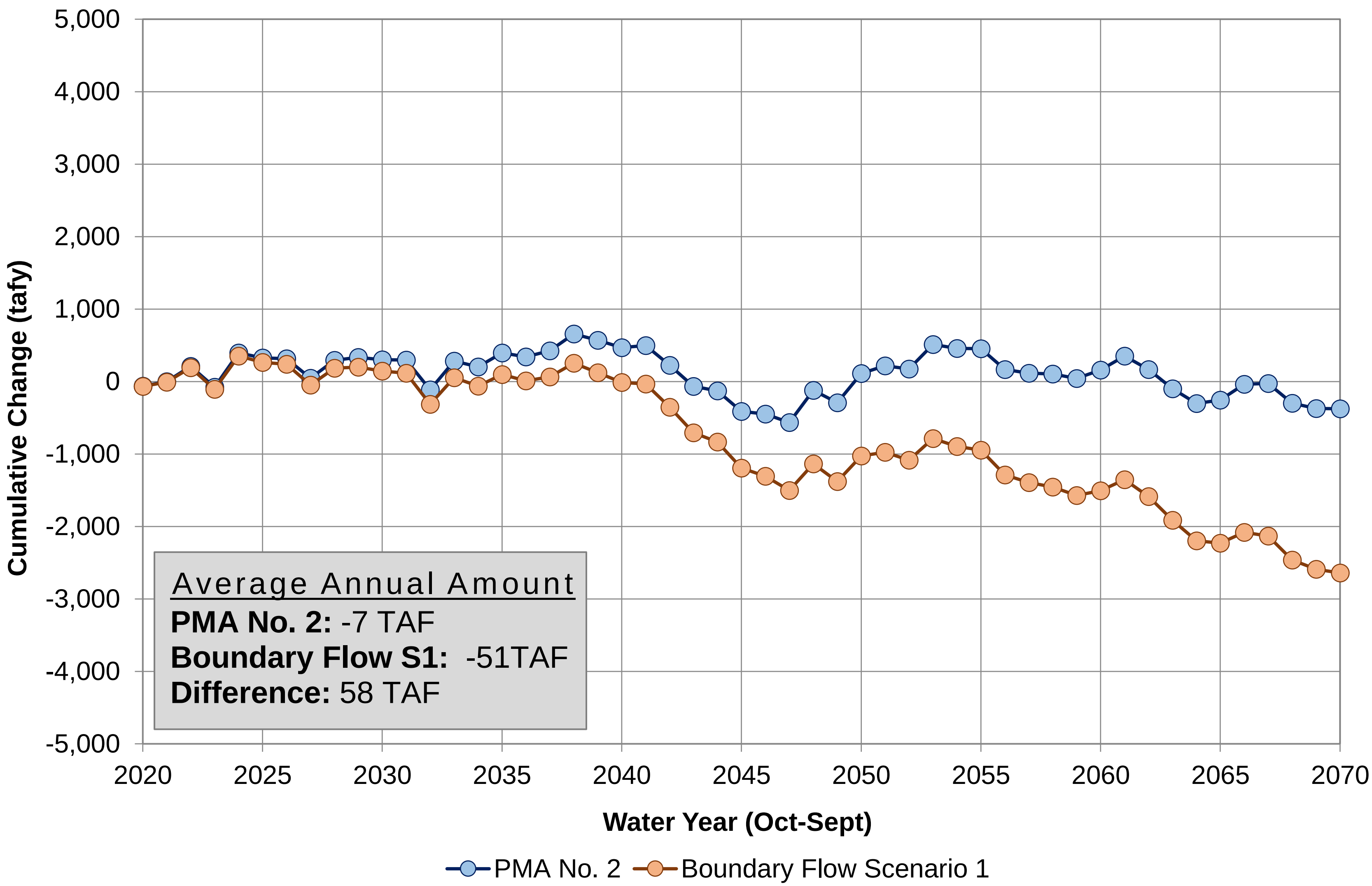

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Figure H-2
Cumulative Change in Groundwater Storage (2020-2070)
PMA No.2 vs Boundary Flow Scenario 1

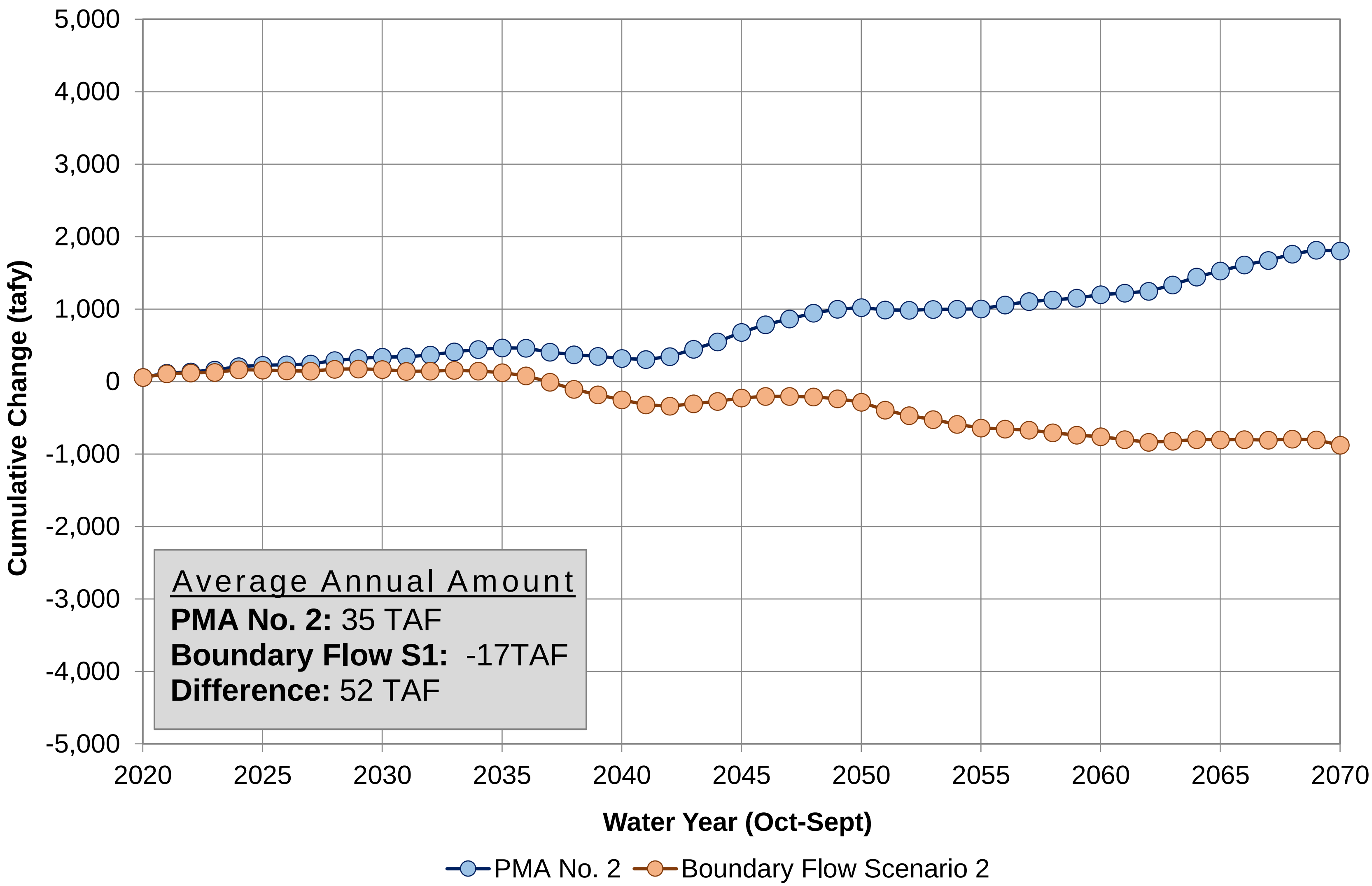

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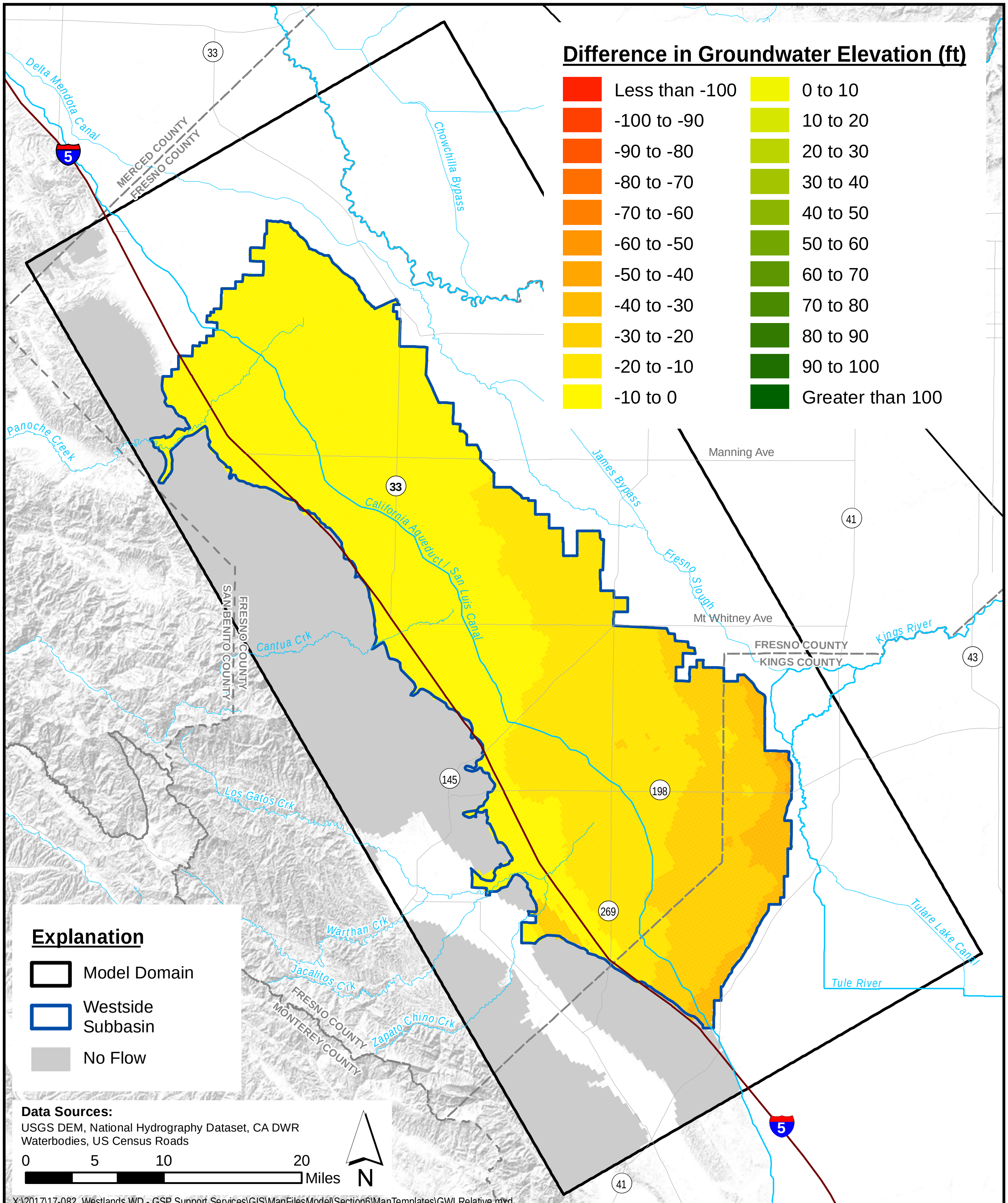
Figure H-3
Cumulative Net Lateral Groundwater Inflow (2020-2070)
PMA No.2 vs Boundary Flow Scenario 1



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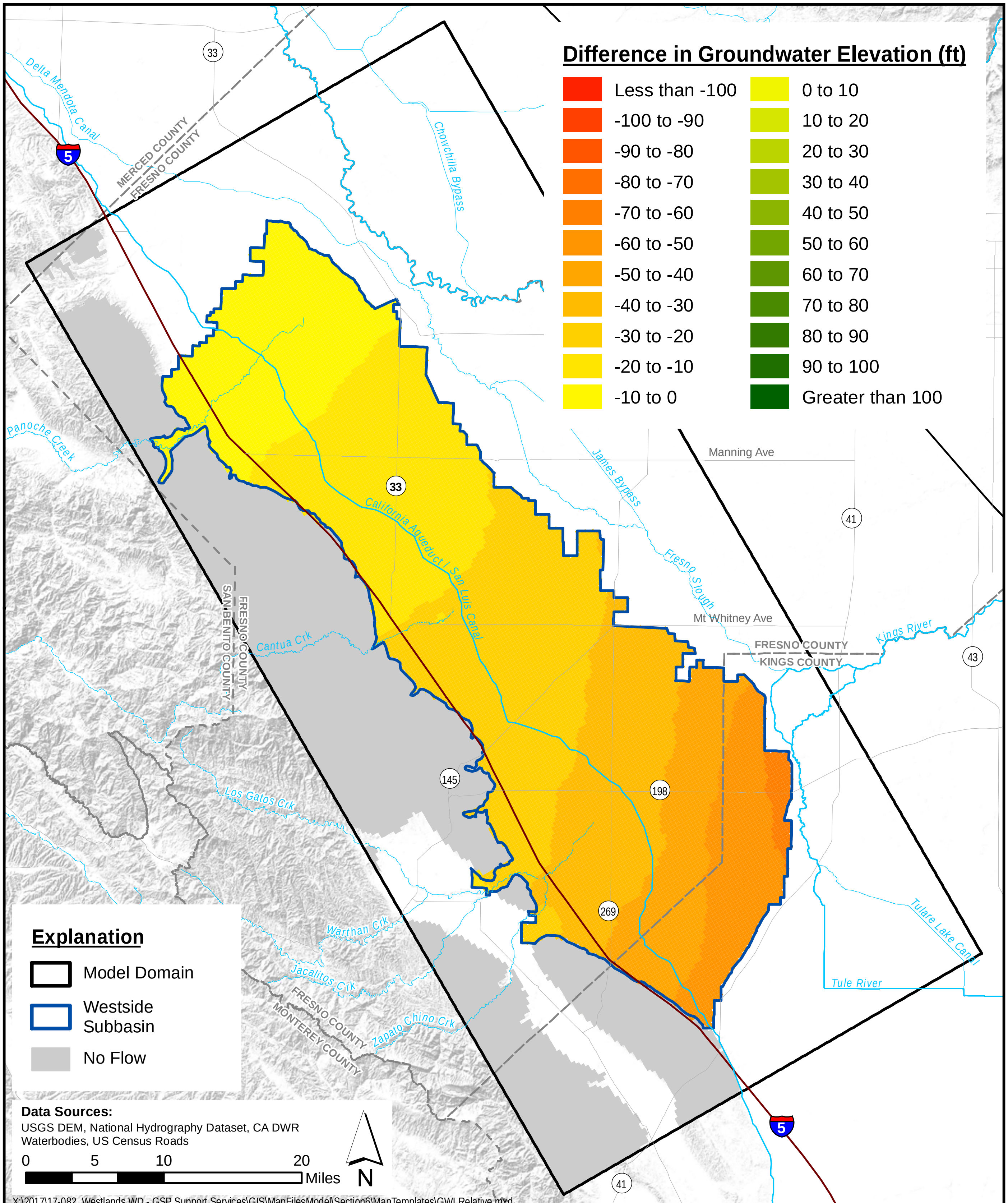
Difference in Groundwater Elevation in 2040
Boundary Flow Scenario 1 - Upper Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-4



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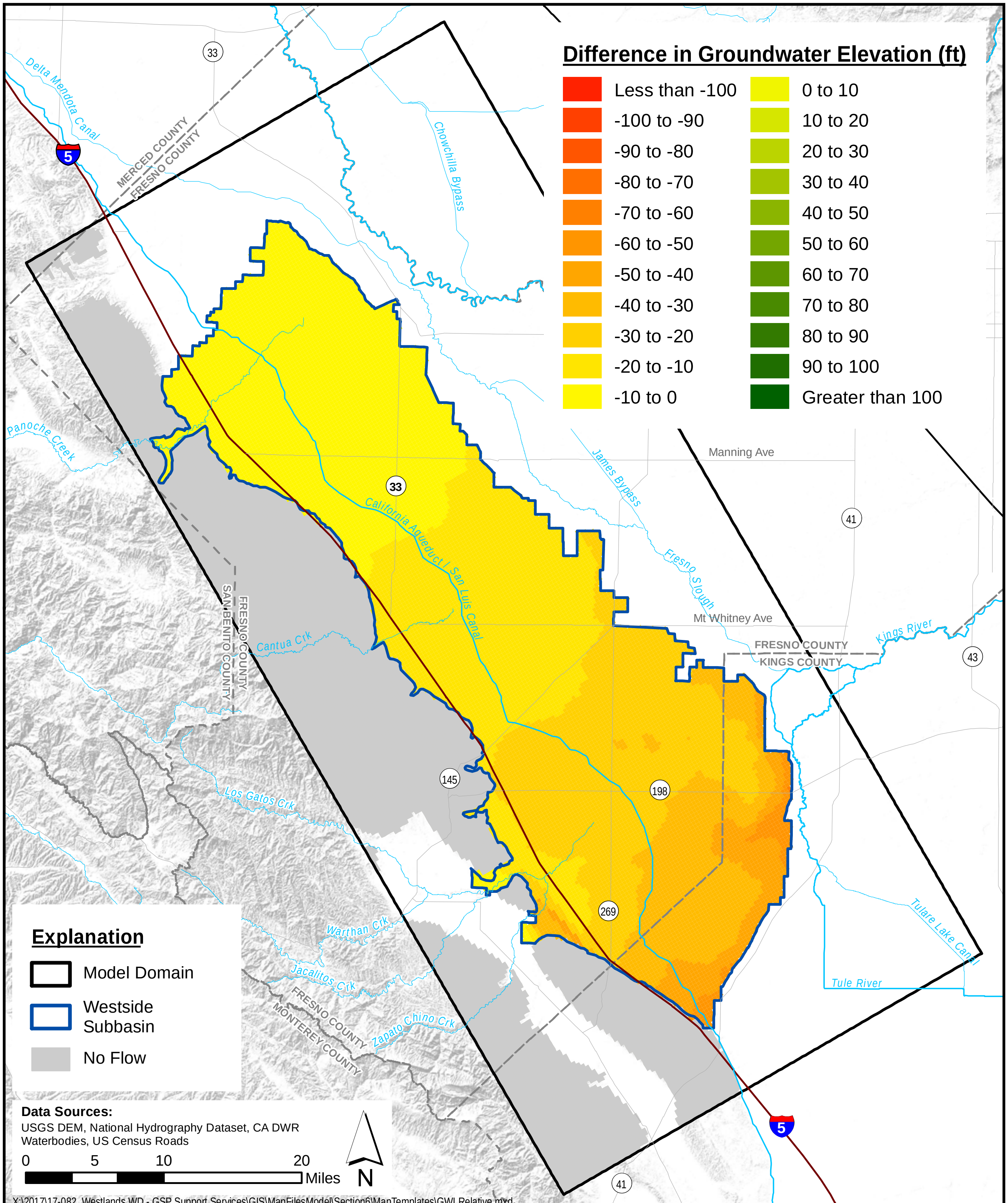
Difference in Groundwater Elevation in 2040
Boundary Flow Scenario 1 - Lower Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-5



Difference in Groundwater Elevation in 2070
Boundary Flow Scenario 1 - Upper Aquifer

Figure H-6

SGMA Sustainability Analyses
Westside Subbasin

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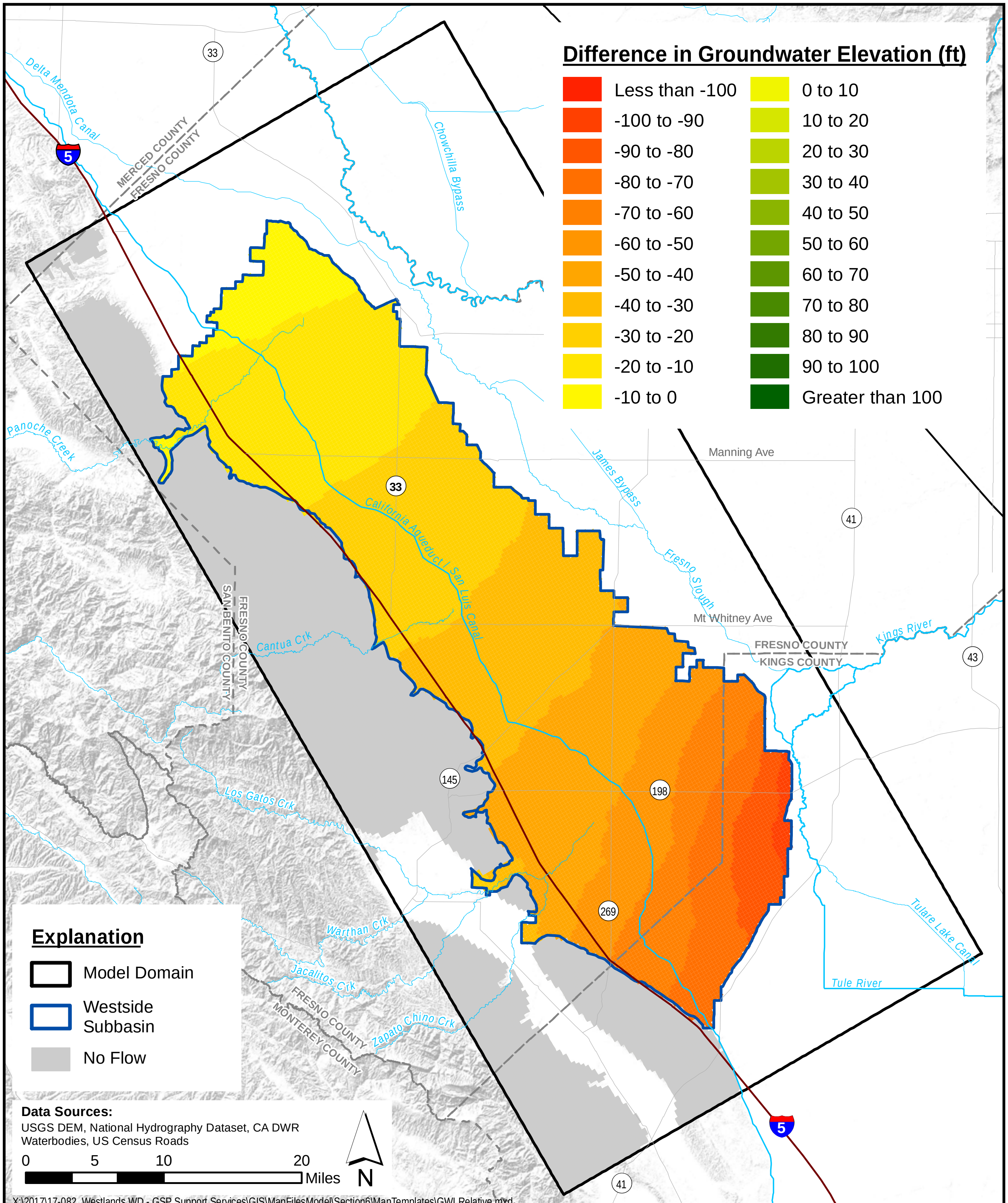

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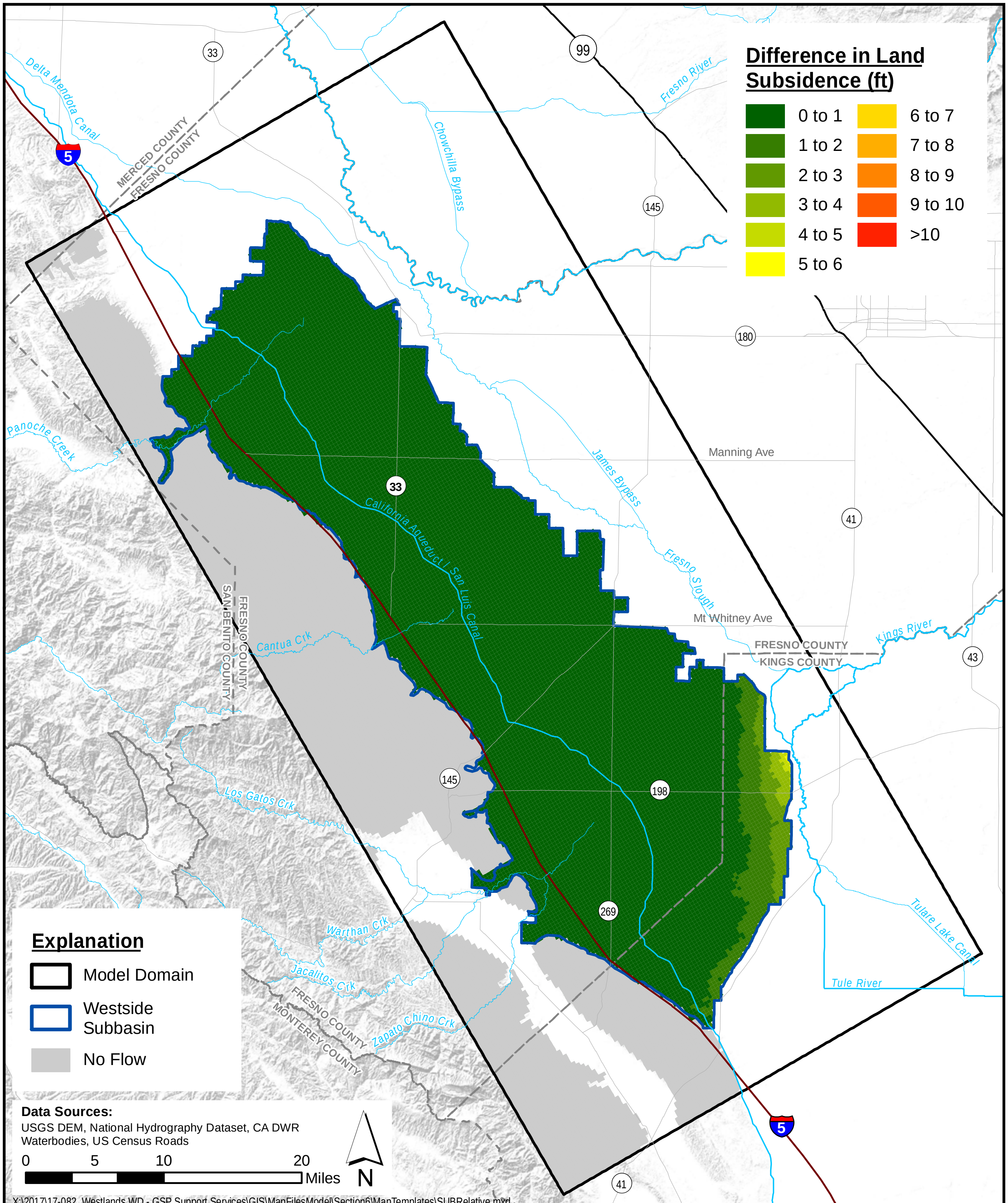
Difference in Groundwater Elevation in 2070
Boundary Flow Scenario 1 - Lower Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-7



Difference Land Surface Subsidence in 2040
Boundary Flow Scenario 1

Figure H-8

SGMA Sustainability Analyses
Westside Subbasin

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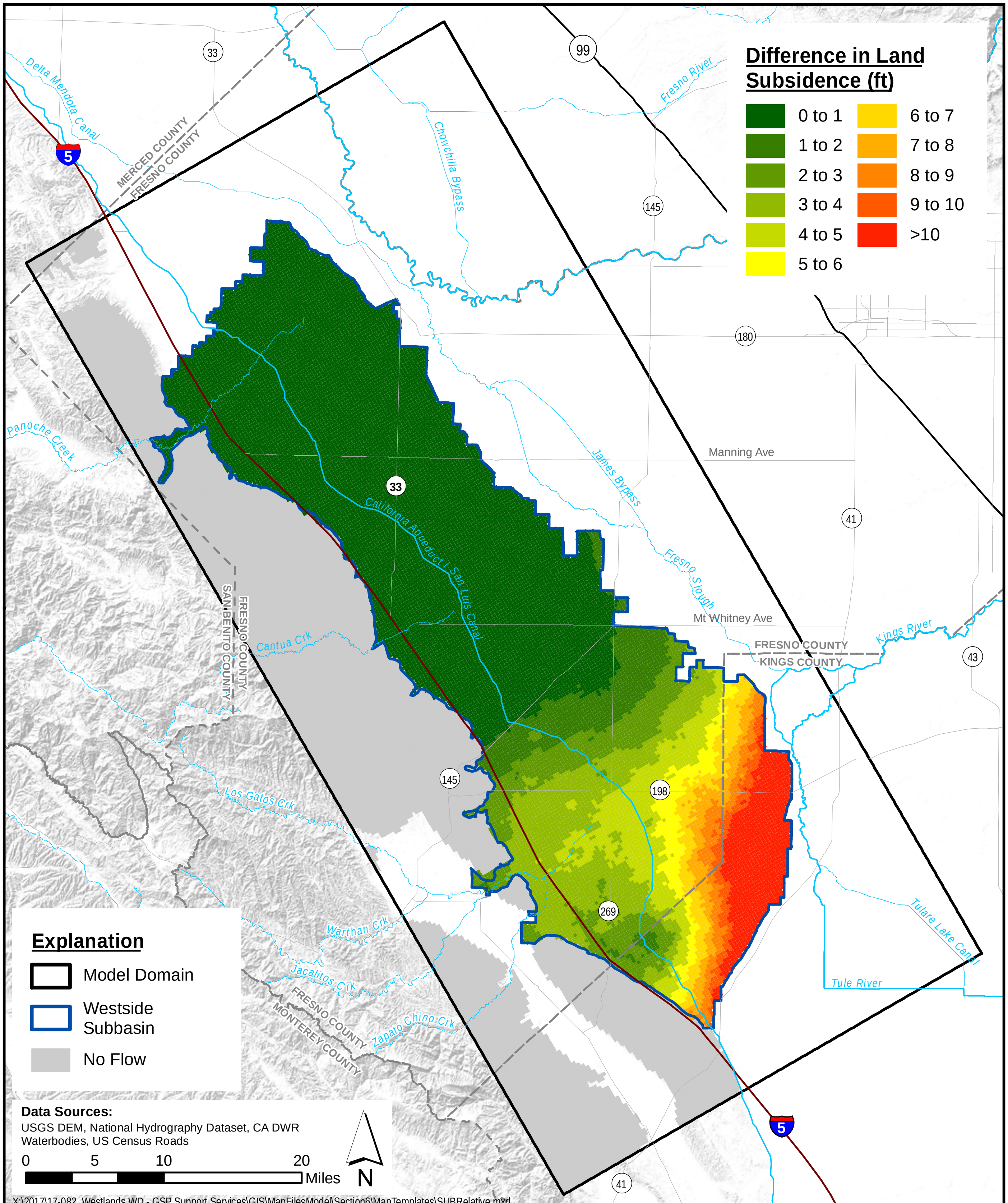

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Difference Land Surface Subsidence in 2070
Boundary Flow Scenario 1

SGMA Sustainability Analyses
Westside Subbasin

Figure H-9

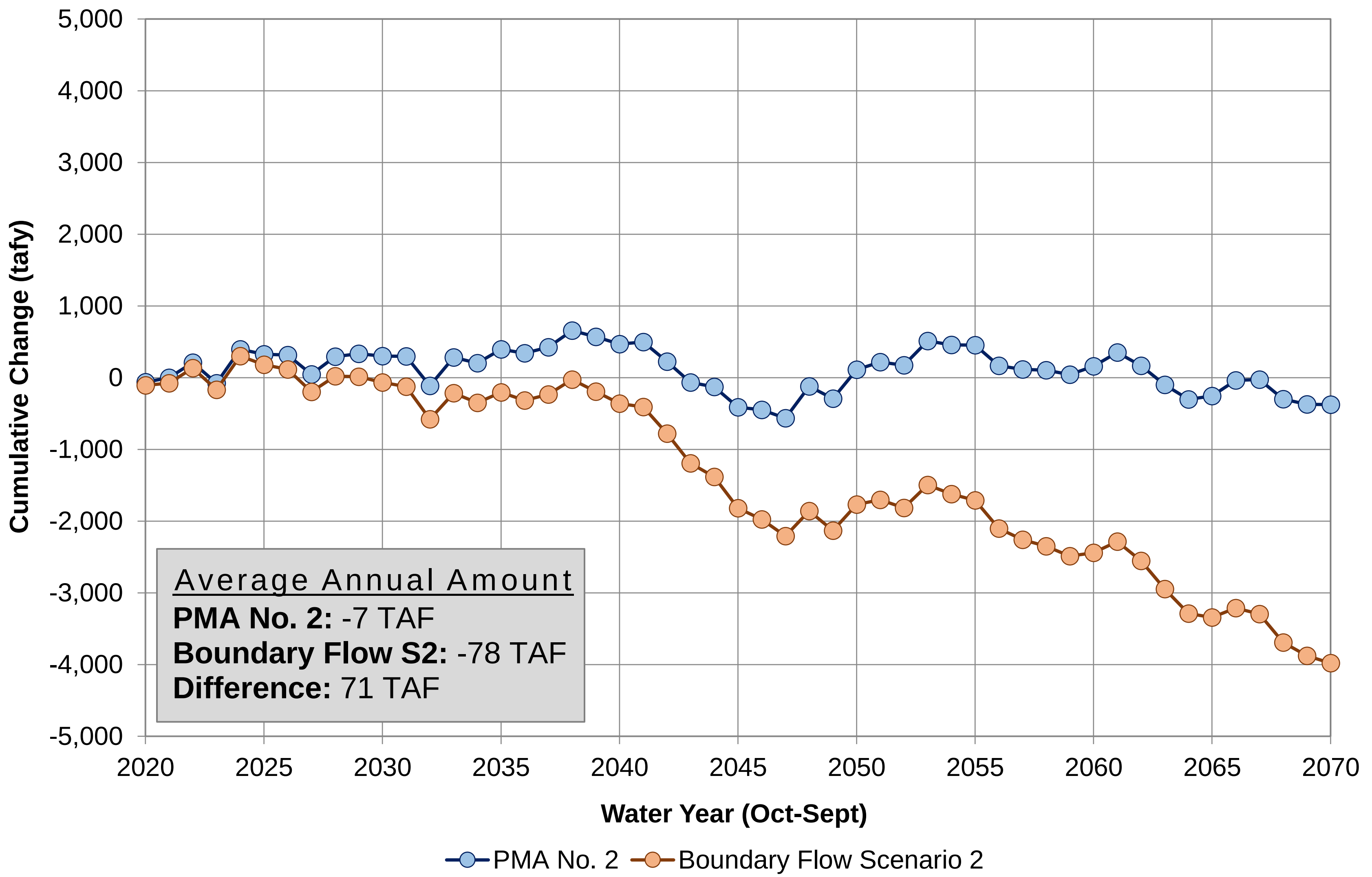

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Figure H-10
Cumulative Change in Groundwater Storage (2020-2070)
PMA No.2 vs Boundary Flow Scenario 2

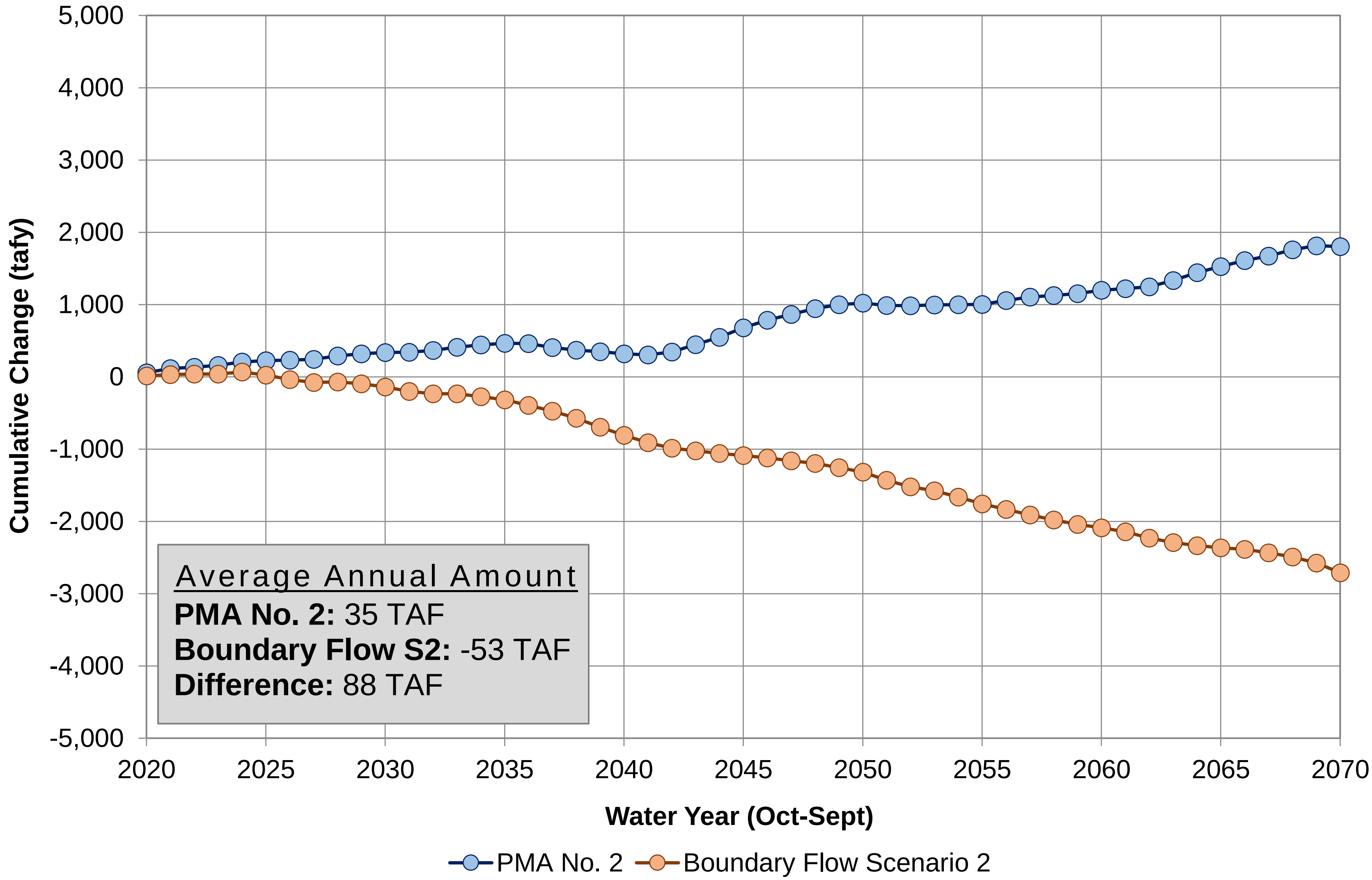

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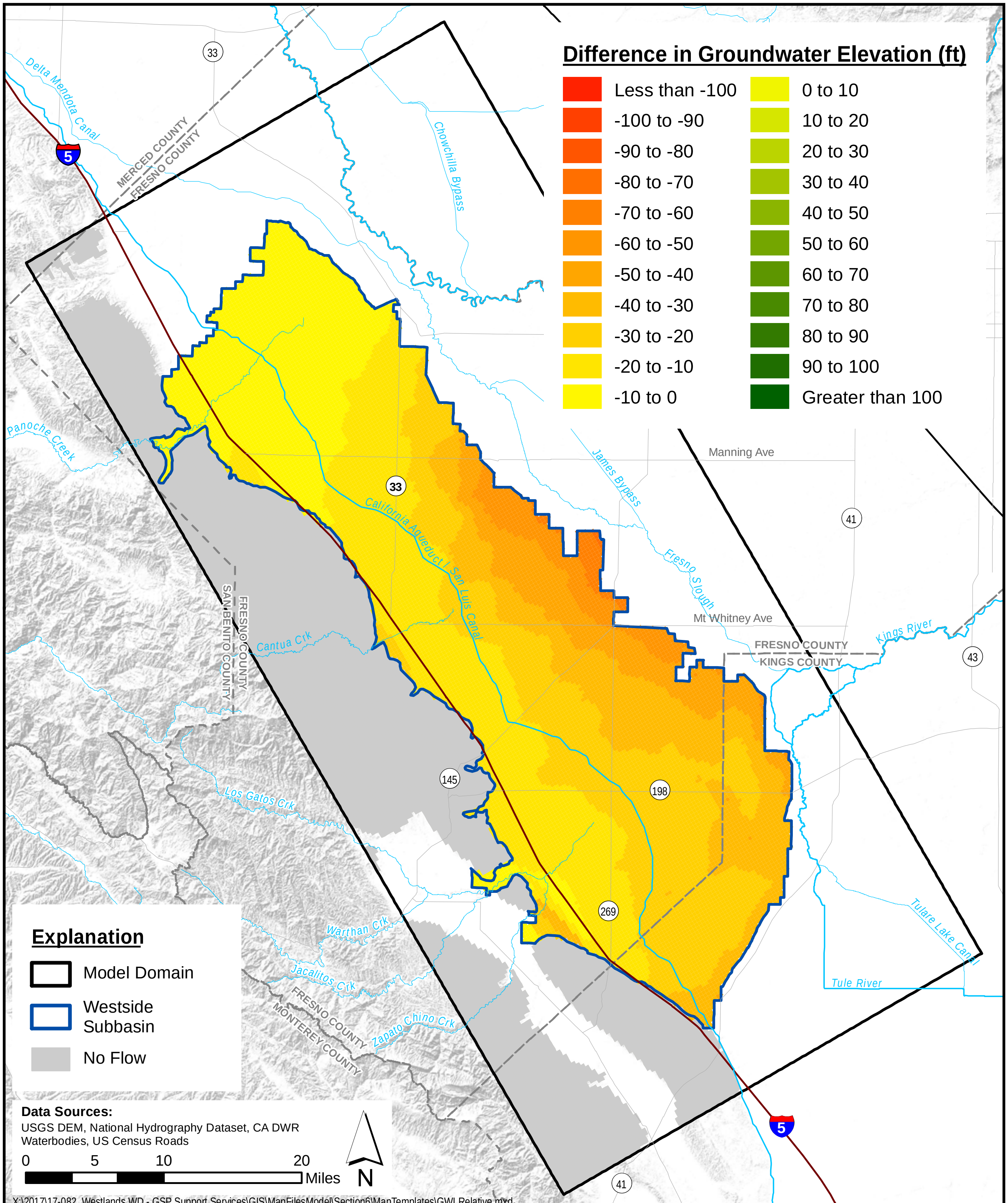
Figure H-11
Cumulative Net Lateral Groundwater Inflow (2020-2070)
PMA No.2 vs Boundary Flow Scenario 2



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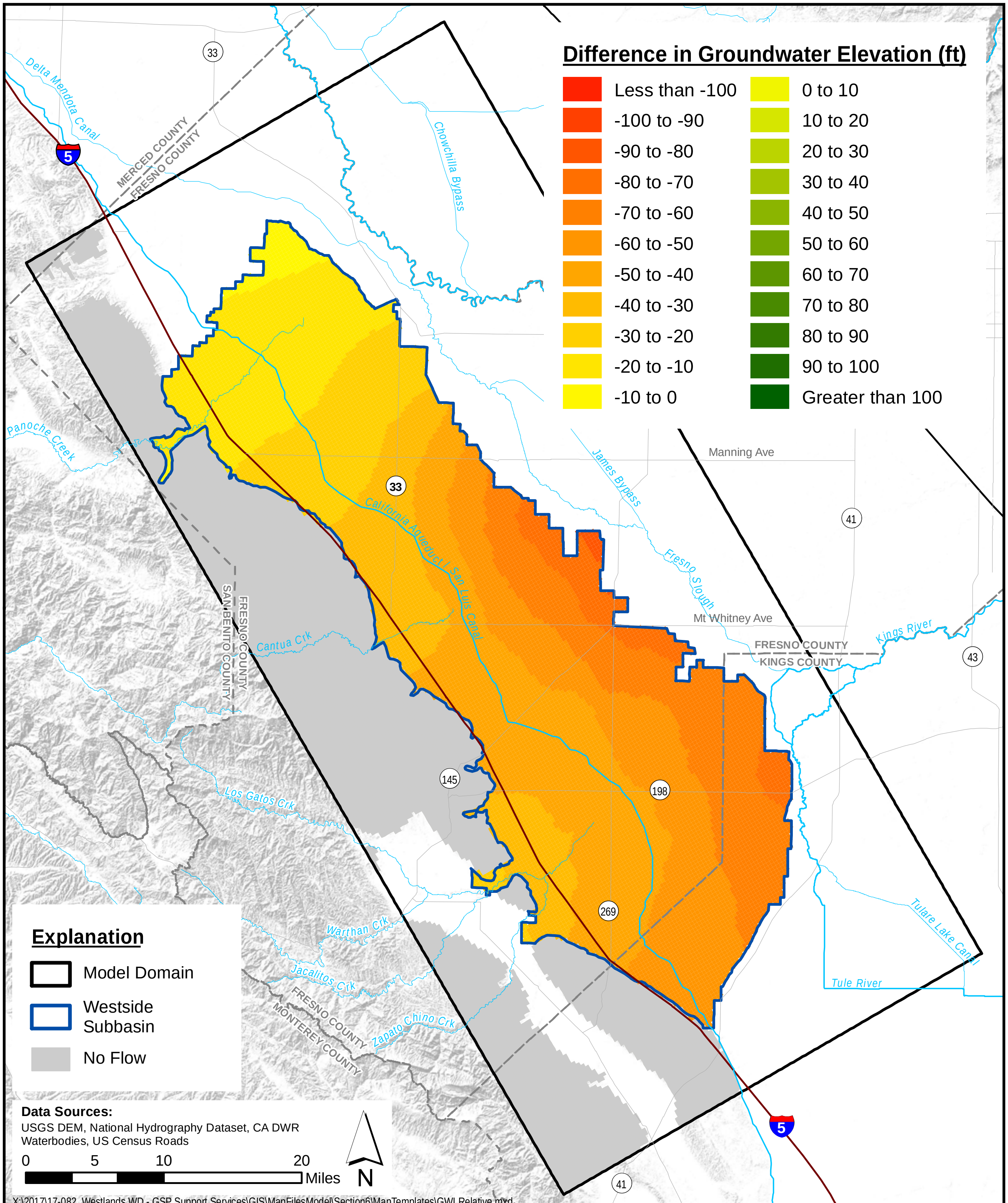
Difference in Groundwater Elevation in 2040
Boundary Flow Scenario 2 - Upper Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-12



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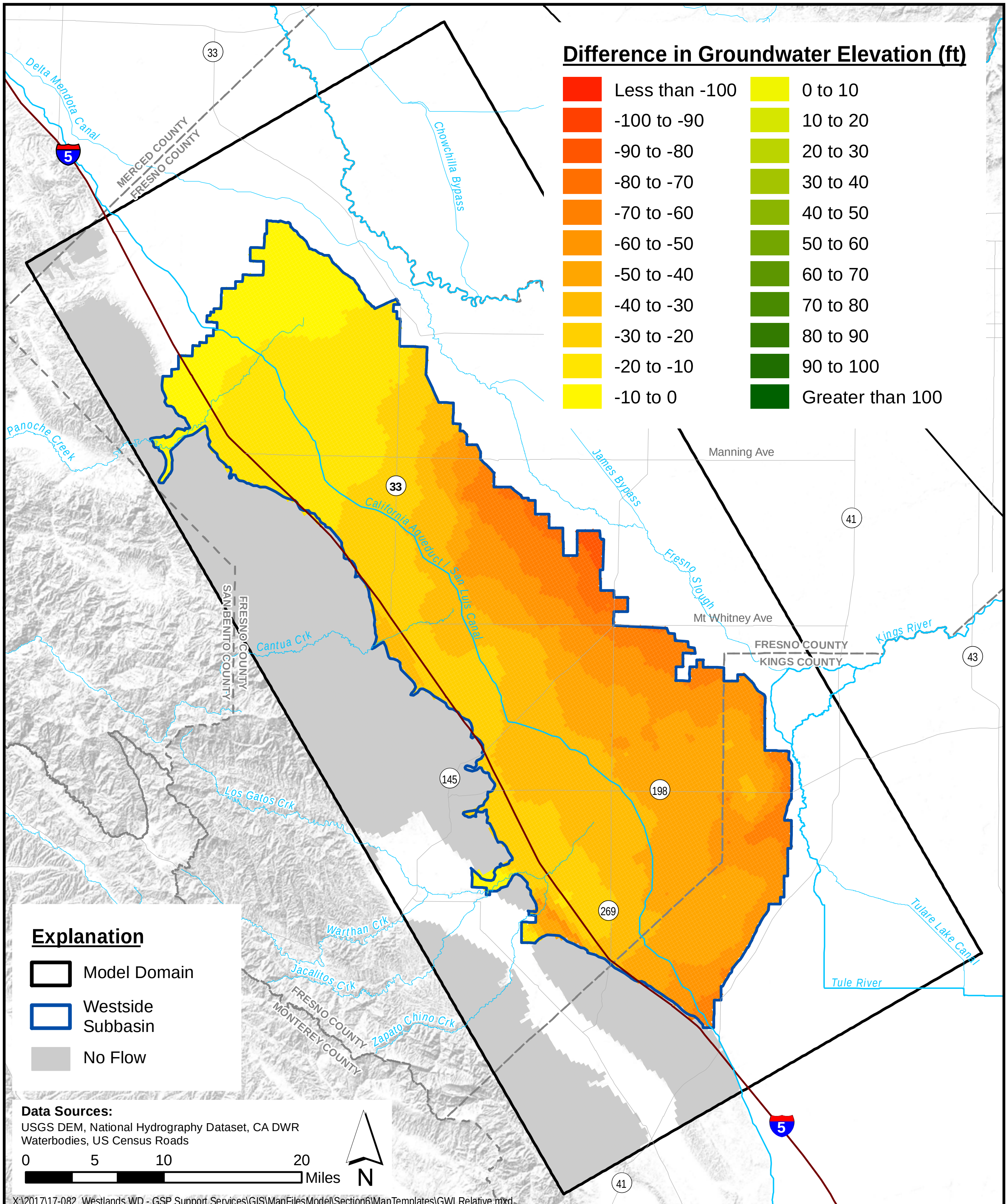
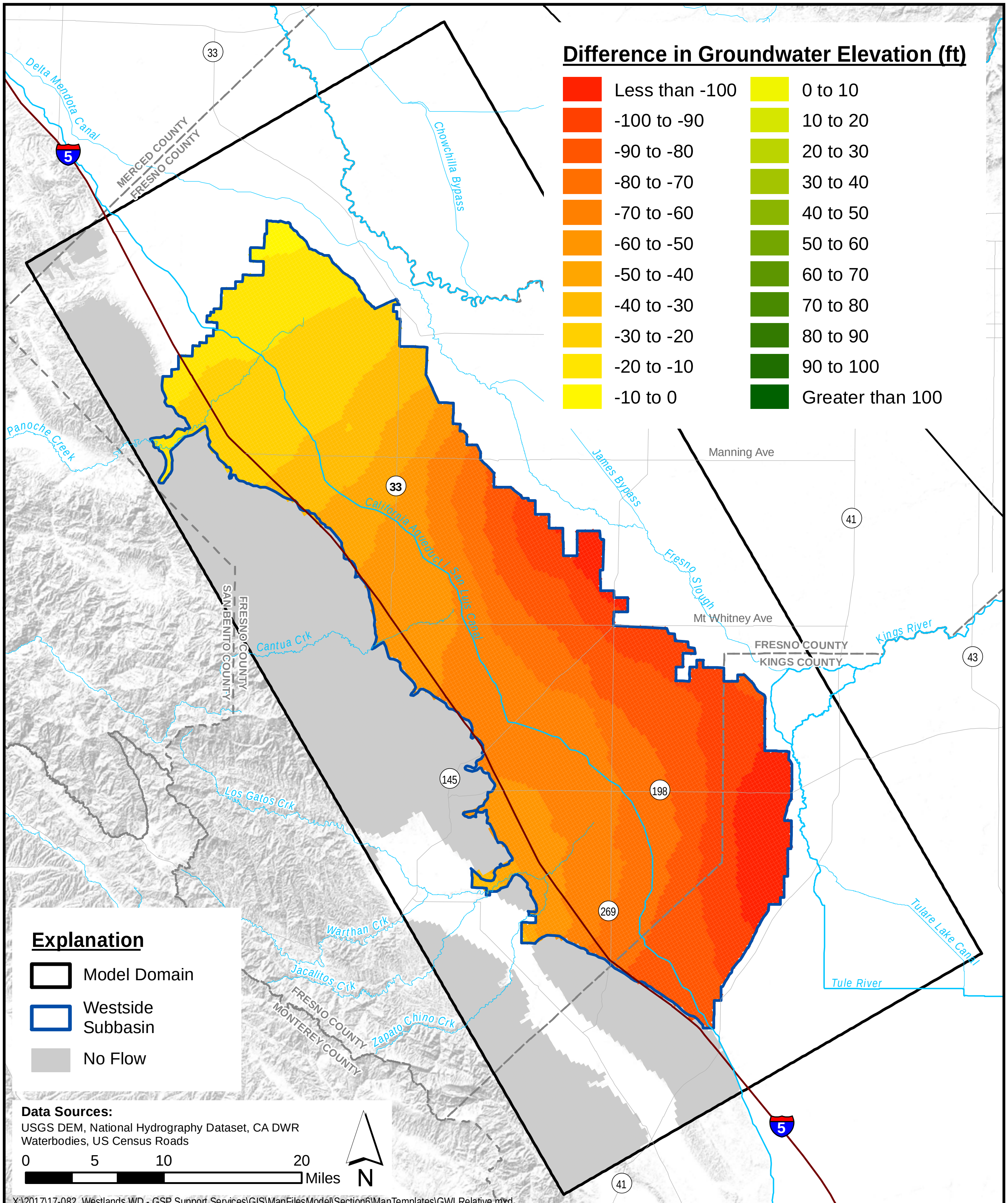
Difference in Groundwater Elevation in 2040
Boundary Flow Scenario 2 - Lower Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-13



Difference in Groundwater Elevation (ft)
Less than -100
-100 to -90
-90 to -80
-80 to -70
-70 to -60
-60 to -50
-50 to -40
-40 to -30
-30 to -20
-20 to -10
-10 to 0
0 to 10
10 to 20
20 to 30
30 to 40
40 to 50
50 to 60
60 to 70
70 to 80
80 to 90
90 to 100
Greater than 100
Explanation
Model Domain
Westside Subbasin
No Flow
Data Sources:
USGS DEM, National Hydrography Dataset, CA DWR Waterbodies, US Census Roads
0 5 10 20 Miles
N
Delta Mendota Canal
MERCED COUNTY
FRESNO COUNTY
Chowchilla Bypass
Panoche Creek
California Aqueduct / San Luis Canal
James Bypass
Fresno Slough
Manning Ave
Mt Whitney Ave
FRESNO COUNTY
KINGS COUNTY
Kings River
SAN BENITO COUNTY
Cantua Crk
Los Gatos Crk
Warthan Crk
Jacalitos Crk
Zapato Chino Crk
MONTEREY COUNTY
Tulare Lake Canal
Tule River
33
5
41
43
145
198
269
X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFilesModel\Section6\MapTemplates\GWLRelative.mxd



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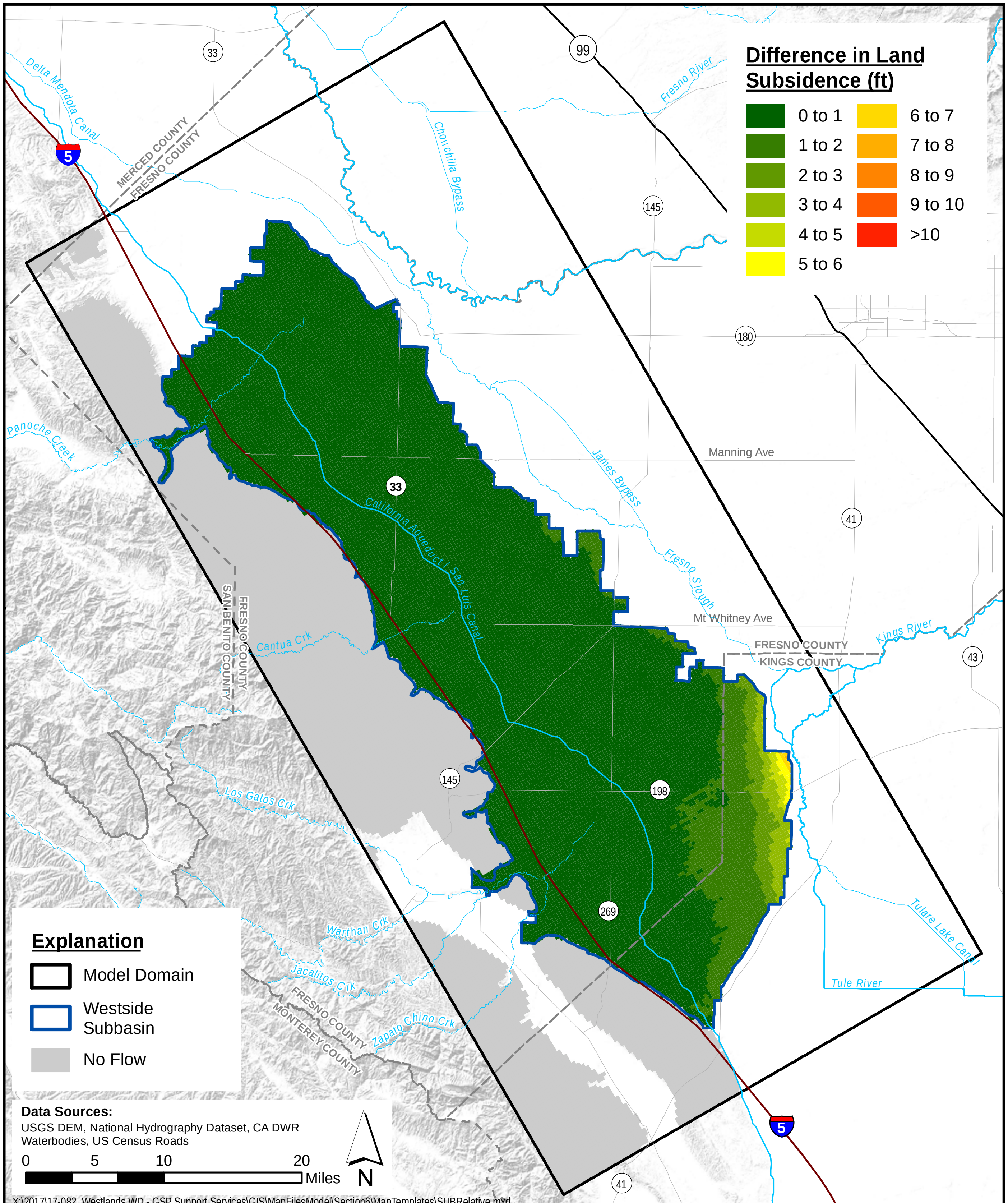
Difference in Groundwater Elevation in 2070
Boundary Flow Scenario 2 - Lower Aquifer

SGMA Sustainability Analyses
Westside Subbasin

Figure H-15



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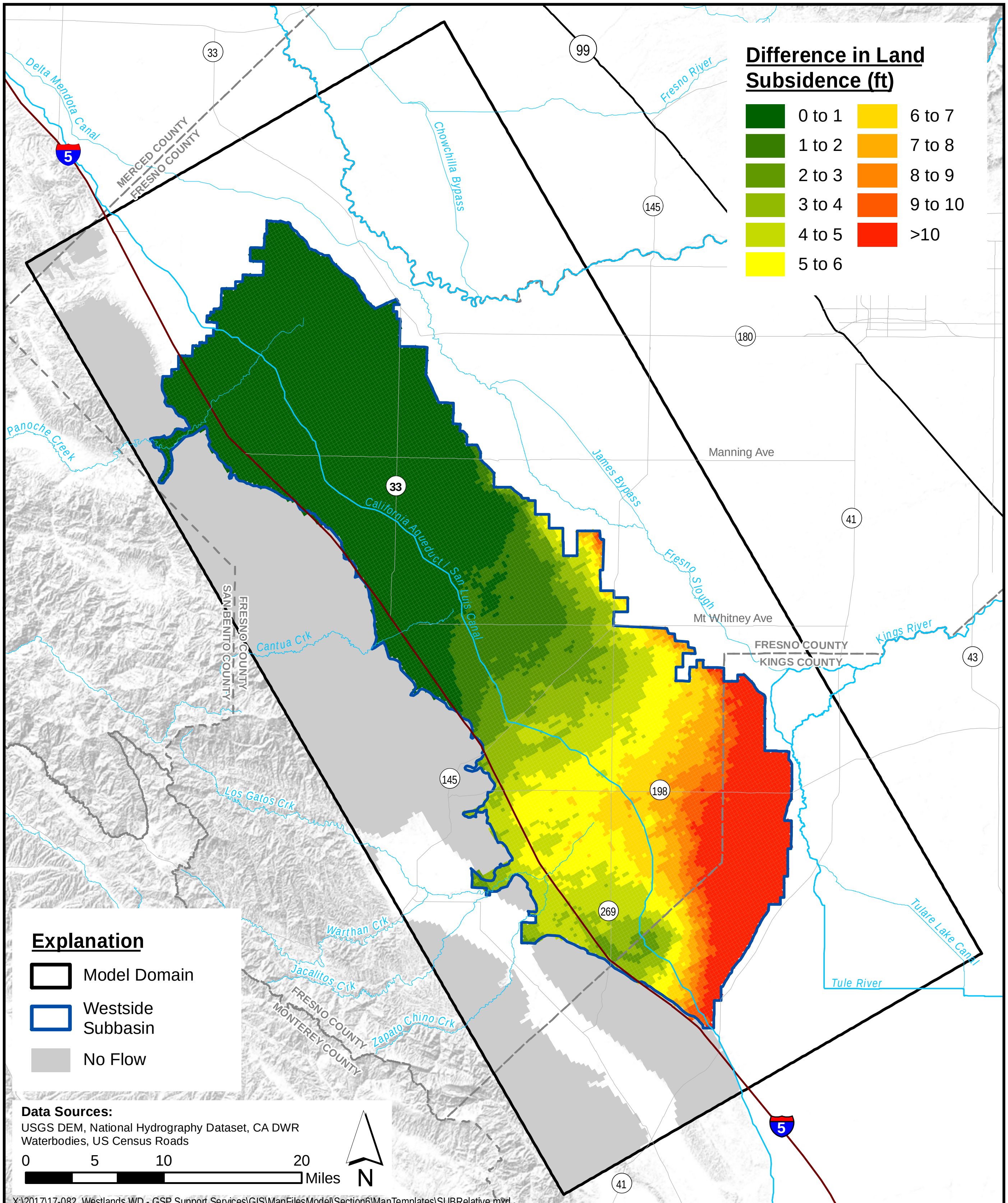
Difference Land Surface Subsidence in 2040
Boundary Flow Scenario 2

SGMA Sustainability Analyses
Westside Subbasin

Figure H-16



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Difference Land Surface Subsidence in 2070
Boundary Flow Scenario 2

SGMA Sustainability Analyses
Westside Subbasin

Figure H-17

Appendix I:

Effect of Pumping Reductions on Historic Groundwater Conditions

APPENDIX I: EFFECT OF PUMPING REDUCTIONS ON HISTORIC GROUNDWATER CONDITIONS

At the request of the Westside GSA, a model projection was developed to evaluate the impact of enacting a hypothetical limit on groundwater pumping during the drought period experienced from 2013 through 2015. The effect on groundwater conditions are evaluated with respect to groundwater level declines and subsidence during this period. Results from this projection are used to help inform the implementation of groundwater allocations as described in **Section 4.2** of the GSP.

Included in Appendix I is:

1. Development of Modified Model Inputs
2. Model Results

I.1 Development of Modified Model Inputs

Inputs to the calibrated version of WSGM were modified to incorporate a maximum limit (or allocation) on groundwater pumping from 2013 through 2015 during which the Westside Subbasin experienced adverse impacts to groundwater levels, groundwater storage and land surface subsidence. This model run is hereafter referred to as the Reduced Allocation Scenario. The framework for determining pumping reductions was based on measured groundwater pumping over irrigable area within each township in the Subbasin (**Figure I-1**). **Figure I-2** shows the amount of groundwater extracted in 2015 divided by the irrigated acreage in each township. Based on this map, an allocation scheme was determined such that the maximum amount of groundwater in each township does not exceed 1.25 acre-feet per irrigated acre within a township. Townships where measured pumping did not exceed this threshold in 2015 were not subjected to pumping limitations.

The maximum pumping limit was implemented in the MODFLOW Farm Process by limiting the maximum pumping rate [L^3/T] allowed in extraction wells within a MODFLOW Farm. This value was determined by:

1. Calculating the amount of pumping in 2015 that is in excess of 1.25 acre-feet per acre in each township based on **Figure I-2**.
2. Aggregating the total amount of excess pumping in 2015 within each MODFLOW Farm.
3. Applying a limit on the maximum pumping rate in wells within each MODFLOW Farm such that the simulated groundwater pumping in 2015 in the calibrated model is reduced by the excess pumping amount within each farm. The targeted pumping reduction in each MODFLOW Farm is shown in **Table I-1**.
4. Applying the maximum allowed pumping rate from wells in each MODFLOW Farm to 2013 and 2014 to reduce pumping in these additional drought years.

I.2 Model Results

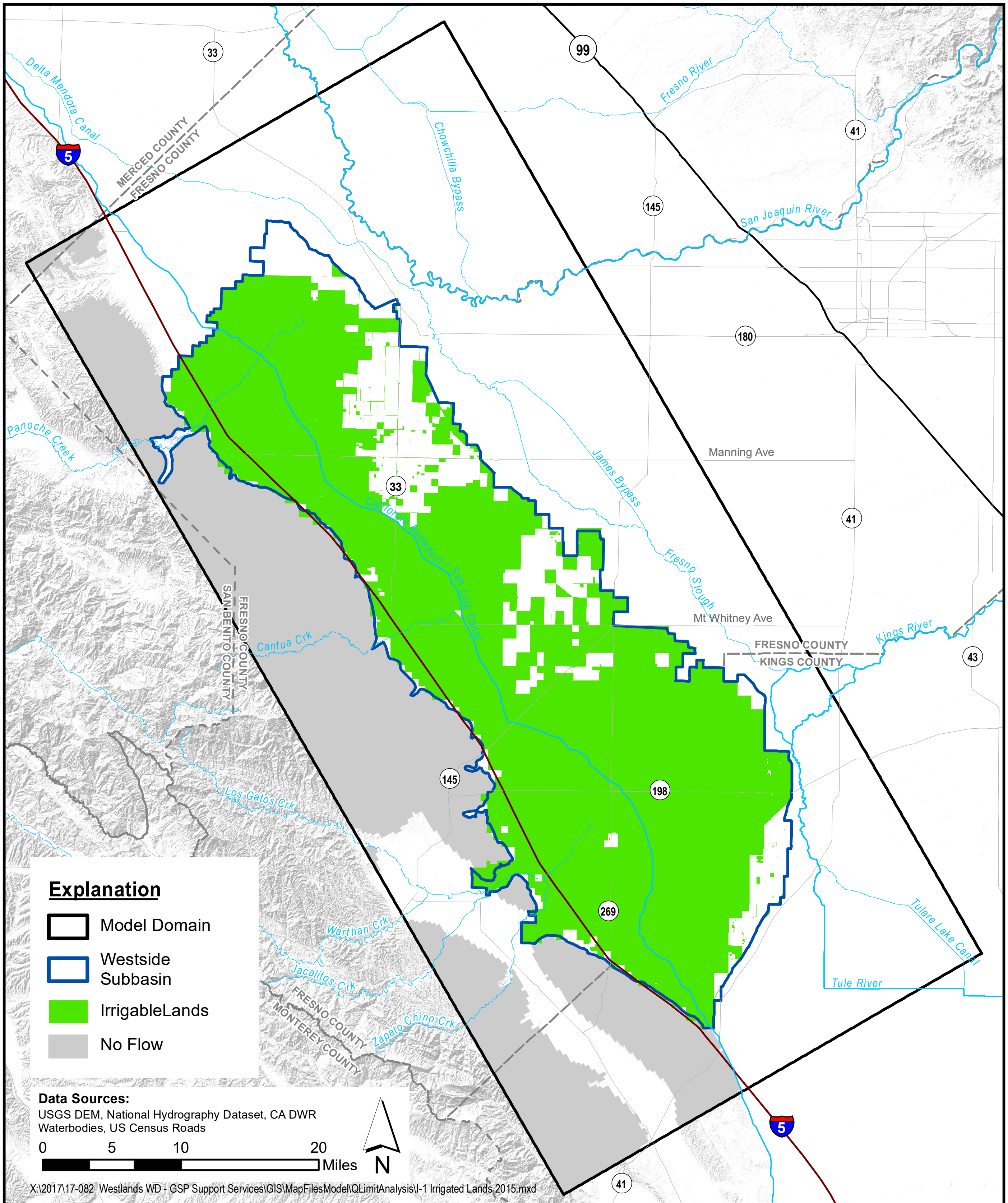
Simulated pumping in the calibrated model and Reduced Allocation Scenario are shown by MODFLOW Farm **Table I-1** and in aggregate in **Figure I-3**. The majority of pumping reductions were simulated in MODFLOW Farms 3, 6, 7, 8 and 9. With respect to the 67,000 AF reduction calculated from the measured data in 2015, the simulated amount of reduction in groundwater pumping in the Reduced Allocation Scenario was 62,000 AF (93%).

The simulated differences in water levels in the Upper and Lower Aquifers in the winter of 2015 are shown in **Figure I-4** and **Figure I-5**. The water level difference between the calibrated and Reduced Allocation Scenario are varied and also influenced by the transmissivity in each respective aquifer. Relative differences are generally correlated with MODFLOW Farms with reduced pumping.

The simulated difference in land surface subsidence in the Reduced Allocation Scenario are compared to the total simulated subsidence accrued from 2013 through 2015 in the calibrated groundwater model (**Figure I-6** and **Figure I-7**). The greatest relative difference in land surface subsidence in correlated with areas where the greatest amount of land subsidence was simulated in the southeastern portion of the Subbasin in the calibrated model (**Figure I-6**).

Table I-1: Simulated Reduction in Groundwater Pumping by Farm

Farm-ID	2013	2014	2015	2015 Target
1	0	0	0	0
2	0	0	0	2,000
3	1,000	8,000	6,000	6,000
4	0	0	0	1,000
5	1,000	6,000	5,000	6,000
6	5,000	19,000	17,000	17,000
7	2,000	9,000	8,000	7,000
8	7,000	27,000	18,000	18,000
9	6,000	12,000	9,000	10,000
10	0	0	0	0
Total	**22,000**	**81,000**	**62,000**	**67,000**



Irrigated Lands in the Westside Subbasin 2015

SGMA Sustainability Analyses
Westside Subbasin

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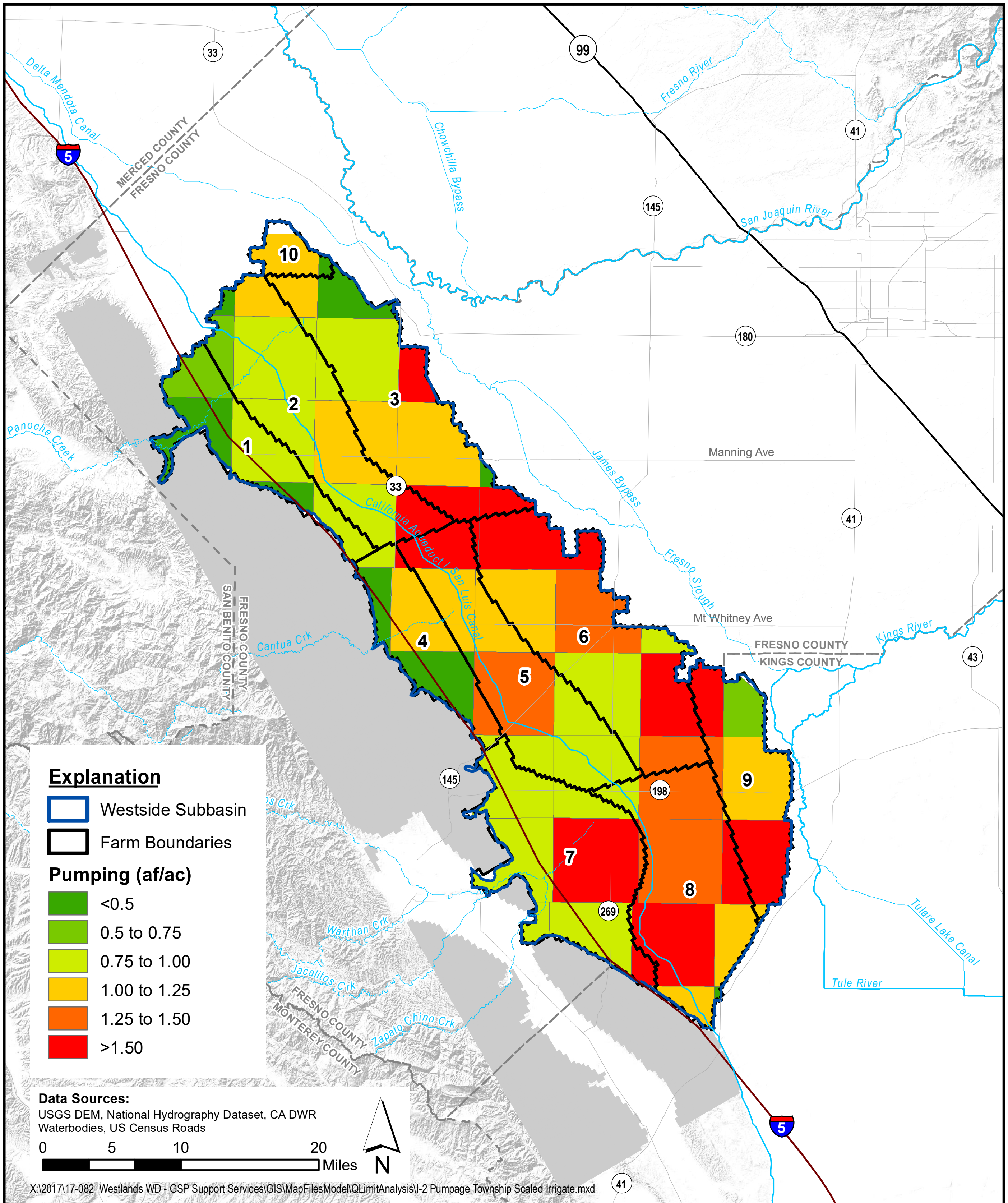
Figure I-1



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Pumpage by Irrigable Area Within Each Township
2015

Figure I-2

SGMA Sustainability Analyses
Westside Subbasin

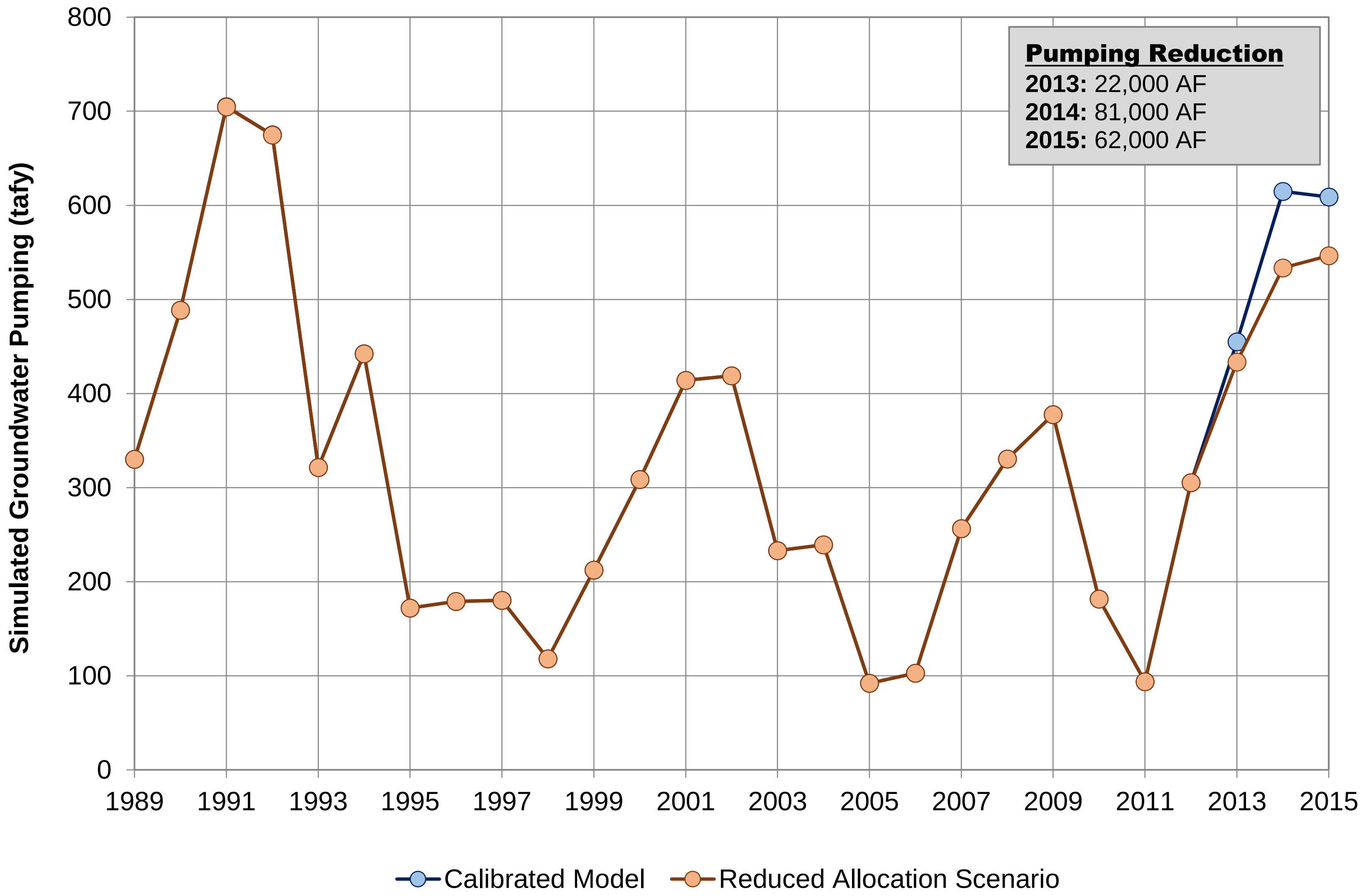

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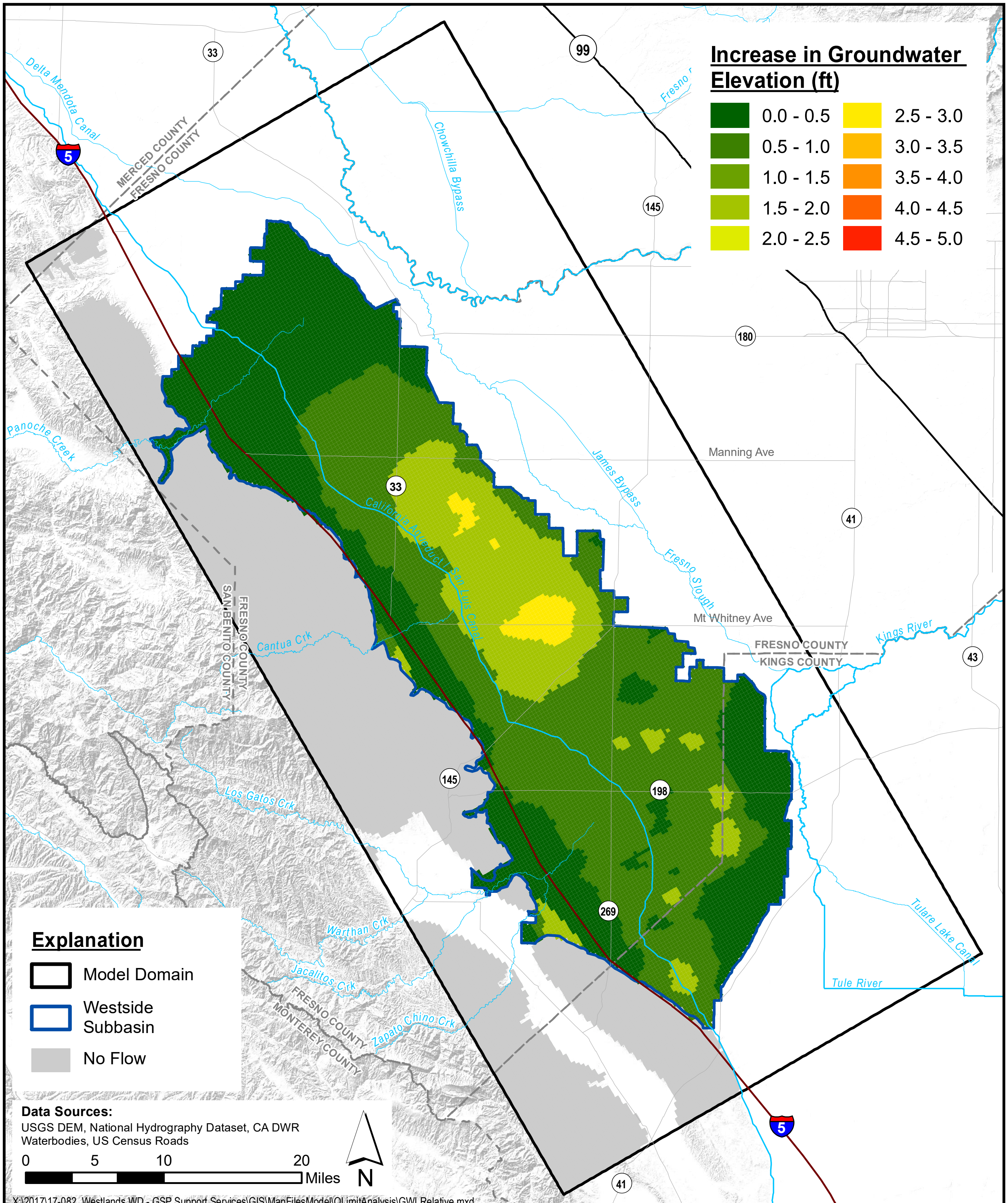
Figure I-3
Simulated Groundwater Pumping
Calibrated Groundwater Flow Model vs Reduced Allocation Scenario



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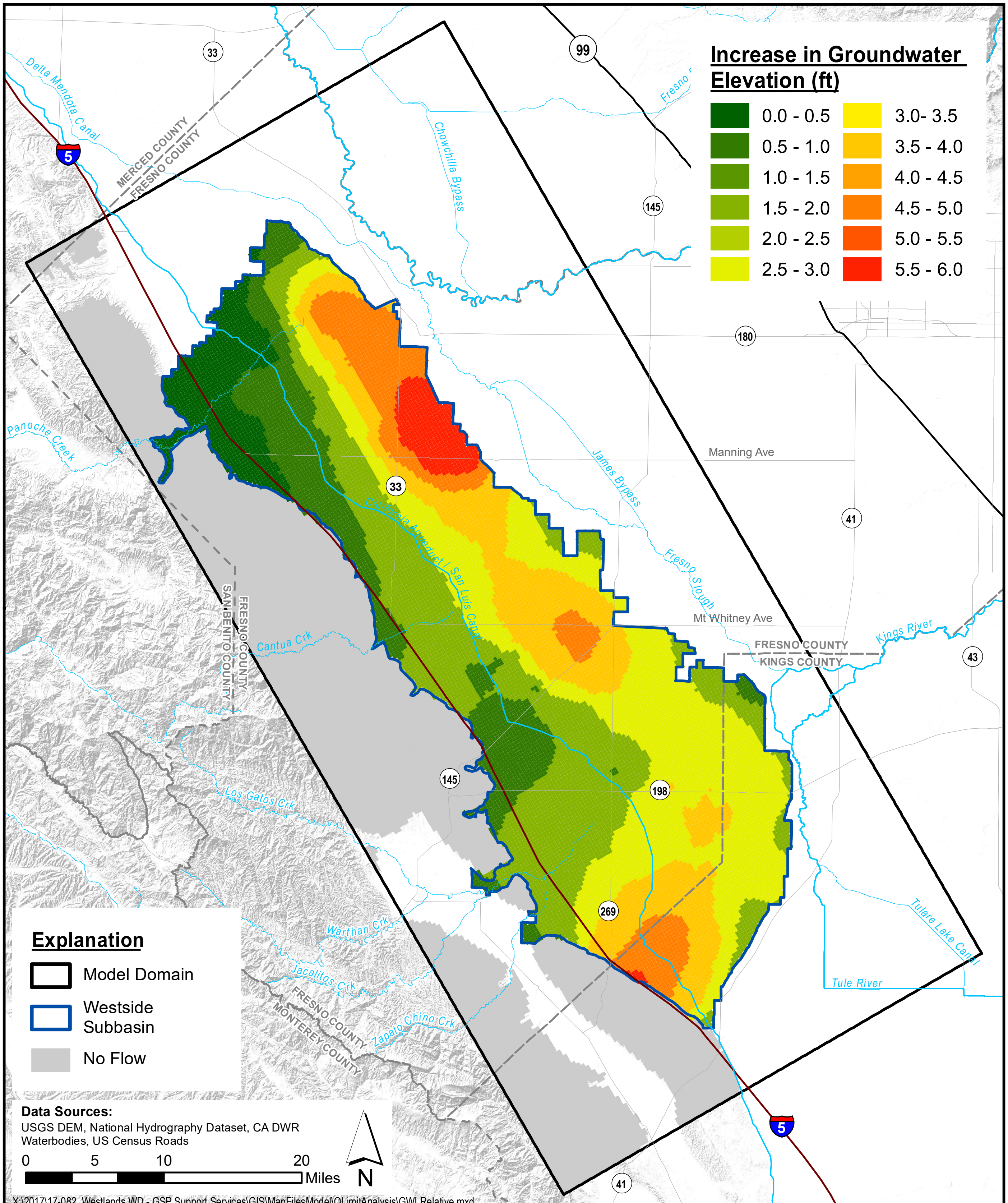
Relative Difference in Groundwater Elevation - Upper Aquifer January 2016

Figure I-4

SGMA Sustainability Analyses
Westside Subbasin



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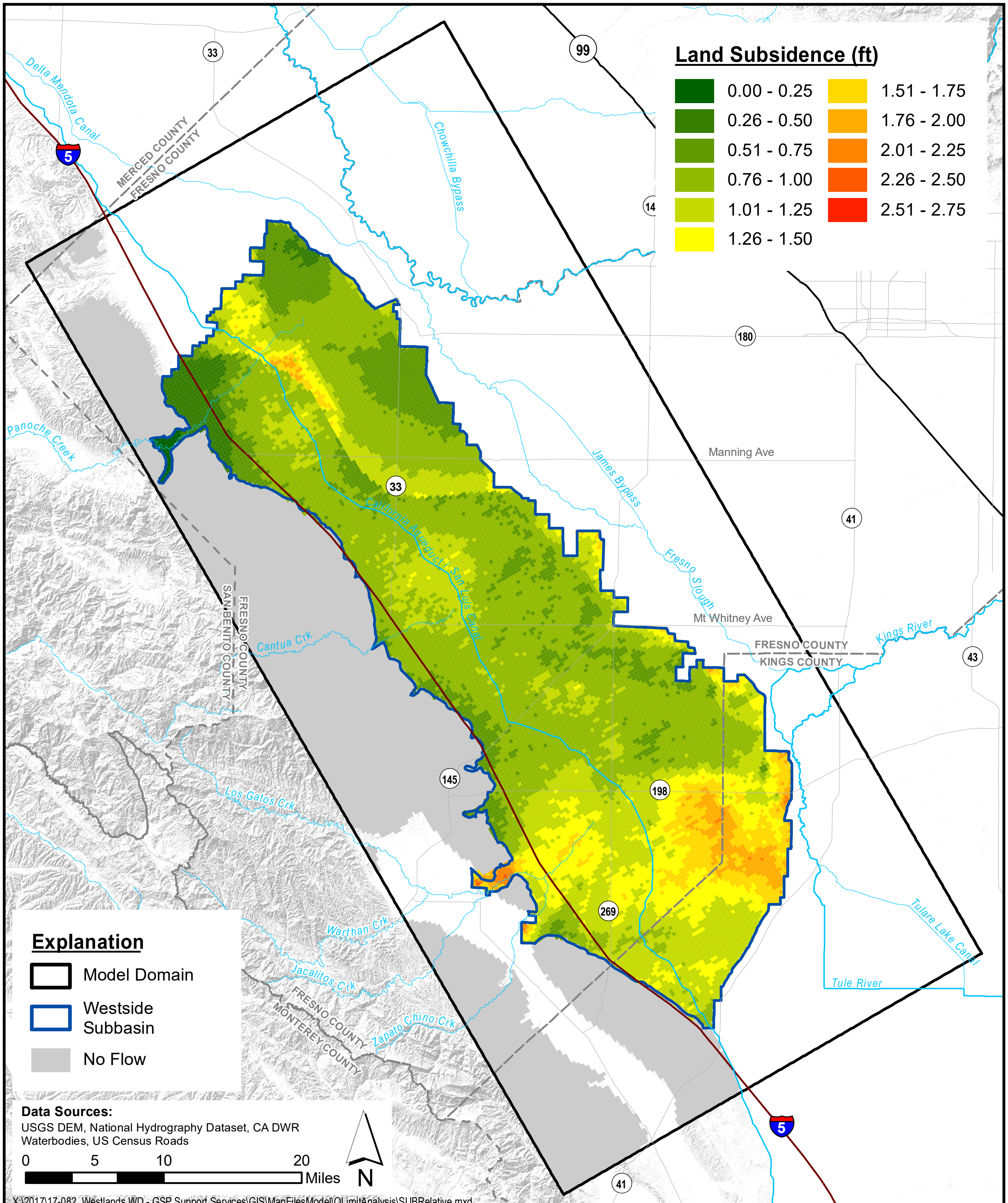
Relative Difference in Groundwater Elevation - Lower Aquifer
January 2016

Figure I-5

SGMA Sustainability Analyses
Westside Subbasin



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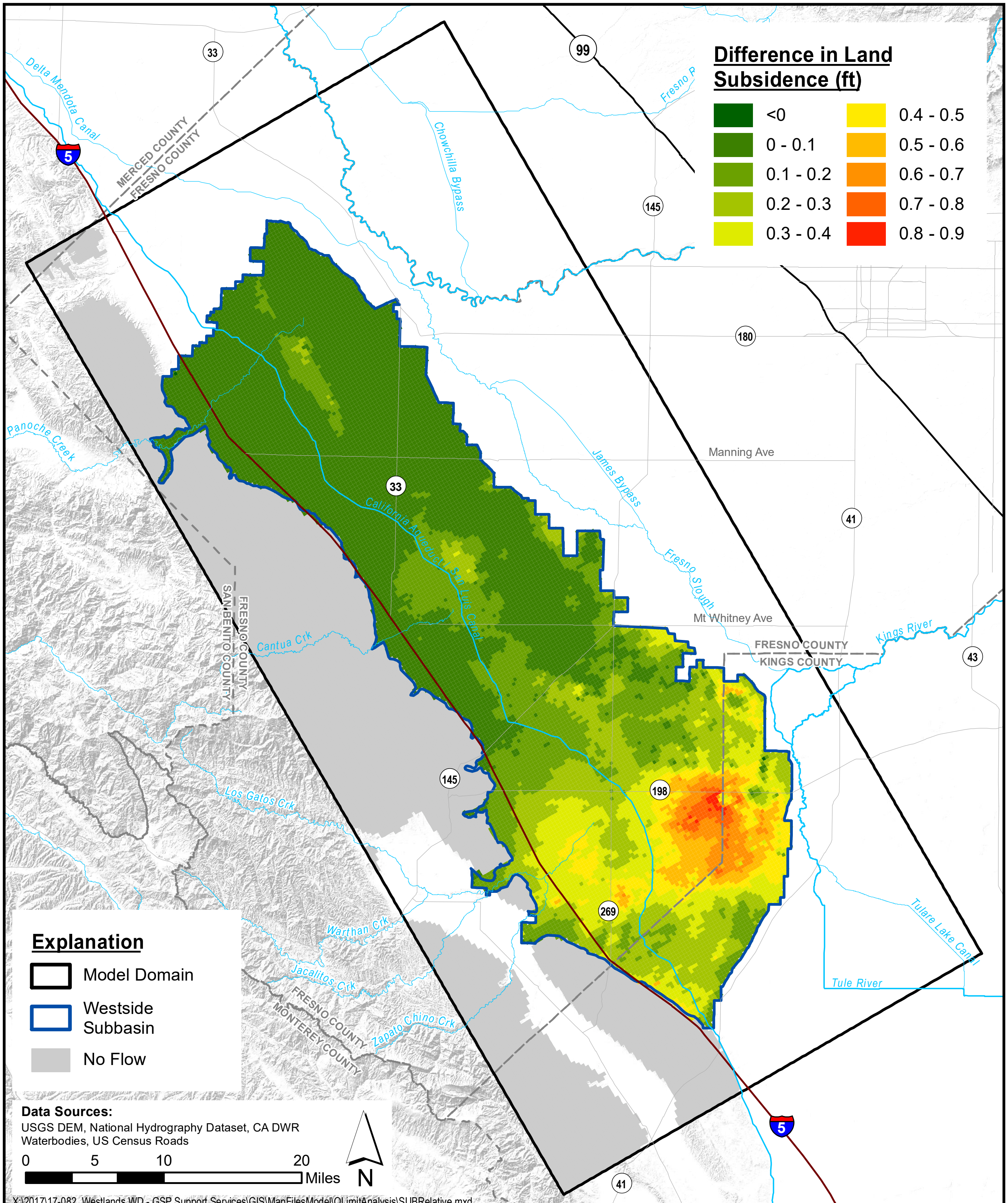
Land Surface Subsidence 2013 through 2015

SGMA Sustainability Analyses
Westside Subbasin

Figure I-6



Relative Difference in Land Surface Subsidence 2013 through 2015

SGMA Sustainability Analyses
Westside Subbasin

Figure I-7

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APPENDIX J

The Implications of Agricultural Water for the Central Valley

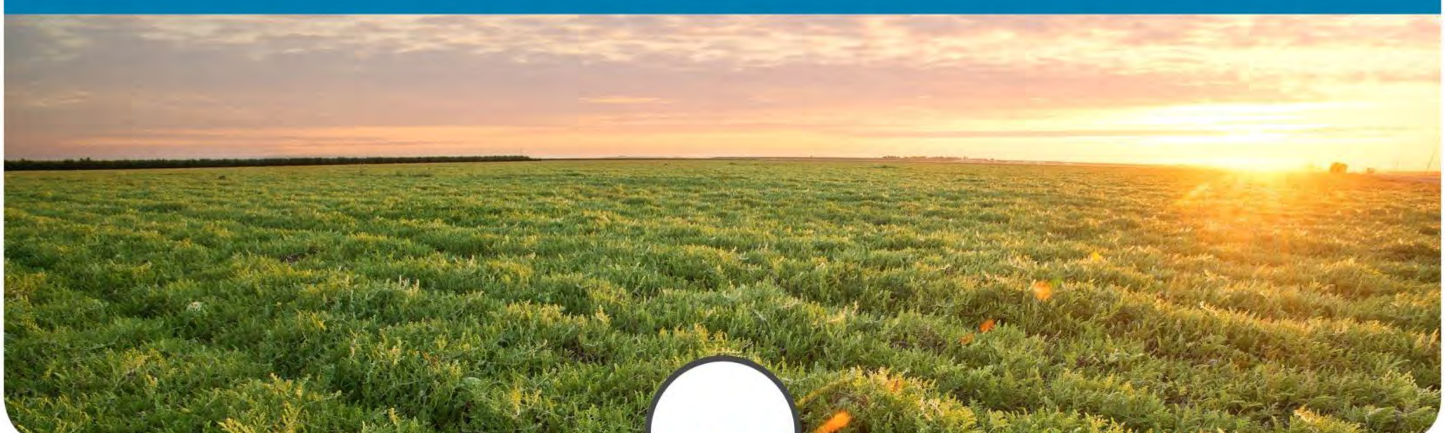
LSCE



The Implications of Agricultural Water for the Central Valley

September 6, 2017

Michael A. Shires, Ph.D.



Westlands Water District

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EXECUTIVE SUMMARY

This report is the companion report to last summer's publication *The Economic Impact of the Westlands Water District on the Local and Regional Economy*. That study had many important findings, including:

- Westlands Water District (WWD) directly accounts for nearly 29,000 jobs and $3.6 billion of economic activity.
- The state's continued failure to provide the contracted water levels has resulted in an 18 percent loss of economic output within the district;
- Economic pressures coupled with the prolonged shortfall in water availability have driven growers to shift to less labor-intensive crops;
- Westlands growers provide significant shares of the national supplies of many key fresh fruit, produce, and nuts; and
- Sustaining domestic production of fresh fruit, produce and nuts serve critical national priorities, including National security**,** environmental protection, worker protection, providing workers with reasonable wages**,** and using scarce water resources efficiently.

In this analysis, the research focuses on the implications to the local economy and communities of the agriculture-driven jobs that Westlands and other water districts in the region foster. Among its most important findings are:

- Consistent and ongoing provision of the full allocation of water to WWD would result in a 19.9 percent increase in employment and more than a 17 percent increase in economic output *from WWD alone.*
- Providing none of the allocation to the growers in the WWD (through either policy choices or a long-term drought) would result in an 80 to 86 percent decrease in both employment and economic output in the district. This would represent 25,000 to 27,000 jobs and more than $3.0 billion of economic output in the local economy.
- In the presence of a long-term water crisis in the region, the economic impacts for Fresno and Kings Counties would be major. Agriculture directly contributes to (conservatively) one in six jobs in Fresno County and one in five jobs in Kings County. It accounts for at least one-sixth of the economic output of Fresno County and nearly one-fourth of the economy in Kings County.
- For solar construction to replace this level of employment in the county, more than $6.24 billion dollars *a year* would have to be invested in new solar projects within the county's boundaries.
- Agriculture provides employment, income and opportunity to a wide range of workers in the region with extremely limited education and training. More than half of agricultural workers have less than a high school education and 95 percent have no college.
- Agriculture does provide a path for social mobility with opportunities to advance and earn significantly higher wages, even for these low skilled workers.

- Almost 90 percent of the workers who would be displaced by disruptions to the agricultural sector in the Central Valley are Hispanic.
- Communities that show success in attracting manufacturing have much better educated labor pools.
- The disappearance or significant reduction of agriculture as a major employer in the region, could have severe consequences for the local economy, including:
    - The loss of billions in public revenues;
    - Major migration from the region could turn local communities into ghost towns;
    - For those that remain behind, they would change from being net contributors to the local economy to recipients of public resources through the social safety net.

In its final section, the study identifies four action items needed to ensure that the region experiences more of the benefits that can be reaped from a vibrant agricultural sector in the region and to avoid the major challenges that would arise if it shrank significantly. These recommendations include:

- Devise a statewide plan for water and water policy in California;
- Expand storage capacities significantly and improve the state's ability to move water between systems and projects;
- Reprioritize the use of available water resources toward agriculture; and
- Expand the water resources available in the state through conservation, desalinization, and recycling.

Agricultural production is a national security asset—especially in today's uncertain global trade climate, it is essential to have a reliable and accessible domestic food supply. There are a limited number of places where the climate, soil and space overlap as they do in the California Central Valley to produce an ideal climate for agriculture.

Not surprisingly, California's irrigation technologies are increasingly among the best in the world. Add to that the state's stringent environmental regulations on the use of pesticides, worker protections, and food handling regulations, and the state's food supply is among the safest in the world.

Once the land that supports this critical national asset is dedicated to other purposes, and once the industrial infrastructure that supports the processing and distribution of these crops are gone, they are almost impossible to rebuild. All it takes is enough water to make it work—a problem that humans have been solving since the first patch of crops were planted in prehistoric times. With the technologies available, we should be able to solve it today.

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INTRODUCTION

This report is the second of a two-part series that examines the economic impacts of U.S. and California water policies on communities within the Central Valley, and especially those within the nation's largest water district—the Westlands Water District. The purpose of these studies is to provide an insight into unintended consequences of the ways that decisions by the state and federal water policy boards have affected those who live and work in and around this agriculturally-focused portion of the Central Valley.

The Central Valley, and especially the areas surrounding the Westlands Water District, are unique. There is nowhere else in the United States, and few places in the world, with the combination of arable and irrigable land, rich soils, relatively mild and stable climate, and long growing seasons that allows the production of climate-sensitive crops like vegetables, nuts, grapes, and other fruit. The region really is the nation's produce aisle—providing a significant fraction of the total national production of many of the items you would find in that section of most American supermarkets. For some crops, such as almonds, the area accounts for nearly all the crop produced globally.

The first study, which estimated the overall economic impact of the Westlands Water District, found that the district had a significant economic footprint. It directly accounts for nearly 29,000 jobs and $3.6 billion of economic activity. Some additional highlights of that study include:

- The state's continued failure to provide the contracted water levels has resulted in an 18 percent loss of economic output within the district;
- Economic pressures coupled with the prolonged shortfall in water availability have driven growers to shift to less labor-intensive crops;
- Westlands growers provide significant shares of the national supplies of many key fresh fruit, produce, and nuts; and
- Sustaining domestic production of fresh fruit, produce and nuts serve critical national priorities, including:
    - **National security:** domestic production of key foodstuffs is essential in a chaotic and shifting international policy landscape;
    - **Environmental protection:** Growers within the United States and California can be held to higher standards than those in foreign locations.
    - **Worker protection:** U.S. labor and occupational safety laws protect workers much better than those which govern production in countries from which the U.S. imports most of its fruit and produce;
    - **Worker wages:** U.S. and California minimum wage requirements provide a more livable and sustainable wage than those guiding production abroad; and
    - **Water efficiency:** Out of necessity, many California growers are among the best in making every drop of water they receive count. This means the most food produced per drop of water

used—minimizing the pressure on aquifers and surface water sources—and allowing them to be prioritized for other uses.

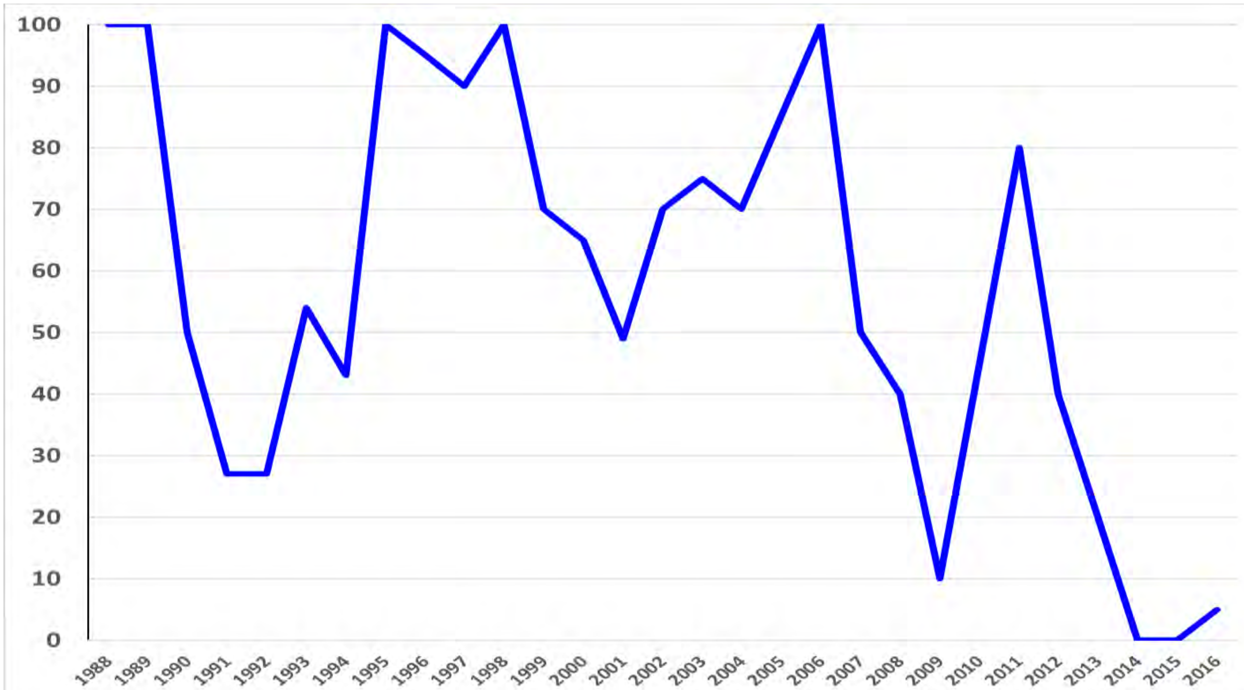
In this study, the analysis turns to the implications of agriculture's important role on the people, communities, and businesses that make up that local economy. To help understand the stakes in this dialogue, it will look at three sets of questions: (1) what role does agriculture play in the local economy? (2) how flexible is the local economy in responding to changes in this economic profile? and (3) what would the impact of such a shift be on local communities? In each instance, this analysis will focus on the dynamics of various policy proposals on agricultural production and what the impact of these changes would be on local communities. The analysis is intended to provide context and insight for the debates over resources and the local economic activity by highlighting the magnitude of these potential impacts and who would be affected by these implications.

The Economic Potential of Agriculture in the Region Is greater than the Present Output

In the last study, the economic footprint of the Westlands Water District, *as it exists*, was evaluated and estimated. But it is important to understand that that analysis looked at where the region was at the end of a five-year drought—a sustained period during which the region and Westlands received significantly less water than the amounts to which they were contractually entitled—in last few years receiving little or *none* of their contractually obligated allocation, as shown in Figure 1.[1]

[1] A portion of this lost water was offset by increased groundwater use. While this strategy was viable for this recent period, new laws will seriously constrain growers' ability to avail themselves in future droughts. As a result, future droughts will have a much more severe impact on the local economy and agriculture in particular.

Figure 1—Share of Contractual Water Allocations Received by Westlands Water District, 1988-2016



SOURCE: WWD data.

As a result, those estimates included an economic picture in which approximately 200,000 acres of arable farmland were fallowed, many crops that had been planted were not harvested, crops that were produced were impacted by the need to grow them with higher-cost, lower-quality pumped groundwater, and, for the crops that were produced, the reliance on higher-salinity groundwater suppressed yields and undermined profitability.

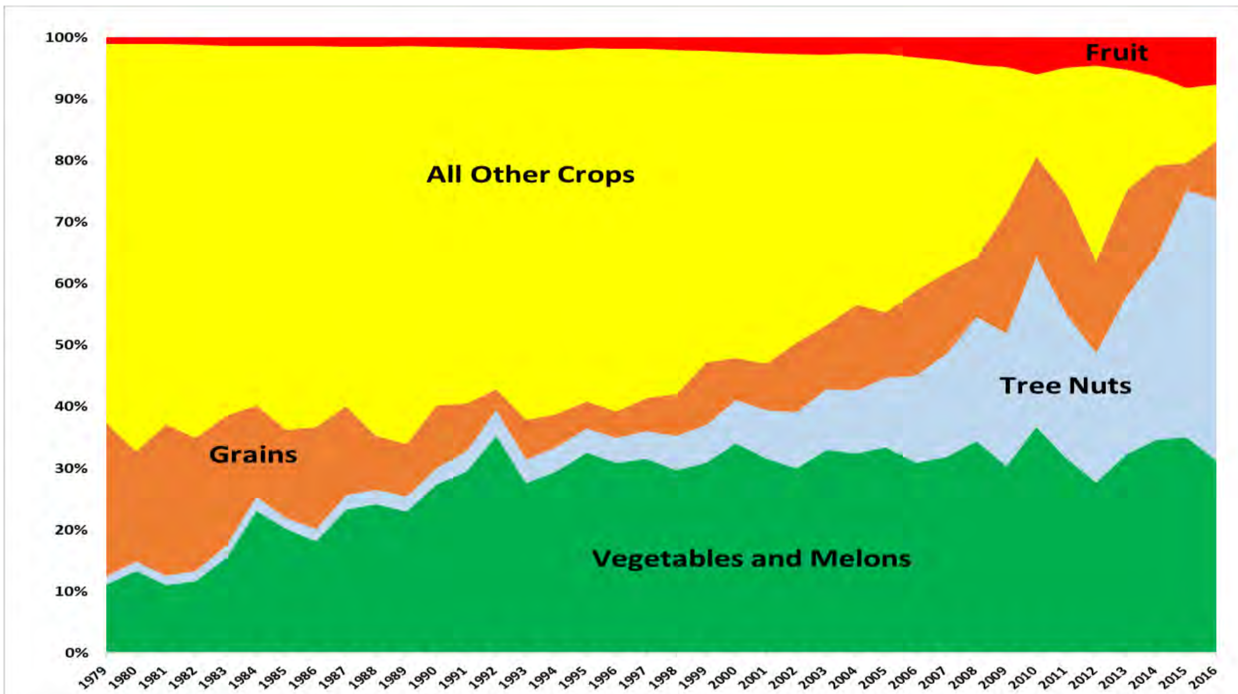
From a practical perspective, the economic impacts from the last study were on the low side of what the true economic potential of the Westlands Water District and agriculture overall in the Central Valley could be. If complete access to water were possible, the economic impact could be even greater. To estimate the magnitude of this impact, this analysis revisited the core components of last year's study and assessed the difference between where WWD is today and where it could be if the full contracted allocation of water were delivered to the district for a sustained period of time.[2] This effectively

[2] The model estimated the acreage that would lie fallow in a normal year and netted that amount from current levels of fallowed acreage to identify the number of acres available to be brought into production. The model first assumed that the permanent crop acreages would not decline in the first year, but might see mild growth consistent with long-term historical averages. After deducting the amount from the available acreage, the balance of available acreage was pro-rated across categories using the dynamic profile from 2011, when the District received 80 percent of its water allocation. This equilibrium was then aged 10 years using long-term District crop acreage trends to grow each crop sector. These acreages were then multiplied by 2016 crop yields and prices to estimate the change in economic output that would arise from receiving a full water allocation. Note that this iteration of the modelling is using the most current data available from the 2016 growing season, so not all computations relative to the base will correspond with the exact totals in the first report. However, the directions and general magnitudes of the changes are comparable.

simulates a scenario where agricultural users in Westlands would receive their full allocation of water, something that has not happened consistently since the 1970s and 1980s.

However, that water would be flowing into a very different agricultural context. Today agricultural water users within the district are much more efficient in the ways they use the water received. Essentially all crops are drip irrigated in the Westlands Water District. Additionally, these same farmers have transitioned from grasses and cotton crops to a larger portfolio of fruits, vegetables, and permanent crops[3] like nut trees, fruit trees, and grape vines. Consequently, the likely portfolio of crops that would be produced from this water flow would likely look quite different from that produced in the 1970s and 1980s. Figure 2 compares the acreage in various crop types over the years.

Figure 2—Distribution Acres Planted Across Crop Categories, Westlands Water District Growers, 1979 – 2016



SOURCE: WWD data.

As this figure shows, the sustained periods of restricted water availability have caused farmers to shift production away from the grasses, hays, and cotton and to higher margin crops like tomatoes, almonds, grapes, pistachios, lettuce and fruit. With today's crop profile as a starting point, it is unlikely that the

[3] "Permanent crops" for the purposes of this discussion are those crops for which the producing stock remain from year to year—usually in the form of a tree or vine. In most instances, these crops require several years of care and growth before yields reach commercially usable and profitable levels. When these crops are allowed to die, it requires years to replace them.

acreage committed to permanent crops like those in the Tree Nut and Fruit categories will suddenly be converted to other purposes.

Estimating what farmers would do with such a bounty of water is a complex process. The specific crop decisions by farmers in each year are generally based on expected production costs such as plantings/seeds, fertilizers, equipment, and other inputs (including the cost and availability of both water and labor), the expected market price, and the riskiness and timing of the crops. They must factor in the state of the soil and the weather as well. Farmers must make educated guesses about each of these parameters and then be right enough on all of them to be able to make enough of a profit to invest in the equipment, seed, and other resources in the next year.

Additionally, the decision process is dynamic. Initial decisions would reflect the major uncertainties about water availability seen in the past several years. As a result, there would be slow initial movement and much of the additional acreage would likely be put into crops that could easily be fallowed in subsequent years. If the state were to develop a reliable, consistent plan for water management that guaranteed these farmers a reliable flow of water, however, the market would eventually move them to portfolio of crops that made the best economic use of the land and water available.

To model these effects, the study examined the historical patterns of planting in the district under a range of scenarios. All models started with 2016 as the base. The analysis then built a crop profile estimating what farmers would do in the immediate term with full access to water and aged those decisions over time to estimate a longer-term equilibrium. These planting decisions were then valued using the most recent crop data available to estimate an overall economic impact. That impact was subsequently inserted into the IMPLAN economic model to estimate the overall economic impacts of this level of farming activity on the local economy. The net results of those models are presented in Figure 3.

Figure 3—Potential Marginal Increases in Economic Activity Associated with Full Availability of Contracted Water Allocation, Westlands Water District

Effect of Full Water on:	Units of Impact		Percent Increase Relative to Base
Planted Acreage	116,387	acres	29.7%
Employment	5,112.9	jobs	19.9%
Overall Output	561,330,491		17.3%

SOURCE: This analysis and Implan.

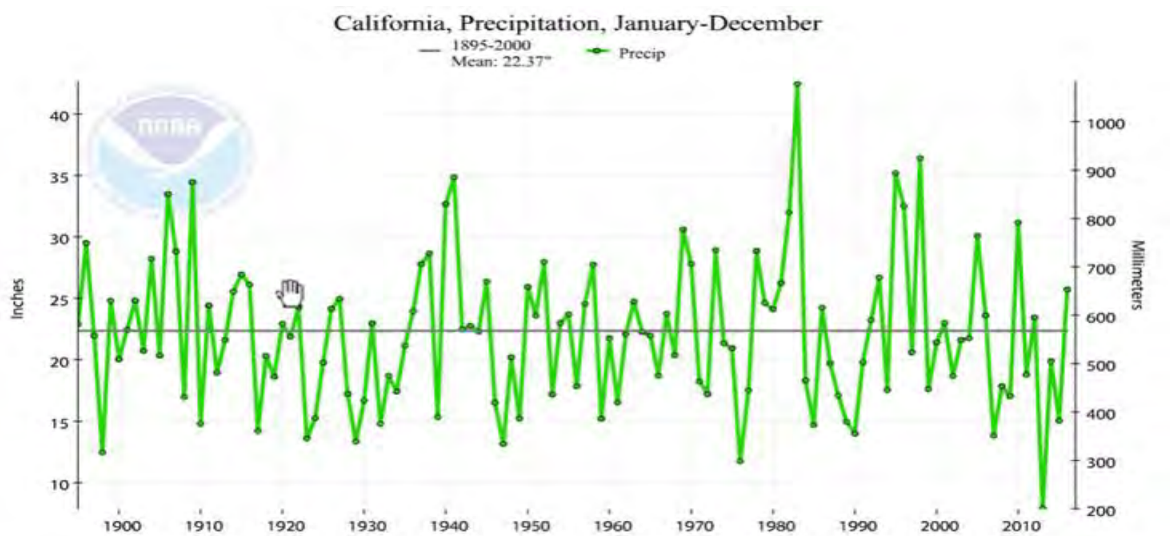
It is estimated that the potential increase from this additional water availability could result in the planting of more than 100,000 additional acres, increase agricultural-related employment by nearly 20 percent and produce an increase in overall employment of about 20 percent or more than 5,000 jobs. Economically, this would result in an increase of $561 million in economic output generated by WWD-related activities, an increase of 17.3 percent. If all Fresno County agriculture were to experience the same output increases as the Westlands Water District from widely available water, this could represent an increase of nearly 15,000 new jobs and $1.6 billion dollars of economic activity.[4]

A Protracted Absence of Water Would Devastate the Local Economy

Another way to understand the economic impact of water policy is to imagine a world where the drought did not end, but rather continued for a protracted period. What would the economic impact be if Westlands Water District received essentially none of the contracted allocations of water for a significant period of time?

While this scenario seems unlikely, remember that the recent drought was only five years. In that relatively short time window, the district received almost none of its allocation three out of the five years of the drought (see Figure 1). Even in the best of those years, the District received only 40 percent of its contracted allocation.

Figure 4—Average Annual California Precipitation, 1895 - 2016



SOURCE: National Oceanographic and Atmospheric Administration, National Centers for Environmental Information, Annual Precipitation Statewide, California 1895 – 2016.

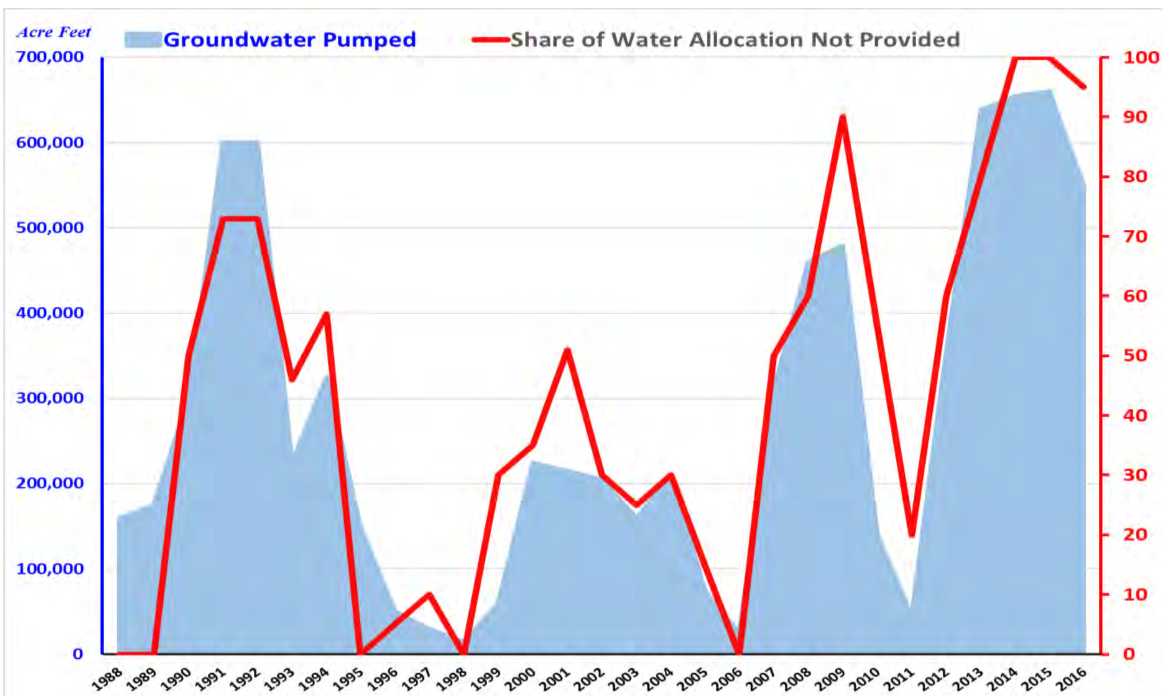
A five-year drought is relatively short from a climatological perspective. Many climate scientists see the 20th century as a relatively wet period in the hydrologic history of California. Even in this relatively wet period, the precipitation cycles have been highly variable as shown in Figure 4. There is evidence from a range of sources that droughts have lasted decades and, in some instances, perhaps even hundreds of years (Stine, 1994, for example). One California drought is estimated to have lasted 240 years. While

[4] The study team recognizes that not all agriculture in Fresno County will have the same experiences as Westlands Water District. These are included for comparative purposes.

planning for such a “megadrought” is beyond the scope of this analysis, it is reasonable to anticipate a drought that could last for a decade or more. In such a world, agricultural output would be much more severely constrained, limited to only what is sustainable through groundwater pumping. If the drought were to continue long enough, agriculture as a meaningful contributor to the local economy could wane and possibly even disappear entirely.

To estimate what a protracted drought would look like economically, the team examined prospective planting scenarios in a world where the district and its growers were limited to only the groundwater that they could pump. In response to the last few years when the state and federal governments did not provide their contracted water allocations, water users in the district dramatically increased their groundwater pumping as see in Figure 5.

Figure 5—Share of Water Allocation Missing and Groundwater Pumped, Westlands Water District, 1988 – 2016



SOURCE: WWD data.

Looking ahead, however, to a future protracted drought, this strategy would be constrained by state law. In September 2014, Governor Brown signed into law the “Sustainable Groundwater Management Act.” This law requires local districts to develop a plan that limits pumping of ground water to proscribed, sustainable levels. The legislation also provides enforcement authority to the State Water

Resources Control Board.[5] As a result, in the next drought, local growers will be limited to a specific level of groundwater pumping that is intended to be sustainable for the aquifer in the long-term and that level is significantly below the levels seen over the past couple years. In WWD's case, their groundwater management plan points to a sustainable groundwater pumping capacity of approximately 225,000 acre-feet.

What would happen to agriculture in such a severely constrained water environment? First, fallowing would surge dramatically—some growers would simply go out of business. In such a drought scenario, it is highly unlikely that other districts would have spare water to sell to WWD growers because they too would be experiencing the drought, so WWD growers would be self-dependent and limited by the 200,000 acre-feet available.

With such a severe drought, prices for all produce, fruit, and farm products would likely spike. Growers would make the inverse of the high-water scenario above. Considering market prices,[6] available water quantities and costs, expected weather patterns, and local infrastructure, they would choose the crops with the very highest returns. In this past drought cycle, this process seemed to favor permanent crops like almonds, pistachios, tree fruit and grapes. But it is also possible that, if the scale and scope of the drought[7] were broad enough, it would drive all prices up roughly comparably and growers would simply turn to a portfolio of crops that roughly resembles what they have produced the past few years. Thus, the team modeled two versions of the low availability scenarios: one where all production shifted to permanent crops wherein historically growers have found some of the highest commercial returns and a second scenario that simply reduced production proportionally (using the ratio of expected groundwater to be available[8] to total water available in 2016) across the board using the 2016 crop acreage profile.[9] The results are presented in Figure 6.

[5] Local Groundwater Sustainability Agencies (GSAs), like the Westlands Water District, will set these levels through the development of a Groundwater Sustainability Plan (GSP). After appropriate public comment and input, the district will adopt the GSP and be responsible for enforcing it.

[6] It is not possible to anticipate fully how broad the drought would be regionally and globally, so it is not possible to estimate the extent to which foreign supplies might offset lost local production.

[7] While this discussion is set in the backdrop of a drought, the decision to divert water away from agriculture for other purposes could be the result of other drivers. In 2016, for example, policymakers chose not to send water to agricultural users even though the state was experiencing significant precipitation at the time.

[8] While the plan has yet to be finalized, this analysis assumes a limit of 200,000 acre feet of water per year from groundwater throughout the protracted drought scenarios.

[9] In the first scenario, the water available is committed to nut trees only by dividing the number of acre feet available by a conservative estimate of the amount of water necessary to sustain them (3.0 acre feet per acre) to estimate the number of acres in production. In the second scenario, the levels of water are estimated for each category of source using historical minimal levels for non-allocation sources, 200,000 acre feet for groundwater, and 0 acre feet from the District's allocation. This total is divided by actual 2016 acre feet available to create a ratio (just under .25) which is used to prorate the acreage in each 2016 crop category. Both acreage estimates are then converted to crop values using the 2016 crop yield and price values which are in turn inserted into the IMPLAN Economic Modeling System to estimate their full impacts.

Figure 6—Simulated Economic Changes of Protracted Drought Relative to Full Water Scenario, Westlands Water District*

	Permanent Crops Only			Reduced Water - All Crops		
Planted Acreage	(441,066)	acres	-86.9%	(410,867)	acres	-80.9%
Agricultural Employment	-26,855.4	jobs	-87.1%	-24,583.7	jobs	-79.8%
Overall Economic Output	-3,275,533,018		-86.2%	-3,009,719,009		-79.2%

SOURCE: This analysis and Implan. NOTE: * - Percentages are the percentage change in the overall economic impact of the Westlands Water District. This means that the Protracted Drought Scenario would reduce the employment fostered by the District's activities by 87.1 percent if growers elected to focus on permanent crops.

A sustained reduction in water would have a profound impact on the economic footprint of the Westlands Water District and its communities—as well as the greater Fresno region of the Central Valley. With such a severe reduction in available water, the acreage planted, agricultural employment and economic activity associated with agriculture would fall by at least 80 percent and even more if growers elected to try to preserve their long-term investment in their permanent crop base by concentrating their scarce water supplies there.

If these scenarios were replicated in districts and communities across the Central Valley, the impacts to the local economy would be devastating. The next section examines this broader role for agriculture in the regional economy.

AGRICULTURE PLAYS A CENTRAL ROLE IN THE LOCAL ECONOMY

The question of the value of water invested in agriculture in the Central Valley can be measured in the lives of its residents and the vibrancy of the region's economy. In a location that is physically remote from other urban concentrations, the local economy is quite heavily dependent on agriculture. Fresno City Hall, for example, is some 160 miles from San Francisco City Hall and 200 miles from Los Angeles City Hall. Even the outlying transportation hubs in Stockton to the north and Bakersfield/Tehachapi to the south are more than a hundred miles away.

Economically, agriculture is one of the primary economic drivers of the region and, along with tourism, one of the primary sources of export-oriented economic activity. Export-oriented goods, in contract to locally-oriented goods and services, are desirable for a local community because they draw sales, capital, and wealth from other regions of the world into the local economy. Locally-oriented business activities, such as retail sales, government, and health services tend to draw the monies spent in the local region from local residents—thus redistributing the same dollars within the community but not really creating new wealth. When goods and services are produced which are purchased from individuals and firms outside the immediate community, new monies are brought into the region from those outside sources, and average wealth increases—often producing higher wages and increasing economic productivity and the overall quality of life for residents.

Because of the unique climate and soil in the region, agriculture can flourish. The growing conditions are so ideal that, in many instances, multiple crops can be harvested on the same parcel in a single year. As a result, agriculture is a dominant sector in the region, outstripped by only the education and health sector and government, as seen in Figure 7. Agriculture directly accounts for one in eight jobs in Fresno County (approximately 50,000 jobs) and 7,500 or one in six in Kings County.

Figure 7—Average Annual Employment by Industry, Fresno and Kings Counties, 2016

	Fresno County		Kings County	
Sector	Employment	Percent	Employment	Percent
Farming	47,000	12%	7,200	16%
Mining, Logging, & Construction	16,200	4%	900	2%
Manufacturing	25,100	7%	4,900	11%
Wholesale Trade	14,400	4%	600	1%
Retail Trade	38,700	10%	4,300	9%
Transportation, Warehousing & Utilities	12,700	3%	1,100	2%
Information	3,800	1%	200	0%
Financial Activities	13,300	3%	900	2%
Professional & Business Services	31,900	8%	1,300	3%
Educational & Health Services	64,200	17%	5,900	13%
Leisure & Hospitality	32,200	8%	3,300	7%
Other Services	11,900	3%	700	2%
Government	71,100	19%	14,600	32%
Total All Industries	**382,500**	**100%**	**45,900**	**100%**

SOURCE: Employment Development Department (EDD), Labor Market Information (LMI).

But these are only the jobs directly identified as being on an actual farm. Far beyond this impact is the dramatic infrastructure that provides equipment, resources, manpower, and services to this sector. To get a sense of this scale, the IMPLAN Software for economic analysis was used to get a measure of the indirect roles that agriculture plays in the Fresno and Kings County economies. This technology uses large, sophisticated economic input-out models to identify the interactions and interdependencies between sectors in the economy. In this scenario, the question was asked, "What would the economic impact be of eliminating all agricultural production in each county?"[10] This estimated loss represents the model's estimate of the sector's overall impact on the county economy. The results are presented in Figure 8.[11]

[10] The models were built separately for each county and the production for sectors 1-10 and 19 were first eliminated providing the results listed under "Share Related to Crops" in Figure 8. The analysis was then repeated eliminating production for sectors 1-15 and 19 in the model, representing the elimination of livestock-based agriculture in each county.

[11] Because of the ways the model is calibrated, the shares are the most important metric.

Figure 8—Estimated Economic Impact of Agricultural Sector, Fresno and Kings Counties, 2014 Base Year

	Fresno County		Kings County	
Employment	**Totals**	**Percent of Total County Employment**	**Totals**	**Percent of Total Employment**
Share Related to Crops	74,908	15.9%	9,075	15.6%
Share Related to Other Ag	5,117	1.1%	3,800	6.5%
Total Agricultural Job Impact	**80,025**	**17.0%**	**12,875**	**22.1%**
Economic Output (*$1,000*)	**Totals**	**Percent of Total Economic Output**	**Totals**	**Percent of Total Economic Output**
Share Related to Crops	9,436,403	13.3%	1,592,485	12.0%
Share Related to Other Ag	1,690,293	2.4%	1,498,960	11.4%
Total Agricultural Output Impact	**11,126,696**	**15.7%**	**3,091,445**	**23.4%**

SOURCE: IMPLAN Economic Impact Analysis System.

As this table shows, the full impact of these jobs is much higher simply than the direct jobs in the agricultural sector. For Fresno County, the impact rises by more than a third from 12 percent of employment to 17 percent of employment. In Kings County, the shares are even higher, rising from 16 percent to 22 percent of employment. In terms of economic activity, nearly one-sixth of Fresno County economy activity and almost one-fourth of Kings County economic activity are tied to agriculture, according to these widely-accepted models.

But in fact, these estimates likely underestimate the overall economic importance of agriculture. They are best calibrated at the margins, estimating the impacts of smaller changes around near the averages of the data upon which they are constructed. To fundamentally erase a huge component of those models would likely affect the underlying coefficients upon which these models are built. In other words, it is likely that they underestimate the full impact of the agricultural sector's importance to the local economy. There is a tipping point where, with enough economic activity curtailed, other major sectors of the economy—things like retail trade, construction, and professional and business services—cross a critical threshold and a wave of firm failures start to emerge.

In metro areas where major industry realignments have occurred—Los Angeles aerospace in the 1990s, steel in Pittsburgh in the 1970s and 1980s, and the automotive industry in Detroit in the 1990s, this phenomenon has been observed. If, in fact, Fresno and Kings Counties were to see a realignment in the local economy that resulted in an 80 percent decline in agricultural employment, the overall impact would more than double the unemployment rate to almost 21 percent (80 percent of the direct farm jobs in Figure 8 alone would raise the unemployment rate to 17.8 percent). In Kings County, the direct jobs impact alone would result in a more than doubling the unemployment rate from 10 percent in 2016 to over 23 percent.

In the next section of this study, the analysis will focus on whether the economy would easily replace the jobs that would be lost in this scenario or whether it would likely be to the region's economic detriment.

How Responsive Could the Local Economy be to a Shift Away From Agriculture?

The question that arises from discussions around the prospect of stripping the Central Valley of its agricultural production is whether those jobs could and would be easily replaced with other new economic opportunities for the displaced workers. One of the keys to the recovery of Los Angeles after the aerospace drawdown of 1992-1994 was the ability of the local economy, in the medium term, to replace some of those jobs. While many middle-class workers did migrate to other regions of the country to pursue new economic opportunities in less impacted labor markets, many others found new employment in other sectors of the economy—especially finance and professional and business services.

Similarly, if workers and employees in Fresno County could find new local work to replace the income they lost when their farm jobs disappeared, then the prospective economic impacts could be relatively neutral. In fact, an argument offered by some is that the new "green" economy is in fact creating thousands of jobs in the Central Valley and thus concerns about disappearing agricultural jobs are not as important. In January 2017, the nonprofit Next 10 published a report entitled *The Economic Impacts of California's Major Climate Programs on the San Joaquin Valley: An Analysis through 2015 and Projections through 2030*. Their analysis found that the eight-county region[12] in the San Joaquin Valley would see 115,900 new jobs because of the state's various green initiatives. These jobs were spread across the fourteen years of the study's time horizon. Figure 9 summarizes the results of that study-adding a provision that spreads the results of the tables out over the time horizon of the study to provide annual estimates of the jobs created. It is crucial to remember that this is across the *eight counties* and that even the regional annual total of almost 8,776 jobs would be an inconsequential offset to the 92,000+ annual jobs lost with a serious shift away from agriculture.

[12] The study included the Fresno, Madera, Merced, Kern, Kings, San Joaquin, Stanislaus, and Tulare Counties—a region of the state encompassing 11 percent of the state population.

Figure 9—New Jobs Created by California Climate Programs in the San Joaquin Valley through 2030

Source of Jobs	Direct Jobs	Total Jobs	Years	Annual Direct Jobs	Annual Total Jobs
Cap and Trade	3,000	10,500	14	214	750
Renewables Portfolio Standard	31,000	88,000	14	2,214	6,286
Energy Efficiency	6,700	17,400	10	670	1,740
Total Jobs Identified	**40,700**	**115,900**		**3,099**	**8,776**

SOURCE: B. Jones *et. al.*, *The Economic Impacts of California's Major Climate Programs on the San Joaquin Valley: An Analysis through 2015 and Projections through 2030*, January 2017, 82 pp.

Layer on top of that the uncertainty around some of the spending included in their estimates. For example, the major part of the "Cap and Trade" expenditures are for the state's high-speed rail proposal. While progress continues *very slowly* on this project, it is heavily dependent on federal dollars for completion—a rather dim prospect for at least the near term.

Additionally, almost all the direct jobs under all three categories are one-time investments which, for the most part, do not create significant, on-going employment opportunities in the longer term. The "Renewable Portfolio Standard" jobs are largely for solar panel construction and the "Energy Efficiency" jobs are largely construction jobs for improvements to existing and new structures. Nearly all of the 3,100 new "green" direct jobs identified in the study would mostly be during the initial construction. Given that many of the large contracting firms engaged on these projects are located largely outside the Central Valley, the long-term contributions of these positions to the local economy may be notional at best.

For some activists, however, there is a vision of converting green fields of crops to dark fields of solar arrays—each panel putting out green energy to help the state meet its goals for renewable electricity generation. Even *National Geographic* featured an article about how solar energy may be "California's next cash crop."[13] But how would this play out economically for workers in the region? Each $10 million invested in solar electricity construction would produce roughly 70 jobs for the roughly one year of actual construction.[14] On-going maintenance has a negligible impact on employment and the revenues generated from the sale of the electricity would accrue to the owners of the land. For local owners, some fraction of these sales would likely re-enter the local economy. But for owners who reside outside the region, this wealth would be diverted out of the local economy. (See the 2003 paper by Stephen Piper[15] for an in-depth treatment of this issue). To replace the loss of 43,000+ farm jobs each year, the

[13] Christina Nunez, "Could Solar Energy Be California's Next Cash Crop?" *National Geographic*, October 30, 2015, http://news.nationalgeographic.com/energy/2015/10/151030-farmland-agriculture-solar-energy-conversion/, accessed June 2017.

[14] This estimate was generated through the IMPLAN models using Fresno County as the base geography.

[15] Stephen Piper, "Estimating the regional economic impacts of retiring agricultural land: methodology and an application in California," *Impact Assessment and Project Appraisal*, December 2003, pp. 293-303.

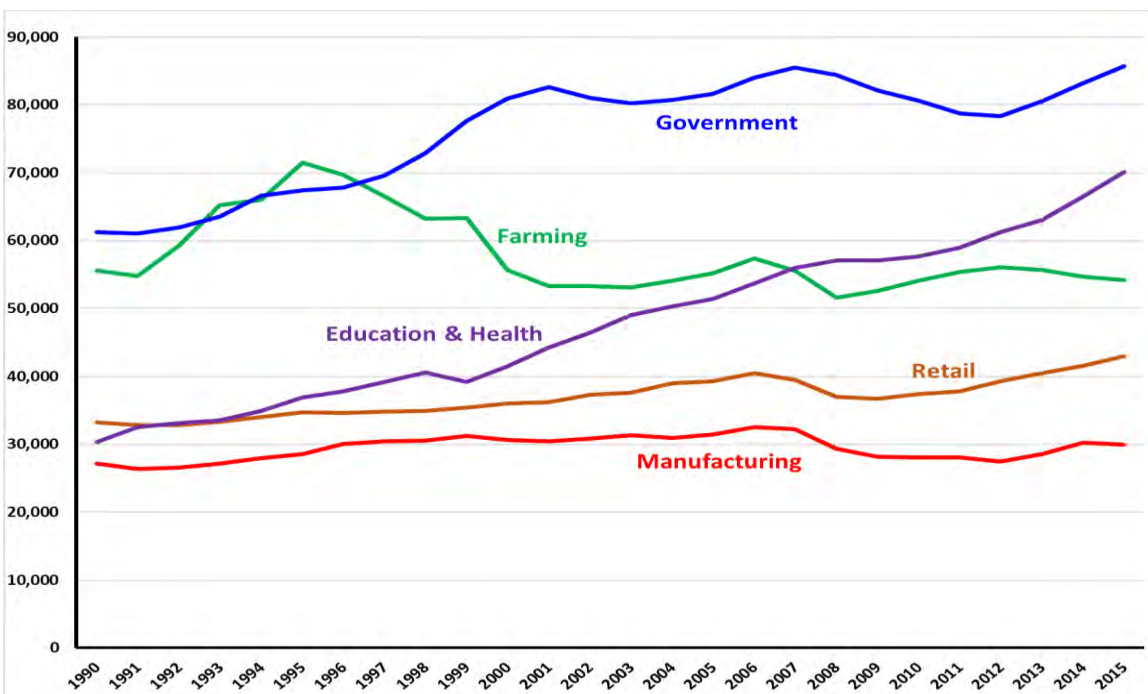
total solar investment would have to total $6.24 billion *annually* indefinitely into the future—a highly unlikely prospect.

If solar and the green jobs from building the high-speed rail project are not the answer to the region's employment needs, what could be the answer to employing the workers likely to become unemployed if agriculture disappears. The next section looks in depth at this question.

IF NOT AGRICULTURE, AND NOT CONSTRUCTION, THEN WHAT?

Farming has historically been the largest non-governmental sector in the Fresno and Kings Counties, as seen in Figure 10, although a surge in early childhood and health care employment has caused Education and Healthcare to surge. If agriculture were to ratchet downward, the question becomes, which sector in the county could surge to pick up the low-skilled employees idled by the change? Education and health care are driven by populations and public expenditure patterns. While California has recently been aggressive about increasing public spending, the question arises—will that increased spending be enough to replace the tens of thousands potentially lost in the worst-case scenarios? Given the pressures on public finance, especially with the health reforms under discussion within Congress and within the Trump Administration, this seems unlikely.

Figure 10—Average Annual Employment in the Five Largest Employment —Industries, Kings and Fresno Counties Combined, 1990-2016



SOURCE: California Employment Development Department, Labor Market Information.

This is the key question: what kind of industry would use the same worker base as agriculture? While workers in agriculture develop an industry-specific skill set, it is not easily transferrable to other industrial sectors. The key then is to: (1) identify other industries and sectors that can take untrained, low-skill, low-experience workers and quickly (one to six months) train them to assume new roles in that industry, and (2) attract those industries to the region for the long-term so that this new employment can offset what would be the lost agricultural employment. What sectors are those? In the Inland Empire and the southern end of the Central Valley, transportation and whole sale trade have fulfilled this role as many large trucking and distribution centers redistribute goods from the Ports of Los Angeles and Long Beach across the continent. Fresno County's relative distance from these hubs, however, limits (but does not preclude) the opportunities for growth in this sector. Health Services is another sector that tends to hire lower-skilled labor and train them into new roles.

Many advocates for environmental policy strategies often argue that, as California pursues more aggressive environmental policies, such as the state's efforts to reduce carbon emissions under the auspices of AB 32, much or all of the requisite manufacturing that is needed to convert the state's economy to these new technologies will be made in California.[16] Underlying these arguments are the belief that, as workers are shifted away from older, carbon-producing industries, they will be employed by the surge in new companies manufacturing the solar panels, scrubbers, windmills, etc. that are called for to reduce carbon emissions. As will be shown in the next section, there is little reason to believe these jobs will come in sufficient to Fresno and Kings Counties.

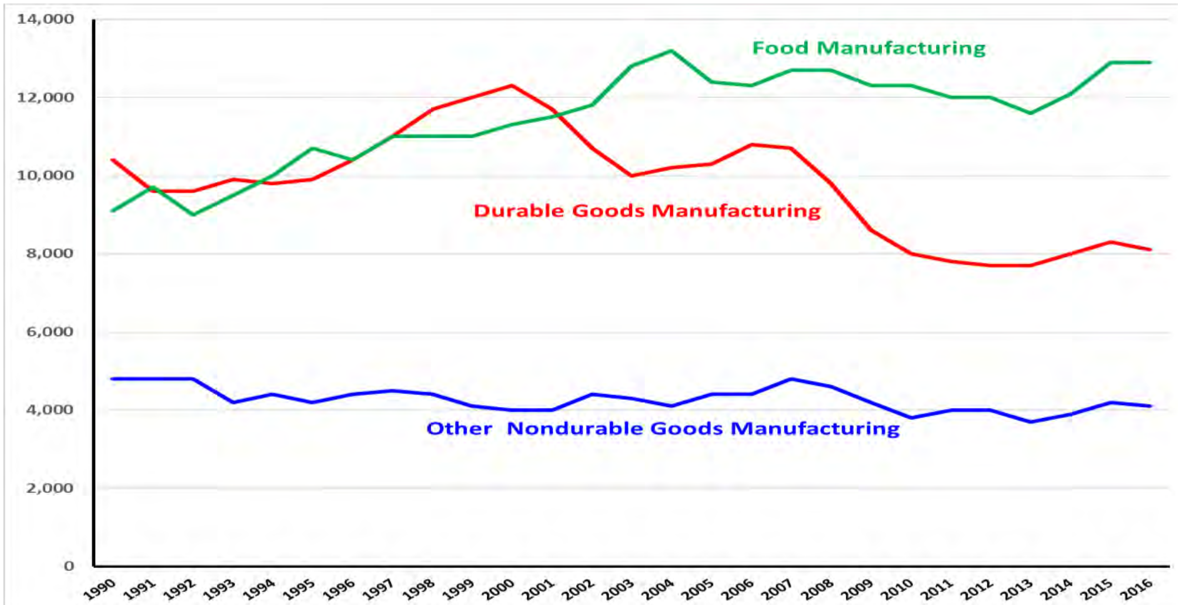
WHAT ABOUT MANUFACTURING?

How likely is this transition? Looking at Figure 10, it is easy to see that manufacturing is just starting to approach the pre-Great Recession levels in the Central Valley. On the surface, the recent upward trend may even point to the Fresno area picking up some new manufacturing positions in response to the many changes incurred under AB 32.

Looking more closely at the employment patterns within manufacturing however shows a different story. Figure 11 shows that the recent surges in manufacturing are in the Food Manufacturing subsector, not in durable goods.

[16] See Appendix D of the California Air Resources Board's *The 2017 Climate Change Scoping Plan Update*, for example.

Figure 11—Average Annual Manufacturing Employment, Fresno County, by Subsector, 1990-2016



SOURCE: California Employment Development Department, Labor Market Information.

In fact, durable goods manufacturing has seen a long-term decline in Fresno County since 2000, when it peaked at about 12,000 jobs, losing more than one in three positions in that period. While the current trends appear to be away from this kind of durable goods manufacturing, could the Fresno County-Kings County area realistically become a hub for new manufacturing in California if the local economy were to shift away from manufacturing?

Manufacturers looking to relocate production look at a wide range of variables and parameters when deciding where to locate new production facilities, including the availability of land, energy, transportation infrastructure and labor availability/quality. For example, one of the biggest barriers to getting manufacturing to move to large urban centers like Los Angeles is the lack of buildable land. Without crops, the Fresno region would have tens of thousands of available acres, so this would not be an issue.

Infrastructure is another critical component for a successful manufacturing center. Transportation-wise, the region is a bit more remote than many other potential sites, but the availability of cheap, available land may make the transportation cost[17] investment viable. and a surge in housing prices in urban parts of the state would make the Central Valley more attractive. The second aspect of infrastructure relates to energy availability—especially electricity. Because of California's doubling down on Renewable Portfolio standards, the future and stability of the California energy has become less certain. The state is mandated to add new renewable energy sources to its energy portfolio. These sources, often driven by

[17] This cost is exacerbated by California's 2017 increases in transportation fuel and use taxes.

solar and wind, are starting to see costs converge (for large utility-scale production) down to the levels previously only achievable by natural gas production.[18] While production and generating costs are competitive, taxes, regulations, and surcharges drive the cost of electricity higher in California than other regions. Additionally, for manufacturing, the reliability and consistency of the energy supply is critical. Because most renewables rely on sources that are not always present (strong sunlight, consistent winds, or an adequate supply of water to allow hydroelectric generation, a deeper reliance on renewables (such as solar, wind and hydroelectric) can render the supply subject to inconsistencies in these resources. The limited availability of water for industrial purposes could affect some manufacturing operations as well.

There is also the question of the workforce itself. Would the Fresno area be a destination of choice for potential manufacturers? To gain a deeper insight into this effect, the team examined those places where manufacturing is migrating to ascertain how Fresno may stack up to these jurisdictions. Forbes.com, in conjunction with Newgeography.com, publishes an annual ranking that looks at the best places for manufacturing in the US.[19] These rankings look at short, medium and long-term trends in employment in the manufacturing sector and identify those with the persistence, momentum and consistency in attracting new manufacturing jobs across the nation for each of the 373 Metropolitan Statistical Areas (MSAs) for which detailed, consistent and comparable manufacturing data are available. Figure 12 provides the top 15 MSAs in that listing. The Fresno MSA came in 149th out of the 373 MSAs ranked, and 68th out of the 169 MSAs with more than 150,000 nonfarm jobs.

[18] See "Unsubsidized Levelized Cost of Energy Comparison," *Lazard's Levelized Cost of Energy Analysis-Version 10.0*, December 2016, presentation, p.2. https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf, accessed June 10, 2017.

[19] Joel Kotkin and Mike Shires, *Where Manufacturing is Thriving in the U.S.*, forbes.com contributed work, June 12, 2017. https://www.forbes.com/sites/joelkotkin/2017/06/12/where-manufacturing-is-thriving-in-the-u-s/#17f6e4fd1ff7, accessed June 13, 2017. Methodological details can be found at www.newgeography.com at http://www.newgeography.com/content/005649-where-manufacturing-is-thriving-in-the-us. Accessed June 13, 2017.

Figure 12—Rankings of the Best Places for Manufacturing Jobs, Large and Midsized MSAs (Total nonfarm jobs > 150,000),[20] 2017

Ranking Among Large and Midsized MSAs	Area	2016 Total Nonfarm Employment (1000s)	2016 Manufacturing Employment (1000s)	Manufacturing Employment Growth Rate 2015-2016	Cumulative Manufacturing Employment Growth Rate 2011-2016
1	Louisville/Jefferson County, KY-IN	670.8	83.3	5.6%	30.2%
2	Lansing-East Lansing, MI	235.5	20.9	7.2%	23.2%
3	Reno, NV	225.1	14.3	5.7%	28.0%
4	Ogden-Clearfield, UT	249.8	32.9	3.2%	19.5%
5	Cape Coral-Fort Myers, FL	262.6	5.8	3.6%	29.6%
6	Deltona-Daytona Beach-Ormond Beach, FL	199.3	11.5	2.7%	26.3%
7	Grand Rapids-Wyoming, MI	551.2	112.9	2.1%	22.7%
8	West Palm Beach-Boca Raton-Delray Beach, FL Metropolitan Division	623.6	19.5	4.1%	27.7%
9	Charleston-North Charleston, SC	350.5	26.2	1.9%	12.8%
10	Kansas City, MO	608.6	45.8	2.9%	17.6%
11	Fort Collins, CO	162.6	13.3	0.0%	17.8%
12	Santa Maria-Santa Barbara, CA	182.9	13.4	2.3%	15.1%
13	Warren-Troy-Farmington Hills, MI Metropolitan Division	1236.6	153.7	1.8%	19.9%
14	Nashville-Davidson--Murfreesboro--Franklin, TN	968.8	83.2	4.1%	23.8%
15	Albany-Schenectady-Troy, NY	466.5	25.8	-0.5%	17.6%
68	**Fresno, CA**	**339.1**	**24.5**	**0.7%**	**6.7%**

SOURCE: Analysis of rankings data from the Bureau of Labor Statistics (Current Employment Survey) data for www.forbes.com and www.newgeography.com

When thinking about the workforce, one of the most available measures of workforce quality is the educational preparation of the workforce. For comparison purposes, the team chose to select two examples of strong performers in the rankings: the Charleston, South Carolina MSA, ranked ninth among the midsized and large MSAs, and Reno, Nevada—ranked third in this group. Charleston was selected because it has roughly the same nonfarm employment base overall as Fresno (350,500 vs. 339,100, respectively) and Reno was selected because of its geographic proximity.

Figure 13 shows the educational profile for the three core counties in each of the three MSAs. Reno and Charleston clearly have much higher overall educational attainment—with nearly 42 percent having bachelor's degrees in Charleston compared to 19 percent in Fresno. Furthermore, more than one in four Fresno workers lacks a high school diploma, nearly twice the share of Reno and three times that of

[20] Smaller MSAs (those with less than 150,000 nonfarm jobs) have much smaller employment bases, are much more volatile in their relative rankings, and are thus harder to compare to larger MSAs like Fresno. For this reason, they were omitted from these comparisons.

Charleston. The workforce in Fresno is less educated, which in turn limits the region's likely attractiveness to potential manufacturing employers.

Figure 13—Educational Attainment, Fresno (CA), Washoe (NV) and Charleston Counties (SC) ***(share of workers aged 25-64)***

Level of Education Completed	Fresno, CA	Washoe, NV (Reno)	Charleston, SC
Less than high school graduate	26%	14%	9%
High school graduate or some college/AA degree	55%	58%	49%
Bachelor's degree or higher	19%	29%	42%
Total	**100%**	**100%**	**100%**

SOURCE: American Community Survey, 2011-2015.

Finally, even if a manufacturer would prefer Fresno to other regions in California, there is the broader question of whether they would pick California over other locations in other states.[21] The highest ranked among the 15 midsized and large California MSAs is Santa Maria-Santa Barbara at #12 and average rank is 67 out of 169 (the median is 62nd). The bottom line is that manufacturing has fallen on hard times in California, even though the Los Angeles-Long Beach-Glendale Metropolitan Division still has the most manufacturing jobs of any MSA in the nation (it came in 149th out of the 169 as it continues a decades-long shedding of manufacturing jobs).

Many argue that it is California's business climate that makes it so hard for manufacturing to thrive in the state. Between its strong environmental regulations, expensive litigation environment, and generally high taxes, it is hard for California localities to compete with other, low-tax jurisdictions. Reno, for example, has no personal income tax.[22]

The bottom line is this: **it is highly unlikely that manufacturing would suddenly replace farm jobs lost if a combination of environmental events and public policy choices led to the loss of a significant share of Central Valley agricultural jobs.**

[21] For example, California competed hard with several other locations to be the site of Elon Musk's $5 billion gigafactory plant only to lose out to Reno, Nevada in 2014.

[22] There are numerous studies, rankings and websites which document the high cost of doing business in California. Some examples (among many others) are *Forbes, "*Best States for Business" (https://www.forbes.com/best-states-for-business/list/#tab:overall) which ranks California #30, *Chief Executive* magazine which ranked California #50 out of 50 states (http://chiefexecutive.net/2017-best-worst-states-business/), the Tax Foundation which ranked California's state and local tax burden in 2017 as #6 among the nation's 50 states.

How Would a Shift Away from Agriculture Affect Local Communities?

If the state were to suffer a significant loss of agricultural jobs in the Central Valley, who would it affect and how would it affect them? While this study so far has measured those costs in jobs and economic output, the reality is each of these jobs lost is a significant disruption in the lives of the individuals, their families, their households, their communities and the state overall. In this section, these shifts will be examined in the context of a scenario wherein: (1) agricultural production is severely limited, and (2) no other sectors expand to capture the newly unemployed agricultural workers (as described in the previous section). The first impact of such a major economic disruption would be an immediate spike in the unemployment rate in the two counties. Figure 14 shows the estimated impact using the coefficients from the "Reduced Water – All Crops" scenario shown previously in Figure 6.[23]

Figure 14—Estimated Unemployment Rates under a Low Water Scenario, Fresno and Kings Counties

Description	Fresno County	Kings County	Combined
Current Farm Employment (2016)	47,000	7,200	54,200
Total Civilian Labor Force (2016)	446,200	57,200	503,400
Current Unemployment Rate	**9.4%**	**10.0%**	**9.5%**
Current Unemployed (2016)	42,100	5,700	47,800
Additional Agricultural Workers Who Lose Jobs in Low Water Scenario	37,483	5,742	43,226
Additional Unemployed due to indirect and induced effects	12,784	1,958	14,743
Estimated Number Unemployed under Low Water Scenario	92,368	13,401	105,769
Estimated Unemployment Rate under Low Water Scenario	**20.7%**	**23.4%**	**21.0%**

SOURCE: This analysis and California EDD Labor Market Information data.

The low water scenario would thus more than double unemployment in the region absent some new industrial base to pick up some of the slack labor. This would be comparable to what happened in the northern part of the state when mining and logging were sharply curtailed in the face of new environmental policies in the 1970s, 1980s and 1990s.

[23] This scenario was chosen to reflect the more generous of the two estimates. If the coefficients from the "Permanent Crops Only" Scenario are applied, estimated unemployment would be 21.7 percent in Fresno County and 24.7 percent in Kings County with a combined unemployment rate of 22.1 percent.

THE INDIVIDUAL DECISION PROCESS—SHOULD I STAY OR SHOULD I GO?

Individuals facing a labor market shock of these proportions would have to decide among several possible options: (1) relocate to another region that has better employment opportunities, (2) pursue a different work in the local community, (3) pursue agricultural work in nearby communities, or (4) stay in place and wait for agricultural production to return to the region. Each of these alternatives has significant implications to the local communities affected by these shocks.

Migrating to a new region is a time-tested response to economic events, especially if the economic shock is local and not national. Bakersfield, for example, saw a major bump in its population during the "Dust Bowl" days of the 1930s as migrants from Oklahoma came west seeking new opportunities. In the case of the Los Angeles aerospace drawdowns in the early 1990s, a significant number of these middle-income workers relocated to other employment outside the Los Angeles region. So much so that real estate prices in the greater Los Angeles area, but especially in the neighborhoods surrounding the aerospace cluster in the South Bay such as Redondo Beach, El Segundo, Manhattan Beach and Lawndale, plummeted as thousands of aerospace workers put their homes on the market at the same time.

Alternatively, workers can choose to pursue new job opportunities. With Fresno's relatively low-educational attainment workforce (especially among agricultural workers), the ability to transition to other occupations would be bounded by both the availability of these positions and the ability of the existing training infrastructure to retrain them for the opportunities that may exist. Wyoming, for example, has sought to retrain coal miners to work as wind farm maintenance technicians in response to the collapse in the demand for coal (fueled in significant part by new regulatory mechanisms).[24] Historically, these retraining programs are fairly limited in scope. In the case of the Wyoming proposal, some 200 coal miners are being retrained to maintain wind generation equipment. In the Central Valley, it would take a lot of retraining investment to retrain more than 100,000 workers.[25]

The third option, to have a longer commute to pursue agricultural work in neighboring communities would be defined by the scale and scope of the event that precipitated the reduction in available water. If the event was locally-focused, such as the result of a policy decision by the state to pick winners and losers in the state's agricultural production process, then the prospect of locally accessible work is higher. If the policy impacts are broader, however, or the water supply shock is the result of a regional drought, then the prospect of remaining in the same location is much less and the individual is much more likely to be forced to relocate to pursue a similar job.

Finally, there is the option of staying in place. This decision would be shaped by a sense that either the shock is likely to be short-lived (e.g. it will rain next year), or that there are strong social safety nets—both public and private—that will allow the individual to weather the storm with a tolerable level of

[24] Diane Cardwell, "Wind Project in Wyoming Envisions Coal Miners as Trainees," *New York Times,* May 21, 2017, https://www.nytimes.com/2017/05/21/business/energy-environment/wind-turbine-job-training-wyoming.html, accessed June 11, 2017.

[25] Because solar generation has many fewer moving parts than wind generation, the personnel costs to maintain solar farms is much lower than wind farms.

disruption. This approach would also be more likely if either new demand for the individual's personal skills arose quickly, or if the scope of the shock is so broad that there really isn't anywhere else to which the individual could migrate that would produce a better quality of life. The latter scenario could include a national recession or even a large-scale drought. In this scenario, the individual would avail themselves of the social safety net available in their local community.

In summary, how such a shock, like a long-term suspension of water deliveries, would impact individuals depends on several unknowns: (1) as previously discussed, does another industry enter the local job market to absorb some or even all the unemployed workers, (2) how widespread are the variables driving the water reduction, (3) how mobile are the affected workers, (4) what expectations exist about the likely duration of the shock, and (5) how robust is the local safety net. Each of these variables would impact the likelihood of the shift and speed with which it would happen.

Impacts on the Local Communities and Workers

From the perspective of the local community, the real question is whether individuals would stay put or whether they would leave. Several communities have had major shocks to their local economies, but very few on the scale and the magnitude of the kind of shock discussed here for the Central Valley. The aerospace drawdown, for example, affected about 400,000 jobs in a county where overall employment at the beginning of the drawdown was around 4.3 million jobs—a reduction of 10 percent.[26] The scenarios discussed in this study are proportionally more than 50 percent greater. Additionally, Los Angeles has a very large and diverse economy. The effects of such a major shock on the Fresno region's more ag-dependent economy could be much greater than even those projected here.

Who Is Affected?

The question of who are the workers potentially affected is important. A detailed review of the demographics of these workers in Fresno County points to an industry that employs tens of thousands of workers with a very wide range of skill levels. Figures 15 and 16 provide summaries of some of the key demographics about agricultural workers in Fresno County who would potentially lose their jobs if the region were to curtail its agricultural production.

In Figure 15, the data provide a description of the numbers of county residents in each occupational description, data on their educational attainment, and the average wages for workers within that occupation. The table shows that, while there is a wide range of educational backgrounds present across the various occupations in the sector, most workers have a very low level of educational attainment. More than half of two of the largest occupational groups lack high school diplomas, including the largest group by far—miscellaneous agricultural workers—which account for nearly three-fourths of workers in

[26] For a detailed discussion of the 1992-1994 aerospace drawdown in Los Angeles County, see Schoeni, *et.al.*, *Life After Cutbacks: Tracking California's Aerospace Workers*, 1996. RAND: Santa Monica, CA, 73 pp. and Dardia, *et.al., Defense Cutbacks: Effects on California's Communities, Firms, and Workers-Executive Summary,* 1996. RAND: Santa Monica, CA, 13 pp.

the sector. Overall, almost half of all agricultural workers in the two counties lack high school diplomas and another 28 percent have no education beyond high school. In a state where 18.5 percent of the population over 25 years of age lacks a high school diploma, this sector provides employment for many of these workers.

Not surprisingly, average wages for these workers in these occupations are also relatively low averaging just $26,076 per year—well below the statewide average of $37,170. At the same time, average wages in the largest occupational group, miscellaneous agricultural workers, earn almost 9 percent more than the average Californian without a high school diploma.

Figure 15—Educational Attainment in Agricultural Occupations and Mean Annual Wages, Fresno and Kings Counties, First Quarter 2014[27]

Occupation	Fresno and Kings County Total Employed	Less than high school diploma	High school diploma or equivalent	Some college, or Associate's Degree	Bachelor's degree	Graduate Degree	Mean Annual Wage
Total, all occupations	*475,700*	*8.%7*	*24.2%*	*30.7%*	*22.5%*	*13.9%*	*$41,861*
Farmers, ranchers, and other agricultural managers	4,025	10.5%	36.8%	29.6%	19.2%	3.9%	$79,022
Agricultural and food science technicians	255	8.2%	20.0%	43.3%	22.8%	5.7%	$41,238
First-line supervisors of farming, fishing, and forestry workers	995	30.7%	32.2%	21.5%	12.7%	2.7%	$31,633
Agricultural inspectors	395	8.5%	21.4%	34.0%	29.6%	6.5%	$42,501
Graders and sorters, agricultural products	2,670	54.8%	28.9%	11.8%	3.9%	0.6%	$19,692
Miscellaneous agricultural workers, including animal breeders	35,525	56.0%	25.8%	12.6%	4.6%	1.0%	$20,967
Packers and packagers, hand	4,965	35.9%	39.9%	19.4%	4.2%	0.7%	$19,939
Overall / Totals	**48,830**	**49.0%**	**28.4%**	**15.2%**	**6.2%**	**1.3%**	**$26,076**

SOURCE: California EDD, OES Employment and Wages by Occupation, http://www.labormarketinfo.edd.ca.gov/LMID/OES_Employment_and_Wages.html, accessed June 18, 2017.

This table also shows a career progression across these occupations as supervisors continue to show a similarly low overall level of educational attainment with 63 percent having only a high school diploma or less, but wages are more than 50 percent higher, averaging $31,633—more than 13 percent above

[27] NOTE: The specific numbers will not correspond exactly to the data presented in previous sections because these are based on residential samples not employer samples. The data in this table reflect surveys of residents of the two counties while data in the preceding tables include data from surveys of employers within the two counties. Additionally, the years used by the EDD to generate the estimates for these data include years earlier than the industry-based data.

the statewide average for Californians with only a high school diploma. Advancing to a higher level of management provides even more dramatic wage increases with farmers, ranchers and other agricultural managers averaging some $79,022 per year. The median for this group (not listed on the table) was $71,635. While there is more education present among this group, nearly half still only have a high school diploma or less.

In Figure 16, the demographics of these workers are listed for each occupation. Not surprisingly, this is a very prevalent Hispanic workforce. More than 95 percent of the two largest occupational groups in agriculture in Fresno County are Hispanic with 89 percent overall. In Kings County, the numbers are slightly lower, but still over 85 percent of workers who would be potentially impacted by the policies addressed in these simulations are Hispanic.

Figure 16—Employment in Agricultural Occupations by Hispanic Ethnicity, Fresno and Kings Counties, 2006-2010

Fresno County			
Total, all occupations	415,700	194,830	46.9%
Farmers, ranchers, and other agricultural managers	3,320	1,175	35.4%
Agricultural and food scientists	220	35	15.9%
Agricultural and food science technicians	210	130	61.9%
First-line supervisors of farming, fishing, & forestry workers	590	450	73.0%
Agricultural inspectors	330	175	53.1%
Graders and sorters, agricultural products	2,225	2,125	95.5%
Miscellaneous agricultural workers, including animal breeders	28,825	27,495	95.4%
Packers and packagers, hand	4,260	3,870	90.8%
Total Affected Occupations	**39,980**	**35,455**	**88.7%**
Kings County			
Total, all occupations	60,000	28,205	47.0%
Farmers, ranchers, and other agricultural managers	705	155	22.0%
Agricultural and food scientists	20	0	0.0%
Agricultural and food science technicians	45	20	44.4%
First-line supervisors of farming, fishing, & forestry workers	405	355	87.6%
Agricultural inspectors	65	49	75.4%
Graders and sorters, agricultural products	445	310	69.6%
Miscellaneous agricultural workers, including animal breeders	6,700	6,320	94.3%
Packers and packagers, hand	705	545	77.3%
Total Affected Occupations	**9,090**	**7,754**	**85.3%**

SOURCE: American Community Survey Estimates, EDD LMI Labor force data. Compiled for Equal Employment Opportunity programs.

In the next two sections, the analysis will look at the economic and human implications of the scenarios developed in this analysis. They are organized around whether workers leave the region in response to the lost agricultural jobs, or whether they remain in the region.

OUT-MIGRATION COULD BE DEVASTATING TO LOCAL COMMUNITIES

The most famous out-migration story in U.S. municipal history may well be the city of Detroit. From the 2000 Census to the 2010 Census, the city lost 25 percent of its population dropping from 951,307 in 2000 to 713,777 in 2010. The population losses continue to mount in this decade with the city dropping another 5.8 percent to an estimated population of 677,116 in 2016. This is a far cry from the city's heyday in 1950 when it was the fourth largest city in America with a population of nearly 2 million residents. Detroit is the story of a city that lost its core industry—automotive manufacturing—as firms moved their production elsewhere domestically and internationally. If the worst-case scenario were to unfold in the Central Valley, it could be a similar story with production (in this case growing crops) shifted elsewhere domestically or overseas.

What would this mean to the local communities? First there would be a dramatic loss of income to local governments. The first part of this loss would come from the lost tax revenues from decreased economic activity—fewer goods purchased so less sales tax revenues, less income earned so less received by the state in income taxes, fewer vehicle miles driven so less received by the state in gasoline tax revenues, etc. The IMPLAN modeling system provides an estimate of these tax losses from the loss of production associated with the activity. Figure 17 shows the lost tax revenues to both state and local governments if agriculture were to shift out of the Fresno County economy.

Figure 17—State and Local Taxes Lost to California and Local Governments in a County without Agriculture (*2017 dollars*)

Tax Description	Annual Tax Revenues Lost
Tax on Corporate Dividends	$2,579,128
Tax on Production and Imports: Sales Tax	$123,002,487
Tax on Production and Imports: Property Tax	$105,154,996
Tax on Production and Imports: Motor Vehicle License	$2,944,515
Tax on Production and Imports: Severance Tax	$69,177
Tax on Production and Imports: Other Taxes	$19,307,974
Tax on Production and Imports: S/L Non-Taxes	$3,344,434
Corporate Profits Tax	$50,021,841
Personal Tax: Income Tax	$138,134,506
Personal Tax: Non-Taxes (Fines- Fees)	$24,712,028
Personal Tax: Motor Vehicle License	$5,151,577
Personal Tax: Property Taxes	$1,770,707
Personal Tax: Other Tax (Fish/Hunt)	$904,849
Total State and Local Tax Revenues Lost	**$477,098,219**

SOURCE: IMPLAN Economic Modeling System.

Agricultural production from Fresno County generates nearly a half a billion dollars of tax revenues for the state and local governments. While some of these lost dollars might be offset if the land were put to other uses, this lost revenue is just that—lost to everyone.

These estimates do not include the cost of development deals crafted by elected officials in their work to bring jobs to the region. The City of Fresno, for example, granted an estimated $16 million dollars in property and sales tax rebates to Amazon to encourage the developer to locate a fulfillment center in the city. While the city loses these tax revenues, officials see the new jobs and economic activity associated with them as a boon to the local community.[28]

Beyond these economic model estimates above, if workers and their students were to opt to leave the region in pursuit of economic opportunity elsewhere, it would go beyond the effects in Figure 17. For example, funding for local school districts are supplemented by significant contributions from the state general fund and allocated to districts on a capitated basis.[29] If the students disappear, then so do the funds. These impacts would be even more pronounced in the small rural communities that surround the City of Fresno. In the City of Huron, for example the impacts could be devastating. In FY 2016, the city

[28] The proposal rebates 90 percent of the city's share of property taxes and 100 percent of the city's share of sales taxes it would earn on purchases the developer makes in Fresno for the next 30 years. The total price tag, capped at $30 million, is expected to be $15.3 million in rebated property tax revenues and $750,000 in rebated sales tax revenues. See the article by Tim Sheehan, "Its Amazon, and its jobs, so Fresno City Council says yes to tax rebates," *Fresno Bee*, December 15, 2016.

[29] The Local Control Funding Formula incorporates not only average daily attendance, but also assigns additional monies for districts with students from low socioeconomic income groups and for students who are eligible for special programs.

received just over $700,000 in property taxes, some 40 percent of the city's operating revenues. If enough individuals left the small city of approximately 7,000 people, those revenues could plummet by half or even more. Additionally, the city has a successor agency to its Redevelopment Agency that is also dependent on long-term property tax revenues to pay off its debt obligations. A protracted hit to property values could render both entities insolvent and force bankruptcy.

In the case of small rural schools, the effects are also significant. If there was an 80 percent reduction in the number of households in the region, it could result in the closure of many of these local schools. Huron Elementary School, which enrolled 854 students in 2016-17 and employed 35 full-time equivalent (FTE) teachers, would only have funding for some 180 students if 80 percent (or more)[30] of the student body departed. It would be very difficult to justify keeping the campus open if there were only 7 or 8 FTEs of teachers remaining. This would require that the students attend elementary school at what is likely to be a more distant location, undermining the very sense of community that local schools imbue.

Beyond public finance, however, a large outmigration would have a very suppressive effect on property values in the region. Not only would this adversely impact those trying to sell their homes, but it would undercut the equity and creditworthiness of those households that remain behind—reducing significantly the extent to which they can contribute to the local economy (if they even still had their job—which is a mixed prospect at best in these small farm communities). In Detroit, at the bottom of the Great Recession, single family homes were selling for as little as $7,000.[31] The median home price in Huron on April 30th, 2017 was $137,700 according to Zillow.com. The bottom line is that a collapse in the agriculture economy could lead to the destruction of these small communities, turning them into the ghost towns of the 21st Century.

IF PEOPLE STAY IN THE AREA, DEPENDENCY ON SOCIAL SAFETY NET SPIKES

Alternatively, displaced agricultural workers could remain in place—continuing to live in their local communities. This could happen if there was a sense that the water disruption was temporary (e.g. waiting for the drought to end), the prospect of alternative employment was high, the scope of the drought was large (thus making it harder to get to the dwindling number of jobs available), or if the state were to "reinforce" its safety net—to create transitional income support for these individuals after the agricultural jobs go away. Some current residents may choose to stay because they very much prefer living in California.

Whatever the reason, the question would then arise—what impact would this have on California and the state economy? First and foremost, it would certainly spike the already high poverty rates within Fresno County. In 2015, as shown in Figure 18, Fresno County had the third highest proportion of its population under the poverty level and Kings County was 9th—well above the statewide average of 15.4 percent. These rates are *before* a prospective agricultural disruption.

[30] It could easily be more than just the overall 80 percent decrease in employment because the community is demographically very young. Some 37.1 percent of all residents are under 18 years of age.

[31] Today, the median home price on Zillow.com for Detroit, Michigan is $40,400 as of April 30, 2017.

The statewide unemployment rate in May 2017 was 4.2 percent. Fresno County and Kings County were at 7.4 and 7.9 percent, respectively, nearly twice the statewide average. In some ways, this surplus is direct refutation of the arguments made by some that a surge in the local labor supply will result in a spike in new manufacturing jobs in the region—the region has been well above the state average in both poverty and unemployment rates, and yet the economy continues to grow at the same modest rates.

Figure 18—Share of County Population under the Poverty Level, 2015

Rank	County	Percent of Population under Poverty Level	Rank	County	Percent of Population under Poverty Level
1	Tulare	27.2	30	Santa Barbara	15.6
2	Merced	25.9	31	Santa Cruz	15.4
3	Fresno	25.2	32	Monterey	15.3
4	Imperial	24.3	33	Mariposa	15.2
5	Del Norte	23.3	34	Tuolumne	14.5
6	Madera	22.6	35	San Luis Obispo	14.4
7	Siskiyou	22.6	36	San Diego	13.9
8	Tehama	22.5	37	Plumas	13.8
9	Kings	22.4	38	Sierra	13.8
10	Kern	21.9	39	Colusa	13.2
11	Yuba	21.6	40	Amador	13.1
12	Butte	21.4	41	Calaveras	13.0
13	Humboldt	20.9	42	Orange	12.7
14	Lake	20.5	43	Inyo	12.4
15	Mendocino	20.3	44	Nevada	12.4
16	Modoc	20.3	45	San Francisco	12.4
17	Trinity	19.7	46	Solano	12.0
18	Stanislaus	19.5	47	Alameda	11.5
19	Alpine	19.0	48	Mono	11.2
20	Shasta	19.0	49	Sonoma	11.0
21	San Bernardino	18.9	50	Contra Costa	10.2
22	Glenn	18.5	51	Napa	10.1
23	San Joaquin	17.5	52	Ventura	9.9
24	Sutter	17.5	53	San Benito	9.3
25	Yolo	17.5	54	El Dorado	9.1
26	Lassen	17.1	55	Placer	8.6
27	Sacramento	16.9	56	San Mateo	8.4
28	Los Angeles	16.7	57	Santa Clara	8.3
29	Riverside	16.2	58	Marin	7.5

SOURCE: American Communities Survey, Bureau of the Census.

The state's welfare program, CalWORKs, reports that 6.6 percent of Fresno County's population are recipients as of January 2016—for a total of 65,059 individuals.[32] If each of the agricultural workers who lose their jobs represent a single household, the total number of people on this program could easily double if there was a significant, persistent disruption to the agriculture sector.[33]

WHAT MUST BE DONE TO AVOID SCENARIOS LIKE THESE

The focus of this analysis is to add depth to the reader's understanding of the human and local community impacts of the economic data presented in the first companion study. While the scenarios included here are bleak and point to the possibility of major disruptions to the lives communities of the Central Valley, they are avoidable. The State of California must address this critical component of the state's agricultural economy.

While it may not have the greatest value-added contribution to the state's GDP, it does provide jobs, livelihoods, and communities to literally hundreds of thousands of Californians across the state. Moreover, these Californians are among the state's most vulnerable—having the fewest alternative economic opportunities upon which to build their lives. This is not about redistributing a few dollars or a few gallons of water, but rather the need to preserve a critical component not only of our economy, but of our California way of life.

While the purpose of this study is diagnostic, it would be incomplete without looking ahead to what can be done to avoid the kind of dire scenarios detailed in this analysis. There are four courses of action that the state must embrace to ensure that this vital thread of our socioeconomic fabric is not torn apart during the next drought: (1) plan ahead; (2) save for a dry day; (3) rebalance the prioritization for the state's poor resources; and (4) double down on water conservation infrastructure throughout the state, including municipal investments as well as technologically advanced irrigation practices, even when there is plenty of water.

WATER PLAN – LOOK AHEAD

The day of the 10-year or 20-year drought will come. It is like the earthquake promised for the Southland—the day will come! In the hydrologic history of the state, there have been numerous instances of droughts much longer than one or two decades. While it is difficult to prepare for a 20-year drought, the state should have a plan in place to survive a 10-year drought without shutting down the water taps in some of the state's remote communities.

[32] California Department of Social Services, Data Systems and Survey Design Bureau, January 2016 data, http://www.cdss.ca.gov/Portals/9/DSSDB/Trends/CWPopReceivingMap.pdf?ver=2017-04-27-144158-637, accessed June 13, 2017.

[33] Average household size in Fresno County is 3.0 per household. This size times the number of potentially displaced workers would easily double the number on public assistance through CalWORKs.

To understand what the state loses by not having a coherent and effective water strategy that combines adequate storage with policies that allow for a consistent and reliable flow of water on a year-to-year basis, one must imagine what it would be to have one. On a macro level, such a strategy would likely have a more robust storage capacity and better understanding of the true biology of the state's ecosystems with specific investments in technologies that would allow for micromanagement of local ecologies rather than the gross water flow strategies used today.

It would also include much more universal use of water-efficient technologies like drip irrigation across the state, extensive graywater recycling and desalinization in coastal urban population centers, and a coherent statewide water strategy that levels out the natural cycles of the hydrologic cycle and creates a reliable, predictable and consistent water flow for urban, agricultural, and environmental uses. While California is a long way from such a forward-looking water policy and billions of dollars in capital investments from realizing it, it will become essential to the state's and nation's economic health to take serious steps toward realizing that goal.

More and Better Storage – Connectedness

The state should invest extensively in new storage to save for the "(not-) rainy day" when the water does not fall from the sky. While numerous proposals have been made, the state should establish a priority for these storage facilities and immediately expedite their construction. The current system should also be examined and re-engineer to maximize the connections between existing and new storage resources so that the scarce water can be moved across all users in the system to maximize the usefulness of each precious drop.

Reprioritization of Agricultural Uses

The state also needs to reconsider its super-prioritization of environmental uses over other uses. Even with federal legislation to remind water administrators that agreements signed by parties in the past are the result of carefully negotiated social compacts, the state needs to ensure that its actions reflect those priorities and agreements. Agriculture is a critical feature of California's economy, not just because of the importance of having a domestic supply of quality fruits, nuts, and produce, but because it provides a livelihood to a critical (and underserved) component of the state's population.

Expand Conservation Throughout State

California needs to follow the path of the nation of Israel which recognized that a reliable water supply that was under its control was an essential part of its national security. Similarly, access to a reliable and adequate supply of fresh water is essential to California's economic future. In response to that imperative, the Israelis invested heavily in desalinization and greywater recycling strategies. Today, not only is Israel relatively water independent, but it exports significant quantities of water to neighboring Jordan. Imagine what California could do with extra water if it could build a comparable infrastructure.

FINAL COMMENTS

Agricultural production is a national security asset—especially in today's uncertain global trade climate— it is essential to have a reliable and accessible domestic food supply. There are a limited number of places where the climate, soil and space overlap as they do in the California Central Valley in order to produce an ideal climate for agriculture.

Not surprisingly, California's irrigation technologies are increasingly among the best in the world. Add to that the state's stringent environmental regulations on the use of pesticides, worker protections, and food handling regulations, and the state's food supply is among the safest in the world. Once the land that supports this critical national asset is dedicated to other purposes, and once the industrial infrastructure that supports the processing and distribution of these crops are gone, they are almost impossible to rebuild. All it takes is enough water to make it work—a problem that humans have been solving since the first patch of crops were planted in prehistoric times. With the technologies available, we should be able to solve it today.

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APPENDIX K

ASR Final Report

Prepared for
Westlands Water District | Fresno, California

Aquifer Storage and Recovery Pilot Study Results

May 2018

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FINAL

Aquifer Storage and Recovery Pilot Study Results

Prepared for

Westlands Water District

Fresno, California

May 2018

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FINAL

Aquifer Storage and Recovery Pilot Study Results

Prepared for

Westlands Water District

Fresno, California

May 2018

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Signature Page

Signatures of principal personnel responsible for development and execution of this Pilot Study.

Robert A. Beggs, PE

Ken Worster, PE
License No. AG 474, Expiration 09/30/18

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List of Acronyms & Abbreviations

AF	acre feet
AMSL	above mean sea level
ASR	Aquifer Storage Recovery
BC	Brown and Caldwell
bgs	Below Ground Surface
CEQA	California Environmental Quality Act
DWR	Department of Water Resources
EPA	Environmental Protection Agency
ft	feet/foot
gpm	gallons per minute
HAA	haloacetic acids
HP	horsepower
MCL	maximum contaminant level
mg/L	milligrams per liter
P&ID	piping and instrumentation diagram
PVC	polyvinyl chloride
SAR	sodium adsorption ratio
TDS	total dissolved solids
THM	trihalomethanes
ug/L	micrograms per liter
USDW	underground source of drinking water
USGS	United States Geological Survey

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Executive Summary

ES-1. General Information

Aquifer storage and recovery (ASR) is the utilization of wells for injection of available surface water into groundwater, and for subsequent recovery of the injected water or a similar volume of groundwater.

Converting existing groundwater production wells in Westlands Water District (Westlands or District) to ASR wells could provide a substantial source of supplemental water for drought years and still maintain sustainability as defined under the new California Groundwater Sustainability Act. The purpose of the ASR Pilot Study was to determine the general feasibility of injection and recovery, investigate water quality impacts, evaluate performance, address unforeseen issues, and provide a basis for estimating costs for injection and recovery of surface water using groundwater wells in the District.

The groundwater basin underlying Westlands is comprised of two principal water-bearing aquifers: (1) an Upper Aquifer above a nearly impervious Corcoran Clay layer containing the Coastal and Sierran aquifers and (2) a Lower Aquifer below the Corcoran Clay containing the Sub-Corcoran aquifer (Westlands, 2013). Recharge for the lower confined aquifer comes generally from east of the District, below the Corcoran Clay and also from areas on the western edge of the District, near the coast range, where the boundary of the Corcoran clay is irregular. (Westlands, 2013)

The evaluation process in the Work Plan (BC, 2016) resulted in the selection of a currently unused well owned by Westlands as the pilot ASR well. The pilot well was located approximately 10 miles south of Mendota. The location of the well, other nearby wells and surface water sources is shown on Figure ES-1. Surface water for the pilot study was obtained from the San Luis Canal and from the Kings River at the Mendota Pool.

The available drilling logs for wells closest to the ASR well showed the Corcoran Clay manifesting as a 100 ft thick layer of blue clay at approximately 600 ft below ground surface (bgs) and sand and gravel layers totaling approximately 60 ft thick below the Corcoran Clay. Water quality ranges from very salty in Shallow Aquifer to moderately salty in the Lower Aquifer, with sodium sulfate as the dominant salt in the Lower Aquifer below the Corcoran Clay.

ES-2. Pilot Study Planning and Facilities

The pilot study well was regulated under the category of an EPA Class V injection well associated with a waiver approval letter from the Regional Water Quality Control Board (Regional Board), who in turn incorporated recommendations for the pilot test from the Division of Drinking Water (DDW). Other regulatory issues of concern were addressed in the ASR Pilot Study Work Plan (BC, 2016) and subsequent letter communications with the Regional Board.

Model simulations of injection and recovery were performed in the Work Plan (BC, 2016) to estimate effects on water levels and the movement of injected water. Based on the results, risks of adverse effects to other wells in the area were determined to be very low.

Geochemical reactions of most concern for the pilot ASR study were dispersion reactions in interbedded clays and possible mobilization of arsenic, hexavalent chromium, and uranium by high redox injection water. Monitoring for these constituents was part of the water quality monitoring program.

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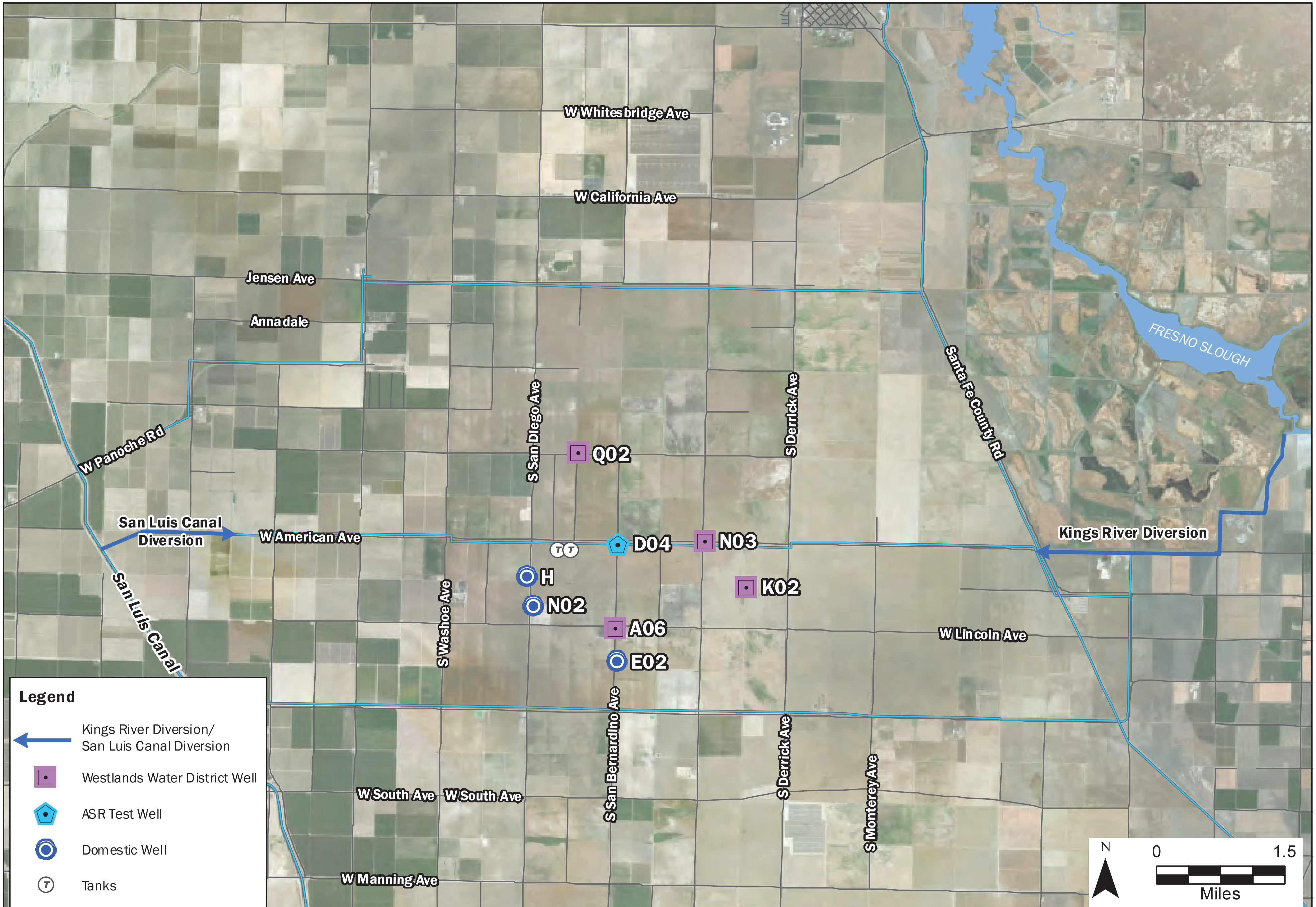

Brown AND Caldwell

PROJECT 148685

DATE 04/03/2018

SITE **Westlands Water District Pilot ASR Study**

TITLE **ASR Pilot Test Well Location, Nearby Wells and Water Sources**

Figure ES-1

Well modifications, rehabilitation, immediate wellhead equipment, and engine operation were provided by Zim Industries of Fresno, California. Well rehabilitation included bailing, scratching, acid treatment, air lifting, and well development pumping. The openings above the Corcoran Clay were closed off with patches per the DDW request. The well construction is shown on Figure ES-4.

Other than equipment at the immediate wellhead, all above-ground equipment was provided by Pacific Southwest Irrigation of Stockton, California. Site layout and key equipment such as filtration, control valves, chlorine injection, and injection water conditioning are called out on Drawings D1, M1, and G1 in Appendix A. The filtration system was selected to simulate a system that would be used for agricultural drip irrigation on a field supplied by an ASR well. A photograph of the installed equipment and related facilities is shown in Figure ES-2.

Figure ES-2. Installed Equipment and Related Facilities

Other features included a low velocity air release chamber, pressure control valves, a booster pump, two 3" downhole injection tubes, and various other valves and monitoring instrumentation. Wellhead control and other equipment are shown in Figure ES-3.

Figure ES-3. Wellhead Control and Other Equipment