APPENDIX D

PIPELINE CORRIDOR MAP VIEWS

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APPENDIX D-1

WETLANDS, WATERBODIES, FLOODPLAINS, AND BIOLOGICAL RESOURCES MAPS

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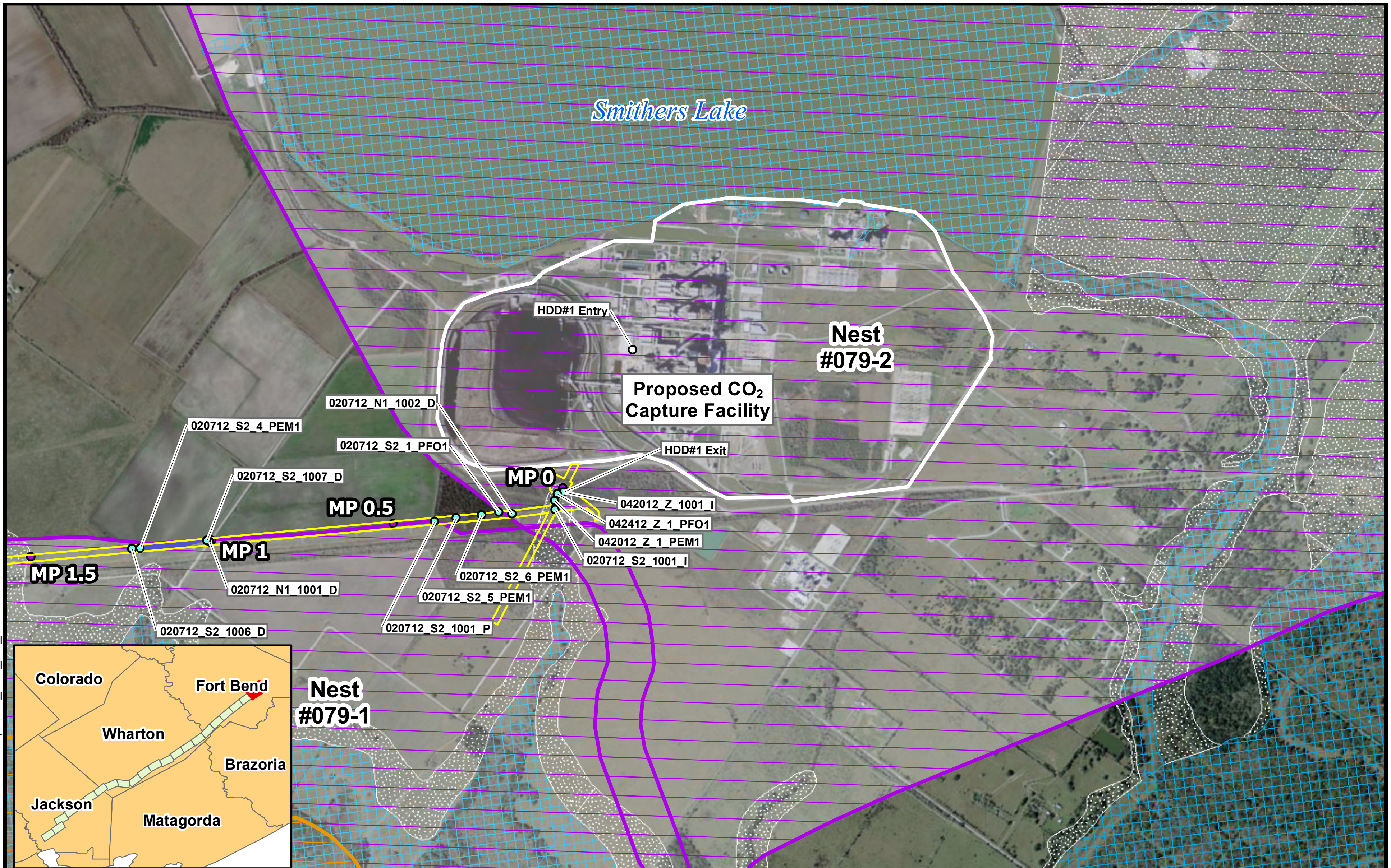

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- Drainage Ditch (D)
- Emergent Wetland (PEM)
- Forested Wetlands (PFO)
- Pond
- Scrub-Shrub Wetlands (PSS)
- Riverine (P,E,I)
- Access Roads
- Proposed Pipeline Corridor ROW
- 100-Year Floodplain
- 500-Year Floodplain

Sensitive Species or Habitat Areas, as Reported in TXNDD

- Bald Eagle
- Rookery
- Threeflower broomweed

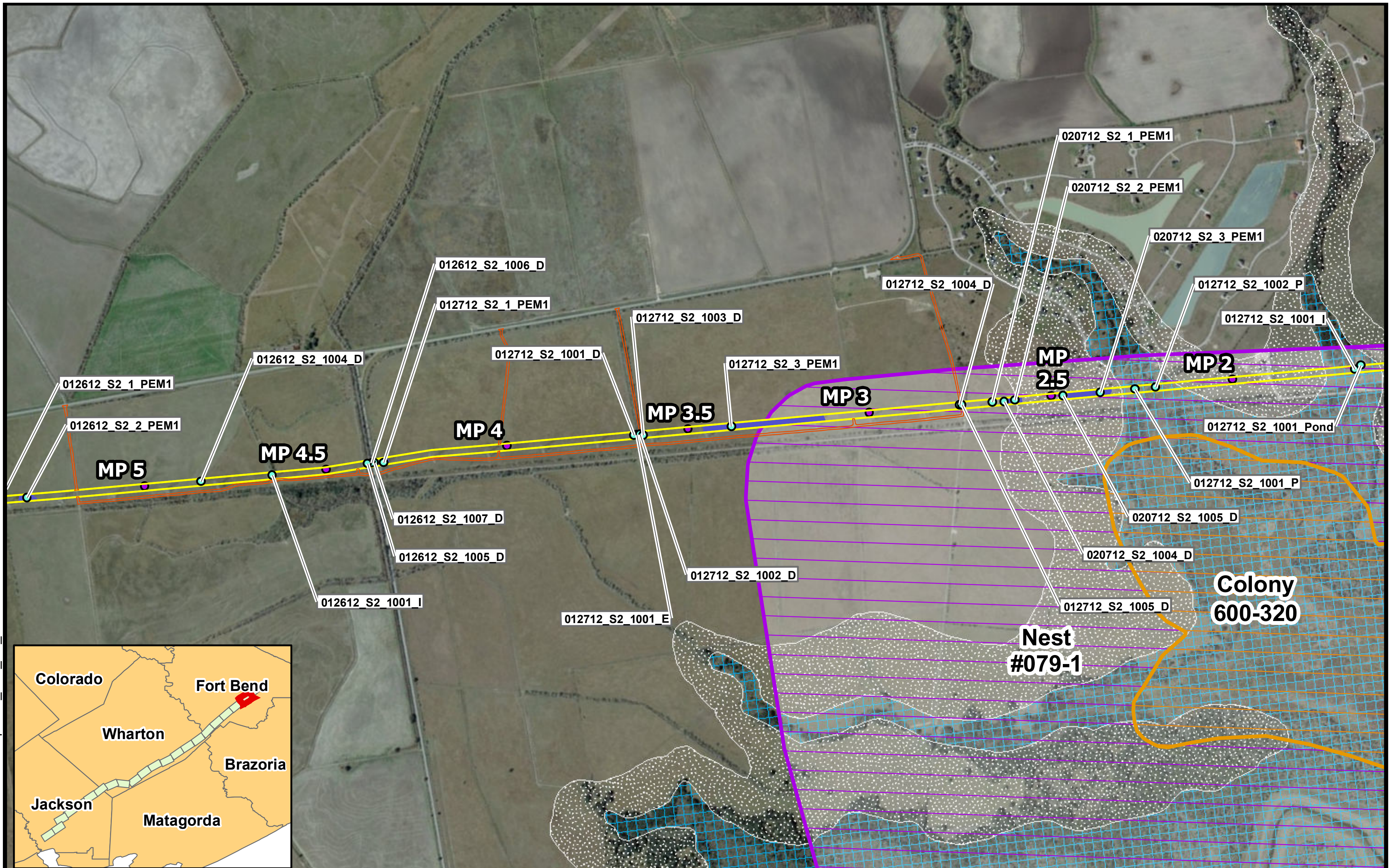
N

0 1,000 2,000 Feet

URS

Wetlands, Waterbodies, Floodplains, and Biological Resources			
NRG W.A. PARISH PCCS PROJECT			
Drawn By: CW	Date: 1/9/2013	Project No.: 25014860	Figure: 1 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
TXNDD sensitive species data (TPWD 2012a)
Aerial photos (ESRI 2012)



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0 1,000 2,000 Feet

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	2 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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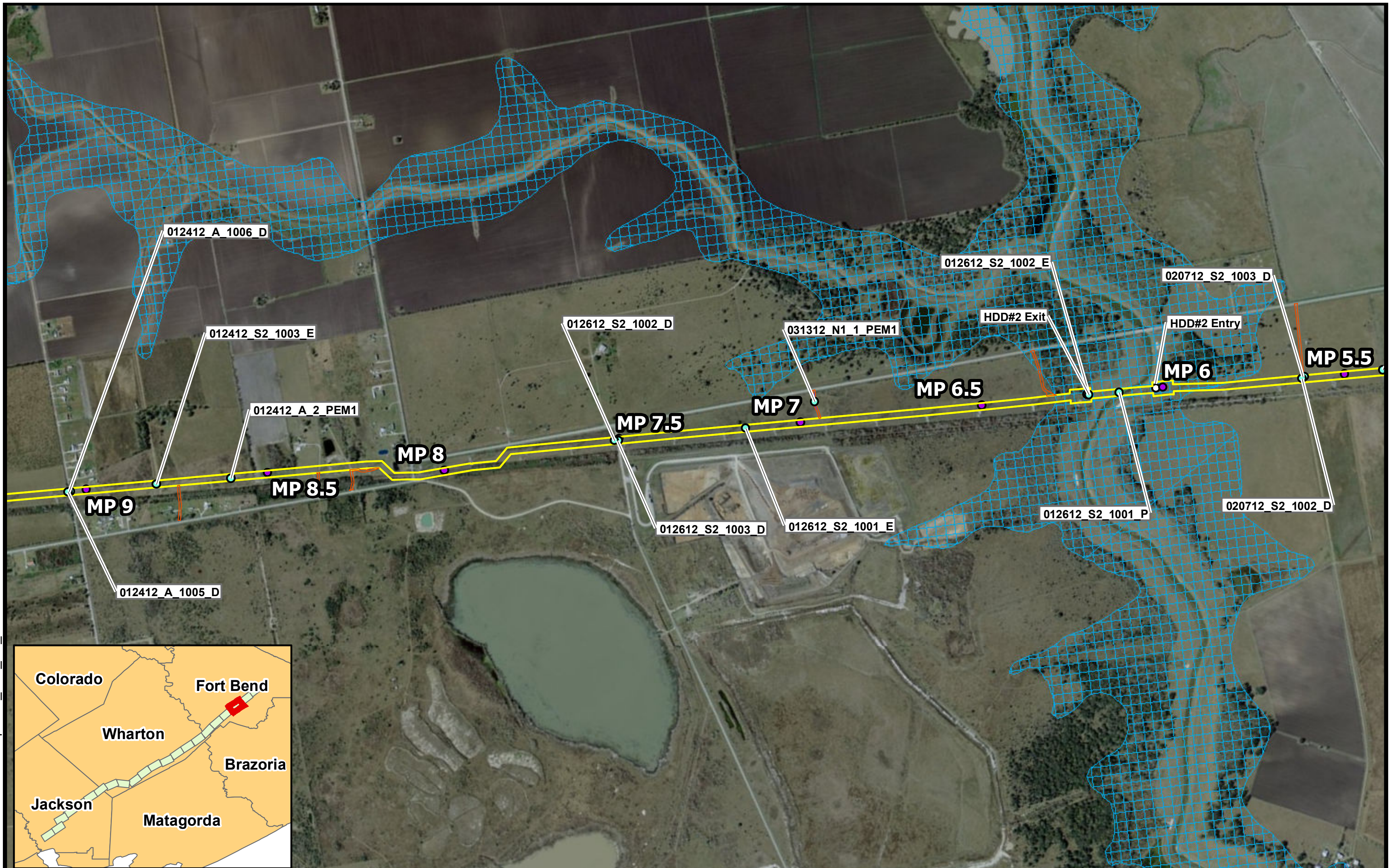

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	3 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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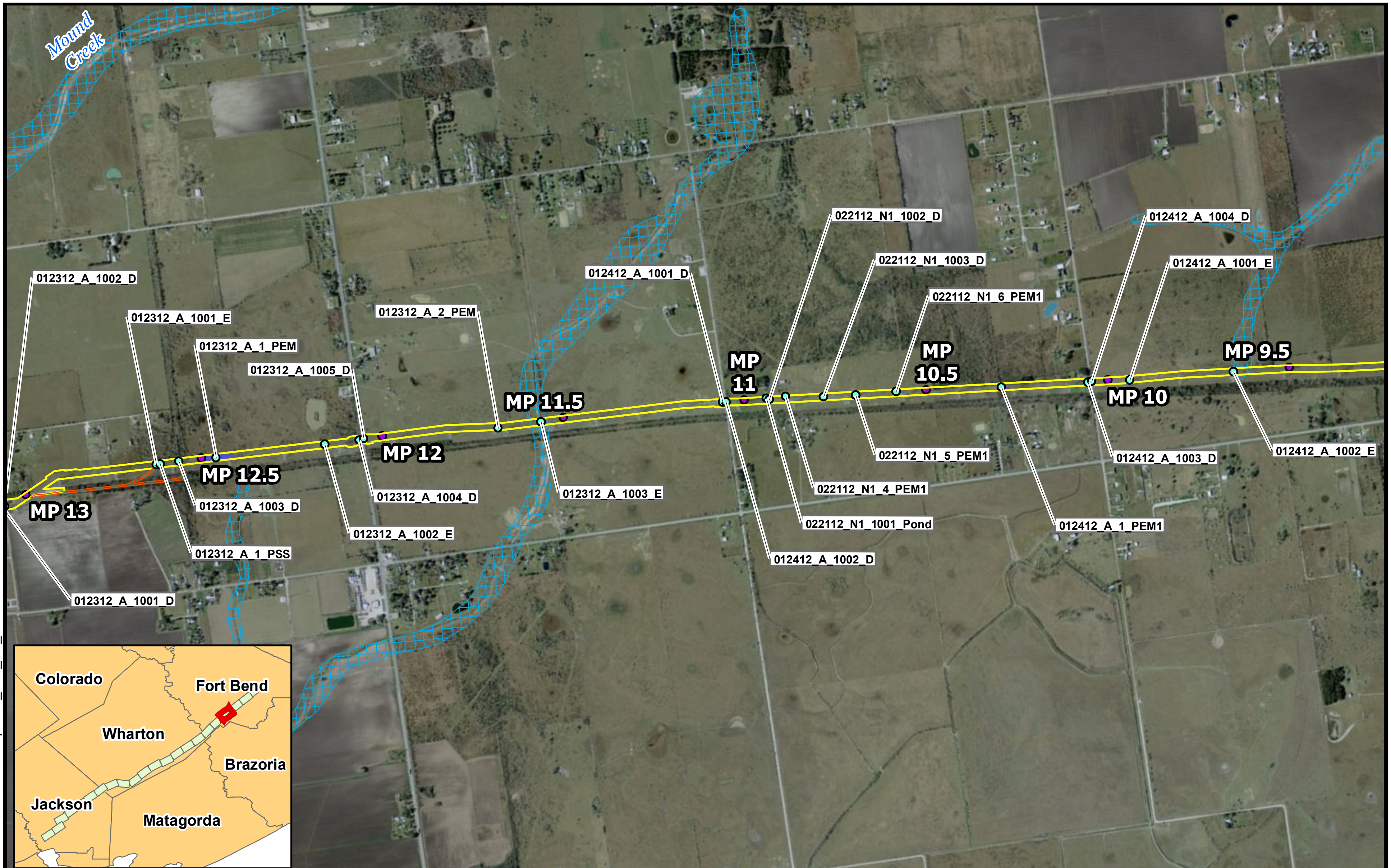

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Drainage Ditch (D)
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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	4 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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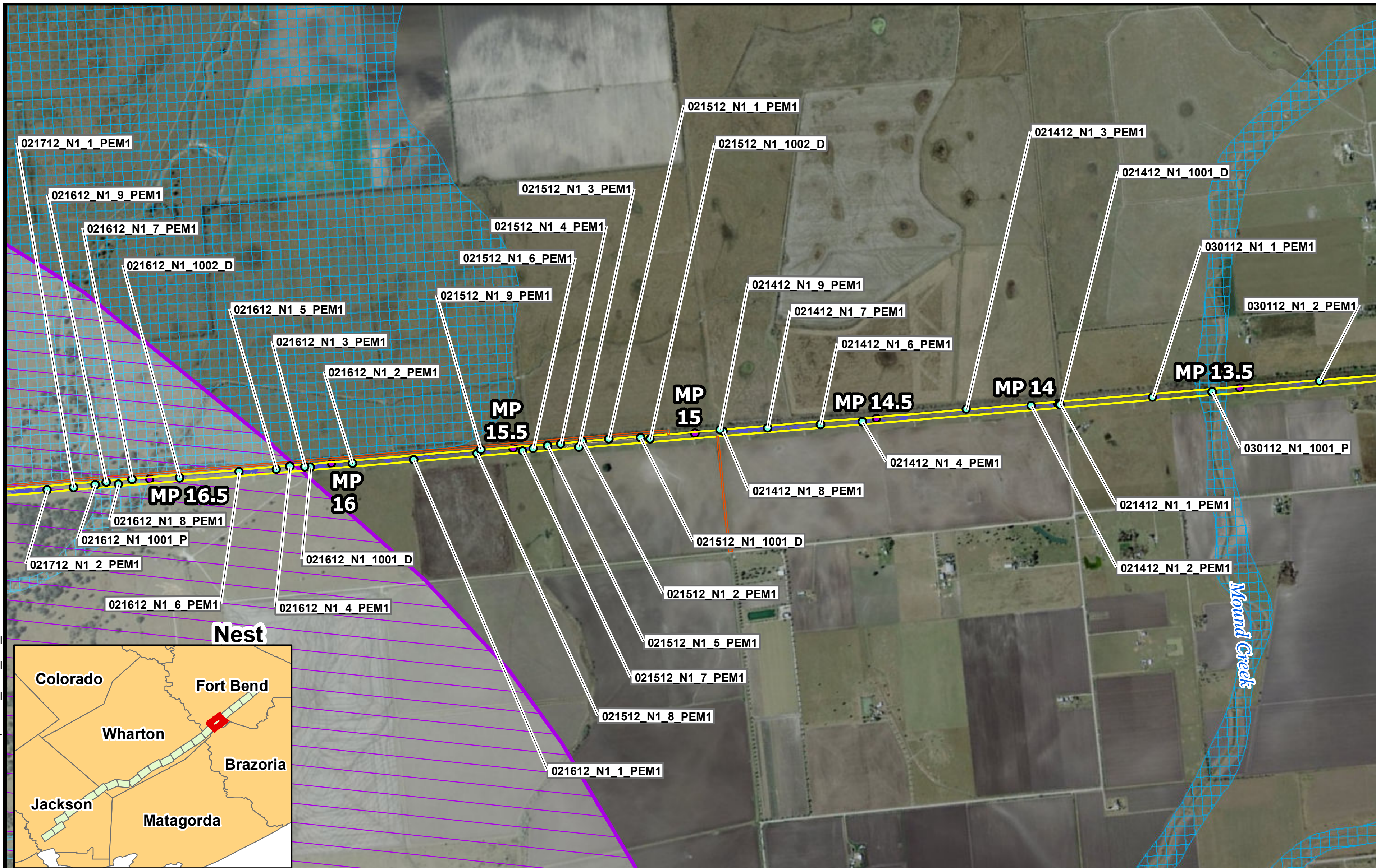

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	5 of 22

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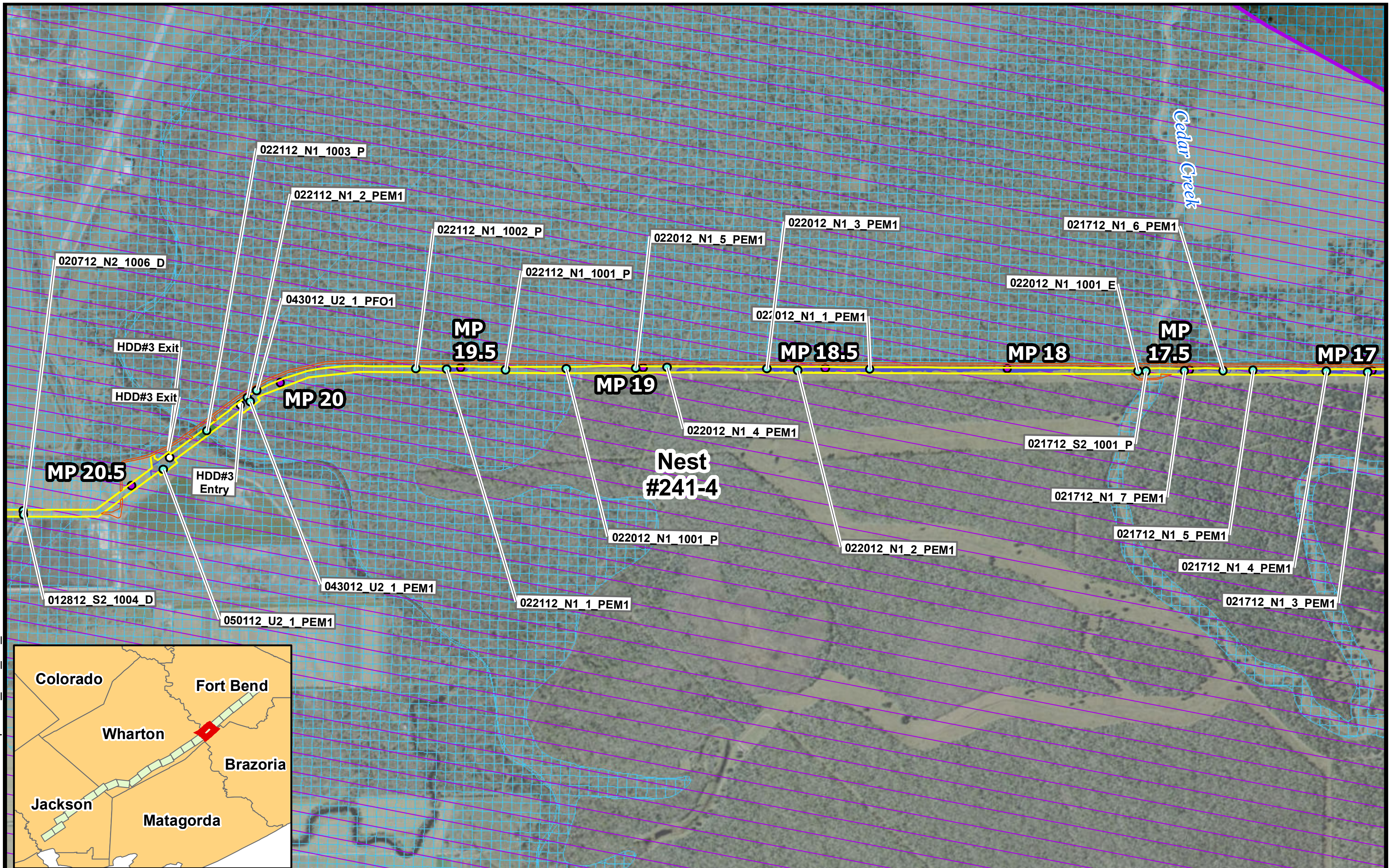

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Drainage Ditch (D)
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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	6 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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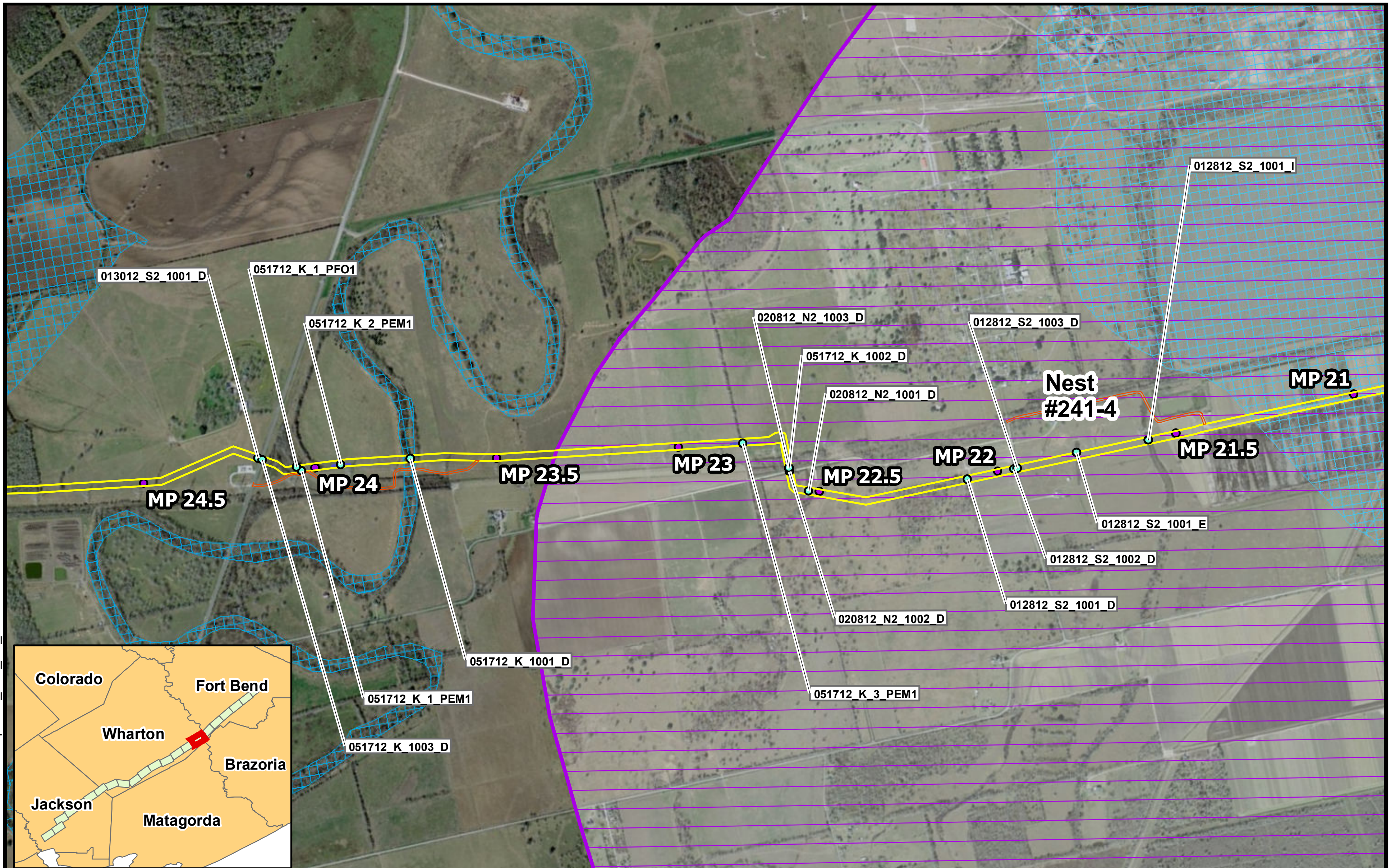

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URS

Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	7 of 22

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Q3 floodplain data (FEMA 1985, 1997, 2006)
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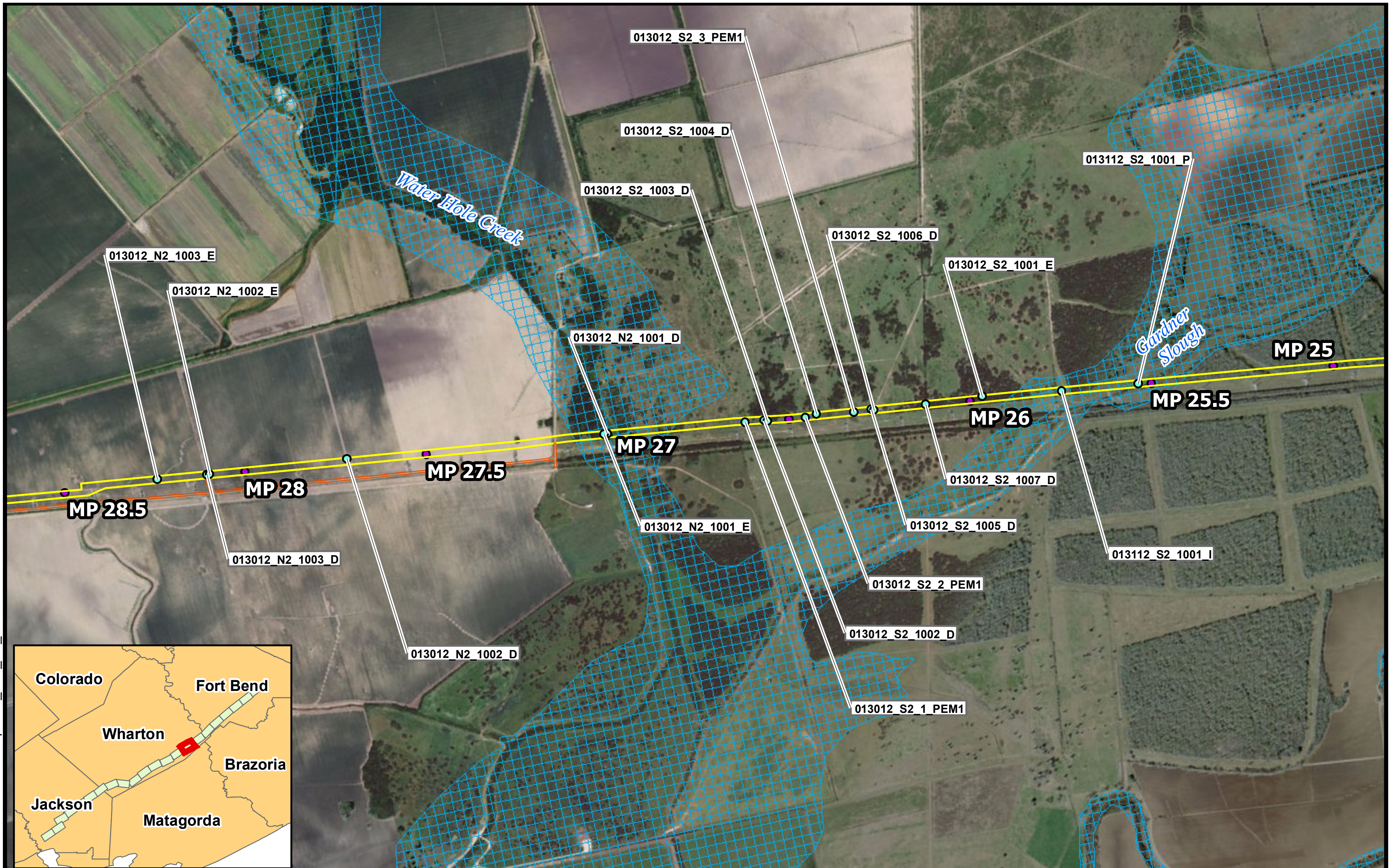

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	8 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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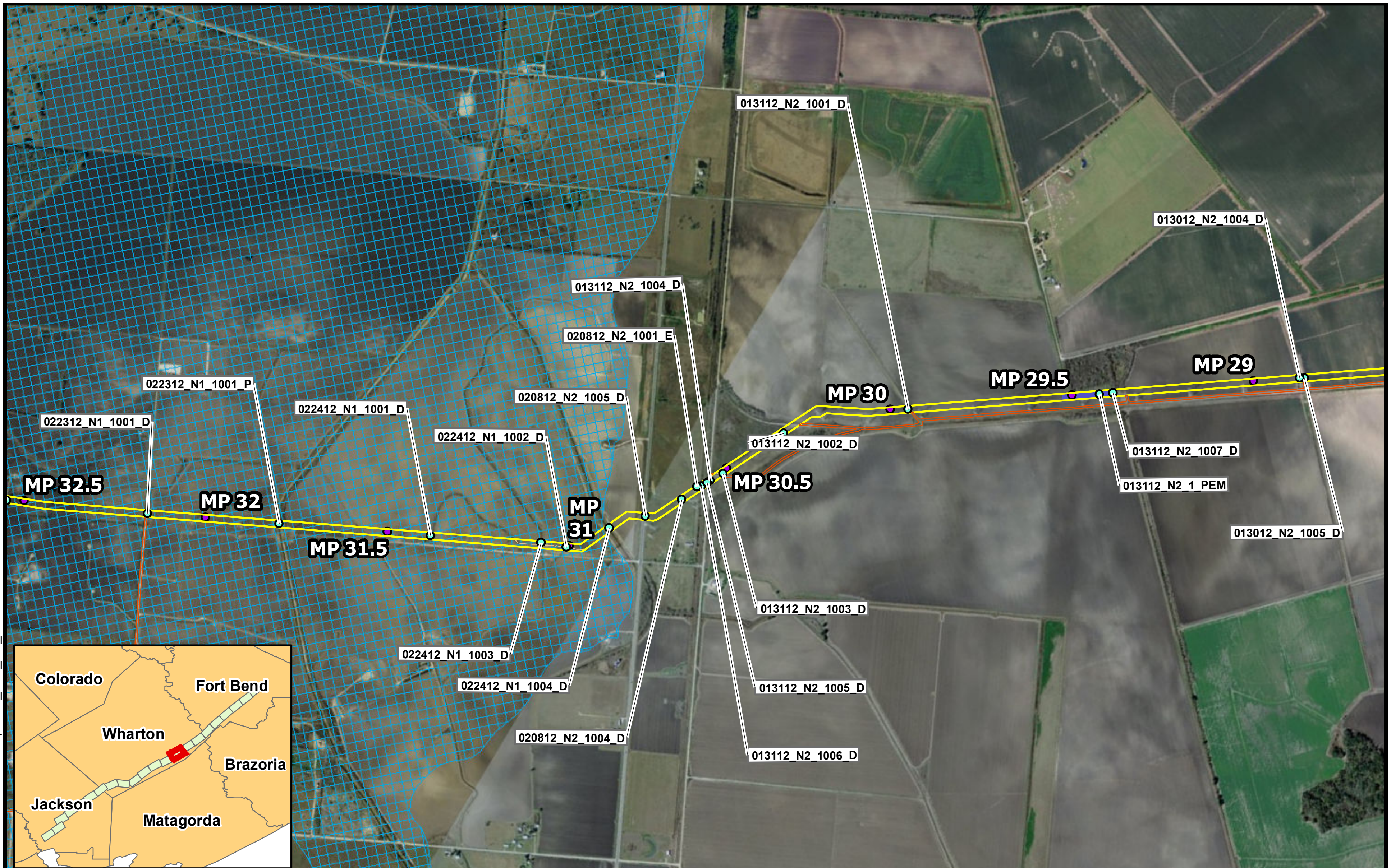

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Drainage Ditch (D)
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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	9 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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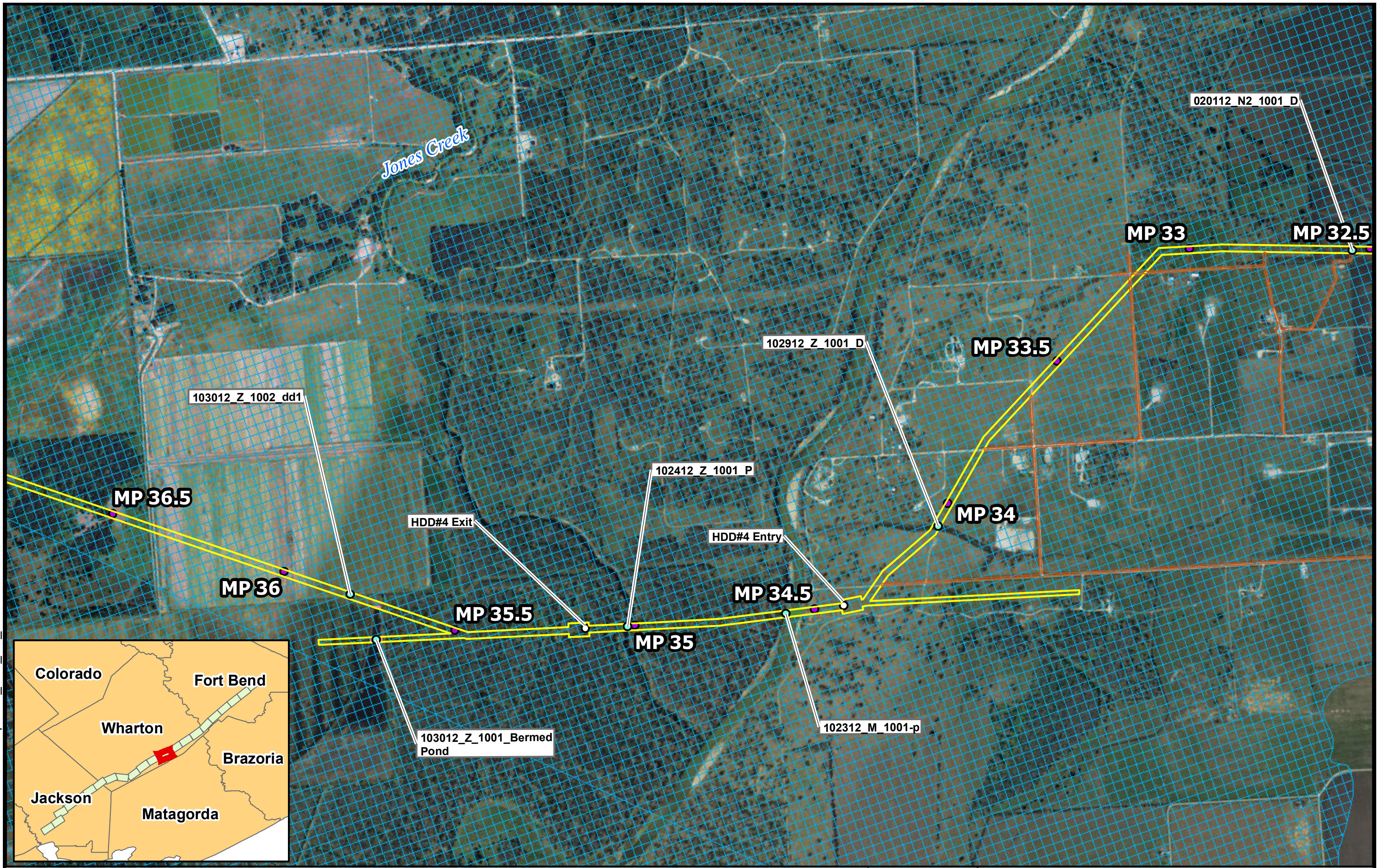

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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Q3 floodplain data (FEMA 1985, 1997, 2006)
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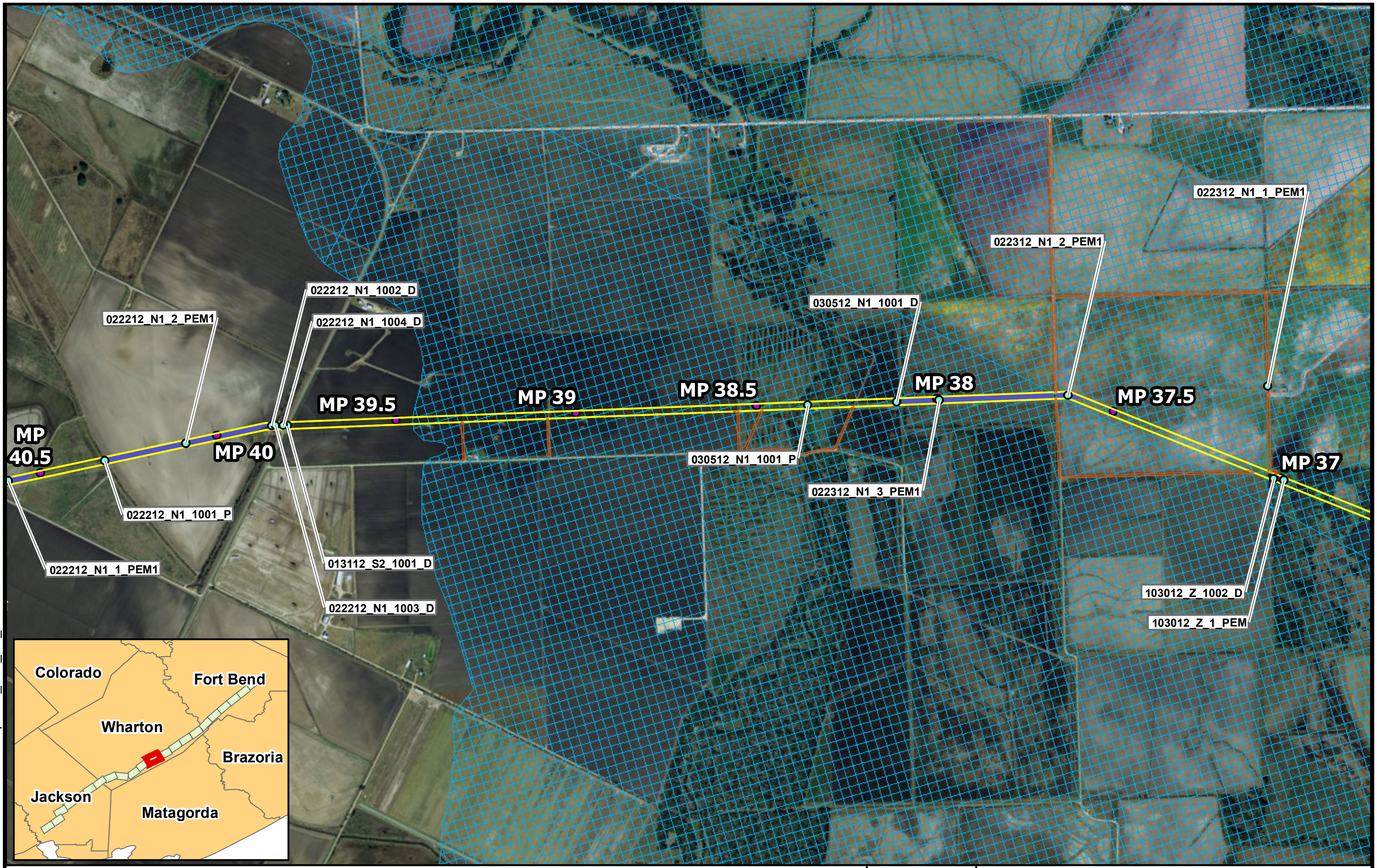

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	11 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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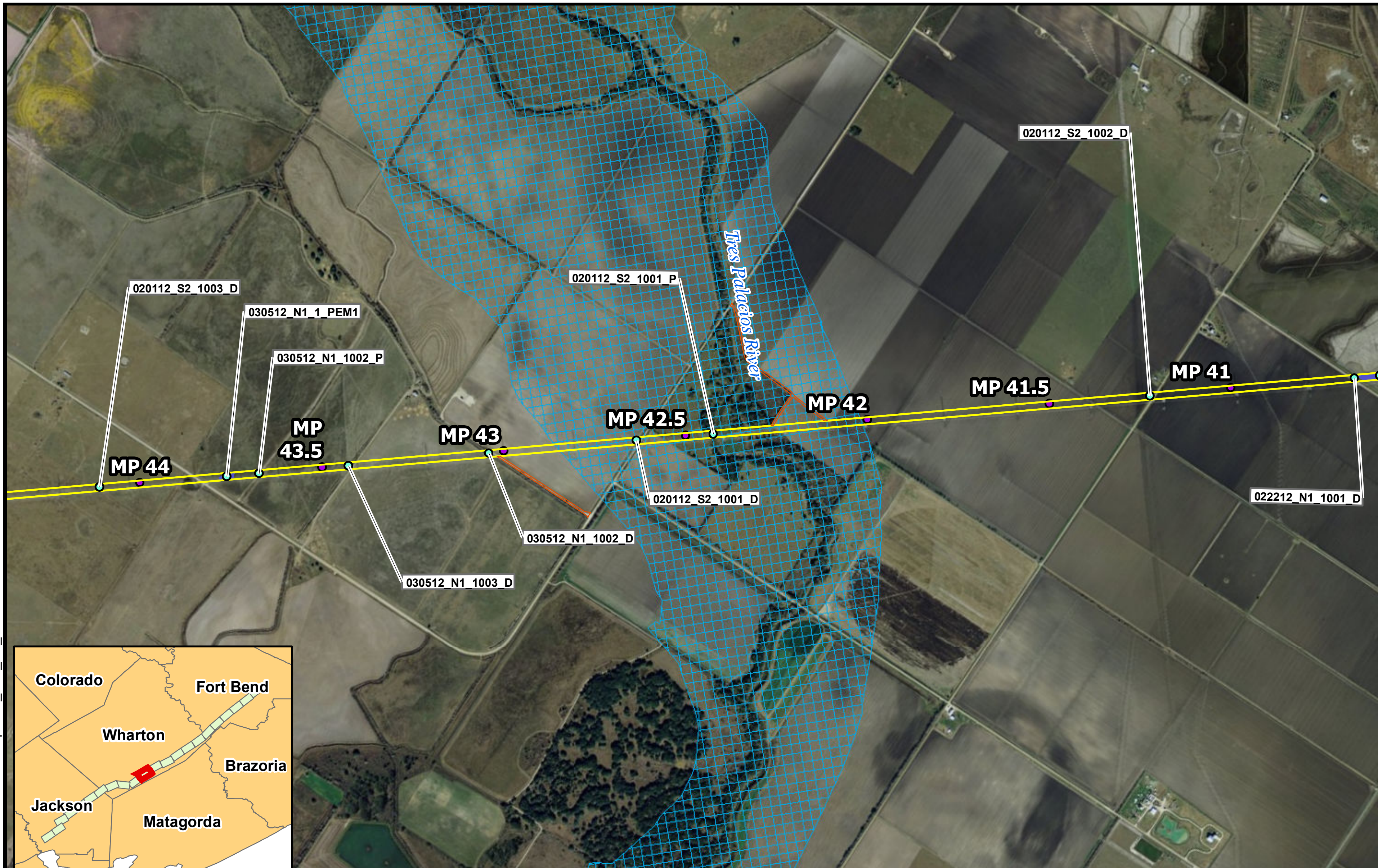

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	12 of 22

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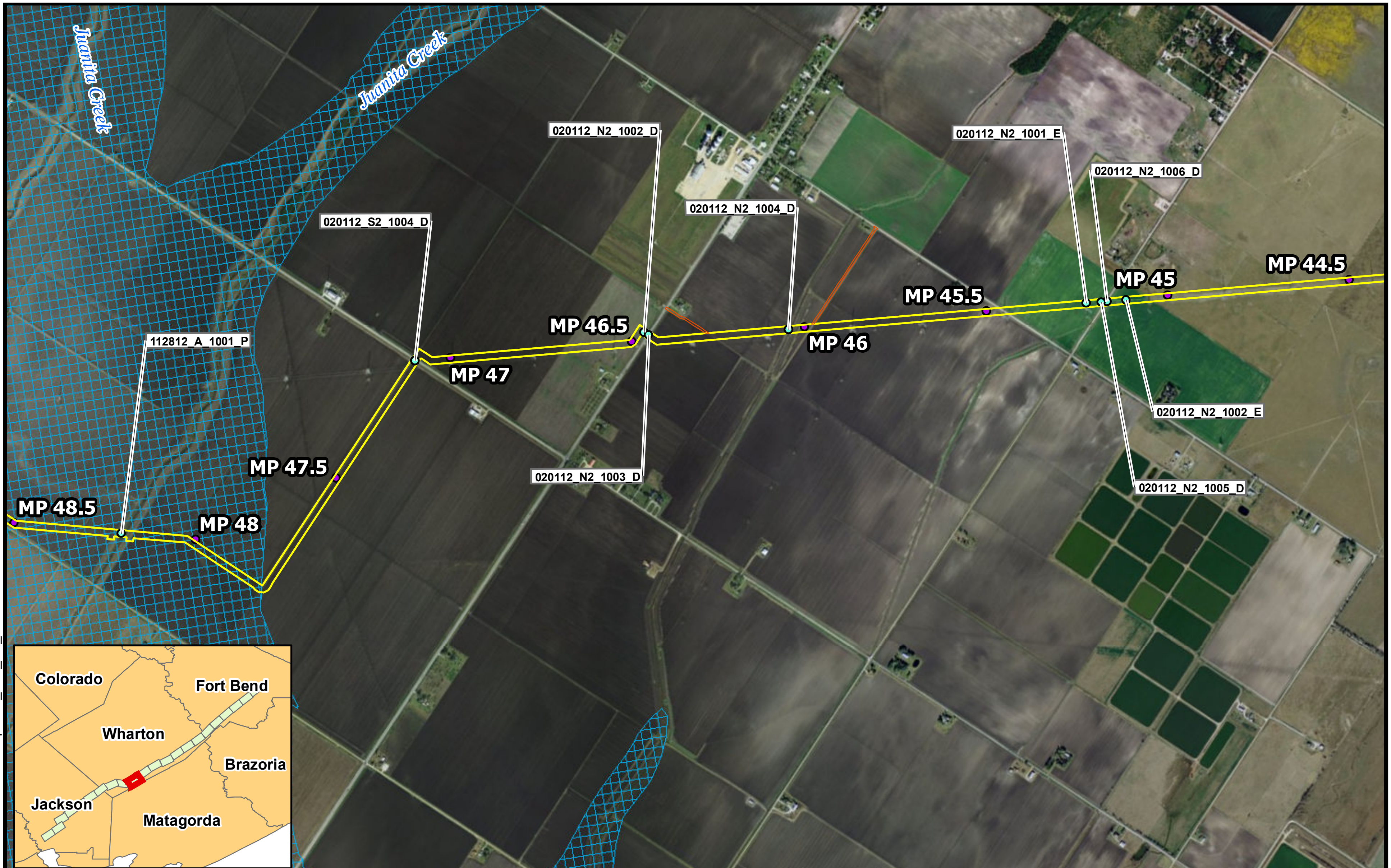

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	13 of 22

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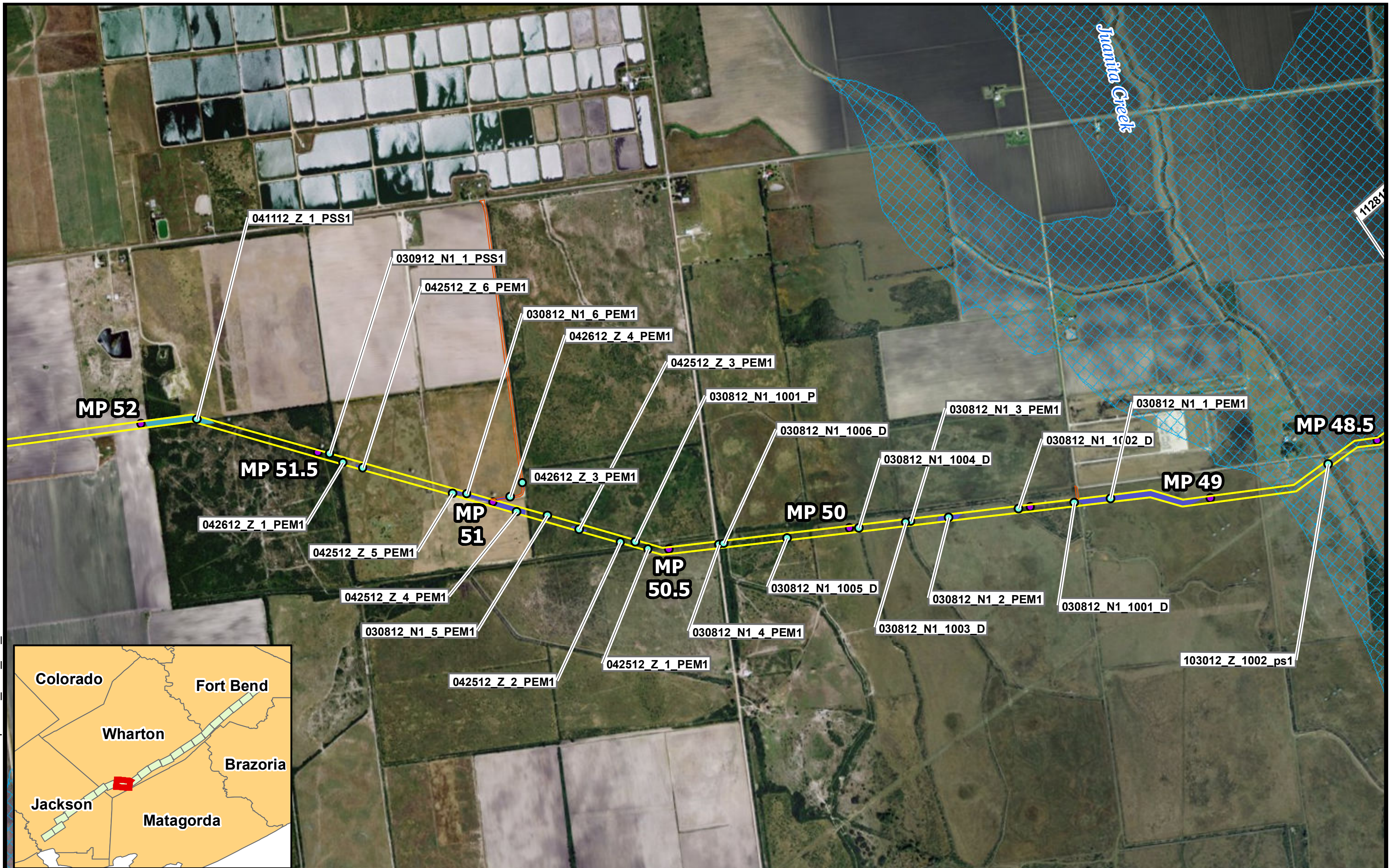

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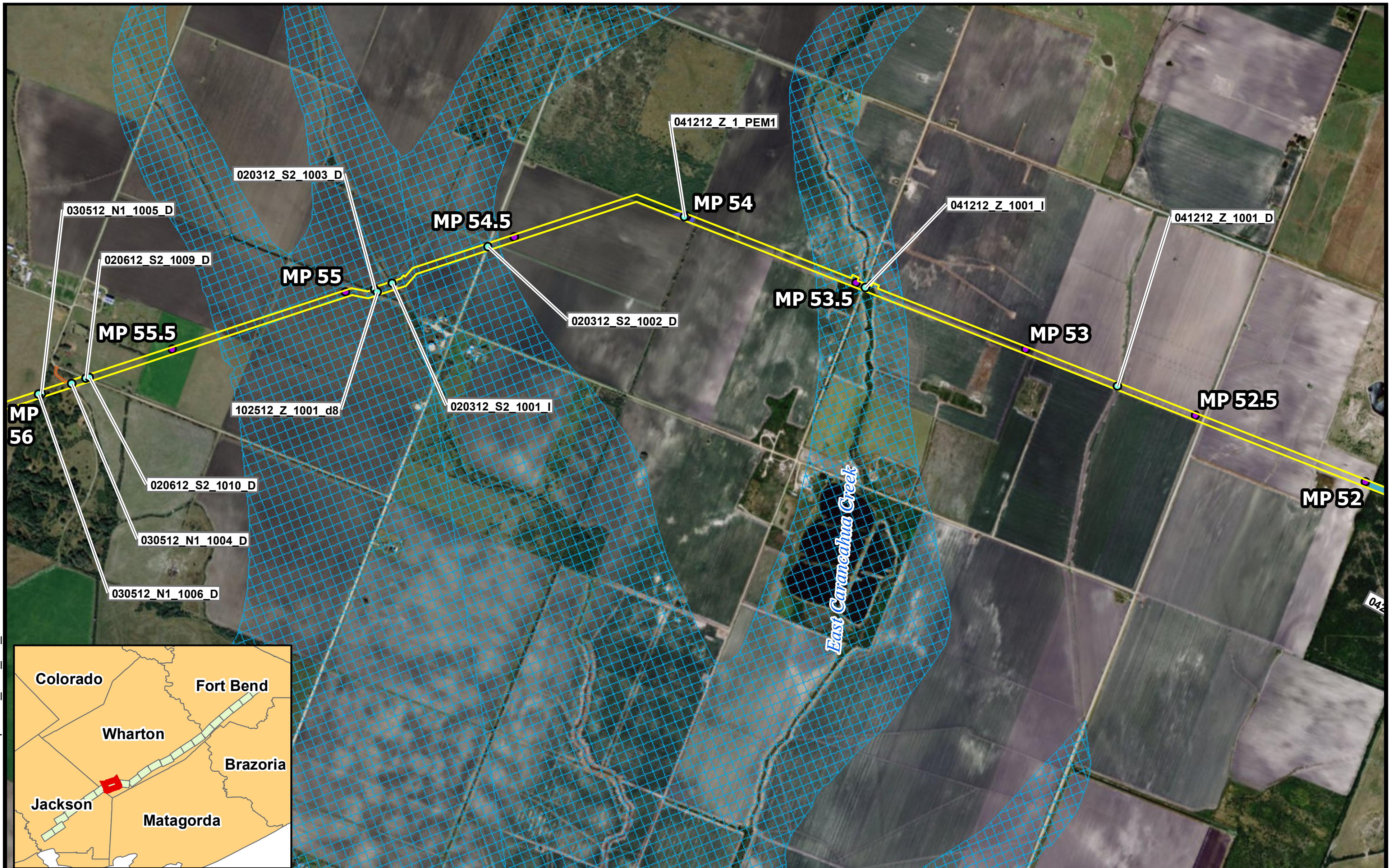

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	15 of 22

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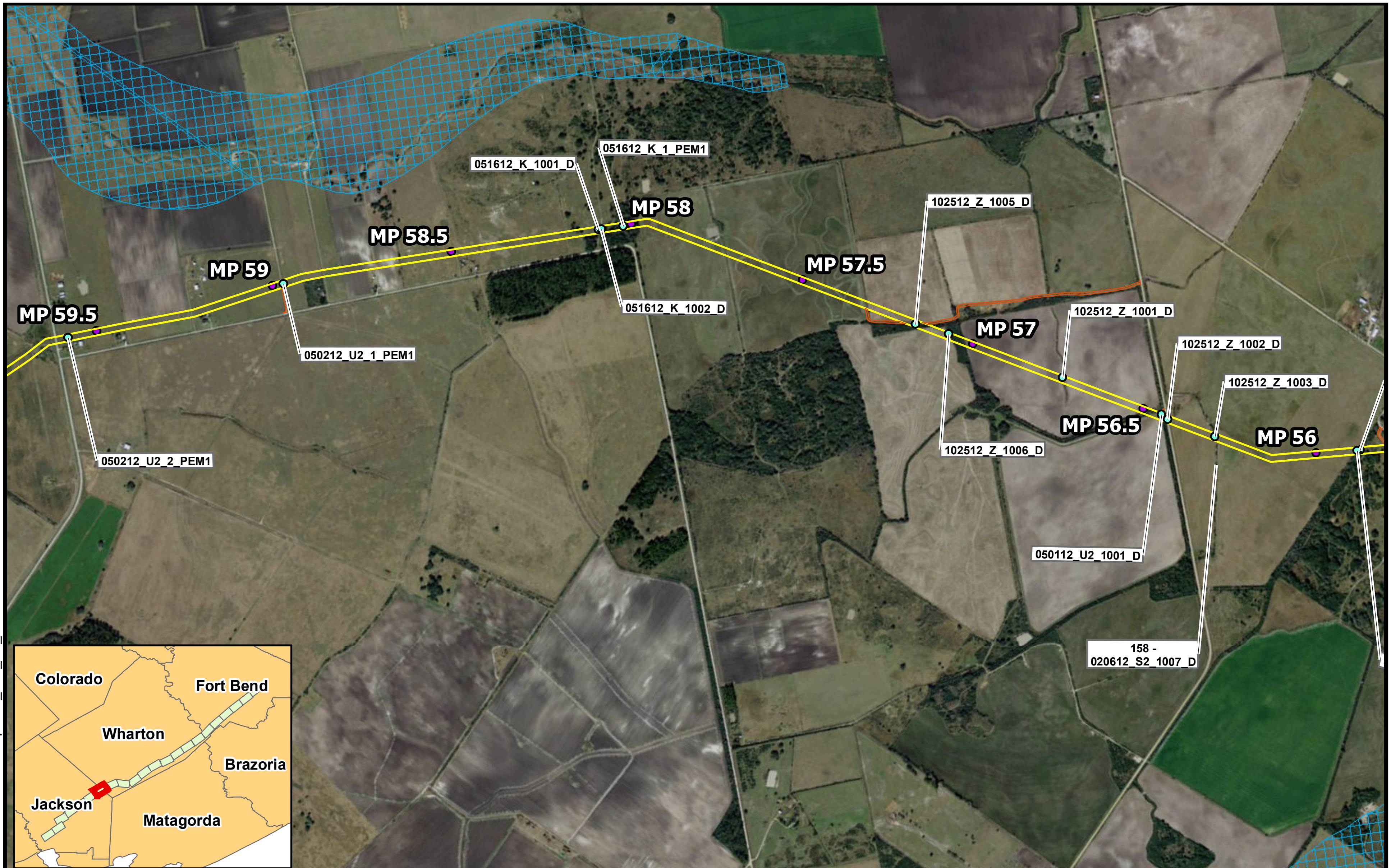

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Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	16 of 22

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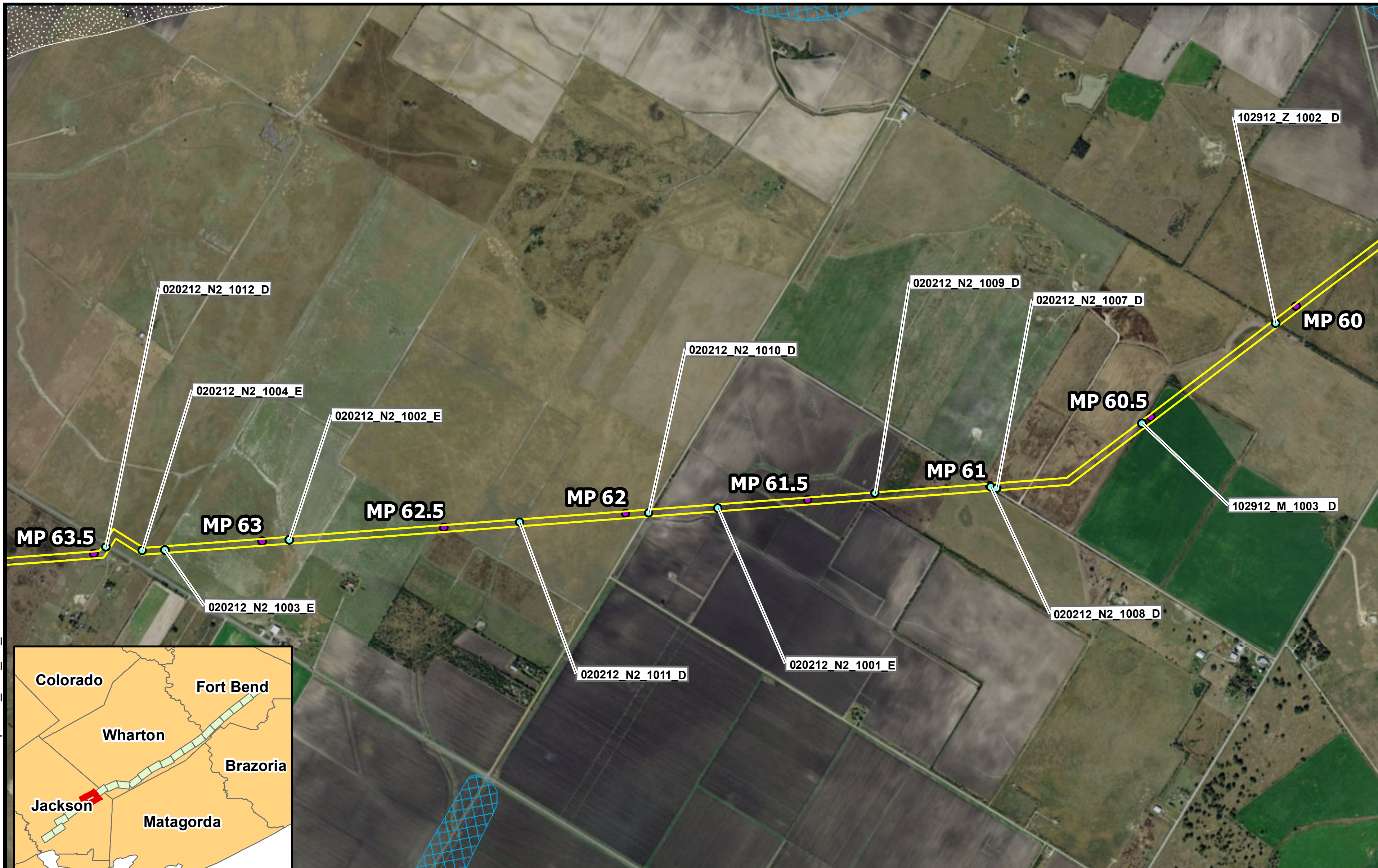

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Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	17 of 22

Q3 floodplain data (FEMA 1985, 1997, 2006)
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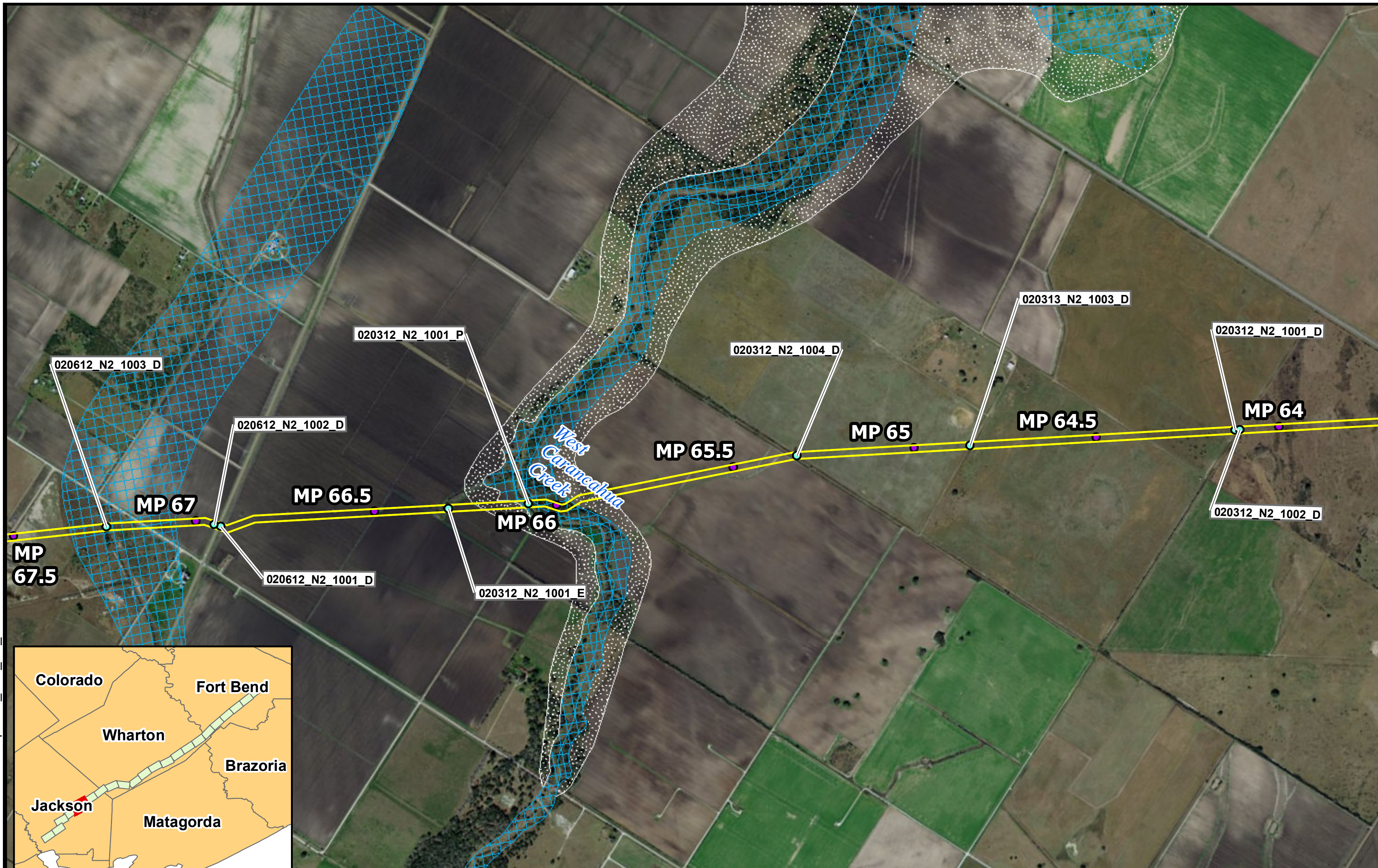

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	1/9/2013	25014860	18 of 22

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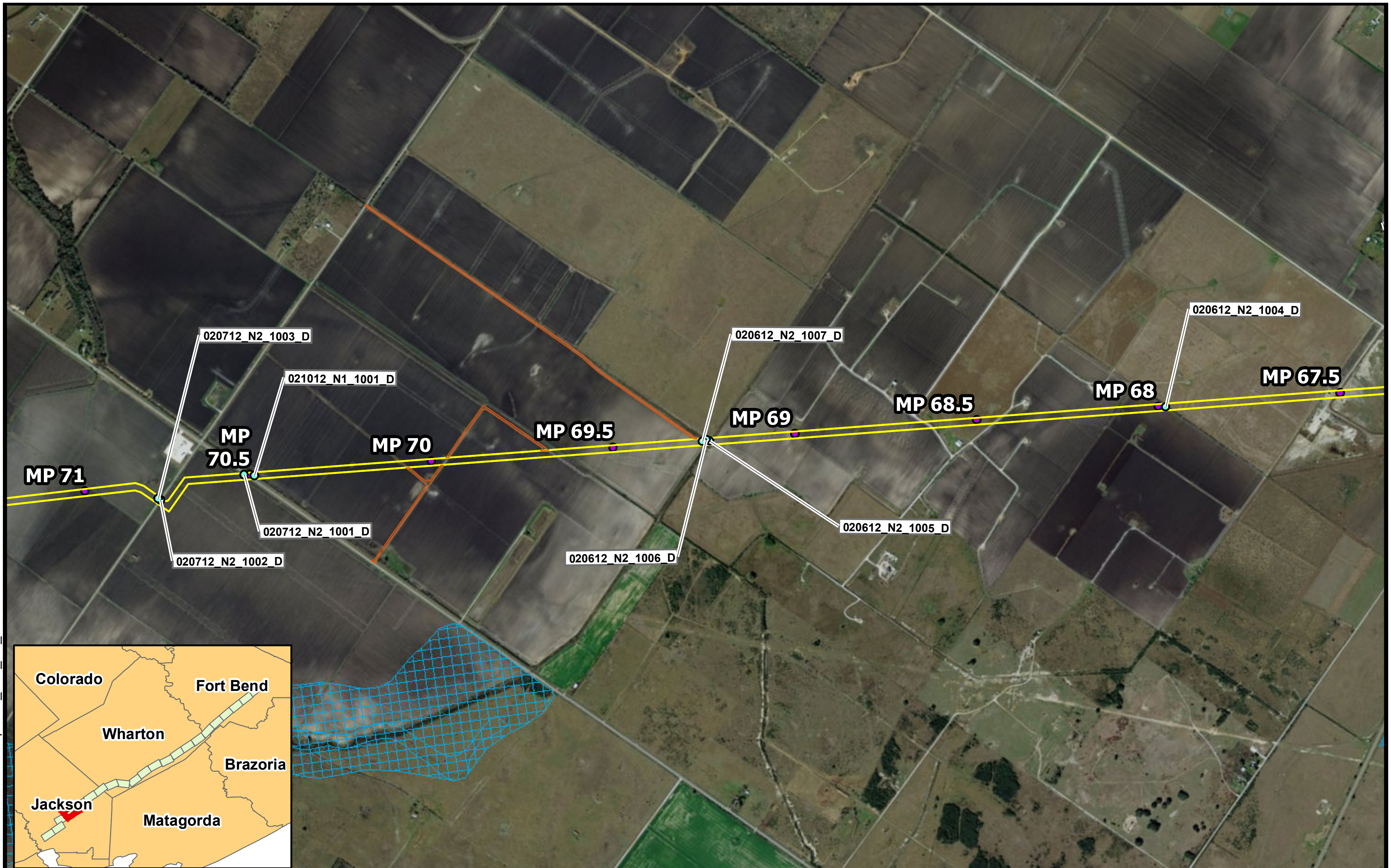

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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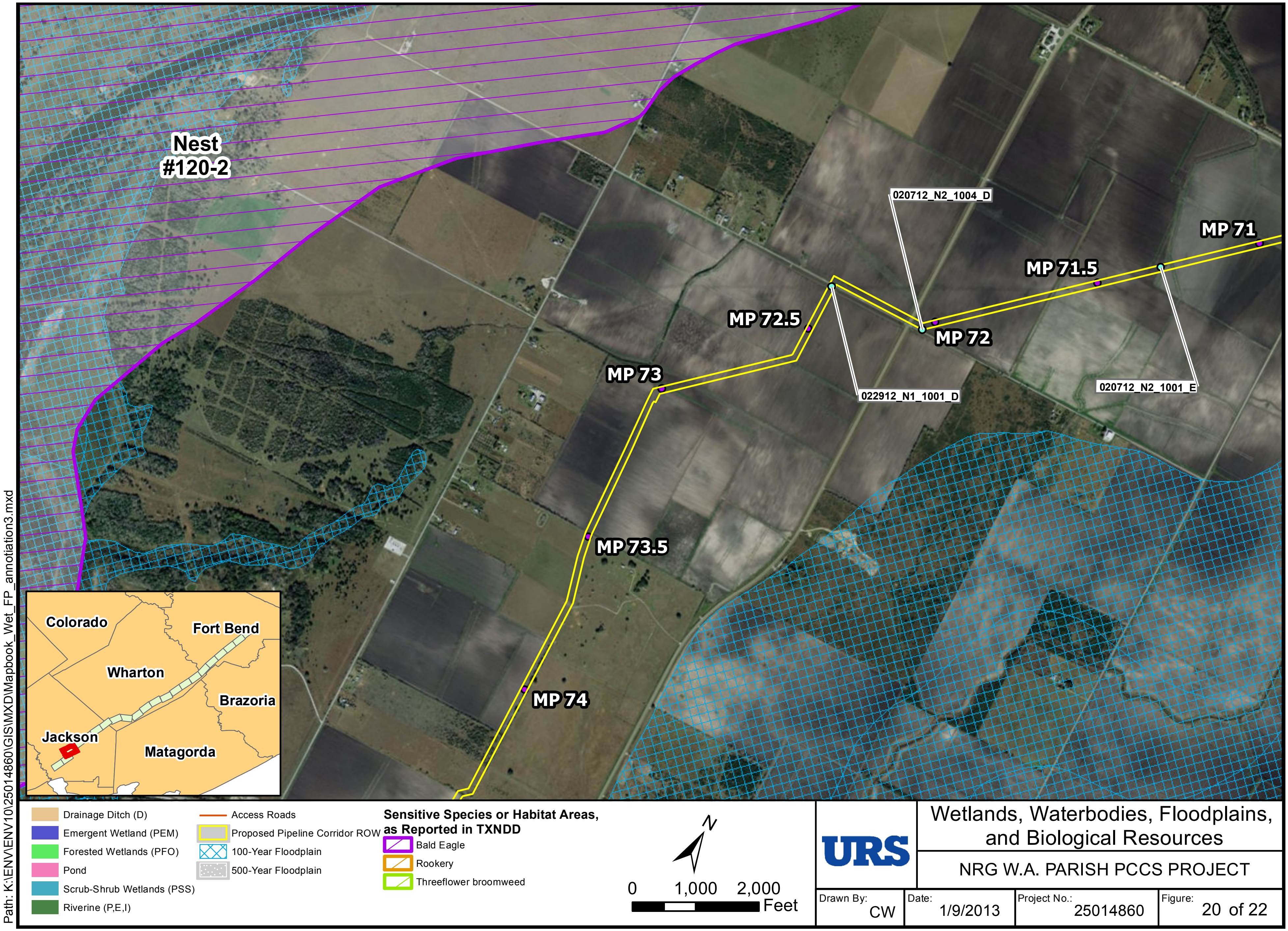

URS

Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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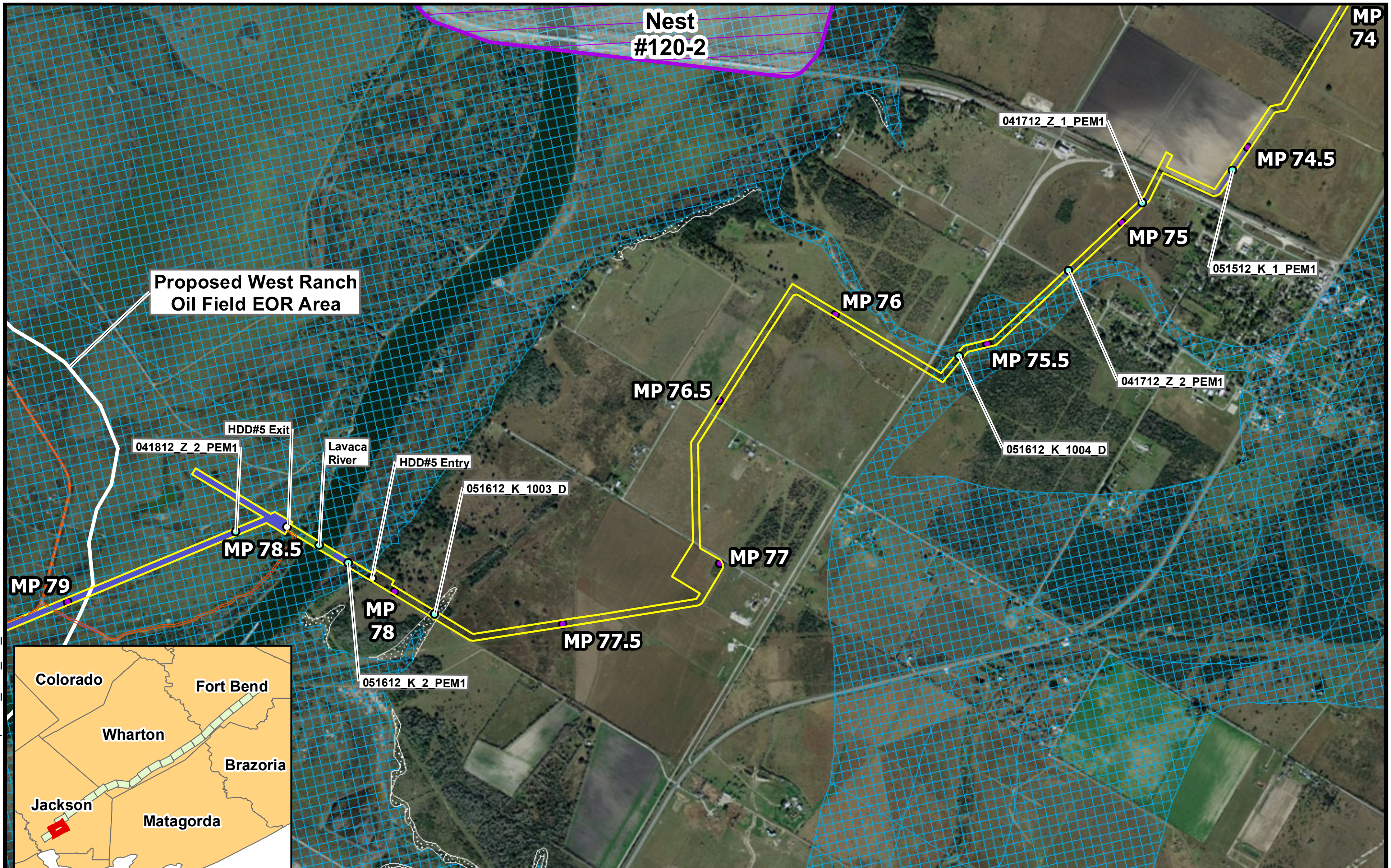

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Feet

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Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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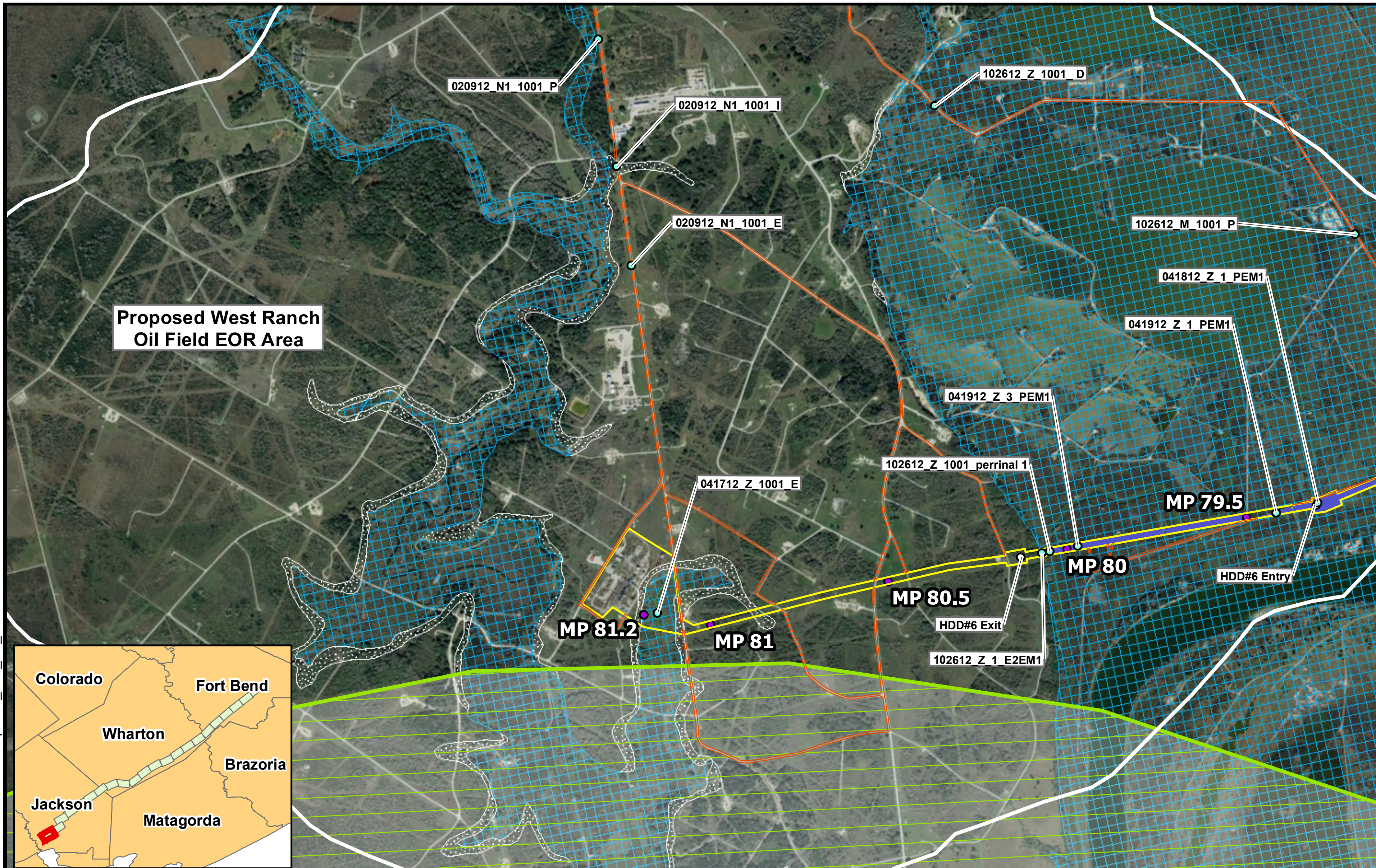
Q3 floodplain data (FEMA 1985, 1997, 2006)
TXNDD sensitive species data (TPWD 2012a)
Aerial photos (ESRI 2012)



Drainage Ditch (D)
Emergent Wetland (PEM)
Forested Wetlands (PFO)
Pond
Scrub-Shrub Wetlands (PSS)
Riverine (P,E,I)

Access Roads
Proposed Pipeline Corridor ROW
100-Year Floodplain
500-Year Floodplain

Sensitive Species or Habitat Areas, as Reported in TXNDD

Bald Eagle
Rookery
Threeflower broomweed

N

0 1,000 2,000 Feet

URS

Wetlands, Waterbodies, Floodplains, and Biological Resources

NRG W.A. PARISH PCCS PROJECT

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Q3 floodplain data (FEMA 1985, 1997, 2006)
TXNDD sensitive species data (TPWD 2012a)
Aerial photos (ESRI 2012)

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APPENDIX D-2

SUMMARY OF WETLANDS DELINEATED ALONG PROPOSED PIPELINE CORRIDOR

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Appendix D-2. Summary of Wetlands Delineated Along Proposed Pipeline Corridor

Wetland ID	Milepost	Wetland Type	Acres
042412_Z_1_PFO1	0.02	Palustrine Forested	0.23
042012_Z_1_PEM1	0.04	Palustrine Emergent	0.07
020712_S2_1_PFO1	0.21	Palustrine Forested	0.02
020712_S2_6_PEM1	0.26	Palustrine Emergent	0.08
020712_S2_5_PEM1	0.33	Palustrine Emergent	0.18
020712_S2_4_PEM1	1.20	Palustrine Emergent	2.41
020712_S2_3_PEM1	2.36	Palustrine Emergent	1.42
020712_S2_2_PEM1	2.60	Palustrine Emergent	0.48
020712_S2_1_PEM1	2.66	Palustrine Emergent	0.15
012712_S2_3_PEM1	3.38	Palustrine Emergent	4.07
012712_S2_1_PEM1	4.34	Palustrine Emergent	0.20
012612_S2_2_PEM1	5.33	Palustrine Emergent	0.55
012612_S2_1_PEM1	5.39	Palustrine Emergent	0.05
031312_N1_1_PEM1	6.96	Palustrine Emergent	0.17
012412_A_2_PEM1	8.60	Palustrine Emergent	0.07
012412_A_1_PEM1	10.29	Palustrine Emergent	0.24
022112_N1_6_PEM1	10.58	Palustrine Emergent	0.08
022112_N1_5_PEM1	10.69	Palustrine Emergent	0.04
022112_N1_4_PEM1	10.89	Palustrine Emergent	0.01
012312_A_2_PEM	11.68	Palustrine Emergent	0.09
012312_A_1_PEM	12.46	Palustrine Emergent	1.11
012312_A_1_PSS	12.61	Palustrine Scrub-Shrub	0.06
030112_N1_2_PEM1	13.28	Palustrine Emergent	0.54
030112_N1_1_PEM1	13.74	Palustrine Emergent	0.21
021412_N1_1_PEM1	13.99	Palustrine Emergent	0.00
021412_N1_2_PEM1	14.07	Palustrine Emergent	0.65
021412_N1_3_PEM1	14.25	Palustrine Emergent	0.00
021412_N1_4_PEM1	14.54	Palustrine Emergent	0.82
021412_N1_6_PEM1	14.65	Palustrine Emergent	0.03
021412_N1_7_PEM1	14.80	Palustrine Emergent	1.21
021412_N1_8_PEM1	14.92	Palustrine Emergent	0.02
021412_N1_9_PEM1	14.93	Palustrine Emergent	0.00
021512_N1_1_PEM1	15.24	Palustrine Emergent	0.11
021512_N1_2_PEM1	15.31	Palustrine Emergent	0.02
021512_N1_3_PEM1	15.32	Palustrine Emergent	0.04
021512_N1_4_PEM1	15.37	Palustrine Emergent	0.06
021512_N1_5_PEM1	15.41	Palustrine Emergent	0.04
021512_N1_6_PEM1	15.44	Palustrine Emergent	0.02
021512_N1_7_PEM1	15.47	Palustrine Emergent	0.11
021512_N1_9_PEM1	15.59	Palustrine Emergent	0.05
021512_N1_8_PEM1	15.60	Palustrine Emergent	0.18
021612_N1_1_PEM1	15.77	Palustrine Emergent	0.57
021612_N1_2_PEM1	15.94	Palustrine Emergent	0.83

Appendix D-2. Summary of Wetlands Delineated Along Proposed Pipeline Corridor

Wetland ID	Milepost	Wetland Type	Acres
021612_N1_3_PEM1	16.07	Palustrine Emergent	0.05
021612_N1_4_PEM1	16.11	Palustrine Emergent	0.02
021612_N1_5_PEM1	16.15	Palustrine Emergent	0.04
021612_N1_6_PEM1	16.25	Palustrine Emergent	0.50
021612_N1_7_PEM1	16.55	Palustrine Emergent	0.03
021612_N1_8_PEM1	16.59	Palustrine Emergent	0.03
021612_N1_9_PEM1	16.62	Palustrine Emergent	0.03
021712_N1_1_PEM1	16.71	Palustrine Emergent	0.16
021712_N1_2_PEM1	16.78	Palustrine Emergent	0.79
021712_N1_3_PEM1	17.01	Palustrine Emergent	1.10
021712_N1_4_PEM1	17.12	Palustrine Emergent	0.31
021712_N1_5_PEM1	17.33	Palustrine Emergent	0.72
021712_N1_6_PEM1	17.41	Palustrine Emergent	0.24
021712_N1_7_PEM1	17.51	Palustrine Emergent	0.27
022012_N1_1_PEM1	18.38	Palustrine Emergent	4.61
022012_N1_2_PEM1	18.58	Palustrine Emergent	0.05
022012_N1_3_PEM1	18.66	Palustrine Emergent	1.25
022012_N1_4_PEM1	18.93	Palustrine Emergent	0.01
022012_N1_5_PEM1	19.02	Palustrine Emergent	0.02
022112_N1_1_PEM1	19.54	Palustrine Emergent	0.49
043012_U2_1_PFO1	20.07	Palustrine Forested	0.01
043012_U2_1_PEM1	20.10	Palustrine Emergent	0.18
022112_N1_2_PEM1	20.10	Palustrine Emergent	0.28
050112_U2_1_PEM1	20.40	Palustrine Emergent	0.23
051712_K_3_PEM1	22.82	Palustrine Emergent	0.28
051712_K_2_PEM1	23.93	Palustrine Emergent	0.27
051712_K_1_PEM1	24.04	Palustrine Emergent	0.02
051712_K_1_PFO1	24.05	Palustrine Forested	0.05
013012_S2_3_PEM1	26.32	Palustrine Emergent	0.35
013012_S2_2_PEM1	26.45	Palustrine Emergent	0.24
013012_S2_1_PEM1	26.62	Palustrine Emergent	0.11
013112_N2_1_PEM	29.42	Palustrine Emergent	1.57
103012_Z_1_PEM	36.99	Palustrine Emergent	0.30
022312_N1_1_PEM1	37.13	Palustrine Emergent	0.09
022312_N1_2_PEM1	37.64	Palustrine Emergent	0.78
022312_N1_3_PEM1	37.99	Palustrine Emergent	4.95
022212_N1_2_PEM1	40.09	Palustrine Emergent	5.33
022212_N1_1_PEM1	40.59	Palustrine Emergent	1.38
030512_N1_1_PEM1	43.76	Palustrine Emergent	0.46
030812_N1_1_PEM1	49.37	Palustrine Emergent	3.98
030812_N1_2_PEM1	49.82	Palustrine Emergent	0.73
030812_N1_3_PEM1	49.92	Palustrine Emergent	0.17
030812_N1_4_PEM1	50.45	Palustrine Emergent	0.07

Appendix D-2. Summary of Wetlands Delineated Along Proposed Pipeline Corridor

Wetland ID	Milepost	Wetland Type	Acres
042512_Z_1_PEM1	50.64	Palustrine Emergent	0.12
042512_Z_2_PEM1	50.72	Palustrine Emergent	0.07
042512_Z_3_PEM1	50.84	Palustrine Emergent	0.22
030812_N1_5_PEM1	50.94	Palustrine Emergent	0.01
042512_Z_4_PEM1	51.02	Palustrine Emergent	0.50
042612_Z_3_PEM1	51.03	Palustrine Emergent	0.06
042612_Z_4_PEM1	51.05	Palustrine Emergent	0.06
030812_N1_6_PEM1	51.16	Palustrine Emergent	1.55
042512_Z_5_PEM1	51.20	Palustrine Emergent	0.11
042512_Z_6_PEM1	51.46	Palustrine Emergent	0.20
042612_Z_1_PEM1	51.52	Palustrine Emergent	0.14
030912_N1_1_PSS1	51.56	Palustrine Scrub-Shrub	0.01
041112_Z_1_PSS1	51.93	Palustrine Scrub-Shrub	2.12
041212_Z_1_PEM1	54.09	Palustrine Emergent	0.65
051612_K_1_PEM1	58.11	Palustrine Emergent	0.08
050212_U2_1_PEM1	59.06	Palustrine Emergent	0.03
050212_U2_2_PEM1	59.67	Palustrine Emergent	0.18
051512_K_1_PEM1	74.66	Palustrine Emergent	0.51
041712_Z_1_PEM1	75.01	Palustrine Emergent	0.41
041712_Z_2_PEM1	75.29	Palustrine Emergent	0.22
051612_K_2_PEM1	78.24	Palustrine Emergent	0.74
041812_Z_2_PEM1	78.59	Palustrine Emergent	12.33
041812_Z_1_PEM1	79.39	Palustrine Emergent	4.84
041912_Z_1_PEM1	79.51	Palustrine Emergent	0.54
041912_Z_3_PEM1	80.06	Palustrine Emergent	6.29
102612_Z_1_E2EM1	80.16	Palustrine Emergent	0.04
Total Palustrine Emergent			***79.4***
Total Palustrine Scrub-Shrub			***2.2***
Total Palustrine Forested			***0.3***
Total Wetlands			**81.9**

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APPENDIX D-3

LAND COVER/HABITAT MAPS

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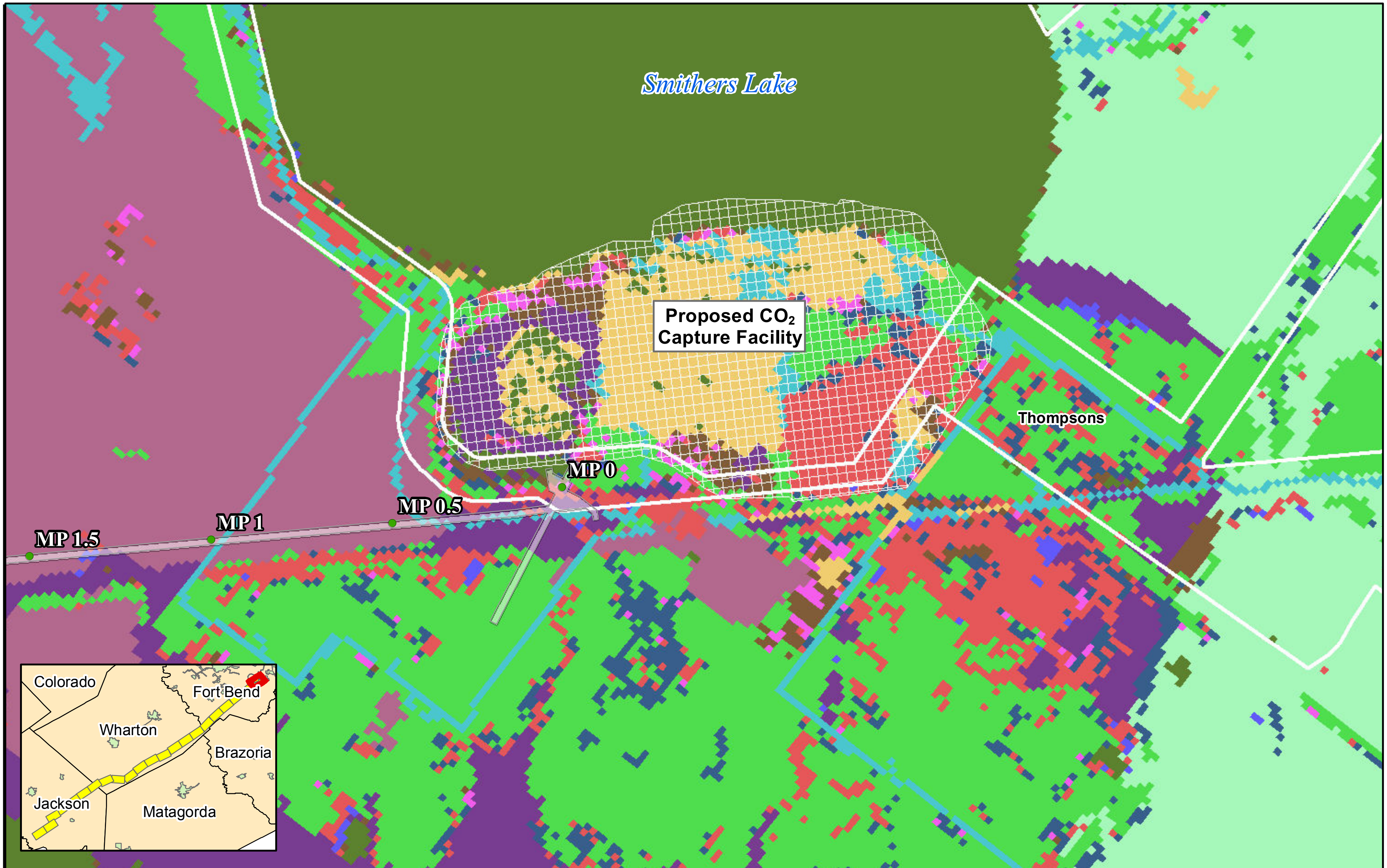

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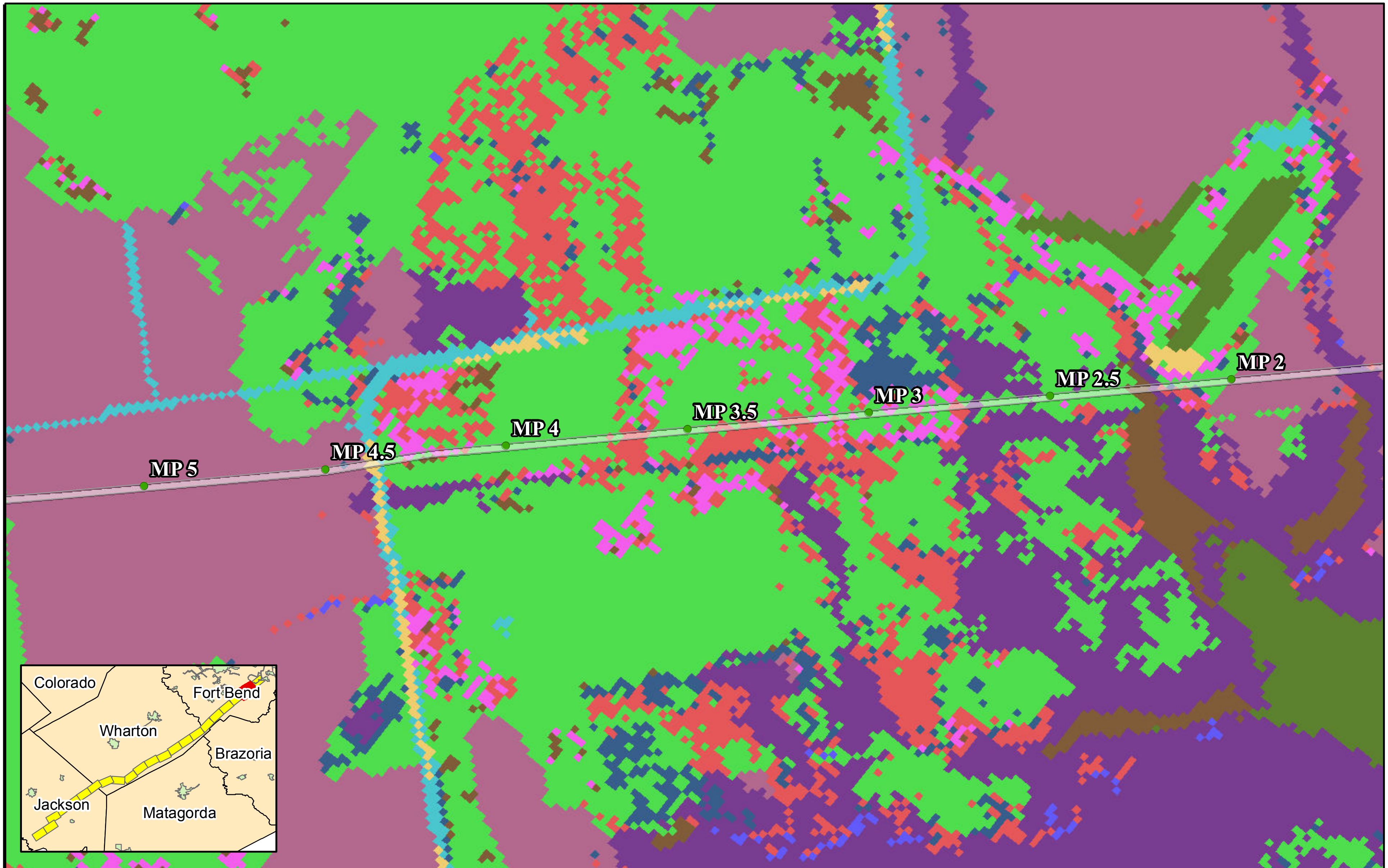
URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	1 of 22

Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	2 of 22

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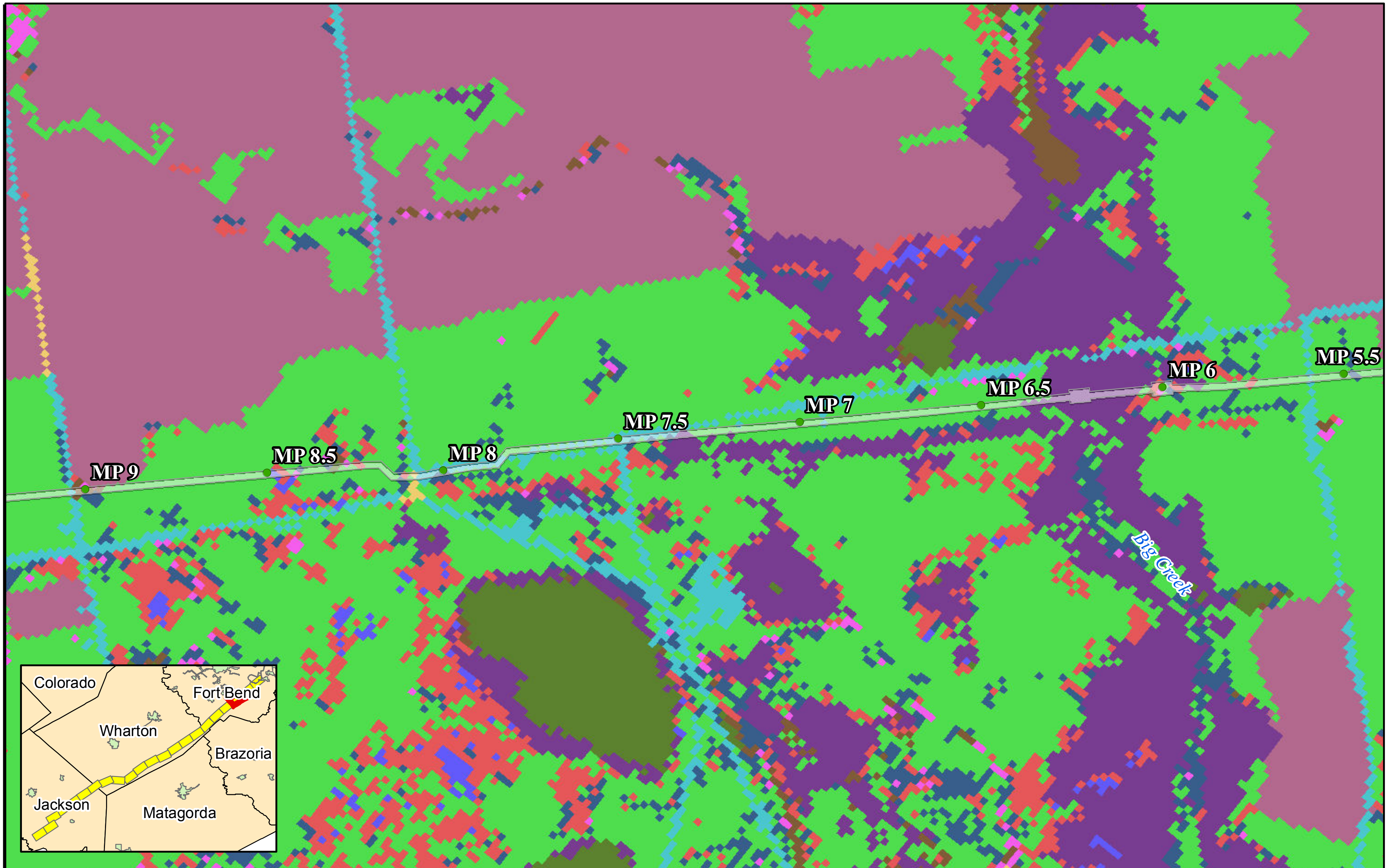
Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

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Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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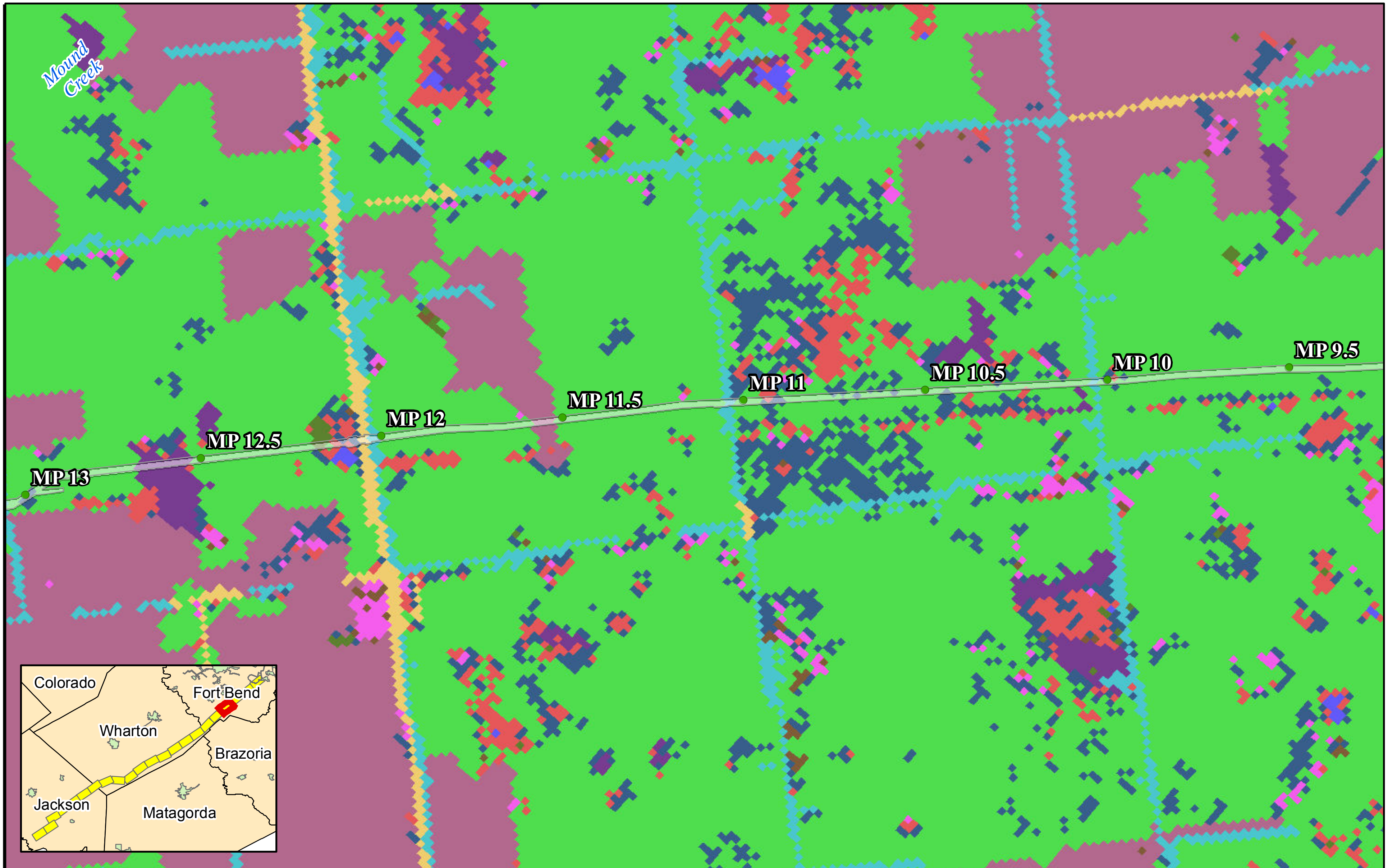
Land Cover/Habitat (NatureServe 2012)



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- Proposed Pipeline Construction ROW
- Milepost Marker
- Agriculture - Cultivated Crops and Irrigated Agriculture
- Agriculture - Pasture/Hay
- Developed-Open Space
- Developed/Disturbed
- Forest & Woodland
- Modified/Managed Southern Tall Grassland
- Open Water
- Semi-Desert
- Shrubland & Grassland
- Successional Shrub/Scrub
- West Gulf Coastal Plain Large River Floodplain Forest
- West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

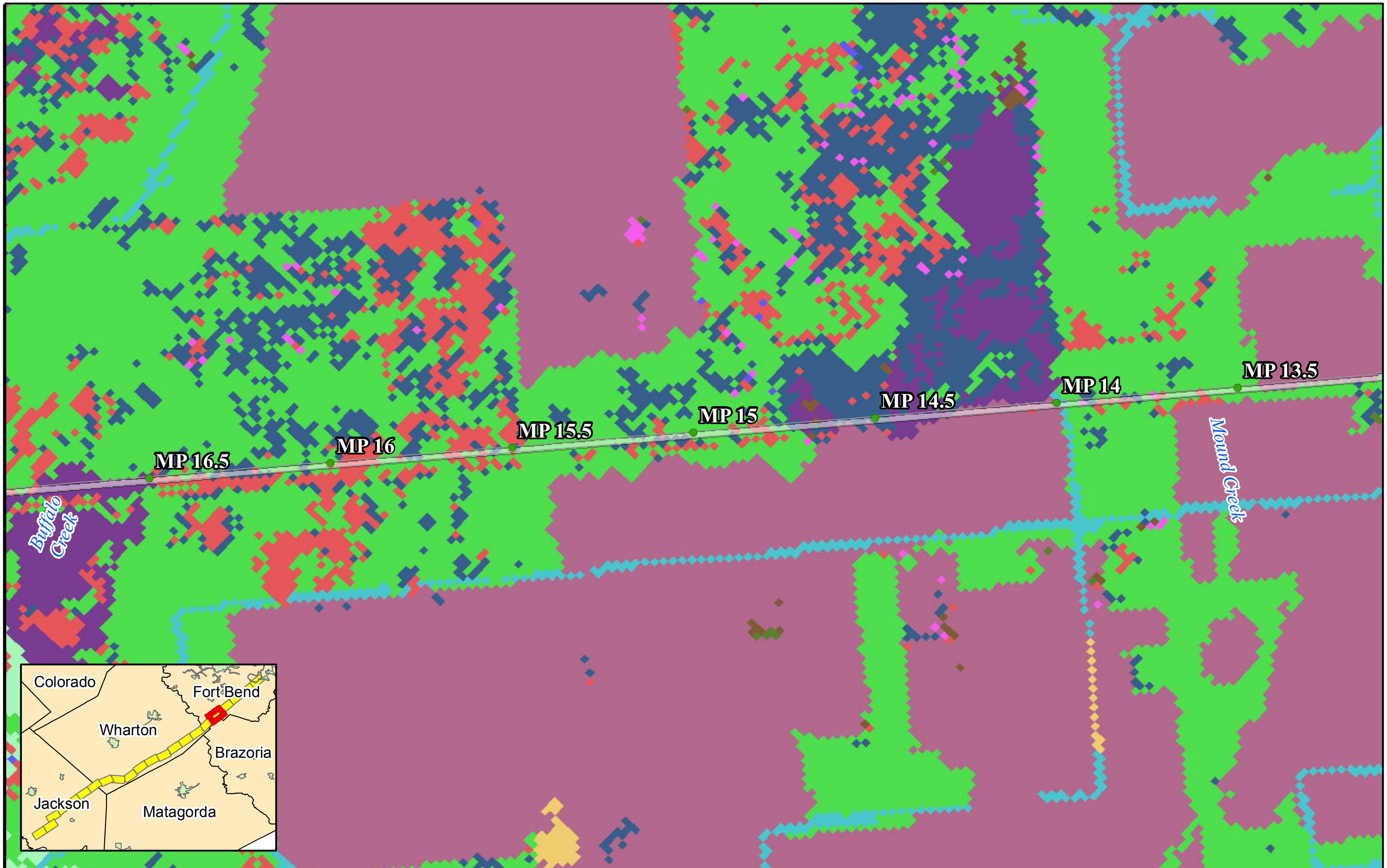
URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	4 of 22

Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

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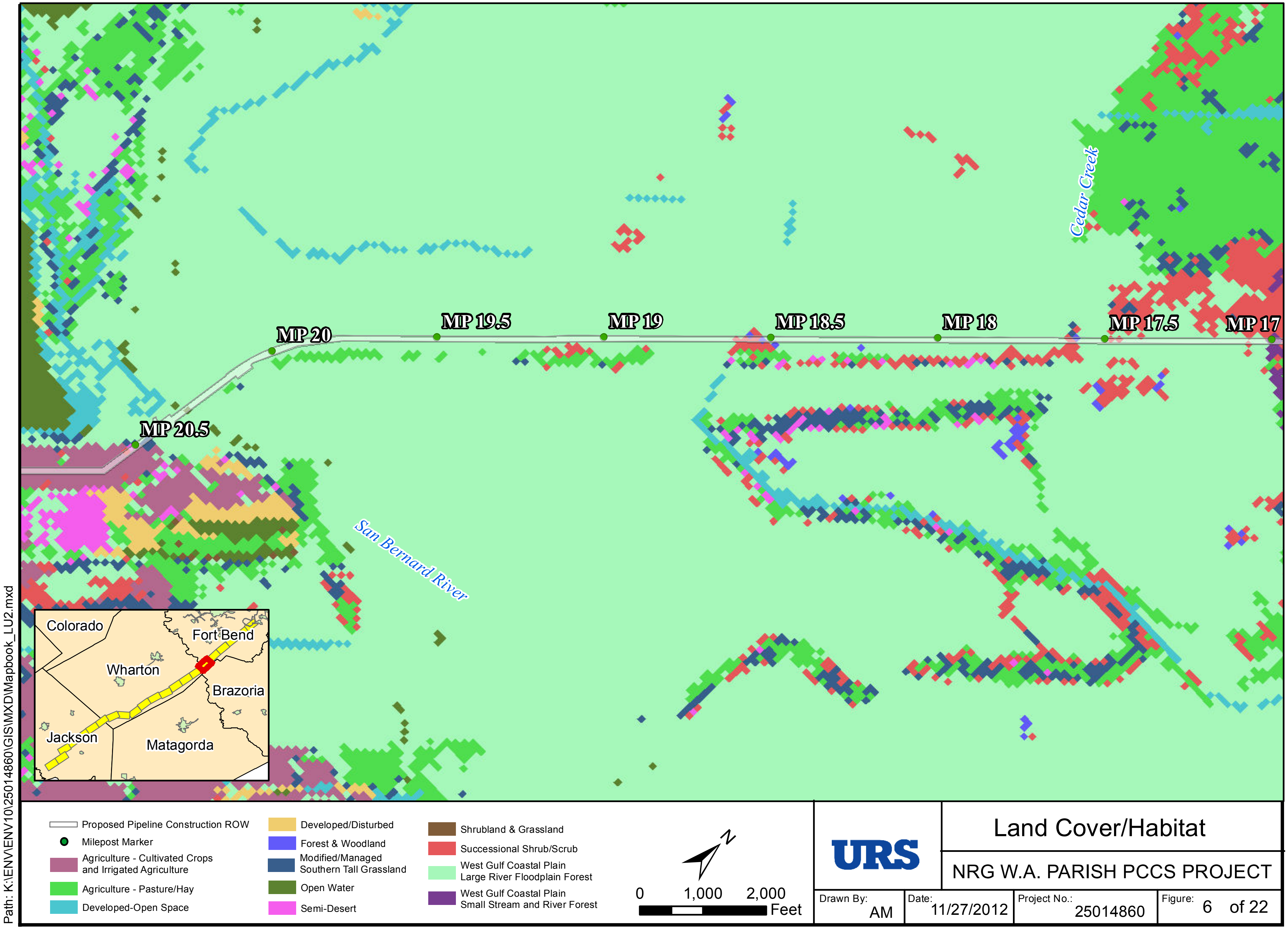
Land Cover/Habitat (NatureServe 2012)



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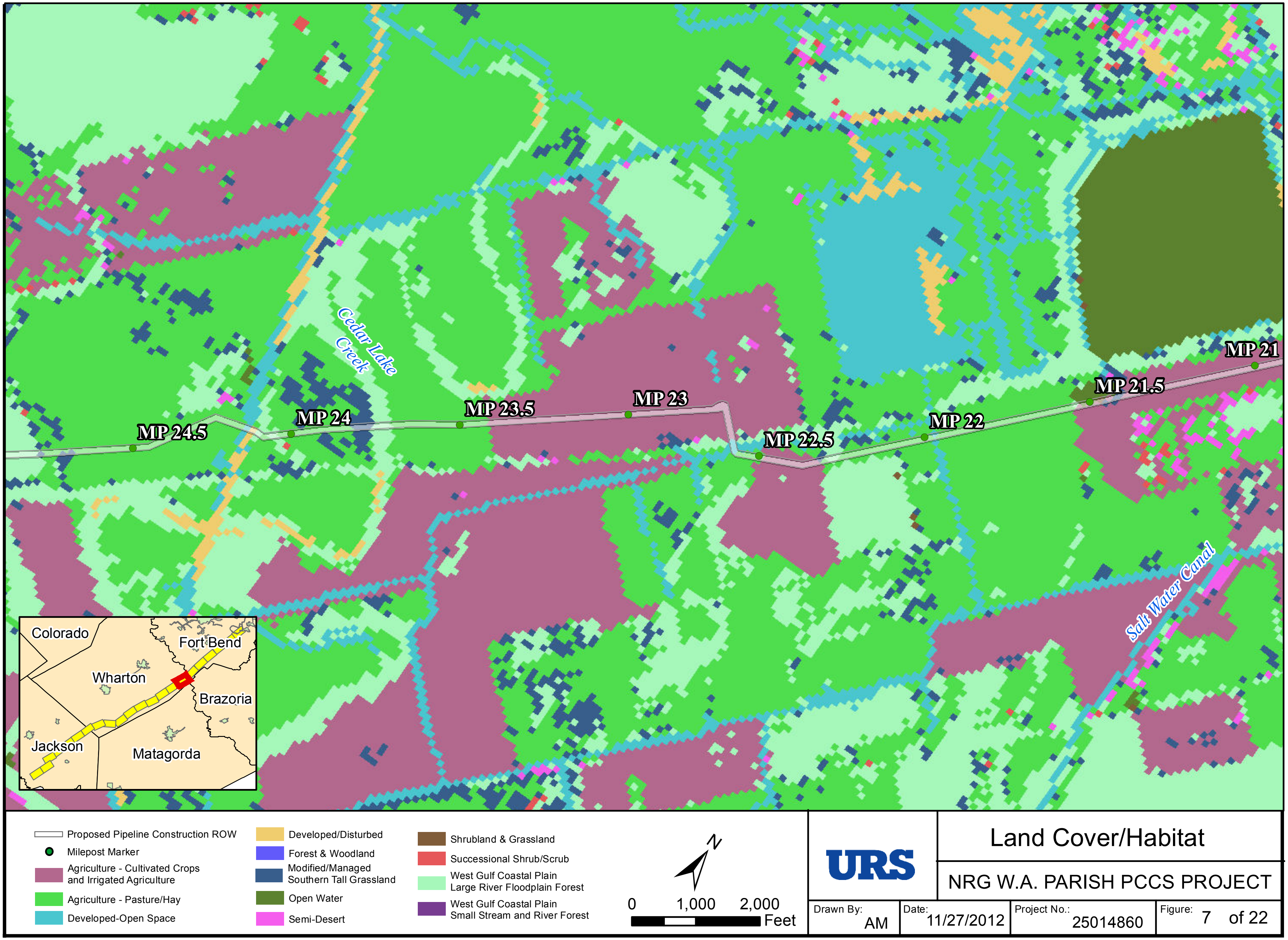
Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	6 of 22

Land Cover/Habitat (NatureServe 2012)



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Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	7 of 22

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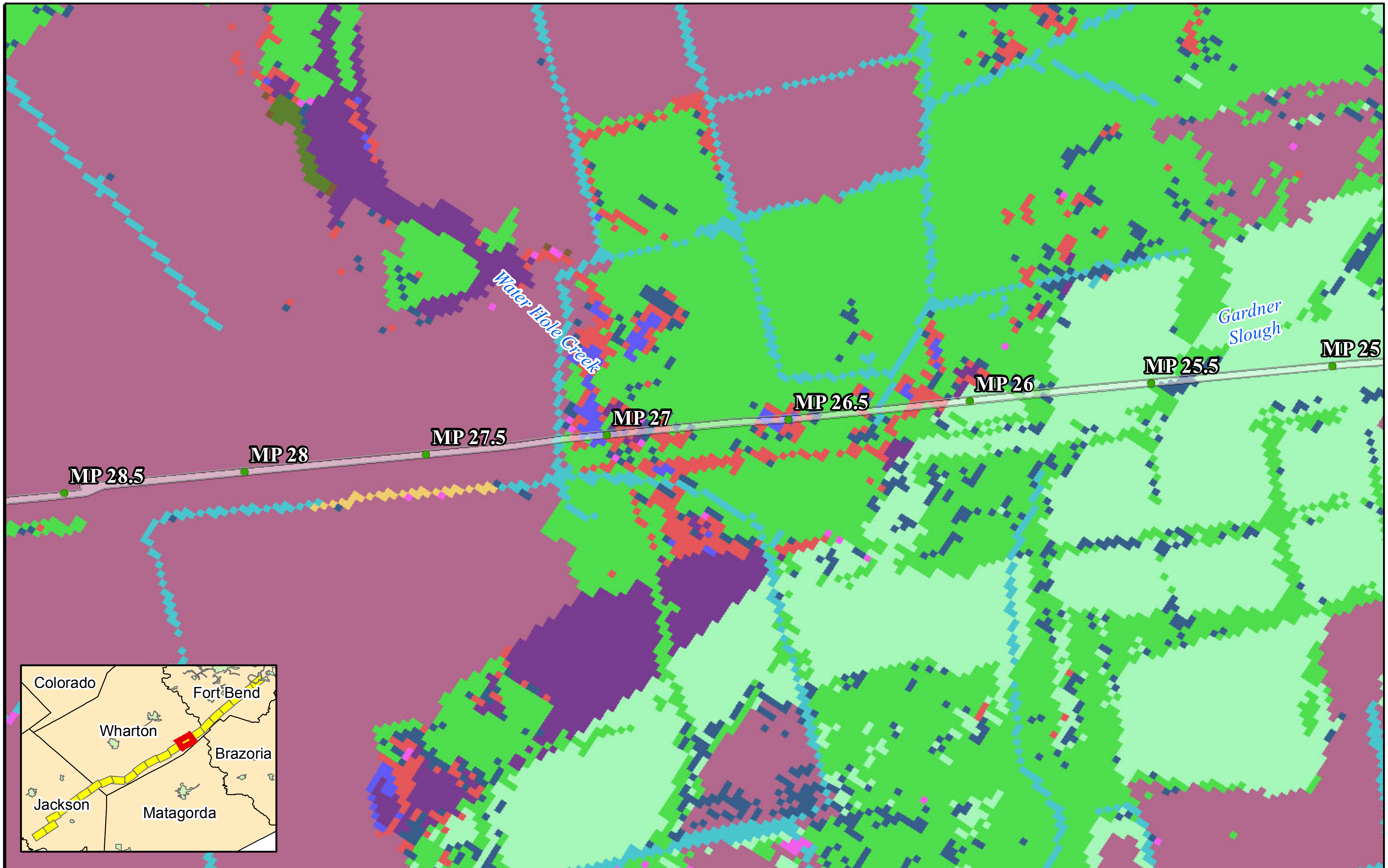
Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By: AM	Date: 11/27/2012	Project No.: 25014860	Figure: 8 of 22

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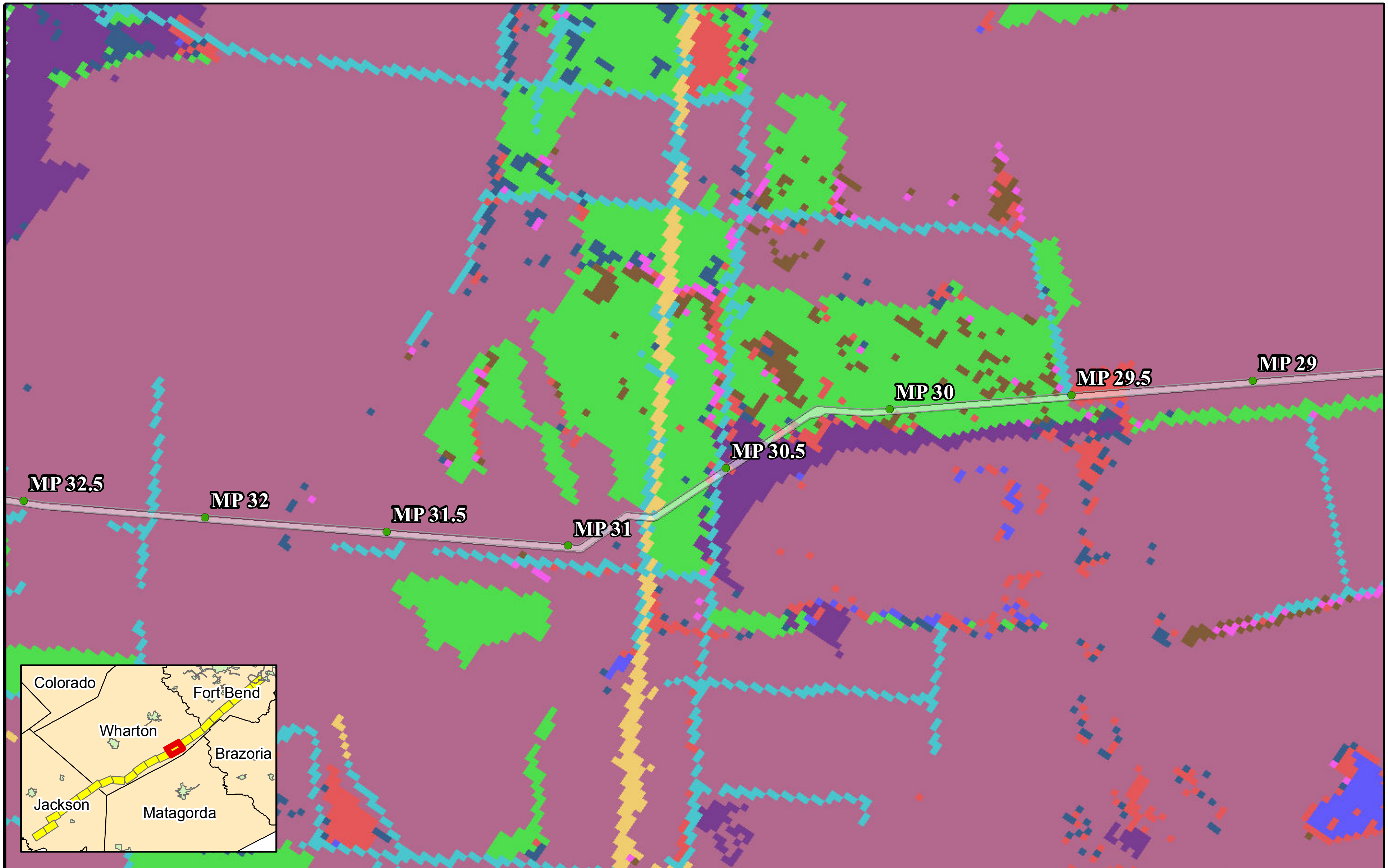
Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	9 of 22

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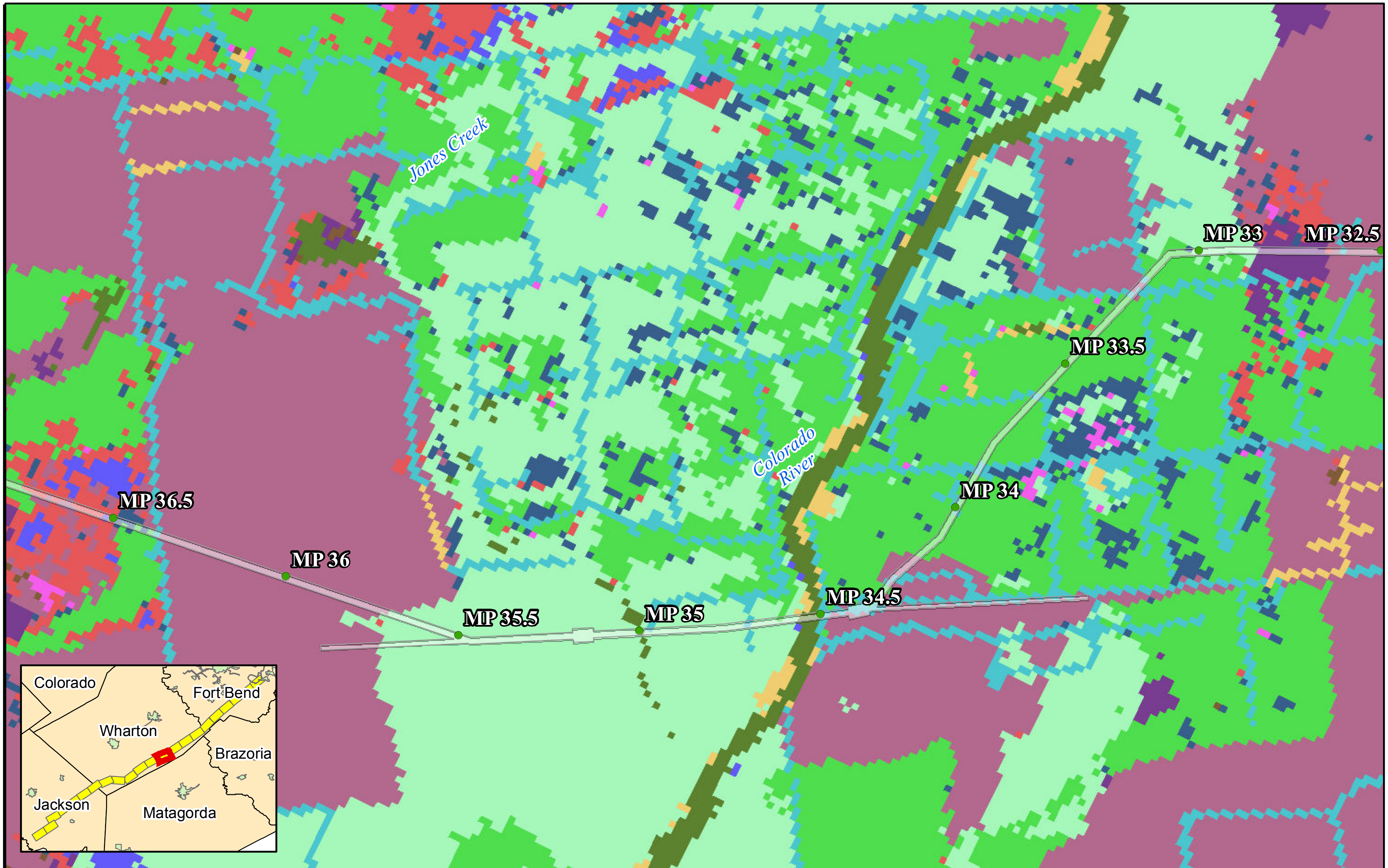
Land Cover/Habitat (NatureServe 2012)



- Proposed Pipeline Construction ROW
- Milepost Marker
- Agriculture - Cultivated Crops and Irrigated Agriculture
- Agriculture - Pasture/Hay
- Developed-Open Space
- Developed/Disturbed
- Forest & Woodland
- Modified/Managed Southern Tall Grassland
- Open Water
- Semi-Desert
- Shrubland & Grassland
- Successional Shrub/Scrub
- West Gulf Coastal Plain Large River Floodplain Forest
- West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	10 of 22

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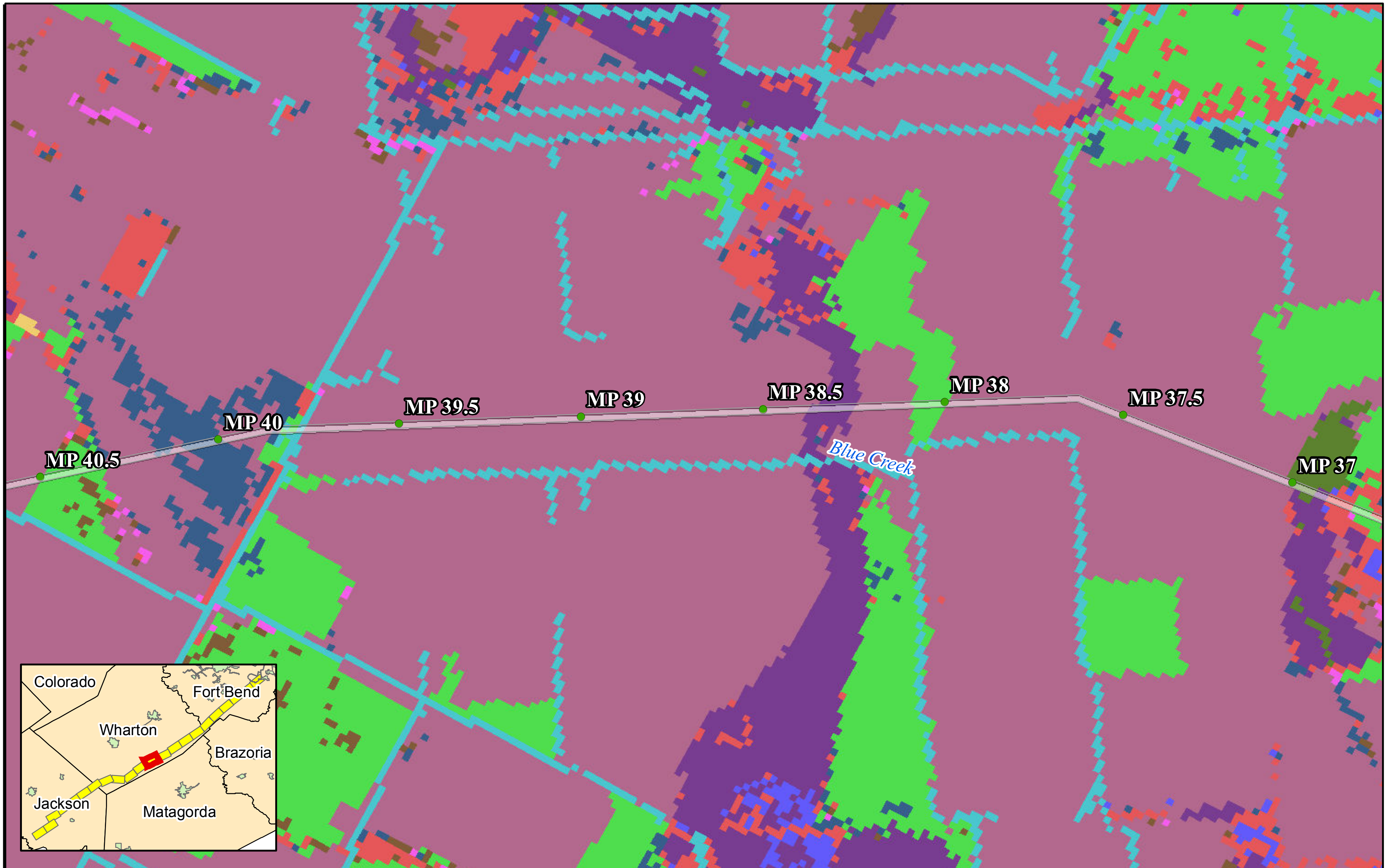
Land Cover/Habitat (NatureServe 2012)



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- Proposed Pipeline Construction ROW
- Milepost Marker
- Agriculture - Cultivated Crops and Irrigated Agriculture
- Agriculture - Pasture/Hay
- Developed-Open Space
- Developed/Disturbed
- Forest & Woodland
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- Semi-Desert
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- West Gulf Coastal Plain Large River Floodplain Forest
- West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

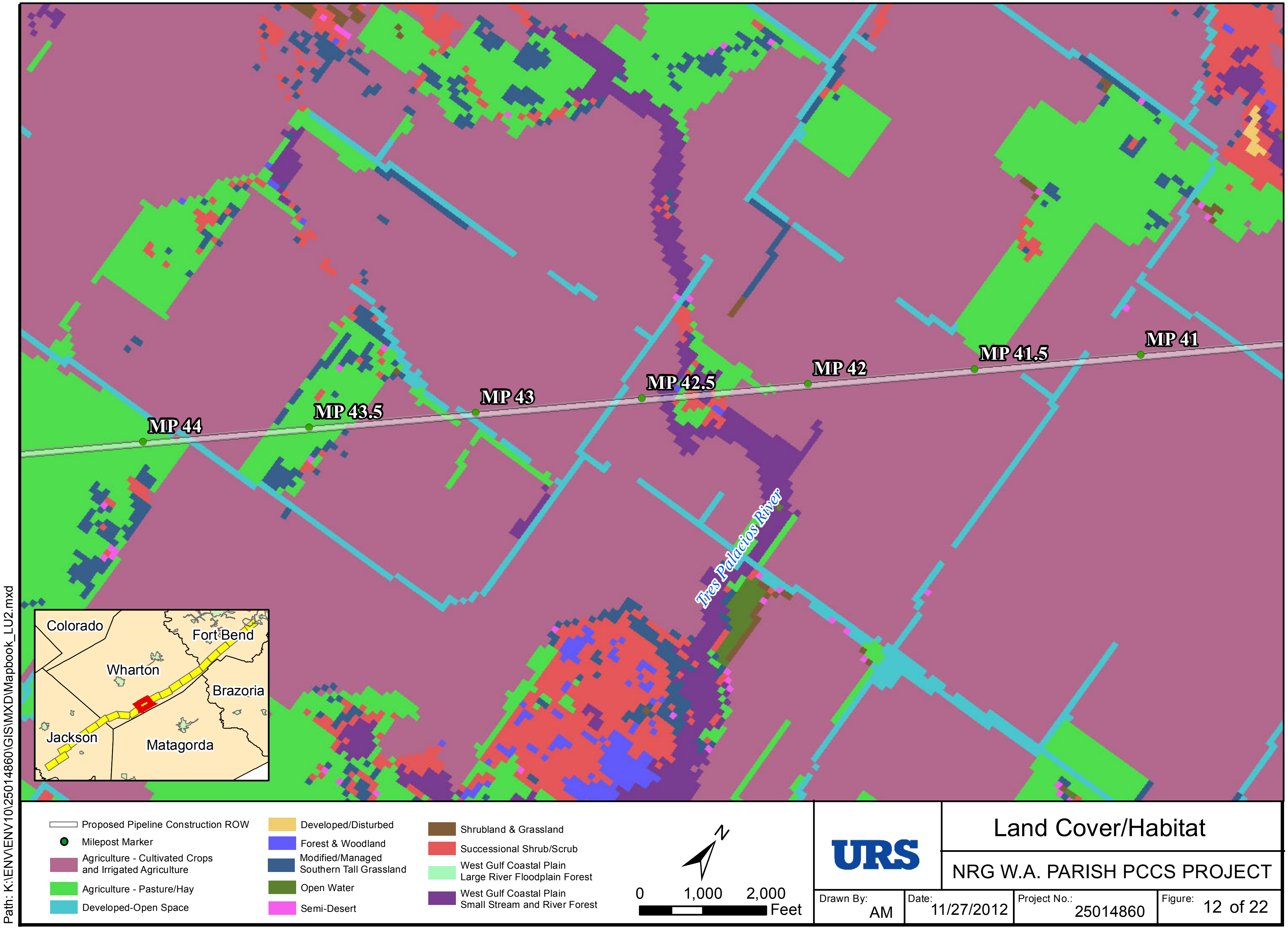
URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	11 of 22

Land Cover/Habitat (NatureServe 2012)



Land Cover/Habitat (NatureServe 2012)

Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By: AM	Date: 11/27/2012	Project No.: 25014860	Figure: 13 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_LU2.mxd

Land Cover/Habitat (NatureServe 2012)

Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	14 of 22

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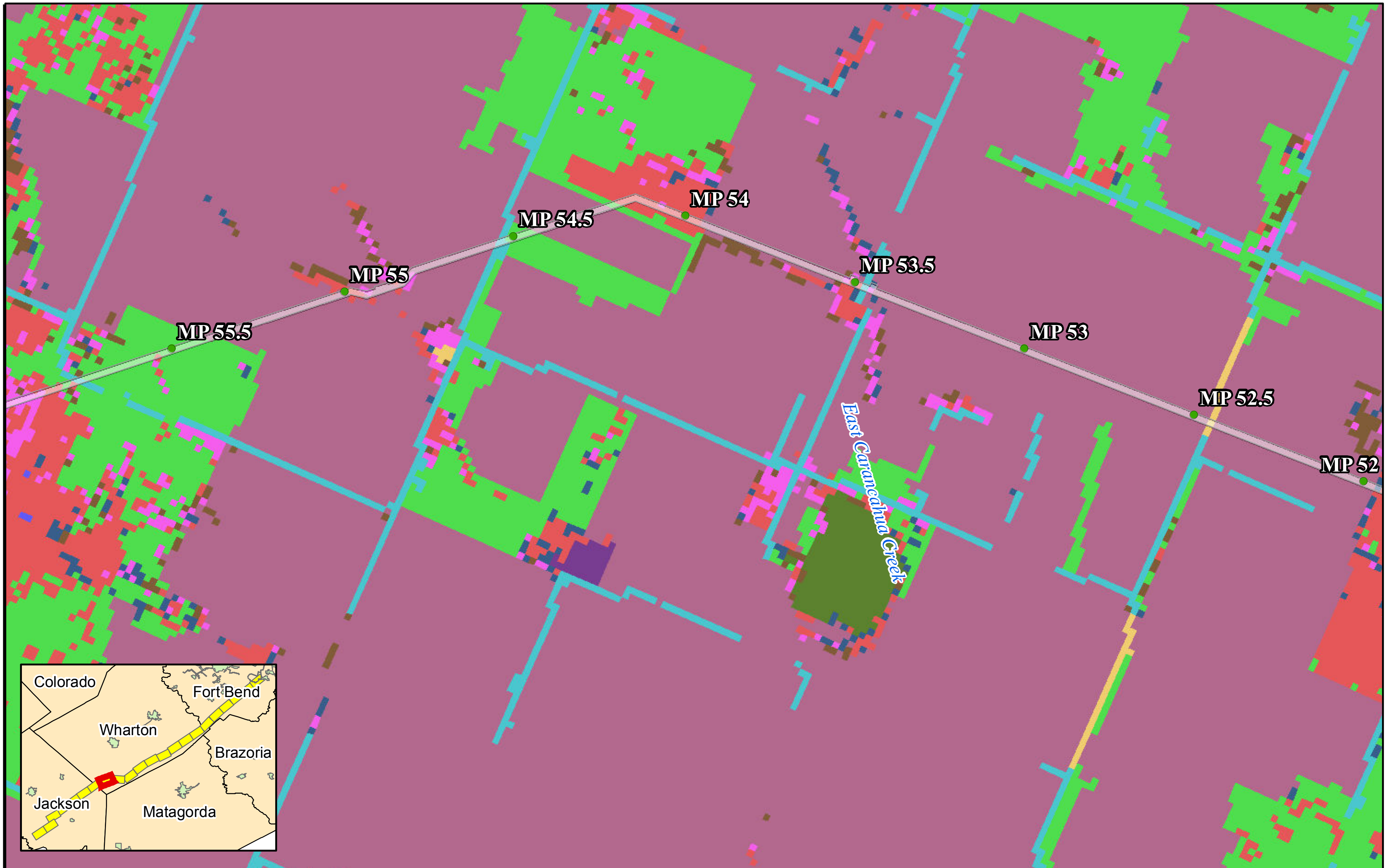
Land Cover/Habitat (NatureServe 2012)



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Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
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Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
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N

0 1,000 2,000 Feet

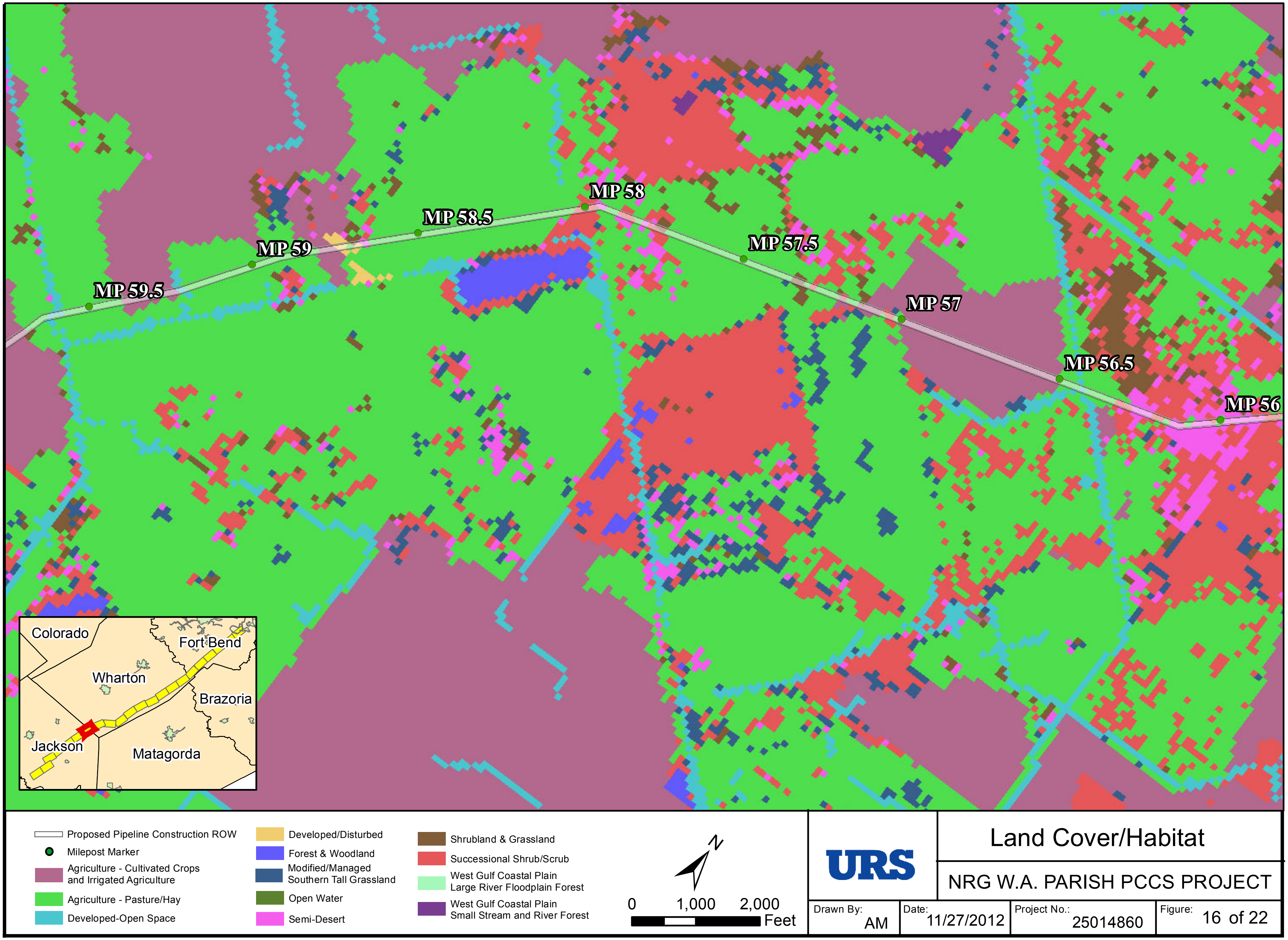
URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	15 of 22

Land Cover/Habitat (NatureServe 2012)



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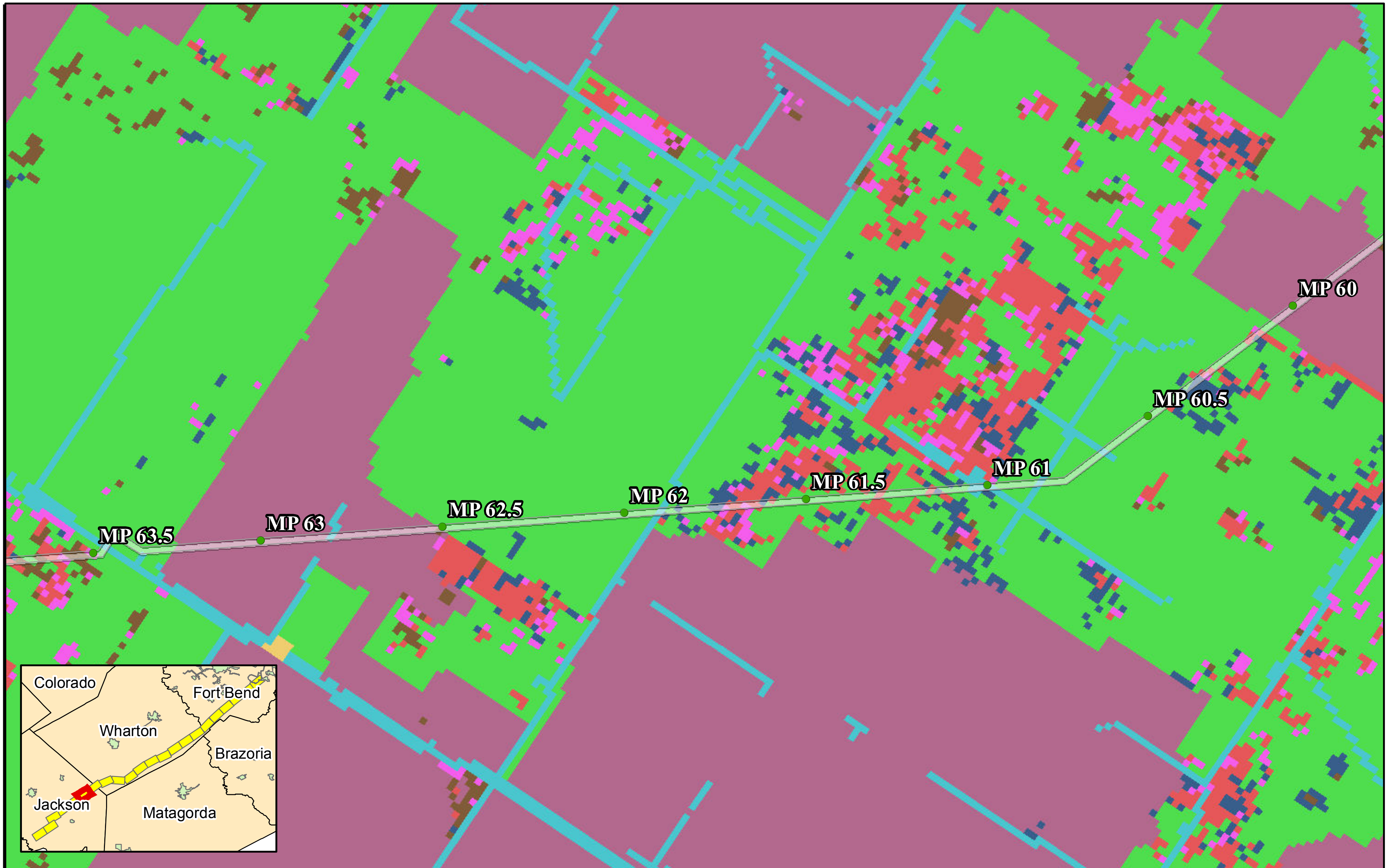
URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	16 of 22

Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

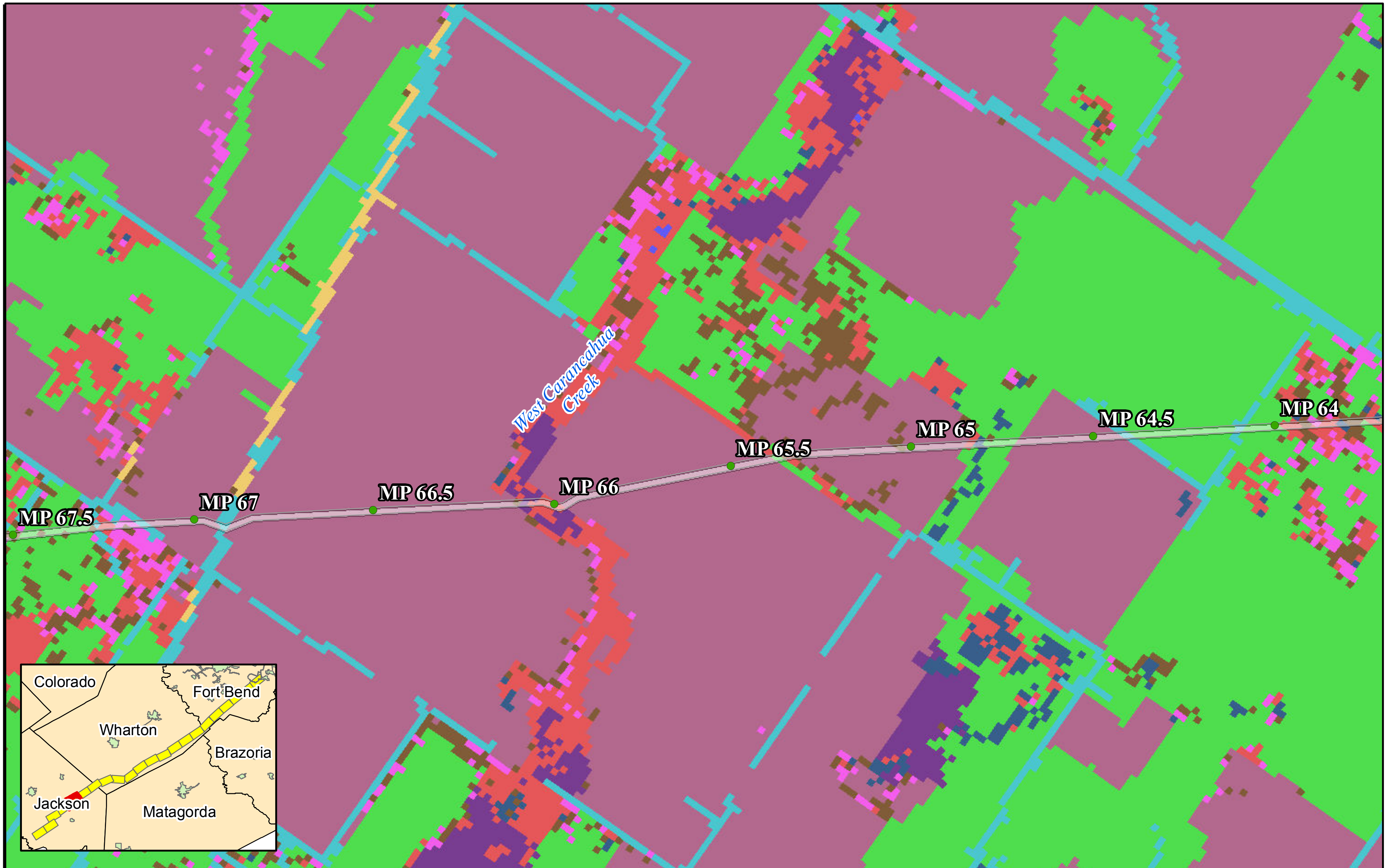
Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	17 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_LU2.mxd

Land Cover/Habitat (NatureServe 2012)



Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	18 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_LU2.mxd

Land Cover/Habitat (NatureServe 2012)

Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

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URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	19 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_LU2.mxd

Land Cover/Habitat (NatureServe 2012)

Proposed Pipeline Construction ROW
Milepost Marker
Agriculture - Cultivated Crops and Irrigated Agriculture
Agriculture - Pasture/Hay
Developed-Open Space
Developed/Disturbed
Forest & Woodland
Modified/Managed Southern Tall Grassland
Open Water
Semi-Desert
Shrubland & Grassland
Successional Shrub/Scrub
West Gulf Coastal Plain Large River Floodplain Forest
West Gulf Coastal Plain Small Stream and River Forest

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URS

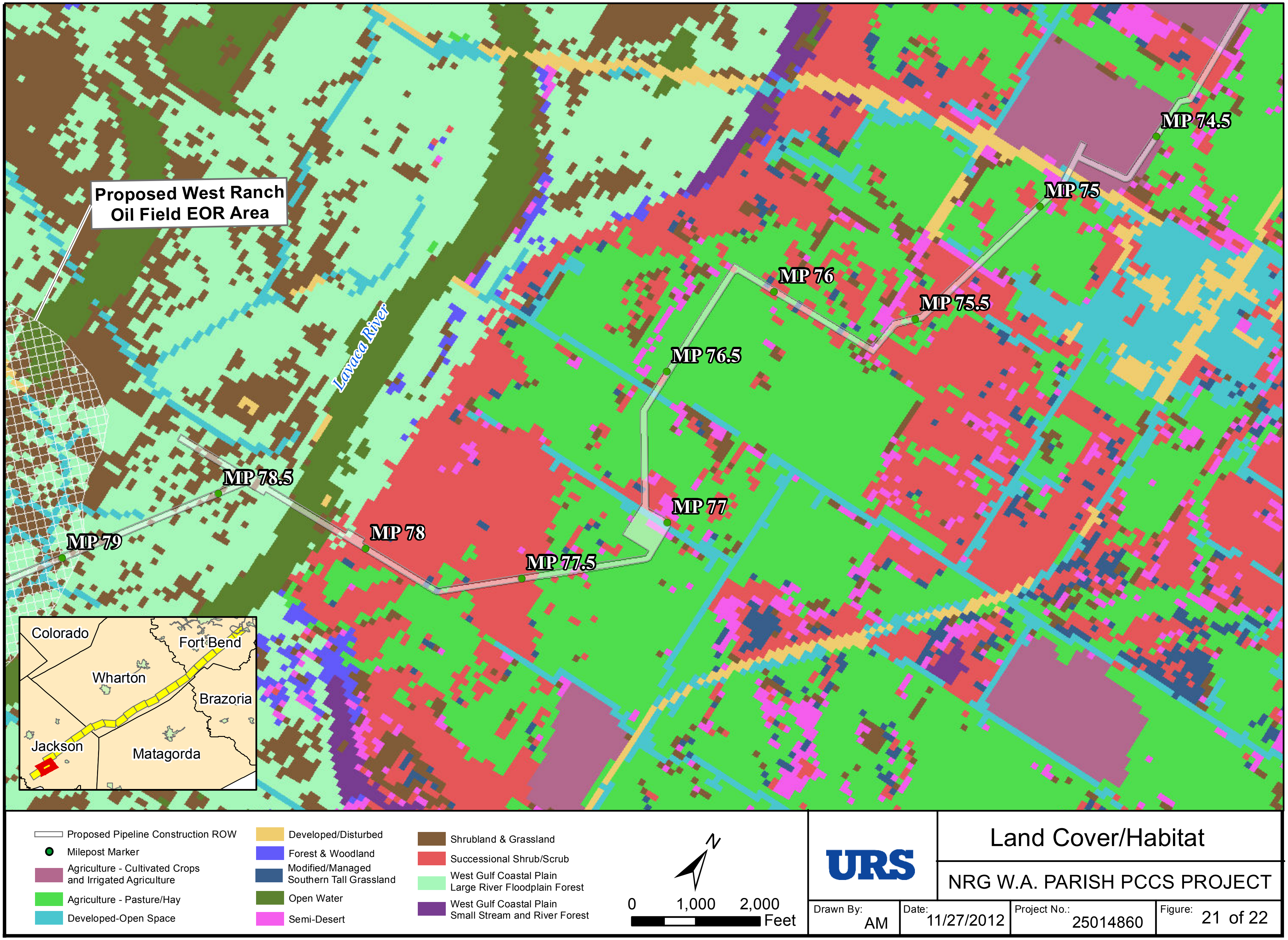
Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	20 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_LU2.mxd

Land Cover/Habitat (NatureServe 2012)



URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	21 of 22

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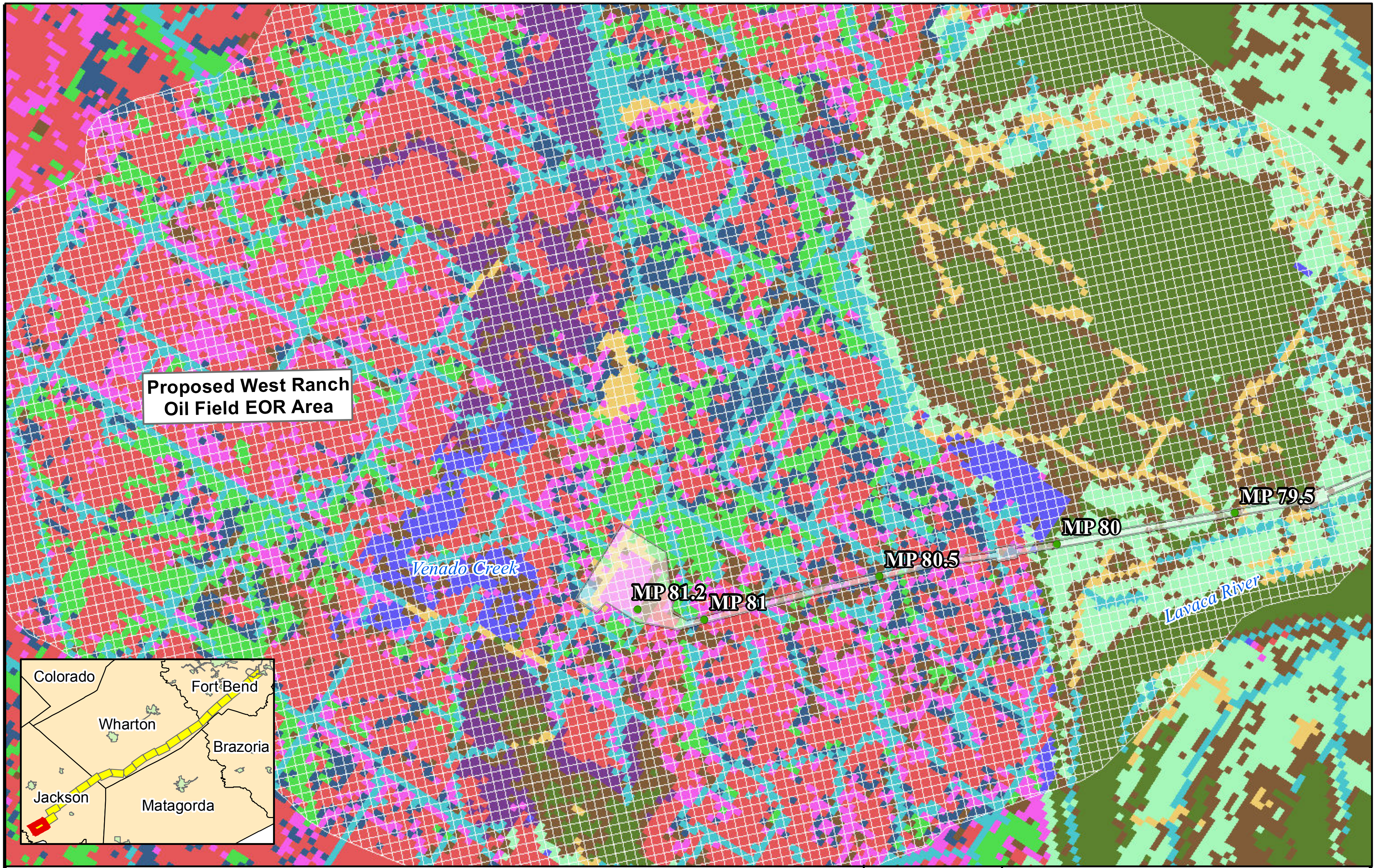
Land Cover/Habitat (NatureServe 2012)



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- Proposed Pipeline Construction ROW
- Milepost Marker
- Agriculture - Cultivated Crops and Irrigated Agriculture
- Agriculture - Pasture/Hay
- Developed-Open Space
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- Forest & Woodland
- Modified/Managed Southern Tall Grassland
- Open Water
- Semi-Desert
- Shrubland & Grassland
- Successional Shrub/Scrub
- West Gulf Coastal Plain Large River Floodplain Forest
- West Gulf Coastal Plain Small Stream and River Forest

N

0 1,000 2,000 Feet

URS

Land Cover/Habitat

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
AM	11/27/2012	25014860	22 of 22

Land Cover/Habitat (NatureServe 2012)

APPENDIX D-4

REVISIONS TO PIPELINE CORRIDOR AND ACCESS ROADS MAPS

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HDD Entry/Exit
No Change
Revised Route
Previous Route

N
0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	1 of 22

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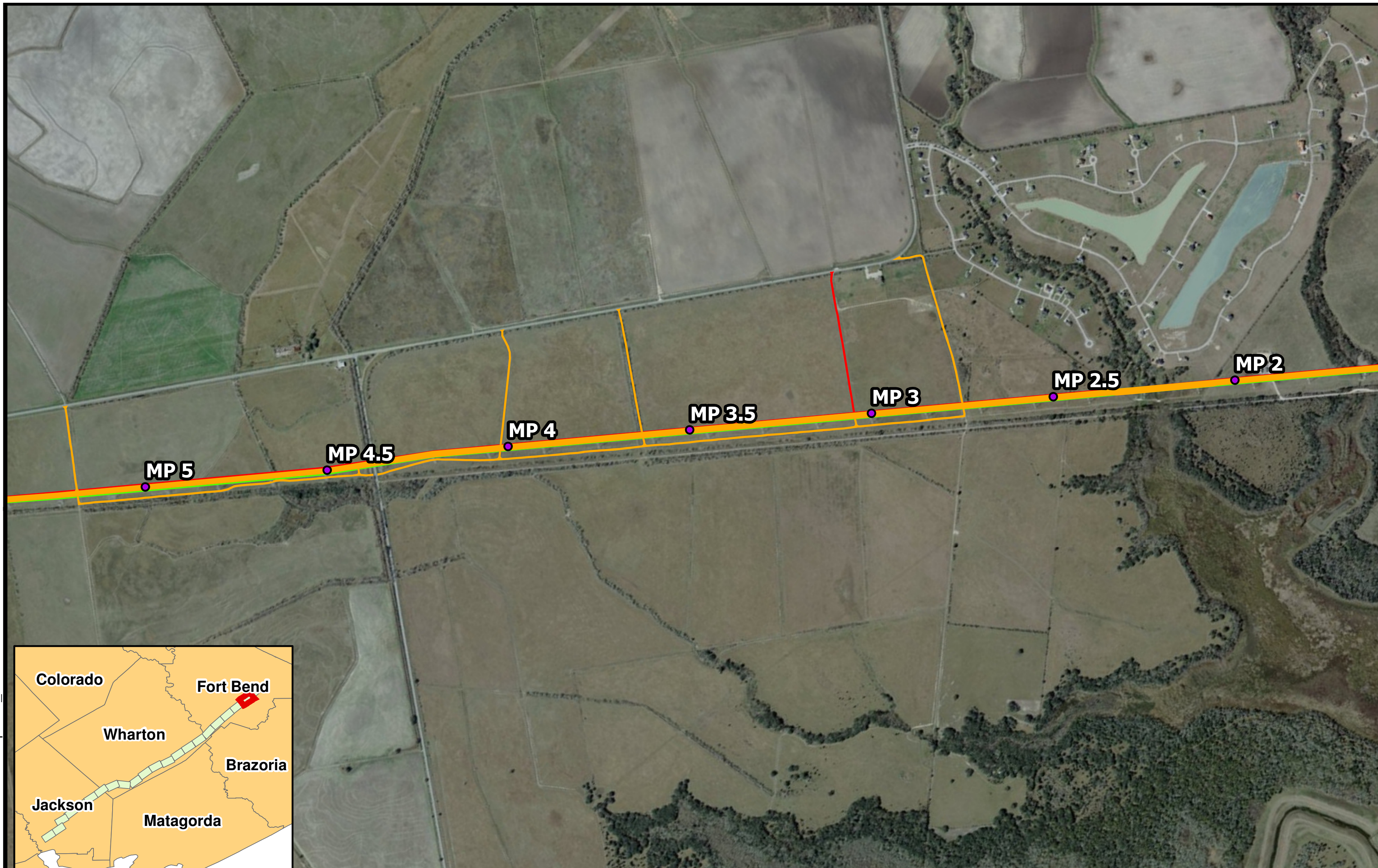

HDD Entry/Exit
No Change
Revised Route
Previous Route

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Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	2 of 22

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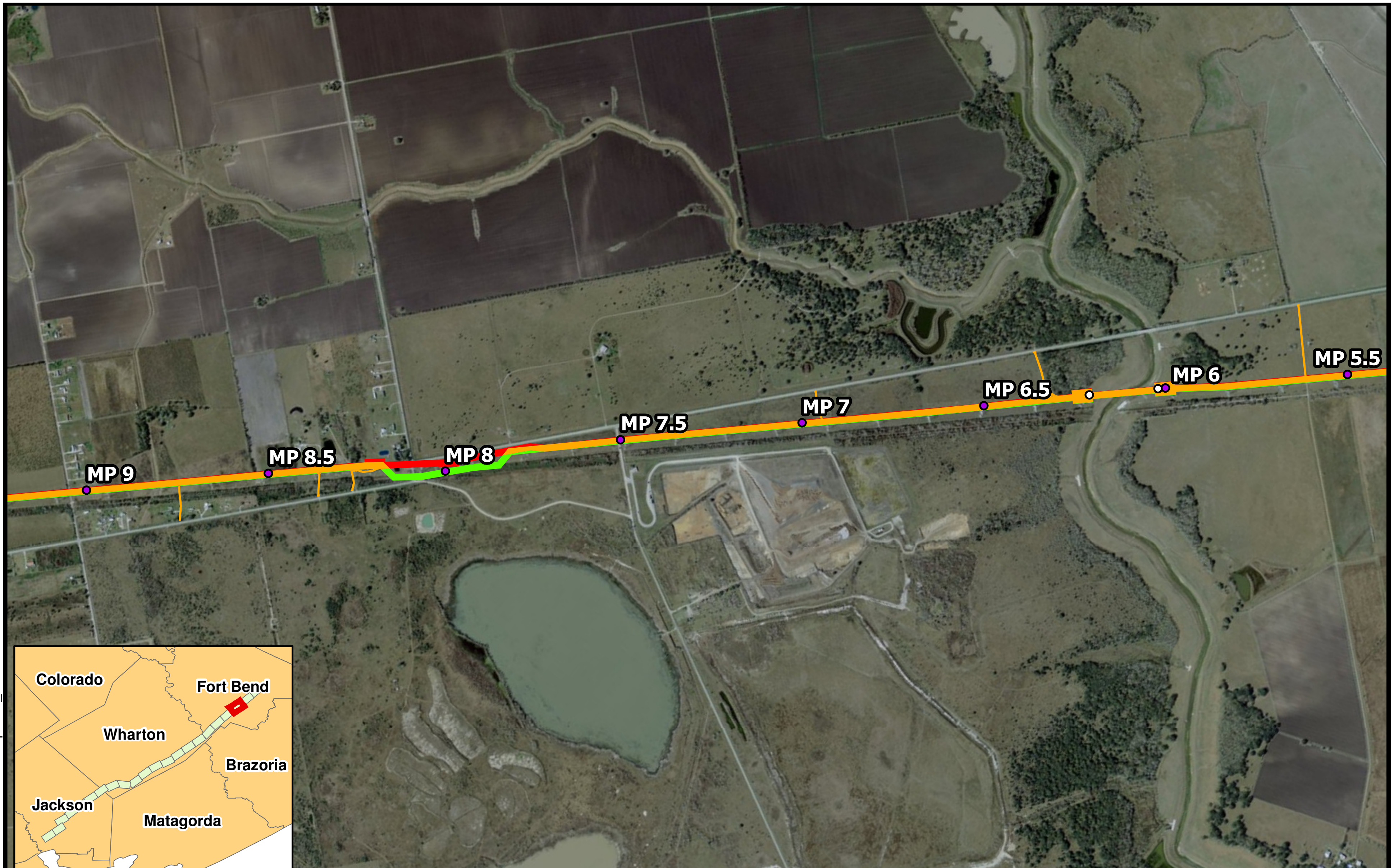

HDD Entry/Exit
No Change
Revised Route
Previous Route

0 1,000 2,000
Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	3 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

0 1,000 2,000 Feet

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	4 of 22

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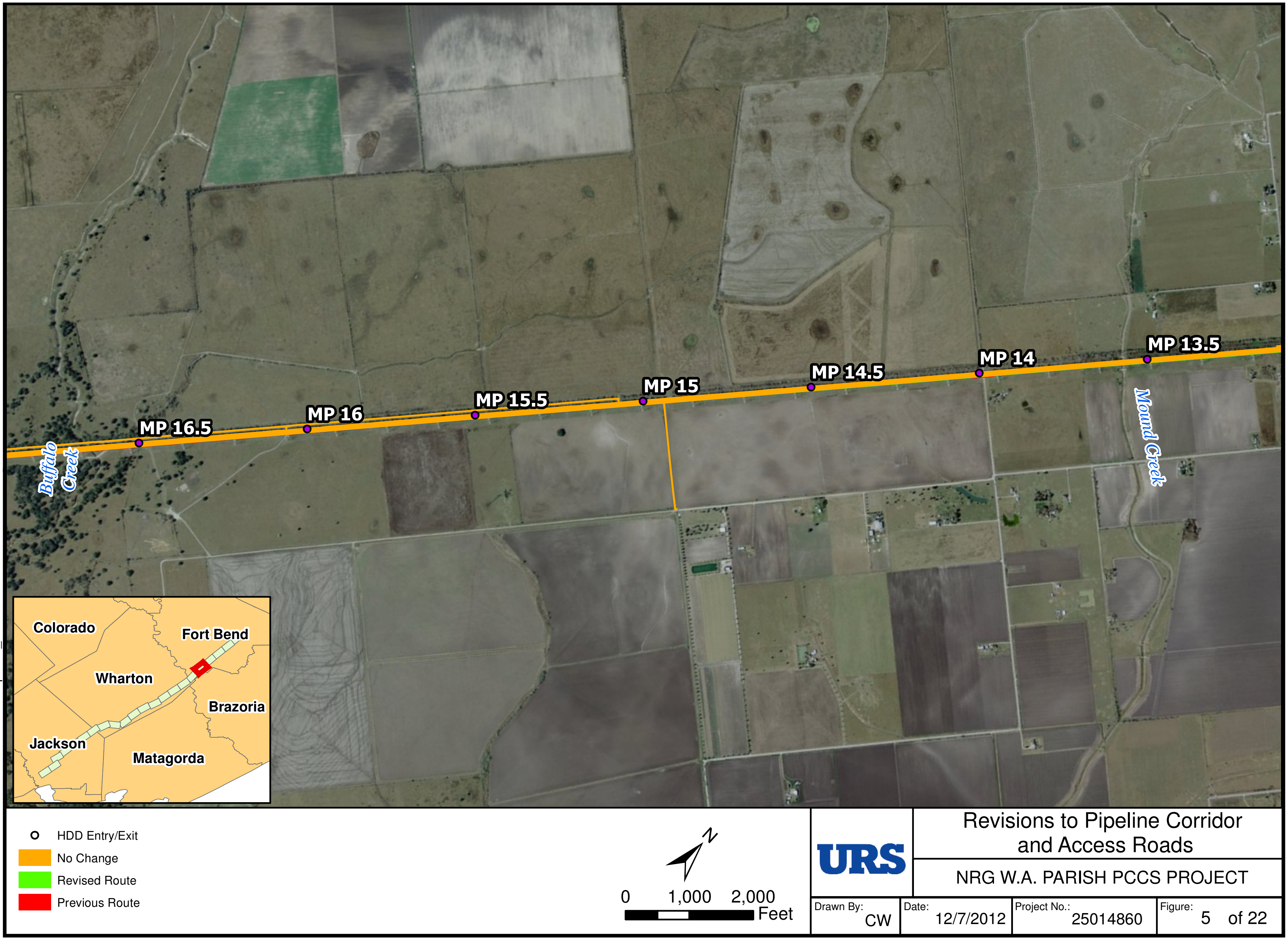

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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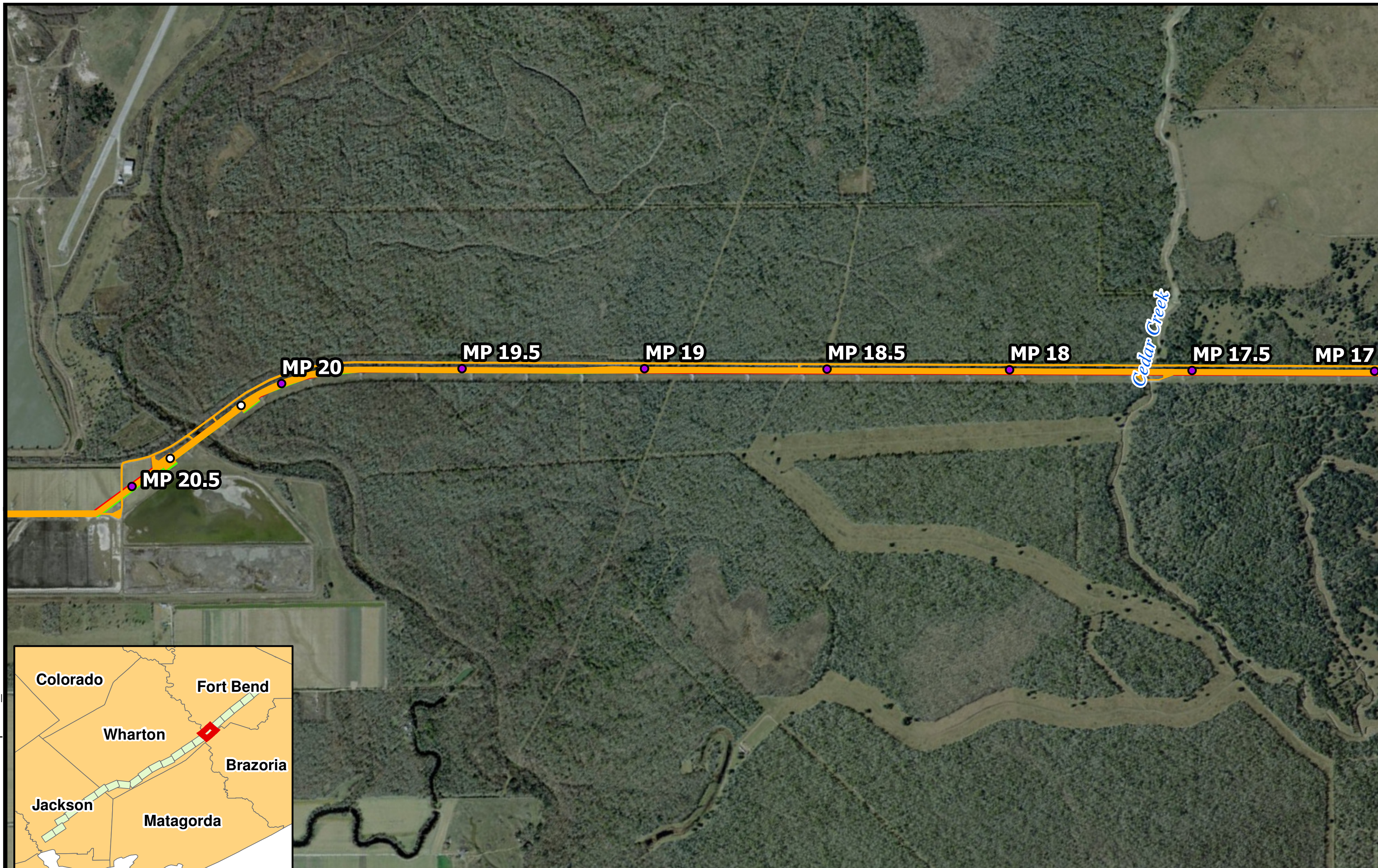

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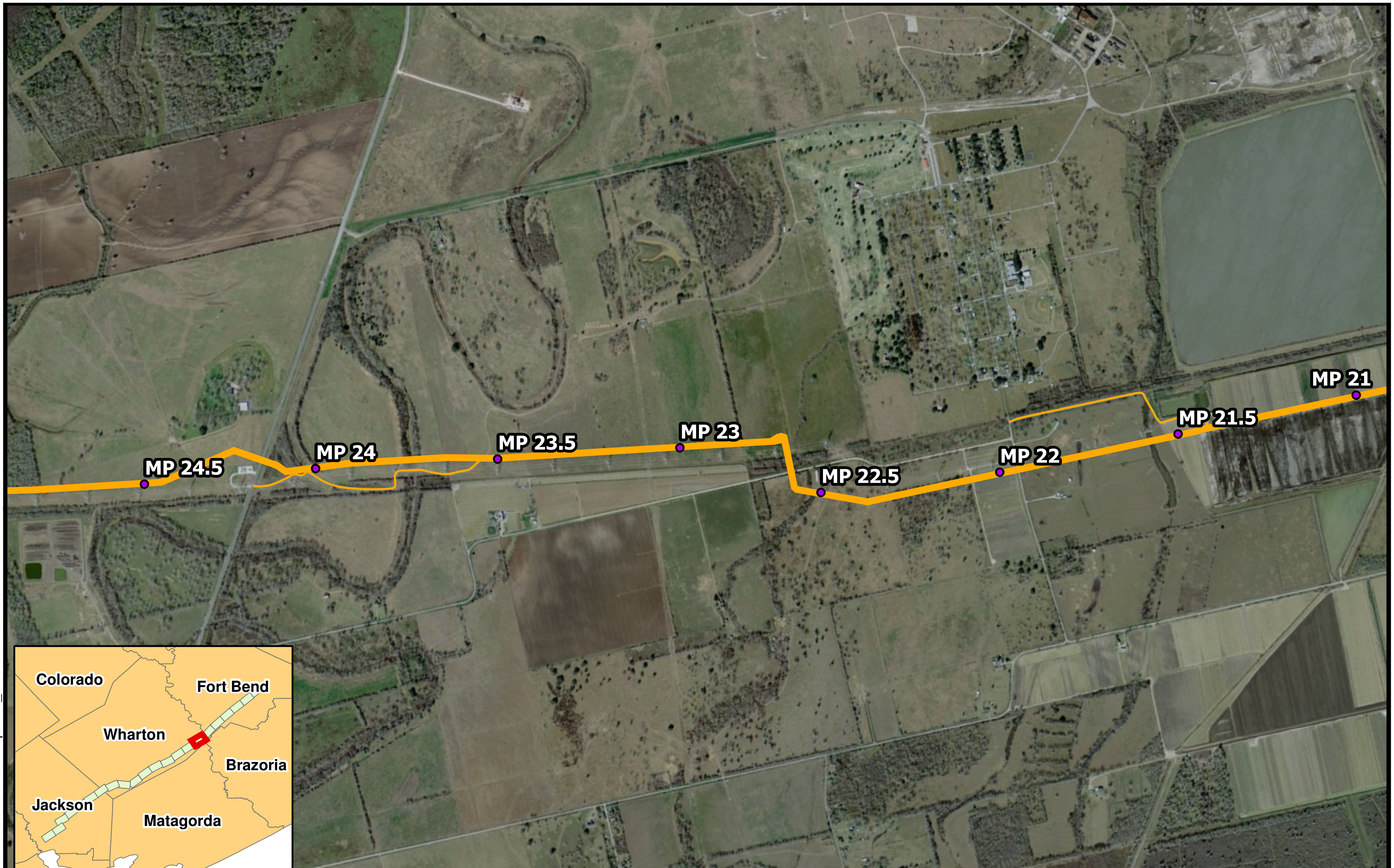
- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

N

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads			
NRG W.A. PARISH PCCS PROJECT			
Drawn By: CW	Date: 12/7/2012	Project No.: 25014860	Figure: 6 of 22



HDD Entry/Exit
No Change
Revised Route
Previous Route

0 1,000 2,000
Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	7 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

HDD Entry/Exit
No Change
Revised Route
Previous Route

N

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	8 of 22

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Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

HDD Entry/Exit
No Change
Revised Route
Previous Route

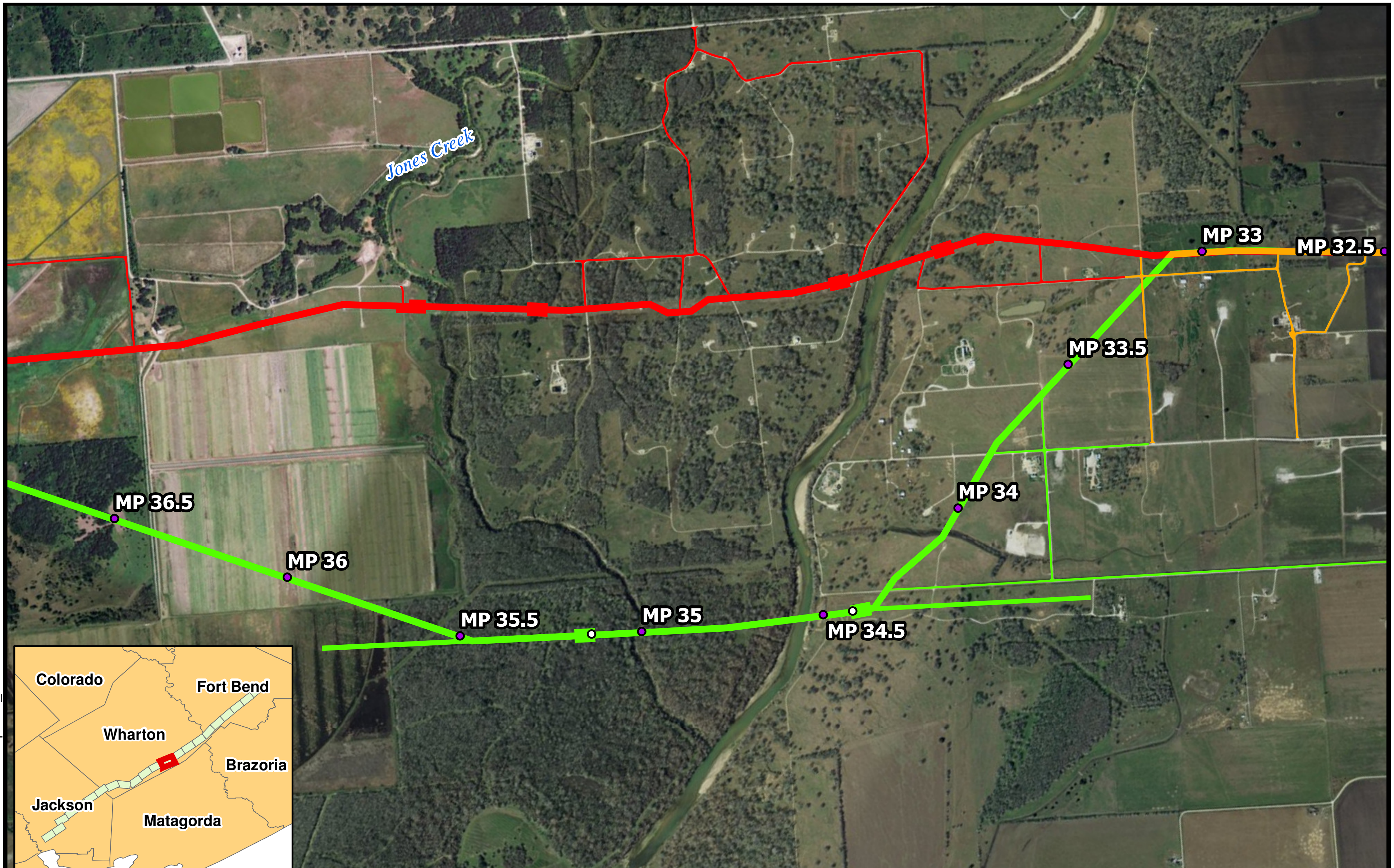
N
0 1,000 2,000
Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	9 of 22



HDD Entry/Exit
No Change
Revised Route
Previous Route

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	10 of 22

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- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

N

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	11 of 22

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- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

N

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	12 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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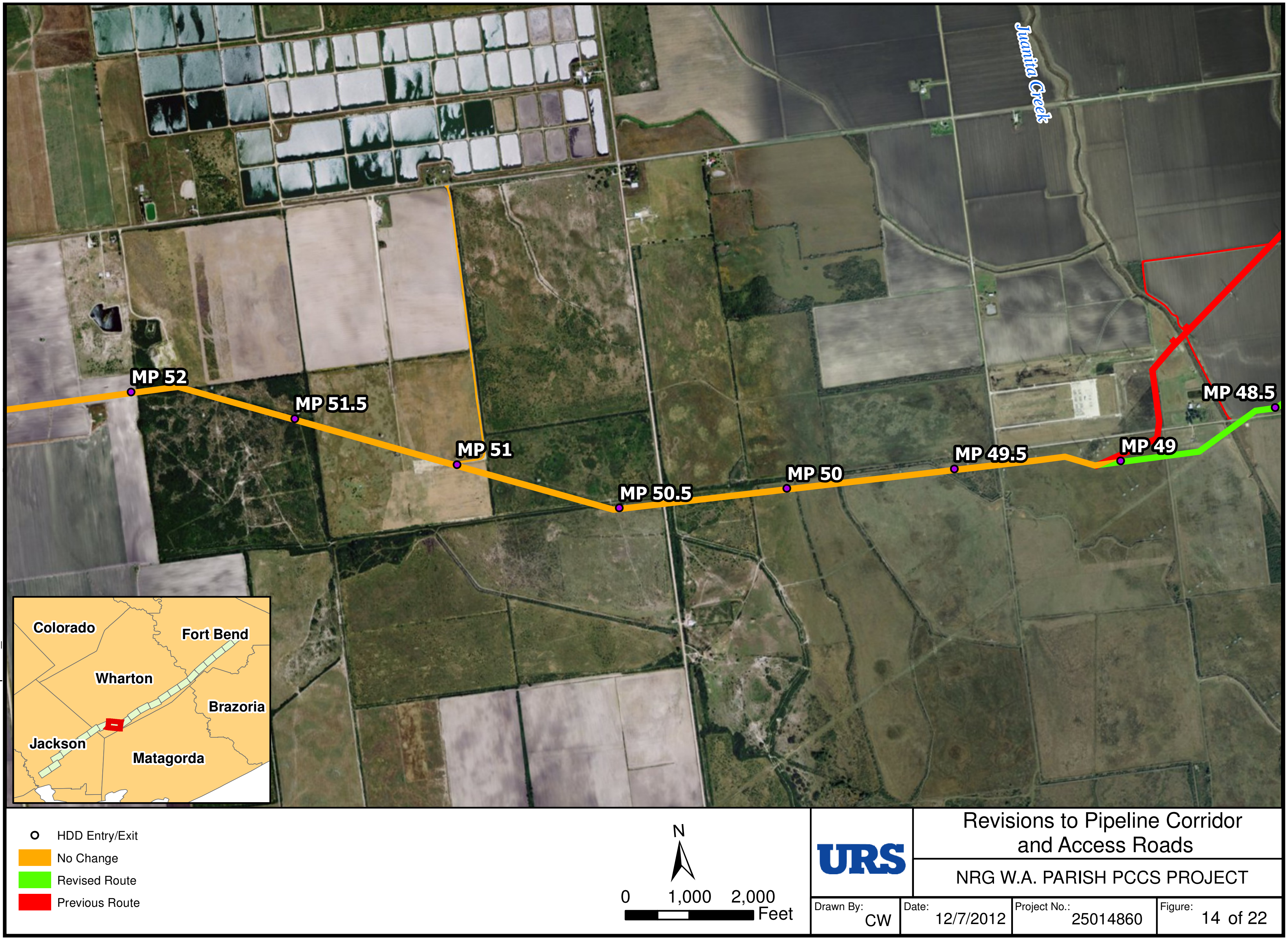

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Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	14 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

HDD Entry/Exit
No Change
Revised Route
Previous Route

N
0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	15 of 22

HDD Entry/Exit
No Change
Revised Route
Previous Route

N

0 1,000 2,000
Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	16 of 22

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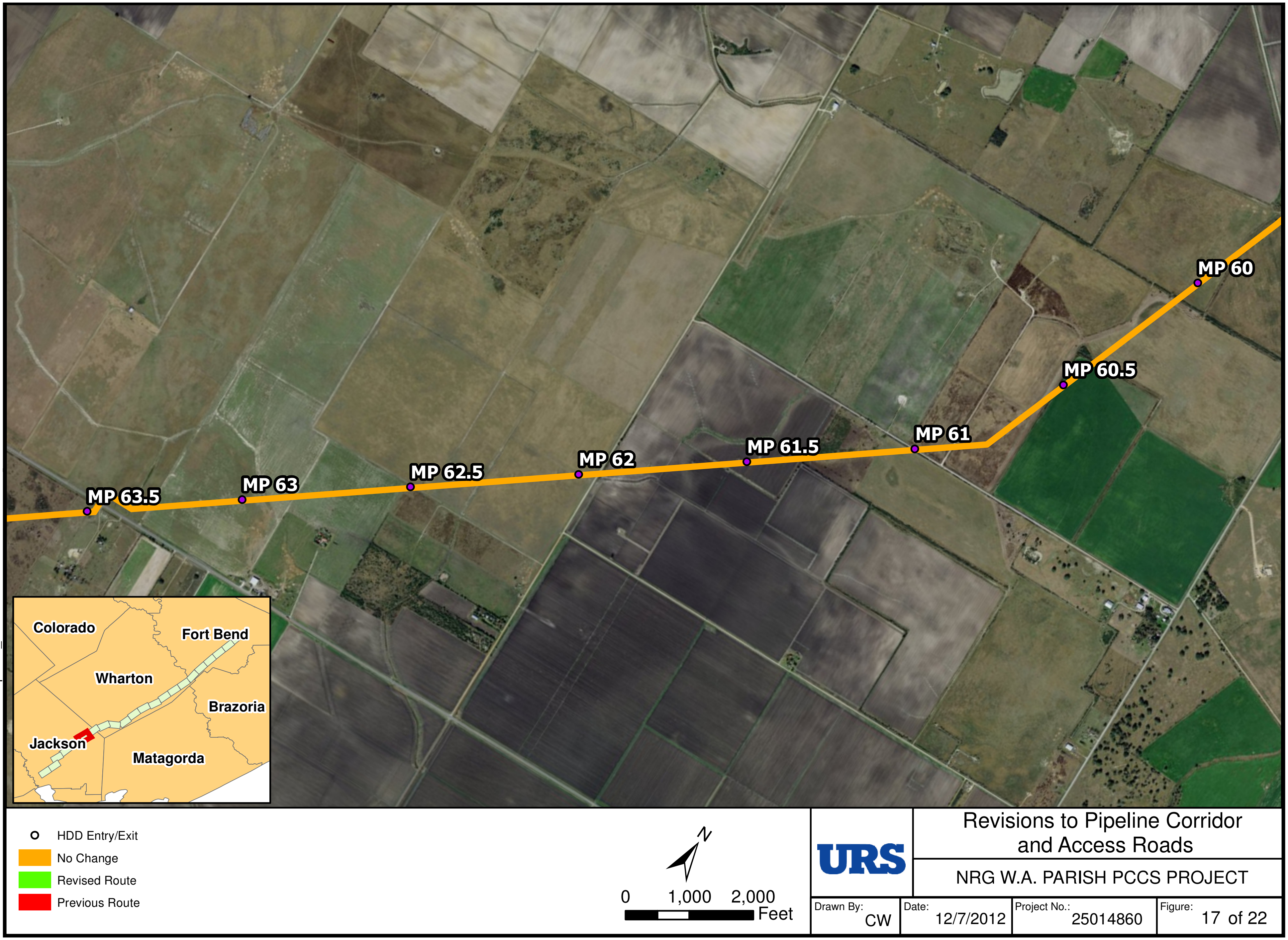

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URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	17 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

HDD Entry/Exit
No Change
Revised Route
Previous Route

N

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URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	18 of 22

HDD Entry/Exit
No Change
Revised Route
Previous Route

N

0 1,000 2,000 Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	19 of 22

Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

HDD Entry/Exit
No Change
Revised Route
Previous Route

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URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
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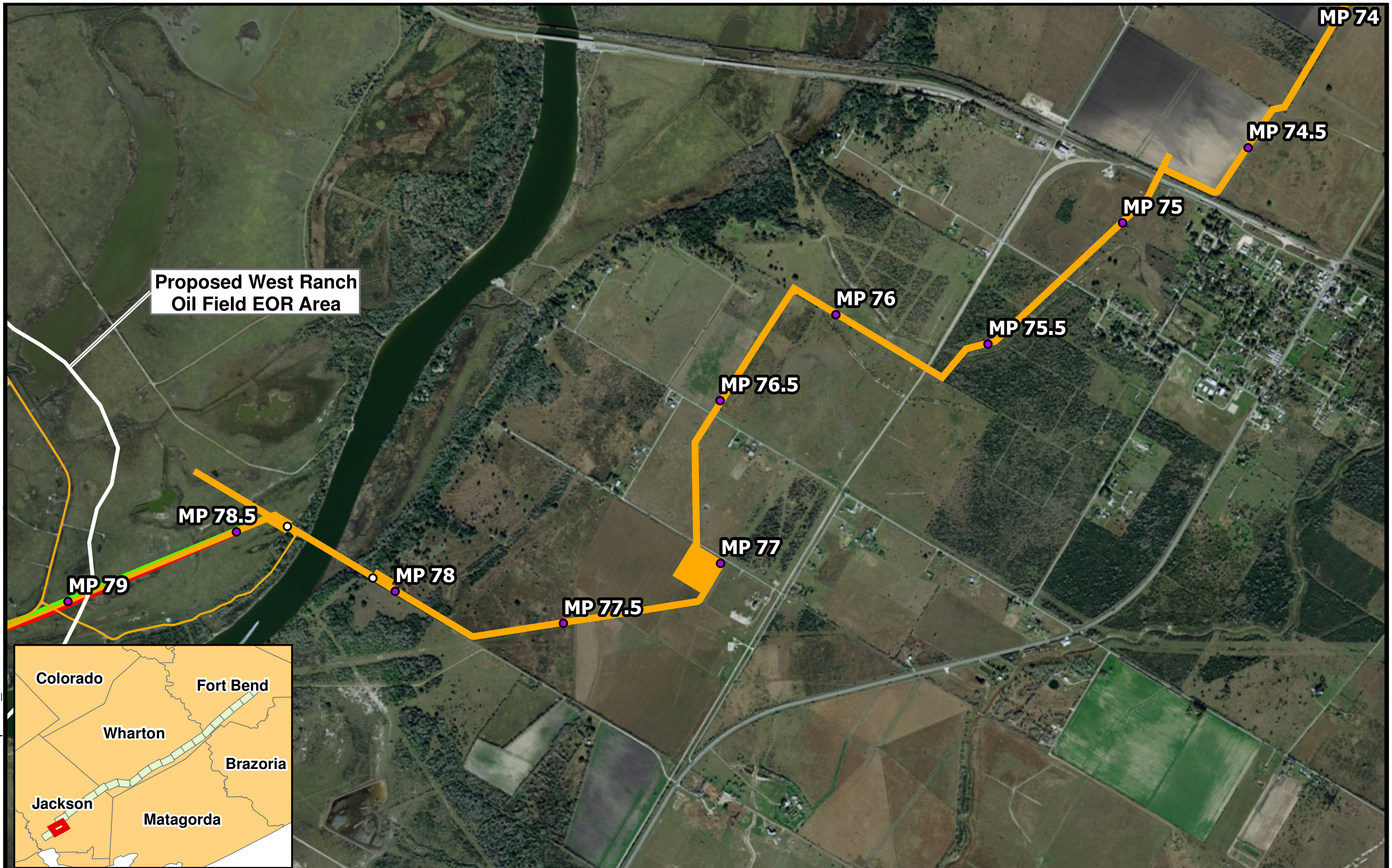

HDD Entry/Exit
No Change
Revised Route
Previous Route

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Feet

URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	21 of 22

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Path: K:\ENV\ENV10\25014860\GIS\MXD\Mapbook_Revisions.mxd

- HDD Entry/Exit
- No Change
- Revised Route
- Previous Route

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URS

Revisions to Pipeline Corridor and Access Roads

NRG W.A. PARISH PCCS PROJECT

Drawn By:	Date:	Project No.:	Figure:
CW	12/7/2012	25014860	22 of 22

APPENDIX E

STATE-LISTED THREATENED AND ENDANGERED SPECIES

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APPENDIX E-1

ANNOTATED COUNTY LISTS OF RARE SPECIES: FORT BEND COUNTY

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FORT BEND COUNTY

AMPHIBIANS

		Federal Status	State Status
Houston toad	*Anaxyrus houstonensis*	LE	E

endemic; sandy substrate, water in pools, ephemeral pools, stock tanks; breeds in spring especially after rains; burrows in soil of adjacent uplands when inactive; breeds February-June; associated with soils of the Sparta, Carrizo, Goliad, Queen City, Recklaw, Weches, and Willis geologic formations

BIRDS

		Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	DL	T

year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Arctic Peregrine Falcon	*Falco peregrinus tundrius*	DL	

migrant throughout state from subspecies' far northern breeding range, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	LE	E

this county within historic range; endemic; open prairies of mostly thick grass one to three feet tall; from near sea level to 200 feet along coastal plain on upper two-thirds of Texas coast; males form communal display flocks during late winter-early spring; booming grounds important; breeding February-July

Bald Eagle	*Haliaeetus leucocephalus*	DL	T

found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Henslow's Sparrow	*Ammodramus henslowii*		

wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles; a key component is bare ground for running/walking

Interior Least Tern	*Sterna antillarum athalassos*	LE	E

subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony

FORT BEND COUNTY

BIRDS

Federal Status | State Status

Peregrine Falcon *Falco peregrinus* DL T

both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (F. p. anatum) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, F.p. tundrius is no longer listed in Texas; but because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.

Sprague's Pipit *Anthus spragueii* C

only in Texas during migration and winter, mid September to early April; short to medium distance, diurnal migrant; strongly tied to native upland prairie, can be locally common in coastal grasslands, uncommon to rare further west; sensitive to patch size and avoids edges.

Western Burrowing Owl *Athene cunicularia hypugaea*

open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

White-faced Ibis *Plegadis chihi* T

prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats

White-tailed Hawk *Buteo albicaudatus* T

near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March-May

Whooping Crane *Grus americana* LE E

potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties

Wood Stork *Mycteria americana* T

forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960

FISHES

Federal Status | State Status

American eel *Anguilla rostrata*

coastal waterways below reservoirs to gulf; spawns January to February in ocean, larva move to coastal waters, metamorphose, then females move into freshwater; most aquatic habitats with access to ocean, muddy bottoms, still waters, large streams, lakes; can travel overland in wet areas; males in brackish estuaries; diet varies widely, geographically, and seasonally

Sharpnose shiner *Notropis oxyrhynchus* C

endemic to Brazos River drainage; also, apparently introduced into adjacent Colorado River drainage; large turbid river, with bottom a combination of sand, gravel, and clay-mud

FORT BEND COUNTY

MAMMALS

		Federal Status	State Status
Louisiana black bear	*Ursus americanus luteolus*	LT	T

possible as transient; bottomland hardwoods and large tracts of inaccessible forested areas

Plains spotted skunk	*Spilogale putorius interrupta*		

catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie

Red wolf	*Canis rufus*	LE	E

extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies

MOLLUSKS

		Federal Status	State Status
False spike mussel	*Quadrula mitchelli*		T

possibly extirpated in Texas; probably medium to large rivers; substrates varying from mud through mixtures of sand, gravel and cobble; one study indicated water lilies were present at the site; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins

Smooth pimpleback	*Quadrula houstonensis*	C	T

small to moderate streams and rivers as well as moderate size reservoirs; mixed mud, sand, and fine gravel, tolerates very slow to moderate flow rates, appears not to tolerate dramatic water level fluctuations, scoured bedrock substrates, or shifting sand bottoms, lower Trinity (questionable), Brazos, and Colorado River basins

Texas fawnsfoot	*Truncilla macrodon*	C	T

little known; possibly rivers and larger streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins

REPTILES

		Federal Status	State Status
Alligator snapping turtle	*Macrochelys temminckii*		T

perennial water bodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October

Texas horned lizard	*Phrynosoma cornutum*		T

open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September

Timber/Canebrake rattlesnake	*Crotalus horridus*		T

FORT BEND COUNTY

REPTILES		Federal Status	State Status

swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto

PLANTS		Federal Status	State Status
Texas prairie dawn	*Hymenoxys texana*	LE	E

Texas endemic; in poorly drained, sparsely vegtated areas (slick spots) at the base of mima mounds in open grassland or almost barren areas on slightly saline soils that are sticky when wet and powdery when dry; flowering late February-early April

Threeflower broomweed *Thurovia triflora*

Texas endemic; near coast in sparse, low vegetation on a veneer of light colored silt or fine sand over saline clay along drier upper margins of ecotone between between salty prairies and tidal flats; further inland associated with vegetated slick spots on prairie mima mounds; flowering September-November

APPENDIX E-2

ANNOTATED COUNTY LISTS OF RARE SPECIES: WHARTON COUNTY

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Last Revision: 10/10/2011 2:25:00 PM

WHARTON COUNTY

BIRDS

		Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	DL	T

year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Arctic Peregrine Falcon	*Falco peregrinus tundrius*	DL	

migrant throughout state from subspecies' far northern breeding range, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	LE	E

this county within historic range; endemic; open prairies of mostly thick grass one to three feet tall; from near sea level to 200 feet along coastal plain on upper two-thirds of Texas coast; males form communal display flocks during late winter-early spring; booming grounds important; breeding February-July

Bald Eagle	*Haliaeetus leucocephalus*	DL	T

found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Henslow's Sparrow	*Ammodramus henslowii*		

wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles; a key component is bare ground for running/walking

Interior Least Tern	*Sterna antillarum athalassos*	LE	E

subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony

Peregrine Falcon	*Falco peregrinus*	DL	T

both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (F. p. anatum) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, F.p. tundrius is no longer listed in Texas; but because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.

Sprague's Pipit	*Anthus spragueii*	C	

only in Texas during migration and winter, mid September to early April; short to medium distance, diurnal migrant; strongly tied to native upland prairie, can be locally common in coastal grasslands, uncommon to rare further west; sensitive to patch size and avoids edges.

WHARTON COUNTY

BIRDS

		Federal Status	State Status
Western Burrowing Owl	*Athene cunicularia hypugaea*		

open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

White-faced Ibis	*Plegadis chihi*		T

prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats

White-tailed Hawk	*Buteo albicaudatus*		T

near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March-May

Whooping Crane	*Grus americana*	LE	E

potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties

Wood Stork	*Mycteria americana*		T

forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960

CRUSTACEANS

		Federal Status	State Status
A crayfish	*Cambarellus texanus*		

shallow water; benthic, burrowing in or using soil; apparently tolerant of warmer waters; prefers standing water of ditches in which there is emergent vegetation; will burrow in dry periods; detritivore

FISHES

		Federal Status	State Status
American eel	*Anguilla rostrata*		

coastal waterways below reservoirs to gulf; spawns January to February in ocean, larva move to coastal waters, metamorphose, then females move into freshwater; most aquatic habitats with access to ocean, muddy bottoms, still waters, large streams, lakes; can travel overland in wet areas; males in brackish estuaries; diet varies widely, geographically, and seasonally

Blue sucker	*Cycleptus elongatus*		T

larger portions of major rivers in Texas; usually in channels and flowing pools with a moderate current; bottom type usually of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles

Sharpnose shiner	*Notropis oxyrhynchus*	C	

endemic to Brazos River drainage; also, apparently introduced into adjacent Colorado River drainage; large turbid river, with bottom a combination of sand, gravel, and clay-mud

WHARTON COUNTY

MAMMALS		Federal Status	State Status
Louisiana black bear	*Ursus americanus luteolus*	LT	T

possible as transient; bottomland hardwoods and large tracts of inaccessible forested areas

Plains spotted skunk	*Spilogale putorius interrupta*		

catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie

Red wolf	*Canis rufus*	LE	E

extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies

MOLLUSKS		Federal Status	State Status
Creeper (squawfoot)	*Strophitus undulatus*		

small to large streams, prefers gravel or gravel and mud in flowing water; Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins

False spike mussel	*Quadrula mitchelli*		T

possibly extirpated in Texas; probably medium to large rivers; substrates varying from mud through mixtures of sand, gravel and cobble; one study indicated water lilies were present at the site; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins

Smooth pimpleback	*Quadrula houstonensis*	C	T

small to moderate streams and rivers as well as moderate size reservoirs; mixed mud, sand, and fine gravel, tolerates very slow to moderate flow rates, appears not to tolerate dramatic water level fluctuations, scoured bedrock substrates, or shifting sand bottoms, lower Trinity (questionable), Brazos, and Colorado River basins

Texas fawnsfoot	*Truncilla macrodon*	C	T

little known; possibly rivers and larger streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins

Texas pimpleback	*Quadrula petrina*	C	T

mud, gravel and sand substrates, generally in areas with slow flow rates; Colorado and Guadalupe river basins

REPTILES		Federal Status	State Status
Texas horned lizard	*Phrynosoma cornutum*		T

open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September

WHARTON COUNTY

REPTILES		Federal Status	State Status
Timber/Canebrake rattlesnake	*Crotalus horridus*		T

swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto

APPENDIX E-3

ANNOTATED COUNTY LISTS OF RARE SPECIES: JACKSON COUNTY

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JACKSON COUNTY

BIRDS

		Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	DL	T

year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Arctic Peregrine Falcon	*Falco peregrinus tundrius*	DL	

migrant throughout state from subspecies' far northern breeding range, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Bald Eagle	*Haliaeetus leucocephalus*	DL	T

found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Brown Pelican	*Pelecanus occidentalis*	DL	

largely coastal and near shore areas, where it roosts and nests on islands and spoil banks

Henslow's Sparrow	*Ammodramus henslowii*		

wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles; a key component is bare ground for running/walking

Interior Least Tern	*Sterna antillarum athalassos*	LE	E

subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony

Mountain Plover	*Charadrius montanus*		

breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous

Peregrine Falcon	*Falco peregrinus*	DL	T

both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (F. p. anatum) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, F.p. tundrius is no longer listed in Texas; but because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.

Reddish Egret	*Egretta rufescens*		T

resident of the Texas Gulf Coast; brackish marshes and shallow salt ponds and tidal flats; nests on ground or in trees or bushes, on dry coastal islands in brushy thickets of yucca and prickly pear

JACKSON COUNTY

BIRDS

		Federal Status	State Status
Snowy Plover	*Charadrius alexandrinus*		

formerly an uncommon breeder in the Panhandle; potential migrant; winter along coast

Sooty Tern	*Sterna fuscata*		T

predominately 'on the wing'; does not dive, but snatches small fish and squid with bill as it flies or hovers over water; breeding April-July

Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*		

wintering migrant along the Texas Gulf Coast beaches and bayside mud or salt flats

Sprague's Pipit	*Anthus spragueii*	C	

only in Texas during migration and winter, mid September to early April; short to medium distance, diurnal migrant; strongly tied to native upland prairie, can be locally common in coastal grasslands, uncommon to rare further west; sensitive to patch size and avoids edges.

Western Burrowing Owl	*Athene cunicularia hypugaea*		

open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

White-faced Ibis	*Plegadis chihi*		T

prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats

White-tailed Hawk	*Buteo albicaudatus*		T

near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March-May

Whooping Crane	*Grus americana*	LE	E

potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties

Wood Stork	*Mycteria americana*		T

forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960

FISHES

		Federal Status	State Status
American eel	*Anguilla rostrata*		

coastal waterways below reservoirs to gulf; spawns January to February in ocean, larva move to coastal waters, metamorphose, then females move into freshwater; most aquatic habitats with access to ocean, muddy bottoms, still waters, large streams, lakes; can travel overland in wet areas; males in brackish estuaries; diet varies widely, geographically, and seasonally

JACKSON COUNTY

FISHES

		Federal Status	State Status
Smalltooth sawfish	*Pristis pectinata*	LE	E

different life history stages have different patterns of habitat use; young found very close to shore in muddy and sandy bottoms, seldom descending to depths greater than 32 ft (10 m); in sheltered bays, on shallow banks, and in estuaries or river mouths; adult sawfish are encountered in various habitat types (mangrove, reef, seagrass, and coral), in varying salinity regimes and temperatures, and at various water depths, feed on a variety of fish species and crustaceans

MAMMALS

		Federal Status	State Status
Louisiana black bear	*Ursus americanus luteolus*	LT	T

possible as transient; bottomland hardwoods and large tracts of inaccessible forested areas

Plains spotted skunk *Spilogale putorius interrupta*

catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie

Red wolf	*Canis rufus*	LE	E

extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies

West Indian manatee	*Trichechus manatus*	LE	E

Gulf and bay system; opportunistic, aquatic herbivore

MOLLUSKS

		Federal Status	State Status
Texas fatmucket	*Lampsilis bracteata*	C	T

streams and rivers on sand, mud, and gravel substrates; intolerant of impoundment; broken bedrock and course gravel or sand in moderately flowing water; Colorado and Guadalupe River basins

REPTILES

		Federal Status	State Status
Green sea turtle	*Chelonia mydas*	LT	T

Gulf and bay system; shallow water seagrass beds, open water between feeding and nesting areas, barrier island beaches; adults are herbivorous feeding on sea grass and seaweed; juveniles are omnivorous feeding initially on marine invertebrates, then increasingly on sea grasses and seaweeds; nesting behavior extends from March to October, with peak activity in May and June

Gulf Saltmarsh snake *Nerodia clarkii*

saline flats, coastal bays, and brackish river mouthss

Kemp's Ridley sea turtle	*Lepidochelys kempii*	LE	E

Gulf and bay system, adults stay within the shallow waters of the Gulf of Mexico; feed primarily on crabs, but also snails, clams, other crustaceans and plants, juveniles feed on sargassum and its associated fauna; nests April through August

JACKSON COUNTY

REPTILES

		Federal Status	State Status
Loggerhead sea turtle	*Caretta caretta*	LT	T

Gulf and bay system primarily for juveniles, adults are most pelagic of the sea turtles; omnivorous, shows a preference for mollusks, crustaceans, and coral; nests from April through November

Texas diamondback terrapin *Malaclemys terrapin littoralis*

coastal marshes, tidal flats, coves, estuaries, and lagoons behind barrier beaches; brackish and salt water; burrows into mud when inactive; may venture into lowlands at high tide

Texas horned lizard *Phrynosoma cornutum* — State Status: T

open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September

Texas scarlet snake *Cemophora coccinea lineri* — State Status: T

mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-September

Texas tortoise *Gopherus berlandieri* — State Status: T

open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November

Timber/Canebrake rattlesnake *Crotalus horridus* — State Status: T

swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto

PLANTS

Federal Status State Status

Shinner's sunflower *Helianthus occidentalis ssp plantagineus*

mostly in prairies on the Coastal Plain, with several slightly disjunct populations in the Pineywoods and South Texas Brush Country

Threeflower broomweed *Thurovia triflora*

Texas endemic; near coast in sparse, low vegetation on a veneer of light colored silt or fine sand over saline clay along drier upper margins of ecotone between between salty prairies and tidal flats; further inland associated with vegetated slick spots on prairie mima mounds; flowering September-November

Welder machaeranthera *Psilactis heterocarpa*

Texas endemic; grasslands , varying from midgrass coastal prairies, and open mesquite-huisache woodlands on nearly level, gray to dark gray clayey to silty soils; known locations mapped on Victoria clay, Edroy clay, Dacosta sandy clay loam over Beaumont and Lissie formations; flowering September-November

APPENDIX F

HEALTH RISK ASSESSMENT

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F HEALTH RISK ASSESSMENT

F.1 INTRODUCTION

The United States (U.S.) Department of Energy (DOE) proposes to provide financial assistance to NRG Energy, Inc. (NRG) for the W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project (Parish PCCS Project). NRG proposes to capture carbon dioxide (CO_2) from a 250-megawatt equivalent (MWe) slipstream taken from the 650-megawatt (MW) Unit 8 at the W.A. Parish Plant in Thompsons, Texas. Unit 8 is one of four coal-fired units at the W.A. Parish Plant. Due to upstream flue gas treatment and the amine-based CO_2 capture system, the captured CO_2 gas would be predominantly CO_2 (i.e., greater than 99.96% CO_2 along with small amounts of nitrogen, water, argon, and oxygen, as discussed below in Section F.4). Approximately 1.6 million tons per year of CO_2 is expected to be captured, compressed, and transported through a 12-inch-diameter, approximately **81**-mile-long pipeline to the West Ranch oil field, which is located near Victoria, Texas. Preliminary estimations indicate that approximately 9 injection wells and 16 production wells would be used initially for enhanced oil recovery (EOR) activities. Over the 20-year span of the proposed project, as many as 130 injection wells and 130 production wells would be used to produce oil from the four target geologic units in the Frio Formation. The proposed project is described in detail in Section 2.3 of this Environmental Impact Statement (EIS).

This appendix describes the potential human health and safety impacts associated with potential releases of CO_2 from the proposed pipelines and injection wells during the 20-year operational period of the Parish PCCS Project. Potential releases from the amine-based solvent storage tank to be located on the power plant property are also evaluated. In addition, the potential for post-injection releases from the target geologic units are evaluated. The health and safety impacts are evaluated in terms of the potential risks to workers and the public. The level of risk is estimated based on the current conceptual design of the Parish PCCS Project and expected operating procedures.

F.2 METHODS OF ANALYSIS

The methods used to analyze the potential health and safety impacts associated with operation of the capture system at the W.A. Parish Plant and pipeline transport to the West Ranch oil field are similar to those developed in consultation with United States (U.S.) Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) and used for the EIS for a previous carbon capture and storage project (DOE 2007a,b). Data from the U.S. Census Bureau for the year 2010 were used to approximate the number of people near the plant and associated facilities that could be affected by any accidents or releases.

The potential health effects were analyzed for workers and the public who may be exposed to releases of captured gases during pipeline transport, at the injection well sites, or from the subsurface formations. Each incident was classified into one of the following categories and frequency ranges:

- **Possible:** Accidents estimated to occur one or more times in 100 years of facility operations (frequency $\geq 1x10^{-2}$ per year).
- **Unlikely:** Accidents estimated to occur between once in 100 years and once in 10,000 years of facility operations (frequency from $1x10^{-2}$ to $1x10^{-4}$ per year).
- **Extremely Unlikely:** Accidents estimated to occur between once in 10,000 years and once in 1 million years of facility operations (frequency from $1x10^{-4}$ to $1x10^{-6}$ per year).

- **Incredible:** Accidents estimated to occur less than one time in 1 million years of facility operations (frequency < $1x10^{-6}$ per year).

F.2.1 Storage Tanks Associated with the Capture System

An amine-based solvent, such as monoethanolamine (MEA) or other solvents with similar properties, would be used to extract the CO_2 from the flue gas. New storage tanks for this solvent would be installed at the plant. As discussed below in Section F.3, potential failure of the refill line valve to the 15,000-gallon solvent tank was evaluated for a scenario where the valve leaks, causing the tank to drain and a pool of amine-based solvent to form. Due to the proprietary makeup of many commercial amine solvents, MEA, a common amine solvent component, was used for this analysis.

The W.A. Parish Plant currently uses aqueous ammonia in its existing selective catalytic reduction (SCR) units to decrease nitrogen oxide emissions. In 2011, about 28.4 million pounds of 29% aqueous ammonium hydroxide was used for the existing units. There are four existing storage tanks with a capacity of 80,000 gallons each. The tanks are equipped with pressure relief valves, vacuum breaker valves with a flame arrestor, and liquid level indicators (NRG 2007). A small additional amount of aqueous ammonia would be needed on a continual basis for the SCR associated with the heat recovery steam generator (HRSG), which is part of NRG's proposed project. Because the amount of additional ammonia that would be used by the proposed project is small compared to the existing facility use and no new tanks are needed, no new evaluations of ammonia tank leaks or accidents involving transport of ammonia to the plant were conducted. The Risk Management Plan (RMP) for the aqueous ammonia storage and handling system at the W.A. Parish Plant (NRG 2007) includes evaluations of tank ruptures and leaks, a failure of the delivery hose from a truck to the ammonia tank, a failure of piping associated with the ammonia supply header and transfer pumps, and pipe corrosion. No accidental releases of ammonia have occurred from the plant's ammonia handling system since its installation. Additional information on materials stored and/or used at the plant is discussed in the Section 3.14 of the EIS (Materials and Waste Management).

F.2.2 Pipeline Corridor

The transport and dispersion of the released gases was estimated through atmospheric dispersion modeling. The predicted concentrations in air were then used to estimate the potential for exposure and any resulting potential impacts on human receptors. The gas concentrations due to the releases to the atmosphere from the CO_2 pipeline and injection wells during operation were simulated using the SLAB model (Ermak 1990). This model simulates both normal and dense gases using thermodynamic properties, and can evaluate supercritical CO_2. DOE used the pipeline-walk methodology, developed for and used in a previous DOE project with similar characteristics (DOE 2007b), to evaluate the effects of the gas phase releases along the entire length of a pipeline and calculate the number of individuals hypothetically exposed to CO_2 from simulated pipeline ruptures and punctures. This method involves performing a series of calculations using the SLAB model along all or a portion of the pipeline at 300 meter intervals, for the range of meteorological conditions likely to occur at a site. The five main steps in the pipeline-walk method for pipeline rupture and puncture release scenarios are described below:

- **Step 1. Summarize meteorological conditions that affect plume transport.** The meteorological data are used to estimate the proportion of time over a year that each atmospheric state occurs (combinations of 16 wind directions and seven stability conditions, for a total of 112 cases).

- **Step 2. Simulate the area potentially affected by a pipeline release.** The SLAB model is run to determine the surface area of the potential impact zone for each of the defined atmospheric states. Separate runs are performed for each potential health-effect level and exposure period for the rupture and puncture scenarios.
- **Step 3. Estimate population affected for each atmospheric state.** The polygons representing the areal extent of each predicted exposure zone for each simulation is superimposed onto a map of the population density data at a point along the pipeline route. The population within the estimated plume area is computed for each census block and then summed if more than one block could be affected.
- **Step 4. Determine the expected number of individuals potentially affected at the specified release points.** The affected population in each exposure zone is next multiplied by the proportion of the time (relative importance) that a given zone could occur. This process is repeated for each of the defined atmospheric states. Since all the atmospheric state cases sum to one, the sum of these products provides the expected number of affected individuals at any selected point along the pipeline.
- **Step 5. Characterize the potential exposure along the entire pipeline.** Tabular and graphical summaries of the expected number of affected individuals at points along the pipeline provide a comprehensive summary of potential health effects from a pipeline release.

The above pipeline-walk routine was repeated for each criteria concentration and exposure duration for the full set of increments at 300-meter spacing along the pipeline section or the entire pipeline route. Separate simulations using the SLAB model are made if the volume in a pipeline segment changes due to a different inner diameter or length between main line valves (MLVs).

F.2.3 Injection Wells

For active injection wells, DOE used the SLAB model to estimate the CO_2 concentrations in air and the extent of a resulting CO_2 plume due to a release from the well. The pipeline-walk routine at the location of the well is used to complete Steps 3 through 5 described above. This methodology provides an estimate of the expected number of people potentially affected by **well** releases. This routine can be conducted at multiple locations to represent the effects of different well locations.

F.3 POTENTIAL RELEASES FROM THE AMINE-BASED SOLVENT TANK

An advanced amine-based absorption technology using an amine-based solvent has been proposed for use in the CO_2 capture system. This section addresses potential releases from the solvent storage tank on the W.A. Parish Plant property, which would be located in the CO_2 capture facility (Figure 2-4). The solvent to be used was represented using the physical and chemical properties of MEA, although other solvents with similar properties may be used in the proprietary system.

Potential failure of the four-inch-diameter refill line valve to the 15,000 gallon solvent tank was evaluated for a scenario where the valve leaks, causing the tank to drain in 0.5 hours and forming a pool of solvent. This type of release is considered to be an unlikely event with a frequency of from 1×10^{-2} per year to 1×10^{-4} per year. Next, the properties of MEA were used to estimate the evaporation rate from a pool using the general methodology from the EPA's Risk Management Program for Offsite Consequence Analysis (EPA 2009) and the specific equation for liquid evaporation (D-1) in Appendix D.2 (EPA 1999). The liquid evaporation rate and computed duration if no response action was taken were then input to the SLAB model to estimate the MEA concentrations in air under a range of meteorological conditions.

The criteria for MEA that pertain to protecting workers and the general public from exposure via inhalation are shown in Table F-1 and discussed in Section 3.15 of this EIS (Human Health and Safety). MEA is not classified as a carcinogen and is primarily an irritant to skin, eyes, and lungs. The compound degrades in the atmosphere via photolysis and reaction with hydroxyl radicals (Shao and Stangeland 2009).

Table F-1. MEA Criteria for Workers and General Public

Parameter	MEA Concentration in Air (ppm)	Effect Level
PAC-1	6 (1 hour or less)	Mild, transient effects could occur – eye & skin irritant
PAC-2	6 (Above 6 for 1 hour or more)	Above 6 serious health effects could occur to lungs
PAC-3	1000	Life-threatening effects could occur to respiratory or nervous systems
IDLH for Workers	30	Immediately dangerous to life or health, leave area or take other protective action if concentration lasts for 30 minutes
Odor Threshold	2.6	Level at which MEA can be detected in air by most people

PAC criteria for MEA (monoethanolamine) (SCAPA 2012); IDLH and Odor Threshold from MEA Material Safety Data Sheet (LyondellBasell 2010). The MEA Protective Action Criteria (PAC-1) indicates when mild and reversible adverse effects can occur if a concentration of 6 ppm lasts for only up to 1 hour (SCAPA 2012). Exposure above 6 ppm or equal to 6 ppm for longer than one hour constitutes PAC-2 exposure, resulting in irreversible adverse effects. These levels are based on Temporary Emergency Exposure Limits (TEEL) values set by the DOE's Subcommittee on Consequence Actions and Protective Assessments (SCAPA), since other criteria were not available for **MEA** including Acute Exposure Guideline Levels (AEGLs) set by the EPA or Emergency Response Planning Guidelines (ERPG) values set by the American Industrial Hygiene Association (AIHA).

ppm = parts per million

The SLAB model provides the maximum distances at which stated air concentrations equal to specific criteria occur over a given period of time. The key input data used in the SLAB modeling are shown in Table F-2. The SLAB model was used to simulate each of the above criteria for durations of 30 and 60 minutes. The results with respect to potential effects on plant workers or off-site residents are discussed.

Table F-2. Input Data Used for Amines Tank Release Scenario

Parameter	Value
Tank Volume, gallons	15,000
Refill Line Diameter, inches	4
Time to Drain Tank, hours	0.5
Pool Area, square feet	61,134.4
Release Rate, grams per second	115.03
Spill Duration, days if no response action taken	5.8
Wind Speed, meters per second	1.5
Temperature, degrees Fahrenheit (°F)	100
Vapor Pressure, millimeters of mercury at 100°F	1.05
Relative Density to Water	1.018
Molecular Weight of Amine-Based Solvent* (grams per mole)	61.06

*Based on properties for monoethanolamine (CAS #141-43-5)

Plant workers near the tank at the time of a release under calm conditions would need to take response actions, since the IDLH criteria of 30 ppm could occur at a distance of 0.3 miles of a release within a potential exposure zone area extending to about nine acres, which is only part of the entire plant footprint of 4,880 acres. Calm conditions occur about 8.8% of the time based on weather at Houston's George Bush Intercontinental Airport (LES 2012). Under other meteorological conditions (i.e., windier conditions), the plume dissipates more quickly, and the MEA concentration in air over a 30- to 60-minute period would be less than 30 ppm. The SLAB results for the tank leak scenario show that the MEA air concentration would not reach 1,000 ppm, the PAC-3 criteria above which life-threatening effects on the respiratory system can occur.

Under calm conditions, the SLAB results show that an MEA concentration in air of 6 ppm, the PAC-1 and PAC-2 level at which people may begin to experience mild irritation, could extend to about 0.9 miles within the area of the plume, which is estimated by the model to be about 47 acres. For comparison, the CO_2 capture facility on the plant property is expected to comprise about 29 acres. The MEA plume would still be retained on the plant property, although it could extend into the southern part of Smithers Lake. Calm conditions occur about 8.2% of the time based on weather data from Houston's George Bush Intercontinental Airport (LES 2012). Thus, no nearby residents or general public in the vicinity of the plant would be affected if a release from the amine-based solvent tank occurred. Under other meteorological conditions (i.e., windier conditions), the plume dissipates more quickly, and an MEA concentration in air of 6 ppm over 60 minutes could extend to a distance of 0.08 miles or less and encompasses a smaller area of 0.6 to 3 acres. A tank release under calm conditions could possibly be detected based on the odor threshold of 2.6 ppm at a distance of about 1.6 miles from the tank. Under other meteorological conditions (i.e., windier conditions), MEA in the air from a release could possibly be detected within a distance of about 0.16 miles from the tank. The nearest residents to the plant are located approximately 0.5 miles east of the site and 1.5 miles southwest. The wind blows toward these directions less than 8% of the time and about 3% of the time, respectively. The odor threshold is below the concentration when even mild and transient effects could occur.

F.4 POTENTIAL EFFECTS RELATED TO ACCIDENTAL PIPELINE RELEASES

F.4.1 Captured Gas Composition

The captured gases are expected to be 99.96% CO_2, with other constituents present in the pipeline as shown in Table F-3. The potential effects from a pipeline release were evaluated using the expected CO_2 concentration. As shown in Table 2-5 in Section 2.3, other trace gases such as sulfur dioxide and ammonia were not expected to be present in the compressed gas because upstream treatment processes would remove them.

Table F-3. Estimated Captured Gas Composition for W.A. Parish Plant

Compound	Quantity*
Carbon dioxide	> 99.96 vol%
Oxygen	< 10 ppmv
Water	< 100 ppmv
Nitrogen + Argon	231 ppmv

Source: NRG 2012g

*Values for compounds were provided by NRG.

vol% = percentage by volume; ppmv = parts per million by volume

F.4.2 Criteria for CO_2

Potential health effects from CO_2 would depend on the concentration and length of exposure, as well as other environmental factors. The evaluation considered gaseous releases that may occur rapidly for only a short time (e.g., rupture of a pipeline) or more slowly over a longer period of time (e.g., leakage from a pipeline puncture or subsurface reservoir).

Potential health effects from inhalation of high concentrations of CO_2 gas can range from headache, dizziness, sweating, and vague feelings of discomfort, to breathing difficulties, increased heart rate, convulsions, coma, and possibly death. The criteria for CO_2 recently changed in February 2012, so that at present the PAC-1 and PAC-2 levels at which mild, reversible, effects and adverse effects such as breathing difficulties can occur are assigned to the same concentration (SCAPA 2012). No health effects to the general public, including susceptible individuals, are expected to occur at CO_2 concentrations of 5,000 ppm or less (i.e., PAC-0). These levels are based on Temporary Emergency Exposure Limits (TEEL) values set by DOE's Subcommittee on Consequence Actions and Protective Assessments (SCAPA), rather than Acute Exposure Guideline Levels (AEGLs) set by EPA or Emergency Response Planning Guidelines (ERPG) values set by the American Industrial Hygiene Association (AIHA).

Table F-4 provides health risk criteria for workers and the public for exposure to CO_2. In general, TEEL values are used until AEGLs or ERPGs are adopted for chemicals. Long-term exposure criteria (i.e., for exposure periods greater than eight hours) have not been developed for CO_2 because CO_2 does not pose an appreciable risk of deleterious effects to humans, including sensitive subgroups, for longer exposure periods. For the puncture releases of the pipeline, CO_2 concentrations were compared to values of 5,000 ppm (i.e., the time-weighted average [TWA] value developed by the U.S. Occupational Safety and Health Administration [OSHA] for an 8-hour period) and to 20,000 ppm and 40,000 ppm (i.e., based on information from EPA 2000). CO_2 can asphyxiate workers if they are quite close to a pipeline rupture, and is an acute health risk. Therefore, the potential for CO_2 as a dense gas to accumulate in low areas or confined spaces such as basements is discussed with respect to the releases evaluated and the setting of the W.A. Parish Plant, the pipeline corridor, and West Ranch well field.

When characterizing the potential for impacts related to accidents, the expected frequency at which such accidents may occur was estimated. The expected frequency of an accident is the chance that the accident might occur for certain types of activities or operations. Accident frequency is typically discussed in terms of the number of occurrences over a period of time. For example, the frequency of occurrence for an accident that can be expected to happen once every 50 years is, one accident divided by the 50-year period (0.02 per year or $2x10^{-2}$ per year). An annual frequency estimate can be converted to a probability estimate by considering the time period of the operation. To characterize the annual frequency of certain events, the terms possible, unlikely, extremely unlikely, and incredible were used as defined previously.

Based on DOE's review, pipeline puncture are considered to be unlikely events (frequency from 1×10^{-2} per year to 1×10^{-4} per year). Although pipeline punctures or ruptures would be unlikely, the potential risks from CO_2 pipeline releases were analyzed using the SLAB model (Ermak 1990) and the pipeline-walk methodology (DOE 2007b).

Table F-4. Potential Health Effects from Exposure to CO_2

Gas	Potential Health Effects	Health Protective Criteria Concentrations – Public[1] (ppm)	Health Protective Criteria Concentrations – Workers[2] (ppm)
Carbon dioxide	No health effects	PAC-0: 5,000 (1 hour or less)	PEL: 5,000 (8 hours)
	Reversible, adverse effects (e.g., headache, dizziness, sweating, vague feelings of discomfort)	PAC-1: 30,000 (1 hour or less) 20,000 (8 hours)	STEL: 30,000 (15 min, up to 4 times/day)
	Irreversible adverse effects (e.g., breathing difficulties, increased heart rate, convulsions, coma)	PAC-2: Above 30,000 (1 hour)	IDLH: 40,000 (30 minutes)
	Life threatening	PAC-3: Above 50,000 (1 hour)	

[1]Based on Protective Action Criteria (PAC) for exposure time of 1 hour or less established by DOE's Subcommittee on Consequence Actions and Protective Assessments (SCAPA, 2012).

PAC-0: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, would experience no health effects (SCAPA, 2011)

PAC-1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience discomfort, irritation, or certain asymptomatic, non-sensory effects; however, these effects are not disabling and are transient and reversible upon cessation of exposure (SCAPA, 2012)

PAC-2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape (SCAPA, 2012)

PAC-3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects, if the concentration was sustained for 60 minutes. (SCAPA, 2012)

Longer term levels for 8 hours are from US EPA 2000, but are not AEGLs. The 8-hour OSHA TWA is 5,000 ppm.

[2] Permissible Exposure Levels (PELs) are legally enforceable standards established by the U.S. Occupational Safety and Health Administration (OSHA, 2009a). Immediately Dangerous to Life and Health (IDLH) levels are recommended criteria established by the National Institute of Safety and Health (NIOSH, 2005), designed to allow a worker to escape within 30 minutes.

Short Term Exposure Limit (STEL) based on 3 percent in air, which is a concentration that it is believed that workers can be exposed to for up to 15 minutes no more than 4 times per day , as defined by ACGIH

ppm = parts per million (by volume)

F.4.3 Simulation of Pipeline Releases

The gases transported in the pipeline would be expected to be 99.96% CO_2 by volume, with other constituents present in the pipeline as shown in Table F-3. The potential effects from a pipeline release were evaluated using the expected CO_2 concentration. As shown in Table 2-4 in Section 2.3 of this EIS, other trace gases such as sulfur dioxide and ammonia would not be expected to be present in the compressed gas.

Two accidental release scenarios (i.e., a pipeline rupture and a pipeline puncture) represent the most likely causes of pipeline releases at larger volumes. A pipeline rupture release would occur if the pipeline was completely severed, for example, by heavy equipment during excavation activities. A rupture could also result from a longitudinal running fracture of a pipe section or a seam-weld failure. In these cases, the entire contents of the pipeline between the two nearest MLVs could be discharged from the severed pipeline within minutes.

A pipeline puncture release is defined here as a three-inch by one-inch hole that could be made by a tooth of an excavator. In such a case, all of the contents in the pipeline between the two nearest control valve stations would discharge into the atmosphere, but the release would occur over a period of several hours, as the opening is small relative to the total volume and the pressure declines as the fluid escapes. No credit is taken for the possible attenuating properties of the pipeline being buried at a depth of approximately three to four feet under compacted soil.

Captured CO_2 would be transported as a supercritical fluid, such that its density resembles a liquid but it expands to fill space like a gas. If CO_2 is released from a pipe, it expands rapidly as a gas and can include both liquid and solid (i.e., dry ice) phases, depending on temperature and pressure. Supercritical CO_2 has a very low viscosity, but is denser than air. A potential release of CO_2 through an open orifice in the pipeline as a gas moving at the speed of sound is referred to as choked or critical flow (Bird, et al. 2002). In the rupture scenario, the escaping gas from the pipeline is assumed to escape as a horizontal jet at ground level, which is typically the worst-case event for heavier-than-air gases (Hanna and Drivas 1987).

Potential releases to the atmosphere represent the primary exposure pathway considered in the exposure analysis. The receptor groups likely to be exposed by releases from the CO_2 pipeline or aboveground equipment at the plant or injection site are on-site workers and off-site populations. In addition to the potential health effects of a release, which would be dependent on the exposure concentrations and local meteorological conditions at the time of a release, workers near a ruptured or punctured pipeline or wellhead are likely to also be affected by the physical forces from the accident itself, including the release of gases at high flow rates and at very high speeds. Workers involved at the location of an accidental release would be potentially affected, possibly due to a combination of effects, such as physical trauma, asphyxiation (i.e., displacement of oxygen in a small confined place), or frostbite from the rapid expansion of CO_2 (e.g., from the pipeline operating pressure of 2,115 pounds per square inch, absolute [psia] to atmospheric pressure [i.e., 15 psia]).

The SLAB model was used to simulate rupture and puncture of the CO_2 pipeline. There are a total number of 12 MLVs planned along the **81**-mile pipeline line from the CO_2 compressor at the W.A. Parish Plant to the West Ranch oil field (see Figure F-1). The inner diameter of the pipeline is 12.090 inches along the pipeline except at crossings where the inner diameter of the pipe would be 11.938 inches, based on information provided by NRG. Six of the MLVs are planned at the crossing of three major rivers (i.e., the San Bernard River, the Colorado River, and the Lavaca River). **One of the** other valves **is** near Blue Creek. The locations of the valves are listed in Table F-5. The distance between the valves as measured along the planned pipeline route are provided in Table F-6.

Four scenarios were selected to represent the distances between the MLVs. The base case conditions for both the large and small pipeline segments were a pressure of 2,115 psia at approximately 38.9 degrees Celsius (°C) (102°F), which means the CO_2 would be transported in a supercritical state. If a pipeline release occurs, part of the supercritical fluid is converted to a dry ice snow form, which then slowly sublimates. The density of the supercritical CO_2 gas is 46.7 pounds per cubic foot (lbs/ft^3) (783.2 kilograms per cubic meter [kg/m^3]). The percent of CO_2 released as a vapor is estimated to be 75% for these temperatures and pressure. The transport of the vapor phase in the atmosphere is then simulated using SLAB and the results compared to appropriate health criteria.

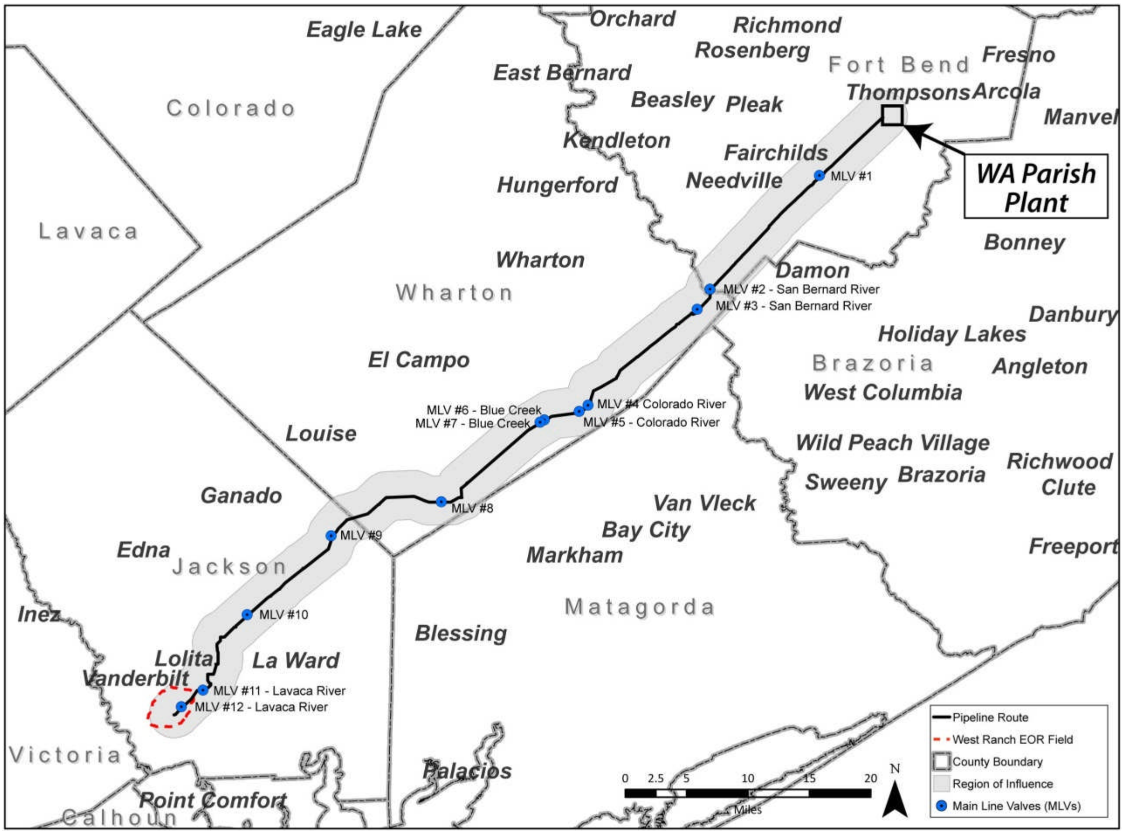

Figure F-1. Map of Planned Pipeline with MLVs between W.A. Parish Plant and West Ranch Oil Field

Table F-5. Planned Locations of Main Line Block Valves along Pipeline

Name	Latitude	Longitude
MLV #1	29° 24' 7.579" N	95° 43' 11.066" W
MLV #2 - San Bernard River	29° 16' 16.807" N	95° 52' 19.895" W
MLV #3 - San Bernard River	29° 14' 51.545" N	95° 53' 23.002" W
MLV #4 - Colorado River	29° 8' 15.864" N	96° 2' 25.095" W
MLV #5 - Colorado River	29° 7' 49.816" N	96° 3' 8.927" W
MLV #6 - Blue Creek	29° 7' 17.421" N	96° 6' 0.464" W
MLV #7 - Blue Creek	29° 7' 7.163" N	96° 6' 20.827" W
MLV #8	29° 1' 37.829" N	96° 14' 28.973" W
MLV #9	28° 59' 23.703" N	96° 23' 26.533" W
MLV #10	28° 53' 55.771" N	96° 30' 20.885" W
MLV #11 - Lavaca River	28° 48' 37.144" N	96° 34' 2.480" W
MLV #12 - Lavaca River	28° 47' 27.681" N	96° 35' 49.066" W

Table F-6. Distances between Valves along Pipeline

Distances between MLVs	Pipeline Length		Pipeline Scenario	Wind Data*
	Meters	Miles		
Plant to MLV #1	11,213	6.97	A	Houston
MLV #1 to MLV #2	20,807	12.93	B	Houston
MLV #2 to MLV #3	3,257	2.02	River crossing	Not applicable
MLV #3 to MLV #4	19,882	12.35	B	Houston
MLV #4 to MLV #5	1,477	0.92	River crossing	Not applicable
MLV #5 to MLV #6	4,821	3.0	Used Scenario A results	Houston
MLV #6 to MLV #7	635	0.39	River crossing	Not applicable
MLV #7 to MLV #8	17,581	10.92	C	Victoria
MLV #8 to MLV #9	16,492	10.24	C	Victoria
MLV #9 to MLV #10	15,433	9.59	C	Victoria
MLV #10 to MLV #11	13,728	8.53	D	Victoria
MLV #11 to MLV #12	3,854	2.39	Used Scenario A results	Not applicable
MLV #12 to End	1,626	1.01	Used Scenario A results	Not applicable

*Wind data used are from LES, 2012. See Figures 3.2- 2 and 3.2- 3 in Section 3.2 of this EIS (Air Quality and Climate).

Seven meteorological stability classes, as defined in Table F-7 and Table F-8, and all 16 different wind directions were used for the two simulations. These simulations were based on local surface wind data from Houston's George Bush Intercontinental Airport National Weather Service Station between 1983 and 1990 or the Victoria/WSO Airport (LES 2012).

As shown in the wind rose diagram (see Figures 3.2- 2 and 3.2- 3 in Section 3.2 of this EIS [Air Quality and Climate]), calm conditions occurred about 8.2% of the time in Houston and 2.2% of the time in Victoria. The predominant wind direction at the George Bush Intercontinental Airport is from the south (11.4% of the time on an annual basis), with significant winds also from the north (10.3%). The predominant wind direction at the Victoria airport is from the south (14% of the time) and almost the same from the north (12.7% of the time).

Table F-7. Pasquill Meteorological Stability Classes

Stability Class	Description
A	Extremely unstable conditions
B	Moderately unstable conditions
C	Slightly unstable conditions
D	Neutral conditions
E	Slightly stable conditions
F	Calm, stable conditions
G	Extremely stable conditions

Source: Turner, 1994

*Classes E and G are not used for the W.A. Parish Plant, pipeline corridor, or West Ranch oil field

Table F-8. Meteorological Conditions Used in SLAB Simulations

Condition	F1	A1	B2	C4	D7	D10	D12
Pasquill Category	F	A	B	C	D	D	D
Average Wind Speed (m/s)	1	1	2	4	7	10	12

m/s =meters per second

Simulations were conducted to determine the impact zone where workers and the public could be exposed to concentrations from pipe ruptures equal to the pertinent short duration health criteria (PAC-0 to PAC-3) for CO_2 and the other criteria that pertain to workers (see Table F-4). The exposure period if a pipe rupture occurred would be less than 15 minutes. However, the criteria sometimes have longer durations (e.g., 30 to 60 minutes). The pipe puncture releases would be longer in duration; the longest exposure period is estimated to be about four hours. There are no longer duration health criteria for CO_2, such as the EPA Acute Exposure Guideline Levels for eight-hour exposures (AEGL-1 through AEGL-3), since CO_2 is an acute hazard, rather than a chronic hazard. The same criteria were used for assessing the potential effects related to punctures. For workers, a simulation was also made to determine the impact zone for 40,000 ppm CO_2 for a 30-minute exposure period.

The potential plume from a given pipeline rupture scenario would be small in areal extent and its position would depend on the wind direction, speed, and stability conditions at the time of the release. Figure F-2 shows the **planned** pipeline route and the population densities from the 2010 U.S. Census. The 2010 U.S. Census data were obtained for tracts within a two-mile corridor on each side of the planned pipeline route.

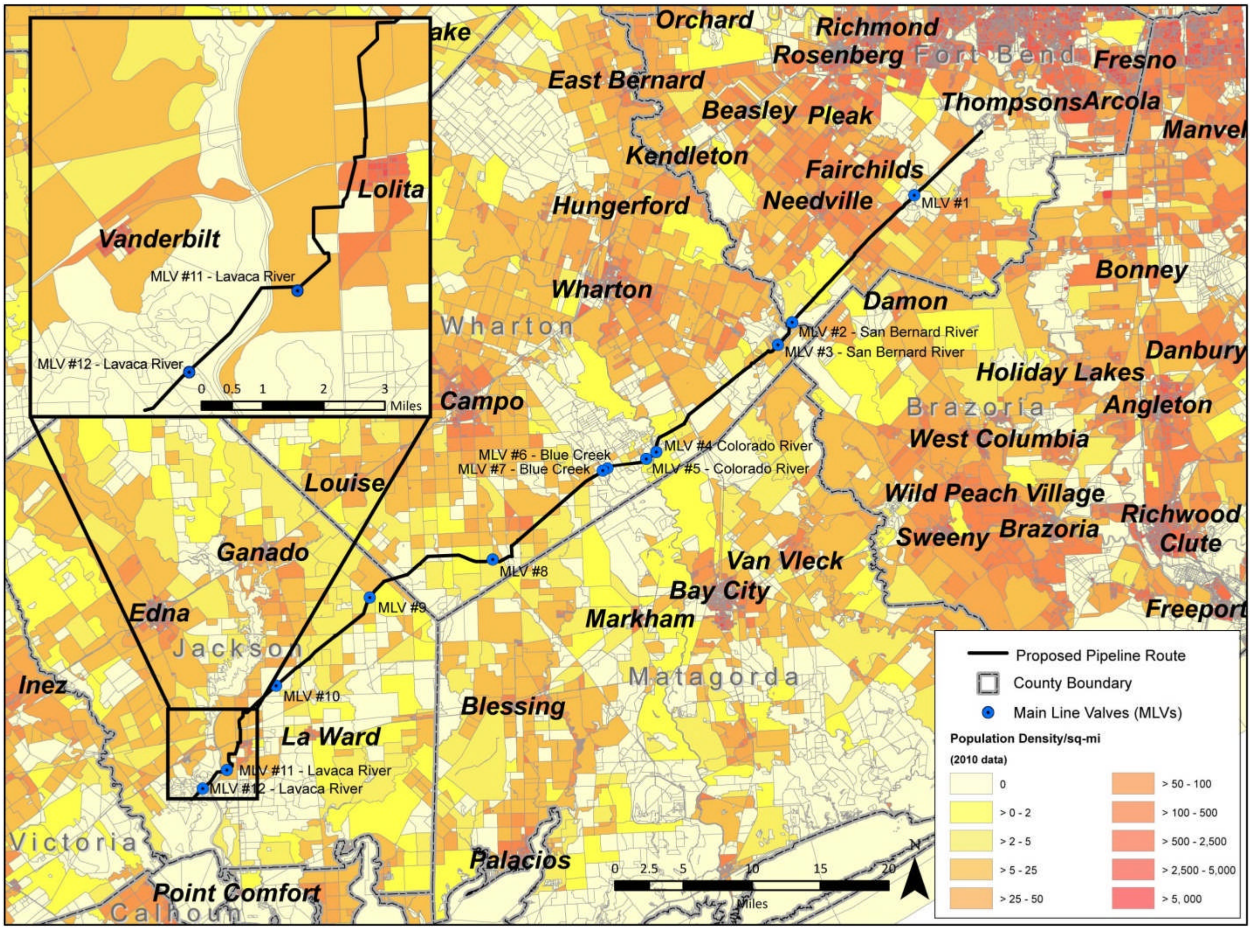

Figure F-2. Potential Population in Vicinity of the Proposed Pipeline Corridor (2010 U.S. Census)

F.4.4 Pipeline Results

Table F-9 shows the estimated distances that a given exposure concentration plume could extend out from a hypothetical pipeline release due to a rupture or puncture for the four pipeline sections. The results shown in this table are for the base case conditions, pressure at 2,115 psia and temperature at 102°F. The rupture is estimated to last for a short time (i.e., less than ten minutes), whereas the puncture is estimated to last for a longer time (i.e., about four hours). Examples of the distances that the exposure zone could extend under calm conditions and under other windier conditions are shown for different criteria for both the rupture and puncture in Table F-9. In many of the simulated cases, the exposure zone extended farthest under calm conditions. The distance shown for the windy conditions provides the second-longest distance for this case. When the longest distance did not occur under calm conditions, the longest distance is shown in the table for the other conditions. See Table F-8 for the definition of the meteorological conditions.

Table F-9. Simulated Plume Transport Distances for Hypothetical Pipeline Releases

Release Type	Averaging Period	Criteria (ppm)	Calm Distance (m)	Calm Meteorological Conditions	Other Distance (m)	Other Meteorological Conditions
Simulation Case: Plant to MLV #1 (Case A)						
Rupture	15 minutes	5,000	2,689	F1	992.5	A1
	15 minutes	30,000	155.7	F1	147.8	D7
	15 minutes	40,000	105.5	F1	105.9	D12
	15 minutes	50,000	79.2	F1	89.6	B2
	30 minutes	40,000	43.1	F1	44.8	D12
	60 minutes	5,000	276.6	F1	236.7	D7
	60 minutes	30,000	25.78	F1	26.23	D12
	60 minutes	50,000	11.5	F1	11.3	D12
Puncture	8 hours	5,000	225.6	F1	117.9	A1
	8 hours	20,000	34.2	F1	30.7	C4
	8 hours	40,000	12.7	F1	12.2	A1
Simulation Case: MLV #1 to MLV #2 and MLV #3 to MLV #4 (Case B)						
Rupture	15 minutes	5,000	3,323.7	F1	1,259.2	C4
	15 minutes	30,000	352.0	F1	280.8	D7
	15 minutes	40,000	230.4	F1	204.4	D7
	15 minutes	50,000	168.05	F1	156.2	D7
	30 minutes	40,000	87.1	F1	89.2	D12
	60 minutes	5,000	630.6	F1	417.5	C4
	60 minutes	30,000	27.6	F1	28.1	D12
	60 minutes	50,000	27.57	F1	28.1	D12
Puncture	8 hours	5,000	444.3	F1	162.8	A1
	8 hours	20,000	74.4	F1	56.0	A1
	8 hours	40,000	28.8	F1	26.2	C4
Simulation Case: MLV #7 to MLV #8, : MLV #8 to MLV #9, and MLV #9 to MLV #10 (Case C)						
Rupture	15 minutes	5,000	3081.5	F1	1,162.5	A1
	15 minutes	30,000	263.0	F1	226.2	D7
	15 minutes	40,000	173.8	F1	160.9	D7
	15 minutes	50,000	127.7	F1	124.9	D10
	30 minutes	40,000	67.9	F1	70.5	D12
	60 minutes	5,000	470.3	F1	346.0	D7

Release Type	Averaging Period	Criteria (ppm)	Calm Distance (m)	Calm Meteorological Conditions	Other Distance (m)	Other Meteorological Conditions
	60 minutes	30,000	21.0	F1	21.2	D12
	60 minutes	50,000	21.0	F1	21.0	All
Puncture	8 hours	5,000	353.3	F1	146.9	A1
	8 hours	20,000	56.5	F1	45.8	C4
	8 hours	40,000	21.84	F1	20.4	C4
Simulation Case: MLV #10 to MLV #11 (Case D)						
Rupture	15 minutes	5,000	2,757.9	F1	1018.8	A1
	15 minutes	30,000	171.2	F1	159.6	D7
	15 minutes	40,000	114.9	F1	113.7	D10
	15 minutes	50,000	86.2	F1	88.4	D12
	30 minutes	40,000	35.4	F1	36.5	D12
	60 minutes	5,000	304.1	F1	253.9	D7
	60 minutes	30,000	28.2	F1	28.8	D12
	60 minutes	50,000	13.1	F1	12.9	D12
Puncture	8 hours	5,000	246.3	F1	123.2	A1
	8 hours	20,000	37.5	F1	33.2	C4
	8 hours	40,000	14.2	F1	13.5	B2

ppm = parts per million; m = meters

Table F-9 shows that the farthest distance along the pipeline route that a CO_2 concentration of 30,000 ppm (PAC-1 and 2 criteria) over 15 minutes could extend from a hypothetical pipeline rupture ranged from 352 meters (1,155 feet) for the section between **MLV #1 and MLV #2 and between** MLV #3 and MLV #4, which **are** the longest section**s**, to **156** meters (**512** feet) for the section between **the plant and MLV #1**. Higher CO_2 concentrations of 50,000 ppm (PAC-3) for an hour would remain near the pipeline at a distance of less than 28 meters (91 feet). The farthest distance from a puncture was much less, as seen in Table F-9. There would be no effects to the general public from a puncture located outside of the exposure zone where a CO_2 concentration of 5,000 ppm (PAC-0 criteria) could occur to a distance of 444 meters (0.02 miles) under calm conditions for the section between **MLV #1 and MLV #2 or** MLV #3 and MLV #4 to 226 meters (561 feet) for the section between the plant and MLV #1. The PAC-0 concentration extended even less under other meteorological conditions when more dissipation would occur from the wind. The distance that an exposure zone could extend at a CO_2 concentration of 40,000 ppm over an 8-hour period ranged from 29 meters (95 feet) to 13 meters (43 feet).

The pipeline-walk method and the population density data were used to estimate the expected numbers of people that could be affected by hypothetical ruptures or punctures of CO_2 for the four pipeline sections based on the percent of time that a plume would be transported by the wind in the different directions and speeds. Table F-10 presents the estimated number of people potentially affected by exposure to CO_2 at various criteria concentrations, resulting from a hypothetical pipeline release for both a rupture and puncture for the longer pipeline sections. The estimated number of people is a calculated number based on the population density within each hypothetical plume given the full range of meteorological conditions that could occur multiplied by the percent of time that each of those conditions could occur.

Table F-10. Estimated Number of People Affected by CO_2 from the Hypothetical Pipeline Releases for Scenario A

Release Type	Exposure Duration	CO_2 Criteria, ppm [Exposure Level]	Number of People Potentially Affected
Rupture	15 minutes	50,000 [PAC-3]	0 for all sections
	15 minutes	30,000 [PAC-2]	0 for all sections
	15 minutes	5,000 [PAC-0]	0-12*
Puncture	8 hours	40,000 [EPA, 2000]	0 for all sections
	8 hours	20,000 [EPA, 2000]	0 for all sections
	8 hours	5,000 [PEL-TWA]	0 for all sections

*Plant to MLV #1 up to four people, MLV #1 to MLV #2 up to 12 people, MLV #10 to MLV #11 up to one person

For each scenario, a pipeline rupture or puncture would statistically affect none or less than one person in all cases, not considering workers located nearby at the time of the release. Based on the results provided in Table F-10, the expected number of off-site receptors affected by potential pipeline releases from ruptures resulting in CO_2 concentrations of 30,000 ppm or higher is less than one person for the four pipeline sections simulated and for two other sections (i.e., MLV #11 to MLV #12 and for MLV #12 to the end of the pipeline) where the results from Case A were used.

The expected number of people that could be affected by an exposure zone with a CO_2 concentration of 5,000 ppm for a 15-minute period along the section between the plant and MLV #1 is four people, between MLV #1 and MLV #2 is 12 people, and between MLV #10 and MLV #11 is one person. The locations where the highest number of people (i.e., 12 people) could potentially be affected by mild discomfort are located about nine miles west of the W.A. Parish Plant (i.e., one to two miles west of MLV #1) in a small tract with a population density of 100 to 500 people per square mile located just north of the pipeline corridor along the section (Figure F-2). The wind blows from the south about 11.4% of the time based on the Houston weather data.

The second-highest number of people (i.e., four people) would be about 2.2 miles west of the W.A. Parish Plant in a small tract next to the pipeline that had a population density of 100 to 500 people per square mile. This tract is also on the north side of the pipeline corridor. The actual population in this tract is 26 to 50. The residences are outside the construction ROW for the pipeline. The last place where one person could be affected between MLV #10 and MLV #11 is near the town of Lolita. The population in the area around the pipeline segment outside of the West Ranch oil field is 51 to 100 along a portion of this section. The population density is 5 to 25 people per square mile closest to the pipeline. The town is farther to the east, so the residences could be farther away from the pipeline.

F.4.5 Estimated Frequencies and Probabilities of Pipeline Releases

Table F-11 shows safety incidents between 1992 and 2011 involving natural gas and CO_2 pipelines in the U.S. CO_2 pipelines have not resulted in any fatalities through 2011 and injuries are rare; the annual incident frequency is 0.06 per 100 miles per year based on incident data from the Office of Pipeline Safety (OPS 2012b). The incident rate for natural gas pipelines is lower, but there have been fatalities. The major cause of failure in serious incidents considering all pipelines is damage (i.e., puncture or rupture) during excavation of existing pipelines for repair or for new pipelines (OPS 2011c). For CO_2 pipelines, weld failures and equipment leaks such as relief valves were the cause of most incidents (OPS 2011b).

Table F-11. Pipeline Safety Record in United States (1992 – 2011)

Pipelines	Natural Gas	Carbon Dioxide
Length (miles)	312,290	4,560
All Incidents	1,702	57
Fatalities	43	0
Injuries	221	1
Property Damage (in $M)	1,505.47	1.91
Incidents per 100 miles per year	0.027	0.062

Note: Based on Office of Pipeline Safety Data through 7/2011 Mileage data (OPS, 2012a; Incident Data (OPS, 2011b and 2012b). Natural gas data included onshore transmission and gathering lines.

$M = millions of dollars

In 2011, there were 312,290 miles of pipelines in the U.S. transporting natural gas in onshore transmission and gathering lines and over 2.1 million miles of distribution lines for natural gas. Crude oil, other petroleum products, and other hazardous liquids were transported in 179,042 miles of pipelines. There were 4,192 miles of CO_2 pipelines in the United States in 2009 and 4,560 miles in 2010 (OPS 2012a), of which most are used for EOR projects. The characteristics and pipeline transportation risks for CO_2 and natural gas or petroleum products are different. For example, CO_2 is expected to be transported by pipeline as a supercritical fluid with a density of approximately 70% to 90% of that of liquid water. If a leak develops along a pipeline, a portion of the escaping fluid would quickly expand to a gas, while the remainder would form a solid (i.e., dry ice snow). CO_2 gas is about 50% heavier than air and would disperse horizontally following the ground contours. In contrast, natural gas in a pipeline is lighter than supercritical CO_2 and is more likely to disperse upwards. Natural gas is also highly flammable, which poses different risks compared to CO_2, which is not flammable.

Office of Pipeline Safety incident data from 1991 through 2011 from the on-line library of the Office of Pipeline Safety (OPS 2012b) were used to calculate the frequency and probability of pipeline ruptures and punctures. Four of the 57 incidents that occurred from 1991 to 2011 with the largest CO_2 releases (i.e., greater than 4,000 barrels) were designated as rupture-type releases. Using the total length of CO_2 pipelines involved of 6,746.37 kilometers (4,192 miles), the annual rupture failure frequency was calculated to **be** $2.96x10^{-5}$ per kilometer per year. Ten of the next largest releases from the existing CO_2 pipelines had losses of CO_2 between 300 and 4,000 barrels. The remaining incidents had releases of less than 100 barrels, although three incidents had CO_2 losses less than 0.1 barrels and one incident had no loss information. The annual rupture failure frequency was calculated to be $7.06x10^{-5}$ per kilometer per year. The annual pipeline failure frequencies and the probability of at least one failure over a 20-year lifetime of the pipelines were calculated assuming the probability of failure to be exponentially distributed with the hazard rate equal to the product of the failure frequency and the pipeline length.

The annual frequency of a rupture on the proposed pipeline is estimated as **3.9**$x10^{-3}$ for the **approximately 81**-mile (**130.8**-kilometer) pipeline to the West Ranch oil field site. The probability of at least one rupture over a 20-year operating period is estimated to be **7.5**$x10^{-2}$. The annual frequency of a puncture on the proposed pipeline to well field is estimated as **9.2**$x10^{-3}$. The probability of a puncture over a 20-year operating period is estimated to be 1.7×10^{-1}. Based on the estimated frequencies of pipeline punctures or ruptures, both releases on the pipeline to the well field are considered unlikely (i.e., having an annual frequency from 1×10^{-2} to 1×10^{-4}).

F.5 POTENTIAL RELEASES FROM SUBSURFACE FORMATIONS

F.5.1 Operation Phase

This section addresses potential releases from the subsurface after injection operations for EOR have ceased. The geology of the West Ranch oil field and the four potential injection zones, 98-A sand unit, 41-A sand unit, Greta sand unit, and Glasscock sand unit are described in Section 3.4, Geology. The planned project would inject an estimated total of 1.6 million tons of CO_2 per year for 20 years to enhance oil recovery in the four zones within the Frio Formation in the West Ranch oil field. The plan is to use a total of 130 wells where each well is centered on a 40-acre area in a 5-spot pattern with one production well in the center and four injection wells at the corners to pump the oil as shown in Figures 3.4-8 and 3.4-9. The CO_2 recovered with the produced oil would be reinserted into the pipeline for reinjection into one of the four formations.

Potential failure of equipment in an example injection well was evaluated using the SLAB model for a well in each of the four sand units. Each new injection well would have an approximately seven-inch-diameter casing that would extend to the full depth of the well (i.e., approximately 6,500 feet bgs). Each well casing would be cemented into place from the total depth of the borehole to ground surface. Because well casings would be cemented into the formation, it is inferred that there would be tubing inside the casing with valves that connect to the CO_2 supply system. The inner diameter of this tubing is estimated as three inches based on the set-up used for the Frio Pilot Test (Hovorka, et al. 2003) and designs for other CO_2 injection wells (e.g., three-inch tubing inside a seven-inch casing). The mass of CO_2 was estimated based on the volume of one well from the ground surface to the depth of injection for each of the four sands and the CO_2 density at the temperature and pressure conditions during the active injection phase. The conditions for the well simulations are shown in Table F-12. Three different possible locations for this example well were used to estimate the number of people that could potentially be affected if a failure of the valve system occurred.

The SLAB model was used to determine the maximum distance at which the concentration of CO_2 over a specified period of time in air equals a given criteria. The lowest criterion used was 5,000 ppm, the PAC-0 level at which no health effects to the general population or susceptible individuals would be expected. The CO_2 concentration of 5,000 ppm is also the OSHA PEL and American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) based on an eight-hour TWA. The next higher criterion used was 30,000 ppm (PAC-1 and PAC-2). Serious adverse and irreversible effects such as breathing difficulties and increased heart rates could occur only if the CO_2 concentration exceeded 30,000 ppm for one hour or more (SCAPA 2012). This value is also the ACGIH STEL based on 3% in air, which is a concentration that it is believed that workers can be exposed to for up to 15 minutes no more than four times per day. The PAC-3 criteria for CO_2 of 50,000 ppm was also evaluated, which is the level above which life-threatening adverse health effects to the general public could occur if the concentration was sustained for 60 minutes. A CO_2 concentration of 40,000 ppm was simulated to evaluate potential effects to workers. Workers need to take protective action if the CO_2 concentration of 40,000 ppm lasts for a 30-minute period, the IDLH limit. The National Institute for Occupational Safety and Health (NIOSH) defines the IDLH limit as the recommended criteria designed to allow a worker time to escape.

Table F-12. Simulation Conditions for CO_2 Released from Active Injection Wells

Injection Zone	Tubing ID (inches)	Tubing Depth (feet)	Mass CO_2 (kg) @2115 psia, 102°F	$Q_{choked-CO_2}$ * (kg/second)	Release Duration (seconds)
98-A	3	6,300	6,550	183	35.8
			(4,913)	(137)	(35.8)
41-A	3	5,800	6,031	183	32.9
			(4,523)	(137)	(32.9)
Greta	3	5,250	5,459	183	29.8
			(4,094)	(137)	(29.8)
Glasscock	3	5,550	5,771	183	31.5
			(4,238)	(137)	(31.5)

*Wellbore volume is based on the total depth of hole. ID = Inner Diameter. CO_2 density = 748.2 kg/m^3 at 102 °F (38.9°C) and 2,115 psia. Choked flow $Q_{choked-CO2}$ is based on CO_2 properties. Modeling assumes emission rates remain constant during release. Values in parentheses show CO_2 after adjustment to eliminate the 25% snow (solid phase) component from the discharge after being released into the atmosphere.

The simulations were made using the SLAB model to determine the maximum distances from the wells where the predicted CO_2 concentrations in air were equal to the pertinent criteria for CO_2 over a period of time. These distances are shown in Table F-12 for a CO_2 concentration of 5,000 ppm over 15-minutes. Next, the pipeline-walk routine was used to evaluate the maximum expected number of people that could be affected from a well release located in the West Ranch oil field near the end of the pipeline. This routine considers the plume shape for different meteorological conditions and the percent of time that the wind blows in various directions. The maximum number of people that potentially could be affected was less than one for each of the four depths of wells, as shown in Table F-2. As shown in Table F-3, the population density is low near the well field. The highest population density is on the east side across the Lavaca River and south of the town of Lolita where the population density is 51 to 100 people per square mile. If an injection well were located on the easternmost part of the well field, the maximum number of people that potentially could be affected by CO_2 from a hypothetical release was less than one for each of the four wells. There is a high school located on the south side of Vanderbilt to the north of the well field. If an injection well were located on this side of the well field, the model results indicate that the plume would not reach the school, which is 0.5 miles from the well field. Within the well field itself, there are no residents, so an injection well near the end of the pipeline would not affect any residents.

Table F-13. Maximum Distances where CO_2 Concentration of 5,000 ppm Could Occur

Well Formation	Well Depth (feet)	Maximum Distance (miles*)	Maximum Number of People Affected
98-A	6,300	0.016	Less than 1
41-A	5,800	0.014	Less than 1
Greta	5,250	0.013	Less than 1
Glasscock	5,550	0.014	Less than 1

*For calm conditions, which occur about 2.3% of the time in vicinity of Victoria Airport.

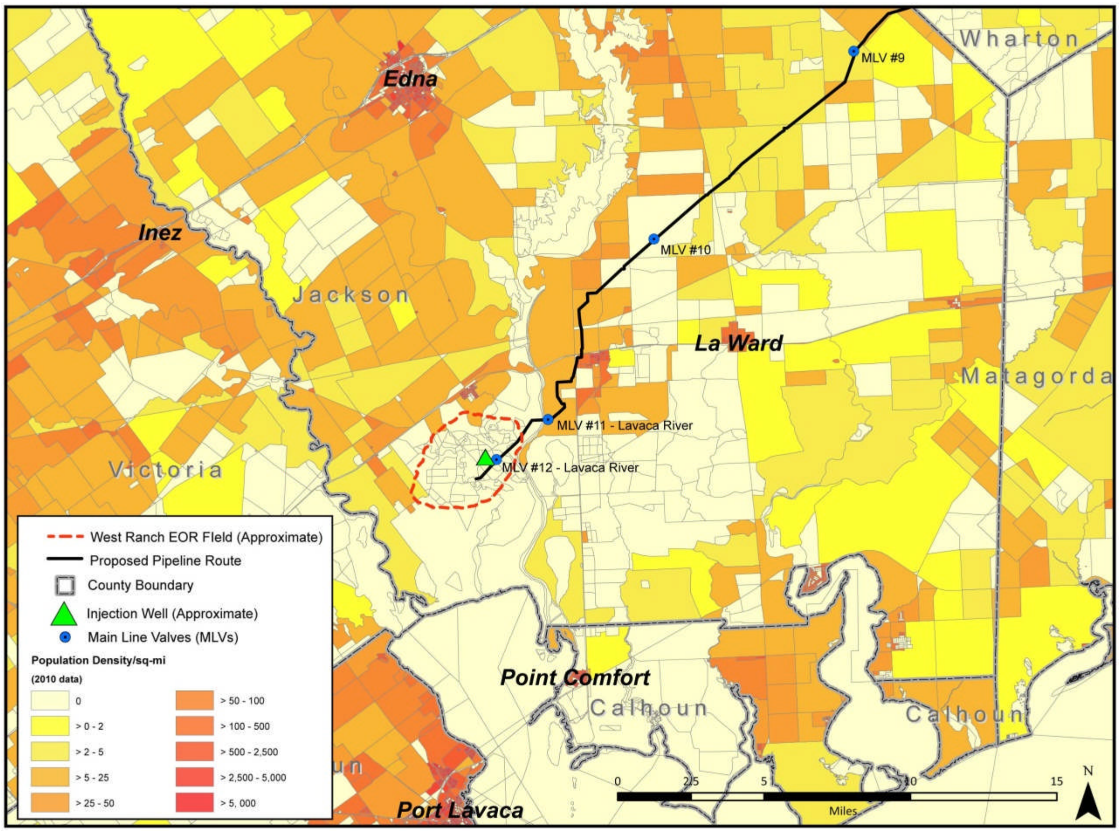

Figure F-3. Population Density near West Ranch Well Field

Higher CO_2 concentrations of 30,000 ppm (PAC-1 and PAC-2) could occur over a 15-minute period, but would remain within about seven to nine feet of an injection well, depending on which formation was used. Higher CO_2 concentrations of 50,000 ppm (PAC-3) could occur, but are estimated to last less than 15 minutes within eight feet of an injection well. The CO_2 concentration of 50,000 ppm had dissipated by 30 minutes. Thus, life-threatening effects to the general public are extremely unlikely to occur. If workers were present near an injection well during a release, a CO_2 concentration of 40,000 ppm (IDLH) is estimated to occur for about 15 minutes within about 6.5 feet of the well, and would not persist at this concentration for 30 minutes.

Injection of CO_2 for EOR has been practiced for over 40 years, particularly in the Permian Basin in west Texas where the first CO_2 injection was conducted for EOR in 1972 and southeastern New Mexico

(NETL 2012a). Since 1972, oil produced using CO_2 has increased to over 80 million barrels per year (NETL 2012a). A successful short-term test was conducted into the Frio Formation northeast of Houston where 1,600 metric tons of CO_2 was injected into a 23-meter-thick sandstone at a depth of 1,500 meters (Hovorka 2006). Most of the information on injection well failures rates is based on experience in the natural gas storage industry, which has been practiced for over 100 years (Benson 2009). The frequency of a release from an injection well during operation is estimated as $2x10^{-5}$ per well per year, based on worldwide data from the 1970's and later (IEA 2006). For this EOR project, up to 130 injection wells are planned to be used. The probability of a failure of one well per year is estimated as $2.6x10^{-3}$ and the probability of at least one well over the 20 years of the project is estimated as $5.1x10^{-2}$. The likelihood of an injection well failure is considered extremely unlikely (i.e., defined as 10^{-4} to 10^{-6} per year) based on the above frequency and the previous experience with injection wells for water flood and saltwater disposal in this oil field.

F.5.2 Post Injection Phase

Potential releases that could cause acute effects (i.e., a high concentration over a short duration) and chronic effects (i.e., a low concentration over a longer duration) were evaluated. Three scenarios could potentially cause acute effects: (1) upward leakage through the CO_2 injection wells; (2) upward leakage through deep oil and gas or saltwater reinjection or disposal wells; and (3) upward leakage through undocumented, abandoned, or poorly constructed deep wells. Six scenarios could potentially cause chronic effects: (1) upward leakage through caprock and seals by gradual failure; (2) release through existing faults due to effects of increased pressure; (3) release through induced faults due to local over-pressure conditions; (4) upward leakage through the CO_2 injection wells; (5) upward leakage through deep oil and gas or saltwater reinjection or disposal wells; and (6) upward leakage through undocumented, abandoned, or poorly constructed wells. One other potential pathway that the CO_2 gas from the subsurface formations could follow is migration into non-target aquifers, which is discussed in Section 3.6 of this EIS.

Table F-14 summarizes the types of potential post-injection releases considered in this analysis. The fluxes (i.e., the amounts of CO_2 that would flow through a unit area per unit time) for these releases were estimated based on the characteristics of the Frio and Anahuac Formations and the planned EOR operations, information on the local geologic setting, and the different types of existing wells in the West Ranch oil field, compared to the sites included in the database. Not all potential release pathways apply to this site.

Table F-14. Potential Types of Releases from EOR Site Based on Database

Release Scenario	Exposure Duration	Potential Volume	Initial Release to
Upward leakage through the caprock due to catastrophic failure and quick release	Short-term	Variable, could be large	Air
Upward leakage through the caprock due to gradual failure and slow release	Long-term	Small	Air and groundwater
Upward leakage through the CO_2 injection well(s)	Short-term and long-term	Variable, could be large	Air and groundwater
Upward leakage through deep oil and gas or saltwater reinjection or disposal wells	Short-term and long-term	Variable, could be large	Air and groundwater
Upward leakage through undocumented, abandoned, or poorly constructed deep wells	Short-term and long-term	Variable, could be large	Air and groundwater
Release through existing faults due to the effects of increased pressure	Long-term	Variable, could be large	Air and groundwater
Release through induced faults due to the effects of increased pressure	Long-term	Variable, could be large	Air and groundwater

The evaluation of the potential effects due to releases from the subsurface storage formations after EOR has ceased was conducted using the following tools:

- An analog database for a previous project (DOE 2007b) was used that included results from studies performed at other CO_2 storage locations and from sites with natural CO_2 accumulations and releases was used for characterizing the nature of potential risks associated with surface leakage due to caprock seal failures, faults, and fractures. It was also used to predict CO_2 releases based on similarities with the reservoirs planned for EOR.
- EPA's SCREEN3 model (EPA 1995) was used to estimate the resulting CO_2 air concentrations if post-injection releases occurred from slow leaks at low flow rates through deep wells or seepage through the caprock and overlying formations. The predicted air concentrations were used to estimate the potential for exposure and any resulting impacts on workers, off-site residents, and sensitive receptors.
- The SLAB model was used to estimate the resulting CO_2 air concentrations from deep oil and gas or abandoned wells when the flow rate was high, but the release occurred only for a short duration.

The CO_2 would be injected into four formations within the thick, regional sandstone, the Frio Formation that extends from a depth of about 5,000 feet to 7,200 feet below ground surface (bgs) in the proposed EOR field. The specific injection target units are the 98-A (or 4-Way) sandstone at a top depth of approximately 6,200 feet bgs and the 41-A sandstone at a top depth of approximately 5,700 feet bgs. Both of these formations are approximately 100 feet thick based on electric well logs from the West Ranch oil field, as indicated in Figure 3.4-3 in Section 3.4 of this EIS (Geology). The 50-foot-thick Greta sandstone, at a top depth of 5,200 feet bgs, may also be used as an injection zone. These sandstone units are highly permeable; for example, the average permeability of the barrier deposits within the 41-A sandstone is greater than 2,000 millidarcies (mD) and the tidal deposits are about 1,000 mD. The Glasscock unit, at a top depth of 5,500 feet bgs, may be considered as an injection zone. This unit is a maximum of 50 feet thick, and is composed of interlayered sand and shale and has a lower permeability than the other units.

The West Ranch oil field has been a major oil and gas producer since 1938 when the first oil well was discovered. The oil field is underlain by a salt dome and is overlain by the 400- to 450-feet-thick Anahuac Formation. The Anahuac Formation is comprised of low permeability shale with two thin sandy units. A secondary seal is also present, the 300- to 500-foot-thick Burkeville Confining System, which is composed of silt and clay.

Factors that affect the potential for post-injection releases from the storage formations include the presence of faults that cut the cap rock(s), active seismicity, deep wells from past oil and gas operations, and abandoned or poorly constructed wells. While there are growth faults along the Gulf Coast, there are no major faults within the West Ranch oil field that cross the Frio Formation or the overlying formations. Thus, no scenarios were simulated for releases of the stored CO_2 along active faults that could extend to or near the surface or releases along faults reactivated or induced by the CO_2 injection or subsequent increased pressure. Large water flood operations or CO_2 injection in the Permian Basin of west Texas have not caused earthquakes (NETL 2012a). Currently, most of the saltwater removed along with the produced oil is reinjected into wells in the West Ranch oil field. The general seismic activity of the region is low, as indicated by no nearby recent earthquakes and a 2% probability of peak acceleration greater than 2% to 4% of the gravity coefficient within 50 years (USGS 2009). Because of low seismic activity and the lack of faults in the EOR area, potential releases along faults were not simulated for the target geologic units in the Frio Formation.

Potential releases such as seepage through the cap rock, along unknown structural or stratigraphic connections, or due to lateral migration into a more permeable zone were evaluated using information from the analog database to identify the likelihood of potential releases and estimated flux rates for the releases. Due to the thickness of the primary cap rock, the Anahuac Formation and its low permeability based on core tests ($5.2x10^{-6}$ mD –Tsang and Apps 2005), a scenario with rapid leakage from the target geologic units to the ground surface was not considered realistic, and thus was not simulated. The rate of slow leakage through the cap rock and other formations was estimated using data for the Weber sandstone from the Rangely EOR Site in Wyoming, which also has a shale cap rock. Recent investigations have confirmed that microseepage rate of CO_2 is low from this EOR site (Klussman 2003). The seepage rates into shallow formations due to unknown structural or stratigraphic connections were based on data for the sandstone formation at the St. John's Dome Site in Arizona. The seepage rate due to lateral migration was based on the Weyburn CO_2 EOR Project, which has a higher rate than some other sites, which was consistent with the higher lateral movement observed in the Frio Pilot Injection Test conducted in 2004 north of Houston (Hovorka, et al. 2006). The SCREEN3 model (EPA 1995) was used to simulate the resulting ambient air concentrations for CO_2 due to the above, hypothetical gradual, slow seepage of gases through the caprock and other overlying formations. The seepage rates were allowed to continue for an extended period of 5,000 years for the slow seepage through the cap rock and for 100 years for migration along unknown structural or stratigraphic connections or lateral migration as a conservative estimate because the leaks could be hard to detect.

Potential leakage from the closed CO_2 injection wells and unknown abandoned or poorly constructed deep wells was also simulated using SCREEN3, since the flux rates were low, and the CO_2 gas would not be supercritical. Potential CO_2 releases through deep wells were estimated based on the estimated diameter of each type of well, the volume of CO_2 that would be injected per well using the planned maximum total number of wells at the site of 130, and the estimated amount of CO_2 retained in the formation, given that about 40% of the injected CO_2 could be removed with the produced oil (Bachu, et al. 2004). The plan at this site is to remove the CO_2 from the produced oil and return it to the pipeline for reinjection. This portion of the CO_2 may be injected into another well at a different location or formation, so it was not included in the estimated volume released from a closed CO_2 injection well or a closed oil and gas well. The full volume injected per well was used for the simulation of an abandoned well to represent the case after the injection and oil production operations are completed. This well was estimated to have a larger diameter (i.e., 12 inches), since there could be damage to the older cement or casing. The diameters used for the other wells were 7.5 inches for the CO_2 injection well based on the planned well design for the inside casing and 8 inches for an older deep oil and gas well.

The high rate fluxes out of the wells were estimated to last for about one week. The low flux rates were estimated as 10% of the high flux rate for the CO_2 injection well and abandoned wells, and were estimated to last for about one year. For the deep oil and gas wells, the high flux rate was set at 10% of the potential volume near the well and 1% for the low rate, since these wells are considered to be better constructed than older, abandoned wells and less likely to leak.

For each type of hypothetical well release scenario considered, the frequency of a release was estimated. There are a large number of active oil and gas wells within the West Ranch oil field, as shown in Figure 3.4-4. The nine producing zones extend from above 5,000 to 6,500 feet bgs (see Figure 3.4-3). There are also 34 produced water disposal well and 14 produced water injection wells within the oil field (BEG 2010). There are also over 50 known plugged and abandoned wells in this oil field. The estimated frequency of a release from a hypothetical deep abandoned well is $1x10^{-3}$ per well per year, which is considered to be unlikely (i.e., between $1x10^{-2}$ per year and $1x10^{-4}$ per year). The probability of a release from one such well over a 20-year period is $2x10^{-2}$, although the probability would increase if the total number of these types of wells is considered (e.g., $2x10^{-1}$ for ten wells). The frequency of a release from deep oil and gas wells is estimated to be $1x10^{-4}$ per well per year, which is also considered to be unlikely. The probability of a release from one such well over a 20-year period is $2x10^{-3}$. The probability of a release from at least one well increases if the estimated total number of wells is considered.

The frequency of potential releases from the CO_2 injection wells is estimated to be low, $2x10^{-5}$ per well per year, which is considered extremely unlikely (i.e., between $1x10^{-4}$ per year and $1x10^{-6}$ per year). The probability of a potential release from one of these wells over a 20-year period is $4x10^{-4}$, which is less than for the other deep wells. The probability of a release in one of the 130 wells over a 20-year period is estimated as $5x10^{-2}$. Because the intent is to repurpose some of the existing oil and gas wells for use as CO_2 injection wells, the total number of wells in the injection area is expected to be less than the sum of the different types of wells discussed.

Table F-15 shows the release flux rates, areas where the release could occur, and the possible durations pertinent to potential releases from the subsurface formations via either migration through the formations or from the above types of wells. Table F-16 presents the estimated CO_2 concentrations for each of the hypothetical scenarios and the risk ratios to determine if there is a potential for acute health effects. The high leakage rates from the three types of wells over an estimated duration of up to one week were compared to the PAC-based criteria for CO_2. The concentration at a distance of 300 feet from the wells was estimated using the SCREEN3 model, which is the planned closest distance to a monitoring well to be set up near the wells used for CO_2 injection. The CO_2 concentrations from all three types of well releases at a distance of 300 feet were all less than 0.1 ppm. The risk ratios were all much less than one, and none were as high as 0.1, so potential health effects from releases from the wells to the general public after the EOR operations have been completed and the well and pipeline equipment removed are extremely unlikely. The CO_2 concentrations from all three types of well releases at a distance of about 100 feet were all less than 0.3 ppm, so the risk ratios were also all less than 0.1. There are no residents living within the West Ranch oil field at present as shown in Figure F-3. In the future, the population density could increase, if the nearest town, Vanderbilt, located to the north of the oil field expands.

Table F-17 presents the estimated CO_2 concentrations for each of the hypothetical scenarios and the risk ratios to determine if there is a potential for chronic health effects. The low leakage rates from the three types of wells for up to one year were compared to the PAC-based criteria for CO_2, since there are no other long-term criteria that have been developed. The high leakage rates from the other types of subsurface releases due to seepage out of the target EOR units were used to calculate the risk ratios, since the concentrations are low. The low rate concentrations are also shown in Table F-17. The distance where the concentrations were evaluated and shown in Table F-17 was 300 feet. The risk ratios were all much less than one, and none were as high as 0.1, so potential health effects from subsurface releases to the general public after the EOR operations have been completed and the well and pipeline equipment removed are extremely unlikely. The CO_2 concentrations at a distance of 100 feet were similar to those at 300 feet for slow seepage through the formations, so the risk ratios were less than one. The CO_2 concentrations from well leaks at the low rates at a distance of 100 feet were less than 0.03 ppm, so the risk ratios were also all less than 0.1.

Table F-15. Potential Subsurface CO_2 Releases and Estimated Flux Rates

Mechanism	Frequency	Frequency Units	Flux Rate, μmol/m^2-s	Flux Area	Duration, Years
Leakage via upward migration through caprock due to gradual and slow release	1x10^{-4}	1/5,000 year item	0.0016-0.034	16.25 miles^2	5,000
Leakage via upward migration through caprock due to catastrophic failure and rapid release	1x10^{-6}	1/5,000 year item	NS[a]	NA	NA
Leakage through existing faults due to increased pressure (regional overpressure)	1x10^{-6}	1/5,000 year item	NS[b]	NA	NA
Leakage through induced faults due to increased pressure (local overpressure)	1x10^{-6}	1/5,000 year item	NS[b]	NA	NA
Leakage due to unknown structural or stratigraphic connections	1x10^{-5}	1/5,000 year item	0.11 -0.20;	16.25 miles^2	100
Leakage due to lateral migration from target unit	1x10^{-5}	1/5,000 year item	0.11 -2.6	16.25 miles^2	100
Leaks from CO_2 injection wells, high rate	2x10^{-5}	1/year-well	2140	0.028 m^2	0.02 (1 week)
Leaks due to CO_2 injection wells, low rate	2x10^{-5}	1/year-well	214	0.028 m^2	1 year
Leaks from deep oil & gas wells, High rate	1x10^{-4}	1/year-well	203	0.03 m2	0.02 (1 week)
Leaks from deep oil & wells, low rate	1x10^{-4}	1/year-well	20	0.03 m^2	1 year
Leaks from deep abandoned	1x10^{-3}	1/year-well	1450	0.07 m^2	0.02

Mechanism	Frequency	Frequency Units	Flux Rate, μmol/m²-s	Flux Area	Duration, Years
or undocumented wells, high rate					(1 week)
Leaks from deep abandoned or undocumented wells, low rate	$1x10^{-3}$	1/year-well	145	0.07 m^2	1 year

Note: 1 μmol/m^2-s (micromoles per square meter per second) = 3.84 g/m^2-day (grams per square meter per day); NA – not applicable; m^2 = square meters
a. NS = not simulated, since release mechanism is considered extremely unlikely due to thick, regional shale cap rock
b. NS = not simulated, since no faults near estimated EOR area

Table F-16. Potential Acute Human Health Effects within 300 feet of Wells in EOR Area

Release Scenario	Gas	Effects: Level (ppmv)	Effects: Type		Exposures: Concentration (ppmv)	Risk Ratio
Upward leakage through the CO_2 injection well(s) (days)	CO_2	5,000	PAC-0	No appreciable health effects	0.06	0.000012
		30,000	PAC-1 and PAC-2	Above this level serious effects possible	0.06	0.000002
		50,000	PAC-3	Above this level, life-threatening effects possible	0.06	0.0000015
Upward leakage through undocumented, abandoned, or poorly constructed wells (days)	CO_2	5,000	PAC-0	No appreciable health effects	0.10	0.00002
		30,000	PAC-1 and PAC-2	Above this level serious effects possible	0.10	0.0000033
		50,000	PAC-3	Above this level, life-threatening effects possible	0.10	0.000002
Upward leakage through oil & gas wells	CO_2	5,000	PAC-0	No appreciable health effects	0.0063	0.0000013
		30,000	PAC-1 and PAC-2	Above this level serious effects possible	0.0063	0.0000002
		50,000	PAC-3	Above this level, life-threatening effects possible	0.0063	0.00000013

Protective Action Criteria (PAC) criteria (SCAPA 2012)
ppmv = parts per million by volume

Table F-17. Potential Chronic Human Health Effects within 300 feet of Wells in EOR Area

Release Scenario	Gas	Effects			Exposures	Risk Ratio
		Level (ppmv)	Type		Concentration (ppmv)	
Upward leakage through caprock and seals, gradual failure and slow release	CO_2	5,000	PAC-0	No appreciable health effects	0.175[a]	0.000035
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	0.175	0.0000058
		50,000	PAC-3.	Above this level, life-threatening effects possible	0.175	0.0000035
Upward leakage through unknown structural or stratigraphic connections	CO_2	5,000	PAC-0	No appreciable health effects	1.031[b]	0.00021
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	1.031	0.000034
		50,000	PAC-3.	Above this level, life-threatening effects possible	1.031	0.000021
Upward leakage due to lateral migration from target unit	CO_2	5,000	PAC-0	No appreciable health effects	13.4[c]	0.0027
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	13.4	0.00045
		50,000	PAC-3.	Above this level, life-threatening effects possible	13.4	0.00027
Upward leakage through the CO_2 injection well(s)	CO_2	5,000	PAC-0	No appreciable health effects	0.0058	0.0000012
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	0.0058	0.0000002
		50,000	PAC-3.	Above this level, life-threatening effects possible	0.0058	0.00000012
Upward leakage through abandoned or undocumented, well(s)	CO_2	5,000	PAC-0	No appreciable health effects	0.010	0.000002
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	0.010	0.0000003
		50,000	PAC-3.	Above this level, life-threatening effects possible	0.010	0.0000002

Release Scenario	Gas	Effects			Exposures	Risk Ratio
		Level (ppmv)	Type		Concentration (ppmv)	
Upward leakage through the oil and gas well(s)	CO_2	5,000	PAC-0	No appreciable health effects	0.00062	0.00000012
		30,000	PAC-1 and PAC-2	Above this level, serious effects possible	0.00062	0.00000002
		50,000	PAC-3.	Above this level, life-threatening effects possible	0.00062	0.000000012

[a]The CO_2 concentration for the low seepage rate through the cap rock was estimated as 0.0082.
[b]The CO_2 concentration for the low seepage rate due to unknown connections was estimated as 0.0.57.
[c]The CO_2 concentration for the low seepage rate due to lateral migration was estimated as 0.058.

Protective Action Criteria (PAC) criteria (SCAPA 2012)
ppmv = parts per million by volume

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