Technical Feasibility of Compressed Air Energy Storage (CAES) Utilizing a Porous Rock Reservoir

Final Report Appendix — Chapter 5

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A501: AMMs and Mitigation Measures

AMMs and Mitigation Measures

The following Avoidance and Minimization Measures (AMMs) and Mitigation Measures were implemented during core drilling operations. Due to the location of the sites in the Central Valley ecoregion, resource issues were fairly homogeneous so these measures applied to all locations. Further, most measures are standard PG&E best management practices for construction activities.

1. Prior to working on-site, all workers shall be provided with Environmental Awareness Training by the USFWS approved biologist. The training addressed the identification and general ecology of giant garter snake (GGS) and other species that have potential to occur in the project area, and the measures to be implemented in order to avoid impacts on these resources. Areas to be avoided were also addressed in the training.
2. Prior to construction, all work areas (e.g., vehicle access, parking, staging) needed to complete the project were identified in coordination with the on-site biologist. All work areas were limited to the minimum area necessary to complete work.
3. If ground-disturbing activity could not be conducted during the GGS active season, preconstruction surveys for potential GGS wintering sites (i.e., burrows and soils crevices) were conducted within two weeks by a qualified biologist to determine if potential GGS wintering sites were present within proposed areas of ground disturbing activity (e.g., the well pad expansion site, road work, application of gravel) and again within 24 hours prior to ground-disturbing activity.
4. All burrows or potential refuge habitat were flagged and avoided. If work was suspended for a period of five days or greater, then the project area had to be resurveyed. If it was determined that potential GGS wintering habitat (e.g., burrows and crevices) were present within areas planned for ground disturbance, ground-disturbing activities were to be postponed until the GGS active season (i.e., between May 1 and October 1). If GGS was encountered at any time during the project, work would stop immediately and the USFWS would be contacted before work proceeds.
5. A biological monitor was required to be on site during all phases of site construction to direct access and construction work around irrigation ditches and other sensitive habitats capable of supporting GGS. If any GGS were observed within the Proposed Action area during work activities, work would cease and the on-site project manager would immediately contact the project biologist, who would contact the USFWS Bay-Delta Fish & Wildlife Office ESA/Regulatory Division, prior to resuming work. The biological monitor had the authority to stop construction to resolve any biological concerns.
6. Access to well pads were confined to existing roads, road shoulders, and other compacted areas. Travel along roads were restricted to the centerline. If placement of gravel on access roads was necessary, the placement was limited to the existing road surface. No gravel was placed on ditch banks or other areas that may support burrows that could be used by GGS. No grading occurred along segments of existing roads that may support burrows that could be used by GGS.
7. The fresh emergent marsh canals and irrigation ditches were designated as environmentally sensitive areas and physical disturbance to these features was avoided during construction.
8. If deemed necessary, an exclusionary fence would be erected to protect potentially sensitive habitat adjacent to project action areas. To ensure that GGS did not become

trapped or entangled, no wattles with plastic monofilament netting were permitted. Burlap or coconut wattles were appropriate substitutes.

9. A qualified biologist pre-approved by the USFWS performed a general pre-construction survey within 72 hours of the start of project construction.
10. Escape ramps at a 45 degree angle or less were provided for any excavations that are greater than one foot that were left open overnight. Smaller holes were covered so that no gaps occurred and inspected each morning for wildlife. Trenches or holes were inspected prior to filling. If special-status wildlife became entrapped, work would stop and the PG&E project biologist would be notified immediately to determine next steps.
11. All construction personnel would visually check for snakes and other wildlife under vehicles and equipment prior to moving them.
12. Construction equipment would be maintained to prevent leaks of fuels, lubricants or other pollutants into aquatic habitats.
13. Whenever possible, refueling and maintenance of vehicles would occur offsite. In cases when that was not possible, refueling and maintenance of vehicles and equipment would be conducted over drip pans and at least 100 feet from any waterway.
14. Open ends of pipes, conduits or other materials stored onsite would be covered to exclude wildlife and would be inspected prior to use.
15. Vehicular speed within the Proposed Action area was limited to 10 miles per hour in order avoid impacts on wildlife that may be located on or near roadways.
16. Watering of roads during dry season work was performed as necessary (approximately 3–4 times a day) in order to reduce potential dust resulting from project associated traffic.
17. Caution was used when handling and/or storing chemicals (fuel, hydraulic fluid, etc.). As part of standard PG&E Best Management Practices (BMPs) crews had appropriate materials on site to provide secondary containment and prevent and manage spills. If groundwater was encountered, a PG&E Environmental Specialist would be contacted.
18. If the scope of work or project location changed, the project biologist was to be contacted prior to commencing work. The project biologist or Land Planner would contact the USFWS Bay-Delta Fish & Wildlife Office ESA/Regulatory Division upon notice of any such changes.
19. Construction related trash was removed from the site daily and upon work completion and the site would be returned to near pre-construction contours and conditions upon project completion.
20. In the event that cultural resources were discovered during construction grading or excavation, project personnel would halt earth-moving activities in the immediate area and contact PG&E's Cultural Resources Specialist.

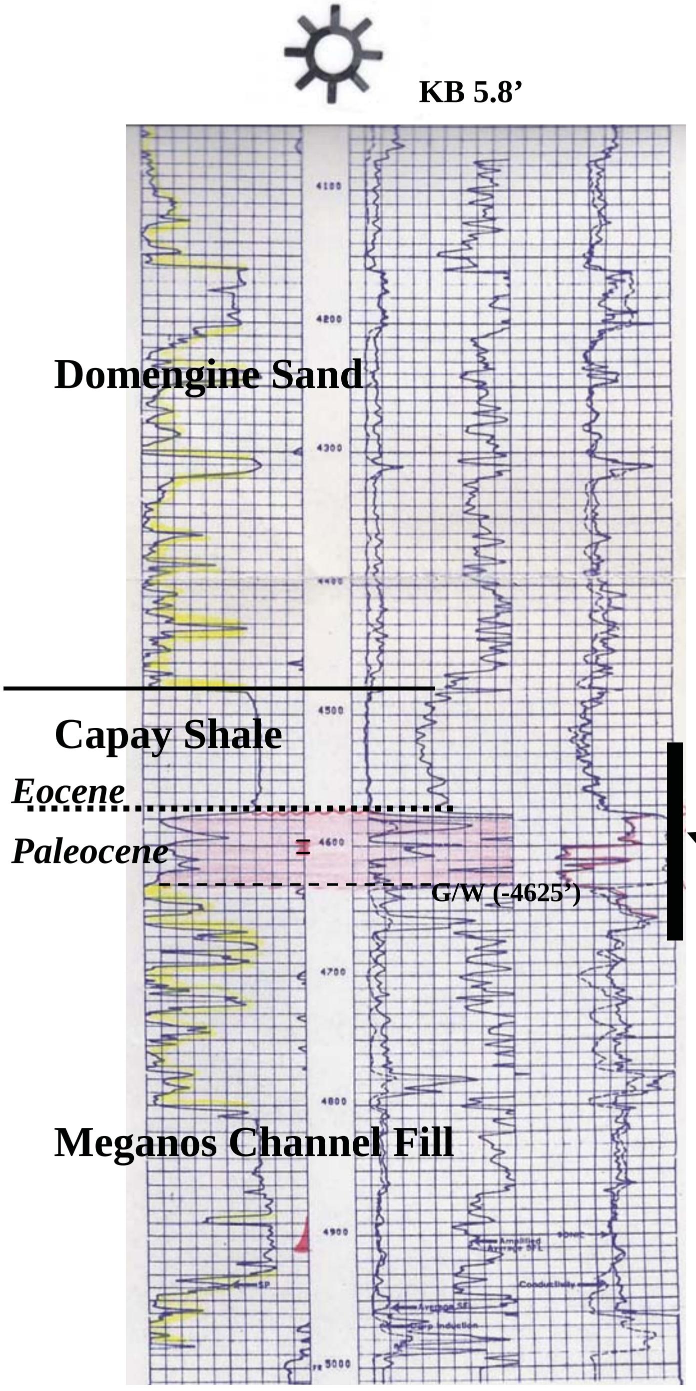
A502: CAES Core Recommendations - East and King

RECOMMENDED CORE INTERVAL

East Islands Gas Field

San Joaquin County, CA

Morias #16-1
Section 16, T3N-R5E



PROPOSED EAST ISLANDS CORE

Top of Core: (4510’)
50’ Capay Shale
65’ Meganos Channel gas reservoir
35’ Meganos Channel below G/W table
Bottom of core: (-4660’)
Total core: 150 ft.

DIRECTIONAL HOLE
500 ft N25W of Morias well.

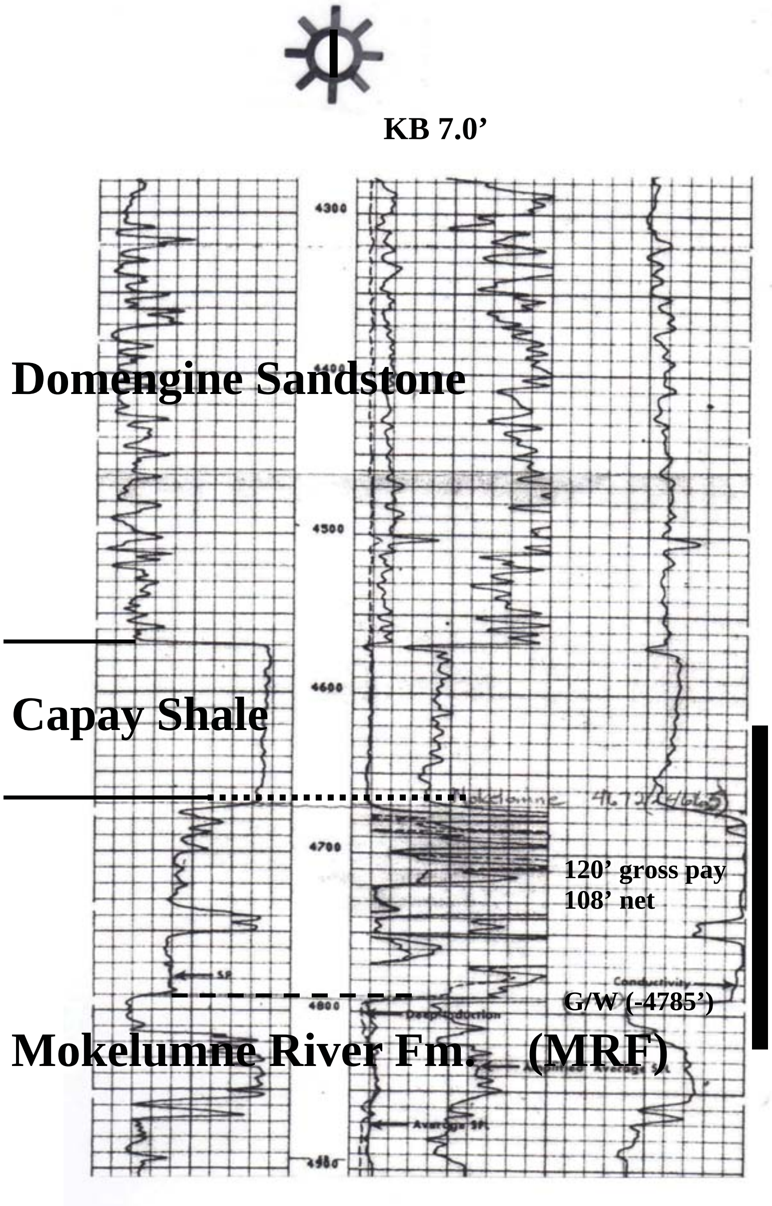
Note that the core bar shows the <u>stratigraphic</u> interval that core is anticipated to penetrate. The cored well is anticipated to encounter 65 ft of gas reservoir at its bottom hole location.

RECOMMENDED CORE DEPTHS

King Island Gas Field

San Joaquin County, CA

Piacentine No. 1-27
Section 27, T3N-R5E



PROPOSED KING ISLAND CORE

Top Core: 4622’ (-4615’)
50’ Capay Shale
120’ MRF Depleted gas sand
30’ MRF below orig. G/W table
Bottom Core: 4822’ (-4815’)
Total Core: 200 ft.
STRAIGHT HOLE

The core bar shows the interval that core is anticipated to penetrate. The cored well will twin the Piacentine #1-27.

A503: Core Analysis Requirements

Core Analysis Items

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Assume 150ft conventional core with 100-120ft sandstone and 30-50ft shale.

Routine analyses 🟦
Advanced analyses required for modeling 🟥

Sequence	Type of Analysis	Description/Purpose	Procedures	Est. Qty.
1	Field Service	Collect, preserve and transport core to laboratory for analyses	Segment conventional core into 3ft sections for transport to laboratory. Record core depths, cut/recovery, preserve and transport.	n/a
2	Core gamma	Accurate placement of the cored section within the well bore (tie to GR log)	Total and spectral	150
3	CT Scanning	Core orientation prior to slabbing to expose maximum dip. Assesment of core quality.	CT scan longitudinally at 0°, 90° with 1 axial per foot	150
4	Slabbing core	Provides a flat surface for core description / photography / profile permeametry		150
5	Core photography	Documentation of core descriptions	White and UV lighting	150
6	Detailed core description	Reservoir lithology, texture, mineralogy, stratification & depositional environment	Air/rock chemical reactions	150
7	Core plugging	1-2 in long cores taken from conventional core for routine core analyses (e.g. porosity, permeability, saturation).	Cut perpendicular to whole core axis, with a few taken parallel to axis.	150
7	thin section petrography	reservoir texture & mineralogy	Do on both fresh and post-analyzed samples	15
7	Scanning electron microscopy (SEM)	Types and habit of clay minerals and porosity	Do on both fresh and post-analyzed samples	15
7	X-ray diffraction (XRD)	Clay & sulfide mineralogy	Do on both fresh and post-analyzed samples	15
8	Matrix and bulk density	Calculate porosity and calibrate density log	Matrix (grain) desity from routine core data Bulk density from CT scanning	150
8	Porosity & permeability	Reservoir capacity for fluid storage and flow. Fraction of pore space occupied by each fluid	On core plugs. Fulid saturations, steady state perm to air (400 psi confining pressure), porosity and grain density by Boyles Law, Lithological and florescense description	150
8	Vertical Permeability	Kv/Kh ratio	Obtain vertical plugs adjacent to routine horizontal plugs	15
8	Sieve analysis	grain size distribution and clay content	Needed for gravel pack design	10
9	Permeability/Porosity Stress Cycling	Hysterisis effects on porosity and permeabilty during repeated injection/withdrawal cycles	Pososity, Klinkenberg corrected air permeability at increasing/decreasing stress cycles	15
9	Capillary pressure (curves)	Affects change in fluid saturation with height above free water level in reservoir.	Air displacing water, high speed	6
9	Capillary entry (threshold) pressure for confining clay unit	Cap-rock seal capacity (displacement pressures)	Up to 8 pressure	3
10	Possion's ratio, Young's modulus			3
10	Critical velocity tests	Determine critical velocities in the sand face prior to inducing sand production or fines movement from injecting and withdrawing operations	Cycling 8 times with 15 minutes each between injection and withdrawal equivalent to 15 MMcf/D injection rate and 30 MMcf/D withdrawal rate at 100 psi differential pressure	3
10	Thick Wall Cylinder	Determine maximum drawdown rate from onset of sand production for well bore stability		3
11	Relative permeability	Ratio of effective permeability of a particular fluid at a particular saturation to absolute permeability of that fluid at total saturation	Unsteady state…Full curve, gas saturation increasing without initial Sw	5
11	Residual gas saturation on imbibition	Gas (air) saturation after gas displaced by water (wetting phase) imbibition	Done w/ relative perm testing	5
11	Secondary & tertiary relative perm testing	Determination of degradation in relative permeability with repeated injection/withdrawal cycles		5

A504: Core Description - Morias 2-16_20-Apr-2013

CORE DESCRIPTION

PG&E Morias #2-16
East Islands Gas Field
San Joaquin Co., California
Sec. 16, T3N-R5E

Described by F. Cressy, 5/3/2013

Coring commenced at 4649 feet and finished at 4764 feet; a total of 115 feet of gross interval cored during four core runs. Coring began in the Eocene Capay shale and penetrated 33.2 feet of the formation. Coring continued into the Paleocene Meganos Canyon fill, recovering 81.8 feet of that unit.

Nearly all good dip indicators show dips of ~20°. These dips reflect the fact that the well was **directionally drilled**. The well bore penetrated the formation at ~20° so the actual dips in the formation are nearly flat. A general description of the formations follows.

GENERAL DESCRIPTION

Capay Shale: 4649’ to 4682.2’ (33.2’)

Predominately claystone: dark greenish gray to dark gray on a fresh surface, waxy luster, appears massive, compact to firm, slightly calcareous w/ occasional small, thin-shelled mollusk fragments. Gradual color change with depth to olive gray and then dark olive gray, fossils increase in abundance, and glauconite increases from <5% at 4665.7’ to about 20% at 4674’. As glauconite increases, the claystone also exhibits an increasingly mottled appearance due to burrowing organisms. At 4676’ scattered pebble clasts appear in the claystone, and at 4678.6’ unit becomes conglomeratic, greenish black color, glauconitic, firm, non-calcareous, w/ rounded clasts to 1’ diameter in a sand matrix. Clasts appear to be mostly chert and volcanic rock fragments; abrupt, unconformable contact with underlying Meganos Fm.

Meganos Channel Fill: 4682.2’ through bottom of cored interval at 4764’ (81.8’)

Predominately sand: interval consists of 90% sand in beds that range from one to 15 feet thick. Sand beds commonly have sharp, scoured bases and tops grading down from thinly laminated, finer-grained, silty sand into medium to coarse grained, poorly sorted, massive sand. Thin beds of dark gray mudstone commonly overlie the sand units. Individual sand beds have the appearance of being rapidly deposited, and commonly contain mudstone and claystone rip-up clasts that are sometimes very abundant. Individual beds commonly have erosional bases and are sometimes amalgamated, with sand lying on sand.

Compositionally, sands are arkosic and contain dark colored chert and volcanic(?) rock fragments. Quartz and feldspar grains are predominately sub-angular, whereas the dark rock fragments are commonly sub-rounded to rounded. Mica is common at times and the sands appear poorly sorted. Granule sized grains are common at times. The sands are easily friable, show little cementation and are non-calcareous. Porosity and permeability are good.

DETAILED DESCRIPTION

DEPTH	THICKNESS	DESCRIPTION
Capay Shale		
4649’ to 4654’	5.0’	Claystone: greenish gray, dark gray on a fresh surface, firm to compact, massive, silty, appears faintly mottled, calcareous, occasional forams & small fossil mollusk frags.
4654’ to 4655.6’	1.6’	Claystone: as above, **fractured zone**, broken up w/ minor polished faces, slightly slickensided.
4655.6’ to 4665.7’	10.1’	Claystone: as above, med gray to med dark gray; from 4664.4’ to 4664.6’ (0.2’), med gray mudstone w/ extensive small (1 x 4 mm) dark gray, clay-filled burrows; gradational to:
4665.7’ to 4674’	8.3’	Claystone: as above, gradual color change from med dark gray at top to med light gray at base, start of common small(0.5 mm) dark greenish gray glauconite pellets increasing to 10% to 15% at base, increasingly more common fossil mollusk fragments, mottled appearance; from 4669.4’ to

		4669.8’ (0.4’) - mudstone is extensively brecciated & broken up, 30° dip at base of brecciated zone; abrupt color and lithology change to:
4674’ to 4676’	2.0’	Glauconitic mudstone: olive gray, ~20% glauconite pellets, firm, highly mottled appearance, rare shell fragments, calcareous; gradational into:
4676’ to 4678.6’	2.6’	Pebbly glauconitic mudstone: mudstone as above, but contains scattered quartz, chert and/or volcanic rock clasts to 2 cm diameter; grades to:
4678.6’ to 4682.2’	3.6’	Conglomerate: dark gray to dark greenish black, glauconitic, non-calcareous, abundant rounded clasts to 5 cm diameter, clasts appear to be mostly chert, volcanic, and quartz; pebbles are clast-supported w/ coarse grained sand matrix, glauconitic at top, non-calcareous, appears tight; somewhat loose material probably caused by movement of hard clasts during slabbing.
Meganos Canyon Fill		Unconformity; gradational contact (poorly defined in core, abrupt on log).
4682.2’ to 4683’	0.8’	Sand: med gray, med to coarse grained, common scattered pebbles to 1 cm diameter, average 5 mm; easily friable, arkosic, sub-angular w/ common sub rounded volcanic(?) rock fragments, poorly sorted; good porosity & permeability; gradational to:
4683’ to 4686’	3.0’	Sand: light med gray, predominantly med grained but ranges from fine to coarse grained, massive at top to faintly but thinly laminated near base; arkosic w/ common dark chert and/or volcanic rock fragments, micaceous, pebbly from 4683.6’ to 4683.8’ (0.2’), carbonaceous laminae, occasional small mudstone rip-ups near base; gradational into:
4686’ to 4689’	3.0’	Sand: med light gray, med to coarse grained, as above, poorly sorted, massive, abundant med dark

		gray mudstone rip-ups between 4687’ to 4688’; sharp contact into:
4689’ to 4691.25’	2.25’	Interbedded fine grained silty sand, siltstone, & mudstone; sand light gray, as above; at times very thinly laminated, carbonaceous, several ~15° dips; thin beds of abundant small (0.5” to 1”) mudstone rip-ups; siltstone & mudstone are dark gray, firm. Sharp contact w/ apparent load casts on:
4691.25’ to 4691.5’	0.25’	Mudstone: olive gray, firm, laminated to very thinly laminated; top of unit shows “sawtoothed” load casts w/ amplitude crests ~2 cm apart; sharp 15° contact with:
4691.5’ to 4692’	0.5’	Sandstone: med dark gray, med to coarse grained, sub-angular grains, arkosic, hard, calcareous, could be a concretion w/ a small thin, hard mudstone rip-up at 4691.7’; sharp contact with:
4692’ to 4692.25’	0.25’	Mudstone: med dark gray, silty firm, massive; sharp 15°contact with:
4692.25’ to 4694’	1.75’	Primarily sand: light gray, as above, predominantly med grained, laminated at top, grades into massive, poorly sorted sand with common mudstone rip-ups; sharp contact with:
4694’ to 4699.25’	5.25’	Primarily sand: med light gray, med to coarse grained, common large granules to 2 mm, arkosic, quartz & feldspar generally sub-angular; volcanic rock fragments generally sub-rounded to rounded; massive, easily friable; top 0.5’ of unit very thinly laminated, common mudstone rip-ups from 4694.5’ to 4695.5’; sharp erosional contact with:
4699.25’ to 4700.75’	1.5’	Interbedded mudstone and thin bedded sand: predominantly thin (20-30 mm) beds of med dark gray mudstone, silty, massive, firm, interbedded w/ thinner (10-20 mm) beds of sand, med gray, fine

		grained, silty; thin, med grained sand bed at 4699.8’ showing an erosional base; sharp contact with:
4700.75’ to 4702.2’	1.45’	Sand: with common mudstone rip-ups; med gray, predominantly med grained, ranges from fine to coarse grained, poorly sorted, massive with common large dark gray mudstone rip-ups to 1” thick x 3” wide.
4702.2’ to 4703.3’	1.1’	Sand: loose, **not in situ**; from core catcher and re-packed in core liner at well site; light gray, predominately medium grained, arkosic, micaceous.
4703.3’ to 4704’	0.7’	No Recovery
4704’ to 4710’	6.0’	Sand: med gray, predominately med grained, as above; top 3 feet very faintly laminated w/ carbonaceous material, w/ ~25° dips, common dark gray mudstone rip-ups in bottom 2 feet, apparent very thin cross laminations in bottom 0.5 feet; sharp erosional contact with:
4710’ to 4710.5’	0.5’	Mudstone: dark gray, firm, massive, silty; sharp contact with:
4710.5’ to 4713.1’	2.6’	Sand: med light gray, med to coarse grained, as above w/ abundant large mudstone rip-ups; sharp erosional contact with:
4713.1’ to 4714.3’	1.2’	Mudstone: med dark gray, thinly laminated, silty, grades down into dark gray carbonaceous muddy, silty sand, very fine to fine grained, with paper thin laminations and slightly convoluted laminations, good ~20° dips; very thin fine grained sand at base; grades into:
4714.3’ to 4717.5’	3.2’	Sand: med light gray, med grained, massive, as above, abundant mudstone rip-ups; sharp 20° erosional contact with:
4717.5’ to 4719.3’	1.8’	Sand: med light gray, predominantly med to coarse

		grained, as above, top 3” is very thinly laminated, carbonaceous, fine grained, grades into massive, med to coarse grained sand; sharp contact with:
4719.3’ to 4720’	0.7’	Sand: med dark gray, fine grained, very thinly laminated/convoluted laminated, ~20° dips, highly carbonaceous at base; grades into:
4720’ to 4727.3’	7.3’	Sand: med light gray, med grained, sub-angular grains, massive, arkosic w/ common dark chert and volcanic(?) rock fragments, occasional mudstone/claystone rip-up; sharp 20° contact with:
4727.3’ to 4728.5’	1.2’	Sand: med gray, fine grained, silty, clayey, top half very thinly laminated, basal part massive; sharp angular erosional contact with:
4728.5’ to 4728.75’	0.25’	Siltstone and silty mudstone: med dark gray, highly carbonaceous w/ paper thin carbonaceous to coaly laminations; graditional into:
4728.75’ to 4732.5’	3.75’	Sand: med gray, fine to med grained at top, w/ very thin carbonaceous laminations showing about 20° dips; grades down into med light gray, med grained massive sand, occasional small dark gray mudstone rip-ups.
4732.5’ to 4734’	1.5’	Sand: loose, **not in situ**; from core catcher and re-packed in core liner at well site; light gray, predominately medium grained, arkosic, w/ common volcanic(?) rock fragments, micaceous.
4734’ to 4738.7’	4.7’	Sand: med gray, predominately med grained but grades gradually to med/coarse grained w/ depth, occasional granules to 3 mm diameter, fair to poor sorting, easily friable, arkosic w/ common dark volcanic(?) rock fragments, sub-angular (rock frags sub-rounded), contains abundant small, med dark gray mudstone rip-ups between 4734.4’-4735.0’; sharp, abrupt contact (apparent 20° dip) with:

4738.7’ to 4739.6’	0.9’	Mudstone: med dark gray, carbonaceous, grades down into very thinly laminated very fine grained silty, carbonaceous sand; sharp contact (good 20° dip) with:
4739.6’ to 4741.2’	1.6’	Sand: med gray, med to coarse grained, poorly sorted, massive, grades down to highly carbonaceous laminated sand, fairly good 30° dips; sharp contact with:
4741.2’ to 4748.4’	7.2’	Sand: light gray, predominantly med to coarse grained, massive w/ common large (to 4”) clasts of dark gray mudstone/claystone rip-ups; grades into:
4748.4’ to 4763.2’	14.8’	Sand: med light gray, med to very coarse grained, sub-angular, common granules to small pebbles to 0.5 cm, massive, easily friable, fair to poor sorting, arkosic, sub-angular grains w/common, sub-rounded dark lithic (volc?) rock fragments, trace thin secondary pyrite coatings on some rock fragments; @ 4755.5’ large (to 2”) rounded, bedded chert(?) cobble, calcareous, light olive gray color, excellent porosity & permeability.
4763.2’ to 4765’	1.8’	Sand: loose**, not in situ**; from core catcher and re-packed in core liner at well site; light gray, predominately medium grained, arkosic, micaceous.

Core Depth and Recovery Summary

Core 1	4649’ to 4674’	Cut 25’, Recovered 25’
Core 2	4674’ to 4704’	Cut 30’, Recovered 30’
Core 3	4704’ to 4734’	Cut 30’, Recovered 30.2’
Core 4	4734’ to 4764’	Cut 30’, Recovered 31’

A505: Core Description Piacentine 2-27 (26-Jun-2013)

CORE DESCRIPTION

PG&E Piacentine #2-27
King Island Gas Field
San Joaquin Co., California
Sec. 27, T3N-R5E

Described by F. Cressy, 4/16/2013; Revised 6/26/13 to incorporate findings of thin section analysis of 15 samples from Mokelumne River Formation.

Coring commenced at 4641 feet and finished at 4816 feet; a gross interval total of 175 feet cored during seven core runs. Coring began in the Eocene lower Domengine Sand, continued through the entire Eocene Capay Shale (unit faulted), and penetrated 129 feet of the top Upper Cretaceous Mokelumne River Formation. A general description of the formations follows.

GENERAL DESCRIPTION

Domengine Sand: 4641' to 4653.5' (12.5 feet lower Domengine)

Predominately sand, light gray, contains thin to thick beds of sand, some fine grained, others medium to coarse grained, minor conglomerate, beds massive to very thinly laminated & cross laminated; arkosic, fair to well sorted, easily friable, excellent porosity and permeability (based on visual inspection); basal 10 inches is hard, calcareous cemented sandstone. Sharp, conformable(?) contact with underlying Capay shale.

Capay Shale: 4653.5' to 4687.1' (33.6'; approx. 75 feet faulted out)

Predominately claystone; dark greenish gray to dark gray on a fresh surface, waxy luster, appears massive, compact to firm, slightly calcareous w/ common scattered large (to 1") pyrite nodules and occasional small, thin shelled mollusk fragments. This claystone appears to contain swelling clays. As it dries, it begins to crack and break into small pieces.

Fault between 4661.8' and 4666'

Top one foot is highly sheared claystone; nearly all fragments have shiny, slickensided surfaces; no recovery in bottom 3 feet.

Claystone below fault is greenish gray (lighter than above), with papery thin laminations; fossils are non-existent or extremely rare. Gradual color change with depth to olive gray and then dark olive gray; fossils increase in abundance; glauconite increases from ~5% at

4673.8’ to about 30% at 4681’. As glauconite increases, the claystone also exhibits an increasingly mottled appearance due to burrowing organisms.

At 4682’, unit becomes conglomeratic, greenish black color, abundant glauconite, hard due to calcareous cement, rounded clasts to 1’ diameter (at wellsite, two cobbles of 2” diameter were noted). Clasts appear to be mostly chert, volcanic, and quartz. Conglomerate extends to 4687.1’, but there was no recovery of bottom 2.5 feet; abrupt, unconformable contact with underlying Mokelumne River Fm.

Mokelumne River Formation: 4687.1’ through bottom of cored interval at 4816’

Upper unit: 4687.1’ to 4755’ (67.9 feet)

Predominately claystone and siltstone; medium gray, paper-thin laminations to mottled, firm, non calcareous; common to abundant biotite mica; at times, contains common carbonaceous material. Minor thin sands, generally very fine to fine grained, silty, clayey.

Sand at 4695’ to 4700’: fine grained, trace medium grained, silty, biotitic, small scale cross laminations; good porosity and permeability.

Sand at 4716.9’ to 4727’: medium gray, very fine grained (top one foot, hard, calcareous cement); below this very fine to fine grained, silty, thinly laminated with abundant mica and/or carbonaceous material(?) and mica, sometimes mottled, minor shale rip ups, minor small scale cross laminations. Good porosity & permeability.

Lower unit: 4755.8’ to 4816’ (60.2 feet)

Predominantly sand; light gray, medium grained, arkosic, common large scale cross-laminations defined by abundant black biotite mica and carbonaceous(?) material; easily friable, excellent porosity and permeability, no cement; at times, massive with a mottled appearance, minor mud clasts (rip ups) and coaly wood fragments; one-foot-thick lignite coal bed at 4795.9’. At bottom of core (4815.4) brownish-gray shale, fissile w/ paper-thin laminations.

At 4784.7’, a large (6’) calcareous concretion observed, very hard, calcareous cement. Corresponds to depth where logs indicate original g/w contact. Other than this, there was no difference noted in sands above and below the original g/w contact.

DETAILED DESCRIPTION

DEPTH	THICKNESS	DESCRIPTION
Domengine Sand		
4641' to 4643'	2.0'	Sand: light gray, pred. medium & coarse grained, fair -well sorted, easily friable, arkosic, faint cross laminations to massive, bedding poorly defined, but appears 2" to 3" wide, no cement, excellent porosity & permeability; gradational to:
4643' to 4643.2	0.2'	Conglomerate: light med gray, clasts to 1" dia, pred quartz and dark gray chert, rounded clasts in matrix of med to coarse sand; gradational to:
4643.2' to 4645'	1.8'	Sand: light to med gray, pred fine to med grained, arkosic; somewhat well defined, thin low-angle cross laminations caused by carbonaceous**(?)** material or biotite.
4645' to 4645.5'	0.5'	Sand: med gray, fine grained, thinly interbedded w/ clayey, slty, very fine grained sand, ~0.5" beds; small normal fault, dips 60°, 0.5" displacement; gradational to:
4645.5' to 4652.7'	7.2'	Sand: light gray, fine to med grained, easily friable, faint very thin (1-2mm) horizontal to low-angle, biotite-rich cross laminations; sharp, horizontal contact overlying:
4652.7' to 4653.5	0.8'	Sandstone: light med gray, very fine to fine grained, hard, calcareous cement, very thinly laminated. Contact very sharp, erosional?
Capay Shale		
4653.5' to 4661.8'	8.3'	Claystone: dk greenish gray, dk gray on a fresh surface, firm to compact, massive, calcareous, common large scattered pyrite nodules to 15mm diameter, abundant small pyrite <1mm, occasional

		small fossil mollusk frags; low angle (25° to 30°) fractures near base.
4661.8’ to 4662.9’	1.1’	**Fault breccia**: highly sheared and broken Capay shale; abundant slickensides, curved with shiny luster.
4662.9’ to 4666’	3.1’	No Recovery
4666’ to 4673.2’	7.2’	Claystone: greenish gray (slightly lighter color than above), firm to compact, paper-thin to very thinly laminated, sl. calcareous, fossils very rare to not present; gradational change to:
4673.2’ to 4682’	8.8’	Claystone: med light gray, then gradational to olive gray at base; loss of laminations, begins exhibiting a burrow-mottled appearance, increasing calcareous cement, increasing fossil mollusk frags, increasing small (0.5mm), rounded glauconite pellets; glauconite increases from ~5% at top to ~30% at base; gradational at base to:
4682’ to 4684.5’	2.5’	Conglomerate: greenish black color, abundant glauconite, hard due to calcareous cement, rounded clasts to 1’ diameter (at wellsite, two cobbles of 2” dia. were noted). Clasts appear to be mostly chert, volcanic, and quartz; appears tight.
4684.5’ to 4687’	2.5’	No Recovery
4687’ to 4687.1’	0.1’	Conglomerate: as above
Mokelumne River Formation		Unconformity; sharp contact
4687.1’ to 4690’	2.9’	Thinly interbedded mudstone, siltstone, and very fine grained sandstone; med gray, sands appears to have fair porosity & permeability; sand is thinly (1-3cm) bedded, silty mudstone in beds 2-4mm thick. Mudstone is sandy (very fine grained), poorly sorted; gradational into:

4690’ to 4692’	2.0’	Mudstone: med gray, silty, firm, massive, non-calcareous; gradational into:
4692’ to 4695’	3.0’	Sand: med gray, very fine grained, silty, friable, massive; gradational into:
4695’ to 4698.4’	3.4’	Sand: light med gray, pred fine grained, but ranges from silt to med grained, arkosic, small scale, very thin, multi-directional cross laminations in 2-4cm beds; fair to good porosity & permeability.
4698.4’ to 4700’	1.6’	Broken up sand, from core catcher, not in-situ. Med gray, very fine grained, silty, clayey, very thinly laminated, firm.
4700’ to 4701’	1.0’	No Recovery
4701’ to 4713.2’	12.2’	Mudstone: med dark gray, slightly burrow mottled, coaly plant debris (1 to 4mm) lying parallel to bedding, minor very fine grained silty sand, grading down to med gray claystone, firm, paper-thin laminations; abrupt, sharp contact with:
4713.2’ to 4713.4’	0.2’	Mudstone: med dark gray, firm, compact, mottled appearance, carbonaceous; gradational into:
4713.4’ to 4716.9’	3.5’	Mudstone: med gray, firm to compact, common small organic fragments in top foot of unit, commonly mottled; gradational into:
4716.9’ to 4717.9’	1.0’	Sandstone: med gray, very fine grained, hard, calcareous cement, tight; sharp contact overlying:
4717.9’ to 4720.5’	2.6’	Sand: med gray, very fine grained , arkosic, silty, clayey, firm to friable, faint convoluted laminations to mottled; gradational into:
4720.5’ to 4721’	0.5’	Interbedded mudstone, med dark gray and med gray, very fine grained sand, very thinly laminated w/ carbonaceous(?) material and abundant mica; sharp contact with:

4721’ to 4727’	6.0’	Sand: as above, fine grained w/ abundant mica and carbonaceous material, mottled; gradational into:
4727’ to 4730.9’	3.9’	Claystone: light gray, paper-thin laminations, common flakes of carbonaceous and coaly material, clayey, very firm, exhibits irregular horizontal partings; sharp contact as parting.
4730.9’ to 4734’	3.1’	Sand: med light gray, very fine grained, arkosic, common mica, clayey, faintly thinly laminated, firm to friable; gradational into:
4734’ to 4744.5’	10.5’	Silty claystone: med dark gray, faintly mottled to very thinly laminated, firm, compact, micaceous w/ common small flakes of carbonaceous material; gradational into:
4744.5’ to 4745.7	1.2’	Sand: med light gray, very fine to fine grained, firm, paper-thin laminations, micaceous, grades down to dark gray carbonaceous mudstone, faintly mottled; irregular contact with:
4745.7’ to 4748.5’	2.8’	Mudstone: med dark gray, firm, compact, occasional very thin silty laminae; grades down to gray black carbonaceous shale, very thin papery laminations w/ irregular horizontal veinlets of lignitic coal to 2mm thick; sharp contact with:
4748.5’ to 4749.2’	0.7’	Mudstone: med dark gray, faint very thin laminations, minor small flakes of carbonaceous material; gradational contact with:
4749.2’ to 4750.7’	1.5’	Sand: med light gray, very fine to fine grained, papery thin laminations & small scale cross laminations; light gray sand laminated w/ dark gray biotite and/or carbonaceous material, upper portion of unit has fine cross laminations, lower portion is shaley w/ parallel laminations; sharp contact with:
4750.7’ to 4755.2’	4.5’	Mudstone & siltstone: dark gray to med dark gray, thin bedded (1-3cm), firm, occasional very fine

		grained sand; gradational contact with:
4755.2’ to 4755.8’	0.6’	Sand: light to med light gray, very fine to med grained, firm to friable, arkosic, very thinly laminated, parallel to low angle cross laminations interbedded w/ silty, micaceous and/or carbonaceous laminae; sharp contact with:
MAJOR LITHOLOGY CHANGE		
4755.8’ to 4759.9’	4.1’	Sand: light to med light gray, very fine to med grained, well sorted, arkosic, paper-thin large scale cross laminations, common mica and/or fine black carbonaceous material, easily friable, excellent porosity& permeability.
4759.9’ to 4765.1’	5.2’	Sand: loose, not in-situ; repacked in core liner at wellsite; light gray, predominately medium grained, arkosic, micaceous, one large fragment was thinly laminated.
4765.1’ to 4778’	12.9’	Sand: light gray, predominately med grained, easily friable, no cement, arkosic, commonly w/ large scale cross laminations, black biotite mica & carbonaceous(?) laminations, single marble-sized calcareous concretion @ 4768.6’; gradational to:
4778’ to 4779.3’	1.3’	Sand: light gray, as above, two large, horizontal-lying, U-shaped lignitic beds that look as if partially ripped up and overturned, associated w/ common small mudstone or shale rip ups to 0.5 to 1.0 cm; gradational into:
4779.3’ to 4786.9’	7.6’	Sand: light gray, med grained, easily friable, thinly laminated with common black biotite mica, large scale 0.5 to 1.0mm cross laminations in 0.2’ to 1.5’ thick beds; large, hard calcareous concretion from 4784.7’ to 4785.4’.
4786.9’ to 4789.1’	2.2’	Sand: loose, not in-situ; repacked in core liner at wellsite; light gray, predominately medium grained, arkosic, micaceous.

4789.1’ to 4789.7’	0.6’	No Recovery
4789.7’ to 4795.9’	6.2’	Sand: light gray, pred med grained, well sorted, easily friable, large scale, low angle thin cross laminations, lignitic woody fragment from 4792.2’ to 4792.3’; sharp, irregular contact, erosional scour(?) at base.
4795.9’ to 4797.1’	1.2’	Lignite coal: dark gray to grayish black, massive, hackly fracture, tough; *Thin section shows extensive replacement of some woody material by very fine pyrite.* Sharply overlies:
4797.1’ to 4798.3’	1.2’	Sand: light gray, med grained, appears massive w/ 2 vertical, sub-parallel carbonaceous “veins” extending below coal, possibly large root cast(?). Lower part of sand is fine grained, faint high angle (45°), very thin cross laminations; sharp contact with:
4798.3’ to 4801.2’	2.9’	Sand: light to med light gray, pred fine grained, large scale cross laminations at top grading down to chaotic, convoluted carbonaceous sand at base; coaly, lignitic material at base of unit, dark gray to grayish black; scoured erosional contact with:
4801.2’ to 4813.2’	12.0’	Sand: light gray, med grained, easily friable, well sorted, prominent low to high angle, large scale thin cross laminations in 0.4’ to 1.0’thick beds, excellent porosity & permeability.
4813.2’ to ~4815-	1.8’	Sand: loose, not in-situ; repacked in core liner at wellsite; light gray, predominately medium grained, arkosic, micaceous.
~4815’ to 4816’	1.0’	Shale & mudstone: dark gray, carbonaceous, very firm, tough, overlies silty mudstone, brownish gray, paper thin laminations, somewhat fissile, occasional very fine grained, thin sand. Note that large angular fragment of carbonaceous shale at top of unit is not

in-situ, but is in its approximate stratigraphic position.

Core Depth and Recovery Summary

Core 1	4641’ to 4666’	Cut 25’, Recovered 22.8’	
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Core 4	4701’ to 4731’	Cut 30’, Recovered 28.2’	
Core 5	4731’ to 4761’	Cut 30’, Recovered 32.0’	includes base of core 4
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Core 7	4791’ to 4816’	Cut 25’, Recovered 27.4’	includes base of core 6

A506: East Island - Reservoir Characterization and Analysis of Suitability for CAES

PACIFIC GAS AND ELECTRIC

Reservoir Characterization And Analysis of Suitability for Compressed Air Energy Storage

East Islands Gas Field
San Joaquin County, California

PGCS-1-LI-022-0018

9 October 2014

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CERTIFICATION AND DISCLAIMER

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RESERVOIR CHARACTERIZATION
AND ANALYSIS OF SUITABILITY
FOR COMPRESSED AIR ENERGY STORAGE

EAST ISLANDS GAS FIELD
SAN JOAQUIN COUNTY, CALIFORNIA

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RESERVOIR CHARACTERIZATION AND ANALYSIS OF SUITABILITY FOR COMPRESSED AIR ENERGY STORAGE

EAST ISLANDS GAS FIELD
SAN JOAQUIN COUNTY, CALIFORNIA

1. INTRODUCTION

Compressed Air Energy Storage (CAES) is a technique that stores, in the form of air, excess energy generated during times of low loads and then utilizes the pressurized air to generate electricity during periods of high demands. In the case of renewable energy resources, such as wind and solar power, the energy generated by these resources is intermittent and highly dependent on the resource (i.e. wind and sun); the energy generated by those resources, does not always match the time periods when customers need it most. Therefore, CAES technology is being investigated as one potential opportunity for storing this intermittent energy for use during higher demand periods. CAES is a key technology for expanding reliance on wind and solar renewable resources for firm, dispatchable electricity production.

The United States Department of Energy (DOE), the California Public Utilities Commission (CPUC), and the California Energy Commission (CEC) have funded Pacific Gas and Electric Company (PG&E) to investigate the viability of using a depleted natural gas field to store energy by injecting compressed air into a subsurface reservoir, during periods of excess and/or low-cost generation, and recovering it by generating electricity using turbo-generation equipment during high demand periods. The application of CAES using a depleted gas reservoir for storage provides several distinct advantages. First, depleted gas reservoirs are proven geologic traps that formerly held natural gas reserves for millions of years and are therefore capable of containing compressed air to power a CAES facility. Second, the subsurface data, including well logs, production, and seismic imaging data, that are needed for characterization of the reservoir and predicting its performance in a CAES application are typically available for natural gas fields. Finally, there are many natural gas fields situated along California's power transmission backbone, and thus ideally located to provide utility-scale power storage to facilitate integration and distribution of renewable energy throughout the state.

The purpose of this report is to document the evaluation of the East Islands Gas Field as a CAES candidate reservoir and to demonstrate its viability for a CAES plant operation. Numerical reservoir simulations were performed in support of the design and operation of a compression testing program and a utility scale project that would require a full field development. Simulation modeling was used for performance matching of the gas wells and prediction of the quantity and location of the remaining native trapped and free gas. The calibrated model was then used to test one idea of a conceptual design for full scale reservoir development to support a utility-scale

CAES plant. These preliminary simulation results are available to support further engineering, economic and environmental evaluations and project feasibility analysis.

2. SUMMARY OF FINDINGS

A. The East Islands Gas Field consists of three distinct gas pools. Two of the three pools are very small one-well accumulations. The third or main pool, where natural gas was produced from two wells, was discovered in 1988. This gas-productive area encompasses about 110 acres. The main pool is a stratigraphic trap created by the intersection of a Meganos Channel upper sand with an anticlinal nose feature. The reservoir drive mechanism is supported by a strong water drive component. Due to the water drive, the current reservoir pressure (February 2014) is about 1,964 pounds per square inch (psi) or within 20 psi of the discovery pressure.

B. The main area of the East Islands Gas Field has produced 3.9 billion standard cubic feet (Bscf) of natural gas with a BTU content of 956 Btu from two wells. Three wells have penetrated the main gas pool, Morais 16-1, Morais 16-2 (PG&E's core-well has not produced), and Stevens 16-1. The Stevens 16-1 was plugged and abandoned in March 1991. The Morais 16-1 well is producing small volumes of gas.

C. The East Islands Gas Field was selected from a screening list of over a dozen Northern California gas fields to conduct more detailed analyses using computer modeling for further assessment of its suitability to support a CAES operation. A core well, Morais 16-2, was drilled in April 2013 to investigate current reservoir conditions and measure petrophysical characteristics through well logging and laboratory analysis of core samples. Based on these data and subsequent reservoir model refinements and simulations, the East Islands Gas Field has emerged as a suitable location to support a permanent 150 MW/10-hour storage facility.

D. The proposed target injection zone consists of the gas-depleted (i.e., water invaded) sands of the Upper Cretaceous Meganos Channel Formation. The Morais sand in the East Islands Gas Field is a very friable sandstone which becomes unconsolidated when cores are brought to the surface releasing overburden stress. Core permeabilities and porosities are high, even at overburden conditions, 800 to 2800 millidarcies and 30 - 32 percent porosity.

E. A reservoir simulation model, built and successfully calibrated to the observed reservoir performance, predicts the Initial Gas in Place (IGIP) is 6.708 Bscf. This equates to a gas recovery factor of 58 percent. The simulation model showed that of the remaining 2.8 Bscf of natural gas, 1.8 Bscf is trapped[1] or residual gas saturation left behind in the water swept portions of the reservoir and 1.0 Bscf is free gas located in an attic gas cap area of

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[1] Trapped gas refers to the gas saturation trapped behind the invading water.

the field. The trapped gas is economically unrecoverable; however, the free gas in the structural attic areas is recoverable to the extent that the well producing the gas (Morais 16-1) is not overrun by water influx from the encroaching aquifer.

F. A full scale CAES operation, of an estimated 150 MWs and 10 hours of storage, and the associated withdrawal/injection requirements using vertical wellbores can be supported in the East Islands Gas Field. The main challenges to the project are creating the required air bubble in as short a time duration as possible, keeping pressures within acceptable guidelines (Section 7.4.1), and building the air bubble such that the impacts of the remaining native natural gas are minimized. Ideally the remaining native gas in the reservoir would be pushed aside and marginalized so that when cycling begins, the methane concentration during withdrawal periods is near zero or at a fraction of the methane LEL[2] in any of the withdrawal wells.

3. RESERVOIR SELECTION

3.1 CAES Criteria

Depleted gas reservoirs in the San Joaquin and Sacramento Valleys have the following advantages for CAES application:

- Their capability to contain compressed air is demonstrated by their proven ability to trap and contain natural gas accumulations for millions of years;
- The subsurface data typically available for natural gas fields, including well logs, production data and seismic imaging data, are useful for characterization of the reservoir and predicting its performance in a CAES application; and
- Their occurrence along California's principal power transmission corridor.

The gas field and reservoir criteria required for potential CAES application include the following:

- **Optimal size**, both in terms of volume and aerial extent. Reservoirs that are too small would not have enough volume to sustain withdrawal operations to meet the project objective, would require frequent recharge and would cause large pressure swings during withdrawal. Reservoirs that are too large would require building and maintaining a much larger air bubble, increasing both development and operating costs. Aerially, the size of the reservoir is important from a development standpoint. More compact reservoirs require less infrastructure to fully develop than those spread across a broader area.

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[2] LEL is defined as the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in the presence of an ignition source (arc, flame, heat).

- **Optimal depth and pressure**, between approximately 3,000 feet (1,300 psi[3]) to 6,000 feet (>2,500 psi), optimally in the 3,500 to 5,000 feet range. Less expensive wells can be drilled into the shallower reservoirs, but this can be offset, at least partially, by needing more wells to achieve the same deliverability due to the lower operating pressure. Based on recently approved gas storage projects in California, storage reservoirs are often permitted to operate at higher than original discovery pressure.[4] Reservoir pressures of up to 0.7 psi/ft. of depth can be acceptable if the reservoir bounding features (caprock, underlying aquifer, spill point, etc.) are capable of handling the higher pressure during the intended operation.

- **Good trapping mechanism**, preferably simple structures such as anticlines or fault traps that are easier to develop and operate than complex structures. The more complex the reservoir becomes (e.g. involving compartmentalization from faulting and/or stratigraphic discontinuities), the more likely it is to require additional wells (added cost) because of the difficulty in placing them optimally in the reservoir and the more difficult it is to operate due to communication barriers within the reservoir. Complex reservoirs are also more difficult to model and predict performance once they are developed.

- **Good caprock and lateral seal**, comprised of very low-permeability geologic materials such as evaporates or shale layers. An optimal shale caprock has low silt/sand content, is reasonably ductile and has not been breached or off-set by faulting over the reservoir. A good lateral seal will have a few or no higher permeability layers occurring at the reservoir boundaries.

- **Limited producing horizons** simplify reservoir size determination and well development. In the case of multiple zones, even if the production of each zone has been isolated, it may require development of multiple zones to achieve the optimal volume requirements for a CAES project. Well design and placement is more difficult with limited horizons, increasing the risk that more injection/withdrawal wells will be required, which in turn increases the development cost.

- **Thick and clean reservoir**, greater than 20 feet, with high ratio of net sand thickness to gross interval thickness to facilitate high flow capacity (based on product of reservoir thickness and permeability) and good hydraulic communication within the reservoir.

- **High Permeability**, representing the ability of a gas or fluid to flow through the reservoir, to facilitate high flow capacity (based on product of reservoir thickness and permeability).

- **High Porosity**, representing the ratio of pore volume to total rock volume, to provide adequate air storage capacity.

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[3] Based on normal hydrostatic gradient of 0.433 psi/ft.
[4] http://cvgasstorage.com/CPUC%20Final%20Decision.pdf

- **Small amount of free gas** remaining in reservoir lowers the risk that native gas concentrations in withdrawn air during CAES operation might exceed the LEL and represent a potential combustion hazard in the presence of an ignition source.

- **Limited mass of oxygen-reactive minerals or organic material** that could deplete oxygen in the reservoir air bubble. Withdrawal air with low oxygen content can create operational problems for certain types of CAES turbo machinery.

- **Small number of historical wells in reservoir** reduces the number of potential remedial plugging and abandonment procedures due to possible leakage pathways in the well bore or annulus that could result in reservoir pressure losses or fluid migration impact to Underground Sources of Drinking Water (USDWs).

Other criteria important for evaluation and development of a CAES site include favorable environmental and cultural factors, proximity to required interconnect facilities (electrical, natural gas, water), and an ability to secure site control of the rights necessary to develop the reservoir, site the power requirement and obtain any required easements to connect the reservoir to the power block.

3.2 Pre-Screening

Several gas fields[5] in the San Joaquin and Sacramento Basins were pre-screened as potential CAES candidates against the evaluation criteria listed above. This pre-screening process resulted in East Islands Gas Field being selected for computer modeling to further assess its suitability to support a CAES plant. The main pool in the field was also chosen for drilling a core well to investigate the reservoir and cap rock characteristics through well logging and laboratory analysis of the core samples. The core well, Morais 16-2, was drilled, cored and logged in April 2013. The results are discussed in Section 5.2.

3.3 Suitability of East Islands Gas Field Reservoir

The following characteristics make the East Islands Gas Field a good candidate for CAES application:

CAES Reservoir Favorable Characteristics	Location in Report where Discussed / Information Provided
Large and high quality subsurface database consisting of well geophysical logs (including neutron-density porosity logs in two wells),	Well geophysical logs: Morais 16-2 logs in Appendix A; Petrophysical report (Morais 16-2) in Appendix B;

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[5] Bowerbank, Bounde Creek, Cache Slough, Clarksburg, Crossroads, East Islands, French Camp, King Island, Liberty Island, McMullin Ranch, Merrill Avenue, Perkins Lake, Rio Jesus, Schohr Ranch, Tracy, Tremont, Trico NW, Vernalis, West Thornton, and Zamora.

CAES Reservoir Favorable Characteristics	**Location in Report where Discussed / Information Provided**
115 ft. of conventional core, production data, pressure data (including repeat formation tester depth-discrete pressures) and 3D seismic.	discussed in Section 5.2.1 Core data (Morais 16-2): Corelab analyses in Appendix C; discussed in Section 5.2.2 and 5.2.3 Production data: discussed in Sections 4.1 and 4.2; presented in Figures 2 – 4 and Table 2 Pressure data: discussed in Sections 4.1 and 4.3; presented in Figure 5 and Table 4 3D seismic data: Not presented due to confidentiality agreement with field operator
Stratigraphic trap and anticlinal structure	Discussed in Sections 5.1.3; presented in Figures 11 and 14
Optimal reservoir depth (approximately 4,700 ft.) and original pressure (approximately 2,000 psi)	Discussed in Sections 4.3 and 5.1.4
Excellent low-permeability caprock (Capay Shale) and lateral seal rock (shale in Meganos Channel Fill); downdip to southwest is a gas-water contact	Corelab analyses in Appendix C; discussed in Sections 5.1.4 and 5.2.3; presented in Figure 14 and in Table 7
Thick sandstone reservoir in Meganos Channel sand with net composite thickness ranging from 40 to 50 ft.	Discussed in Section 5.1.4; presented in Figure 14
High porosity (34%) and high permeability (1465 millidarcies (mD); corrected to confining stress) reservoir	Discussed in Section 5.2.3; presented in Table 5
Moderate reservoir volume (6.7 Bscf initial gas in place) allowing high ratio of reservoir volume to CAES air bubble working volume	Discussed in Section 2, 7.2.2 and 7.3
Small amount of free gas remaining in attic gas caps (approximately 1 Bscf)	Discussed in Sections 4.2 and 7.2.2

CAES Reservoir Favorable Characteristics	Location in Report where Discussed / Information Provided
Small number of wells potentially requiring remedial abandonment	Wells drilled in Meganos Channel Morais Sand discussed in Section 4.1
Small percentage mass of pyrite in reservoir rock, with potential to react with, and consume oxygen	Corelab x-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses provided in Appendix C.
Favorable/manageable environmental/cultural factors, logistics, and site control agreements	Not discussed in this document.

4. FIELD HISTORY

4.1 Development

The East Islands Gas Field is located in the Sacramento Valley gas province between the cities of Stockton and Sacramento. It is situated under farm land in Sections 15 and 16, T3N-R5E, in San Joaquin County (**FIGURES 1 and 2**) about ten miles northwest of downtown Stockton. The field consists of three distinct gas pools (**FIGURE 3**). Two of the three pools are very small one-well accumulations. The main pool lies in Section 16 where natural gas was produced from two wells, the Morais 16-1 and the Stevens 16-1 wells.

The East Islands Gas Field was discovered in January 1981 by the Argo Petroleum Buttes-Coldani 15-44X well; however, the main two-well pool of the field was not discovered until February 1988 when TXO Production Company completed the Morais 16-1 well, drilled to a total depth of 5,000 feet. The Morais well encountered a Meganos channel sand with gas pay from 4,577 – 4,630 ft. There was underlying water and peripheral water in the channel down-dip to the southwest. The well was completed flowing at a rate of 2,205 Mcfd through a 20/64ths-inch choke on production test. The 30-minute shut-in tubing pressure was reported at 1,700 pounds per square inch gauge (psig).

Since the field was discovered in 1981, it has produced 4.04 Bscf of gas from four wells (as of April 2014). The wells are listed in **TABLE 1** along with pertinent well information. The main two-well gas pool has produced the majority of the gas, an estimated 3.88 Bscf. Most of the main pool gas was produced from a single well, the Morais 16-1 (3.72 Bscf). The accumulation covers approximately 110 acres and is interpreted to have a maximum net gas column of 50 feet; with an observed gas column of 48 feet in the Morais 16-1 well.

The Morais 16-1 is the only remaining active producer in the field. The other three wells are plugged and abandoned. Princeton Natural Gas LLC took over operations of the Morais 16-1 well in November 2006. As of April 2014, the well was producing intermittently, at a rate of 37 Mscf per day.

A core well, Morais 16-2, was drilled by PG&E in March 2013 to gather reservoir characterization data for this CAES project. A gross interval of 115 feet was cored with 100 percent recovery during four core runs in the Meganos Channel formation and overlying Capay shale. The well was cased but not completed and is anticipated to be an observation well should there be a field testing phase for this reservoir.

4.2 Well Production Performance

Production data for the East Islands wells was obtained from the California Division of Oil, Gas and Geothermal Resources (DOGGR). The DOGGR is the state of California repository for oil, gas, and geothermal well information and it publishes statistics on drilling, production, and injection (http://opi.consrv.ca.gov/opi/opi.dll). The cumulative gas and water production for the East Island Gas Field is 4.04 Bscf of natural gas and 96.4 thousand barrels of water (Mbw), through April 2014. **TABLE 2** presents the cumulative production data by well.

FIGURES 4 - **7** are graphs of the monthly production data for all the East Islands wells. The completion/recompletion histories of the two wells in the main pool are presented in **TABLE 3**. This information is useful for interpreting the changes in gas and water production rates for example; a well's gas rate typically increases after a recompletion event in which cement is squeezed into the lowest perforations of the well to eliminate bottom or flank water production.

The main East Islands reservoir producing mechanism is a water drive. The water drive is an aquifer that underlies and surrounds the reservoir on three sides. It encroaches into the gas reservoir as the reservoir pressure decreases due to the high-pressure gas in the pores of the reservoir expanding out into (and being produced from) the wells. The water drive is a strong drive because the recharge rate is approximately equal to the reservoir's fluid withdrawal rate. See the Reservoir Pressure discussion in Section 4.3. A water drive is not as effective as an expansion-gas drive producing mechanism for recovery of the in-situ native gas because the encroaching water flows around and traps pockets of gas in the reservoir resulting in trapped gas saturation. The trapped or residual gas saturation is typically about one-third of the initial hydrocarbon saturation. Evidence of a bottomwater drive is seen in the increase in water production as a result of water breakthrough and subsequent recompletion well work identified in **TABLE 3**.

The geologic interpretation of the gas field (discussed in Section 5 below) coupled with the well production performance indicate that there is presently as attic gas cap area in the structural high portion containing the remaining free gas in the field. The Morais 16-1 well, when it is active, currently produces gas at a rate of about 37 thousand standard cubic feet per day (Mscfd) from the attic gas cap area. The reservoir simulation model built for this report (see Section 5.1) predicts some 1.0 Bscf of free native gas remaining in the free gas cap at this time.

4.3 Reservoir Pressure

The reservoir pressure history for the main pool of the East Islands Gas Field was constructed using surface tubing pressures retrieved from the DOGGR website. In addition, tubing pressure data from well workovers were obtained from the well history records. The initial reservoir pressure for the main pool is estimated to be 1,970 psig at 4,623 ft. (source: Stevens 16-1 DOGGR well records). Current reservoir pressure is 1,964 psig at 4,593 ft. in April 2014 (**TABLE 4**).

There are no reported bottomhole reservoir pressures in the East Islands wells. As a result, surface tubing pressures were converted to estimated bottomhole pressures over the life of the wells. The tubing pressures are surface flowing pressures reported by the operator on a monthly basis. The conversion from flowing surface pressure to bottomhole pressure was made using an estimated hydraulic head[6] added to the reported tubing pressure.

The estimated bottomhole pressures are considered good quality for those time periods of no associated water production because there is a known single phase gas gradient between surface and bottomhole. The estimated bottomhole pressures become much less valid or invalid as the quantity of water increases with the produced gas because there is a varying unknown gas-water mixture in the wellbore with a higher pressure gradient between the known surface tubing pressure and the unknown bottomhole pressure.

The calculated bottomhole pressures by well over the life of the field are shown for the main pool wells in **FIGURE 8**. Although the tubing pressures are flowing pressures, the corresponding static reservoir pressures are expected to be close to these numbers because there is minimal pressure drawdown during flow due to the high reservoir permeability. The estimated bottomhole pressures are used throughout this report to represent the reservoir pressure behavior over time.

Current reservoir pressure is within 20 psi of the original discovery pressure. When the Morais 16-2 core well was drilled In April 2013, reservoir pressure measurements were taken in the East Islands gas reservoir using the Halliburton Reservoir Description Tool (RDT) tool. This tool allows multiple in-situ pressure measurements to be made at various depths using a special probe. The measured pressures are shown in **TABLE 4**. The RDT pressures for the Meganos Channel Morais Sand ranged from 1,964 psig to 1,996 psig.

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[6] The estimated hydraulic head was determined using a correlation for gas wells (Gray, 1974), derived empirically, that accounts for the hydrostatic and frictional fluid losses in a wellbore under a variety of flow conditions. Using the Gray correlation and the gas rate, water-gas ratio, and tubing head pressure averaged for the period May 1988 to May 2012, a calculation was made of 290.3 psi and 328.1 psi hydraulic heads for the Morais 1-16 and Stevens 1-16, respectively. In the case of a few tubing pressures, the specific monthly gas and water production rates were used in the Gray correlation to calculate that month's bottomhole pressure.

4.4 Material Balance P/z

The early time pressure data in the East Islands wells, before detection of the water drive, are useful for predicting the approximate size (IGIP) of the gas reservoir. The estimated bottomhole pressures (P) divided by their respective gas deviation factors (z) plotted against the cumulative gas production for the field is a simple P/z material balance method. The method assumes that as gas is produced from the reservoir, there will be a corresponding change in the reservoir pressure that depends on the volume of natural gas produced and the remaining gas-in-place. Without any water influx, these data should theoretically extrapolate to the IGIP at a zero P/z value. With water influx, the reservoir pressure decline is retarded or offset by the water encroachment and the P/z data will not extrapolate to the IGIP but rather trend to a value higher than the IGIP.

The P/z plot is shown in **FIGURE 9**. A trendline is drawn for a straight line extrapolation of the early P/z data to a zero P/z value and a corresponding IGIP of 6.7 Bscf. This value is the IGIP determined by reservoir simulation (see Section 7.2). The trendline is a good fit of the early P/z data and is an independent confirmation of the simulation model IGIP.

5. RESERVOIR CHARACTERIZATION

5.1 Geology

5.1.1 Regional Setting

The East Islands Gas Field is located in northern San Joaquin County, California and lies within the northern third of the Great Valley geomorphic province of California (**FIGURE 1**). The Great Valley is an asymmetrical structural trough with a steep west flank and a more gently dipping east flank. It is situated between the Coast Ranges to the west and the Sierra Nevada Range to the east and includes the San Joaquin Valley to the south and the Sacramento Valley to the north. The eastern flank of the southern Sacramento Valley, where the East Islands Gas Field is located, is underlain at depth by a basement complex of relatively impermeable metamorphic and crystalline plutonic rocks. These are overlain by marine sedimentary rocks, followed by non-marine volcanic and alluvial deposits derived from the coast range to the west and the Sierra Nevada to the east (Edmondson, et al., 1967). Major regional faults are not known to be present near the site.

The project location regionally lies on the west-dipping homocline between two cross-valley arches, the Thornton Arch to the north and the Stockton Arch (and Fault) to the south. These and other nearby structural features are shown on **FIGURE 10**, based on a map modified from Beyer (1988). In an east-west direction, the project location lies equidistant between the Midland Fault, located approximately 12 miles to the west, and the Willows Fault, whose inferred location is approximately 12 miles to the east. The Stockton and Midland faults are major subsurface faults that were active during the Late Cretaceous through the Eocene.

The East Islands Gas Field is an erosional remnant within the Meganos submarine canyon complex (also called Meganos Channel) that was eroded and filled during Paleocene time (**FIGURE 10**). Marine sedimentary sequences in the Sacramento and northern San Joaquin Valley include organic shales that serve both as source rocks for natural gas and, by virtue of their low permeability, as seals or cap rocks for gas accumulations in permeable sandstones reservoirs. Petroleum is generally not found in the Sacramento and northern San Joaquin Valley, but natural gas fields have been extensively developed, including the subject field.

Prior experience and regional studies of the Paleocene Meganos Canyon significantly influenced the interpretation of the field. The structure at the top of thick channel sands in the Meganos Canyon fill, especially those at the top of the canyon-fill, is commonly anticlinal, created by greater compaction of shaley sediments at the margins of the thick channel sands (**FIGURE 11**). The axes of these compaction anticlines follow the trend of the underlying thick channel sands. The thick Meganos channel sands are overlain and capped by thick (100') impermeable Eocene Capay shales that drape over the thick sandstone (**FIGURE 12**). Meganos Channel shales also provide a lateral impermeable seal to reservoir sands.

5.1.2 Data Utilized and Interpreters Involved in Geological and Reservoir Evaluation

The structural and stratigraphic interpretations presented in the referenced maps and cross-sections and discussed in Sections 5.1.2 and 5.1.3 are mostly based on correlations of geophysical well logs that were downloaded from the DOGGR online data site:

http://www.conservation.ca.gov/dog/Online_Data/Pages/Index.aspx

For many of the wells, only a basic suite of open-hole geophysical well logs comprising, at a minimum, spontaneous potential (SP) and resistivity logs (sometimes referred to as "correlation logs"), were run by the well operator. So-called "porosity" logs were run in three of the five wells completed in the East Islands Gas Field Morais sand reservoir (Morais 16-1, Morais 16-2 and Stevens 16-1). Sonic porosity logs were run in many of the other wells surrounding the East Islands Gas Field.

Data from a 3D seismic survey were also used in the evaluation of the East Islands Gas Field reservoir and geology. The 3D seismic data volume used in the interpretation represents a small portion of a regional (250 mi^2) 3D seismic survey shot in 1999 by Eagle Geophysical for DDD Energy and Enron. The current East Islands Gas Field operator acquired an approximately 1 mi^2 portion of the survey encompassing the field from PacSeis of Denver, Colorado. The processed seismic data results are not exhibited in this report as they are subject to a confidentiality agreement.

Interpretation of regional and local geologic structure and stratigraphy (sequence of rock layers) presented in Sections 5.1.3 and 5.1.4, and development of the regional geologic maps and cross-sections, was performed by Frank Cressy, a State of California Professional Geologist. Mr. Cressy also prepared the interpretation of the stratigraphy of the East Islands Gas Field and the Morais sand gas reservoir and development of the geologic maps and cross-sections used in this study.

5.1.3 Geological Interpretation

The geologic interpretation of the East Islands main gas reservoir is controlled by subsurface data where wells are present and the interpretation is constructed using well control, seismic data, regional geological knowledge of the Meganos Channel, and oil and gas exploration concepts. The structure of the main pool is a stratigraphic trap created by the intersection of an uppermost Meganos Channel sand (Morais sand) with the anticlinal nose (**FIGURE 11**). The accumulation covers about 110 acres with a NNW-SSE length of about 4,500 feet and a maximum width of about 1,200 feet. The eastern, up-dip boundary of the field and trap closure had originally been thought to be the result of faulting. Although the up-dip edge of the seismic anomaly nearly parallels that of the previously interpreted fault, it is now believed to represent the up-dip edge of a narrow channel sand.

The gas pool limits are defined by the edges of a higher amplitude event in the seismic data that lies in a NNW-SSE orientation and is interpreted to be a gas-filled sand channel. The best well in the field, the Morais 16-1, correlates with the higher amplitude portion of the anomaly. The Stevens 16-1 well is located within the northern area of the pool at the eastern edge of the amplitude anomaly. The well location at the anomaly’s edge corresponds well with the stratigraphy of the productive sand which is nearly shaled-out at this location.

The eastern limit of the pool is controlled by the channel edges and the western down-dip limit where the sand channel widens is thought to be defined by a gas/water contact. The north and south boundaries of the anomaly are the gas/water contact. The maximum thickness of the channel sand is about 100 feet in the Morais 16-1 well (**FIGURE 13**). Gas pay is present in the top 48 ft. of the sand in this well, and bottom water is probably present throughout most of the channel. The channelized reservoir appears to be uncomplicated internally by faulting or internal stratigraphic discontinuities.

5.1.4 Stratigraphy

As depicted on the cross section D-D’ (**FIGURE 14**), thin productive sands at the top of the Meganos Channel fill in the Stevens #16-1 well may be in limited communication with the main reservoir sand encountered in the Morais #16-1 well. The original interpretation of the field assumed that the thick reservoir and channel sand at the top of the Meganos Canyon fill was shaling-out westerly toward the Stevens #16-1 well, and that two thin (~12 ft.) gas sands in the equivalent interval in the Stevens #16-1 well were in communication with the main sand in the Morais #16-1 well. However, the water table in the Morais well was encountered at a subsea depth of -4,625 feet. In the Stevens well, an apparent water table was encountered in a 12 ft.

thick lower sand at a subsea depth of -4,631 feet, suggesting that the lower gas sand is hydraulically separate and not in communication with the main sand reservoir. The Meganos Channel Sand Net Pay Isochore Map (**FIGURE 15**) is prepared based on this interpretation.

The Capay Shale overlies the Morais channel sand and it forms the seal or cap rock for gas trapped in the uppermost sands at the main East Islands gas reservoir, as well as numerous other gas fields in the southern Sacramento Valley. The Capay is composed of thick gray-green silty mudstones and forms an excellent seal over the gas reservoir. The basal Capay contains abundant glauconite over a thin basal conglomeratic zone. The Capay Shale is just less than 100 ft thick over the East Islands Gas Field (**FIGURE 12**).

The Eocene-age Domengine Formation sandstone conformably overlies the Capay Shale. The Domengine Formation is over 800 feet thick in the vicinity of East Islands and is composed predominately of well-sorted, clean quartzose sandstone with thin interbeds of gray siltstone and claystone. The Domengine sandstone is conformably overlain by the Nortonville shale, another regional marine shale unit. The late Eocene-age Markley Formation overlies the Nortonville Shale, possibly as an unconformable surface. It consists of 200 to 300 feet of interbedded marine mudstone, siltstone, and sandstone.

Over 3,000 feet of non-marine sediments unconformably overlie the Eocene sediments and represent the final stages of the basin filling. These sediments range in age from Miocene through the Pliocene and are capped by several hundred feet of Pleistocene to Recent alluvial and lacustrine sediments.

5.2 Rock Properties

A full range of physical, textural, mineralogical and hydraulic properties of the target injection zone (Meganos Channel Morais sand) have been determined through petrophysical analysis of conventional and sidewall cores taken in the Morais 16-2 well and wireline logs run in the well. This section summarizes the coring and logging programs and the analytical results.

5.2.1 Geophysical Logging Program

A comprehensive wireline open hole logging program that included porosity logs in the target injection zone was conducted by Halliburton during drilling of the Morais 16-2 core well in April 2013. The logs and information obtained during the logging programs are summarized in the table below. Copies of the logs for the Morais 16-2 core well are provided in **APPENDIX A**.

Summary of Geophysical Log Type and Purpose – East Islands Core Well

Logging / Coring Program		Primary Purpose	Logging Depth Morais 16-2
Open-Hole	Mud Log	Lithology, rate of penetration, gas shows, core intervals	4200' – 4993'
	Spontaneous Potential (SP) log	Sand layer definition, formation water salinity	527' - 4985'
	Dual induction log (DIL)	Formation water salinity, hydrocarbon indicator, water/hydrocarbon saturation (with porosity measurements)	
	Micro-resistivity Tool (MRT)	Flushed and invaded zone resistivity, permeability indicator	
	Gamma Ray (GR) log	Shale indicator	
	Compensated Spectral Natural Gamma log	Define contributions from the three main GR emitters in rock: uranium, thorium and potassium	
	Formation Density Compensated (FDC) log	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)	
	Compensated Neutron Log (CNL)	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)	
	Caliper log (CAL)	Show variations in borehole size and geometry	
	Pressure Transient Analysis Tool (RDT)	Depth-discrete pressure measurement, permeability determination.	Ran 12 pressure tests between 4550' and 4762' MD
	Sidewall Cores (SWC)	Collect core samples for analysis of porosity, permeability, grain density and fluid saturations. Compare results to those from conventional core and relate to future well SWC results.	Shot 24 percussion sidewall cores between 4681' and 4762' MD
	Directional Survey	Measure hole inclination and azimuth; determine well path and true vertical depth vs. measured depth	Survey from 600' to 4648'
Cased-Hole	Cement bond log (GR-N-RCBL)	Evaluate integrity of annular cement seal and identify channels that might allow fluids to migrate between formations	Surface to 4902'

Analysis and interpretation of the Morais 16-2 geophysical logs was performed by Digital Formation, a petrophysical consulting company located in Denver, Colorado. Provided in **APPENDIX B** is the Digital Formation report, which includes the analytical methodology, formulas and rock property results, as well as composite interpretation log for the Morais 16-2 core well.

5.2.2 Coring Program

During drilling of the Morais 16-2 core well in April 2013, sidewall cores (SWCs) and conventional cores were collected from the Meganos Channel sands and the overlying Capay Shale confining unit. Coring commenced at 4649 feet and finished at 4764 feet (MD); a total of 115 feet of gross interval cored during four core runs with 100 percent recovery. Coring began in the Eocene Capay shale and penetrated 33.2 feet of the formation. Coring continued into the Paleocene Meganos Canyon fill, recovering 81.8 feet of that unit. A general core description is given in **APPENDIX C**.

Core plugs were collected at 1-foot intervals from the conventional core between depths of 4,649 to 4,765 feet (ft.-MD) and 24 SWCs were collected between depths of 4,681 and 4,762 ft. The cores was transported to Core Lab in Bakersfield, California where they were slabbed, photographed, described, and underwent core spectral gamma and CT scanning. The Core Lab analyses results are provided in **APPENDIX D**.

Routine core analyses were performed on all of the core plugs and SWCs. Advanced core analyses were performed on a small subset of the core plugs, ranging from 3 to 15 samples, depending on the analysis. Sample selection for advanced analyses was based on the results of the routine analyses. The number of samples selected for each advanced analysis was based on professional judgment of the reservoir engineer regarding how many samples provided a representative sample population. General criteria for advanced analyses sample selection were to stay above the original GWC, avoid unconsolidated core material and cover the range of permeability seen in the routine samples. The following routine and advanced core analyses were performed:

Core Analyses	**Description**	**Samples Selection Criteria**
Routine Analyses (all samples)		
Porosity	Total pore space in sample as a percentage of total sample volume. Used in all reservoir volumetric calculations.	All core plugs and SWC samples tested.
Grain density	Density of reservoir solids whose value determined by rock mineralogy. Input to formula relating sample porosity and bulk density.	All core plugs and SWC samples tested.

Core Analyses	Description	Samples Selection Criteria
Horizontal permeability to air	Intrinsic characteristic of rock that determines how easily air can pass through it. Measured parallel to rock layering, which is preferential flow direction in reservoir. High horizontal permeability indicator of good reservoir quality.	All core plugs and SWC samples tested.
Fluid saturation	Percentage of rock porosity occupied by water. Affects the relative permeability of reservoir with respect to air, with permeability to air decreasing as fluid saturation increases.	All core plugs and SWC samples tested.
V-clay	Ratio of clay (or shale) volume to total rock matrix volume; expressed as a decimal. High V-clay usually indicates low reservoir quality. Used as correction factor in log porosity calculations.	All core plugs and SWC samples tested.
Advanced Special Core Analyses (Selected Samples)		
Vertical permeability (15)	Permeability measured perpendicular to rock layering. Indicates ability of fluid to flow vertically within layers, or between layers. Low vertical permeability characteristic of a good caprock.	Representative sampling of Meganos Channel Morais sand.
Porosity and permeability at 4 confining stresses (13)	Porosity and permeability measured at confining stresses representative of reservoir pressures. Due to sediment compaction, porosity and permeability decrease with depth. Results used to derive correction factor to correct porosity and permeability measured at laboratory (ambient) pressure to reservoir pressure conditions.	Representative sampling of Meganos Channel Morais sand.
Relative permeability (3)	In a multi-phase reservoir, relative permeability is the ratio of the effective permeability of the phase of interest to the absolute permeability, where the flow of each phase is inhibited by the presence of the other phases. Relevant to CAES application in a depleted gas reservoir characterized by multi-phase flow (air, native gas and water).	Representative sampling of Meganos Channel Morais sand; same approx. depths as for capillary pressure samples.
Capillary pressure (4)	Pressure necessary to squeeze a fluid through a pore throat (works against the interfacial tension between different phases); higher for smaller pore diameter. Used to characterize vertical water saturation profile and transition zone from 100% water production to 100% gas (or air) production.	Representative sampling of Meganos Channel Morais sand; same approx. depths as for relative permeability samples.
Mercury injection capillary (4)	Provides porosity, recovery efficiency, irreducible water saturation, pore-throat size, pore-throat size distribution and threshold pressure.	Representative sampling of Meganos Channel Morais sand; same approx. depths as for capillary pressure samples.

Core Analyses	Description	Samples Selection Criteria
Scanning electron microscopy (SEM) and thin section analysis (10)	Provides rock mineralogy, fabric and texture, authigenic constituents, and pore types.	Representative sampling of Meganos Channel Morais sand; same samples analyzed by XRD.
Bulk and clay X-ray diffraction (XRD) (10)	Provides bulk rock and clay mineralogy.	Representative sampling of Meganos Channel Morais sand; same samples evaluated by SEM and thin section.

5.2.3 Core and Log Analyses and Results

This Section provides a discussion of the analyses and results of core and log analysis for the Meganos Channel Morais sand (reservoir injection zone) and the Capay Shale confining unit. Selected porosity and permeability data and analysis results have been tabulated and plotted, as follows:

Exhibit	Data Source	Geologic Unit*	Data and Analysis Presented
Table 5	Morais 16-2 Conventional Core	MCS	Porosity and permeability at ambient stress (250 psi) and confining stress (2700 psi), average porosity and permeability (ambient and stress conditions), and ratio of stress to ambient permeability
Table 6	Morais 16-2 Conventional Core	MCS	Vertical-horizontal permeability anisotrophy ratio
Table 7	Morais 16-2 Conventional Core	Capay Shale	Horizontal permeability
Fig. 16	Morais 16-2 neutron-density logs and conventional core	MCS	Cross-plot of log porosity and core porosity
Fig. 17	Morais 16-2 special core analysis	MCS	Cross-plot of ambient permeability (lab conditions) versus stressed permeability (reservoir conditions)

Exhibit	Data Source	Geologic Unit*	Data and Analysis Presented
Fig. 18	Morais 16-2 conventional core	MCS	Cross-plot of core porosity and horizontal permeability
*MCS = Meganos Channel Sand			

Meganos Channel Sands Reservoir Injection Zone

Porosity, water saturation, and permeability for the Meganos Channel sands comprising the injection zone were determined based on digital analysis of geophysical logs and laboratory analysis of cores (conventional and SWC) from the Morais 16-2.

A cross-plot of log and core derived porosities prepared by Digital Formation (**FIGURE 16**) indicates good correlation between the two data sets. Conventional core plugs were taken every foot for routine core analysis, and 13 samples were analyzed for vertical permeability and permeability at confining stress. Due to the high density of core plug sampling and the various types of routine and advanced core analyses performed, the porosities derived from core analysis are considered much more reliable than those derived from geophysical log interpretation. Also, the log permeability curve on the Digital Formation composite log (**APPENDIX B**), derived from an equation that relates permeability to porosity and water saturation (Timur Equation – see Digital Formation Report in **APPENDIX B**), is considered much less reliable that the core derived permeabilities. Accordingly, the analysis below is based solely on the Core Lab analyses results.

Average (arithmetic) core porosity and horizontal permeability of the reservoir sands are 34.5% and 1464 md, respectively (**TABLE 5**). The permeability value of 1464 md is based on an average of 77 horizontal permeability measurements at ambient stress (250 psi) corrected to a confining stress of 2,700 psi. There is a significant correction from the lab conditions of 250 psi confining stress to the reservoir stress conditions of 2,700 psi. For the 13 samples tested to a confining stress of 2,700 psi, the average ratio of stress to ambient permeability was 0.265. Similarly, when the stressed permeabilities are plotted against the unstressed permeabilities, there is an excellent correlation (**FIGURE 17**).

There is a fair porosity-permeability relationship based on a cross-plot of 115 porosity and permeability analyses of core plugs from the conventional core collected from the Morais 16-2 core well, as shown in **FIGURE 18**. Vertical permeability of the 15 samples tested for the Meganos Channel Morais sand ranged from 329 to 13,195 mD, and the average (arithmetic) vertical to horizontal permeability anisotropy ratio is 1.006 (**TABLE 6**).

Capay Shale Confining Zone (Caprock)

The Capay Shale is a confining zone that provides the overlying impermeable seal (caprock) for the Meganos Channel sands at East Islands. To evaluate the sealing capacity of the Capay Shale, the horizontal permeability of the zone was measured for the conventional core cut in the Capay Shale. The harmonic mean of eight horizontal ambient stress (250 psi) permeability measurements in the Capay Shale, corrected to 2,700 psi confining stress as described above, is 0.09 md (**TABLE 7**). Vertical to horizontal permeability in the sands is essentially 1:1, but it may not be 1:1 in the Capay Shale at confining stress. Even at this low permeability (0.09 md), the Capay Shale could not be considered an impermeable barrier.

Further caprock/threshold pressure testing was performed to test the sealing nature of the caprock (**APPENDIX F**). Three samples from the Capay Shale in the Piacentine 2-27 at the neighboring King Island field were flow-through saturated with test brine to ensure complete saturation. Nitrogen gas was injected from the top starting at 100 psi and increasing to 2,000 psi maximum pressure. Gas pressure and volume of brine produced was recorded and used to calculate the effective water permeability at each injection pressure. All three samples behaved the same in this test. During the initial flow through saturation overnight, there was no brine produced. As the injection pressure increased, there was no brine produced and the effective water permeability was non-detectable. There was no gas breakthrough at the maximum delta 2000 psi injection pressure. These results support a conclusion that the East Islands reservoir caprock is an impermeable seal at reservoir conditions.

5.3 Fluid Properties

There is one gas analysis for the East Islands Gas Field. A gas sample was collected in the Morais 16-1 well in January 2013. The gas analysis is presented by **TABLE 8**. The East Islands gas is predominantly methane at 93.8 percent contaminated with 5.9 percent nitrogen. The gas specific gravity is 0.581 and the heat content is 956 BTU per scf. There is a very small quantity of ethane (0.2 percent) in the gas.

There are no reservoir water samples or analyses available for any of the wells in the East Islands field; however, a water sample collected from the Mokelumne River Formation reservoir in the nearby King Island Gas Field in April 2014 for Piacentine 2-27 well is considered relevant for comparison based on similar depth and stratigraphic position occupied by the Mokelumne River Formation at King Island and the Meganos Channel sands at East Islands. **APPENDIX E** presents the complete geochemical analysis for the Piacentine 2-27 water sample. The total dissolved solids (TDS) measurement for this sample is 14,000 ppm and total sodium chloride is 13,000 ppm. This sample is believed to be a good representation of the formation water in the Meganos Channel sands at East Islands. This salinity information is used in the petrophysical calculations for the Morais 16-2 wireline logs.

6. MODEL DESCRIPTIONS

6.1 Static Model

A numerical simulation model study was conducted by MHA Petroleum Consultants (Denver, CO) to help design the bubble development program, predict air/water displacement and estimate reservoir pressure levels for a given air bubble design volume. The simulation model covers the gas-productive area of the main pool of the East Islands Gas Field plus the underlying flank and bottom water wherever there is porous and permeable sand.

The first step in the simulation study was to construct a three-dimensional (3D) geologic (static) model for the Morais sand gas pool at East Islands. A detailed geologic description of the main Meganos reservoir at East Islands Gas Field by F. Cressy was provided to MHA Petroleum Consultants. Data provided included three geologic reports, maps, cross-sections, and well data including digitized well logs. MHA utilized these data in the construction of a 3D geologic model of the East Islands field. The static model built in Petrel was then exported in Eclipse format for simulation modeling.

The lateral limits of the main area of the East Islands Gas Field were determined from well log correlations (as depicted on geologic cross-section in **FIGURE 14**) and from seismic profiles and amplitude anomaly maps developed by geophysicist Tom Fassio from the field operator’s 3D seismic survey (Section 5.1.2). The high amplitude anomaly on the seismic data is the result of a strong acoustic impedance contrast between the relatively high impedance Capay Shale and the relatively low impedance gas-charged reservoir.

6.1.1 Model Construction

FIGURE 3 is the base map of the East Islands Gas Field and shows nearby well control. The static model covers the main two-well field that is highlighted on this map. The bottomhole location of the Morais 16-2 core well is located approximately 700 feet northwest of the Morais 16-1 well location. **FIGURE 19** presents a type log for the main pool based on the Morais 16-1 well log.

The geologic interpretation of the East Islands Gas Field has evolved with access to the large 3D seismic survey. Based on the seismic amplitude map over the East Islands Gas Field, the geologic interpretation of the main pool of the East Islands Gas Field is a stratigraphic trap. The gas bearing uppermost section of the Meganos channel sand intersects the anticlinal nose as an up-dip edge of a narrow channel sand thereby creating the stratigraphic trap. The edge of the Meganos channel system controls the east and west limits of the gas pool while the narrow north and south boundaries visible on the seismic amplitude map are most likely defined by a gas-water contact. **FIGURE 20** shows the isochore and net-to-gross (NTG) maps for the Meganos channel system (Morais and Stevens sands) that were used to build the static model framework.

The maximum thickness of the uppermost Meganos channel (the Morais sand) occurs in the

Morais 16-1 well (95 feet). The majority of the channel sandstone thickness has well developed porosity up to 33 percent except in the very uppermost part where the porosity drops below 20 percent. A clear gas-water contact occurs on the Morais 16-1 sonic log at -4,625 ft. resulting in approximately 55 total feet of gas column (**FIGURE 19**). The Stevens well is located at the northeastern edge of the amplitude anomaly. The Meganos channel has shaled out into two thin sands at this location (Morais sand). Porosity in these Morais sands average 24 percent. Several wells located to the north and south of the main pool have varying thicknesses of Meganos channel present supporting the seismic interpretation of a narrow north-south trending channel system. However, only the Morais and Stevens wells are located within the higher amplitude section of the channel system.

6.1.2 Structural Framework

The Schlumberger Petrel software was used to build the East Islands three dimensional (3D) geologic model. The geologic interpretation of the main gas pool does not contain any faults therefore the 3D grid was built as a simple rectangular model. The structural framework was constructed with a cell x,y increment of 50 ft. by 50 ft. The fine x,y increment was chosen specifically to prevent unnatural layer pinchouts at the edge of the narrow Meganos channel system. To avoid this issue no further upscaling, or homogenization, was applied to the static model prior to export in Eclipse simulation format.

The base Capay unconformity surface was used as the top surface in the model. The Stevens surface was mapped from well logs and used as the top surface between the Morais and Stevens sands. Then the Morais and Stevens gross isochores were hung from the Capay and Stevens surfaces respectively. The model was confined to the productive channel area only (125 acres) with a flat GWC applied at -4,625 ft. **FIGURE 21** shows map and cross-sectional views through the static model.

Once the model structural framework was built, the two model zones (Morais and Stevens zones) representing the Meganos channel system were subdivided into layers (**FIGURE 22**). The Morais Zone 1 was layered flat with an average layer thickness of five feet. In the Stevens Zone 2 (non-reservoir) flat layers were created with an average thickness of 12 feet. The final regional static model 50 ft. by 50 ft. grid cells with 60 layers (Zones 1 and 2) for a total of 966,600 grid cells.

6.1.3 Porosity Distribution

Porosity values for distribution within the static model were obtained from the well logs (Stevens 16-1, Morais 16-1 and Morais 16-2). The Morais 16-1 porosity log was edited to remove abnormally low porosity values in the upper 20 feet of the Morais sand (Zone 1). No edits were performed on the Stevens 16-1. A petrophysical well log was generated for the recent Morais 16-2 well using both core and logs. The porosity logs for the three wells were upscaled into the new model. Upscaling involves averaging the input log curves with a 0.5 ft. depth increment into the model layers where the average thickness is approximately 5 feet per layer in Zone 1 Morais and 12 feet per layer in the Zone 2 Stevens.

The Zone 1 Morais channel sandstones have a distinct bimodal distribution. The thick clean channel sandstones encountered in the Morais 16-1 and Morais 16-2 have average 33% porosity while the thinner, more silt-rich sandstones encountered in the Stevens 16-1 average 24% porosity. It was important to capture the limited extent of the Stevens 16-1 anomalous silt-rich Morais sandstones in the model. To confine these lower porosity sands to the area around the Stevens 16-1 well two discrete 'facies' logs were generated for the high porosity Morais sand (at the two Morais wells (typical of regional Meganos channel sands)) and the low porosity Morais sand encountered at Stevens well. **FIGURE 23** shows the well logs, the 'facies' logs, the model zone layering log for the as well as a porosity histogram for Zone 1 Morais sand showing distinct bimodal character.

Probability cubes were then created for the two 'facies'. Each upscaled 'facies' log was distributed throughout the probability cube with a probability between 0 and 1 based on the perceived areal extent of each 'facies'. These probability cubes were then combined stochastically to arrive at a single realization of a Morais sand 'facies' model. **FIGURES 24** to **26** illustrate the process of generating the final 'facies' model for the East Islands field.

Well log porosity values were then distributed stochastically within the static model while also being conditioned to the 'facies' model. That is, each of the Morais sand 'facies' (high porosity and low porosity) were distributed using different variogram input. The low porosity 'facies' was constrained using a limited variogram to the immediate area around the Stevens 16-1 well. A much wider variogram was applied to the higher porosity 'facies' typical of Meganos channel fill systems. **FIGURE 27** shows a general intersection slice of distributed porosity in Zones 1 and 2 through the three wells. Note the limited extent of the poorer porosity around the Stevens 16-1 well.

The static model porosity cube was used to generate distributed permeability using a porosity-permeability transform developed from the recent Morais 16-2 core. Further discussion of the transform used in simulation modeling is found in Section 6.2.1.

The initial water saturation was set as an average value of 22 percent. Subsequent capillary pressure core analysis tests (**APPENDIX C**) showed initial water saturations in the range of 21 to 25 percent at a height of 25 feet above the contact.

6.1.4 Net-to-Gross Distribution

A net-to-gross map representing the ratio of net sand thickness to gross interval thickness was created by Frank Cressy (**FIGURE 28**) for the static model area using the limited well control. In addition, several realizations of reservoir net-to-gross properties were generated using various porosity cutoffs. In the end, it was necessary that the net-to-gross factor be set equal to 1 for the static model to create the sufficient reservoir size (6 to 7 Bscf) as indicated by the P/z material balance work.

6.1.5 Volumetric Gas-in-Place

The volumetrics for the Meganos Channel Morais sand were calculated using constant initial gas saturation of 78 percent, gas-water contact at -4,625 ft., initial gas formation volume factor of 0.006891 rcf/scf, and the distributed, variable porosity cube. The results were an initial gas-in-place of 6.5 Bscf. This is a preliminary estimate for use in verifying that the constructed static model has sufficient gas-in-place for the next phase of the study, the dynamic modeling phase.

6.2 Dynamic Model

The East Islands static model was exported from the Petrel software as a series of ASCII grid files (structural framework, porosity, Petrel well connection and well completion files) in preparation for the dynamic modeling phase of the project. These formatted files are compatible as input to the ECLIPSE simulation software package (Schlumberger). No further upscaling, or homogenization, was applied to the geologic model in the x,y,z direction because a) the layer pinchout issue discussed previously (Section 6.1.2) and b) the need to maintain layer thickness in the Stevens #16-1 where the uppermost Meganos channel sands are thin and silty.

A dynamic simulation model was created from the static model to match the reservoir performance and simulate the process of air injection into the reservoir for CAES full-field development scenarios. The simulation model consists of 90,613 active gridblocks or cells. Each cell is 50 feet by 50 feet in area. There are a total of 42 layers[7]. The layers vary in thickness from 1 to 6 feet thick with an average of 5.2 ft. in thickness. The dynamic model grid is created using corner-point geometry after importing the static model framework (also corner-point geometry) constructed with the Petrel software. The model grid is shown by **FIGURES 29**[8] through **31**. Four cross-sections (two North-South and two West-East) are made through the entire model grid to illustrate the gridding scheme. The locations of the cross-sections are given in **FIGURE 30**. The same four cross-sections will be used in future figures in this report to display other model properties and simulation results.

The East Islands dynamic model is much more than a conceptual model; it is intended to be a replica of the gas reservoir. It is constructed based on the best available geologic maps, cross-sections and information from wireline well logs. The gas reservoir is bounded at the top by the

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[7] A total of 60 layers were exported from the static geologic model; however, layers 43 through 60 were not retained in the dynamic model because of problems with thin, discontinuous layers that increased the initial runtimes beyond any benefit to the simulation solution. All the removed layers were in the aquifer below the gas reservoir (Stevens zone). The removed layers were replaced with an analytical aquifer attached to the bottom of the dynamic model which was calibrated to provide the necessary water influx to match the observed reservoir pressures.

[8] The plan view (aerial) displays of the ECLIPSE model grid in this report are the first occurrence of the defined properties of the active layers throughout the grid, not fixed to any one particular layer.

Capay Shale, an impermeable cap rock, by an unconformity on one side and peripheral water on the other three sides.

6.2.1 Model Construction

The geologic structural framework of the dynamic model is populated with the structural depths from the static model. **FIGURES 32** and **33** are grid displays of the depths assigned to the gridblocks in the dynamic model (compare **FIGURE 32** for the dynamic model with **FIGURE 21** for the static model). The dynamic model grid cells are populated with porosity, permeability and initial water saturation arrays based on the well log data and estimated petrophysical correlations. Porosity values are sourced from the static model output and are based on the available density-neutron wireline log information upscaled and distributed stochastically throughout the model area (**FIGURES 34** and **35**).

The gridblock permeabilities are determined using a porosity-permeability transform derived from the Morais 16-2 conventional core information described in Section 5.2.2 and presented by **FIGURE 18**. The transformed permeabilities are further reduced by the equation:

$$y = (0.2276)\ x^{1.0152}$$

Where, y = transformed permeability at net reservoir stress, mD

x = unstressed lab permeability, mD

The is the equation of the power correlation presented in **FIGURE 17** to adjust from the laboratory confining stress conditions (250 psi) to the in situ reservoir stress conditions (2,700 psi) for each grid cell. The permeability distribution in the dynamic model is shown by **FIGURES 36** and **37**.

6.2.2 Saturation Distribution

An initial GWC of -4,625 ft. subsea is used in the dynamic model. For the initial water saturation distribution, the model uses a constant 22 percent in all gridblocks above the initial gas-water contact. The gas saturation above the contact is the pore space (porosity) not occupied by the initial water saturation. **FIGURE 38** shows a comparison between the 22 percent initial water saturation versus the measured lab capillary pressure data (Morais 16-2 core).

The producing mechanism in the East Islands Gas Field is a combination of gas expansion and a strong water drive. Water influx models are mathematical models that simulate and predict aquifer performance. When successfully integrated into a reservoir simulator, the net result is a model that effectively simulates performance of a water drive reservoir such as East Islands. To simulate the bottomwater drive identified for this reservoir, a Carter-Tracy infinite-acting aquifer is attached to the bottom-most layers of the model grid (Carter-Tracy is a popular mathematical aquifer model). This analytical aquifer is used to simulate the water influx into the gas-filled pore space known to have occurred during the producing life of the reservoir. **FIGURES 39** through **42** present the distribution of initial gas and water saturations (in terms of molar density) in the dynamic model.

6.2.3 Relative Permeability

Straight-line relationships are used for the gas-water relative permeability curves in the ECLIPSE model (**FIGURE 43**). The initial water saturation endpoint of the relative permeability curve is the specified initial water saturation (22 percent) assigned to all the grid cells. The minimum or residual gas saturation (S_{gr}) to water displacement in the relative permeability curve is 23 percent defined using the S_{gr} versus porosity relationship reported by the Gas Research Institute (Katz, 1964).

$$S_{gr} = (-1.2778 \text{ x Porosity, fraction}) + 0.6172$$

$$= 0.23$$

Where, porosity = 30.4 percent (average of 2,700 psi stressed core samples Morais 16-2)

The model is initialized at original conditions for the initial GWC (-4,625 ft. subsea) and discovery reservoir pressure (rounded to 2,000 psig). The distribution of initial reservoir pressure is shown by **FIGURES 44** and **45**. The IGIP in the model before calibration was 6.7 Bscf.

7. RESERVOIR SIMULATION

7.1 ECLIPSE Simulator

The simulations in this study were performed using the ECLIPSE commercial numerical simulator, a Schlumberger software product. ECLIPSE is a three-dimensional (3-D) finite difference black oil simulator used for modelling oil and natural gas hydrocarbon systems. For the East Islands reservoir, the model is used in the fully compositional mode (E300) for simulating the injection and withdrawal of ambient air. In this mode, the various components of the natural gas (methane, ethane, nitrogen and CO_2) and air (nitrogen and oxygen) are specified in the model with their own properties of viscosity, density and compressibility (**TABLE 9**).

Before going to the fully compositional mode, the simulator was run in the standard “black oil” (E100) mode, represented as a two-component system of natural gas and water, to complete the history matching portion of the simulation work. The E100 version of the model ran more quickly than the E300 version and output was more manageable. After the E100 model was calibrated to the historical reservoir performance, the model was converted to the compositional E300 version to be able to simulate CAES operations. The entire history match period was re-run for the converted E300 model to confirm that the history match calibration was preserved for the conversion from E100 to E300.

7.2 History Match

7.2.1 Calibration

To make the model as realistic as possible, it was calibrated (history-matched) to the historical production and reservoir pressure performance for the three producing gas wells in the field. During history-matching, the actual gas production rate is specified for each well in the model and the wells are ‘matched’ to the reported flowing and static bottomhole pressures and water production rates. The calibration process involves global adjustments to the pore volume (variable porosity and initial water saturations), trapped gas saturation, variable permeability and the use and location of the infinite-acting water aquifers.

The graphs showing the model history match are presented by **FIGURES 46** through **49**. The history matching exercise seeks to establish as best as possible the current reservoir conditions of gas/water saturation and pressure distributions prior to the start of the compression testing program. A better measure of the quality of the history match, as far as water production is concerned, is a comparison of the location of water influx in the reservoir versus the location of water encroachment in the model. This comparison is given in **FIGURE 50** for the water levels in the simulation model at the time of observed water breakthrough in the Morais 16-1 and Stevens 16-1 wells.

7.2.2 Remaining Gas-in-Place

The IGIP determined for the final history-matched dynamic model is 6.708 Bscf[9]. This is the volume of natural gas that results in the best simulation fit of the historical production and pressure performance of the two field producers. The cumulative gas production from the main East Islands field (through April 2014) is 3.875 Bscf. The cumulative gas recovery factor is 57.7 percent. This means that there is about 2.83 Bscf of native natural gas remaining in the reservoir. Of the 2.83 Bscf remaining natural gas, the simulation model predicts approximately 1.0 Bscf is free gas located in an attic gas cap area of 80 acres and 1.8 Bscf is residual gas which is trapped in the water swept portions of the reservoir.

7.3 Full Field Development Modeling

Following the history match, the East Islands dynamic simulation model was used to predict the reservoir performance for a full scale CAES operation. Full scale CAES operation for East Islands is defined as the reservoir development sufficient to support a 150 megawatt CAES plant generating power for peak demand periods up to 10 hours. In terms of withdrawal rate, the surface requirement for a 150 megawatt plant is expected to be a total field-wide equivalent deliverability of 550 MMscf per day.

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[9] The IGIP breakdown is: C1 = 6.294 Bscf, C2 = 0.016 Bscf, CO_2 = 0.00212 Bscf, and N_2 = 0.395 Bscf.

The conceptual design for the CAES operation includes the drilling of vertical wells into the reservoir. The vertical wells are used to create a large “working volume” air bubble. The permeable sands of the Meganos Channel Morais Sand, including the gas reservoir and the underlying aquifer, comprise the injection zone that will experience increased pressures as a result of the air injection. As air is injected, the displacement of the native natural gas and water will cause pressures within the water-invaded gas reservoir sands in the uppermost portion of the Morais sands to increase and this pressure increase is expected to be transmitted throughout the reservoir sands relatively rapidly. The increase in pressure will cause some water to flow out of the reservoir into the underlying and surrounding aquifer. In addition, water flow and pressure will take place laterally until it reaches the relatively impermeable shales deposited at the edge of the Meganos Channel. The lateral propagation of pressure will be limited by the lateral extent of the reservoir and underlying aquifer sands at East Islands.

7.3.1 Design Criteria

The design criteria for the full field plan investigated by the East Islands model are shown by **FIGURE 51**. This simulation was intended to be a first approximation of what might be developed for a 150 MW CAES plant.

An air withdrawal/injection schedule consisting of 10 hours withdrawal followed by 10 hours of injection was used for a daily cycle (total 24 hrs. with two 1-hr transition shut-in periods). The injection rate is 50 percent of the withdrawal rate based on original daily injection design criteria (could be higher depending on facility injection equipment). This cycle is repeated daily for a week in the simulation model then the depleted volume of air is replaced by air injection over the corresponding weekend such that there is no net change in bubble volume by the end of a 7-day period, i.e. zero bubble growth.

7.3.2 Well Plan

The well plan for the full field CAES simulation case is shown by **FIGURES 52** and **53**. A simple well plan was investigated with the dynamic model. It consists of 14 vertical wells (FFD1 – FFD14) located surrounding the Morais 16-1 well. Wells are spaced approximately 100 feet apart. The vertical wells are completed in the top 10 to 25 ft. (2 to 5 layers) of the reservoir (**FIGURES 54** and **55**).

Three wells are used to build the air bubble cushion at a rate of 5.0 MMscfd injection per well (**FIGURE 56**). The bubble build period is 11.5 months. A total of 3.61 Bscf of air is injected prior to initiation of the air cycling operations. The maximum reservoir pressure is limited to 3,000 psi.

7.3.3 Simulated CAES Operations

The results for the CAES full field operation case were obtained to show proof of concept for the project. This is not an optimized case but it is a good demonstration of the feasibility of a proposed CAES operation in the East Islands Gas Field. A primary objective was to investigate the level of natural gas concentrations that may be encountered in the withdrawal air. This is important because even a depleted gas reservoir will contain some residual gas, the injected air will mix with residual gas in the reservoir to some extent and when air is withdrawn from the reservoir it may contain small amounts of natural gas.

The cycles for an initial six week period of the 150 MW CAES plant operation are presented by **FIGURES 57** to **59**. The cycling follows the design schedule in **FIGURE 51**. The figures show the model predictions for methane gas concentration, water production and average reservoir pressure. The amount of methane gas in the produced air on a field basis during a 10-hr withdrawal period is predicted up to a maximum of 2.3 percent.[10] This is below the LEL for methane gas in air. The model also predicts there will be no water production during the cycling sequence. Finally the predicted average reservoir pressure increases from 2,000 psi (current) to nearly 3000 psi during the bubble build and cycling operation (**FIGURE 60**).

A primary benefit of the dynamic model is the ability to predict the movement of the native natural gas (methane) in the reservoir in response to the air injection during the bubble development stages. An optimized full field design should mitigate the potential for explosive conditions in the wellbore and surface equipment due to reaching the LEL for methane in the withdrawal gas at any well. The methane concentrations during the full field bubble development stages in the model (beginning, middle and end) are shown in **FIGURES 61** through **70**.

The average methane concentration in the produced air during the withdrawal/injection cycling of air for the CAES power plant operation is shown in **FIGURE 58** for the first six week cycles. The methane concentration is below 3 percent for the field-wide average for this case although some individual wells produce up to 5 percent methane (another example of why this is not an optimized case). The maximum methane concentration in the withdrawal air for each well is shown by **FIGURE 71**.[11]

The methane concentrations in the reservoir at the end of the short cycle testing sequence for the full field case are shown in **FIGURES 72** through **75**. The cycling operation is only simulated for six weeks. Longer simulated cycling operations will likely show that the predicted change in methane concentrations over an extended period of plant operations will decrease with time; however this assumption was not investigated for this full field case.

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[10] Further modeling optimization of the bubble build period and cycling sequence is likely to lower the maximum methane concentrations.

[11] There are options to reduce the predicted maximum methane concentration in wells such as using an inside-out bubble build and cycling sequence.

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A507: East Island Cultural Resouce Survey

Cultural Resource Survey for the PG&E CAES – East Island Project, San Joaquin County, California

Prepared for

Pacific Gas and Electric Company

Prepared by

SWCA Environmental Consultants

September 2012

CULTURAL RESOURCE SURVEY
FOR THE PG&E CAES – EAST ISLAND PROJECT
SAN JOAQUIN COUNTY, CALIFORNIA

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Archaeological and other heritage resources can be damaged or destroyed through uncontrolled public disclosure of information regarding their location. This document contains sensitive information regarding the nature and location of archaeological sites which should not be disclosed to the general public or unauthorized persons.

Information regarding the location, character, or ownership of a cultural resource is exempt from the Freedom of Information Act pursuant to 16 USC 470w-3 (National Historic Preservation Act) and 16 USC Section 470(h) (Archaeological Resources Protection Act).

MANAGEMENT SUMMARY

Purpose and Scope: SWCA Environmental Consultants (SWCA) was retained by Pacific Gas and Electric (PG&E) to conduct a cultural resource study in support of the PG&E Compressed Air Energy Storage (CAES) – East Island Project (project). The study area consists of 4.43 hectares (10.95 acres) of land located approximately 9 miles (14.5 miles) southwest of the City of Lodi in San Joaquin County, California. The cultural resource study consisted of a cultural resource record and literature search, Native American consultation, cultural resource survey of the study area, and preparation of a cultural resource technical report documenting the results of the inventory and providing management recommendations.

Dates of Investigation: A search of the California Historical Resources Information System (CHRIS) was conducted by the Central California Information Center (CCIC) at California State University, Stanislaus in Turlock, California, and the results were received on August 23, 2012. Cultural resource specialists conducted an intensive-level cultural resource survey on August 28, 2012.

Findings of the Investigation: Two prior cultural resource studies have been conducted within a 1-mile radius of the area of potential effects (APE). The records and literature search did not indicate any previously recorded cultural resources within a 1-mile radius of the APE. SWCA archaeologists did not identify any other cultural resources in the APE.

Investigation Constraints: Ground visibility was generally poor throughout the study area due to obstruction by vegetative ground cover and gravel. Additionally, a portion of the study area was unable to be surveyed because it is currently used for agricultural production and was densely covered with corn crops during the cultural resource survey.

Recommendations Summary: The results of this study indicate that the study area does not contain cultural resources. Therefore, SWCA recommends no additional cultural resource work for this project at this time. However, in the event that cultural resources are discovered during construction grading, trenching, or excavation, project personnel should halt earth-moving activities in the immediate area and notify a qualified archaeologist to evaluate the resource.

Disposition of Data: This report will be on file with the following entities: the CCIC located at California State University, Stanislaus; PG&E; and SWCA. All field notes and records related to the current project are on file at SWCA’s Pasadena office. All geographical information systems data created during this study are on file at SWCA’s Pasadena office and PG&E.

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INTRODUCTION

SWCA Environmental Consultants (SWCA) was retained by Pacific Gas and Electric (PG&E) to conduct a cultural resource study in support of the PG&E Compressed Air Energy Storage (CAES) – East Island project (project). The study area consists of 4.43 hectares (10.95 acres) of land located approximately 9 miles (14.5 miles) southwest of the City of Lodi in San Joaquin County, California (Figures 1 and 2). The cultural resource study consisted of a cultural resource record and literature search, Native American consultation, cultural resource survey of the study area, and preparation of a cultural resource technical report documenting the results of the inventory and providing management recommendations.

Project Description

The project would use renewable energy from sources such as wind to inject compressed air into an underground reservoir and then use it to help power a turbine generator during peak periods when the energy is needed most. It would be implemented in three phases: site selection and feasibility analysis; licensing and permitting; and construction and operation.

The East Island reservoir site consists of the expansion of the existing Morais well pad to the north and east for a total area of 43 × 67 meters (m) (140 × 220 feet). The well pad will support a drilling rig and other equipment for the purpose of core drilling tests to determine whether the East Island reservoir is a viable candidate for the CAES project. Construction of the well pad will require importing non-native fill material (e.g., sand and gravel) to stabilize the site so that it can support a drilling rig. The access route may also require grading prior to construction. Site preparation will include importing gravel and sand and performing grading and compaction, and will occur over a 1- to 2-week period starting as early as October 2012. Core drilling is planned to start as early as November 2012 following site preparation, and will consist of mobilizing a drill rig with supporting equipment, conducting core drilling to approximately 5,000 feet below the surface.

Area of Potential Effects

An area of potential effects (APE) is defined as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties (36 Code of Federal Regulations [CFR] 800.16(d)). The proposed project is located within unincorporated San Joaquin County in an area primarily characterized by agricultural land use. The archaeological or direct APE represents portions of the study area that would be directly affected by the proposed undertaking, and includes areas where ground disturbance may result from the proposed project (Figure 3). A study area was established to include both the direct APE and a buffer, and included an approximately 60-m (200-foot) buffer around the construction footprint, or well pad site, and an 8-m (25-foot) buffer from the edges of the access route from the point at which it splits from the paved, public road (Figure 4). The vertical APE extends to approximately 1,524 m (5,000 feet) below the existing ground surface, or the depth to which core drilling will be conducted.

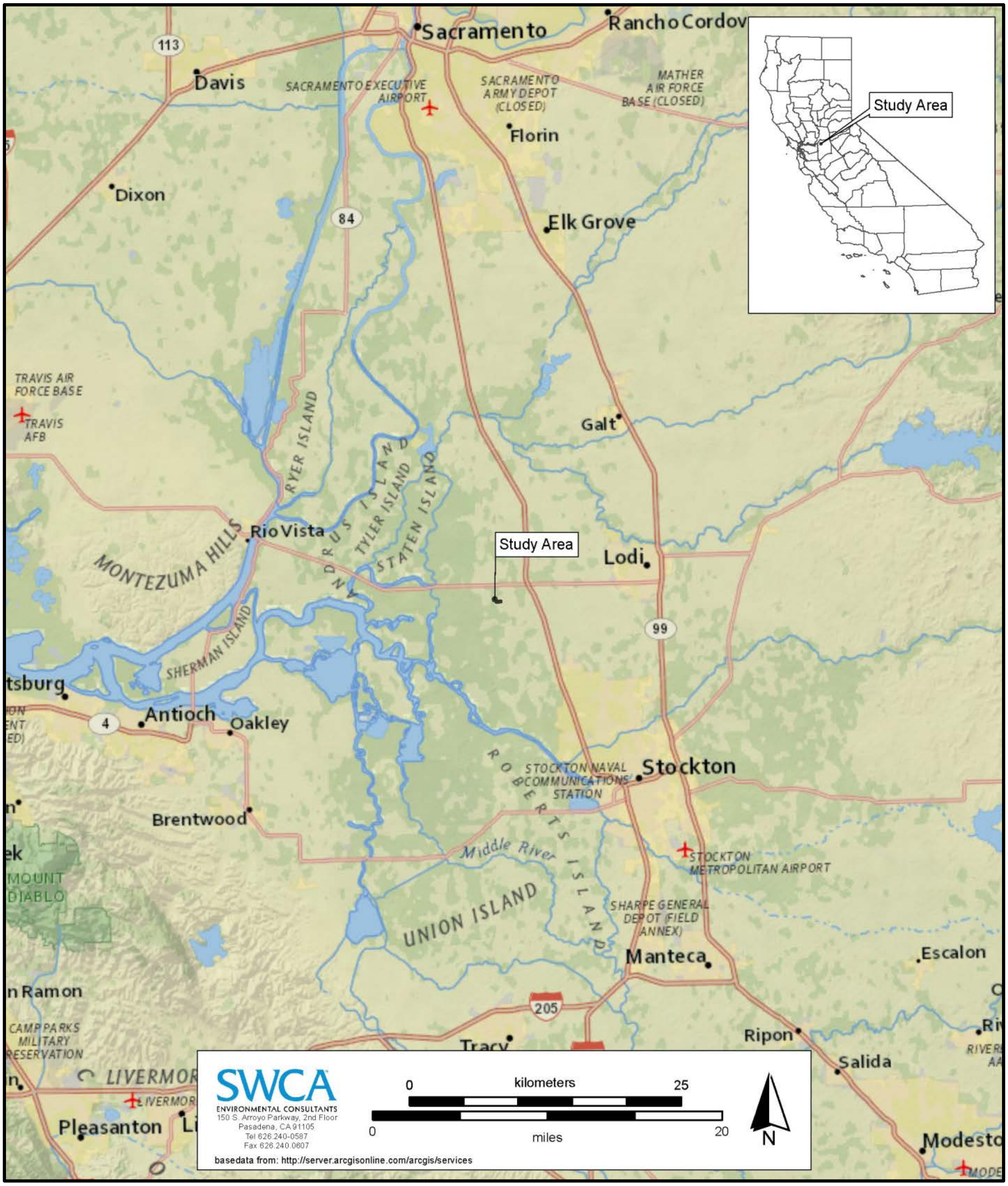

Figure 1. Location of the study area.

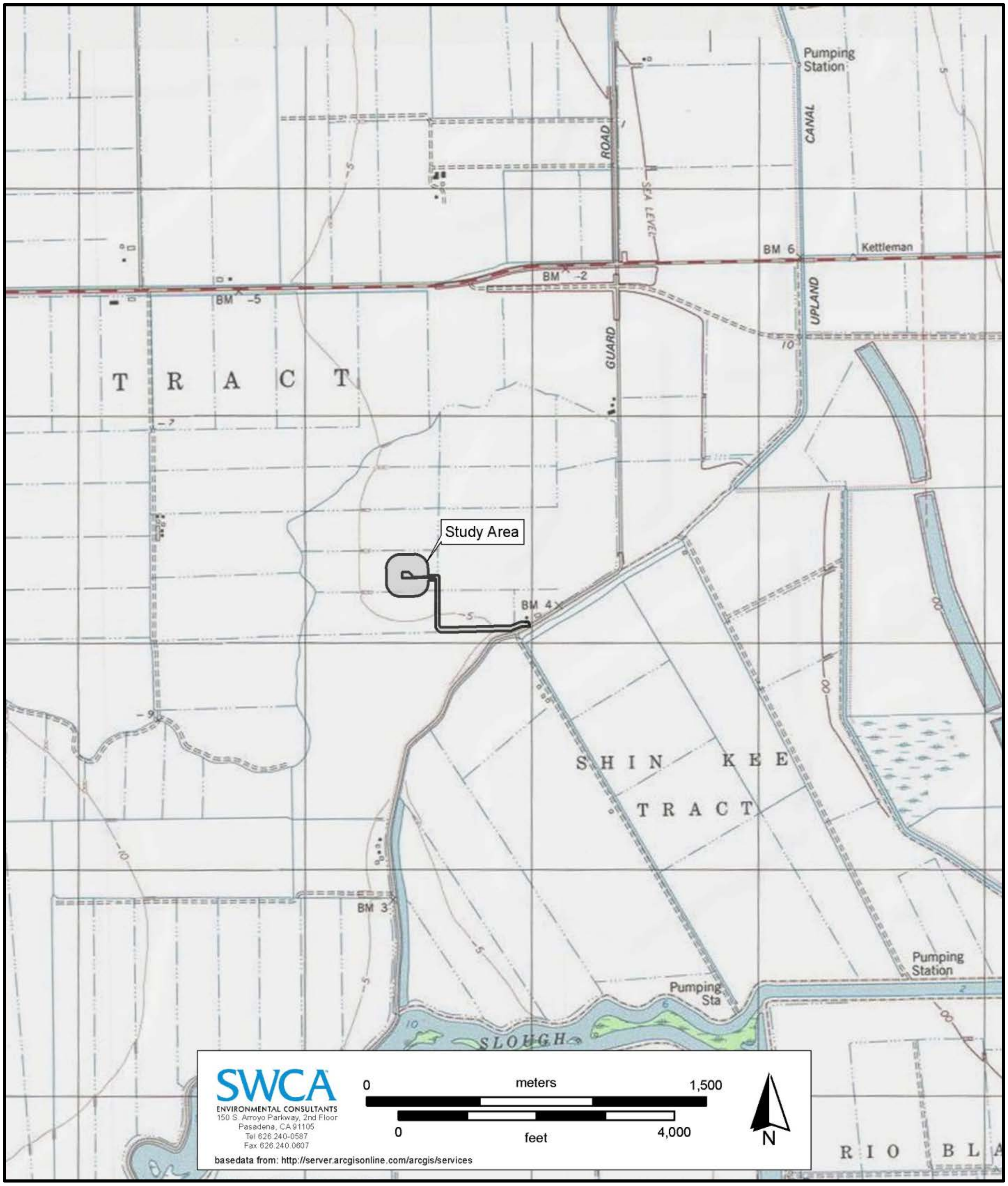

Figure 2. Detailed location of the study area.

Figure 3. Project area of potential effects

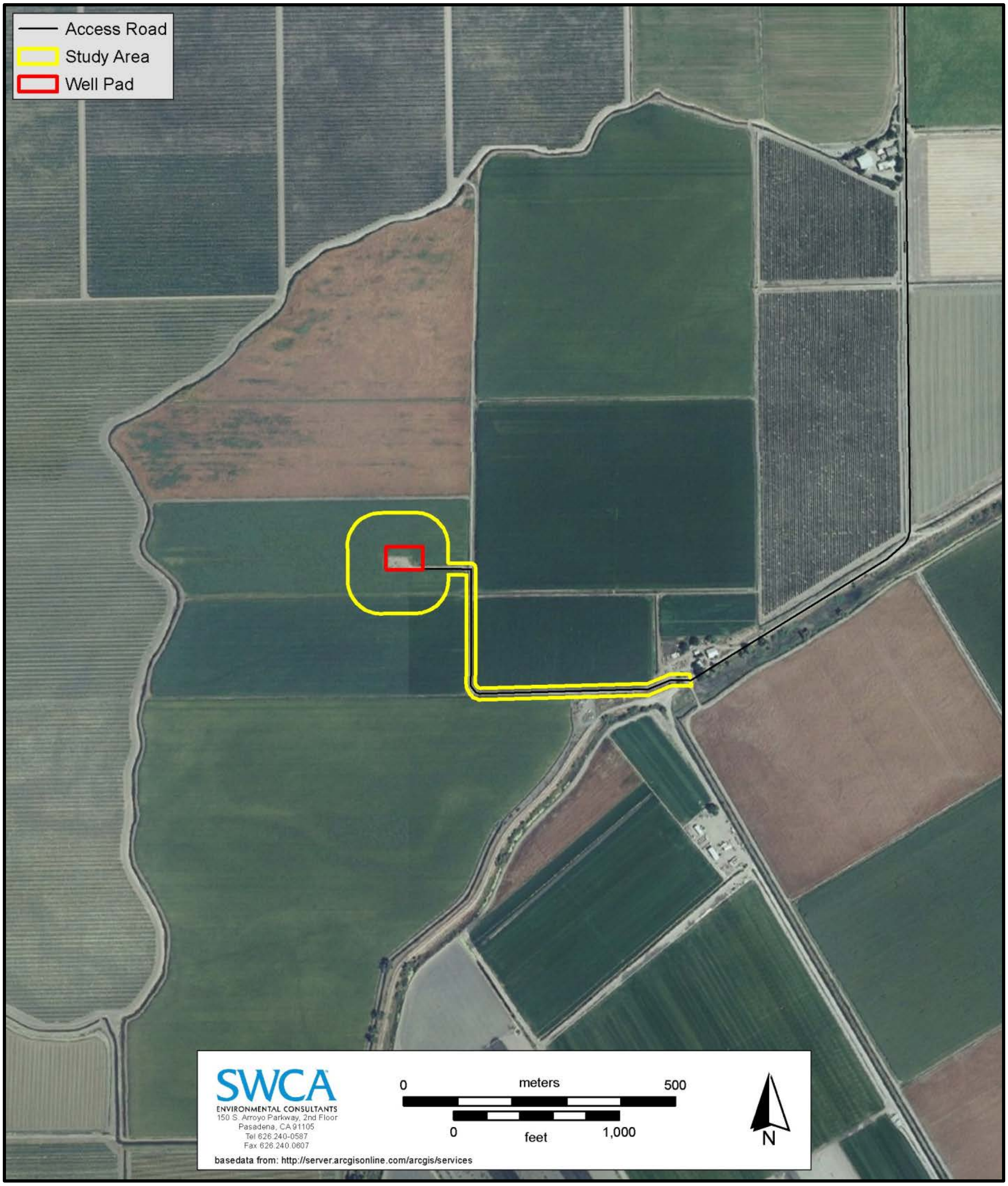

Figure 4. Study area map.

REGULATORY SETTING

This section identifies federal regulations, state legislation, and local statutes, ordinances, and guidelines that govern the identification and treatment of cultural resources and analysis of project-related effects on cultural resources. The lead agency must consider these requirements in making decisions on projects that may affect cultural resources. The current study was conducted in compliance with both federal and state laws, particularly Section 106 of the National Historic Preservation Act (NHPA) and the California Environmental Quality Act (CEQA).

Federal

National Historic Preservation Act

The current study was completed under the provisions of the NHPA of 1966, as amended (16 United States Code 470f). Cultural resources are considered during federal undertakings chiefly under Section 106 of the NHPA through one of its implementing regulations, 36 CFR 800 (Protection of Historic Properties), as well as the National Environmental Policy Act (NEPA). Properties of traditional religious and cultural importance to Native Americans are considered under Section 101(d)(6)(A) of the NHPA. Other relevant federal laws include the Archaeological Data Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1989.

Section 106 requires federal agencies to take into account the effects of their undertakings on any district, site, building, structure, or object that is included in or eligible for the National Register of Historic Places (NRHP) and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on such undertakings (36 CFR 800.1). Under Section 106, cultural resources must be identified and evaluated; effects on historic properties are reduced to acceptable levels through mitigation measures or agreements among consulting and interested parties. Historic properties are those resources that are listed in or are eligible for the NRHP in accordance with the criteria listed below (36 CFR 60.4) (ACHP 2010).

The quality of *significance* in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess *integrity* of location, design, setting, materials, workmanship, feeling and association and that

(A) are associated with events that have made a significant contribution to the broad patterns of our history;

(B) are associated with the lives of persons significant in our past;

(C) embody the distinctive characteristics of a type, period, or method of installation, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

(D) have yielded, or may be likely to yield, information important in prehistory or history.

Impacts of a project to significant cultural resources that affect the characteristics of any resource that qualify it for the NRHP are considered a significant effect on the environment. Under 36 CFR 800.5(a)(2), adverse effects on historic properties include, but are not limited to

(i) physical destruction of or damage to all or part of the property;

(ii) alteration of a property;

(iii) removal of the property from its historic location;

(iv) change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance;

(v) introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features;

(vi) neglect of a property which causes its deterioration; and

(vii) transfer, lease, or sale of property out of federal ownership or control without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance.

State

California Environmental Quality Act

CEQA requires a lead agency to determine whether a project may have a significant effect on historical resources (Section 21084.1). If it can be demonstrated that a project will cause damage to a unique archaeological resource, the lead agency may require that reasonable efforts be made to permit any or all of these resources to be preserved in place or left in an undisturbed state. To the extent that they cannot be left undisturbed, mitigation measures are required (Section 21083.2[a], [b], and [c]).

Section 21083.2(g) defines a *unique archaeological resource* as an archaeological artifact, object, or site about which it can be clearly demonstrated that without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

(1) Contains information needed to answer important scientific research questions and that there is a demonstrable public interest in that information.

(2) Has a special and particular quality such as being the oldest of its type or the best available example of its type.

(3) Is directly associated with a scientifically recognized important prehistoric or historic event or person.

A *historical resource* is a resource listed in, or determined to be eligible for, the California Register of Historical Resources (CRHR) (Section 21084.1); a resource included in a local register of historical resources (Section 15064.5[a][2]); or any object, building, structure, site, area, place, record, or manuscript that a lead agency determines to be historically significant (Section 15064.5[a][3]).

Public Resources Code (PRC) Section 5024.1, Section 15064.5 of the CEQA Guidelines, and PRC Sections 21083.2 and 21084.1 were used as the basic guidelines for this cultural resource study. PRC Section 5024.1 requires an evaluation of historical resources to determine their eligibility for listing in the CRHR. The purpose of the register is to maintain listings of the state's historical resources and to indicate which properties are to be protected from substantial adverse change. The criteria for listing resources on the CRHR were expressly developed to be in accordance with previously established criteria developed for listing in the NRHP, enumerated below.

According to PRC Section 5024.1(c)(1–4), a resource is considered historically significant if it (i) retains "substantial integrity," and (ii) meets at least one of the following criteria:

(1) Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage.

(2) Is associated with the lives of persons important in our past.

(3) Embodies the distinctive characteristics of a type, period, region, or method of installation, or represents the work of an important creative individual, or possesses high artistic values.

(4) Has yielded, or may be likely to yield, information important in prehistory or history.

Impacts to significant cultural resources that affect the characteristics of any resource that qualify it for the NRHP or adversely alter the significance of a resource listed on or eligible for the CRHR are considered a significant effect on the environment. These impacts could result from “physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of an historical resource would be materially impaired” (CEQA Guidelines, Section 15064.5 [b][1], 2000). Material impairment is defined as demolition or alteration “in an adverse manner [of] those characteristics of an historical resource that convey its historical significance and that justify its inclusion in, or eligibility for inclusion in, the California Register…” (CEQA Guidelines Section 15064.5[b][2][A]).

ENVIRONMENTAL SETTING

The study area is in the Sacramento-San Joaquin Delta region, an area in the California Central Valley lowlands that is defined by the confluence of the Sacramento, American, Mokelumne, and San Joaquin Rivers. The topography of the study area is virtually flat, with elevations ranging from approximately -1.5 to 1.5 meters (-5 to 5 feet) (Figure 5). Climate is characterized by warm, dry summers, and mild, moist winters. Summer temperatures have highs around 32 degrees Celsius (90 degrees Fahrenheit), and winter temperatures have highs around 13 degrees Celsius (55 degrees Fahrenheit).

Figure 5. Overview of study area; view to the south.

Although current land uses in the APE include agricultural croplands, the area near the APE was characterized by vegetation communities that include freshwater marshland near permanent water in low-lying areas, seasonal wetlands and vernal pools within grasslands and woodlands, riparian scrub/forest along drainages, and grasslands and oak woodlands in valley foothill areas. With this mosaic of ecological communities, and in view of the ethnographic descriptions of the Northern Valley Yokuts (Kroeber 1925; Latta 1977; Wallace 1978) who historically occupied the area, it would appear the APE and surrounding area would have provided a very productive environment for its prehistoric occupants, one well suited to a hunting-gathering economy with a variety of fish, waterbirds, small and large mammals, and edible plant species.

CULTURAL SETTING

Prehistoric Overview

California prehistory is divided into three broad temporal periods that reflect similar cultural characteristics throughout the state: Paleoindian period (ca. 9000–6000 B.C.), Archaic period (6000 B.C.–A.D. 500), and Emergent period (A.D. 500–Historic Contact) (Fredrickson 1973, 1974, 1994a).
The Archaic is divided further into Lower (6000–3000 B.C.), Middle (3000–1000 B.C.), and Upper (1000 B.C.– A.D. 500) periods, generally governed by climatic and environmental variables, such as the drying of pluvial lakes at the transition from the Paleoindian to the Lower Archaic.

The APE lies in what generally is described as the Delta subregion of the Central Valley Archaeological Region, which is one of eight arbitrary organizational divisions of the state (Moratto 1984). This archaeological subregion surrounds the Sacramento-San Joaquin Delta in the middle of the Central Valley and mainly includes portions of Contra Costa, Sacramento, San Joaquin, Solano, and Yolo Counties.

Occupation in the Sacramento-San Joaquin Delta region during the Prehistoric period is estimated to have occurred as early as 12,000 years ago, but only a few archaeological sites have been identified that predate 5,000 years ago. It is possible that Holocene alluvial deposits buried many prehistoric sites in this area, and Moratto (1984:214) estimates that as much as 10 m of sediment accumulated along the lower stretch of the Sacramento River drainage system during the last 5,000–6,000 years. CA-CCO-637 in eastern Contra Costa County, for example, is one of the few early Holocene-age sites in the region, with a record of human occupation as early as 8,500 years ago during the Lower Archaic (Meyer and Rosenthal 1998). The archaeological remains at that site were discovered approximately 2 m below the surface within an alluvial fan near Kellogg Creek.

Prehistoric material culture in central California subsequent to the Paleoindian and Lower Archaic periods has been categorized according to “horizons” or “patterns” that define broad technological, economic, social, and ideological elements over long periods of time and large areas. The taxonomic system historically used for central California is a tripartite classification scheme with Early, Middle, and Late Horizons. This Central California Taxonomic System (CCTS) was the result of efforts of a number of researchers (e.g., Beardsley 1954; Heizer 1949) and was developed further after the advent of radiocarbon dating (Fredrickson 1973, 1974; Heizer 1958; Ragir 1972).

Today, a series of generalized periods associated with regionally based “patterns” are typically used as part of the CCTS for the Sacramento Delta area, San Francisco Bay area, and North Coast ranges (Bennyhoff and Fredrickson 1969; Fredrickson 1973, 1974). Smaller units of patterns are referred to as “aspects” and “phases,” which emphasize more local features. Revisions of the widely accepted CCTS (Bennyhoff 1994; Fredrickson 1994a, 1994b) are found in a recent volume edited by Hughes (1994).

Fredrickson (1973, 1974) defined several regionally based patterns, three of which are specific to the prehistory of the APE. Referred to as the Windmiller Pattern, Berkeley Pattern, and Augustine Pattern, each represents a general pattern of resource exploitation, as identified between 2500 B.C. and the beginning of Euro-American contact in the early 1800s. The Windmiller Pattern was first identified at the Windmiller site (CA-SAC-107) near the Cosumnes River in Sacramento County; the Berkeley Pattern was initially identified at the West Berkeley site (CA-ALA-307) in Alameda County on the east side of the San Francisco Bay; and the Augustine Pattern was identified at the Augustine site (CA-SAC-127) in the Sacramento-San Joaquin Delta. These patterns are present within the following horizon sequences: Middle Archaic period/Windmiller Pattern (formerly Early Horizon), Upper Archaic period/Berkeley Pattern (formerly Middle Horizon), and Emergent period/Augustine Pattern (formerly Late Horizon).

Windmiller Pattern (2500–500 B.C.)

Clearly documented evidence for human occupation in the general area is found at sites characteristic of the Windmiller Pattern during the Middle Archaic period. These sites date to as early as 4,500 years ago and as late as 2,500 years ago (2500–500 B.C.). Such sites often contain manos and metates (grinding stones), as well as many mortar fragments, indicating that acorns and/or various seeds formed an important part of the diet (Moratto 1984:201).

In addition to plant foods, the subsistence system included many other food resources, such as deer, elk, pronghorn, rabbits, and waterfowl. Numerous faunal remains have been documented at Windmiller Pattern sites, along with large quantities of projectile points. Also, the presence of angling hooks and baked clay artifacts possibly used as net or line sinkers, along with the remains of sturgeon, salmon, and smaller fishes, indicates that fishing was an additional source of food (Fredrickson 1973; Heizer 1949; Ragir 1972). Items made of baked clay included net sinkers, pipes, and discoids, as well as cooking "stones." Ground and polished charmstones, impressions of twined basketry, shell beads, and bone tools also have been found at Windmiller Pattern sites. Some items, such as shell beads, obsidian tools, and quartz crystals, were obtained by trade.

The archaeological record during the Windmiller Pattern indicates that people practiced a mixed procurement strategy of both game and wild plants, with the addition of acorns and/or seeds. The mixed exploitation of a wide range of natural resources ties into a seasonal foraging strategy. Populations likely occupied the lower elevations of the Sacramento Valley in the winter months and shifted to higher elevations during the summer (Moratto 1984:206). Mortuary practices included burials, accompanied by grave goods, in cemeteries that were separate from the habitation sites.

Berkeley Pattern (500 B.C.–A.D. 500)

Over a 1,000-year period, the Windmiller Pattern began to shift to the more specialized adaptive Berkeley Pattern during the Upper Archaic period. A shift to a greater reliance on acorns as a dietary staple is interpreted during the Berkeley Pattern from the increase in mortars and pestles, along with a decrease in manos and metates. Mortars and pestles are better suited to crushing and grinding acorns, whereas manos and metates were used primarily for grinding wild grass grains and seeds (Moratto 1984:209–210).

As demonstrated by the artifact assemblage, hunting remained an important aspect of food procurement during the Berkeley Pattern (Fredrickson 1973:125–126). The archaeological record, which consists of numerous large shell midden/mounds, also demonstrates that occupants at most Berkeley Pattern sites near water (both fresh and salt) made intensive use of aquatic resources.

The artifact assemblage also includes shell beads and ornaments, as well as numerous types of bone tools. Interment continues to dominate mortuary practices, but a few cremations are also found at Berkeley Pattern sites.

Artifact assemblages and radiocarbon dating of sites from this period suggest this subsistence pattern may have developed in the San Francisco Bay region and later spread to surrounding coastal locales and into central California. Moratto (1984:207–211) suggests that the pattern is related to the expansion of Eastern Miwok populations from the San Francisco Bay area to the Sacramento Valley and Sierra foothills.

Augustine Pattern (A.D. 500–historic contact)

The Augustine Pattern is evidenced by a number of changes in subsistence, foraging, and land-use patterns that begin to reflect the use pattern known from Historic period Native American groups in the area. A substantial increase in the intensity of subsistence exploitation (including fishing, hunting, and gathering [particularly the acorn]) evidenced in the archaeological record correlates directly with population growth (Moratto 1984:211–214).

Tools and cooking implements include shaped mortars and pestles, hopper mortars, bone awls used for producing coiled baskets, and the bow and arrow. Pottery vessels, known as Cosumnes Brownware, are found in some parts of the Central Valley and most likely developed during this period from the prior baked clay industry.

During this period, an increase in sedentism led to the development of social stratification, accompanied by a shift to elaborate ceremonial and social organization. Exchange networks, with the use of clamshell disk beads as currency, also developed during the Augustine Pattern. Mortuary practices during this pattern included flexed burials and pre-interment burning of offerings in a grave pit, as well as cremation of high-status individuals (Fredrickson 1973:127–129; Moratto 1984:211). Additional items of material culture include flanged tubular pipes, harpoons, and small Gunther barbed series projectile points.
The Augustine Pattern may represent the southward expansion of Wintu populations (Moratto 1984: 211–214).

Ethnographic Overview

The APE is located in an area historically occupied by the Penutian-speaking Plains Miwok, a subgroup of the Eastern Miwok (Kroeber 1925; Levy 1978; Shipley 1978:84). The Plains Miwok historically occupied the lower Mokelumne River, Cosumnes River, and the Sacramento River from Rio Vista to Freeport (Levy 1978:398–399). Neighboring groups included the Nisenan to the north, Patwin and Bay Miwok to the west, Northern Valley Yokuts to the south, and the Washoe to the east.

Spanish mission records, diaries, and journals have provided the most comprehensive study of the Miwok, as well as some ethnographical studies done in the first half of the twentieth century (Bennyhoff 1977; Levy 1978:399). Much of the history of the Plains Miwok, however, is incomplete.

The villages of the Plains Miwok were divided into “tribelets,” political units that were also structured by similarities in language and ethnicity. The tribelets averaged 300–500 persons, and each held claim to a designated portion of territory within the lands of the Plains Miwok, which also extended to the natural resources within each territory (Levy 1978:410). Each tribelet’s territory contained a main village and smaller satellite villages. Within a tribelet’s main village was an assembly or dance house, either a large semi-subterranean structure or a simpler circular brush structure (Kroeber 1925:447). Other structures included semi-subterranean or aboveground conical houses made with tule-matting, conical sweathouses, winter grinding houses, and acorn granaries (Levy 1978:408–409). The Plains Miwok also practiced cremation (Kroeber 1925:452).

The rich resources of the Sacramento-San Joaquin Delta and surrounding areas provided the Plains Miwok with food and material needs. The primary food staple was the acorn, supplemented by waterfowl, fish, shellfish, and large and small mammals (Bennyhoff 1977; Levy 1978). The Miwok are best described as seasonally mobile hunter-gatherers with semi-permanent villages. The delta islands were also used regularly for hunting and fishing base camps. Permanent settlements of the Plains Miwok were located on high ridges or knolls near watercourses or on the sandy islands in the delta.

The Plains Miwok collected plant greens and roots in the spring; seeds and nuts in the spring, summer, and early fall; and acorns in the late fall/early winter (Levy 1978:402–403). Acorns, particularly from the prevalent valley oak (*Quercus lobata*) could be stored for some time in the conical-shaped granaries prior to processing. Tule elk, pronghorn antelope, and mule deer, as well as smaller mammals such as jackrabbits, cottontails, beaver, squirrels, and woodrats, were regularly hunted. Game birds included many types of waterfowl, mountain and valley quail, pigeons, jays, and woodpeckers. In addition to salmon, the Plains Miwok fished for sturgeon and lamprey (Levy 1978:402–403).

A wide array of tools, implements, and enclosures were used by the Plains Miwok for hunting and gathering of natural resources. Among those used for hunting land mammals and birds were the bow and arrow, traps and snares, nets, and enclosures/blinds. Communal hunting drives were employed for both large and small mammals. Many plants were collected using wooden tools: long poles for dislodging acorns and pinecones, fire-hardened digging sticks for roots, and beaters for dislodging seeds. Once collected, seeds, roots, and nuts were placed in burden baskets and transported for processing or storage (Levy 1978:403–404).

The Plains Miwok used a variety of tools to process food resources. These included portable stone mortars and pestles, bedrock mortars, anvils, woven strainers and winnowers, leaching and boiling baskets, woven drying trays, and knives. Unprocessed acorns were stored in conical granaries. Various foods were baked in earth ovens. Exotic items such as obsidian, steatite, and shell indicate they traded with coastal groups and mountain tribes (Levy 1978).

The Native American population in the Sacramento Valley came into contact with European culture beginning in the late 1700s, as a result of increased incursions into the area by the Spanish. Traditional lifeways were drastically altered during the early to mid-1800s as Spanish colonization and proselytization, Mexican land grants, and the American takeover and settlement pushed indigenous peoples into the rugged California interior and reduced their numbers through transport to the missions, disease, and slaughter. Beginning in the early 1800s, most of the Plains Miwok converts were transported to Mission San José (Levy 1978:400–402). Many resisted and tried to return to their villages in the delta. Plains Miwok fought the invaders in the 1820s and 1830s, and with neighboring Yokuts, they also attacked Mexican coastal settlements. The secularization of the missions followed, spurred in part by these activities. During the war with Mexico in the 1840s, the Miwoks aided the United States (Cook 1960, 1962).

The California Gold Rush of 1849 and the continuing influx of Euro-Americans into formerly remote regions of California was the final cultural blow for many California Indians, including the Miwok bands near the study area. With the loss of most of their traditional lands, as well as enslavement, slaughter, and disease, surviving Miwok labored for the growing lumber, ranching, farming, and mining industries (Levy 1978:401).

During the first half of the twentieth century, acquisitions of land by the federal government (from 2 acres to more than 300 acres) created a number of reservations, or *rancherias*, for the Plains Miwok, along with the Northern and Central Sierra Miwok. Between 1934 and 1972, the U.S. Bureau of Indian Affairs then terminated relations with most of these rancherias, although since 1984, the status has been restored to most of the rancherias (Slagle 2005). Today, although there is no unified California Miwok tribal organization at a state or federal level, there are seven rancherias that have primarily or exclusively Eastern Miwok populations. These are the Buena Vista Rancheria (Plains Miwok/Amador County), the Chicken Ranch Rancheria (Central Sierra division of Eastern Miwok/Tuolumne County), the Ione Rancheria (Northern Sierra and Plains Miwok/Amador County), the Jackson Rancheria (Northern Sierra and Plains Miwok/Amador County), the Sheep Ranch Rancheria (Northern Sierra Miwok/Calaveras County), the Shingle Springs Rancheria (Plains Miwok/El Dorado County), and the Tuolumne Rancheria (Central Sierra Miwok/Tuolumne County) (Slagle 2005).

Historic Overview

Post-contact history for the state of California is generally divided into three periods: the Spanish period (1769–1822), the Mexican period (1822–1848), and the American period (1848–present). Although there were brief visits by Spanish, Russian, and British explorers from 1529 to 1769, the beginning of Spanish settlement in California occurred in 1769 with an establishment of Mission San Diego, one of the 21 missions established from 1769 to 1823. The Mexican period began when news of the successful revolution by Mexico against the Spanish crown reached California in 1822. This period is marked by an extensive era of land grants, most of which were in the interior of the state, and by exploration by American fur trappers west of the Sierra Nevada Mountains.

With the signing of the Treaty of Guadalupe Hidalgo in 1848, ending the Mexican-American War, California became a territory of the United States. The discovery of gold in 1848 at Sutter’s Mill near Sacramento and the resulting Gold Rush era influenced the history of the state and the nation. The rush of tens of thousands of people to the gold fields also had a devastating impact on the lives of indigenous Californians, with the introduction and concentration of diseases; the loss of land and territory, including traditional hunting and gathering locales; violence; malnutrition; and starvation. Thousands of settlers and immigrants continued to pour into the state, particularly after the completion of the transcontinental railroad in 1869.

With continued growth, California continues to be a national leader in agriculture and poultry production, ranching (cattle and sheep), aerospace and communications industries, as well as the film and entertainment business. The wealth of California’s natural resources (e.g., lumber, petroleum deposits, minerals, fish) also continues to contribute to its growth and development.

San Joaquin County

San Joaquin County was one of the original 27 counties of California, created in 1850 at the time of statehood (Hoover et al. 2002:369). The county’s geographical location in the center of the state between the Sierra Nevada mountain range to the east and the San Francisco Bay to the west has made it a prime location for business and industry. The county is accessible from almost all parts of the state by means of the Port of Stockton, the interstate highway system, railroads, and airports. Captain Charles M. Weber was instrumental in developing the city of Stockton as the county seat and as a port of entry, where the two large rivers that drain the northern and southern halves of the great Central Valley meet at the Sacramento-San Joaquin Delta. Ships today still deliver cargo to the Port of Stockton via the Stockton Channel, the deep-water slough that leads into the San Joaquin River, next to which Captain Weber laid out the town of Tuleburg (now Stockton) in 1847.

Agriculture and livestock have defined San Joaquin County’s past and continue to play an important role in the present and foreseeable future. The many rivers in the area, including the San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers, form rich agricultural land as well as marshlands for abundant wildlife. In 1813, Lieutenant Gabriel Moraga led an expedition in the lower portion of California’s Central Valley, giving the name San Joaquin to the large river that flows northward through the county (Hoover et al. 2002:369). Later immigrants were attracted to the abundance of wildlife within or along the rivers, including waterfowl, fish, and fur-bearing animals. In 1827, American explorer and trapper Jedediah Smith traveled through the San Joaquin Valley. Other trappers soon followed, including employees of the Hudson’s Bay Company in 1832 (Hoover et al. 2002:370).

Irrigation is an important part of the history of the productive agricultural and livestock economy of the county. The Miller and Lux Company, a cattle company known across the west, had vast holdings in the San Joaquin Valley. Founded by German immigrant Henry Miller (formerly Heinrich Alfred Kaiser) and partner Charles Lux, their lands and herds could be found throughout the state of California. They built an empire by acquiring rancho property and driving cattle to market in San Francisco (Hoover et al. 2002:435). The Miller and Lux Company also pioneered irrigation projects in the San Joaquin Valley, beginning with completion of the San Joaquin Canal in the 1870s. This ambitious project began on the San Joaquin River near Fresno Slough, and then ran north through Merced County and into Stanislaus County. The company also controlled more than 50 miles of land along Kern River, which they were able to parlay into a system of canals to irrigate dry lands that then became productive agricultural fields (Beck and Haase 1974:76; Hoover et al. 2002:94).

As large landowners reclaimed San Joaquin County through irrigation in the late nineteenth century, they began to lease San Joaquin Delta farmland to energetic farmers, many of them Asian immigrants. These new opportunities were so great that by 1901 there were nearly two thousand Chinese immigrants in San Joaquin County, half of which were farmers or farm laborers (Stuart 2012). One of the first to arrive was Chin Lung, who in 1901 planted a crop of potatoes on an eleven-hundred acre piece of land just west of Stockton. Over the next twenty years, Chin Lung farmed approximately one thousand acres per season, and was the principal employer of Chinese laborers in San Joaquin County (Stuart 2012). Chin became the first Chinese immigrant to purchase farmland in San Joaquin County in 1910, expanding his holdings two years later with the purchase of the Shin Kee Tract, which he named after a store he owned in San Francisco (Stuart 2012). Chin owned the tract until the early 1920s, when he would lose his property due to the Alien Land Acts of 1920 and 1923.

The history of San Joaquin County would not be complete without mention of the Tidewater Southern Railway. Begun as an electric interurban railway, the line opened its initial 32 miles of mainline between Stockton and Modesto in October 1912 (Tidewater Southern Railway 2007). The railway connected on the north to the Central California Traction Company Railroad, which served the Central Valley from Stockton to Sacramento. The Tidewater Southern was a successful venture, with 24 trains operating daily between Stockton and Modesto by 1916. The same year, it extended the rails to Turlock and to Hilmar. The last tracks of the Tidewater Southern were added in 1918, a 6.6-mile-long north-south branch between Manteca and Manteca Junction. The previous year, most of the rolling stock had been purchased by the Western Pacific Railroad. The number of passengers declined with the onset of the Depression, and the last interurban ran in 1932. This decline was offset, however, by an increase in freight transport, particularly agricultural products. Diesel power entirely replaced the electrified type by the late 1940s, and the line was upgraded in the 1950s and 1960s. Today, the original Tidewater Southern line between Stockton and Turlock is served as part of the Union Pacific Railroad; the Western Pacific merged into the Union Pacific in 1982.

BACKGROUND RESEARCH

California Historical Resources Information System Records Search

On August 22, 2012, a search was requested of the California Historical Resources Information System (CHRIS) at the Central California Information Center (CCIC), located at California State University, Stanislaus in Turlock, California. The search included any previously recorded cultural resources and investigations within a 1.6-kilometer (1-mile) radius of the APE. The CHRIS search also included a review of the NRHP, the CRHR, the California Points of Historical Interest list, the California Historical Landmarks list, the Archaeological Determinations of Eligibility list, and the California State Historic Resources Inventory list. Additionally, the records search included a review of historic maps covering the APE. A letter dated August 23, 2012, from the CCIC summarizing the results of the records search and providing a bibliography of prior cultural resources studies is provided in Appendix A of this report.

Prior Cultural Resource Studies within 1 Mile of the APE

The records searches identified two prior cultural resource studies within 1 mile of the APE (Table 1). Of this, none were located in the APE.

Table 1. Prior Cultural Resource Studies within 1 Mile of the APE

CCIC Report No.	Title of Study	Author	Year	Proximity to the APE
SJ-03804	Department of Transportation Negative Archaeological Survey Report, 10-SJP-12 P.M. 0.1/10.1, E.A. 10-0A8400.	Laylander, Don.	1999	Outside
SJ-06354	A Cultural and Paleontological Resources Study for the Shin Kee Tract Wetland Restoration Project	Konzak, Michael and Andy Grass	2007	Outside

Previously Recorded Cultural Resources within 1 Mile of the APE

The records search failed to identify any previously recorded cultural resources within 1 mile of the APE.

Historic Map Review

In addition to reviewing previously conducted studies and previously recorded site records, SWCA examined the study area on historic maps provided by the CCIC. An early General Land Office map from 1868 shows the current APE as largely undeveloped and describes the land as “swamp and overflowed.” By 1883, there is still no evidence of development; however, the landowner is listed as R.C. Sargent. In a map from 1939, the area appears to have been divided into agricultural tracts, and by 1952, buildings (some of which appear to be presently extant) are in place adjacent to the current APE on present-day Guard Road.

Sacred Lands File Search and Initial Native American Coordination

Native American coordination was initiated for this project on August 24, 2012. As part of the process of identifying cultural resources in or near the APE, the Native American Heritage Commission (NAHC) was contacted to request a review of the Sacred Lands File. The NAHC faxed a response on September 5, 2012 (Appendix B), and stated that Native American cultural resources were not identified within 0.5 mile of the APE, but noted that it is always possible for cultural resources to be unearthed during construction activities. The NAHC also provided a contact list of nine Native American individuals or tribal organizations that may have knowledge of cultural resources in or near the APE. Letters were prepared and mailed to each of the NAHC-listed contacts on September 6, 2012, requesting information regarding any Native American cultural resources in or immediately adjacent to the APE.

SWCA has received no responses regarding the coordination letters to date. One follow-up telephone call will be made to each Native American contact on September 20, 2012. The results of these efforts will be forwarded to the PG&E at this time. A complete record of Native American coordination to date is provided in Table 2.

Table 2. Record of Native American Coordination Efforts

NAHC-Provided Contact	Coordination Efforts	Results of Coordination Efforts
Ohlone/Costanoan P.O. Box 717 Linden, California 95236 Contact: Katherine Erolina Perez	**9/6/12:** Letter sent via U.S. Mail	To be determined
Miwok 4305 39th Avenue Sacramento, California 95824 Contact: Randy Yonemura	**9/6/12:** Letter sent via U.S. Mail	To be determined
Miwok P.O. Box 84 Wilseyville, California 95987 Contact: Briana Creekmore	**9/6/12:** Letter sent via U.S. Mail	To be determined
Buena Vista Rancheria 1418 20th Street, Suite 200 Sacramento, California 95811 Contact: Rhonda Morningstar Pope, Chairperson	**9/6/12:** Letter sent via U.S. Mail	To be determined
California Valley Miwok Tribe 10601 North Escondido Place Stockton, California 95212 Contact: Silvia Burley, Chairperson	**9/6/12:** Letter sent via U.S. Mail	To be determined
Ione Band of Miwok Indians P.O. Box 699 Plymouth, California 95669 Contact: Yvonne Miller, Chairperson	**9/6/12:** Letter sent via U.S. Mail	To be determined

Table 2. Record of Native American Coordination Efforts

NAHC-Provided Contact	Coordination Efforts	Results of Coordination Efforts
Ione Band of Miwok Indians Cultural Committee 604 Pringle Avenue #42 Galt, California 95632 Contact: Billie Blue, Chairperson	**9/6/12:** Letter sent via U.S. Mail	To be determined
Wilton Rancheria 9300 West Stockton, Suite 200 Elk Grove, California 95758 Contact: Andrew Franklin, Chairperson	**9/6/12:** Letter sent via U.S. Mail	To be determined
Wilton Rancheria 9300 West Stockton, Suite 200 Elk Grove, California 95758 Contact: Steven Hutchason, Director of Cultural Preservation	**9/6/12:** Letter sent via U.S. Mail	To be determined

METHODS

SWCA Cultural Resources Specialists Katie Martin and William Kendig conducted an intensive-level pedestrian survey to identify any archaeological or historic built environment resources (i.e., buildings, structures, and objects) that may occur in the study area. Ms. Martin and Mr. Kendig surveyed the entire study area by walking linear transects spaced no more than 15 m (49 feet) apart. The ground surface was examined for the presence of prehistoric artifacts (e.g., flaked stone tools, tool-making debris, stone milling tools), historic artifacts (e.g., metal, glass, ceramics), sediment discoloration that might indicate the presence of a cultural midden, and depressions and other features indicative of the former presence of structures or buildings (e.g., post holes, foundations). A Trimble global positioning system receiver with sub-meter accuracy was used to maintain transect accuracy and to record the location of cultural resources in the study area. This fieldwork did not include subsurface testing.

Ms. Martin and Mr. Kendig documented their fieldwork using a field notebook, digital camera, close-scale field maps, and aerial photographs. Copies of the field notes and digital photographs are on file at the SWCA Pasadena office.

RESULTS

SWCA cultural resource specialists did not identify any archaeological or built environment resources in the study area as a result of the intensive-level survey. Ground visibility was poor (approximately 0% in some areas) due to heavy vegetation and agricultural production. A portion of the study area, approximately 3 hectares (7.5 acres), could not be surveyed due to dense corn crops surrounding the well pad (Figure 6). Corn stalks were approximately 1.5 m (5 feet) high, and no access paths into the field were present (Figure 7). Additionally, portions of the study area have been heavily disturbed due to ground-disturbing activities associated with the construction of the access road and extant well pad, including equipment and fencing (Figure 8).

Figure 6. Survey coverage map.

Figure 7. Portion of the well pad and access road; view to the east.

Figure 8. Overview of well pad; view to the west.

DISCUSSION AND RECOMMENDATIONS

Discussion

The goal of this study is to identify cultural resources in the PG&E CAES – East Island study area and provide management recommendations for those resources. The results of the literature and records search indicated that two surveys within 1 mile of the study area were completed in 1999 and 2007. No previously recorded cultural resources were identified as a result of the literature and records search. The NAHC Sacred Lands File search was also negative for cultural resources within 0.5 mile of the study area. Finally, SWCA cultural resource specialists failed to identify cultural resources during the intensive-level survey.

Recommendations

Although a portion of the APE was unable to be surveyed due to dense corn crops, and other portions were subject to poor ground visibility, the study area is significantly disturbed due to ongoing agricultural activities, which are likely to have exposed any substantial archaeological resources. Additionally, only previously disturbed soil within the APE is expected to be impacted during ground-disturbing activities. Therefore, there is a low potential for encountering undisturbed archaeological materials in the APE during project implementation. No additional cultural resource mitigation measures should be necessary beyond standard measures to minimize impacts to the unanticipated discovery of buried cultural resources or the unanticipated discovery of human remains. These standard measures are described below.

However, ground disturbance associated with the proposed project does have some potential to impact previously unrecorded cultural resources. SWCA recommends that the following measures be taken to identify additional cultural resources in the study area, to prevent or reduce the significance of project-related impacts to cultural resources and to satisfy the requirements of Section 106 and CEQA.

Inadvertent Discovery of Cultural Resources

In the event that cultural resources are exposed during ground-disturbing activities, construction activities (e.g., grading, grubbing, or vegetation clearing) should be halted immediate near the discovery.
An archaeologist who meets the Secretary of the Interior’s Professional Qualifications Standards (National Park Service 1983) should then be retained to evaluate the find’s significance under CEQA.
If the discovery proves to be significant, additional work, such as data recovery excavation, may be warranted and should be discussed in consultation with the lead agency.

Inadvertent Discovery of Human Remains

The discovery of human remains is always a possibility during ground disturbances; State of California Health and Safety Code Section 7050.5 addresses these findings. This code section states that no further disturbance shall occur until the County Coroner has made a determination of origin and disposition pursuant to PRC Section 5097.98. The Coroner must be notified of the find immediately. If the human remains are determined to be prehistoric, the coroner will notify the NAHC, which will determine and notify a most likely descendant (MLD). The MLD shall complete the inspection of the site within 48 hours of notification and may recommend scientific removal and nondestructive analysis of human remains and items associated with Native American burials.

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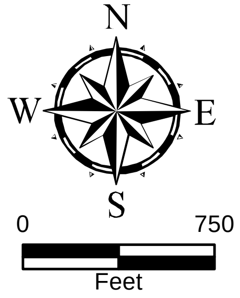
A508: East Island Map

SOURCE:
California Department of Conservation
Division of Oil, Gas and Geothermal Resources.
F.B. Cressy Jr. *East Islands*
Gas Field Gross Pay Isochore.
All locations approximate.

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

LEGEND

×	Surface Location	▬	Gross Pay Isochore
○	District 6 Wells	▭	Drill PAd
◎	ApproximateTop Core Target Location		



PG&E
CAES PROJECT

WorleyParsons
resources & energy

EAST ISLANDS GAS FIELD
APPROXIMATE TARGET LOCATION

SWL	MT	3/14/2013
108010-00365		3C

A509: East Island BCA

North State Resources, Inc.

Date:	October 12, 2012	**PG&E Order #:**	8105484
To:	Land and Environmental Management—Catalina Reyes, Biologist		
From:	North State Resources, Inc.— John W. Hunt, Biologist		
Project:	PG&E Compressed Air Energy Storage Sites–Proposed Investigative Geologic Core Sampling at the East Island Morais Well.		
Subject:	Final Biological Constraints Analysis of the East Island Morais Well, San Joaquin County, California		

Introduction and Summary

Mr. John W. Hunt, NSR Biologist, conducted a biological constraints analysis for the proposed Geologic Core Sampling Phase of Pacific Gas and Electric Company (PG&E) Compressed Air Energy Storage Project (project) at the proposed East Island Morais natural gas well pad expansion area and associated access roads (project area). The area surveyed consist of all areas within 20 feet of proposed access roads and all areas within 250 feet of the existing well pad and the proposed well pad expansion area (Figure 1, Appendix A). The objective of the project is to expand and utilize the existing footprint of the Morais natural gas well site to stage geological core sampling equipment. The geological core sampling will be used to determine the suitability of the project vicinity for compressed air storage within depleted subterranean natural gas reservoirs.

A field reconnaissance was conducted on August 20, 2012 with Ms. Catalina Reyes, PG&E Biologist. The project area includes all the proposed access road, existing well pad and staging area, and well pad expansion areas identified by PG&E technical staff during the field review on August 20, 2012 (Figure 2, Appendix A).

Giant garter snake, listed as threatened under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA); Swainson's hawk, listed as threatened under CESA; loggerhead shrike, designated as California species of special concern (SC); and white-tailed kite, a state fully protected (FP) species, have the potential to be adversely affected or impacted by the project This document provides Avoidance and Minimization Measures (AMMs) that will avoid effects on these species.

The vegetated irrigation ditches within the project area appear to meet wetland criteria and may qualify as waters of the United States. All other portions of the existing access road, the existing well pad, and the well pad expansion area do not appear to meet wetland criteria and are not considered to qualify as potential waters of the United States. All determinations concerning waters of the United States should be considered preliminary and tentative unless verified in writing by the U.S. Army Corps of Engineers.

The proposed project will receive federal funding from the U.S. Department of Energy (USDOE). As such, the USDOE is required under section 7 of the federal Endangered Species Act to determine whether the proposed project may affect federally listed and proposed species or proposed or designated critical habitat. If the USDOE determines that the project may affect federally listed species or critical habitat, consultation with the U.S. Fish and Wildlife Service and/or National Marine Fisheries Services is required.

Project Description

The objective of the project is to collect approximate 10-inch diameter geological core samples from the subsurface natural gas formation at depth approximately 4,000-5,000 feet. Cores will be used determine the suitability of the subsurface formation for compressed air storage. Compressed air storage involves utilizing appropriate geological formations (e.g., depleted natural gas reservoirs) to store surplus energy in the form of compressed air during periods of low electric demand. This stored energy can then be utilized during periods of higher electric demand, improving the efficiency of energy distribution through the power grid.

The project area is located approximately 6 miles northwest of the city of Stockton in northwestern San Joaquin County, California. It is situated south of State Highway 12 approximately 1.3 miles west of Interstate 5 at approximately 38.103683°, -121.433416° (Figure 2, Appendix A). Site access is from the northwest along Guard Road, which is a public road. A smaller, unnamed dirt road provides access to the Morais Well from Guard Road.

Given that existing access roads are available, road construction necessary for project will be limited to widening of approximately 150 feet of access immediately east of the existing well pad. Improvements to this section of road include widening the access road approximately 4 feet to the north (14-foot final width) along approximately 150 feet of road (approximately 0.01 acre). A turning radius will be constructed on the east side of the existing road east of the culvert to provide a sufficient turning radius. Expansion of the road and turning radius will involve clearing existing crops grading, compacting the subgrade, placing aggregate base, and compacting the final road grade. At the junction of the Morais well pad access with the primary unnamed dirt access road, steel plates will be laid over timbers placed to span the primary irrigation ditch, extending the effective access 10 feet south of the culvert. Placement of the steel plates will facilitate site access while avoiding direct impacts or modifications on the existing primary irrigation ditch. Additional improvements to the existing access roads from the culvert to 350 feet south will be limited to light graveling of the unnamed dirt road if determined necessary (e.g., work to occur during the wet season) with the assumption no additional grading will be required. No road improvement will occur east of the 90 degree corner towards Guard Road. If grading is required, it will be limited to the existing road and will not extend beyond the compacted surface. All vehicle traffic will be on the existing access roads and all staging will be contained within the existing well pad. Water trucks will be used as necessary to reduce dust during site access and other construction activities. Approximately 28 truck trips will be required to import well pad material to the site. An additional five truck trips will be required to remove drill-core samples and associated material from the site. If well pad expansion area is restored to pre-project conditions, an additional 28 truck trips will be required to remove temporary well pad expansion materials, which will total 61 truck trips. Best Management Practices (BMPs) and AMMs will be implemented to avoid impacts on potential waters of the United States.

The existing Morais well pad will be expanded north and east of the existing well pad to total approximately 0.8-acre area (220 x 160 feet), which increases the size by approximately 0.5 acre. Cropland within the selected area will be cleared in order to accommodate the well pad expansion. After clearing the vegetation, approximately 1 foot of crushed rock will be placed within the cleared area and compacted with a roller. If necessary, woven geotextile fabric will be placed as an underlayment for the overlying gravel fill.

After the well pad expansion area has been established (i.e., cleared of vegetation, rocked, and compacted), well drilling equipment will be moved onto the expansion area. The primary equipment includes the drill rig, mud and water tanks and pumps, shaker tanks, electric generators, diesel fuel tanks, and drill pipe racks. Geologic sampling will consist of drilling a 10 inch diameter well to a depth of approximately 4,000-5,000 feet and extracting a geological core sample not greater than 4 inches in diameter. All sections of the core sample will be removed offsite for analysis and storage. All peripheral material (e.g., cuttings and drilling mud) removed during the coring process will be immediately placed in proper storage receptacles and removed offsite for disposal at an authorized facility. The drilling crew, plus engineers, temporary workers and site visitors, will consist of an average of approximately 12 workers per shift, with three shifts per day. A maximum of 20 workers may be present during various operations. In addition to worker vehicles, service and delivery vehicles will access the site during the drilling phase including equipment trucks for all aspects of the effort. All drilling activities will be completed in compliance with the County Gas and Oil Well Improvement Plan approval.

Once the core samples are obtained and the remaining hole is plugged and abandoned per California Division of Oil Gas and Geothermal Resources (DOGGR) and Environmental Protection Agency (EPA) standards, the drilling equipment will be dismantled and demobilized from the site. Construction equipment similar to that used during well pad development will be used to remove the pad materials and return the site to near pre-project conditions. This includes spreading of any surface vegetation or roots stockpiled during site preparation. All removed material will be disposed of at suitable landfills or recycled consistent with county grading or other permit requirements. However, the property owner may elect to retain the pad for farm equipment staging and storage.

Well pad construction and improvements to access roads will occur over a two-week period commencing as early as October 2012. Drilling activities will occur virtually continuously for up to approximately six weeks. If elected to remove the well pad, restoration of the site will take up to two weeks.

Habitat and Affected Environment

The project area is situated in a landscape that currently supports active agricultural operations, an existing natural gas well site, and access roads. The project area is located within the “Delta Islands”. The Delta Islands are areas of former marshlands of the Sacramento–San Joaquin Delta that were historically reclaimed for agricultural use by the construction of levees/dikes and draining to enable farming.

Habitats within the areas surveyed (Figure 3 and Figure 4, Appendix A) include flood irrigated row crops, irrigation ditches, and ruderal herbaceous vegetation along the unnamed dirt access road to the Morais Well. Irrigated pastures, row crops, irrigation ditches, scattered ornamental trees, and fresh emergent wetland border segments of Guard Road (paved) leading to the unnamed dirt access road.

Fields around the well pad are planted in corn (*Zea mays*). Corn and safflower (*Carthamus tinctorius*) were planted in fields along the access roads. Some of the cornfields adjacent to the access roads in the project area were being flood irrigated during the August 20, 2012 field reconnaissance. All agricultural fields within the project area are disked and cropped on an annual rotation. All fields are actively farmed and regularly disked, harvested and/or disturbed to the edge of the existing access road. Ruderal vegetation along the perimeter of the well pad includes rip-gut brome (*Bromus diandrus*), Bermuda grass (*Cynodon dactylon*), black mustard (*Brassica nigra*), and knotweed (*Polygonum arenastrum*).

Irrigation ditches are maintained for irrigation purposes and are often mechanically and chemically cleared of vegetation. When vegetated, plants dominating these features include watergrass (*Echinochloa crus-galli*) in wetter areas to ruderal upland vegetation dominated by Bermuda grass and Johnson grass (*Sorghum halepense*). These features are only flooded during irrigation cycles, which are typically every two weeks.

The fresh emergent wetland occurring southeast of Guard Road is densely vegetated by bulrush (*Schoenoplectus acutus*). Fremont's cottonwood (*Populus fremontii*) and dense ruderal herbaceous understory dominated by poison hemlock (*Conium maculatum*) border the perimeter of the wetland.

Methods

The determination of the potential for the project area to support habitat for special-status species, waters of the United States, and other sensitive biological resources was established through desktop review and a field reconnaissance. The desktop review was completed using a series of database searches and a review of pertinent resources (Attachment 1). Special-status species[1] listed in the U.S. Fish and Wildlife (USFWS) species list for San Joaquin County and species reported in the CNDDB to occur within a 5-mile radius of the project area were considered in the evaluation (e.g., listed shrimp, valley elderberry longhorn beetle, giant garter snake) (Appendix B). Additionally, special-status species not included in the USFWS species list or CNDDB records were considered due to their known geographic range and/or the presence of potential habitat (e.g., white-tailed kite, loggerhead shrike, ringtail). Special-status species shown in the USFWS and CNDDB queries (Appendix B) that are not included in Table 1 lack habitat within the project area or the project area is not within the range of the species. These species are not analyzed further in this document.

Following completion of the field reconnaissance, an assessment of local, state, and federal permitting requirements was conducted to determine if the proposed project requires permits or authorizations from the local government or state and federal regulatory agencies. No local or state, permits addressing biological resources are anticipated to be required. Depending on final configuration of the proposed well pad expansions and access, authorization from the United States Army Corps of Engineers (Corps) may be required for discharge of fill into waters of the United States.

Special-Status Species and Potential Impacts

The fresh emergent wetland and irrigation ditches within the project area contains potentially suitable habitat for eleven special-status plant species including: watershield (*Brasenia schreberi*), bristly sedge (*Carex comosa*), woolly rose-mallow (*Hibiscus lasiocarpus* var. *occidentalis*), Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), Mason's lilaeopsis (*Lilaeopsis masonii*), Delta mudwort (*Limosella subulata*), eel-grass pondweed (*Potamogeton zosteriformis*), Sanford's arrowhead (*Sagittaria sanfordii*), marsh skullcap (*Scutellaria galericulata*), side-flowering skullcap (*Scutellaria lateriflora*), and Suisun marsh aster (*Symphyotrichum lentum*). The proposed project will not result in disturbance to the fresh emergent wetland and irrigation ditches. Therefore, the proposed project will not result in impacts on special-status plant species.

Special-status animal species that were determined to have the potential to occur in or near the project area, and that could be adversely affected by the proposed project, include giant garter snake (*Thamnophis gigas*), Swainson's hawk (*Buteo swainsoni*), white-tailed kite (*Elanus leucurus*), and loggerhead shrike (*Lanius ludovicianus*) (Table 1).

The fresh emergent wetland, irrigation ditches, and associated uplands within and near the project area provide potentially suitable habitat for giant garter snake (GGS). The CNDDB reports GGS occurrences from marsh habitat within Coldani Marsh approximately 0.4 mile east of the project. If GGS are present within the project area during the inactive season (i.e., October 1 to May 1), when work is anticipated to

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[1] Special-status species: Listed, candidate, or proposed for listing as threatened or endangered under the Endangered Species Act, or California Endangered Species Act, California Native Plant Protection Act, California Species of Special Concern, and California Fully Protected Species. Special-status plants include California rare plant rank (RPR) 1A, 1B and 2.

occur, adverse impacts (e.g., injury or death) on GGS could result from vehicular traffic or ground disturbance associated with project activities.

The fresh emergent wetland along Guard Road provides high quality habitat for GGS (Figure 3); however, Guard Road is paved and no road improvements (i.e. addition of gravel or grading) that could have potential negative effects on inactive GGS are required to access the well pad. In addition, during the inactive period from October 1 to May 1(when work is scheduled), the likelihood of encountering GGS on the road is low since GGS are likely in burrows and are not as active on the surface; thus, no effects on GGS are expected to result from additional travel on Guard Road. However, if construction occurs during the GGS active period, the likelihood of encountering a snake along or within Guard Road greatly increases.

Irrigation ditches adjacent to the project area could provide dispersal habitat for juvenile GGS and the uplands in the project area may provide wintering habitat. However, these ditches are only flooded during irrigation cycles, which are typically every two weeks and water delivery is anticipated to end prior to the fall or winter harvest. These ditches are also maintained (e.g., vegetation removal and recontouring) to sufficiently deliver water to crops, which reduces the amount of emergent vegetation required for GGS escape cover and foraging habitat (Miller, Hornaday et al. 1999). These ditches do not support a prey base (e.g., amphibians or fish), which further reduces the likelihood GGS would occur in these ditches along dirt access roads and around the well pad area.

Burrows and other underground refuge are important to GGS during summer and winter to escape unfavorable winter cold temperatures or excessive summer heat. The GGS recovery plan states that wintering habitat can be up to 250 meters (820 feet) from the edge of marsh habitat (Miller, Hornaday et al. 1999). A fresh emergent wetland approximately 1,800 feet southeast of the Morais Well provides both aquatic and upland habitat for GGS. A series of irrigation ditches connects this fresh emergent wetland to the proposed well pad expansion area thus, irrigation ditches could provide dispersal habitat for juvenile GGS and the uplands in the project area may provide wintering habitat. Typically, the USFWS defines upland habitat as all areas occurring within 200 feet of aquatic habitat (White 1997). Following this guideline, the highest potential of adverse impacts on GGS is most likely to occur from project activities along the access roads since they are located within 200 feet of aquatic habitat and provide potential habitat for winter burrows. If burrows are located under the access roads that require improvement, burrows can collapse and snakes can become entombed.

Despite the presence of vegetated irrigation ditches that may support dispersal of GGS, these provide marginal to poor habitat. Based on landscape habitat use analysis of studies conducted by Wylie et al (Wylie, Graham et al. 1995; Wylie, Casazza et al. 1997; Wylie, Casazza et al. 2002; Wylie, Casazza et al. 2002) provided in the Solano Multispecies Habitat Conservation Plan (Solano HCP), low quality ditch habitat associated with rice fields provided an artificial marsh habitat that provides the essential components (e.g., appropriate cover, high food availability, and upland refuge) to support GGS. Alternatively, studies conducted in high quality marsh habitat surrounded by fallow fields did not locate GGS or found them at very low densities. Based on these results, areas supporting marginal to poor habitat or small, isolated patches of good habitat are presumed to not support GGS due to lack of surrounding aquatic habitat (Solano County Water Agency 2009). Within the project area, the surrounding aquatic habitat is of marginal to poor quality and thus, it is unlikely that GGS would use these for dispersal.

The upland habitat that the project area provides (i.e., upland habitat along access routes and within well pad expansion area) is also poor to marginal habitat for GGS. As part of existing agricultural activities, potential upland habitat for GGS within and immediately around proposed project area are extensively disked, tilled and planted with row crops to the edge of the existing well pad and likely precludes occupation of burrowing mammals that would provide refugia for GGS Additionally, no burrows or other refugia were observed around the existing well pad, in the pad expansion area, or along the Morais well access road proposed for expansion, and no ground squirrel activity was observed during the field reconnaissance in these area. Based on the distance from high quality aquatic habitat (greater than 200 feet), poor quality dispersal habitat provided by the irrigation ditches (e.g., lack of perennial water, periodic clearing of vegetation), documented lack of use in non-rice agricultural lands, the lack of burrows or other refugia, and the lack of ground squirrel activity near the well pad expansion area, the irrigation ditches and the associated farmed upland provide low quality habitat and the likelihood for GGS to occur within the pad expansion area and portions of the access roads to be graded is very low. However, because of the proximity of a known population 0.4 miles east of the project and the availability of moderate to high quality marsh aquatic habitat 1,800 feet southeast of the proposed well pad expansion area, AMMS are provided to avoid potential impacts on GGS.

To minimize potential adverse effects on GGS during road improvement activities and well pad construction, a survey for burrows shall be conducted 24 hours prior to any modifications to access roads or well pad construction (i.e., grading compacting, or addition of gravels). If burrows are observed during the inactive period, they shall be flagged and grading or addition of gravel along the shoulder shall avoid all burrows. To minimize impacts during the active or inactive period, all vehicles will travel in the road center along all dirt or paved access roads at a speed limit of 10 mph or less.

Due to the aquatic habitat along Guard Road (Figure 3) and poor visibility while driving, if construction activities, occurs during the active period, a biological monitor will drive in front of heavy construction vehicles (i.e. dump trucks, drill rigs, etc.) on all dirt roads during entry/exit of project site. The biologist will lead vehicles at a maximum speed of 10 mph, watch for signs of snakes, and stop and investigate the road if there are any concerns. The preferred access road will be likely used; however, if the alternate route along King Island Road is used, all AMMs developed for dirt roads will be implemented.

Potential nesting habitat (e.g., trees, power poles/towers) for Swainson’s hawk occurs within the project area and within 0.5 mile of the project area. Noise generated by expanding the pad, exploration drilling, site restoration, and other construction activities could adversely affect this species if active nests are located within 0.5 mile. Project implementation is expected to commence as early as October 2012 and extend for a total of four to six weeks, which is outside of the nesting season for these species. If project implementation is confined to this period, the proposed project will not result in adverse effects on this species. However, if work will occur during the nesting season (i.e., March 1–July 31), protocol-level surveys for Swainson’s hawk will be required. If active nests are detected present within 0.5 mile of project activities, construction activity will stop immediately and will not resume until the PG&E Biologist or Land Planner contacts the USFWS and California Department of Fish and Game (CDFG) Biologist to discuss possible AMMs, which could include avoidance buffers, reconsidering access routes, and additional surveys.

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name **Scientific Name**	**Listing Status**[1] **(Fed/State)**	**Habitat Requirements**	**Potential for Significant Impact**	**Avoidance and Minimization Measures**
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	T/—	Elderberry shrubs associated with riparian forests which occur along rivers and streams.	None. No elderberry shrubs were observed within the project area.	None required
Delta smelt *Hypomesus transpacificus* **Critical habitat**	T/T	Estuarine systems in the Sacramento-San Joaquin Delta.	None. Irrigation ditches are intermittently flooded, often dry, and do not provide habitat for this species. The nearest CNDDB record is 3.1 miles west of the project area. Additionally, connectivity between the fresh emergent wetland along Guard Road and sloughs is fragmented through multiple levees joined by culverts, which reduces the likelihood for this species to occur. Traffic is common on Guard Road and access to the site will not require any modifications to Guard Road or its shoulders adjacent to the fresh emergent wetland, thus access to the project area would not affect this species.	None required
Sacramento splittail *Pogonichthys macrolepidotus*	—/SC	Shallow, dead-end sloughs with submerged vegetation.	None. Irrigation ditches are intermittently flooded, often dry, and do not provide habitat for this species. The nearest CNDDB record is 7.3 miles northwest of the project area. Additionally, connectivity between the fresh emergent wetland and sloughs is fragmented through multiple levees joined by culverts, which reduces the likelihood for this species to occur. Traffic is common on Guard Road and access to the site will not require any modifications to Guard Road or its shoulders adjacent to the fresh emergent wetland, thus access to the project area would not affect this species.	None required

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name **Scientific Name**	**Listing Status[1] (Fed/State)**	**Habitat Requirements**	**Potential for Significant Impact**	**Avoidance and Minimization Measures**
Longfin smelt *Spirinchus thaleichthys*	—/SC	Sloughs of Suisun Bay and Delta.	None. Irrigation ditches are intermittently flooded, often dry, and do not provide habitat for this species. Additionally, connectivity between the fresh emergent wetland and sloughs is fragmented through multiple levees joined by culverts, which reduces the likelihood for this species to occur. Traffic is common on Guard Road and access to the site will not require any modifications to Guard Road or its shoulders adjacent to the fresh emergent wetland, thus access to the project area would not affect this species.	None required
California red-legged frog *Rana draytonii*	T/SC	Require aquatic habitat for breeding, also uses a variety of other habitat types including riparian and upland areas. Adults prefer dense, shrubby or emergent vegetation associated with deep-water pools with fringes of cattails and dense stands of overhanging vegetation. This species also breeds in ephemeral ponds that support little or no vegetation.	None . This species is outside the current known range (CWHR) and there are no occurrences within 5 miles of the project area. Additionally, the San Joaquin County Multispecies Habitat Conservation and Open Space Plan (SJMHCP) concludes that CRLF is extirpated from the valley floor (San Joaquin County 2000). This species is not expected to occur in the project area.	None required.

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name Scientific Name	Listing Status[1] (Fed/State)	Habitat Requirements	Potential for Significant Impact	Avoidance and Minimization Measures
Giant garter snake *Thamnophis gigas*	T/T	Freshwater marshes and low gradient streams with emergent vegetation. Adapted to drainage canals and irrigation ditches with mud substrate.	Very Low. An extant population of giant garter snake (GGS) occurs within the Coldani Marsh area approximately 0.4 mile to the east of the project area. The fresh emergent wetland approximately 1,800 feet southeast of the Morais Well provides both aquatic and upland habitat for GGS.GGS may occur in the irrigation ditches adjacent to the Morais well pad, however, these features appeared to be heavily managed (e.g., regularly clearing of vegetation and recontouring) and it is expected that potential GGS occupancy would not be sustainable and likely limited to dispersal. Burrows are absent from the upland habitat further reducing potential for occupancy.	Pre construction surveys Biological monitor Water quality BMPs
Western pond turtle *Emys marmorata*	—/SC	Slow water aquatic habitat with available basking sites. Hatchlings require shallow water with dense submergent or short emergent vegetation. Requires an upland oviposition site near the aquatic site.	None. The fresh emergent wetland along Guard Road may provide aquatic habitat for this species. Traffic is common on Guard Road and access to the site will not require any modifications to Guard Road or its shoulders adjacent to the fresh emergent wetland, thus access to the project area would not affect this species.	None required.
California black rail *Laterallus jamaicensis coturniculus*	—/T, FP	Coastal and inland marsh habitat.	None. The fresh emergent wetland adjacent to Guard Road provides breeding and foraging habitat for this species. Traffic is common on Guard Road and access to the site will not require any modifications to Guard Road or its shoulders adjacent to the fresh emergent wetland, thus access to the project area would not affect this species.	None required

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name Scientific Name	Listing Status[1] (Fed/State)	Habitat Requirements	Potential for Significant Impact	Avoidance and Minimization Measures
Swainson's hawk *Buteo swainsoni*	—/T	Breeds in stands with few trees in juniper-sage flats, riparian areas, and oak savannah; forages in adjacent livestock pasture, grassland or grain fields.	Moderate. Larger trees and stands of trees occurring within 0.5 mile of the project area provide potential nesting habitat for Swainson's hawk. There are fourteen recorded CNDDB occurrences of nesting Swainson's hawk within 5 miles of the project area with the nearest occurring 2 miles northeast. Noise generated by project activities could disrupt nesting behavior and nest success if Swainson's hawks are nesting within 0.5 mile of the project area.	If work is expected to occur during nesting season (March 1 to July 31), Swainson's hawk nesting surveys will be performed following CDFG protocol developed by the Swainson's Hawk Technical Advisory Committee.
White-tailed kite *Elanus leucurus*	—/FP	Nests in tall shrubs and trees, forages in grasslands, agricultural fields and marshes.	Moderate. Isolated trees and shrubs near proposed access roads and existing farm facilities provide potential nesting habitat for this species. The nearest CNDDB record is 2.7 miles southeast of the project area.	Nesting bird surveys required within the breeding season (February 15-August 31).
Loggerhead shrike *Lanius ludovicianus*	—/SC	Nests in tall shrubs and dense trees, forages in grasslands, marshes, and ruderal habitats.	Low. Isolated trees and shrubs near proposed access roads and existing farm facilities provide potential nesting habitat for this species.	Nesting bird surveys required within the breeding season (February 15-August 31).

[1] Status Codes: : Federal and State Codes: T = Threatened; SC = Species of Special Concern (State), FP = Fully Protected (State)

Cornfields border all sides of the proposed well pad and provide potential foraging habitat for Swainson's hawks. These fields were actively growing during the August 20, 2012 field visit and are anticipated to be harvested in late fall/early winter. CDFG Swainson's hawk guidelines (California Department of Fish and Game 1994) were considered in assessing impacts on the loss of foraging habitat for Swainson's hawk and although fallow cornfields are listed as potential foraging habitat, the fields around the well pad are largely inaccessible during the breeding season and would lie fallow after most Swainson's hawks have migrated south. These fields provide limited foraging opportunities and the conversion of approximately 0.5 acre of corn would have no significant affects on Swainson's hawk foraging habitat.

Nesting habitat for loggerhead shrike and white-tailed kite occur in the trees and shrubs adjacent to Guard Road within the project area. As with the Swainson's hawk, construction activities could have adverse impacts on nesting success for these species depending on the timing of the work. Disturbance to vegetation and removal of existing crops for well pad expansion should be conducted outside of the nesting season (i.e., between August 31-February 15) in order to avoid potential effects on nesting birds. If work is to occur during the nesting season for these species (February 15–August 31), nesting bird surveys will occur 72 hours prior to the start of construction to determine if birds are nesting in the area. If nesting birds are found PG&E will halt work and consult with CDFG and USFWS to establish AMM's to protect nest (i.e. establish buffers).

Waters of the United States and Potential Impacts

An assessment for potential waters of the United States was conducted during the August 20, 2012 field reconnaissance. Two irrigation ditches were observed at the East Island Morais Well pad site. A primary vegetated irrigation ditch (primary ditch) flows from south to north, paralleling the west side of the existing ranch road (Figure 4, Appendix A). This ditch flows through a culvert under the junction of the ranch road with the Morais Well access road. A second vegetated irrigation ditch (secondary ditch) flows from east to west from the primary ditch. This ditch parallels the southern boundary of the Morais Well pad access road before turning north and terminating in the northwest corner of the existing well pad.

The primary irrigation ditch was recently recontoured and largely cleared of vegetation, however, watergrass (a hydrophytic plant) was observed re-colonizing the ditch and was the dominant species bordering this feature. The secondary irrigation ditch supported a prevalence of hydrophytic vegetation (monotypic stand of watergrass); however, this feature appeared to have been regularly flood irrigated at intervals and was in the process of being irrigated at the time of the field reconnaissance. Irrigation ditches adjacent to the access road within the project area were also observed to support a prevalence of hydrophytic vegetation; many of these features contained flowing or ponded water and are a primary conveyance for irrigation or tail water within and near the project area. The ditches within the project area are part of an extensive irrigation system that drains into or are adjacent (separated by a berm) to White Slough, which qualifies as waters of the United States. Water is generally pumped in or out of White Slough depending on need to irrigate farmland or to pump out water to keep the area from flooding. Given that the irrigation ditches support hydrophytic vegetation, are subject to extended inundation and/or saturation, and are tributary to waters of the United States, the features are considered as potential waters of the United States. A discharge of fill is not anticipated at this time and no potential waters of the United States would be directly impacted. If a discharge of fill is required (e.g., to replace a culvert), authorization to discharge fill into a waters of the United States from the Corps may be required. AMMs have been incorporated into the proposed project to avoid the potential for indirect impacts on waters of the United States.

Although the USFWS National Wetlands Inventory identifies the entire project area as farmed wetlands, the existing access roads, the existing well pad, and the proposed well pad expansion areas (excluding the irrigation ditches) do not appear to currently meet wetland criteria. The existing access roads and the existing well pad consist of compacted surfaces that are graded and unvegetated; and do not exhibit evidence of long-duration ponding or saturation, or exhibit other indications of wetland hydrology. The proposed well pad expansion areas currently support a leveled and routinely disked agricultural field that is planted with corn. Field inspection of this area did not identify the presence of hydrophytic vegetation or evidence of soil inundation/saturation unrelated to routine irrigation. Based on observation of the water level in an unnamed irrigation canal approximately 0.4 miles north of the existing well pad, the surface of the agricultural field appeared to be at least 3 feet above the water table at the time of the field inspection. Given the lack of hydrophytic vegetation and an absence of indications of a current wetland hydrology, the existing access roads, the existing well pad, and the proposed well pad expansion areas above the existing irrigation ditches are not considered to qualify as potential waters of the United States.

It is important to note that the field assessment did not involve a formal delineation using the Corps methodology and no detailed investigations for wetland hydrology were conducted. The entire project area was historically Sacramento–San Joaquin Delta marshland prior to dikes/draining and conversion to agricultural production. Areas of agricultural production that were formerly wetlands may still qualify as jurisdictional wetlands if hydrological characteristics remain to the extent that hydrophytic vegetation would return if the agricultural activities ceased. The determinations provided in this document concerning wetland hydrology are based on a single visual assessment conducted on August 20, 2012. Definitive documentation of the status of wetland hydrology generally cannot be provided by a single visual assessment during the dry season. Therefore, all determinations provided in this document concerning waters of the United States should be considered preliminary and tentative unless verified in writing by the Corps.

Other Sensitive Biological Resources

Migratory birds and raptors (i.e., birds of prey) protected under the federal Migratory Bird Treaty Act and the California Department of Fish and Game Code may nest on open ground, vegetation, or structures within the project area. Construction activities could have adverse impacts on nesting success for birds nesting near the construction site. If disturbance to vegetation and removal of existing crops for well pad expansion is conducted outside of the nesting season, then no impacts to nesting birds are expected to result from well pad expansion activities. If work is to occur during the nesting season for these species (February 15–August 31), nesting bird surveys will be occur 72 hours prior to the start of construction required to determine if birds are nesting in the area.If nesting birds are found PG&E will halt work and consult with CDFG and USFWS to establish AMM’s to protect nest (i.e. establish buffers).

Avoidance and Minimization Measures (22 total):

1. Prior to working on-site, all workers shall be provided with Environmental Awareness Training by a qualified biologist approved by USFWS and CDFG. The training shall address the identification and general ecology of GGS Swainson’s hawk, nesting birds and other special-status species that have potential to occur in the project area, and the AMMS to be implemented in order to avoid impacts on these resources. Areas to be avoided shall also be addressed in the training. Please contact project biologist, Catalina Reyes (925-808-8811) two weeks prior to construction to schedule the training.

2. Prior to construction, all work areas (e.g., vehicle access, parking, staging) needed to complete the project shall be identified in coordination with the on-site biologist. Due to the presence of sensitive resources, some work areas may need to be adjusted. All work areas shall be limited to the minimum area necessary to complete work.

3. If practicable, ground disturbing activity (e.g. vegetation removal, compaction, and placement of gravel fill) at all the well pad site shall be conducted during the active season for giant garter snake (GGS) (i.e., between May 1 and October 1). If ground-disturbing activity cannot be conducted during the GGS active season, preconstruction surveys for potential GGS wintering sites (i.e., burrows and soils crevices) shall be conducted within two weeks by a qualified biologist approved by USFWS and CDFG to determine the if potential GGS habitat is present within proposed areas of ground disturbing activity (e.g., the well pad expansion site, road work, application of gravel) and again within 24 hours prior to ground disturbing activity).

4. All burrows or potential refuge habitat shall be flagged and avoided. If work is suspended for a period of five days or greater, then the project area must be resurveyed. If it is determined that potential GGS wintering habitat (e.g., burrows and crevices) is present within areas planned for ground disturbance, ground-disturbing activities shall be postponed until the GGS active season (i.e., between May 1 and October 1). If GGS is encountered at any time during the project, work will stop immediately and the USFWS and CDFG will be contacted before work proceeds.

5. A biological monitor shall be on site during all phases of construction to direct access and construction work around irrigation ditches and other sensitive habitats capable of supporting GGS. If any GGS are observed within the project area during work activities, work shall cease and the on-site project manager shall immediately contact the project biologist, Catalina Reyes (925-808-8811) prior to resuming work. The biological monitor has the authority to stop construction to resolve any biological concerns.

6. Access to well pads shall be confined to existing roads, road shoulders, and other compacted areas. Travel along roads shall be restricted to the centerline. If placement of gravel on access roads is necessary, the placement shall be limited to the existing road surface. No gravels shall be placed ditch banks or other areas that may support burrows that could be used by GGS. No grading shall occur along segments of existing roads that may support burrows that could be used by GGS.

7. The fresh emergent marsh and irrigation ditches will be designated as environmentally sensitive areas and physical disturbance to these features will be avoided during construction.

8. If deemed necessary, an exclusionary fence shall be erected to protect potentially sensitive habitat adjacent to the existing well pad. To ensure that GGS does not become trapped or entangled, no wattles with plastic monofilament netting are permitted. Burlap or coconut wattles are appropriate substitutes.

9. A qualified biologist approved by USFWS and CDFG shall perform a general pre-construction survey within 72 hours of the start of project construction.

10. Provide escape ramps at a 45 degree angle or less for any excavations that are greater than one foot that are left open overnight. For smaller holes, cover <u>so that no gaps occur</u> and inspect each morning for wildlife. Inspect prior to filling any trenches or holes. If special-status wildlife becomes entrapped, work shall stop and the PG&E project biologist, Catalina Reyes, shall be notified immediately to determine next steps.

11. All construction personnel shall visually check for snakes and other wildlife under vehicles and equipment prior to moving them.

12. Construction equipment will be maintained to prevent leaks of fuels, lubricants or other pollutants into aquatic habitats.

13. Whenever possible, refueling and maintenance of vehicles shall occur offsite. In cases when this is not possible, refueling and maintenance of vehicles and equipment will be conducted over drip pans and at least 100 feet from any waterway.

14. Open ends of pipes, conduits or other materials stored onsite will be covered to exclude wildlife and will be inspected prior to use.

15. Vehicular speed within the project area shall be limited to 10 miles per hour in order avoid impacts on wildlife that may be located on or near roadways. If construction activities, including addition of gravel, occurs during the active period, a biological monitor will drive in front of heavy construction vehicles (i.e. dump trucks, drill rigs, etc.) on all dirt roads during entry/exit of project site. Biologist will lead vehicles at a minimum speed of 10 mph, watch for signs of snakes, and stop and investigate the road if there are any concerns.

16. Watering of roads during dry season work shall be performed as necessary (approximately 3–4 times a day) in order to reduce potential dust resulting from project associated traffic.

17. All potential nesting substrate (e.g., shrubs and trees) that requires removal to construct the project should be removed before the onset of the nesting season (i.e., prior to February 15), if feasible. This will help preclude nesting and substantially decrease the likelihood of direct impacts on nesting birds. If this is not feasible then a nesting bird survey of potential nesting substrate will be performed 72 hours prior to its removal.

18. Surveys for nesting raptors and migratory birds (including Swainson's hawk) shall be required if project construction is to occur during the nesting season (February 15–August 31; March 1-July 31 for Swainson's hawk). Surveys shall be conducted by a qualified biologist approved by USFWS and CDFG .

    Surveys for Swainson's hawk shall follow the California Department of Fish and Game protocol developed by the Swainson's Hawk Technical Advisory Committee (Appendix C).

    Surveys for other nesting birds will consist of performing an initial survey after February 15, 2013 or within a month of the start of project date if project is to begin later in the nesting bird season. A second nesting bird survey shall be performed within 72 hours of the start of construction. The surveys shall be repeated if work is suspended for five days or more. Please contact project biologist, Catalina Reyes (925-808-8811) 2 weeks prior to construction schedule surveys.

19. Caution shall be used when handling and/or storing chemicals (fuel, hydraulic fluid, etc.). As part of standard PG&E Best Management Practices (BMPs) crews shall have appropriate materials shall be on site to provide secondary containment and prevent and manage spills. If groundwater is encountered, contact PG&E Environmental Specialist Bryon Nicholson (415-990-0139).

20. Crews shall implement all standard PG&E BMPs outlined in the Good Housekeeping Activity Specific Erosion and Sediment Control Plan (January 2011) as needed.

21. If the scope of work or project location changes, contact project biologist Catalina Reyes (925-808-8811) prior to commencing work. The project biologist or Land Planner (Ernie Ralston, 515-973-3215) will contact the USFWS Bay-Delta Fish & Wildlife Office ESA/Regulatory Division and the Dept. of Fish & Game-Bay Delta Region upon notice of any such changes.

22. Remove construction related trash from the site daily and upon work completion and return site to near pre-construction contours and conditions upon project completion.

Attachment 1. Desktop Review Results

Source	Results
County	San Joaquin
USGS Quadrangle	Terminous, California (Unsectioned Area of the Empire Tract)
Aerial Photographs – Google Earth 2012 & Bing Aerial Imagery 2012	Primarily row crops, ditches and potential emergent or other wetlands present.
Land Ownership California Protected Areas Database (CPAD)	None. Private Ownership.
USFWS official list	Attached.
Federally Designated Critical Habitat (within 5-mile radius)	Within Delta Smelt Critical Habitat and approximately 1-mile north of steelhead critical habitat.
CNDDB-5-mile radius	Attached.
CNDDB owl viewer	Not within range of Spotted Owl.
CNPS-9 quad search	Attached.
PG&E Raptor Concentration Zones (RCZ)	Within RCZ.
National Audubon Society Important Bird Areas (IBA)	Within Sacramento-San Joaquin IBA.
U.S. Department of Agriculture (USDA) Web Soil Survey	Project area entirely within guard clay loam, poorly drained.
USFWS National Wetlands Inventory	Entire project area included within farmed wetlands (Pf) in USFWS NWI with scatter fringes of freshwater emergent marsh (PEM) near access roads.
PG&E San Joaquin HCP or other HCPs, NCCPs	Within PG&E San Joaquin HCP.
Known Swainson's Hawk, golden or bald eagle nest sites	CNDDB Swainson's hawk nesting record within 5 miles of project area. Nearest CNDDB occurrence is 2 miles northeast of the project area. No golden or bald eagle occurrences within 5 miles.
PG&E VELB Conservation Program Range	Within PG&E VELB Conservation Program Range.
CWHR (California Wildlife Habitat Relations) species.	CWHR was reviewed to identify other species that habitat is present and within range (e.g., white-tailed kite, ringtail).

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Photograph 1. View west from paved Guard Road onto unnamed dirt access road.

Photograph 2. Fresh emergent wetland adjacent to Guard Road.

Photograph 4. View south at the junction of the unnamed dirt access road and entrance to the East Island Morais well pad showing the primary irrigation ditch running south-north along the west side of the unnamed dirt access road .

Photograph 5. Primary irrigation ditch running south-north along the west side of the unnamed dirt access road at the intersection to the access road for Morais Well.

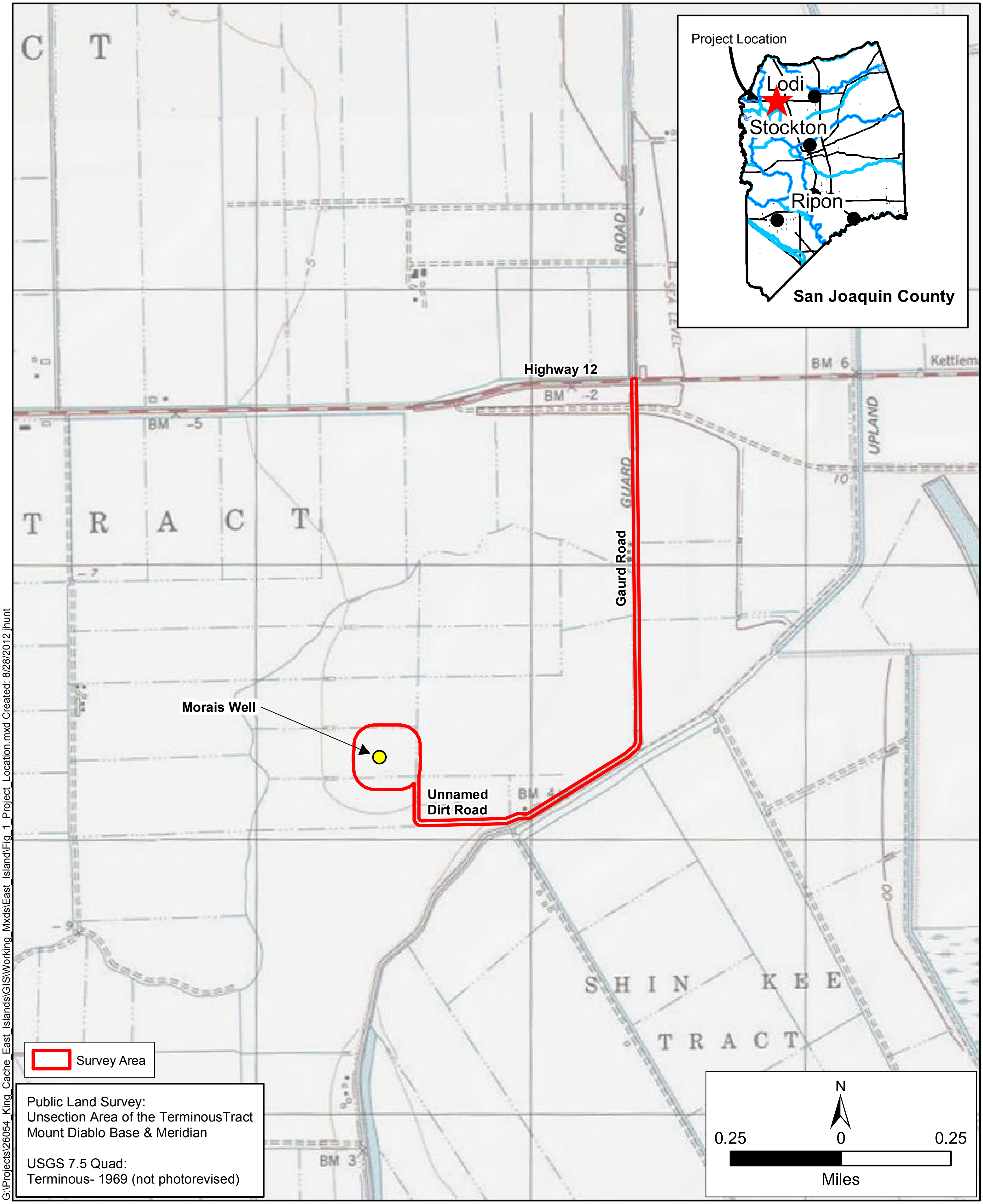
Photograph 6. Secondary irrigation ditch running east-west along the south side of the access road leading to the East Island Morais Well pad.

Photograph 7. The existing well pad consists of packed dirt and gravels.

Photograph 9. View northwest toward proposed expansion area from existing East Island Morais well pad. Existing fields were previously disked and farmed to the north edge of the existing well pad and well pad access road with no intervening vegetation.

APPENDIX A

Figures



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East Island, San Joaquin County, California

North State Resources, Inc.

Figure 1. Project Location and Vicinity Map

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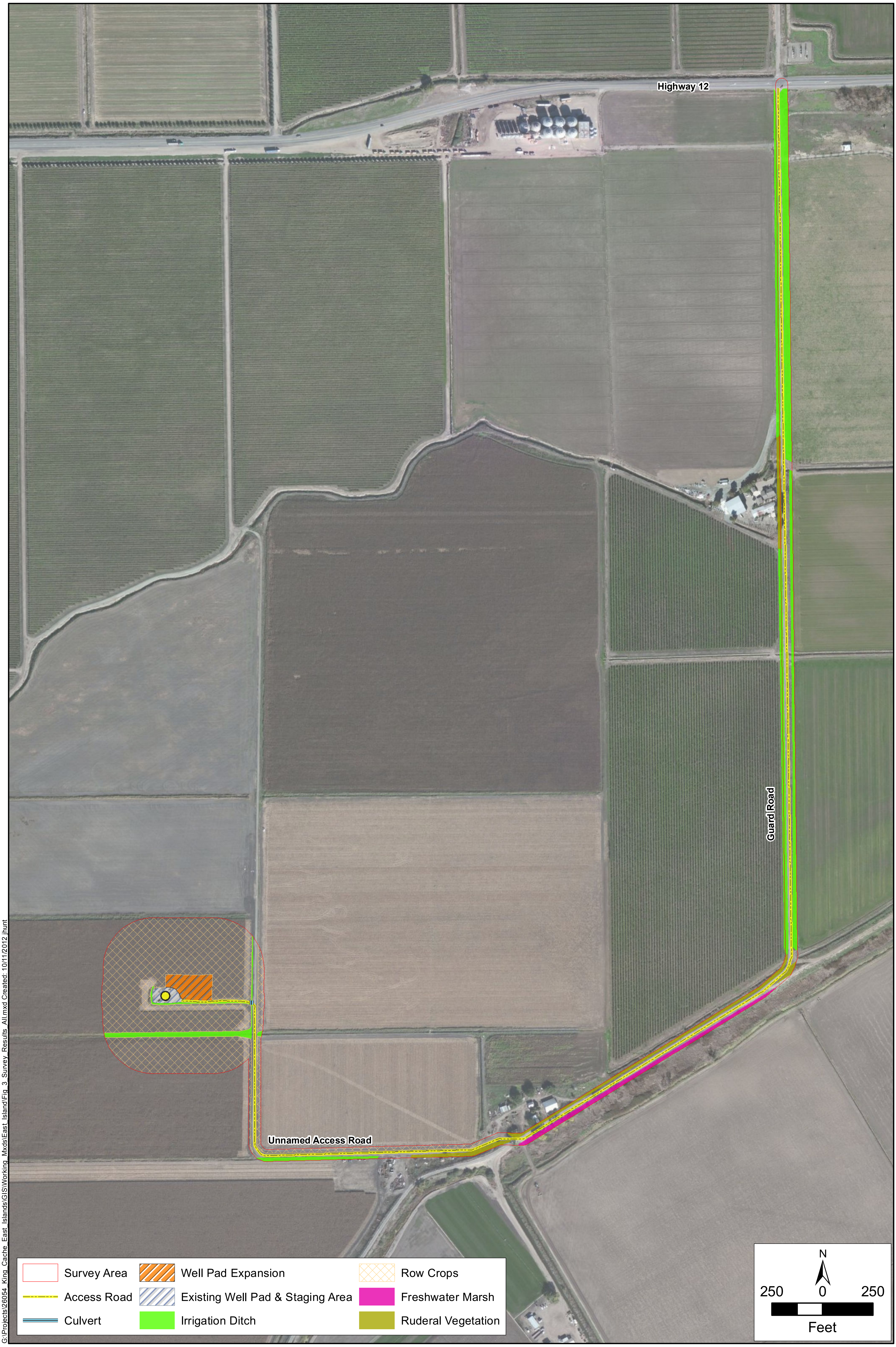
North State Resources, Inc.

East Island, San Joaquin County, California

Figure 2. Project Area



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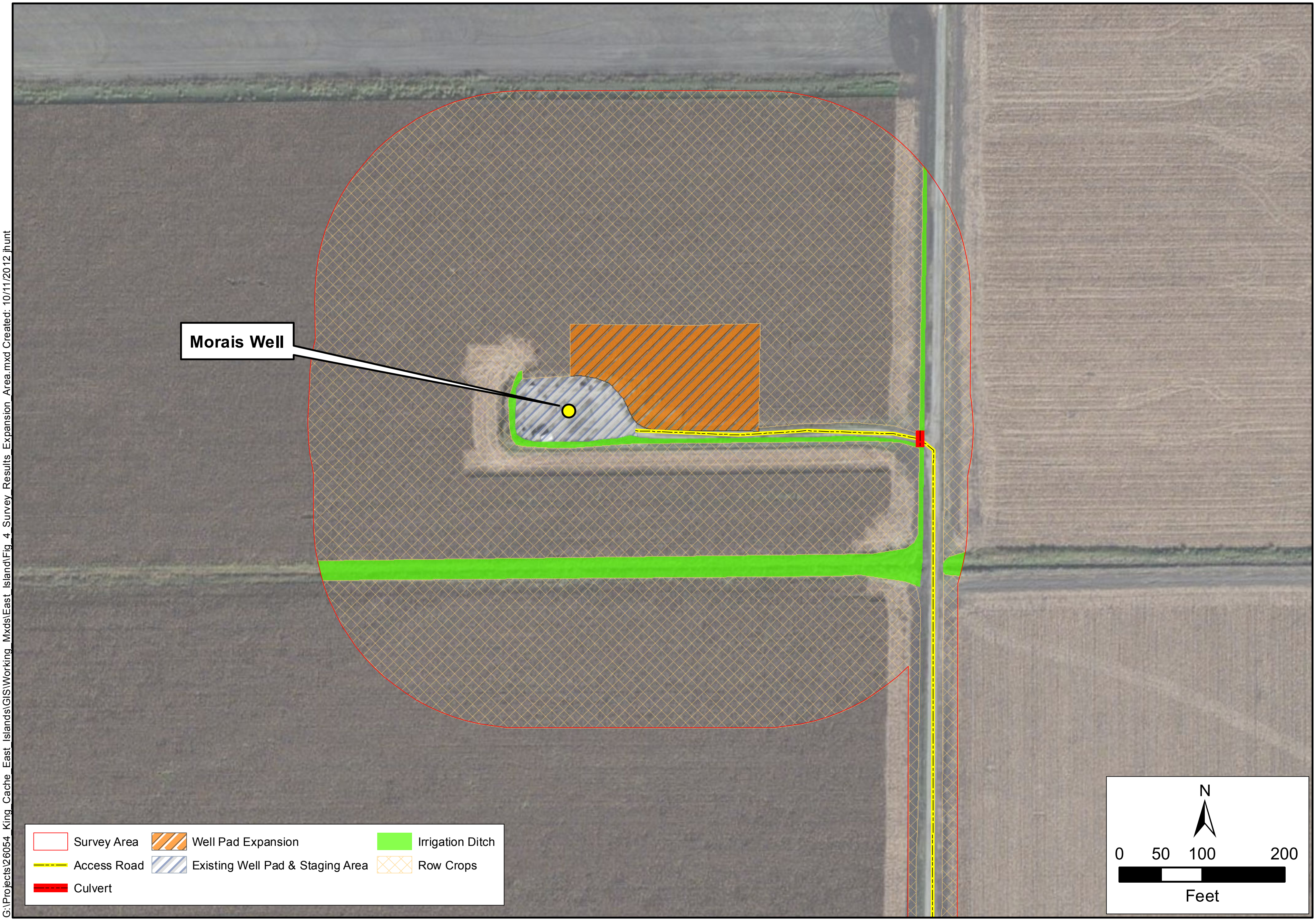
East Island, San Joaquin County, California

North State Resources, Inc.

Figure 3. Survey Results

G:\Projects\26054 King Cache East Islands\GIS\Working Mxds\East Island\Fig 4 Survey Results Expansion Area.mxd Created: 10/11/2012 jhunt



East Island, San Joaquin County, California

North State Resources, Inc.

Figure 4. Survey Results - Well Pad Expansion Area

APPENDIX B

USFWS, CNDDB, and CNPS Queries

U.S. Fish & Wildlife Service

Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 120816041228

Database Last Updated: September 18, 2011

Quad Lists

Listed Species

Invertebrates

- *Branchinecta lynchi*
  - vernal pool fairy shrimp (T)
- *Desmocerus californicus dimorphus*
  - valley elderberry longhorn beetle (T)
- *Lepidurus packardi*
  - vernal pool tadpole shrimp (E)

Fish

- *Acipenser medirostris*
  - green sturgeon (T) (NMFS)
- *Hypomesus transpacificus*
  - Critical habitat, delta smelt (X)
  - delta smelt (T)
- *Oncorhynchus mykiss*
  - Central Valley steelhead (T) (NMFS)
  - Critical habitat, Central Valley steelhead (X) (NMFS)
- *Oncorhynchus tshawytscha*
  - Central Valley spring-run chinook salmon (T) (NMFS)
  - winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

- *Ambystoma californiense*
  - California tiger salamander, central population (T)
- *Rana draytonii*
  - California red-legged frog (T)

Reptiles

- *Thamnophis gigas*
  - giant garter snake (T)

Mammals

- *Sylvilagus bachmani riparius*
  - riparian brush rabbit (E)

Quads Containing Listed, Proposed or Candidate Species:

TERMINOUS (479C)

County Lists

San Joaquin County

Listed Species

Invertebrates

Branchinecta conservatio
- Conservancy fairy shrimp (E)
- Critical habitat, Conservancy fairy shrimp (X)

Branchinecta longiantenna
- longhorn fairy shrimp (E)

Branchinecta lynchi
- Critical habitat, vernal pool fairy shrimp (X)
- vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
- valley elderberry longhorn beetle (T)

Elaphrus viridis
- delta green ground beetle (T)

Lepidurus packardi
- Critical habitat, vernal pool tadpole shrimp (X)
- vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris
- green sturgeon (T) (NMFS)

Hypomesus transpacificus
- Critical habitat, delta smelt (X)
- delta smelt (T)

Oncorhynchus mykiss
- Central Valley steelhead (T) (NMFS)
- Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
- Central Valley spring-run chinook salmon (T) (NMFS)
- Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
- Critical habitat, winter-run chinook salmon (X) (NMFS)
- winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
- California tiger salamander, central population (T)
- Critical habitat, CA tiger salamander, central population (X)

Rana draytonii
- California red-legged frog (T)
- Critical habitat, California red-legged frog (X)

Reptiles

Masticophis lateralis euryxanthus
- Alameda whipsnake [=striped racer] (T)

Critical habitat, Alameda whipsnake (X)

Thamnophis gigas
giant garter snake (T)

Birds

Rallus longirostris obsoletus
California clapper rail (E)

Vireo bellii pusillus
Least Bell's vireo (E)

Mammals

Neotoma fuscipes riparia
riparian (San Joaquin Valley) woodrat (E)

Sylvilagus bachmani riparius
riparian brush rabbit (E)

Vulpes macrotis mutica
San Joaquin kit fox (E)

Plants

Amsinckia grandiflora
Critical habitat, large-flowered fiddleneck (X)
large-flowered fiddleneck (E)

Arctostaphylos myrtifolia
Ione manzanita (T)

Castilleja campestris ssp. succulenta
Critical habitat, succulent (=fleshy) owl's-clover (X)
succulent (=fleshy) owl's-clover (T)

Cordylanthus palmatus
palmate-bracted bird's-beak (E)

Lasthenia conjugens
Critical habitat, Contra Costa goldfields (X)

Orcuttia viscida
Critical habitat, Sacramento Orcutt grass (X)
Sacramento Orcutt grass (E)

Tuctoria greenei
Greene's tuctoria (=Orcutt grass) (E)

Candidate Species

Birds

Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

Key:

(E) *Endangered* - Listed as being in danger of extinction.
(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.
(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.
(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.
Critical Habitat - Area essential to the conservation of a species.
(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.
(C) *Candidate* - Candidate to become a proposed species.
(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.
(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.
- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be November 14, 2012.

Count of CNAME						
SNAME	**CNAME**	**FEDLIST**	**CALLIST**	**RPLANTRANK**	**SRANK**	**Total**
Brasenia schreberi	**watershield**	None	**None**	2.3	S2	1
Buteo swainsoni	**Swainson's hawk**	None	**Threatened**	(blank)	S2	18
Coastal and Valley Freshwater Marsh	**Coastal and Valley Freshwater Marsh**	None	**None**	(blank)	S2.1	3
Elanus leucurus	**white-tailed kite**	None	**None**	(blank)	S3	1
Emys marmorata	**western pond turtle**	None	**None**	(blank)	S3	14
Hibiscus lasiocarpos var. occidentalis	**woolly rose-mallow**	None	**None**	1B.2	S2.2	17
Hypomesus transpacificus	**Delta smelt**	Threatened	**Endangered**	(blank)	S1	3
Laterallus jamaicensis coturniculus	**California black rail**	None	**Threatened**	(blank)	S1	3
Lathyrus jepsonii var. jepsonii	**Delta tule pea**	None	**None**	1B.2	S2.2	2
Lepidurus packardi	**vernal pool tadpole shrimp**	Endangered	**None**	(blank)	S2S3	1
Lilaeopsis masonii	**Mason's lilaeopsis**	None	**Rare**	1B.1	S2	10
Limosella subulata	**Delta mudwort**	None	**None**	2.1	S2.1	3
Scutellaria lateriflora	**side-flowering skullcap**	None	**None**	2.2	S1	2
Symphyotrichum lentum	**Suisun Marsh aster**	None	**None**	1B.2	S2	10
Thamnophis gigas	**giant garter snake**	Threatened	**Threatened**	(blank)	S2S3	3
Valley Oak Woodland	**Valley Oak Woodland**	None	**None**	(blank)	S2.1	1
Grand Total						**92**

CNPS Inventory of Rare and Endangered Plants

Status: Plant Press Manager window with 21 items - Fri, Aug. 17, 2012 18:17 c

Reformat list as: Standard List - with Plant Press controls ▾

ECOLOGICAL REPORT

scientific	family	life form	blooming	communities	elevation	CNPS
Astragalus tener var. tener	Fabaceae	annual herb	Mar-Jun	•Playas (Plyas) •Valley and foothill grassland (VFGrs)(adobe clay) •Vernal pools (VnPls)/alkaline	1 - 60 meters	List 1B.2
Atriplex cordulata var. cordulata	Chenopodiaceae	annual herb	Apr-Oct	•Chenopod scrub (ChScr) •Meadows and seeps (Medws) •Valley and foothill grassland (VFGrs)(sandy)/saline or alkaline	0 - 560 meters	List 1B.2
Atriplex joaquinana	Chenopodiaceae	annual herb	Apr-Oct	•Chenopod scrub (ChScr) •Meadows and seeps (Medws) •Playas (Plyas) •Valley and foothill grassland (VFGrs)/alkaline	1 - 835 meters	List 1B.2
Blepharizonia plumosa	Asteraceae	annual herb	Jul-Oct	•Valley and foothill grassland (VFGrs)/Usually clay.	30 - 505 meters	List 1B.1
Brasenia schreberi	Cabombaceae	perennial rhizomatous herb aquatic	Jun-Sep	•Marshes and swamps (MshSw)/freshwater	30 - 2200 meters	List 2.3
California macrophylla	Geraniaceae	annual herb	Mar-May	•Cismontane woodland (CmWld) •Valley and foothill grassland (VFGrs)/clay	15 - 1200 meters	List 1B.1
Carex comosa	Cyperaceae	perennial rhizomatous herb	May-Sep	•Coastal prairie (CoPrr) •Marshes and swamps (MshSw)(lake margins) •Valley and foothill grassland (VFGrs)	0 - 625 meters	List 2.1
Chloropyron palmatum	Orobanchaceae	annual herb hemiparasitic	May-Oct	•Chenopod scrub (ChScr) •Valley and foothill grassland (VFGrs)/alkaline	5 - 155 meters	List 1B.1
Eryngium	Apiaceae	annual/perennial		•Riparian scrub (RpScr)	3 - 30	List

racemosum		herb	Jun-Oct	(vernally mesic clay depressions)	meters	1B.1
Hibiscus lasiocarpos var. occidentalis	Malvaceae	perennial rhizomatous herb emergent	Jun-Sep	•Marshes and swamps (MshSw)(freshwater)	0 - 120 meters	List 1B.2
Juglans hindsii	Juglandaceae	perennial deciduous tree	Apr-May	•Riparian forest (RpFrs) •Riparian woodland (RpWld)	0 - 440 meters	List 1B.1
Lathyrus jepsonii var. jepsonii	Fabaceae	perennial herb	May-Jul(Sep), Months in parentheses are uncommon.	•Marshes and swamps (MshSw)(freshwater and brackish)	0 - 4 meters	List 1B.2
Legenere limosa	Campanulaceae	annual herb	Apr-Jun	•Vernal pools (VnPls)	1 - 880 meters	List 1B.1
Lilaeopsis masonii	Apiaceae	perennial rhizomatous herb	Apr-Nov	•Marshes and swamps (MshSw)(brackish or freshwater) •Riparian scrub (RpScr)	0 - 10 meters	List 1B.1
Limosella subulata	Scrophulariaceae	perennial stoloniferous herb	May-Aug	•Marshes and swamps (MshSw)	0 - 3 meters	List 2.1
Potamogeton zosteriformis	Potamogetonaceae	annual herb aquatic	Jun-Jul	•Marshes and swamps (MshSw)(assorted freshwater)	0 - 1860 meters	List 2.2
Sagittaria sanfordii	Alismataceae	perennial rhizomatous herb emergent	May-Oct	•Marshes and swamps (MshSw)(assorted shallow freshwater)	0 - 650 meters	List 1B.2
Scutellaria galericulata	Lamiaceae	perennial rhizomatous herb	Jun-Sep	•Lower montane coniferous forest (LCFrs) •Meadows and seeps (Medws) (mesic) •Marshes and swamps (MshSw)	0 - 2100 meters	List 2.2
Scutellaria lateriflora	Lamiaceae	perennial rhizomatous herb	Jul-Sep	•Meadows and seeps (Medws) (mesic) •Marshes and swamps (MshSw)	0 - 500 meters	List 2.2
Symphyotrichum lentum	Asteraceae	perennial rhizomatous herb	May-Nov	•Marshes and swamps (MshSw)(brackish and freshwater)	0 - 3 meters	List 1B.2
Tropidocarpum capparideum	Brassicaceae	annual herb	Mar-Apr	•Valley and foothill grassland (VFGrs)(alkaline hills)	1 - 455 meters	List 1B.1

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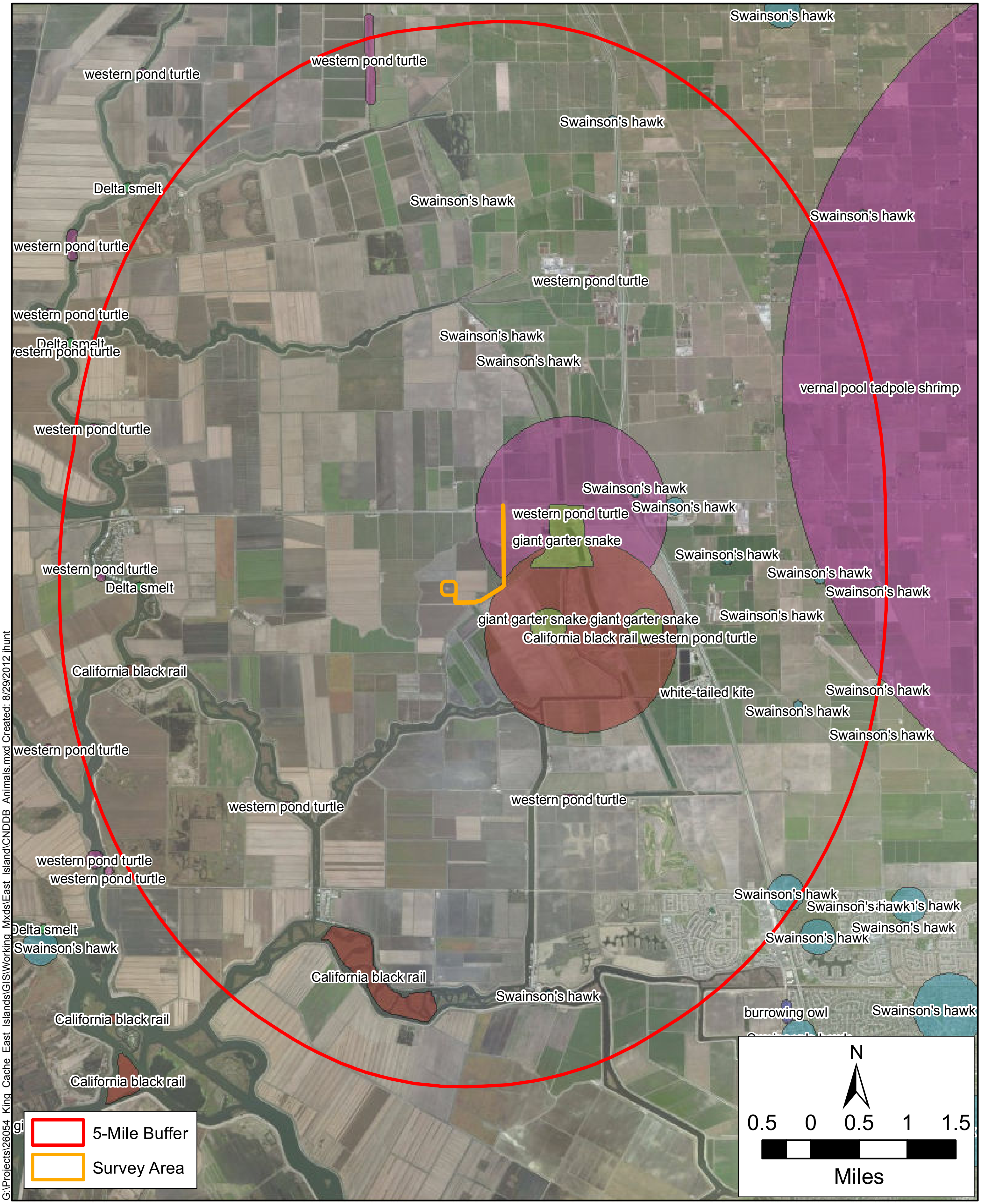
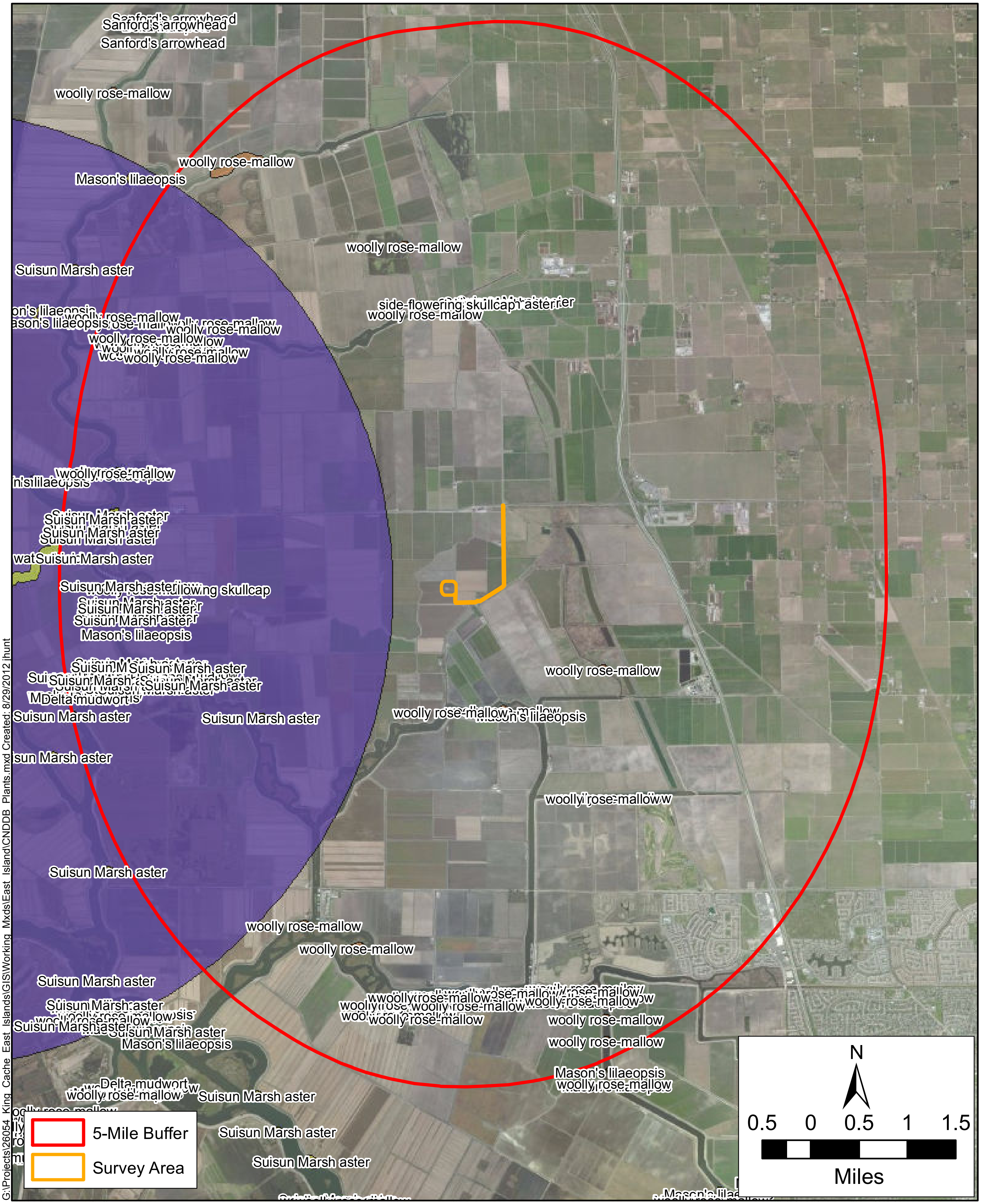


East Island, San Joaquin County, California

North State Resources, Inc.

Animals CNDDB Results



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East Island, San Joaquin County, California

North State Resources, Inc.

Plants CNDDB Results

APPENDIX C

Swainson’s Hawk Survey Protocol

RECOMMENDED TIMING AND METHODOLOGY
FOR SWAINSON'S HAWK NESTING SURVEYS
IN CALIFORNIA'S CENTRAL VALLEY

Swainson's Hawk Technical Advisory Committee

May 31, 2000

This set of survey recommendations was developed by the Swainson's Hawk Technical Advisory Committee (TAC) to maximize the potential for locating nesting Swainson's hawks, and thus reducing the potential for nest failures as a result of project activities/disturbances. The combination of appropriate surveys, risk analysis, and monitoring has been determined to be very effective in reducing the potential for project-induced nest failures. As with most species, when the surveyor is in the right place at the right time, Swainson's hawks may be easy to observe; but some nest sites may be very difficult to locate, and even the most experienced surveyors have missed nests, nesting pairs, mis-identified a hawk in a nest, or believed incorrectly that a nest had failed. There is no substitute for specific Swainson's hawk survey experience and acquiring the correct search image.

METHODOLOGY

Surveys should be conducted in a manner that maximizes the potential to observe the adult Swainson's hawks, as well as the nest/chicks second. To meet the California Department of Fish and Game's (CDFG) recommendations for mitigation and protection of Swainson's hawks, surveys should be conducted for a ½ mile radius around all project activities, and if active nesting is identified within the ½ mile radius, consultation is required. In general, the TAC recommends this approach as well.

Minimum Equipment

Minimum survey equipment includes a high-quality pair of binoculars and a high quality spotting scope. Surveying even the smallest project area will take hours, and poor optics often result in eye-strain and difficulty distinguishing details in vegetation and subject birds. Other equipment includes good maps, GPS units, flagging, and notebooks.

Walking vs Driving

Driving (car or boat) or "windshield surveys" are usually preferred to walking if an adequate roadway is available through or around the project site. While driving, the observer can typically approach much closer to a hawk without causing it to fly. Although it might appear that a flying bird is more visible, they often fly away from the observer using trees as screens; and it is difficult to determine from where a flying bird came. Walking surveys are useful in locating a nest after a nest territory is identified, or when driving is not an option.

Angle and Distance to the Tree

Surveying subject trees from multiple angles will greatly increase the observer's chance of detecting a nest or hawk, especially after trees are fully leafed and when surveying multiple trees in close proximity. When surveying from an access road, survey in both directions. Maintaining a distance of 50 meters to 200 meters from subject trees is optimal for observing perched and flying hawks without greatly reducing the chance of detecting a nest/young: Once a nesting territory is identified, a closer inspection may be required to locate the nest.

Speed
Travel at a speed that allows for a thorough inspection of a potential nest site. Survey speeds should not exceed 5 miles per hour to the greatest extent possible. If the surveyor must travel faster than 5 miles per hour, stop frequently to scan subject trees.

Visual and Aural Ques
Surveys will be focused on both observations and vocalizations. Observations of nests, perched adults, displaying adults, and chicks during the nesting season are all indicators of nesting Swainson’s hawks. In addition, vocalizations are extremely helpful in locating nesting territories. Vocal communication between. hawks is frequent during territorial displays; during courtship and mating; through the nesting period as mates notify each other that food is available or that a threat exists; and as older chicks and fledglings beg for food.

Distractions
Minimize distractions while surveying. Although two pairs of eyes may be better than one pair at times, conversation may limit focus. Radios should be off, not only are they distracting, they may cover a hawk’s call.

Notes and Species Observed
Take thorough field notes. Detailed notes and maps of the location of observed Swainson’s hawk nests are essential for filling gaps in the Natural Diversity Data Base; please report all observed nest sites. Also document the occurrence of nesting great homed owls, red-tailed hawks, red-shouldered hawks and other potentially competitive species. These species will infrequently nest within 100 yards of each other, so the presence of one species will not necessarily exclude another.

TIMING

To meet **the minimum level** of protection for the species, surveys should be completed for **at least** the two survey periods immediately prior to a project’s initiation. For example, if a project is scheduled to begin on June 20, you should complete 3 surveys in Period III and 3 surveys in Period V. However, it is always recommended that surveys be completed in Periods II, III and V. **Surveys should not be conducted in Period IV.**

The survey periods are defined by the timing of migration, courtship, and nesting in a “typical” year for the majority of Swainson’s hawks from San Joaquin County to Northern Yolo County. Dates should be adjusted in consideration of early and late nesting seasons, and geographic differences (northern nesters tend to nest slightly later, etc). If you are not sure, contact a TAC member or CDFG biologist.

Survey dates **Survey time** **Number of Surveys**
Justification and search image

I. *January-March 20 (recommended optional)* *All day* *1*

Prior to Swainson's hawks returning, it may be helpful to survey the project site to determine potential nest locations. Most nests are easily observed from relatively long distances, giving the surveyor the opportunity to identify potential nest sites, as well as becoming familiar with the project area. It also gives the surveyor the opportunity to locate and map competing species nest sites such as great homed owls from February on, and red-tailed hawks from March on. After March 1, surveyors are likely to observe Swainson's hawks staging in traditional nest territories.

II. *March 20 to April 5* *Sunrise to 1000* *3*
1600 to sunset

Most Central Valley Swainson's hawks return by April 1, and immediately begin occupying their traditional nest territories. For those few that do not return by April 1, there are often hawks ("floaters") that act as place-holders in traditional nest sites; they are birds that do not have mates, but temporarily attach themselves to traditional territories and/or one of the site's "owners." Floaters are usually displaced by the territories' owner(s) if the owner returns.

Most trees are leafless and are relatively transparent; it is easy to observe old nests, staging birds, and competing species. The hawks are usually in their territories during the survey hours, but typically soaring and foraging in the mid-day hours. Swainson's hawks may often be observed involved in territorial and courtship displays, and circling the nest territory. Potential nest sites identified by the observation of staging Swainson's hawks will usually be active territories during that season, although the pair may not successfully nest/reproduce that year.

III. *April 5 to April 20* *Sunrise to 1200* ***3***
1630 to Sunset

Although trees are much less transparent at this time, 'activity at the nest site increases significantly. Both males and females are actively nest building, visiting their selected site frequently. Territorial and courtship displays are increased, as is copulation. The birds tend to vocalize often, and nest locations are most easily identified. This period may require a great deal of "sit and watch" surveying.

IV. *April 21 to June 10* *Monitoring known nest sites only*
Initiating Surveys is not recommended

Nests are extremely difficult to locate this time of year, and even the most experienced surveyor will miss them, especially if the previous surveys have not been done. During this phase of nesting, the female Swainson's hawk is in brood position, very low in the nest, laying eggs, incubating, or protecting the newly hatched and vulnerable chicks; her head may or may not be visible. Nests are often well-hidden, built into heavily vegetated sections of trees or in clumps of mistletoe, making them all but invisible. Trees are usually not viewable from all angles, which may make nest observation impossible.

Following the male to the nest may be the only method to locate it, and the male will spend hours away from the nest foraging, soaring, and will generally avoid drawing attention to the nest site. Even if the observer is fortunate enough to see a male returning with food for the female, if the female determines it is not safe she will not call the male in, and he will not approach the nest; this may happen if the observer, or others, are too close to the nest or if other threats, such as rival hawks, are apparent to the female or male.

V. ***June 10 to JuIy 30 (post-fledging)*** ***Sunrise to 1200*** ***3***
1600 to sunset

Young are active and visible, and relatively safe without parental protection. Both adults make numerous trips to the nest and are often soaring above, or perched near or on the nest tree. The location and construction of the nest may still limit visibility of the nest, young, ‘and adults.

DETERMINING A PROJECT’S POTENTIAL
FOR IMPACTING SWAINSON'S HAWKS

LEVEL OF RISK	**REPRODUCTIVE SUCCESS (Individuals)**	**LONGTERM SURVIVABILITY (Population)**	**NORMAL SITE CHARACTERISTICS** (Daily Average)	**NEST MONITORING**
HIGH	Direct physical contact with the nest tree while the birds are on eggs or protecting young. (Helicopters in close proximity)	Loss of available foraging area. Loss of nest trees.	Little human-created noise, little human use: nest is well away from dwellings, equipment yards, human access areas, etc. *Do not include general cultivation practices in evaluation.*	**MORE**
↕	Loss of nest tree after nest building is begun prior to laying eggs.	Loss of potential nest trees.		↕
	Personnel within 50 yards of nest tree (out of vehicles) for extended periods while birds are on eggs or protecting young that are < 10 days old.	Cumulative: Multi-year, multi-site projects with substantial noise/personnel disturbance.		
	Initiating construction activities (machinery and personnel) within 200 yards of the nest after eggs are laid and before young are > 10 days old.	Cumulative: Single-season projects with substantial noise/personnel disturbance that is greater than or significantly different from the daily norm.		
	Heavy machinery only working within 50 yards of nest.			
	Initiating construction activities within 200 yards of nest before nest building begins or after young > 10 days old.		Substantial human-created noise and occurrence: nest is near roadways, well-used waterways, active airstrips, areas that have high human use. *Do not include general cultivation practices in evaluation.*	
LOW	All project activities (personnel and machinery) greater than 200 yards from nest.	Cumulative: Single-season projects with activities that “blend” well with site’s “normal’ activities.		LESS

A510: East Island Drilling Program

IRANI ENGINEERING
PETROLEUM ENGINEER
2625 FAIR OAKS BLVD., SUITE 10
SACRAMENTO, CALIFORNIA 95864
916-482-2847
FAX 916-482-7514

April 1, 2012

PG&E
East Island Core Well

Location: ? North and ? East from Southwest corner of
Section ?, T ?, R ?, MDB&M, San Joaquin County., California.
Elevation: +?′ ground. +?′ KB (assume 12' KB)
X=?, Y=?

Take all measurements from KB Which is 12'above ground.
Keep hole full at all times.
Comply with Standing Orders attached.

Drilling and Abandonment Program (Drill Pipe: 5″, 19.5#, 4-1/2″ IF thread)

Building Location, Set Conductor, Rat Hole, Mouse Hole

1. Build location. Pilings might be required to stabilize the rig.

2. 6'X6′ diameter cellar will be constructed. Rat hole and mouse hole for the rig will be dug by a water well driller.

3. 16" conductor will be cemented at 60' using a water well driller.

Rig Move, Drill 12-1/4″ hole to ~600′+, Cement 9-5/8″ casing, Install BOE.

1. Move in drilling rig. Rig up. Install riser and flow line on 16" conductor. Install mud cleaners and centrifuge. Have a full water tank before spud. In addition have a frac tank on location and fill it with water.

2. Run 12-1/4″ rental bit, 3-16/32" jets, 2-DC,s, HW and drill to 600′. Use both pumps with 6" liners.

3. Do not log surface hole.

4. Cement 9-5/8″, 36″, J-55, ST&C casing at ~600′ with 120 sacks of Class G cement premixed 6% gel and 3% CaCl2 followed with 100 Class G cement premixed 3% CaCl2. Displace cement with freshwater. Tack weld and Bakerlok bottom 4 collars, weld shoe solid. Run float shoe and insert 40' above shoe. Run a centralizer 15' above shoe. Use top rubber plug only and plug holding head. Bump plug on insert. Pressure test to 500 psig. Perform 60 sacks top job using cement premixed 3% CaCl2.
   Note: The cement volume is calculated at 70% excess.

5. After 2 hours WOC, land casing. Weld casing head (have welders on the hook). Test weld 500 psig. Install Series 900 dual hydraulic control gate and Hydril GK. Test according to Standing Orders. Notify DOG to witness. Pressure test casing to 1000 psig.

Change hole to Cypan mud System. Drill 8-1/2″ hole to 5300′.

1. Drill out the shoe of 9-5/8″ casing. Change hole to Cypan mud system with low PH. Use the following BHA: 8-1/2″ new long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 5" drill pipe. Drill to 5300′. Use both pumps with 6" liners.
   Have an additional mill tooth bit on location.
2. Wipe hole every 4 to 8 hours. Wipe hole to shoe on the first three wiper runs after that 10 stands will suffice. Wipe hole to shoe every 50 to 60 hours.
3. Install mud loggers at 5000'.
4. Have 9.8 ppg mud weight by 3000'.
5. Mud loggers report any unusual gas readings to the company man immediately.
6. Check for flow before coming out of hole.
7. Drift survey every 1000'.
8. Keep pipe moving at all times.

Core well from 5300′ to 5500′.

1. Pick up 8-1/2″X3″ core bit with 6-1/2″X3″X30′ barrel Continuous Wireline Coring System, 4 drill collars with stabilizers, 5″ drill pipe. Cut 3″ core from 5300′ to 5500′. Have Core Lab on location to collect cores per core handling instruction attached to this program. After reaching TD of 5500′ pull out.

Condition Hole before Logging.

1. Run the following BHA to clean hole before logging: 8-1/2″ bit, bit sub, Bumper sub, 30 Hw's, 5" drill pipe.
2. Circulate and condition mud. POH.

Logging Program

1. Run DIL/Sonic/GR/Neutron/Density from 600′ to TD. Run EMI from 4500′ to 5500′. If ordered take formation water samples using RFT tool.

Mud logging Program

1. Install mud loggers at 5000′. Circulate as necessary for evaluation. Open hole tests will not be run. Take one set W&D samples every 30'. E-mail daily log copies to PG&E, Worleyparsons, and Irani. Watch pit level monitor closely at all times. Keep 3 spliced log copies in trailer.

Mud Program.

Cypan mud system with low PH from 600′ to TD.

Depth	Weight	Viscosity	Water Loss
0'- 600′	Spud mud	65 sec.	NC
600′-3000'	9.0-9.8 ppg.	35-45 sec.	6cc/30 min
3000'- TD	9.8-10.0 ppg.	35-45 sec.	6cc/30 min

Have sufficient mud material on location to raise mud weight .66 ppg. Adjust mud weight to maintain mud log base line below 30 units and to stabilize shale.

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STANDING ORDERS, DRILLING & REMEDIAL OPERATIONS

Operator PG&E Well No. East Island Core Well

Contractor ? Rig No. ?

*1. Prior to drilling out the surface casing, the blowout preventers and all associated equipment shall be pressure tested to 50% of the rated worEast pressure (Bag preventer to 40%). Equipment to be tested separately are: Pipe rams, blind rams, bag preventer, kelly cock, standpipe valve, kill line (stop valve, check valve) and blow down line (each valve, choke and bean). Blow down manifold shall have at least one operating pressure gage of a range at least 1000 psig higher than blowout preventer rated worEast pressure. DOG to witness.
*2. Blowout preventers on protection and production casing shall be tested as above to 70% of rated pressure (Bag to 50%).
*3. Each drilling crew is to have at least one blowout drill weekly.
*4. Before tripping, check the ditch for flow with pumps off.
*5. Daily record the one-half pump stroke standpipe pressure.
6. Measure drill pipe on first trip after installing mud loggers.
7. All casing run shall be carefully visually inspected for pipe body and thread defects as it is unloaded. Casing shall not be permitted to drop from trucks, roll it off on ramps.
8. All casing shall have threads "bright" cleaned and a teflon pipe dope (Bakerseal, TF-17) liberally applied.
9. Keep hole full at all times.
*10. Check operation of BOE each round trip.
11. Take all measurements from KB.
12. Drilling rig mud pits shall have a calibrated tank to gage mud used to fill the hole on trips.

Each 60′ stand of 5″ drill pipe takes 0.43 barrels.

*Shall be entered on tour sheet and signed by person in responsible charge.
Date: April 1, 2012

Core Labratories personnel will catch and handle core. Core (aluminum liner) will be cut into 3 ft. lengths and capped on both ends immediately after retrieval to surface.
For the caprock, be sure the barrels are full before capping. Any space should be filled with drilling mud.
For each 3 ft segment, the top and bottom should be labeled and footages marked on barrel. Core boxes labeled appropriately.
The core should be stored at ambient temperature and then transported to Core Labs facility in Bakersfield at completion of coring. Should ambient temperature exceed 70°F, then core will be kept chilled using dry ice. (Each well will have two continuously cored intervals. There will be a short time break between each interval. Each cored interval can be shipped independently if desired.)
The portions of caprock to analyze for threshold pressure testing will be identified from the e-log by PG&E personnel before any core is slabbed. These intervals are not to be slabbed but set aside for shipment to the lab that will test the core.
The core will be slabbed 2/3rd; 1/3rd. The 2/3rd portion will be used for sampling; the 1/3rd portion for core description.
Routine core analysis for P&P will be one per foot. Samples for special core analysis and petrography will be selected after those tests are completed. The P&P analyses need to be completed as soon as possible.
Samples for sieve analysis should be selected as the core is plugged for P&P. Those analyses should be conducted as soon as possible.
Core Labs will store the core chilled until PG&E requests otherwise.

Abandonment Program

TD ~5500′ MD, BFW at ~400′.
Surface Casing: 9-5/8″ 36″ set at ~600′
Hole size: 8-1/2″ hole at 5500′, MW=10 ppg
Note: This is a straight hole.

1. Run open-ended drill pipe to 5500′.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% NaCl at 5500′. Pull up to 4700′. Wait on cement for 6 hours. Locate top Of cement plug which must be above 5200′. Notify DOG to witness.

2. Pull up drill pipe to 700′.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% CaCl2 at 700′. Pull up to surface. Wait on cement for 6 hours. Locate top Of cement plug which must be above 300′. Notify DOG to witness.

3. Cut casing 5′ below ground. Plug casing with 25 lineal feet of cement. Weld steel plate on stub. Notify DOG to witness.

Rig down and move out the drilling rig.

1. Make sure the rat hole and mouse hole are covered and red taped during the rig move. Place a fence around the cellar as soon as the rig has moved off.

Geological Prognosis

Anticipated Formation Tops

Depth	**DEPTH**
Base of USDW	~400'
Top of	?'
Total Depth	5500’

Daily distribution list

1. Daily drilling report should be e-mailed to PG&E, Worleyparsons, and Irani.

Contact e-mails and phone numbers

PG&E contact: ?

Worlyparsons: Cotact: ?

Irani Engineering:

Saeed Irani: Airani1234@Gmail.com
Work: 916-482-2847
Cell: 916-715-6493
Iraj Irani: Iraj_Irani@Yahoo.com
Mary Halpin: mhalpin98@yahoo.com
Jayne Buchannan: Jayneb123@yahoo.com

A511: Piacentine 2-27 Geochemical Analysis Final

4-29-13

Petroleum Services

Geochemical Analysis

Pacific Gas and Electric Company

Piacentine 2-27 Well

King Island Field
San Joaquin County, California

FINAL REPORT

April 29, 2013

CL File: 57111-513082PG

Performed by:
Core Laboratories, Inc.
3437 Landco Drive
Bakersfield, California 93308
(661) 325-5657

Core Lab
RESERVOIR OPTIMIZATION

Petroleum Services Division
3437 Landco Dr.
Bakersfield, California 93308
Tel: 661-325-5657
Fax: 661-325-5808
www.corelab.com

April 29, 2013

Joseph C. Chan
Pacific Gas and Electric Company
6121 Bollinger Canyon Rd., Rm 2510C
San Ramon, CA 94583

Subject: Geochemical Analysis
File No.: 57111-513082PG

Dear Mr. Chan:

Enclosed are final geochemical data for produced water samples submitted to our laboratory from well Piacentine 2-27, King Island Field, San Joaquin County, CA.

Geochemical analysis was performed on a rush basis as requested by PG&E. One water sample was analyzed by Zalco Laboratories, Bakersfield. The remaining two water samples are being held in referigerated storaged pending additional analysis.

Thank you for this opportunity to be of service to Pacific Gas and Electric Company. Please do not hesitate to contact us at (661-325-5657) if you have any questions regarding these results or if we can be of any additional service.

Sincerely,
Core Laboratories

Larry Kunkel
Area Manager - West Coast

Distribution: 1 original report, 1 CD copy: Addressee

CLB
Listed
NYSE

ZALCO LABORATORIES, INC.
Analytical & Consulting Services

4309 Armour Avenue
Bakersfield, California 93308

(661) 395-0539
FAX (661) 395-3069

Core Laboratories
3437 Landco Dr
Bakersfield CA 93308

Laboratory No: 1304060-01
Date Received: 4/5/2013
Date Reported: 4/9/2013

Attention: Larry Kunkel

Sample Identification: Chamber 1507
Sampled by: Date: 3/26/2013 Time:
Report Notes:

COMPLETE GEOCHEM ANALYSIS

pH.. 7.68
Electrical Conductivity (EC).................. 21.3
(millimhos/cm @ 25 C)

Specific Gravity @ 60 F... 1.009
Resistivity.................... 0.4695
(ohm meters @ 25 C)

Constituents	mg/L	meq/L	Reacting %
Calcium, Ca	430	21	4.72
Magnesium, Mg	130	11	2.35
Sodium, Na	4300	190	41.14
Potassium, K	33	0.84	0.19
Iron, Fe (total)	< 1.0	0	0
Alkalinity as:			
Hydroxide, OH	0	0	0
Carbonate, CO3	0	0	0
Bicarbonate, HCO3	150	2.5	0.54
Chloride, Cl	8200	230	50.86
Sulfate, SO4	42	0.87	0.19
Sulfide, S	< 1.0		
Boron, B	9.6		
Barium, Ba	3.2		
Silica, SiO2	< 40		
Strontium, Sr	15		
Totals (Sum)	13200	456	100

Total Dissolved Solids, (Gravimetric)	14000
Calculated Hardness, CaCO3	1600
Total Alkalinity, CaCO3	150
Sodium Chloride, (total)	13000

Primary Salinity	82.66
Secondary Salinity	14.14
Total Salinity	96.8

Cation/Anion Balance, %	3.0%
Sodium, Na (Calculated), mg/L	4635.12
Langelier Scale Index	1.13
Stiff/Davis Stability Index	1.11

Primary Alkalinity	0
Secondary Alkalinity	0
Total Alkalinity	0

Laboratory Authorization

ZALCO LABORATORIES, INC.
Analytical & Consulting Services

4309 Armour Avenue
Bakersfield, California 93308

(661) 395-0539
FAX (661) 395-3069

Core Laboratories, Inc.
3437 Landco Drive
Bakersfield, CA 93308

Project: Master
Project #: Placentine 2-27
Attention: Larry Kunkel

Work Order No.: **1304060**
Reported: 04/15/2013
Received: 04/05/2013 08:20

Lab Sample ID: **1304060-01**
Client Sample ID: Chamber 1507

Collected By:
Date Collected: 3/26/2013 12:00:00AM

Analyte	Results	PQL		Units	Flag	Method	Date Prepared	Date Analyzed	Init.
Alkalinity									
Total Alkalinity	150	10		mg/L		SM 2320B	4/5/13	4/5/13	SAM
Bicarbonate (HCO3)	150	10		mg/L		SM 2320B	4/5/13	4/5/13	SAM
Carbonate (CO3)	<10	10		mg/L		SM 2320B	4/5/13	4/5/13	SAM
Hydroxide (OH)	<10	10		mg/L		SM 2320B	4/5/13	4/5/13	SAM
General Chemistry			*MCL Limits*						
Fluoride	<1.0	1.0	*2*	mg/L		EPA 300.0	4/5/13	4/5/13	LME
Nitrate as NO3	<20	20	*45*	mg/L		EPA 300.0	4/5/13	4/5/13	LME
Sulfide	<1.0	1.0		mg/L		SM 4500-S F	4/5/13	4/5/13	SS
Total Suspended Solids	32	2.5		mg/L	I-02	SM 2540 D	4/5/13	4/5/13	SAM
Electrical Conductivity	21	0.010		mmhos/cm		SM 2510B	4/5/13	4/5/13	SAM
Nitrite as NO2	<10	10		mg/L	I-02	EPA 353.2	4/5/13	4/5/13	LME
Phosphate (as PO4)	<0.30	0.30		mg/L		SM4500P E	4/5/13	4/5/13	LME
Resistivity	0.4695	0.01000		Ohm-Meters		SM 2510 B	4/9/13	4/9/13	MAC
Ammonium as NH4	13	1.0		mg/L		SM4500NH3D	4/8/13	4/8/13	MSS
Bromide	34	1.0		mg/L		EPA 300.0	4/5/13	4/5/13	LME
Chloride	8200	500		mg/L		EPA 300.0	4/5/13	4/5/13	LME
pH	7.68			pH Units	I-02	EPA 150.1	4/5/13	4/5/13	SAM
Sulfate as SO4	42	5.0		mg/L		EPA 300.0	4/5/13	4/5/13	LME
Total Dissolved Solids	14000	10		mg/L	I-02	SM 2540C	4/5/13	4/5/13	SAM
Hardness									
Hardness (as CaCO3)	1600	2.0		mg/L		SM 2340B	4/5/13	4/5/13	SS
Metals - As Received									
Aluminum	<500	500		ug/L		EPA 200.7	4/5/13	4/15/13	SS
Magnesium	130	0.50		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Potassium	33	5.0		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Sodium	4600	70		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Calcium	430	0.50		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Iron	<1.0	1.0		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Boron	9.6	1.0		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Barium	3.2	1.0		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Copper	<0.50	0.50		mg/L		EPA 200.7	4/5/13	4/5/13	SS
Silica (SiO2)	<40	40		mg/L		EPA 200.7	4/5/13	4/5/13	SS

NSS: Non Sufficient Sample H: Exceeds Analysis Hold Time TTLC: Total Threshold Limit Concentration STLC: Soluble Threshold Limit Concentration TCLP: Toxicity Characteristic Leaching Procedure MCL: Maximum Contaminant Level *: See Case Narrative

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Note: Samples analyzed for regulatory purposes should be put on ice immediately after sampling and received by the laboratory at temperatures between 0-6°C. Microbiological analysis requires samples to be at least 4-10°C when received at the laboratory. For additional information regarding the limitations of the method(s) referred to, please call us at 661-395-0539.

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Core Laboratories, Inc.
3437 Landco Drive
Bakersfield, CA 93308

Project: Master
Project #: Placentine 2-27
Attention: Larry Kunkel

Work Order No.: **1304060**
Reported: 04/15/2013
Received: 04/05/2013 08:20

Lab Sample ID: **1304060-01**
Client Sample ID: Chamber 1507

Collected By:
Date Collected: 3/26/2013 12:00:00AM

Analyte	Results	PQL	Units	Flag	Method	Date Prepared	Date Analyzed	Init.
Metals - As Received								
Strontium	15	1.0	mg/L		EPA 200.7	4/5/13	4/5/13	SS
Manganese	<0.30	0.30	mg/L		EPA 200.7	4/5/13	4/5/13	SS
Zinc	<0.50	0.50	mg/L		EPA 200.7	4/5/13	4/15/13	SS
Petroleum Chemistry								
Specific Gravity @ 60/60 °F	1.009				ASTM D 4052	4/9/13	4/9/13	MAC

NSS: Non Sufficient Sample H: Exceeds Analysis Hold Time TTLC: Total Threshold Limit Concentration STLC: Soluble Threshold Limit Concentration TCLP: Toxicity Characteristic Leaching Procedure MCL: Maximum Contaminant Level *: See Case Narrative
The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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CERTIFICATE OF ANALYSIS

Client: Zalco
CAS LAB NO: 131138
Analyst: LL

Date Sampled: 03/26/13
Date Received: 04/05/13
Date Analyzed: 04/05/13
Sample Matrix: Water

Total Organic Carbon
Standard Method 5310B

CAS Lab #	Sample ID	RESULTS (mg/L)	Dilution Factor	PQL (mg/L)	MDL (mg/L)
131138-01	1304060-01	21	10	2.0	0.40

QUALITY CONTROL REPORT

130405-MB	Method Blank	ND	1	0.2	0.04

A512: King Island - Reservoir Characterization and Analysis of Suitability for CAES

WorleyParsons
resources & energy

PACIFIC GAS AND ELECTRIC

Reservoir Characterization And Analysis of Suitability for Compressed Air Energy Storage

King Island Gas Field
San Joaquin County, California

108010-00365 – PGEC-

26 May 2014

Power
WorleyParsons Limited
2330 East Bidwell Street, Sacramento (Folsom) CA 95630, United States of America
Tel: +1 916 817 3920
Fax: +1 916 983 1935

WorleyParsons
resources & energy

PACIFIC GAS AND ELECTRIC

CERTIFICATION AND DISCLAIMER

This report has been prepared under the review and supervision of Alan Burzlaff, P. E. as an employee of MHA Petroleum Consultants, and with expertise in reservoir engineering and numerical simulation. The report was prepared with the assistance of Mark Ausburn, P.G., as an employee of WorleyParsons and with expertise in petroleum geology; and Michael Tietze, C.E.G, as an employee of Jacobson James & Associates, and with expertise in engineering geology and deep well hydrology. Their signatures and stamps appear below. The findings, recommendations, specifications and/or professional opinions presented herein have been prepared in accordance with generally accepted professional geologic and petroleum engineering practice for similar projects, and within the scope of the project. There is no warranty, express or implied, and no assumption of any legal liability or responsibility for the accuracy, completeness, or usefulness of any information or process disclosed in this report. The reservoir modeling results in this report should not be regarded as exact quantities or predictions of actual reservoir performance.

______________________________	______________________________
MHA Petroleum Consultants Alan A. Burzlaff, P. E. Vice-President	Jacobson James & Associates Michael Tietze, C.E.G Principal Engineering Geologist

____

WorleyParsons Group
Mark Ausburn, P.G.
Senior Supervising Geologist

RESERVOIR CHARACTERIZATION
AND ANALYSIS OF SUITABILITY
FOR COMPRESSED AIR ENERGY STORAGE

KING ISLAND GAS FIELD
SAN JOAQUIN COUNTY, CALIFORNIA

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RESERVOIR CHARACTERIZATION
AND ANALYSIS OF SUITABILITY
FOR COMPRESSED AIR ENERGY STORAGE

KING ISLAND GAS FIELD
SAN JOAQUIN COUNTY, CALIFORNIA

1. INTRODUCTION

Compressed Air Energy Storage (CAES) is a technique that stores, in the form of air, excess energy generated during times of low loads and then utilizes the pressurized air to generate electricity during periods of high demands. In the case of renewable energy resources, such as wind and solar power, the energy generated by these resources is intermittent and highly dependent on the resource (i.e. wind and sun); the energy generated by those resources, does not always match the time periods when customers need it most. Therefore, CAES technology is being investigated as one potential opportunity for storing this intermittent energy for use during higher demand periods. Under California's existing Renewable Portfolio Standard, utilities must supply 33 percent of all electricity retail sales from eligible renewable resources by the year 2020. Much of this renewable generation is expected to be derived from the addition of new solar and wind power generation. As such, energy storage is a potential strategy to mitigate the intermittent effects and enable greater entry of wind and solar power into the existing electrical power generation and transmission system. CAES is a key technology for expanding reliance on wind and solar renewable resources for electricity production.

The United States Department of Energy (DOE), the California Public Utilities Commission (CPUC), and the California Energy Commission (CEC) have funded Pacific Gas and Electric Company (PG&E) to investigate the viability of using a depleted natural gas field to store energy by injecting compressed air into a subsurface reservoir, during periods of excess and/or low-cost generation, and recovering it by generating electricity using turbo-generation equipment during high demand periods. The application of CAES using a depleted gas reservoir for storage provides several distinct advantages. First, depleted gas reservoirs are proven geologic traps that formerly held natural gas reserves for millions of years and are therefore capable of containing compressed air to power a CAES facility. Second, the subsurface data, including well logs, production, and seismic imaging data, that are needed for characterization of the reservoir and predicting its performance in a CAES application are typically available for natural gas fields. Finally, the Sacramento Valley Basin contains many natural gas fields that are situated along California's power transmission backbone, and thus ideally located to provide utility-scale power storage to facilitate integration and distribution of renewable energy throughout the state.

The purpose of this report is to document the selection of the King Island gas field as a CAES candidate reservoir and to demonstrate its viability for a full-scale CAES plant operation. Numerical computer simulations were performed in support of the design and operation of a compression testing program and a utility scale project that would require a full field development. Initially, modeling was used for performance matching of the gas wells and prediction of the quantity and location of the remaining native free gas. Next, modeling was used to assist in baseline test planning and to predict test performance related to reservoir pressure response, air bubble development, deliverability, and water production. Once the proposed field test is completed, modeling will be used to assist in the interpretation of the test results, the reconciliation of anticipated and actual reservoir response, and to allow for problem diagnosis in conjunction with the available test instrumentation.

To conduct the compression testing program, an Injection/Withdrawal (I/W) test well will be drilled and completed in the King Island gas field and the well will be used first to inject compressed oxygen-depleted air to create a “bubble” within the boundaries of the original gas pool. Two existing nearby gas wells will be converted into observation wells and temporary air compression equipment and other equipment will be installed to perform the test. During the approximately 90-day test, the test well will be used to perform a series of injection, withdrawal and pressure fall-off and build-up tests while monitoring the test well and the observation wells. After completion of the test, a decommissioning period will follow to evaluate post-test pressure declines. Eventually a decision will be made to either shut the well in and place it in inactive status or plug and abandon the well.

The data collected during the compression test will aid in the assessment of reservoir performance on a pilot scale. The data from the test will then be used to refine the computer model of the reservoir and develop a conceptual design for full scale reservoir development to support a utility-scale CAES plant. The data collected and interpreted will be used to support subsequent engineering, economic and environmental evaluations and conclude the project feasibility analysis.

2. SUMMARY OF FINDINGS

A. The King Island gas field was discovered in 1985. The gas-productive area encompasses about 235 acres. The field is an elliptical anticlinal structure, an erosional remnant of Mokelumne River Formation strata created by deep erosion of the Meganos submarine canyon in the surrounding area. The reservoir had an initial depletion drive mechanism subsequently supported by a partial bottomwater drive component. High porosity and permeability of the reservoir have yielded high gas production rates for this area. Due to the water drive, the current reservoir pressure (February 2014) is about 1,900 psi or within 180 psi of the discovery pressure.

B. The proposed target injection zone consists of the gas-depleted (i.e., water invaded) sands of the Upper Cretaceous Mokelumne River Formation in the King Island gas field. The field has produced over 10.5 billion standard cubic feet (Bscf) of natural gas with a BTU content of 930 Btu from three wells. Four wells have penetrated the gas pool, Piacentine 1-27, Piacentine 2-27 (PGE's core-well has not produced), Moresco A1 and Citizen-Green 1. The Citizen-Green 1 and Piacentine 1-27 wells are producing small volumes of gas.

C. The King Island gas field was selected from a screening list of over a dozen Northern California gas fields to conduct more detailed analyses using computer modeling for further assessment of its suitability to support a CAES operation. A core well, Piacentine 2-27, was drilled in March-April 2013 to investigate current reservoir conditions and measure petrophysical characteristics through well logging and laboratory analysis of core samples. Based on these data, subsequent reservoir model refinements and simulations and the expected ability of the reservoir to support a permanent 300 MW/10-hour storage facility, the King Island gas field has emerged as the preferred location to perform a compression test during a second phase of the project.

D. The Mokelumne River Formation in the King Island gas field is a very friable sandstone which becomes unconsolidated after bringing cores to surface and releasing overburden stress. Core permeabilities and porosities are high, even at overburden conditions, 800 to 2800 millidarcies and 30 -32 percent porosity.

E. A reservoir simulation model, built and successfully calibrated to the observed reservoir performance, predicts the Initial Gas in Place (IGIP) is 13.8 Bscf. This equates to a gas recovery factor of 76 percent. The simulation model showed that of the remaining 3.2 Bscf of natural gas, 2.2 Bscf is trapped[1] or residual gas saturation left behind in the water swept portions of the reservoir and 1.0 Bscf is free gas located in two attic gas cap areas in the western and eastern sides of the field. The trapped gas is economically unrecoverable; however, the free gas in the structural attic areas is recoverable to the extent that wells producing the gas (Citizen Green 1 and Piacentine 1-27) are not overrun by water influx from the Mokelumne River Formation aquifers.

F. The portion of the native natural gas in the reservoir is predicted to be produced with the withdrawal gas during the proposed compression testing program; however, the compression testing program, according to the simulation model, should not produce methane in sufficient concentrations to exceed the lower explosive limit LEL[2] in the produced air.

G. A full scale CAES operation, of up to 300 MWs and 10 hours of storage, and the associated withdrawal/injection requirements using a combination of horizontal and vertical wellbores can be supported in the King Island Gas Field. The main challenges to the project are creating the required air bubble in as short a time duration as possible, keeping pressures within acceptable guidelines (Section 7.4.1), and building the air bubble

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[1] Trapped gas refers to the gas saturation trapped behind the invading water.

[2] LEL is defined as the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in the presence of an ignition source (arc, flame, heat).

such that the impacts of the remaining native natural gas are minimized. Ideally the remaining native gas in the reservoir would be pushed aside and marginalized so that when cycling begins, the methane concentration during withdrawal periods is near zero or at a fraction of the methane LEL in any of the withdrawal wells.

3. RESERVOIR SELECTION

3.1 CAES Criteria

Depleted gas reservoirs in the San Joaquin and Sacramento Valleys have the following advantages for CAES application:

- Their capability to contain compressed air is demonstrated by their proven ability to trap and contain natural gas accumulations for millions of years;
- The subsurface data typically available for natural gas fields, including well logs, production data and seismic imaging data, are useful for characterization of the reservoir and predicting its performance in a CAES application; and
- Their occurrence along California's principal power transmission corridor.

The gas field and reservoir criteria required for potential CAES application include the following:

- **Optimal size**, both in terms of volume and aerial extent. Reservoirs that are too small would not have enough volume to sustain withdrawal operations to meet the project objective, would require frequent recharge and would cause large pressure swings during withdrawal. Reservoirs that are too large would require building and maintaining a much larger air bubble, increasing both development and operating costs. Aerially, the size of the reservoir is important from a development standpoint. More compact reservoirs require less infrastructure to fully develop than those spread across a broader area.

- **Optimal depth and pressure**, between approximately 3,000 feet (1,300 psi[3]) to 6,000 feet (>2,500 psi), optimally in the 3,500 to 5,000 feet range. Less expensive wells can be drilled into the shallower reservoirs, but this can be offset, at least partially, by needing more wells to achieve the same deliverability due to the lower operating pressure. Based on recently approved gas storage projects in California, storage reservoirs are often permitted to operate at higher than original discovery pressure.[4] Reservoir pressures of up to 0.7 psi/ft. of depth can be acceptable if the reservoir bounding features (caprock, underlying aquifer, etc.) are capable of handling the higher pressure during the intended operation.

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[3] Based on normal hydrostatic gradient of 0.433 psi/ft.

[4] http://cvgasstorage.com/CPUC%20Final%20Decision.pdf

- **Good trapping mechanism**, preferably simple structures such as anticlines or fault traps that are easier to develop and operate than complex structures. The more complex the reservoir becomes (e.g. involving compartmentalization from faulting and/or stratigraphic discontinuities), the more likely it is to require additional wells (added cost) because of the difficulty in placing them optimally in the reservoir and the more difficult it is to operate due to communication barriers within the reservoir. Complex reservoirs are also more difficult to model and predict performance once they are developed.

- **Good caprock and lateral seal**, comprised of very low-permeability geologic materials such as evaporites or shale layers. An optimal shale caprock has low silt/sand content, is reasonably ductile and has not been breached or off-set by faulting over the reservoir. A good lateral seal will have a few or no higher permeability layers occurring at the reservoir boundaries.

- **Limited producing horizons** simplify reservoir size determination and well development. In the case of multiple zones, even if the production of each zone has been isolated, it may require development of multiple zones to achieve the optimal volume requirements for a CAES project. Well design and placement is more difficult with limited horizons, increasing the risk that more injection/withdrawal wells will be required, which in turn increases the development cost.

- **Thick and clean reservoir**, greater than 20 feet with high ratio of net sand thickness to gross interval thickness to facilitate high flow capacity (based on product of reservoir thickness and permeability) and good hydraulic communication within the reservoir.

- **High Permeability**, representing the ability of a gas or fluid to flow through the reservoir, to facilitate high flow capacity (based on product of reservoir thickness and permeability).

- **High Porosity**, representing the ratio of pore volume to total rock volume, to provide adequate air storage capacity.

- **Small amount of free gas** remaining in reservoir lowers the risk that native gas concentrations in withdrawn air during CAES operation might exceed the LEL and represent a potential combustion hazard in the presence of an ignition source.

- **Limited mass of oxygen-reactive minerals or organic material** that could deplete oxygen in the reservoir air bubble. Withdrawal air with low oxygen content can create operational problems for certain types of CAES turbo machinery.

- **Small number of historical wells in reservoir** reduces the number of potential remedial plugging and abandonment procedures due to possible leakage pathways in the well bore or annulus that could result in reservoir pressure losses or impact to Underground Sources of Drinking Water (USDWs).

Other criteria important for evaluation and development of a CAES site include favorable environmental and cultural factors, proximity to required interconnect facilities (electrical, natural gas, water), and an ability to secure site control of the rights necessary to both develop the reservoir, site the power requirement and any required easements to connect the reservoir to the power block.

3.2 Pre-Screening

Several gas fields[5] in the San Joaquin and Sacramento Basins were pre-screened as potential CAES candidates against the evaluation criteria listed above. Three gas field reservoirs were selected for computer modeling to further assess their suitability to support a CAES plant, and two of these, East Islands Gas Field and King Island Gas Field, were selected for drilling core wells to investigate reservoir and cap rock characteristics through well logging and laboratory analysis of the core samples. While both of these fields are deemed suitable for CAES application, the King Island Gas Field has a larger reservoir more likely able to meet the project requirement of supporting a 300 MW and 10 hours of storage facility. Accordingly, the King Island Gas Field was selected for CAES feasibility compression testing.

3.3 Suitability of King Island Gas Field Reservoir

The following characteristics make the King Island Gas Field an excellent candidate for CAES application:

CAES Reservoir Favorable Characteristics	Location in Report where Discussed / Information Provided
Large and high quality subsurface database consisting of well geophysical logs (including neutron-density porosity logs in two wells), 175 ft. of conventional core, production data, pressure data (including repeat formation tester depth-discrete pressures) and 3D seismic.	**Well geophysical logs**: Piacentine 2-27 logs in Appendix A; Petrophysical report (Piacentine 2-27 and Citizen Green 1) in Appendix B; discussed in Section 5.2.1 **Core data** (Piacentine 2-27): Corelab analyses in Appendix C; discussed in Section 5.2.2 and 5.2.3 **Production data**: discussed in Sections 4.1 and 4.2; presented in Figures 2 – 4 and Table 1 **Pressure data**: discussed in Sections 4.1 and 4.3;

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[5] Bowerbank, Bounde Creek, Cache Slough, Clarksburg, Crossroads, East Islands, French Camp, King Island, Liberty Island, McMullin Ranch, Merrill Avenue, Perkins Lake, Rio Jesus, Schohr Ranch, Tracy, Tremont, Trico NW, Vernalis, West Thornton, and Zamora.

CAES Reservoir Favorable Characteristics	**Location in Report where Discussed / Information Provided**
	presented in Figure 5 and Table 2 **3D seismic data**: Not presented due to confidentiality agreement with field operator
Anticlinal structure	Discussed in Sections 2, 5.1.3 and 6.1.1; presented in Figures 9, 14, 15, 16 and 23
Optimal reservoir depth (approximately 4,700 ft.) and pressure (approximately 2,050 psi)	Discussed in Sections 4.3 and 5.1.4.
Excellent low-permeability caprock (Capay Shale) and lateral seal rock (shale in Meganos Channel Fill)	Corelab analyses in Appendix C; discussed in Sections 5.1.4 and 5.2.3; presented in Figures 11, 14, 15, 16 and 22 and in Table 5
Thick sandstone reservoir in Mokelumne River Formation (MRF) with net composite thickness ranging from 65 to 175 ft.	Discussed in Section 5.1.4; presented in Figures 14, 15, 16 and 22
High porosity (31%) and high permeability (807 millidarcies (mD); corrected to confining stress) reservoir	Discussed in Sections 2 and 5.2.3; presented in Table 3
Large reservoir volume (13.8 Bscf initial gas in place) allowing high ratio of reservoir volume to CAES air bubble working volume	Discussed in Section 2, 7.2.2 and 7.3
Small amount of free gas remaining in attic gas caps (approximately 1 Bscf)	Discussed in Sections 4.2 and 7.2.2

CAES Reservoir Favorable Characteristics	Location in Report where Discussed / Information Provided
Small number of wells potentially requiring remedial abandonment	Wells drilled in Mokelumne River Formation gas reservoir discussed in Section 4.1
Small percentage mass of pyrite in reservoir rock, with potential to react with, and consume oxygen	Corelab x-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses provided in Appendix C. Air chamber test of core sample report provided in Appendix D and summary provided in Section 5.2.4.
Favorable/manageable environmental/cultural factors, logistics, and site control agreements	Not discussed in this document.

4. FIELD HISTORY

4.1 Development

The King Island gas field (**FIGURE 1**) was discovered by Quintana Petroleum Corporation in September 1985 in the Moresco Unit A No. 1 well, which flowed gas at an initial production rate of 8,200 thousand standard cubic feet (Mscf) per day through a 25/64-inch choke with 1,635 pounds per square inch (psi) tubing pressure. The following year, in July 1986, Quintana drilled the Piacentine 1-27 well which was also successfully completed in the same gas pool. The well tested at an initial rate of 10,000 Mscf per day and 1,635 psi flowing tubing pressure. In December 1994, Sierra Resources took over operations of the two wells, eventually abandoning the Moresco well in August 1997 after water encroachment and an unsuccessful recompletion attempt. Sierra Resources was successful in recompleting the Piacentine 1-27 well in 1997, and production continued through December 2004, when operations were transferred to Princeton Natural Gas LLC. At that time, the well was producing at a rate of 25 Mscf per day.

In July, 2005, Source Energy Corporation successfully completed the King Island 1-28 well about one-half mile west of the Quintana wells. The well tested 455 Mscf per day with 1,560 psi flowing tubing pressure through a 1/8-inch choke. With a shut-in surface pressure of 1,840 psi, the 1-28 well was determined to be a new pool discovery and it produced 100,204 Mscf before water encroachment. This well has been determined to have been completed in a Meganos Channel Fill sand, outside of and hydraulically separated from the King Island Mokelumne River Formation reservoir, based on analysis of pressure and 3D seismic data and correlation of geophysical well logs.

Princeton Natural Gas took over operations of the King Island 1-28 well in February 2008. The well was re-named the Citizen Green 1 and re-drilled to 6,920 ft. TVD in December 2011 as part of a West Coast Regional Carbon Sequestration Partnership (WESTCARB) characterization project to assess the suitability of the southern Sacramento Basin for CO_2 sequestration. The well was eventually completed in an attic gas area of the King Island gas pool and has been producing at a rate of 150-250 Mscfd.

A core well, Piacentine 2-27, was drilled by PG&E in March 2013 to gather reservoir characterization data for this CAES project. A gross interval of 175 feet was cored with 98 percent recovery during seven core runs in the Mokelumne formation and overlying Capay shale. The well was cased but not completed and is scheduled to be an observation well for the field testing phase of the project.

4.2 Well Production Performance

Production data for the King Island wells was obtained from the California Division of Oil, Gas and Geothermal Resources (DOGGR). The DOGGR is the state of California repository for oil, gas, and geothermal well information and it publishes statistics on drilling, production, and injection (http://opi.consrv.ca.gov/opi/opi.dll). The cumulative gas and water production for the King Island gas field is 10.7 Bscf of natural gas and 74.0 thousand barrels of water (Mbw), through January 2014. **TABLE 1** presents the cumulative production data by well. The Citizen Green 1 and Piacentine 1-27 are still active producers. The Piacentine 2-27 core well has been idle since December 2013 pending the start of the planned compression field test.

FIGURES 2 - **4** are graphs of the monthly production data for the King Island wells. The graphs are annotated with the major recompletion and workover information during the life of the wells. This information is useful for interpreting the changes in gas and water production rates for example; a well's gas rate typically increases after a recompletion event in which cement is squeezed into the lowest perforations of the well to eliminate bottomwater production.

The King Island reservoir producing mechanism is a partial bottomwater drive. The bottomwater drive is a water aquifer that underlies the reservoir and encroaches into the gas reservoir as the reservoir pressure decreases due to the high-pressure gas in the pores of the reservoir expanding out into (and being produced from) the wells. The bottomwater drive is a partial drive because the recharge rate is less than the reservoir's fluid withdrawal rate (initially). See the Reservoir Pressure discussion in Section 4.3. A water drive is not as effective as an expansion-gas drive producing mechanism because the bottomwater flows around and traps pockets of gas in the reservoir resulting in a trapped gas saturation. The trapped or residual gas saturation is typically about one-third of the initial hydrocarbon saturation. Evidence of a bottomwater drive is seen in the increase in water production as a result of water breakthrough and subsequent recompletion well work identified on the Moresco A1 and Piacentine 1-27 production graphs (FIGS. 2 and 3).

The geologic interpretation of the gas field (discussed in Section 5 below) coupled with the well production performance indicate that there are presently two attic gas cap areas (in the east and west structural highs) containing the remaining free gas in the field. The attic gas caps are not connected directly but rather indirectly through the water-swept geologic saddle between the two areas. The Citizen Green 1 well is currently producing gas at a rate of 150 Mscfd from the west attic gas cap area and the Piacentine 1-27 well has been producing about 25 Mscfd intermittently from the east attic gas cap area. The reservoir simulation model built for this report (see Section 5.1) predicts about 1.0 Bscf of free native gas remaining in the two free gas caps at this time with the majority of the gas (0.9 Bscf) remaining in the west gas cap area.

4.3 Reservoir Pressure

The reservoir pressure history for the King Island gas field was constructed using predominantly surface tubing pressures retrieved from the DOGGR website. In addition, tubing pressure data from well initial productivity tests were obtained from the well history records. Original reservoir pressure is estimated to be 2,080 psig at 4,744 ft. (Moresco A1 well, October 1985). Current reservoir pressure is 1,898 psig at 4,684 ft. in February 2014 (**TABLE 2**).

There are very few reported bottomhole reservoir pressures in the King Island wells. As a result, surface tubing pressures were converted to estimated bottomhole pressures over the life of the wells. The tubing pressures are surface flowing pressures reported by the operator on a monthly basis. The conversion from flowing surface pressure to bottomhole pressure was made using a multiphase correlation for gas wells (Gray, 1974), derived empirically, that accounts for the hydrostatic and frictional fluid losses in a wellbore under a variety of flow conditions.

The estimated bottomhole pressures are considered good quality for those time periods of little or no associated water production but the estimated bottomhole pressures are less valid as the quantity of water increases with the produced gas because the measured tubing pressures will be low due to the higher pressure gradient of the gas-water mixture.

The estimated bottomhole pressures by well over the life of the field are shown for the King Island wells in **FIGURE 5**. Although these are flowing pressures, the corresponding static reservoir pressures are expected to be close to these numbers because there is minimal pressure drawdown during flow due to the high reservoir permeability. The estimated bottomhole pressures are used throughout this report to represent the reservoir pressure behavior over time. The early bottomhole pressures (up to January 1995) for the Piacentine 1-27 and Moresco A1 wells track one another. Late-time bottomhole pressure data (from January 2005) for the Piacentine 1-27 and Citizen Green 1 wells also overlay each other. This is evidence that the wells are in good pressure communication and there is no geologic compartmentalization. These reservoir pressure data are the key information used to calibrate the predicted pressures from the dynamic simulation model.

The reservoir pressure decreased from 2,080 psi to 800 psi during the first eight years of gas production (8.0 Bscf). Over the next 20 years the reservoir pressure increased back to within 180 psi of original pressure due water in-flowing into the reservoir. The reservoir producing mechanism is a partial water drive because the early time decrease in reservoir pressure indicates that the water influx rate is much less than the total gas withdrawal rates during that same time period.

When the Piacentine 2-27 core well was drilled In March 2013, reservoir pressure measurements were taken in the King Island gas reservoir using the Halliburton RDT tool. This tool allows multiple in-situ pressure measurements to be made at various depths using a special probe. The measured pressures are shown in **TABLE 2**. The RDT pressures for the Mokelumne River formation ranged from 1909 psia to 1994 psia.

Current static bottomhole reservoir pressures were obtained by wireline electronic gauges in the Citizen Green 1 and Piacentine 1-27 wells in mid-February 2014 (**TABLE 2**). The measured bottomhole pressures were 1,898 psig (at 4,684 ft.) and 1,883 psig (at 4,664 ft.), respectively. The surveys showed that the current reservoir pressure is within 180 psi of the original discovery pressure and indicate the lateral pressure gradient between the Piacentine 1-27 and the Citizen Green 1 well is relatively flat.

4.4 Material Balance P/z

The early time pressure data in the King Island wells, before detection of the water drive, are useful for predicting the approximate size (IGIP) of the gas reservoir. The estimated bottomhole pressures (P) divided by their respective gas deviation factors (z) plotted against the cumulative gas production for the field is a simple P/z material balance method. The method assumes that as gas is produced from the reservoir, there will be a corresponding change in the reservoir pressure that depends on the remaining volume of natural gas. Without any water influx, these data should theoretically extrapolate to the IGIP at a zero P/z value. With water influx, the reservoir pressure decline is retarded or offset by the water encroachment and the P/z data will not extrapolate to the IGIP but rather trend to a value higher than the IGIP.

The P/z plot is shown in **FIGURE 6**. The straight line extrapolation of the early P/z data to a zero P/z value gives about 15.8 Bscf. As turns out, however, 15.8 Bscf is greater than the subsequent 13.8 Bscf for IGIP determined by reservoir simulation (see Section 7.2) which suggests that the early P/z data are already being affected by the bottomwater drive.

5. RESERVOIR CHARACTERIZATION

5.1 Geology

5.1.1 Regional Setting

The King Island Gas Reservoir is located in northern San Joaquin County between the cities of Stockton and Sacramento, and lies within the northern third of the Great Valley geomorphic province of California (**FIGURE 7**). The Great Valley is an asymmetrical structural trough with a steep west flank and a more gently dipping east flank. It is situated between the Coast Ranges to the west and the Sierra Nevada Range to the east and includes the San Joaquin Valley to the south and the Sacramento Valley to the north. The eastern flank of the southern Sacramento Valley, where the King Island Gas Field is located, is underlain at depth by a basement complex of relatively impermeable metamorphic and crystalline plutonic rocks. These are overlain by marine sedimentary rocks, followed by non-marine volcanic and alluvial deposits derived from the coast range to the west and the Sierra Nevada to the east (Edmondson, et al., 1967).

The King Island Gas Field is an erosional remnant within the Meganos submarine canyon complex (also called Meganos Channel) that was eroded and filled during Paleocene time (**FIGURE 8**). Marine sedimentary sequences in the Sacramento and northern San Joaquin Valley include organic shales that serve both as source rocks for natural gas and, by virtue of their low permeability, as seals or cap rocks for gas accumulations in permeable sandstones reservoirs. Petroleum is generally not found in the Sacramento and northern San Joaquin Valley, but natural gas fields have been extensively developed, including the subject field.

5.1.2 Data Utilized and Interpreters Involved in Geological and Reservoir Evaluation

The structural and stratigraphic interpretations presented in the referenced maps and cross-sections and discussed in Sections 5.1.2 and 5.1.3 are mostly based on correlations of geophysical well logs that were downloaded from the DOGGR and gas online data site:

http://www.conservation.ca.gov/dog/Online_Data/Pages/Index.aspx

For most of the wells, only a basic suite of open-hole geophysical well logs comprising, at a minimum, spontaneous potential (SP) and resistivity logs (sometimes referred to as “correlation logs”), were run by the well operator. So-called “porosity” logs were run in only two of the four wells completed in the King Island gas field Mokelumne River Formation reservoir (sonic, density and neutron logs in the Piacentine 2-27 and Citizen Green 1). Only sonic logs were run in two other wells just outside of the King Island gas field (King Island 33-1 and King Island 1-28).

Data from a 3D seismic survey were also used in the evaluation of the King Island gas field reservoir and geology. The 3D seismic data volume used in the interpretation represents a small portion of a regional (250 mi^2) 3D seismic survey shot in 1999 by Eagle Geophysical for DDD Energy and Enron. The current King Island gas field operator acquired an approximately 1 mi^2 portion of the survey encompassing the field from PacSeis of Denver, Colorado. The processed seismic data results are not exhibited in this report as they are subject to a confidentiality agreement.

Interpretation of regional and local geologic structure and stratigraphy (sequence of rock layers) presented in Sections 5.1.3 and 5.1.4, and development of the regional geologic maps and cross-sections, was performed by Frank Cressy, a State of California Professional Geologist. Interpretation of the structure and stratigraphy of the King Island gas field and the Mokelumne River Formation gas reservoir presented in Section 6.1, and development of King Island gas field geologic maps and cross-section, was performed by Dr. Doug Imperato, PhD and State of California Professional Geologist. Development and interpretation of seismic profiles and amplitude anomaly maps derived from the field operator's 3D seismic survey was performed by Tom Fassio, a consulting geologist/geophysicist based in Denver, Colorado.

5.1.3 Structure

The general structure of the Upper Cretaceous formations (Starkey, H&T and Mokelumne River) is a homocline dipping from approximately 2° to 6° to the southwest, based on regional seismic data, well control, and sparse dipmeter data (**FIGURE 9**). The structure of the Eocene formations (Capay, Domengine, Nortonville, and Markley) overlying the Mokelumne River Formation is complicated by the presence of the underlying Paleocene-age Meganos Channel, which eroded as much as 1,600 feet of the Mokelumne River Formation (**FIGURE 10**). Subsequent filling of this large submarine canyon by varying amounts of sandstone and shale resulted in an undulating base Capay surface due to differential compaction of Meganos Formation shales near channel edges, around the perimeter of the large erosional "island" at King Island, and over thick sandstone channels within the Meganos Channel fill sediments (**FIGURE 9**). The resultant compaction-related synclines and anticlines (upwards and downwards convex folds of stratigraphic layers, respectively) are superimposed on the regional homoclinal pattern.

The Capay shale is thicker over the erosional arms of the Meganos Channel to the east and west of King Island (>150 feet thick), and thinner over King Island where Meganos Channel fill onlaps the Mokelumne River Formation (mostly from 90-120 feet thick; **FIGURE 11**).

The project location regionally lies on the west-dipping homocline between two cross-valley arches, the Thornton Arch, 12 miles to the north, and the Stockton Arch (and Fault), located 14 miles to the south. These and other nearby structural features are shown on **FIGURE 8**, based on a map modified from Beyer (1988). In an east-west direction, the project location lies equidistant between the Midland Fault, located approximately 12 miles to the west, and the Willows Fault, whose inferred location is approximately 12 miles to the east (**FIGURE 8**). The Stockton and Midland faults are major subsurface faults that were active during the Late Cretaceous through the Eocene. The King Island Gas Field is an elliptical anticlinal structure resulting primarily from erosion of the upper Mokelumne River Formation by the Meganos Channel.

Major regional faults are not known to be present near the site, but a small southwest-dipping normal fault has been mapped immediately south of the King Island Gas Field in Section 33, T3N-R5E. The fault has a displacement of about 150 feet and appears to cut out Meganos Channel shales in the Piacentine #1 well, and basal Domengine sand in the King Island 1-33 well (**FIGURE 12**). Seismic profiles from the field operator's 3D seismic survey (Section 5.1.2) suggest that the Miocene non-marine sediments have not been offset by this fault, and therefore, that movement ceased on this fault prior to their deposition. This interpretation is also supported by correlation of well logs for the wells in and near King Island, which suggests the fault displaces the Nortonville Shale and was active during deposition of the Eocene-age Markley Formation, but does not displace the overlying Plio-Miocene sediments.

An offset that cuts out 60 feet of Capay Shale in the Piacentine 2-27 and a similar amount of section in the overlying lower part of the Domengine Sand in the Piacentine 1-27 was mapped in the field. However, the underlying Mokelumne River Formation appears unfaulted and there is no offset of stratigraphy near the original gas/water contact (GWC) in the gas reservoir as determined from the well logs. This suggests that the offset represents an ancient (Eocene) submarine landslide on the eastern side of the King Island Gas Field (**FIGURE 11**). On this flank, the Rio Blanco 1 well encountered nearly 70 feet of an anomalous sandy shale interval at the top Capay Shale that is interpreted as the landslide deposit.

The Piacentine 1-27 and 2-27 wells lie near the head of the paleo-landslide, and the Rio Blanco well lies at its depositional toe. Sediment loading during early deposition of the Domengine Formation is believed to have triggered a glide plane failure in the underlying Capay Shale which slid a section of Capay and lower Domengine to the southeast towards the axis of the Meganos Channel. Such glide plane failures can occur at relatively low angles in shales. Based upon interpretation of seismic profiles from the field operator's 3-D seismic survey (Section 5.1.2), the deeper Mokelumne River and Starkey horizons, as well as shallower horizons, are not broken, suggesting the fault is limited to the Capay and basal Domengine Formation. Since the landslide "soled-out" in the Capay shale, the underlying, more competent, Mokelumne River Formation was not cut or displaced.

5.1.4 Stratigraphy

The stratigraphy underling the vicinity of the King Island Gas Field is described below and shown on the accompanying stratigraphic column (**FIGURE 13**) and graphically on several cross sections. The locations of regional cross sections A-A', B-B' and C-C' are shown on **FIGURES 9 - 11** and the cross sections are presented as **FIGURES 14** through **16**, respectively. The geophysical well log correlations and regional formation markers upon which the cross sections are based are in accordance with the regional stratigraphic framework presented in Edmondson, et al. (1967). The well logs are marked on the cross-sections and can be downloaded from the DOGGR website (see Section 5.1.2).

The deepest well in the immediate vicinity of the King Island Gas Field is the Osborne "Piacentine" 1 (Sec. 28, T3N-R5E), which was drilled to a total depth of 10,500 feet into Upper Cretaceous E-zone Winters Formation shale, which is interpreted as a marine slope facies deposit. Deep-water sandstones of equivalent age, and also belonging to the Winters Formation, lie westward of the Osborne well. Based on regional studies (Edmondson, et al., 1967; California Division of Oil and Gas, 1982), there is an estimated 5,000 feet of older Upper Cretaceous sediments that lie below the maximum depth of the Osborne well and above the basement rocks.

Overlying the Winters Formation shale is a 1,650-feet thick sequence of sandstones and shale belonging to the shallow marine Starkey Formation sands that are, in part, age equivalent to the deep-water, basinal Winters Formation sandstones. A 100+ foot thick mudstone and claystone unit, referred to as the H&T Shale regionally overlies the Starkey Formation.

Overlying the H&T Shale are Upper Cretaceous fluvial-deltaic sediments of the Mokelumne River Formation. The Mokelumne River Formation reaches nearly 1,600 feet in thickness, based on formation boundary correlations of geophysical well logs in the region (Section 5.1.2), and is composed predominately of thick interbedded, fluvial-deltaic sandstones with thin interbeds of siltstones, mudstones and shale (**FIGURE 17**).

The formation boundaries upon which the isopach map is based (base of Capay Shale and top of H&T Shale) for all of the wells in **FIGURE 17** are consistent with the formation boundary correlations in the regional cross-sections (**FIGURES 14 - 16**). Minor lignite is also present. Several successions of thin marine flooding events within the formation are represented by widespread shale beds that allow good intra-formational correlations. Complete sections of the Mokelumne River Formation are present in the Moresco A-1 well (Sec. 28, T3N-R5E), the discovery well of the King Island Gas Field, and the Citizen Green 1 well (Sec. 28, T3N-R5E) (**FIGURE 13**).

The King Island field gas reservoir occurs in the uppermost Mokelumne River Formation sand package that ranges in gross thickness from approximately 130 to 245 feet (65 to 175 feet net sand thickness). The top of the Mokelumne River Formation reservoir is an erosional surface at the base of the overlying Capay Shale (discussed below), that occurs between depths of approximately 4,665 to 4,790 feet. Around the perimeter of the erosional domal high, the gas reservoir thins rapidly to zero due the erosion by the Meganos Channel along the flanks of the erosional high. The gas accumulation, with up to 112 feet of net pay, is sealed at the top by the Capay shale and on all four sides by Meganos Channel fill that is comprised mostly of shale (**FIGURES 14 - 16**) along the Channel margins.

During the Paleocene, the sea level fell and the Mokelumne River Formation was deeply eroded by the Paleocene Meganos Channel. As much as 1,300 feet of the Mokelumne River Formation was eroded on all sides of King Island, and in the deepest portions of the channel to the southeast of King Island, the entire Mokelumne River section was eroded (**FIGURE 17**). A rising sea level caused the erosional valley to be subsequently filled by late Paleocene Meganos Formation marine sandstones, siltstones and shales. The channel-fill sediments were complexly deposited, but in general, thick sandstones are more common to the north of King Island and lie near the axis of the channel arms. Based on review of geophysical well logs (Section 5.1.2) shown on the Meganos Channel fill isopach map (**FIGURE 10**) and the cross-sections in **FIGURES 14 - 16**, shaley sediments nearly completely fill the channel to the south of King Island and generally occur along the channel margins in the sandier areas.

The Mokelumne River Formation at King Island remained as a large erosional remnant or island between two erosional arms of the Meganos Channel system. Meganos Channel fill sediments were not encountered in the four wells (Piacentine 1-27, Piacentine 2-27, Moresco et al Unit 1, and the Citizen Green 1) in the King Island Gas Field. Five wells that lie immediately off the flanks of the field (Rio Blanco 1, Klein 1-28, King Island 1-28, King Island 1-33, and Piacentine 1) encountered varying thicknesses of primarily shaley Meganos Channel fill sediments, with a maximum of 450 feet penetrated in the Rio Blanco 1 (**FIGURE 15**). The Piacentine 1, King Island 1-33 and the Klein 1-28 penetrate a thin sequence of Meganos Channel fill near the edges of the channel before entering Mokelumne River Formation sands that are stratigraphically below the Mokelumne River Formation sands in which the King Island gas pool occurred.

The King Island 1-28 and the Rio Blanco 1 reached total depth in the Meganos Channel fill. The interpretation of the contact between the Meganos Channel and the Mokelumne River Formation in the vicinity of the King Island gas field is based on correlations of the geophysical well log shown in **FIGURES 14 - 16**, and a seismic amplitude anomaly map from the operator’s 3D seismic survey (Section 5.1.2). In particular, the laterally continuous Mokelumne River Formation sand packages are readily recognized on electric logs and correlated between wells in the area of the King Island gas field. In contrast, sands within the Meganos Channel fill are more lenticular and discontinuous.

Mokelumne River Formation sediments and the younger Meganos Channel fill sediments are unconformably overlain by the Eocene-age Capay Shale, a regional marine mudstone that is present under much of the central and southern Sacramento basin north of the Stockton fault (**FIGURE 8**). The unit ranges in thickness between 90 and 120 feet in the vicinity of King Island as evidenced by the geophysical logs (Section 5.1.2) of nine wells located in and immediately adjacent to the field shown on maps in FIGURE 9 (top of Capay structure map) and **FIGURE 11** (Capay isopach map), and on the cross-sections in **FIGURES 12, 14, 15 and 16**).

The unit is thicker where it overlies thick intervals of Meganos Channel fill sediments (**FIGURE 11**). This unit forms the seal or cap rock for gas trapped in the uppermost Mokelumne River Formation sands at King Island, as well as numerous other gas fields in the southern Sacramento Valley. The Capay is composed of thick gray-green silty mudstones and forms an excellent seal over the gas reservoir. The basal Capay contains abundant glauconite over a thin basal conglomeratic zone.

The Eocene-age Domengine Formation sandstone conformably overlies the Capay Shale. The Domengine Formation is nearly 800 feet thick in the vicinity of King Island, based on correlation of formation boundaries (top of Domengine and top of Capay Shale) on the geophysical well logs shown in **FIGURES 14 - 16**, and is composed predominately of well-sorted, clean quartzose sandstone with thin interbeds of gray siltstone and claystone. The Domengine sandstone is conformably overlain by the Nortonville shale, another regional marine shale unit that reaches thicknesses between 100 and 200 feet in the vicinity of King Island. The late Eocene-age Markley Formation overlies the Nortonville Shale, possibly as an unconformable surface. At King Island, it consists of 200 to 300 feet of interbedded marine mudstone, siltstone, and sandstone (**FIGURES 14 - 16**).

Over 3,000 feet of non-marine sediments unconformably overlie the Eocene sediments and represent the final stages of the basin filling. These sediments range in age from Miocene through the Pliocene and are capped by several hundred feet of Pleistocene to Recent alluvial and lacustrine sediments.

5.2 Rock Properties

A full range of physical, textural, mineralogical and hydraulic properties of the target injection zone (Mokelumne River Formation) and overlying confining zone (Capay Shale) have been determined through petrophysical analysis of conventional and sidewall core taken in the Piacentine 2-27 well, and wireline logs run in the Piacentine 2-27 well and the Citizen Green 1 well. This section summarizes the coring and logging programs and the analytical results.

5.2.1 Geophysical Logging Program

A comprehensive wireline open hole logging program that included porosity logs in the target injection zone was conducted by Halliburton during drilling of the Piacentine 2-27 core well in March 2013 and by Schlumberger during drilling of the Citizen Green 1 well in December 2011. The logs and information obtained during the logging programs are summarized in the table below. Copies of the logs for the Piacentine 2-27 core well are provided in **APPENDIX A**. Copies of most of the logs for the Citizen Green 1 (with exception of the nuclear magnetic resonance log and sonic log) are available at the DOGGR and gas online data site:

http://www.conservation.ca.gov/dog/Online_Data/Pages/Index.aspx.

Summary of Geophysical Log Type and Purpose – King Island Wells

Logging / Coring Program		Primary Purpose	Logging Depth	
			Piacentine 2-27	**Citizen Green 1**
Open-Hole	Mud Log	lithology, rate of penetration, gas shows	4200' - 4970'	3000' – 4995'
	Spontaneous Potential (SP) log	Sand layer definition, formation water salinity	613' - 4960'	516' - 7554'
	Dual induction log (DIL)	Formation water salinity, hydrocarbon indicator, water/hydrocarbon saturation (with porosity measurements)		
	Micro-resistivity Tool (MRT)	Flushed and invaded zone resistivity, permeability indicator		
	Gamma Ray (GR) log	Shale indicator		
	Formation Density Compensated (FDC) log	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)		
	Compensated Neutron Log (CNL)	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)		
	Sonic log (SL)	Formation interval velocity, synthetic seismograms. Can be used for porosity determination, though usually inferior to FDC/CNL.		
	Caliper log (CAL)	Show variations in borehole size and geometry		
	Electrical Micro Imaging (EMI) log	Formation texture, sedimentary features, fractures, thin-bed and lamination characterization	3800' - 4960'	Not Performed
	Nuclear Magnetic Resonance (NMR)	Clay-bound, capillary-bound and movable water; free-fluid, effective and total porosity.	3800' - 4957'	3600' - 7542'
	Repeat Formation Tester (RFT)	Depth-discrete water sampling, pressure measurement, permeability determination. Identification of USDWs, and the USDW base. Water sample collection with Multi-sample Module (MRMS).	Ran 13 pressure tests between 4630' - 4890'; and collected water sample (in 3 cylinders) at 4774'	Not Performed
Cased-Hole	Cement bond log (CBD)	Evaluate integrity of annular cement seal and identify channels that might allow fluids to migrate between formations	Surface to 4868'	Not Available

Analysis and interpretation of the Piacentine 2-27 and Citizen Green 1 geophysical logs was performed by Digital Formation, a petrophysical consulting company located in Denver, Colorado. Provided in **APPENDIX B** is the Digital Formation report, which includes the analytical methodology, formulas and rock property results, as well as composite interpretation logs, for the Piacentine 2-27 core well and Citizen Green 1 well.

5.2.2 Coring Program

During drilling of the Piacentine 2-27 core well in March-April 2013, sidewall cores (SWCs) and conventional core were collected from the Mokelumne River Formation target injection zone and the overlying Capay Shale confining unit. Core plugs were collected at 1-foot intervals from the conventional core between depths of 4,641 to 4,816 feet (ft.-MD) and 22 SWCs were collected between depths of 4,640 and 4,809 ft. The cores was transported to Core Lab in Bakersfield, California where they were slabbed, photographed, described, and underwent core spectral gamma and CT scanning. The Core Lab analyses results are provided in **APPENDIX C**.

Routine core analyses were performed on all of the core plugs and SWCs. Advanced core analyses were performed on a small subset of the core plugs, ranging from 3 to 15 samples, depending on the analysis. Sample selection for advanced analyses was based on the results of the routine analyses. The number of samples selected for each advanced analysis was based on professional judgment of the reservoir engineer regarding how many samples provided a representative sample population. General criteria for advanced analyses sample selection were to stay above the original GWC, avoid unconsolidated core material and cover the range of permeability seen in the routine samples. The following routine and advanced core analyses were performed:

Core Analyses	Description	Samples Selection Criteria
Routine Analyses (all samples)		
Porosity	Total pore space in sample as a percentage of total sample volume. Used in all reservoir volumetric calculations.	All core plugs and SWC samples tested.
Grain density	Density of reservoir solids whose value determined by rock mineralogy. Input to formula relating sample porosity and bulk density.	All core plugs and SWC samples tested.
Horizontal permeability to air	Intrinsic characteristic of rock that determines how easily air can pass through it. Measured parallel to rock layering, which is preferential flow direction in reservoir. High horizontal permeability indicator of good reservoir quality.	All core plugs and SWC samples tested.
Fluid saturation	Percentage of rock porosity occupied by water. Affects the relative permeability of reservoir with respect to air, with permeability to air decreasing as fluid saturation increases.	All core plugs and SWC samples tested.

Core Analyses	Description	Samples Selection Criteria
V-clay	Ratio of clay (or shale) volume to total rock matrix volume; expressed as a decimal. High V-clay usually indicates low reservoir quality. Used as correction factor in log porosity calculations.	All core plugs and SWC samples tested.
Advanced Analyses (No. Selected samples)		
Sieve analysis (15)	Provides particle size distribution of sample. Used in well screen and gravel pack design.	Representative sampling of upper MRF reservoir.
Vertical permeability (15)	Permeability measured perpendicular to rock layering. Indicates ability of fluid to flow vertically within layers, or between layers. Low vertical permeability characteristic of a good caprock.	1 sample in caprock (Capay Shale); rest providing representative sampling of upper MRF reservoir, including lower lobe.
Porosity and permeability at 4 confining stresses (15)	Porosity and permeability measured at confining stresses representative of reservoir pressures. Due to sediment compaction, porosity and permeability decrease with depth. Results used to derive correction factor to correct porosity and permeability measured at laboratory (ambient) pressure to reservoir pressure conditions.	Representative sampling of upper MRF reservoir.
Relative permeability (5)	In a multi-phase reservoir, relative permeability is the ratio of the effective permeability of the phase of interest to the absolute permeability, where the flow of each phase is inhibited by the presence of the other phases. Relevant to CAES application in a depleted gas reservoir characterized by multi-phase flow (air, native gas and water).	Representative sampling of upper MRF reservoir; same approx. depths as for capillary pressure samples.
Critical velocity (3)	Determine flow rate at which fines migration in reservoir begins to occur, potential causing permeability impairment.	Clean sand samples in upper MRF reservoir.
Capillary pressure (6)	Pressure necessary to squeeze a fluid through a pore throat (works against the interfacial tension between different phases); higher for smaller pore diameter. Used to characterize vertical water saturation profile and transition zone from 100% water production to 100% gas (or air) production.	Representative sampling of upper MRF reservoir; same approx. depths as for relative permeability samples.
Mercury injection capillary (6)	Provides porosity, recovery efficiency, irreducible water saturation, pore-throat size, pore-throat size distribution and threshold pressure.	Representative sampling of upper MRF reservoir; same approx. depths as for capillary pressure samples.

Core Analyses	Description	Samples Selection Criteria
Caprock Analysis - Capillary entry pressure (3)	Threshold pressure at which nitrogen injection into caprock sample shows breakthrough. Test performed at confining reservoir stress provides gas breakthrough pressure, vertical permeability to air and effective permeability to brine. Provides indication of caprock effectiveness in CAES application.	Representative sampling of caprock (Capay Shale).
Triaxial compression testing deriving the elastic constants: Poisson's ratio, Young's modulus & compressive strength (3)	Elastic constants used for fracture gradient prediction and evaluation of sanding or fines migration potential.	Representative sampling of MRF reservoir, including upper "shaled-out" lobe.
Thick wall cylinder (3)	Simulates loading conditions under downhole stresses, providing pressures at which a hole will start producing sand or cause other problems like casing collapse. Test results provides pressures at which internal hole and external wall experiences initial and catastrophic failure.	Clean sand samples in upper MRF reservoir.
Scanning electron microscopy (SEM) and thin section analysis (15)	Provides rock mineralogy, fabric and texture, authigenic constituents, and pore types.	Representative sampling of MRF reservoir; same samples analyzed by XRD.
Bulk and clay X-ray diffraction (XRD) (15)	Provides bulk rock and clay mineralogy.	Representative sampling of MRF reservoir; same samples evaluated by SEM and thin section.

Notes:
MRF = Mokelumne River Formation

5.2.3 Core and Log Analyses and Results

This Section provides a discussion of the analyses and results of core and log analysis for the Mokelumne River Formation reservoir injection zone and the Capay Shale confining unit. Selected porosity and permeability data and analysis results have been tabulated and plotted, as follows:

Exhibit	Data Source	Geologic Unit	Data and Analysis Presented
Table 3	Piacentine 2-27 Conventional Core	MRF*	Porosity and permeability at ambient stress (250 psi) and confining stress (2700 psi), average porosity and permeability (ambient and stress conditions), and ratio of stress to ambient permeability
Table 4	Piacentine 2-27 Conventional Core	MRF	Vertical-horizontal permeability anisotrophy ratio
Table 5	Piacentine 2-27 conventional core	Capay Shale	Horizontal and vertical permeability
Fig 18	Piacentine 2-27 neutron-density logs and conventional core	MRF	Cross-plot of log porosity and core porosity
Fig. 19	Piacentine 2-27 conventional core	MRF	Cross-plot of core porosity and horizontal permeability
Fig. 20	Piacentine 2-27 conventional core	MRF	Cross plot of vertical and horizontal permeability
*MRF = Mokelumne River Formation			

Mokelumne River Formation Reservoir Injection Zone

Porosity, water saturation, and permeability for the Mokelumne River Formation sands comprising the injection zone were determined based on digital analysis of geophysical logs from the Piacentine 2-27 and Citizen Green 1 and laboratory analysis of cores (convention and SWC) from the Piacentine 2-27.

A cross-plot of log and core derived porosities prepared by Digital Formation (**FIGURE 18**) indicates poor correlation between the two data sets. Conventional core plugs were taken every foot for routine core analysis, and 15 samples were analyzed for vertical permeability and permeability at confining stress. Due to the high density of core plug sampling and the various types of routine and advanced core analyses performed, the porosities derived from core analysis are considered much more reliable than those derived from geophysical log interpretation. Also, the log permeability curve on the Digital Formation composite log (**APPENDIX B**), derived from an equation that relates permeability to porosity and water saturation (Timur Equation – see Digital Formation Report in **APPENDIX B**), is considered much less reliable that the core derived permeabilities. Accordingly, the analysis below is based solely on the Core Lab analyses results.

Average (arithmetic) core porosity and horizontal permeability of the reservoir sands are 31% and 807 md, respectively (**TABLE 3**). The permeability value of 807 md is based on an average of 162 horizontal permeability measurements at ambient stress (250 psi), corrected to confining stress of 2,700 psi based on the average ratio of ambient to stress permeability of 0.282 (**Table 3**). There is a reasonably good porosity-permeability relationship (correlation coefficient of 0.77) based on a cross-plot of 162 porosity and permeability analyses of core plugs from the conventional core collected from the Piacentine 2-27 core well, as shown in **FIGURE 19**.

Vertical permeability of Mokelumne River Formation reservoir sands ranged from 278 to 17,855 mD, and the average (arithmetic) vertical to horizontal permeability anisotropy ratio is 0.80 (**TABLE 4**). A cross-plot of vertical and horizontal permeability measurements indicates a good correlation coefficient of 0.94, as shown in **FIGURE 20**.

Capay Shale Confining Zone (Caprock)

The Capay Shale is a confining zone that provides the overlying impermeable seal (caprock) for the Mokelumne River Formation reservoir at King Island. To evaluate the sealing capacity of the Capay Shale, the vertical permeability of the zone was measured (**TABLE 5**).

Two approaches were used to determine the harmonic mean vertical permeability at confining stress of the Capay Shale. The first approach took the harmonic mean of three caprock/threshold pressure analyses providing vertical permeability at 2,600 psi confining stress and one vertical permeability analysis at ambient stress (250 psi), corrected to 2,700 psi confining stress based on the average ratio of ambient to stress permeability of 0.282 (**Table 3**). The harmonic mean vertical permeability based on the first approach was 0.04 md (**Table 5**). The second approach took the harmonic mean of 17 horizontal ambient stress (250 psi) permeability measurements in the Capay Shale, corrected to 2,700 psi confining stress as described above, and further corrected to vertical permeability using the average vertical to horizontal permeability anisotropy ratio of 0.80 (**Table 4**). The harmonic mean vertical permeability based on the second approach was 0.06 md (**Table 5**). These two vertical permeability estimates are nearly the same and represent reasonable estimates of the vertical permeability of the Capay Shale at confining stress.

Caprock / threshold pressure testing was performed to test the sealing nature of the caprock. Three samples were flow-through saturated with test brine to ensure complete saturation. Nitrogen gas was injected from the top starting at 100 psi and increasing to 2,000 psi maximum pressure. Gas pressure and volume of brine produced was recorded and used to calculate the effective water permeability at each injection pressure. All three samples behaved the same in this test. During the initial flow through saturation overnight, there was no brine produced. As the injection pressure increased, there was no brine produced and the effective water permeability was non-detectable. There was no gas breakthrough at the maximum delta 2000 psi injection pressure. These results support a conclusion that the King Island reservoir caprock is an impermeable seal at reservoir conditions.

5.2.4 Air Chamber Test

A pressurized core testing program was performed to investigate the potential interaction between injected air and reservoir materials at the depleted King Island gas field reservoir. The program involved a screening-level laboratory analysis of reservoir core material to evaluate the potential for oxygen-consuming chemical reactions that could occur when air is injected into the reservoir. The program was conducted by Core Laboratories on the 4,755.65 ft. core plug from the Piacentine 2-27 conventional core collected in the Mokelumne River Formation reservoir sands. A report presenting the procedures and results of the program, including laboratory analyses of air and core samples, tables and graphs, is provided in **APPENDIX D**. A summary of the test procedures and results is provided below.

The test involved collection and analysis of air samples taken from a pressurized chamber containing the core plug sample at various time intervals and pressures. XRD and SEM analysis of the sample before the test identified minerals (pyrite, siderite and iron-bearing clays) and organic material with the potential to react with, and consume the oxygen in the air introduced into the air chamber (**APPENDIX D, Table 1**). Air samples were collected from the chamber at the end of 3, 4 and 5 days at decreasing pressures of 2,100, 1,000 and 100 psi, respectively. The air samples were analyzed for helium, hydrogen, argon, oxygen, carbon dioxide, nitrogen, methane, ethane, and carbon isotopes ($\delta^{13}CO_2$ and $\delta^{13}CH_4$ – day-5 sample only) (**APPENDIX D, Table 2**). XRD and SEM were performed on the post-test core plug sample to identify any possible mineralogical or textural changes produced by the test (**APPENDIX D, Table 1**).

At the end of the initial 3-day 2,100 psi test period, concentrations of all gas constituents except C_1 and C_2 hydrocarbons were unchanged from the initial laboratory air concentrations. Subsequent samples collected at 1,000 psi (4 days) and 100 psi (5 days) exhibited decreased oxygen concentrations and increased nitrogen, carbon dioxide, helium, and methane concentrations (**APPENDIX D, Table 2**). SEM examination of the pre-test and post-test core samples did not identify any textural or mineralogical differences, which is consistent with the small amount of oxygen consumption that occurred during the short test duration.

Delayed ex-solution of reaction products is a likely mechanism to explain the lack of gas composition change after the first 3 days. Depressurization release of natural gas originally trapped within the core sample and an induction (latency) period for the oxygen consumption reaction are additional likely causes of the initially invariant gas composition. Decreasing oxygen concentrations in days 4 and 5 indicate that oxygen was consumed during the test; however, the nature of the oxygen-consuming reaction cannot be determined based only on the gas phase analysis data.

Based on the $\delta^{13}CO_2$ data, a small portion of the carbon dioxide concentrations could be associated with King Island natural gas; however, it is likely that some of the carbon dioxide originated from reaction of the core minerals with oxygen. A likely source of the carbon dioxide is from siderite reaction with acid, with the acid produced from pyrite reaction with oxygen, or from oxidation of iron in siderite with associated release of carbon dioxide. Isotopically, a carbonate source for the carbon dioxide cannot be uniquely demonstrated because the carbon isotopic signature of the siderite is not known.

Based on the results of the 5-day test, a relatively small reduction in oxygen concentration (from an assumed initial concentration of 20% to a final 19.5%) would be predicted for field testing. Such a small change in the oxygen concentration indicates that 5-day cycle times during field testing or operations would be unlikely to significantly reduce oxygen concentrations and that a relatively small amount of oxygen depletion is likely to occur over a reservoir cycle period of one to two weeks.

5.3 Fluid Properties

There are two gas analyses and one water analysis for the King Island gas field. Gas samples were collected in the Moresco A1 well in October 1985 and in the Piacentine 1-27 in January 2013. The gas analyses are presented by **TABLES 6** and **7**, respectively. The gas analyses show that the King Island gas is predominantly methane at 91.7 percent contaminated with 8.2 percent nitrogen. The gas specific gravity is 0.589 and the heat content is 915 to 933 BTU per scf. There is a very small quantity of ethane (0.1 percent) in the gas.

A bottomhole reservoir water sample was taken in the Piacentine 2-27 well using Halliburton's Reservoir Description Tool (RDT) tool. This is the only known formation water sample and analysis for the field. **APPENDIX E** presents the complete geochemical analysis for the water sample. The total dissolved solids (TDS) measurement for the sample is 14,000 ppm and total sodium chloride is 13,000 ppm. This salinity information is used in the petrophysical calculations for the Citizen Green 1 and Piacentine 2-27 wireline logs. It is also needed to apply for an Underground Injection Control (UIC) permit with the EPA. Based on the TDS analysis results, the reservoir is not considered an Underground Source of Drinking Water (USDW), which is defined by the EPA as a formation with water TDS concentrations less than 10,000 ppm.

6. MODEL DESCRIPTIONS

6.1 Static Model

A numerical simulation model study was conducted by MHA Petroleum Consultants (Denver, CO) to help design the bubble development program, predict air/water displacement and estimate reservoir pressure levels for a given air bubble design volume. The simulation model covers the gas-productive area of the King Island gas field plus the underlying bottom water wherever there is porous and permeable Mokelumne River Formation sand. The model domain ends where the Mokelumne River Formation is truncated by a subcrop at the edge of the Meganos Channel on all four sides of the field (see Section 5.1 above).

The first step in the simulation study was to construct a three-dimensional (3D) geologic (static) model for the Mokelumne River Formation gas pool at King Island. Data provided by Doug Imperato (Section 5.1.2) included several geologic reports, maps, cross-sections, and well data including digitized well logs.

The lateral limits of the King Island gas field were determined from well log correlations (as depicted on geologic cross-sections in **FIGURES 14 - 16**), from limited reservoir pressure data for wells inside and outside of the King Island field Mokelumne River Formation reservoir (Piacentine 1-27 and King Island 1-28), and from seismic profiles and amplitude anomaly maps developed by geophysicist Tom Fassio from the field operator's 3D seismic survey (Section 5.1.2). The high amplitude anomaly on the seismic data is the result of a strong acoustic impedance contrast between the relatively high impedance Capay Shale and the relatively low impedance gas-charged reservoir. **FIGURE 21** shows that the inferred outline of the Mokelumne River Formation gas pool closely corresponds to the outline of the seismic amplitude anomaly.

6.1.1 Model Construction

Geologic reports, along with maps, cross-sections and well data including digitized well logs, were provided to MHA by Doug Imperato (Section 5.1.2) for the construction of the 3D geologic model. FIGURE 21 is a base map of the King Island field and nearby well control. The outline of the seismic amplitude anomaly is shown on this map as well as the inferred boundary of the gas pool.

A major unconformity occurs at the top of the Mokelumne River Formation (base of the overlying Eocene Capay formation) forming the top seal of the King Island reservoir. The Mokelumne River Formation sands are interpreted as an erosional domal remnant of the Eocene Meganos submarine canyon incisement. The Klein 1-28 well defines the southwest limit of the reservoir as the Mokelumne River Formation sands have been completely eroded in this location.

The geologic interpretation of the King Island Gas Field has evolved with access to seismic amplitude data. In addition, the recent drilling of the Citizen Green 1 and Piacentine 2-27 wells provided additional data beyond the well data from the Moresco A1 and Piacentine 1-27 wells that allowed the reservoir geometry and geology to be interpreted with a greater degree of certainty. The Mokelumne River Formation was divided into an Upper and Lower Reservoir based on correlations across the King Island field area (see **FIGURE 22**). This interpretation helps establish the structural and stratigraphic relationship of the flow units in the reservoir. The structure maps used to build the static model are shown in **FIGURES 23** - **25**. The field is interpreted as an anticlinal feature with two structural closures.

There are nine wells in the vicinity of the King Island gas pool with digitized well logs. One well (Ripken 21-1) was considered to be located too far northwest of the King Island pool to be of use. All of these wells were input into the King Island static model for use in building the structural framework and calculating and distributing porosity and water saturation.

6.1.2 Structural Framework

The Schlumberger Petrel software (2012.4) was used to build the King Island 3D geologic model. Prior to building the structural framework of the Top Mokelumne River Formation structure contours were remapped in Petrel and tied exactly to all well control. **FIGURE 26** shows the areal extent of the model to include five key wells: Moresco 1, Citizen Green 1 (original hole and re-drill), King Island 1-33, Piacentine 1-27 and Piacentine 2-27. Two zones were constructed; an Upper Reservoir Sand and a Lower Reservoir sand **(FIGURE 27)**. The model cell size was kept small to reduce edge cell effects under the Capay Shale unconformity surface. The final 3D static model statistics contains 459,270 grid cells with 63 layers (81 x 90 x 63) as shown on **FIGURE 28**. The x-y dimensions of the cells are 50 ft. by 50 ft. and the layers are an average of 4.7 feet thick.

6.1.3 Porosity Distribution

The King Island 1-28 and 1-33 wells have sonic porosity logs only and are located outside the subcrop limit of the Mokelumne River Formation reservoir. The only other wells in the King Island field with porosity logs are the Citizen Green 1 and Piacentine 2-27 wells. Both wells have density/neutron as well as sonic porosity logs and penetrate the Mokelumne River Formation reservoir. The Piacentine 2-27 well has petrophysical well logs with a calculated porosity curve calibrated to conventional core data (see Section 5.2.1 and 5.2.3).

The general scarcity of porosity logs in the Mokelumne River Formation reservoir introduces uncertainty in the porosity and water saturation distributions within the 3D static model. Geostatistical simulation is well accepted in the petroleum industry as a method for characterizing heterogeneous reservoirs with limited data by interpolating between the measured well data at discrete locations. The King Island model porosity grids were built using Sequential Gaussian simulation (a geostatistical method used to simulate continuous variables such as petrophysical properties) with the Citizen Green 1 and Piacentine 2-27 upscaled density porosity and a generated histogram distribution based on the well logs as input. The resulting stochastic property distribution has an average porosity of 33 percent in the Mokelumne reservoir. **FIGURE 29** shows a west to east cross-section of distributed porosity in the Mokelumne reservoir.

The overall lack of modern well logs within the field area made determination of water saturation difficult. Although the Citizen Green 1 and Piacentine 2-27 wells had porosity logs through the reservoir sands, the lower part of the Mokelumne reservoir in both wells had been depleted of gas and swept by water. Capillary pressure data were used to define the initial water saturation distribution in the dynamic model (Section 6.2.2); however, for volumetric calculations in the static model, the initial water saturation was set as an average value of 22 percent based on calculated water saturation for the Citizen Green wireline logs through the free gas cap. Subsequent capillary pressure core analysis tests (**APPENDIX C**) showed initial water saturations in the range of 10 to 20 percent.

6.1.4 Net-to-Gross Distribution

Reservoir net-to-gross (NTG), representing the ratio of net sand thickness to gross interval thickness, was determined separately for the Upper and Lower reservoir sands. Based on total and net sand thickness maps provided by PG&E's geologist, a NTG ratio was determined for each well and then field wide NTG contours were constructed following the general outline of the thickness maps. The NTG contours were mapped to create a surface that was then applied to the model in each zone. **FIGURE 30** shows the Upper Reservoir and Lower Reservoir NTG surfaces applied in the model.

6.1.5 Volumetric Gas-in-Place

The static model volumetrics were calculated for the reservoir by applying a flat (-4,783 ft. subsea) initial GWC to the distributed rock properties within the 3D model. The Mokelumne gas pool covers 213 acres with 12,654 acre-ft. The IGIP for the static model is 14.9 Bscf assuming a constant initial water saturation of 22 percent and an initial Gas Formation Volume Factor (Bgi) = 0.00673 scf/rcf. This is only a preliminary estimate for use in verifying that the constructed static model has sufficient gas-in-place for the next phase of the study, the dynamic modeling phase.

6.2 Dynamic Model

The King Island static model was exported from the Petrel software as a series of ASCII grid files (structural framework, porosity, Petrel well connection and well completion files) in preparation for the dynamic modeling phase of the project. These formatted files are compatible as input to the ECLIPSE simulation software package (Schlumberger). No further upscaling, or homogenization, was applied to the geologic model in the x,y,z direction.

A dynamic simulation model was created from the static model to match the reservoir performance and simulate the process of air injection into the reservoir for CAES testing and full-field development scenarios. The simulation model consists of 147,983 active gridblocks or cells. Each cell is 50 feet by 50 feet in area. There are a total of 63 layers. The layers vary in thickness from 4 to 5 feet thick with an average of 4.92 ft. in thickness. The dynamic model grid is created using corner-point geometry after importing the static model framework (also corner-point geometry) constructed with the Petrel software. The model grid is shown by **FIGURES 31** and **32**. Four cross-sections (two N-S and two W-E) are made through the entire model grid to illustrate the gridding scheme. The locations of the cross-sections are given in **FIGURE 33**. The same four cross-sections will be used in future figures in this report to display other model properties and simulation results.

The King Island model is much more than a conceptual model; it is intended to be a replica of the gas reservoir. It is constructed based on the best available geologic maps, cross-sections and information from wireline well logs. The gas reservoir is bounded at the top by the Capay Shale, an impermeable cap rock, and on all four sides by the Meganos Channel fill, which consists of impermeable mudstones and shales.

6.2.1 Model Construction

The geologic structural framework of the dynamic model is populated with the structural depths from the static model. **FIGURES 34** and **35** are grid displays of the depths assigned to the gridblocks in the dynamic model. (Compare **Figure 34** for the dynamic model with **Figure 26** for the static model to confirm that the top of structure for the Mokelumne reservoir is the same between the two models.) The dynamic model grid cells are populated with porosity, permeability and initial water saturation arrays based on the well log data and estimated petrophysical correlations. Porosity values are sourced from the static model output and are based on the available density-neutron wireline log information upscaled and distributed stochastically throughout the model area (**FIGURES 36** and **37**).

The gridblock permeabilities are determined using a porosity-permeability transform derived from the Piacentine 2-27 conventional core information described in Section 5.2.2 and presented by **FIGURE 38**. The transformed permeabilities are further reduced by a factor of 0.282 (from Table 3) to adjust from the laboratory confining stress conditions (250 psi) to the in situ reservoir stress conditions (2,700 psi) for each grid cell. The permeability distribution in the dynamic model is shown by **FIGURES 39** and **40**.

6.2.2 Saturation Distribution

An initial GWC of -4,783 ft. subsea is used in the dynamic model. For the initial water saturation distribution above the GWC, the model uses the Leverett J-Function[6] option to scale the water-gas capillary pressure (Pc) functions (**FIGURE 41**) according to the porosity and permeability values in each gridblock. The J-function relationships assign a unique Pc curve and initial water saturation for each simulation cell based on porosity and permeability of that cell. Above the GWC, the gas saturation is the pore space (porosity) not occupied by the initial water saturation. **FIGURE 42** shows a comparison between the Pc curves for the dynamic model versus the measured lab data (Piacentine 2-27 core).

Water influx models are mathematical models that simulate and predict aquifer performance. When successfully integrated into a reservoir simulator, the net result is a model that effectively simulates performance of a water drive reservoir such as King Island. To simulate the bottomwater drive identified for this reservoir, a Carter-Tracy infinite-acting aquifer is attached to the bottom-most layers of the model grid (Carter-Tracy is a popular mathematical aquifer model). This analytical aquifer is used to simulate the water influx into the gas-filled pore space known to

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[6] The Leverett J-Function is a mathematical model for correlating capillary pressure data in unconsolidated sands with similar pore types and wettability but with different permeabilities.

have occurred during the producing life of the reservoir. **FIGURES 43** and **44** present the distribution of initial gas saturation in the dynamic model.

6.2.3 Relative Permeability

Straight-line relationships are used for the gas-water relative permeability curves in the ECLIPSE model (**FIGURE 45**). The initial water saturation endpoints of the relative permeability curves are scaled to the specific initial water saturation assigned to each grid cell by the Leverett J-Function. This is the end-point scaling feature of the ECLIPSE software and the purpose is to make the initial water saturation immobile in all grid cells above the initial GWC.

The minimum or residual gas saturation (S_{gr}) to water displacement in the relative permeability curve is defined using the S_{gr} versus porosity relationship reported by the Gas Research Institute (Katz, 1964).

$$S_{gr} = (-1.2778 \text{ x Porosity, fraction}) + 0.6172$$

This equation is set in the Eclipse model with the only exception that S_{gr} is set to zero for any cell below the original GWC. It was suggested that the inferred residual gas saturation data (1-Sw) from the Piacentine 2-27 core may be compared to the residual gas saturations predicted by the Katz correlation above, however the core data had no resemblance to the Katz correlation. This is likely due to the expansion of the natural gas as the core was depressurized during retrieval.

The model is initialized at original conditions for the initial GWC (-4,783 ft. subsea) and discovery reservoir pressure (rounded to 2,100 psig). The IGIP in the model before calibration was 15.2 Bscf.

6.2.4 Pore Volume vs Depth

To define the strength and volume of the aquifer influx, a hydrocarbon pore volume versus depth analysis was made with the King Island dynamic model. A graph of the cumulative hydrocarbon pore volume at depths above the original GWC is shown by **FIGURE 46**. Horizontal lines drawn on this exhibit represent the depths and times at which the King Island wells were impacted by water influx into what is assumed to be the bottom perforations open at the time. The total volume of water influx into the gas-filled pore space is about 19.2 million reservoir barrels.

7. RESERVOIR SIMULATION

7.1 ECLIPSE Simulator

The simulations in this study were performed using the ECLIPSE commercial numerical simulator, a Schlumberger software product. ECLIPSE is a three-dimensional (3-D) finite difference black oil simulator used for modelling oil and natural gas hydrocarbon systems. For the King Island reservoir, the model is used in the fully compositional mode (E300) for simulating the injection and withdrawal of air (and oxygen-depleted air). In this mode, the various components of the natural gas (methane, ethane, nitrogen and CO_2) and air (nitrogen and oxygen) are specified in the model with their own properties of viscosity, density and compressibility (**TABLE 8**).

Before going to the fully compositional mode, the simulator was run in the standard "black oil" (E100) mode, represented as a two-component system of natural gas and water, to complete the history matching portion of the simulation work. The E100 version of the model ran more quickly than the E300 version and output was more manageable. After the E100 model was calibrated to the historical reservoir performance, the model was converted to the compositional E300 version to be able to simulate CAES operations. The entire history match period was re-run for the converted E300 model to confirm that the history match calibration was preserved for the conversion from E100 to E300.[7]

7.2 History Match

7.2.1 Calibration

To make the model as realistic as possible, it was calibrated (history-matched) to the historical production and reservoir pressure performance for the three producing gas wells in the field. During history-matching, the actual gas production rate is specified for each well in the model and the wells are 'matched' to the reported flowing and static bottomhole pressures and water production rates. The calibration process involves global adjustments to the pore volume (variable porosity and initial water saturations), trapped gas saturation, variable permeability and the use and location of the infinite-acting water aquifers.

The graphs showing the model history match are presented by **FIGURES 47** through **55**. The history matching exercise seeks to establish as best as possible the current reservoir conditions of gas/water saturation and pressure distributions prior to the start of the compression testing program. A better measure of the quality of the history match, as far as water production is concerned, is a comparison of the location of water influx in the reservoir versus the location of water encroachment in the model. This comparison is given in **APPENDIX F** which is a more detailed examination of the history match results for the water influx.

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[7] For a period of time during the dynamic modeling effort, the E100 model was optionally configured as a three-component system of water, natural gas and solvent gas. The solvent option in E100 (as it is referred to) was used to track the injected air volumes independent of formation water and any 'native' free gas remaining in the reservoir. The solvent was defined using the properties of air (viscosity, density, compressibility, etc.) which differ from the properties of the residual natural gas. The solvent and natural gas in the reservoir are immiscible, and do not mix at the reservoir temperature and pressure conditions; however, the density differences between air (more dense) and natural gas (less dense) are honored by the simulator. Use of the solvent option provided valuable insight into the interaction between the injection air and the native gas in the reservoir. The solvent option was abandoned in favor of a fully compositional model after it was determined that greater precision was required for tracking the methane concentration of the native gas in the reservoir during injection and withdrawal periods of the compression testing program and CAES full field operations. All simulation results presented in this report are for the E300 model.

7.2.2 Remaining Gas-in-Place

The IGIP determined for the final history-matched dynamic model is 13.794 Bscf. This is the volume of natural gas that results in the best simulation fit of the historical production and pressure performance of the three field producers. (Note: the 13.8 Bscf is less than the 15.8 Bscf from the P/z plot because water influx was impacting reservoir pressures immediately after the start of gas production.) The cumulative gas production from the main King Island field (through January 2014) is 10.594 Bscf (excluding 0.1 Bscf from the King Island 1-28 well which was determined to have produced from a sand in the Meganos Channel Fill that was not hydraulically connected to the Mokelumne River Formation reservoir). The cumulative gas recovery factor is 76.8 percent. This means that there is about 3.2 Bscf of native natural gas remaining in the reservoir. Of the 3.2 Bscf remaining natural gas, the simulation model predicts approximately 1.0 Bscf is free gas located in the two attic gas cap areas and 2.2 Bscf is residual gas which is trapped in the water swept portions of the reservoir.

The remaining free attic gas is found in the two structural highs in the field and it does not extend over the entire reservoir area. The ECLIPSE model finds that the attic gas in the east structure is about 90 MMscf and that there is 920 MMscf of free gas in the west structure. Each structural high has a different GWC at the end of the history match. The west area GWC in the Citizen Green well is -4,708’ subsea from logs and in the model. The estimated GWC for the east structure, predicted by the model, is -4,678’ subsea. The different contacts are related to the saddle between structural areas and the continued gas production from the east lobe (Piacentine 1-27) while the attic gas in the west lobe was not being produced until tapped by the Citizen Green well.

7.3 Compression Testing Program

PG&E proposes to conduct a field test for air injection and withdrawal from the King Island Gas Field. The proposed compression testing program will involve the injection of oxygen-depleted air in an injection/withdrawal (I/W) well over a period of two months to build an “air bubble” approximately 500 million standard cubic feet (MMscf) in size and conduct a series of injection, flow and pressure transient tests while observing the reservoir response. Based on the results of testing with oxygen-depleted air, a short test involving the injection of ambient air may be conducted if certain decision criteria are met, including stringent safety criteria. The total duration of the compression test is not expected to exceed 90 days.

Test Phase	Test Activity	Tentative Duration (Days)	Cumulative Test Duration (Days)
1 Bubble Building	N2 injection at up to 14 MMscfd	44	44
	Injection Falloff Test (FOT)	2	46
2 Bubble Equilibration	Shut-in Period	2	48
	Multi-rate Injection Test up to 10 MMscfd	1.5	49.5
	Shut-in Period	3	52.5
3 Withdrawal/Injection Cycle Testing	Well Cleanup and Shut-in Period	2	54.5
	Isochronal Test (flow after flow) up to 30 MMscfd	0.5	55
	Shut-in Period	2	57
	Series 1: N2 cycling up to 15 MMscfd withdrawal and up to 10 MMscfd re-injection	3.5	60.5
	Shut-in Period	4	64.5
	Series 2: N2 cycling up to 45 MMscfd withdrawal and up to 10 MMscfd re-injection	3.5	68
4 Preliminary Data Evaluation and Post Test Equilibration	Evaluate data and make decisions regarding further testing with ambient air	7	75
5 Ambient Air Testing (as directed)	Injection of ambient air at up to 10 MMscfd followed by flow testing up to 25 MMscfd	11	86

Notes:

1. Actual duration of the test phases may change based on equipment performance under field operating conditions. The test will be followed by a post-test monitoring period up to 9 months.
2. N2 = oxygen-depleted air with an oxygen content less than approximately 5 percent.

The compression testing program is divided into five phases as summarized above and presented graphically by **FIGURE 56**. The phases are 1) bubble building, 2) bubble equilibration and isochronal testing, 3) withdrawal and injection cycle testing, 4) post-cycle testing data evaluation and 5) additional ambient air testing.

The medium injected into the depleted gas reservoir at King Island will be air with its oxygen content depleted to a molar concentration of approximately 5 percent. This depleted air will consist of the following components: 94 mole % nitrogen; 5 mole % oxygen; 1 mole % argon; and traces of carbon dioxide and other gases.

If a decision is made to conduct injection/withdrawal testing using ambient air, the chemical makeup of the injected fluid will be as follows: 78 mole % nitrogen; 21 mole % oxygen; 1 mole % argon; and traces of carbon dioxide and other gases.

Since air is composed mostly of nitrogen, the compressibility of oxygen-depleted air and ambient air is essentially identical. Both gas mixtures are essentially inert to the proposed tubing and casing materials. The main difference between the two gas mixtures is the presence of sufficient oxygen in ambient air to allow combustion if a combustible gas is present at a concentration in excess of the LEL. This is important because even a depleted gas reservoir will contain some residual gas, the injected air will mix with residual gas in the reservoir to some extent, and if air is produced from the reservoir it may contain small amounts of natural gas. Combustion would require three components, known as the three legs of the combustion triangle: fuel, oxygen, and an ignition source.

Prior to a decision to proceed with injection testing using ambient air, the data from the tests conducted using oxygen-depleted air will be evaluated to determine if such a test can be conducted safely.

7.3.1 Bubble Development

The bubble development portion of the simulation was intended to answer at least two questions: 1) what size bubble is required to reduce the potential for water production during withdrawal testing and 2) what size bubble is needed to displace the native natural gas out away from the I/W wellbore to limit the concentration of methane in the withdrawal gas to below the LEL level? At the same time, the injection rate to achieve an adequate bubble size had to be determined for an assumed 60 days of continuous air injection.

Three main measures determined whether the bubble size was adequate. First, the vertical distance between the bottom of the wellbore completion and the air-water interface must be adequate to reduce the potential for water production via water coning during the withdrawal period. Second, there must be enough stored air so that the average pressure in the reservoir is not dramatically affected during the air cycle testing. A maximum pressure deviation of about 10 percent is considered to be acceptable. Finally, for safety purposes, the methane concentration (or native natural gas) in the withdrawal gas must be less the lowest concentration (percentage) in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). At a concentration in air lower than the LEL, gas mixtures are "too lean" to burn.

Methane gas has a LEL of five percent. If the withdrawal gas has less than five percent methane, an explosion cannot occur even if a source of ignition is present. Given that this field test is the first known test of CAES in a natural gas reservoir, for safety measures, the injected air will be depleted of oxygen (to 5 mole %) for the primary 500 MMscf bubble. Subsequent ambient air testing is included in the testing program, as directed, but only if it is determined that the methane concentration in the withdrawal stream will be sufficiently below the LEL.

Various bubble sizes were investigated with the calibrated King Island model. The largest size was 950 MMscf and the smallest size was 500 MMscf. The final selected size of 500 MMscf was found to be adequate to achieve the desired withdrawal cycling rates without significant water production (less than 80 barrels per MMscf), less than 200 psi drawdown in the reservoir around the I/W well, and with very low concentration of methane (less than 1 percent). The bubble could be built with compressors sized to achieve this volume in the less than a 60 day period (13 MMscfd injection).

The size of the proposed bubble (0.5 Bscf) is between 3 - 4 percent of the estimated IGIP in the King Island Gas Field (13.8 Bscf). The results from the Eclipse model for the bubble development (beginning, middle and end) are shown in **FIGURES 57** through **62**. These figures show the methane fraction in the model cells because it is the best parameter from the compositional simulator output to visualize the location of the injected bubble. The grey areas in the areal view and cross-sectional views through the model are gridblocks where the methane concentration is less than 1 mole percent. Methane concentration is very low in these cells where the oxygen-depleted air injectate has completely displaced the native gas and mobile water. The methane concentration is at 92 mole percent (red areas) where only native gas is present in the gridblocks in the form of free gas saturation or trapped residual gas saturation in the water swept areas. **FIGURE 63** is another cross-section view showing methane concentration and the extent of the bubble at the end of Cycle Test Program 1.

7.3.2 Iso-Thermal Cycle Testing

The withdrawal and re-injection cycling sequence shown in **FIGURE 56** is simulated with the King Island model.[8] After the bubble is built and the isochronal testing performed, there are two periods of injection/withdrawal cycling for the test well. Each cycling period is a week in duration alternating between withdrawal and re-injection of oxygen-depleted air. The daily cycle rates and volumes are designed to simulate the demand curve for a full-scale CAES facility. This is expected to be a 24-hr cycle repeated five days a week with full mass-balance replacement of the air bubble on weekends.

The cycling test sequence used in the dynamic model simulation is presented in **TABLE 9**. The predicted methane rates and water rates during the cycle testing are show by **FIGURES 64** and **65**. The methane concentration at the end of Phase 3 of the testing program is approximately the same as the methane concentrations for the end of the bubble build (**FIGURES 61 and 62**).

The bottomhole pressures predicted during the entire compression testing program are shown on **FIGURE 66**. In addition, a simulation case was run to investigate the pressure falloff during the decommissioning of the reservoir post-compression testing. The average reservoir pressure for the field, predicted to increase by 250 psi during the bubble build and cyclic testing phases, is shown to decrease slowly over time after the ambient air testing phase. The model is run for a

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[8] The simulations are done for a constant reservoir temperature of 120 degrees F. Near wellbore thermal effects are not considered in this model.

full year after all testing is completed to investigate the pressure falloff rate over that period. **FIGURE 67** shows the pressure falloff and water efflux volumes for the attached aquifer.

7.3.3 Methane Concentration

A primary benefit of the King Island dynamic model is the ability to predict the movement of the native natural gas (methane) in the reservoir in response to air injection (oxygen-depleted air or atmospheric air) during the proposed compression testing program. The safe operation of the field test is the overriding priority and therefore the test design must mitigate any possibility of the potential for explosive conditions in the wellbore and surface equipment due to reaching the LEL for methane in the withdrawal gas. Because there is numerical dispersion (“smearing”) inherent in any simulation model as a function of the size and shape of the grid blocks, a sensitivity analysis was made with the gridding around the I/W well in the dynamic model. Local Grid Refinement (LGR) cases (4) were run to investigate the gridding effects on predictions of methane concentration. Grid block sizes ranged from 50 ft. x 50 ft. size (original) down to a 5 ft. by 5 ft. size around the I/W model well as well as a radial LGR in I/W well block only.

The LGR sensitivity analysis found that there is a small impact on the level of predicted methane concentrations in the withdrawal gas and in the grid cells surrounding the I/W well, generally the smaller the gridblocks, the lower the predicted methane concentration (**FIGURES 68** and **69**). The LGR grid block sizes are noted on each display in **FIGURES 68 and 69**. For the cycle testing in the Phase 3 period (i.e. 42-63 days with oxygen-depleted air – **FIGURE 56**) there is minor improvement with finer grid cells. In no case does the methane concentration exceed 0.5 percent methane in the withdrawal stream. The %methane is higher during the optional Phase 4 withdrawal testing (ambient air) due to among other things a longer withdrawal period, but the model prediction never goes above 1.0 percent methane in the withdrawal stream.

7.4 Full Field Development Modeling – Pre Testing

Following the simulated compression testing program, the King Island dynamic simulation model was used to predict the reservoir performance for a full scale CAES operation. Full scale CAES operation for King Island is defined as the reservoir development sufficient to support a 300 megawatt CAES plant generating power for peak demand periods up to 10 hours. In terms of withdrawal rate, the surface requirement for a 300 megawatt plant is expected to be a total field-wide equivalent deliverability of 1.1 Bscf per day.

The conceptual design for the CAES operation includes the drilling of vertical and horizontal wells into the reservoir. The vertical wells are used to create a large “working volume” air bubble in the reservoir. The permeable sands of the Mokelumne River Formation, including the gas reservoir and the underlying aquifer, comprise the injection zone that will experience increased pressures as a result of the air injection. As air is injected, the displacement of the native natural gas and water will cause pressures within the water-invaded gas reservoir sands in the uppermost portion of the Mokelumne sands to increase and this pressure increase is expected to be transmitted throughout the reservoir sands relatively rapidly. The increase in pressure will cause some water to flow slowly out of the reservoir through the underlying shale and siltstone and into the underlying aquifer sequence. In addition, water flow and pressure will take place laterally until it reaches the relatively impermeable shales deposited at the edge of the Meganos Channel. The lateral propagation of pressure will be limited by the lateral extent of the reservoir and underlying aquifer sands at the King Island.

7.4.1 Design Criteria

The original design criteria for the full field plan investigated by the King Island model are shown by **FIGURE 70**. This simulation was intended to be a first approximation of what might be developed for a 300 MW CAES plant.

A withdrawal/injection schedule consisting of 10 hours withdrawal followed by 10 hours of injection was used for a daily cycle (total 24 hrs. with two 1-hr transition shut-in periods). The injection rate is 50 percent of the withdrawal rate based on original daily injection design criteria (could be higher depending on facility injection equipment). This cycle is repeated daily for a week in the simulation model then the depleted volume of air is replaced by air injection over the corresponding weekend such that there is no net change in reservoir volume or pressure by the end of a 7-day period, i.e. zero bubble growth.

7.4.2 Well Plan

The well plan for the full field CAES simulation case is shown by **FIGURES 71** and **72**. A number of different well plans were investigated with the dynamic model for a variety of vertical and horizontal well combinations. The hybrid case presented with this report provided the best results in terms of minimizing methane concentration during the initial plant withdrawal cycles. It consists of 11 vertical (FF1 – FF11) and 12 horizontal wells (FFH1 – FFH12). The vertical wells are completed in the top 54 ft. (11 layers) of the reservoir (**FIGURE 73**). The horizontal well laterals in the model are placed just above the original GWC and extend 500 ft. in length.

In addition, four additional aquifer production wells (WAT1 – WAT4) are needed to remove water from the reservoir during the bubble building period. Without the water production, the reservoir pressure will quickly increase above the maximum assigned BHP limit of 3000 psi. Although, there is water efflux back into the aquifer, it is at a very slow rate (consistent with the rate at which water came into the reservoir under primary production) such that there needs to be supplemental water removal to be able to build the project air bubble in a reasonable period of time, in this case, the bubble build period is 14 months (**FIGURE 74**). A total of 7.65 Bscf of air is injected in addition to the 0.5 Bscf of air injected during the compression testing program for a total bubble size of 8.15 Bscf.

7.4.3 Simulated CAES Operations

The results for the CAES full field operation case were obtained in an iterative manner primarily to minimize methane concentration in the withdrawal air. It is not an optimized case and it contains certain inefficiencies; for example, there are wells, horizontal and vertical, used for injection but not used during the withdrawal cycle. Nevertheless, the presented case is a good demonstration of the feasibility of a proposed CAES operation in the King Island Gas Field. The full field bubble development stages in the model (beginning, middle and end) are shown in **FIGURES 75** - **80**. The average methane concentration in the produced air during the withdrawal/injection cycling of air for the CAES power plant operation is shown in **FIGURE 81** for the first few cycles. The %methane is below 3 percent for the field-wide average for this case although some individual wells produce up to 9 percent methane (another example of why this is not an optimized case). As expected, the %methane decreases with continued CAES cycle operations (**FIGURE 82**). Additional results and displays from the full field case are included in **APPENDIX G.**

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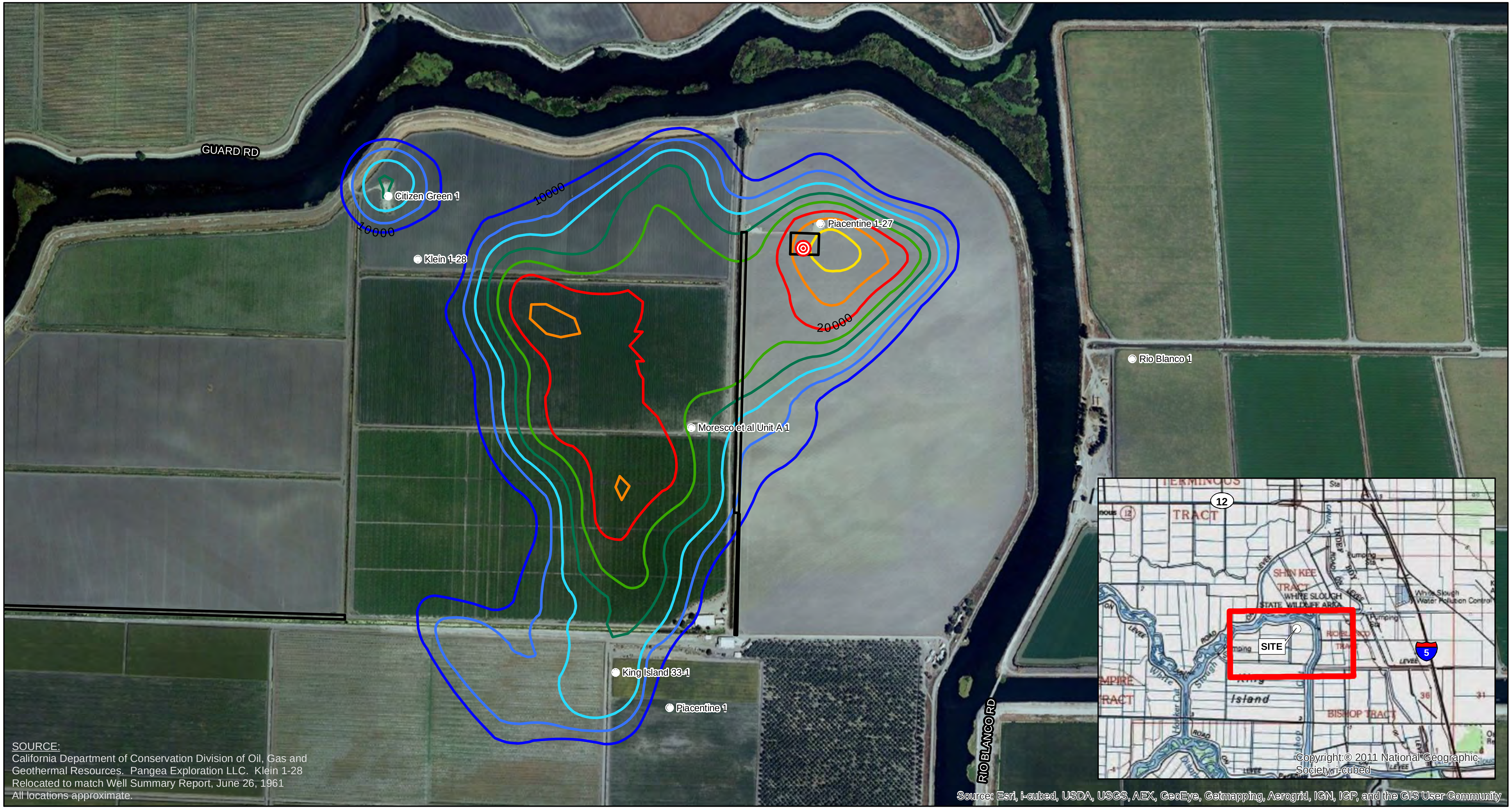
A513: King Island Map



SOURCE:
California Department of Conservation Division of Oil, Gas and Geothermal Resources. Pangea Exploration LLC. Klein 1-28
Relocated to match Well Summary Report, June 26, 1961
All locations approximate.

Copyright:© 2011 National Geographic Society, i-cubed

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

LEGEND

◎ Approximate Top Core Target Location (Approximately the same location as the surface location due to vertical drilling)

○ District 6 Wells

Seismic Amplitude Units

		—	14000	—	20000
—	10000	—	16000	—	22000
—	12000	—	18000	—	24000

N
W E
S

0 1,250
Feet

PG&E
CAES PROJECT

WorleyParsons
resources & energy

SWL	MA	1/4/2013
108010-00365	2E	

KING ISLAND GAS FIELD
TARGET LOCATION

A514: Kings Island Cultural Resource Survey Final

Cultural Resource Survey for the PG&E CAES – King Island Project, San Joaquin County, California

Prepared for

Pacific Gas and Electric Company

Prepared by

SWCA Environmental Consultants

October 2012

CULTURAL RESOURCE SURVEY
FOR THE PG&E CAES – KING ISLAND PROJECT
SAN JOAQUIN COUNTY, CALIFORNIA

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SWCA Project No. 23910
SWCA Cultural Resource Report No. 12-392

October 2012

Keywords: Cultural resource survey; 4 potential cultural resources; 41.4 acres; San Joaquin County; Terminous quadrangle; Township 3 North, and Range 5 East

Archaeological and other heritage resources can be damaged or destroyed through uncontrolled public disclosure of information regarding their location. This document contains sensitive information regarding the nature and location of archaeological sites which should not be disclosed to the general public or unauthorized persons.

Information regarding the location, character, or ownership of a cultural resource is exempt from the Freedom of Information Act pursuant to 16 USC 470w-3 (National Historic Preservation Act) and 16 USC Section 470(h) (Archaeological Resources Protection Act).

MANAGEMENT SUMMARY

Purpose and Scope: SWCA Environmental Consultants (SWCA) was retained by Pacific Gas and Electric Company (PG&E) to conduct a cultural resource study in support of the PG&E Compressed Air Energy Storage (CAES) – King Island Project (project). The study area consists of 16.75 hectares (41.4 acres) of land located approximately 14.25 kilometers (8.9 miles) southwest of the City of Lodi in San Joaquin County, California. The cultural resource study consisted of a cultural resource record and literature search, Native American consultation, cultural resource survey of the study area, and preparation of a cultural resource technical report documenting the results of the inventory and providing management recommendations.

Dates of Investigation: A search of the California Historical Resources Information System (CHRIS) was conducted by the Central California Information Center (CCIC) at California State University, Stanislaus in Turlock, California, and the results were received on August 28, 2012. Cultural resource specialists conducted an intensive-level cultural resource survey on August 28, 2012.

Findings of the Investigation: Seven prior cultural resource studies have been conducted within a 1.6-kilometer (1-mile) radius of the area of potential effects (APE), one of which included a portion of the APE. The records and literature search also indicates that five cultural resources have been previously recorded within a 1-mile radius of the APE, none of which are located in the study area. Three buildings (SWCA-KING-1, SWCA-KING-2, and SWCA-KING-3) were identified in the study area along one of the potential access roads (Alternate B). Visual observation and initial research of these buildings suggest that they may be older than 50 years and as such, could be potential cultural resources. SWCA archaeologists did not identify any other cultural resources in the APE.

Investigation Constraints: Ground visibility was generally poor throughout the study area due to obstruction by vegetative ground cover, pavement, and gravel. A portion of the study area along the eastern side of Alternate B was unable to be fully surveyed to the full 25-foot-wide buffer from the edge of the access road due to an adjacent waterway.

Recommendations Summary: SWCA cultural resource specialists identified three buildings and an irrigation canal along Alternate B as a result of the intensive-level survey (SWCA-KING-1, SWCA-KING-2, SWCA-KING-3, and SWCA-KING-4). Visual observation and initial research of these resources suggest that they may be potential cultural resources. Until these resources are formally recorded and evaluated, SWCA recommends that they be treated as though they are significant, and that the project avoid impacting them. Alternate A would not have direct or indirect effects on these buildings, and SWCA recommends that the project use this access route, while avoiding the use of Alternate B. If it becomes necessary to use Alternate B, SWCA recommends that SWCA-KING-1, SWCA-KING-2, SWCA-KING-3, SWCA-KING-4 be formally evaluated to determine their significance before the start of any construction activities.

However, in the event that cultural resources are discovered during construction grading, trenching, or excavation, project personnel should halt earth-moving activities in the immediate area and notify a qualified archaeologist to evaluate the resource. In the event of the discovery of human remains during project implementation, relevant state law shall be followed, beginning with a cessation of disturbance and the placing of a call to the county coroner.

Disposition of Data: This report will be on file with the following entities: the CCIC at California State University, Stanislaus; PG&E; and SWCA. All field notes and records related to the current project are on file at SWCA's Pasadena office. All geographical information systems data created during this study is on file at SWCA's Pasadena office and PG&E.

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INTRODUCTION

SWCA Environmental Consultants (SWCA) was retained by Pacific Gas and Electric Company (PG&E) to conduct a cultural resource study in support of the PG&E Compressed Air Energy Storage (CAES) – King Island Project (project). The study area consists of 16.75 hectares (41.4 acres) of land located approximately 14.25 kilometers (8.9 miles) southwest of the City of Lodi in San Joaquin County, California. The cultural resource study consisted of a cultural resource record and literature search, Native American consultation, cultural resource survey of the study area, and preparation of a cultural resource technical report documenting the results of the inventory and providing management recommendations.

Project Description

The project would use renewable energy from sources such as wind to inject compressed air into an underground reservoir and then use it to help power a turbine generator during peak periods when the energy is needed most. It would be implemented in three phases: site selection and feasibility analysis, licensing and permitting, and construction and operation.

The King Island reservoir site consists of the expansion of the existing Piacentine well pad to the west for a total area of 42 × 67 meters (m) (140 × 220 feet). The well pad will support a drilling rig and other equipment for the purpose of core drilling tests to determine whether the King Island reservoir is a viable candidate for the CAES project. Construction of the well pad will require importing non-native fill material (e.g., sand and gravel) to stabilize the site so that it can support a drilling rig. Access routes may also require grading prior to construction. Site preparation will include importing gravel and sand and performing grading and compaction, and will occur over a 1- to 2-week period starting as early as October 2012. Core drilling is planned to start as early as November 2012 following site preparation, and will consist of mobilizing a drill rig with supporting equipment, conducting core drilling to approximately 1,524 m (5,000 feet) below the surface.

Area of Potential Effects

An area of potential effects (APE) is defined as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties (36 Code of Federal Regulations [CFR] 800.16(d)). The proposed project is located within unincorporated San Joaquin County in an area primarily characterized by agricultural land use. The archaeological or direct APE boundary represents portions of the study area that will be directly affected by the proposed undertaking, and includes areas where ground disturbance may result from the proposed project. Specifically, the direct APE consists of the construction footprint, or well pad site, and two potential access roads (Alternate A and Alternate B). The vertical APE extends to approximately 1,524 m (5,000 feet) below the existing ground surface, or the depth to which core drilling will be conducted. A study area was established to include both direct and indirect effects, and included an approximately 61-m (200-foot) buffer around the well pad site, and a 7.6-m (25-foot) buffer from the edges of each of the potential access roads (Figure 3).

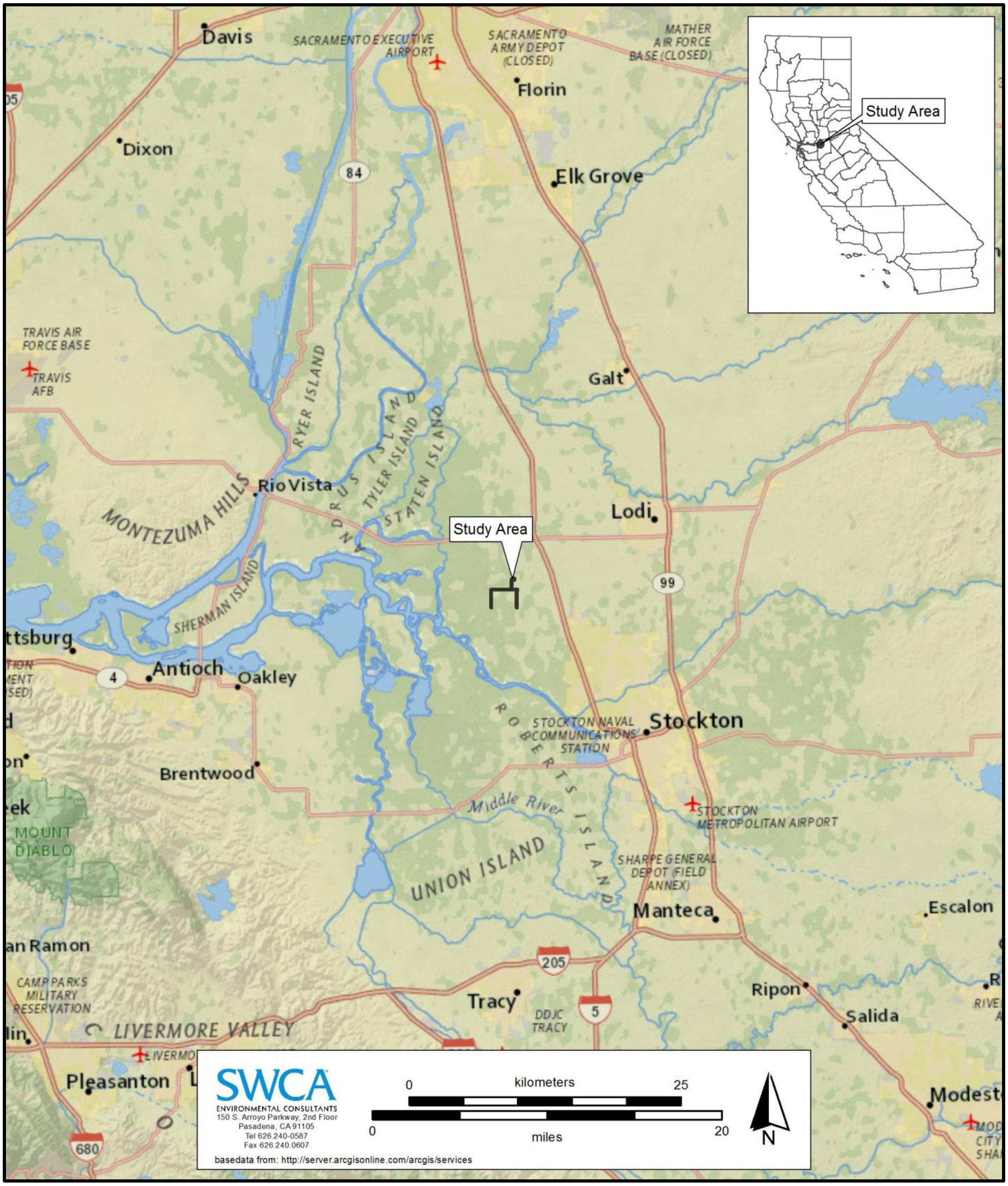

Figure 1. Location of the study area.

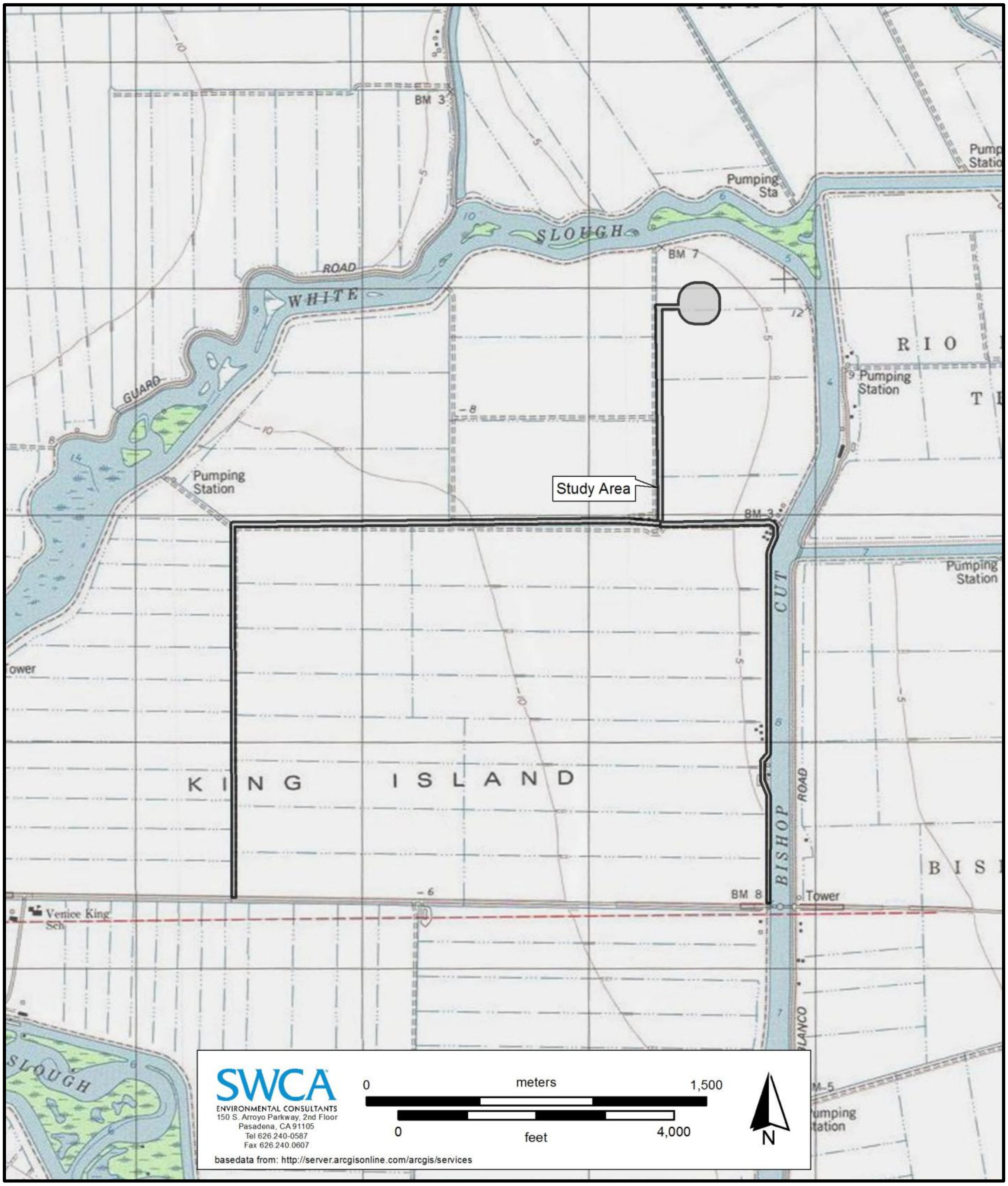

Figure 2. Detailed location of the study area.

Figure 3. The area of the potential effects in relation to Alternate A and B.

REGULATORY SETTING

This section identifies federal regulations, state legislation, and local statutes, ordinances, and guidelines that govern the identification and treatment of cultural resources and analysis of project-related effects on cultural resources. The lead agency must consider these requirements in making decisions on projects that may affect cultural resources. The current study was conducted in compliance with both federal and state laws, particularly Section 106 of the National Historic Preservation Act (NHPA) and the California Environmental Quality Act (CEQA).

Federal

National Historic Preservation Act

The current study was completed under the provisions of the NHPA of 1966, as amended (16 United States Code 470f). Cultural resources are considered during federal undertakings chiefly under Section 106 of the NHPA through one of its implementing regulations, 36 CFR 800 (Protection of Historic Properties), as well as the National Environmental Policy Act (NEPA). Properties of traditional religious and cultural importance to Native Americans are considered under Section 101(d)(6)(A) of the NHPA. Other relevant federal laws include the Archaeological Data Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1989.

Section 106 requires federal agencies to take into account the effects of their undertakings on any district, site, building, structure, or object that is included in or eligible for the National Register of Historic Places (NRHP) and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on such undertakings (36 CFR 800.1). Under Section 106, cultural resources must be identified and evaluated; effects on historic properties are reduced to acceptable levels through mitigation measures or agreements among consulting and interested parties. Historic properties are those resources that are listed in or are eligible for the NRHP in accordance with the criteria listed below (36 CFR 60.4) (ACHP 2010).

The quality of *significance* in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess *integrity* of location, design, setting, materials, workmanship, feeling and association and that

(A) are associated with events that have made a significant contribution to the broad patterns of our history; or

(B) are associated with the lives of persons significant in our past; or

(C) embody the distinctive characteristics of a type, period, or method of installation, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

(D) have yielded, or may be likely to yield, information important in prehistory or history.

Impacts of a project to significant cultural resources that affect the characteristics of any resource that qualify it for the NRHP are considered a significant effect on the environment. Under 36 CFR 800.5(a)(2), adverse effects on historic properties include, but are not limited to

(i) physical destruction of or damage to all or part of the property;

(ii) alteration of a property;

(iii) removal of the property from its historic location;

(iv) change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance;

(v) introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features;

(vi) neglect of a property which causes its deterioration;

(vii) transfer, lease, or sale of property out of federal ownership or control without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance.

State

California Environmental Quality Act

CEQA requires a lead agency to determine whether a project may have a significant effect on historical resources (Section 21084.1). If it can be demonstrated that a project will cause damage to a unique archaeological resource, the lead agency may require that reasonable efforts be made to permit any or all of these resources to be preserved in place or left in an undisturbed state. To the extent that they cannot be left undisturbed, mitigation measures are required (Section 21083.2[a], [b], and [c]).

Section 21083.2(g) defines a *unique archaeological resource* as an archaeological artifact, object, or site about which it can be clearly demonstrated that without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

(1) Contains information needed to answer important scientific research questions and that there is a demonstrable public interest in that information.

(2) Has a special and particular quality such as being the oldest of its type or the best available example of its type.

(3) Is directly associated with a scientifically recognized important prehistoric or historic event or person.

A *historical resource* is a resource listed in, or determined to be eligible for, the California Register of Historical Resources (CRHR) (Section 21084.1); a resource included in a local register of historical resources (Section 15064.5[a][2]); or any object, building, structure, site, area, place, record, or manuscript that a lead agency determines to be historically significant (Section 15064.5[a][3]).

Public Resources Code (PRC) Section 5024.1, Section 15064.5 of the CEQA Guidelines, and PRC Sections 21083.2 and 21084.1 were used as the basic guidelines for this cultural resource study. PRC Section 5024.1 requires an evaluation of historical resources to determine their eligibility for listing in the CRHR. The purpose of the register is to maintain listings of the state's historical resources and to indicate which properties are to be protected from substantial adverse change. The criteria for listing resources on the CRHR were expressly developed to be in accordance with previously established criteria developed for listing in the NRHP, enumerated below.

According to PRC Section 5024.1(c)(1–4), a resource is considered historically significant if it (i) retains "substantial integrity," and (ii) meets at least one of the following criteria:

(1) Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage.

(2) Is associated with the lives of persons important in our past.

(3) Embodies the distinctive characteristics of a type, period, region, or method of installation, or represents the work of an important creative individual, or possesses high artistic values.

(4) Has yielded, or may be likely to yield, information important in prehistory or history.

Impacts to significant cultural resources that affect the characteristics of any resource that qualify it for the NRHP or adversely alter the significance of a resource listed on or eligible for the CRHR are considered a significant effect on the environment. These impacts could result from “physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of an historical resource would be materially impaired” (CEQA Guidelines, Section 15064.5 [b][1], 2000). Material impairment is defined as demolition or alteration “in an adverse manner [of] those characteristics of an historical resource that convey its historical significance and that justify its inclusion in, or eligibility for inclusion in, the California Register…” (CEQA Guidelines Section 15064.5[b][2][A]).

ENVIRONMENTAL SETTING

The study area is in the Sacramento-San Joaquin Delta region, an area in the California Central Valley lowlands that is defined by the confluence of the Sacramento, American, Mokelumne, and San Joaquin Rivers. The topography of the study area is virtually flat, with elevations ranging from approximately 0 to 3 meters (0 to 10 feet) above mean sea level (Figure 4). The region’s climate is characterized by warm, dry summers, and mild, moist winters. Summer temperatures have highs around 32 degrees Celsius (90 degrees Fahrenheit), and winter temperatures have highs around 13 degrees Celsius (55 degrees Fahrenheit).

Figure 4. Overview of study area; view to the north.

Although current land uses in the APE include agricultural croplands, the area near the APE was characterized historically by vegetation communities that included freshwater marshland near permanent water in low-lying areas, seasonal wetlands and vernal pools within grasslands and woodlands, riparian scrub/forest along drainages, and grasslands and oak woodlands in valley foothill areas. With this mosaic of ecological communities, and in view of the ethnographic descriptions of the Plains Miwok (Kroeber 1925; Latta 1977; Wallace 1978) who historically occupied the area, it would appear that the study area and surround area would have provided a very productive environment for its prehistoric occupants, one well-suited to a hunting-gathering economy with a variety of fish, waterbirds, small and large mammals, and edible plant species.

CULTURAL SETTING

Prehistoric Overview

California prehistory is divided into three broad temporal periods that reflect similar cultural characteristics throughout the state: Paleoindian period (ca. 9000–6000 B.C.), Archaic period (6000 B.C.–A.D. 500), and Emergent period (A.D. 500–Historic Contact) (Fredrickson 1973, 1974, 1994a). The Archaic is divided further into Lower (6000–3000 B.C.), Middle (3000–1000 B.C.), and Upper (1000 B.C.– A.D. 500) periods, generally governed by climatic and environmental variables, such as the drying of pluvial lakes at the transition from the Paleoindian to the Lower Archaic.

The APE lies in what generally is described as the Delta subregion of the Central Valley Archaeological Region, which is one of eight arbitrary organizational divisions of the state (Moratto 1984). This archaeological subregion surrounds the Sacramento-San Joaquin Delta in the middle of the Central Valley and mainly includes portions of Contra Costa, Sacramento, San Joaquin, Solano, and Yolo Counties.

Occupation in the Sacramento-San Joaquin Delta region during the Prehistoric period is estimated to have occurred as early as 12,000 years ago, but only a few archaeological sites have been identified that predate 5,000 years ago. It is possible that Holocene alluvial deposits buried many prehistoric sites in this area, and Moratto (1984:214) estimates that as much as 10 m of sediment accumulated along the lower stretch of the Sacramento River drainage system during the last 5,000–6,000 years. CA-CCO-637 in eastern Contra Costa County, for example, is one of the few early Holocene-age sites in the region, with a record of human occupation as early as 8,500 years ago during the Lower Archaic (Meyer and Rosenthal 1998). The archaeological remains at that site were discovered approximately 2 m below the surface within an alluvial fan near Kellogg Creek.

Prehistoric material culture in central California subsequent to the Paleoindian and Lower Archaic periods has been categorized according to “horizons” or “patterns” that define broad technological, economic, social, and ideological elements over long periods of time and large areas. The taxonomic system historically used for central California is a tripartite classification scheme with Early, Middle, and Late Horizons. This Central California Taxonomic System (CCTS) was the result of efforts of a number of researchers (e.g., Beardsley 1954; Heizer 1949) and was developed further after the advent of radiocarbon dating (Fredrickson 1973, 1974; Heizer 1958; Ragir 1972).

Today, a series of generalized periods associated with regionally based “patterns” are typically used as part of the CCTS for the Sacramento Delta area, San Francisco Bay area, and North Coast ranges (Bennyhoff and Fredrickson 1969; Fredrickson 1973, 1974). Smaller units of patterns are referred to as “aspects” and “phases,” which emphasize more local features. Revisions of the widely accepted CCTS (Bennyhoff 1994; Fredrickson 1994a, 1994b) are found in a recent volume edited by Hughes (1994).

Fredrickson (1973, 1974) defined several regionally based patterns, three of which are specific to the prehistory of the APE. Referred to as the Windmiller Pattern, Berkeley Pattern, and Augustine Pattern, each represents a general pattern of resource exploitation, as identified between 2500 B.C. and the beginning of Euro-American contact in the early 1800s. The Windmiller Pattern was first identified at the Windmiller site (CA-SAC-107) near the Cosumnes River in Sacramento County; the Berkeley Pattern was initially identified at the West Berkeley site (CA-ALA-307) in Alameda County on the east side of the San Francisco Bay; and the Augustine Pattern was identified at the Augustine site (CA-SAC-127) in the Sacramento-San Joaquin Delta. These patterns are present within the following horizon sequences: Middle Archaic period/Windmiller Pattern (formerly Early Horizon), Upper Archaic period/Berkeley Pattern (formerly Middle Horizon), and Emergent period/Augustine Pattern (formerly Late Horizon).

Windmiller Pattern (2500–500 B.C.)

Clearly documented evidence for human occupation in the general area is found at sites characteristic of the Windmiller Pattern during the Middle Archaic period. These sites date to as early as 4,500 years ago and as late as 2,500 years ago (2500–500 B.C.). Such sites often contain manos and metates (grinding stones), as well as many mortar fragments, indicating that acorns and/or various seeds formed an important part of the diet (Moratto 1984:201).

In addition to plant foods, the subsistence system included many other food resources, such as deer, elk, pronghorn, rabbits, and waterfowl. Numerous faunal remains have been documented at Windmiller Pattern sites, along with large quantities of projectile points. Also, the presence of angling hooks and baked clay artifacts possibly used as net or line sinkers, along with the remains of sturgeon, salmon, and smaller fishes, indicates that fishing was an additional source of food (Fredrickson 1973; Heizer 1949; Ragir 1972). Items made of baked clay included net sinkers, pipes, and discoids, as well as cooking “stones.” Ground and polished charmstones, impressions of twined basketry, shell beads, and bone tools also have been found at Windmiller Pattern sites. Some items, such as shell beads, obsidian tools, and quartz crystals, were obtained by trade.

The archaeological record during the Windmiller pattern indicates that people practiced a mixed procurement strategy of both game and wild plants, with the addition of acorns and/or seeds. The mixed exploitation of a wide range of natural resources ties into a seasonal foraging strategy. Populations likely occupied the lower elevations of the Sacramento Valley in the winter months and shifted to higher elevations during the summer (Moratto 1984:206). Mortuary practices included burials, accompanied by grave goods, in cemeteries that were separate from the habitation sites.

Berkeley Pattern (500 B.C.–A.D. 500)

Over a 1,000-year period, the Windmiller Pattern began to shift to the more specialized adaptive Berkeley Pattern during the Upper Archaic period. A shift to a greater reliance on acorns as a dietary staple is interpreted during the Berkeley Pattern from the increase in mortars and pestles, along with a decrease in manos and metates. Mortars and pestles are better suited to crushing and grinding acorns, whereas manos and metates were used primarily for grinding wild grass grains and seeds (Moratto 1984:209–210).

As demonstrated by the artifact assemblage, hunting remained an important aspect of food procurement during the Berkeley Pattern (Fredrickson 1973:125–126). The archaeological record, which consists of numerous large shell midden/mounds, also demonstrates that occupants at most Berkeley Pattern sites near water (both fresh and salt) made intensive use of aquatic resources.

The artifact assemblage also includes shell beads and ornaments, as well as numerous types of bone tools. Interment continues to dominate mortuary practices, but a few cremations are also found at Berkeley Pattern sites.

Artifact assemblages and radiocarbon dating of sites from this period suggest this subsistence pattern may have developed in the San Francisco Bay region and later spread to surrounding coastal locales and into central California. Moratto (1984:207–211) suggests that the pattern is related to the expansion of Eastern Miwok populations from the San Francisco Bay area to the Sacramento Valley and Sierra foothills.

Augustine Pattern (A.D. 500–historic contact)

The Augustine Pattern is evidenced by a number of changes in subsistence, foraging, and land-use patterns that begin to reflect the use pattern known from Historic period Native American groups in the area. A substantial increase in the intensity of subsistence exploitation (including fishing, hunting, and gathering [particularly the acorn]) evidenced in the archaeological record correlates directly with population growth (Moratto 1984:211–214).

Tools and cooking implements include shaped mortars and pestles, hopper mortars, bone awls used for producing coiled baskets, and the bow and arrow. Pottery vessels, known as Cosumnes Brownware, are found in some parts of the Central Valley and most likely developed during this period from the prior baked clay industry.

During this period, an increase in sedentism led to the development of social stratification, accompanied by a shift to elaborate ceremonial and social organization. Exchange networks, with the use of clamshell disk beads as currency, also developed during the Augustine Pattern. Mortuary practices during this pattern included flexed burials and pre-interment burning of offerings in a grave pit, as well as cremation of high-status individuals (Fredrickson 1973:127–129; Moratto 1984:211). Additional items of material culture include flanged tubular pipes, harpoons, and small Gunther barbed series projectile points.
The Augustine Pattern may represent the southward expansion of Wintu populations (Moratto 1984: 211–214).

Ethnographic Overview

The APE is located in an area historically occupied by the Penutian-speaking Plains Miwok, a subgroup of the Eastern Miwok (Kroeber 1925; Levy 1978; Shipley 1978:84). The Plains Miwok historically occupied the lower Mokelumne River, Cosumnes River, and the Sacramento River from Rio Vista to Freeport (Levy 1978:398–399). Neighboring groups included the Nisenan to the north, Patwin and Bay Miwok to the west, Northern Valley Yokuts to the south, and the Washoe to the east.

Spanish mission records, diaries, and journals have provided the most comprehensive study of the Miwok, as well as some ethnographical studies done in the first half of the twentieth century (Bennyhoff 1977; Levy 1978:399). Much of the history of the Plains Miwok, however, is incomplete.

The villages of the Plains Miwok were divided into “tribelets,” political units that were also structured by similarities in language and ethnicity. The tribelets averaged 300–500 persons, and each held claim to a designated portion of territory within the lands of the Plains Miwok, which also extended to the natural resources within each territory (Levy 1978:410). Each tribelet’s territory contained a main village and smaller satellite villages. Within a tribelet’s main village was an assembly or dance house, either a large semi-subterranean structure or a simpler circular brush structure (Kroeber 1925:447). Other structures included semi-subterranean or aboveground conical houses made with tule-matting, conical sweathouses, winter grinding houses, and acorn granaries (Levy 1978:408–409). The Plains Miwok also practiced cremation (Kroeber 1925:452).

The rich resources of the Sacramento-San Joaquin Delta and surrounding areas provided the Plains Miwok with food and material needs. The primary food staple was the acorn, supplemented by waterfowl, fish, shellfish, and large and small mammals (Bennyhoff 1977; Levy 1978). The Miwok are best described as seasonally mobile hunter-gatherers with semi-permanent villages. The delta islands were also used regularly for hunting and fishing base camps. Permanent settlements of the Plains Miwok were located on high ridges or knolls near watercourses or on the sandy islands in the delta.

The Plains Miwok collected plant greens and roots in the spring; seeds and nuts in the spring, summer, and early fall; and acorns in the late fall/early winter (Levy 1978:402–403). Acorns, particularly from the prevalent valley oak (*Quercus lobata*) could be stored for some time in the conical-shaped granaries prior to processing. Tule elk, pronghorn antelope, and mule deer, as well as smaller mammals such as jackrabbits, cottontails, beaver, squirrels, and woodrats, were regularly hunted. Game birds included many types of waterfowl, mountain and valley quail, pigeons, jays, and woodpeckers. In addition to salmon, the Plains Miwok fished for sturgeon and lamprey (Levy 1978:402–403).

A wide array of tools, implements, and enclosures were used by the Plains Miwok for hunting and gathering of natural resources. Among those used for hunting land mammals and birds were the bow and arrow, traps and snares, nets, and enclosures/blinds. Communal hunting drives were employed for both large and small mammals. Many plants were collected using wooden tools: long poles for dislodging acorns and pinecones, fire-hardened digging sticks for roots, and beaters for dislodging seeds. Once collected, seeds, roots, and nuts were placed in burden baskets and transported for processing or storage (Levy 1978:403–404).

The Plains Miwok used a variety of tools to process food resources. These included portable stone mortars and pestles, bedrock mortars, anvils, woven strainers and winnowers, leaching and boiling baskets, woven drying trays, and knives. Unprocessed acorns were stored in conical granaries. Various foods were baked in earth ovens. Exotic items such as obsidian, steatite, and shell indicate they traded with coastal groups and mountain tribes (Levy 1978).

The Native American population in the Sacramento Valley came into contact with European culture beginning in the late 1700s, as a result of increased incursions into the area by the Spanish. Traditional lifeways were drastically altered during the early to mid-1800s as Spanish colonization and proselytization, Mexican land grants, and the American takeover and settlement pushed indigenous peoples into the rugged California interior and reduced their numbers through transport to the missions, disease, and slaughter. Beginning in the early 1800s, most of the Plains Miwok converts were transported to Mission San José (Levy 1978:400–402). Many resisted and tried to return to their villages in the delta. Plains Miwok fought the invaders in the 1820s and 1830s, and with neighboring Yokuts, they also attacked Mexican coastal settlements. The secularization of the missions followed, spurred in part by these activities. During the war with Mexico in the 1840s, the Miwoks aided the United States (Cook 1960, 1962).

The California Gold Rush of 1849 and the continuing influx of Euro-Americans into formerly remote regions of California was the final cultural blow for many California Indians, including the Miwok bands near the study area. With the loss of most of their traditional lands, as well as enslavement, slaughter, and disease, surviving Miwok labored for the growing lumber, ranching, farming, and mining industries (Levy 1978:401).

During the first half of the twentieth century, acquisitions of land by the federal government (from 2 acres to more than 300 acres) created a number of reservations, or *rancherias*, for the Plains Miwok, along with the Northern and Central Sierra Miwok. Between 1934 and 1972, the U.S. Bureau of Indian Affairs then terminated relations with most of these rancherias, although since 1984, the status has been restored to most of the rancherias (Slagle 2005). Today, although there is no unified California Miwok tribal organization at a state or federal level, there are seven rancherias that have primarily or exclusively Eastern Miwok populations. These are the Buena Vista Rancheria (Plains Miwok/Amador County), the Chicken Ranch Rancheria (Central Sierra division of Eastern Miwok/Tuolumne County), the Ione Rancheria (Northern Sierra and Plains Miwok/Amador County), the Jackson Rancheria (Northern Sierra and Plains Miwok/Amador County), the Sheep Ranch Rancheria (Northern Sierra Miwok/Calaveras County), the Shingle Springs Rancheria (Plains Miwok/El Dorado County), and the Tuolumne Rancheria (Central Sierra Miwok/Tuolumne County) (Slagle 2005).

Historic Overview

Post-contact history for the state of California is generally divided into three periods: the Spanish period (1769–1822), the Mexican period (1822–1848), and the American period (1848–present). Although there were brief visits by Spanish, Russian, and British explorers from 1529 to 1769, the beginning of Spanish settlement in California occurred in 1769 with an establishment of Mission San Diego, one of the 21 missions established from 1769 to 1823. The Mexican period began when news of the successful revolution by Mexico against the Spanish crown reached California in 1822. This period is marked by an extensive era of land grants, most of which were in the interior of the state, and by exploration by American fur trappers west of the Sierra Nevada Mountains.

With the signing of the Treaty of Guadalupe Hidalgo in 1848, ending the Mexican-American War, California became a territory of the United States. The discovery of gold in 1848 at Sutter's Mill near Sacramento and the resulting Gold Rush era influenced the history of the state and the nation. The rush of tens of thousands of people to the gold fields also had a devastating impact on the lives of indigenous Californians, with the introduction and concentration of diseases; the loss of land and territory, including traditional hunting and gathering locales; violence; malnutrition; and starvation. Thousands of settlers and immigrants continued to pour into the state, particularly after the completion of the transcontinental railroad in 1869.

With continued growth, California continues to be a national leader in agriculture and poultry production, ranching (cattle and sheep), aerospace and communications industries, as well as the film and entertainment business. The wealth of California's natural resources (e.g., lumber, petroleum deposits, minerals, fish) also continues to contribute to its growth and development.

San Joaquin County

San Joaquin County was one of the original 27 counties of California, created in 1850 at the time of statehood (Hoover et al. 2002:369). The county's geographical location in the center of the state between the Sierra Nevada mountain range to the east and the San Francisco Bay to the west has made it a prime location for business and industry. The county is accessible from almost all parts of the state by means of the Port of Stockton, the interstate highway system, railroads, and airports. Captain Charles M. Weber was instrumental in developing the city of Stockton as the county seat and as a port of entry, where the two large rivers that drain the northern and southern halves of the great Central Valley meet at the Sacramento-San Joaquin Delta. Ships today still deliver cargo to the Port of Stockton via the Stockton Channel, the deep-water slough that leads into the San Joaquin River, next to which Captain Weber laid out the town of Tuleburg (now Stockton) in 1847.

Agriculture and livestock have defined San Joaquin County's past and continue to play an important role in the present and foreseeable future. The many rivers in the area, including the San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers, form rich agricultural land as well as marshlands for abundant wildlife. In 1813, Lieutenant Gabriel Moraga led an expedition in the lower portion of California's Central Valley, giving the name San Joaquin to the large river that flows northward through the county (Hoover et al. 2002:369). Later immigrants were attracted to the abundance of wildlife within or along the rivers, including waterfowl, fish, and fur-bearing animals. In 1827, American explorer and trapper Jedediah Smith traveled through the San Joaquin Valley. Other trappers soon followed, including employees of the Hudson's Bay Company in 1832 (Hoover et al. 2002:370).

Irrigation is an important part of the history of the productive agricultural and livestock economy of the county. The Miller and Lux Company, a cattle company known across the west, had vast holdings in the San Joaquin Valley. Founded by German immigrant Henry Miller (formerly Heinrich Alfred Kaiser) and partner Charles Lux, their lands and herds could be found throughout the state of California. They built an empire by acquiring rancho property and driving cattle to market in San Francisco (Hoover et al. 2002:435). The Miller and Lux Company also pioneered irrigation projects in the San Joaquin Valley, beginning with completion of the San Joaquin Canal in the 1870s. This ambitious project began on the San Joaquin River near Fresno Slough, and then ran north through Merced County and into Stanislaus County. The company also controlled more than 50 miles of land along Kern River, which they were able to parlay into a system of canals to irrigate dry lands that then became productive agricultural fields (Beck and Haase 1974:76; Hoover et al. 2002:94).

The history of San Joaquin County would not be complete without mention of the Tidewater Southern Railway. Begun as an electric interurban railway, the line opened its initial 32 miles of mainline between Stockton and Modesto in October 1912 (Tidewater Southern Railway 2007). The railway connected on the north to the Central California Traction Company Railroad, which served the Central Valley from Stockton to Sacramento. The Tidewater Southern was a successful venture, with 24 trains operating daily between Stockton and Modesto by 1916. The same year, it extended the rails to Turlock and to Hilmar. The last tracks of the Tidewater Southern were added in 1918, a 6.6-mile-long north-south branch between Manteca and Manteca Junction. The previous year, most of the rolling stock had been purchased by the Western Pacific Railroad. The number of passengers declined with the onset of the Depression, and the last interurban ran in 1932. This decline was offset, however, by an increase in freight transport, particularly agricultural products. Diesel power entirely replaced the electrified type by the late 1940s, and the line was upgraded in the 1950s and 1960s. Today, the original Tidewater Southern line between Stockton and Turlock is served as part of the Union Pacific Railroad; the Western Pacific merged into the Union Pacific in 1982.

BACKGROUND RESEARCH

California Historical Resources Information System Records Search

On August 22, 2012, a search was requested of the California Historical Resources Information System (CHRIS) at the Central California Information Center (CCIC), located at California State University, Stanislaus in Turlock, California. The search included any previously recorded cultural resources and investigations within a 1.6-kilometer (1-mile) radius of the APE. The CHRIS search also included a review of the NRHP, the CRHR, the California Points of Historical Interest list, the California Historical Landmarks list, the Archaeological Determinations of Eligibility list, and the California State Historic Resources Inventory list. Additionally, the records search included a review of historic maps covering the APE. A letter dated August 23, 2012, from the CCIC summarizing the results of the records search and providing a bibliography of prior cultural resources studies is provided in Appendix A of this report.

Prior Cultural Resources Studies within 1 Mile of the APE

The records searches identified seven prior cultural resource studies within 1 mile of the APE (Table 1). Of this, one (SJ-00767) was conducted within a portion the APE; a brief summary of this study is provided in the paragraph that follows.

Table 1. Prior Cultural Resource Studies within 1 Mile of the APE

CCIC Report No.	Title of Study	Author	Year	Proximity to the APE
SJ-00727	Cultural Resources Evaluation for the Proposed Water Supply Pipeline and treatment Plant Locations for the City of Stockton, San Joaquin County, California	Chavez, David	1978	Outside
SJ-00767	Cultural Resource Investigations of the Eight Mile Road Bridge No. 1043 Over Bishop Cut, San Joaquin County, California	Napton, L. Kyle	1982	**Within**
SJ-05534	A Cultural and Paleontological Resources Study for the Paradise Village Development Project	Kelley, John and Susan Huster	2003	Outside
SJ-05985	Caltrans Historic Bridge Inventory Update: Metal Truss, Movable, and Steel Arch Bridges	McMorris, Christopher	2004	Outside
SJ-06331	Archaeological/Resources Presence/Absence Testing at P-39-004492 (Southern Bishop Tract Farm Site), Westlake Villages Project, Stockton, San Joaquin County, California	Longfellow, J.	2006	Outside
SJ-06410	A Cultural and Paleontological Resources Study for the Spanos Parcel Project	Kelley, John, Susan Huster, and Ben Matzen	2005	Outside
SJ-06843	Stockton Delta Project: Cultural Resources Inventory Report	ESA	2007	Outside

SJ-00767

In 1982, L. Kyle Napton prepared *Cultural Resource Investigations of the Eight Mile Road Bridge No. 1043 Over Bishop Cut San Joaquin County, California* for the County of San Joaquin, Department of Public Works. The cultural resource assessment preceded the proposed replacement of the Eight Mile Bridge No. 1043 over Bishop Cut, with a survey area that encircled the bridge by approximately 500 feet, and which includes small portion of the current APE. Methods of investigation included a review of ethnographic literature, the NRHP, and the California Register of Historic Sites, as well as search of records at the California Office of Historic Preservation. Additionally, a field survey of the study area was undertaken by professional archaeologists. No cultural resources were identified as a result of the study, and a finding of no significant impact upon cultural resources was determined.

Previously Recorded Cultural Resources within 1 Mile of the APE

The records searches identified five previously recorded cultural resources within 1 mile of the APE (Table 2). Of these five, none are located in the study area. Two resources (Bridge #29C-0114 and Bridge

#29C-0290) were not formally listed by the CCIC, but rather referenced in *Caltrans Structure Maintenance & Investigations, Historical Significance – Local Agency Bridge, San Joaquin County* (2012) as not eligible for the NRHP.

Table 2. Previously Recorded Cultural Resources within 1 Mile of the APE

Primary No.	Trinomial	Resource Description	NRHP Eligibility	Recorder and Year	Proximity to Study Area
P-39-004492	–	Southern Bishop Tract Farm	Not evaluated; updated records states buildings are no longer extant	Kelley, John, and Susan Huster, 2003; and Longfellow, Joy, 2006.	Outside
P-39-004540	–	Bridge #29C-0219 – White Slough	Ineligible	CDM/JMC, 2003	Outside
P-39-005038	–	Venice School	Not evaluated	San Joaquin County Superintendent of Schools	Outside
–	–	Bridge #29C-0114 – Bishop Canal	Ineligible	Caltrans	Outside
–	–	Bridge #29C-0290 – Telephone Cut	Ineligible	Caltrans	Outside

Historic Map Review

In addition to reviewing previously conducted studies and previously recorded site records, SWCA examined the study area on historic maps provided by the CCIC. Maps from the mid- to late-nineteenth century show the study area as largely undeveloped, describing it as “swamp and overflowed land.” By 1939, a U.S. Geological Survey (USGS) map shows development of the levee system, with the present-day irrigation canal in place along the eastern portion of the study area, and initial roads encircling the interior of what is by then named “King Island.” A USGS map from 1952 shows the development of the additional access roads and buildings, including what appear to be the three extant buildings in the current study area (SWCA-KING-1, SWCA-KING-2, and SWCA-KING-3).

Sacred Lands File Search and Initial Native American Coordination

Native American coordination was initiated for this project on August 24, 2012. As part of the process of identifying cultural resources in or near the APE, SWCA contacted the Native American Heritage Commission (NAHC) to request a review of the Sacred Lands File. The NAHC faxed a response on August 28, 2012 (Appendix B), and stated that Native American cultural resources were not identified within 0.5 mile of the APE, but noted that it is always possible for cultural resources to be unearthed during construction activities. The NAHC also provided a contact list of seven Native American individuals or tribal organizations that may have knowledge of cultural resources in or near the APE. Letters were prepared and mailed to each of the NAHC-listed contacts on September 4, 2012, requesting information regarding any Native American cultural resources in or adjacent to the APE.

One response has been received to date in regarding the coordination letters, and is included in Appendix B of this report. In an email dated September 8, 2012, Ms. Silvia Burley of the Miwok Tribe requested that she be contacted if artifacts or human remains associated with the Miwok Tribe were discovered during the course of the project.

No additional responses have been received to date. One follow-up phone call will be made to each Native American contact on September 18, 2012. The results of these efforts will be forwarded to the PG&E at that time. Table 3 provides a complete record of Native American coordination to date.

Table 3. Record of Native American Coordination Efforts

NAHC-Provided Contact	Coordination Efforts	Results of Coordination Efforts
Miwok 4305 39th Avenue Sacramento, California 95824 Contact: Randy Yonemura	**9/2/12:** Letter sent via U.S. Mail	To be determined
Miwok P.O. Box 84 Wilseyville, California 95987 Contact: Briana Creekmore	**9/2/12:** Letter sent via U.S. Mail	To be determined
Buena Vista Rancheria 1418 20th Street, Suite 200 Sacramento, California 95811 Contact: Rhonda Morningstar Pope, Chairperson	**9/2/12:** Letter sent via U.S. Mail	To be determined
California Valley Miwok Tribe 10601 North Escondido Place Stockton, California 95212 Contact: Silvia Burley, Chairperson	**9/2/12:** Letter sent via U.S. Mail **9/8/12:** Ms. Burley replied via email that she had no concerns regarding the project, but asked that she is notified if Miwok artifacts or human remains are discovered during the course of the project.	No further reaction required
Ione Band of Miwok Indians P.O. Box 699 Plymouth, California 95669 Contact: Yvonne Miller, Chairperson	**9/2/12:** Letter sent via U.S. Mail	To be determined
Ione Band of Miwok Indians Cultural Committee 604 Pringle Avenue #42 Galt, California 95632 Contact: Billie Blue, Chairperson	**9/2/12:** Letter sent via U.S. Mail	To be determined
Wilton Rancheria 9300 West Stockton, Suite 200 Elk Grove, California 95758 Contact: Andrew Franklin, Chairperson	**9/2/12:** Letter sent via U.S. Mail	To be determined.
Wilton Rancheria 9300 West Stockton, Suite 200 Elk Grove, California 95758 Contact: Steven Hutchason, Director of Cultural Preservation	9/2/12: Letter sent via U.S. Mail	To be determined.

METHODS

SWCA Cultural Resources Specialists Katie Martin and William Kendig conducted an intensive-level pedestrian survey to identify any archaeological or historic built environment resources (i.e., buildings, structures, and objects) that may occur in the study area. Ms. Martin and Mr. Kendig surveyed the entire study area by walking linear transects spaced no more than 15 m (49 feet) apart. The ground surface was examined for the presence of prehistoric artifacts (e.g., flaked stone tools, tool-making debris, stone milling tools), historic artifacts (e.g., metal, glass, ceramics), sediment discoloration that might indicate the presence of a cultural midden, and depressions and other features indicative of the former presence of structures or buildings (e.g., post holes, foundations). A Trimble global positioning system (GPS) receiver with sub-meter accuracy was used to maintain transect accuracy and to record the location of cultural resources in the study area.

Ms. Martin and Mr. Kendig documented their fieldwork using field forms, a digital camera, close-scale field maps, and aerial photographs. Copies of the field notes and digital photographs are on file at the SWCA Pasadena office.

RESULTS

During the intensive-level field survey for cultural resources, ground visibility was poor in the study area (approximately 0% in some areas) due to obstruction by vegetative ground cover. Other areas of the study area were heavily disturbed due the construction of the access roads and agricultural activities (Figures 5 and 6). A portion of the study area along the eastern side of Alternate B was unable to be fully surveyed to the full 25-foot-wide buffer from the edge of the access road due to an adjacent waterway (Figure 7).

Four potential cultural resources were identified in the study area as a result of the intensive-level survey and were recorded on California Department of Parks and Recreation 523 series forms (Appendix C). Three buildings, SWCA-KING-1, SWCA-KING-2, and SWCA-KING-3, and an irrigation canal, SWCA-KING-4, are situated within the 25-foot-wide buffer of the Alternate B access road (Figure 8). Visual observation and initial research using historic maps indicate SWCA-KING-1, SWCA-KING-2, and SWCA-KING-3 were constructed between 1939 and 1952. Each of the three buildings is rectangular in plan and feature gabled roofs, sheathed in corrugated metal sheets.

SWCA-KING-4 is a segment of an irrigation canal, which is commonly known as Bishop Cut. The canal, which historic topographic maps indicate was constructed by 1939, is approximately 330 feet wide and connects White Slough from the north to Disappointment Slough 2.75 miles to the south. The waterfront portion of the canal is composed of rip-rap along steep banks, and it is bound by Rio Blanco Road to the east and a private access road to the west. SWCA-KING-4 includes the 1 mile portion of the canal from the vicinity of Telephone Cut to Bridge #29C-0114 to the south.

Figure 5. Portion of the study area; view to the east.

Figure 6. Agricultural activities in the study area; view to the west.

Figure 7. Paved access road (Alternate B) and irrigation canal; view to the south.

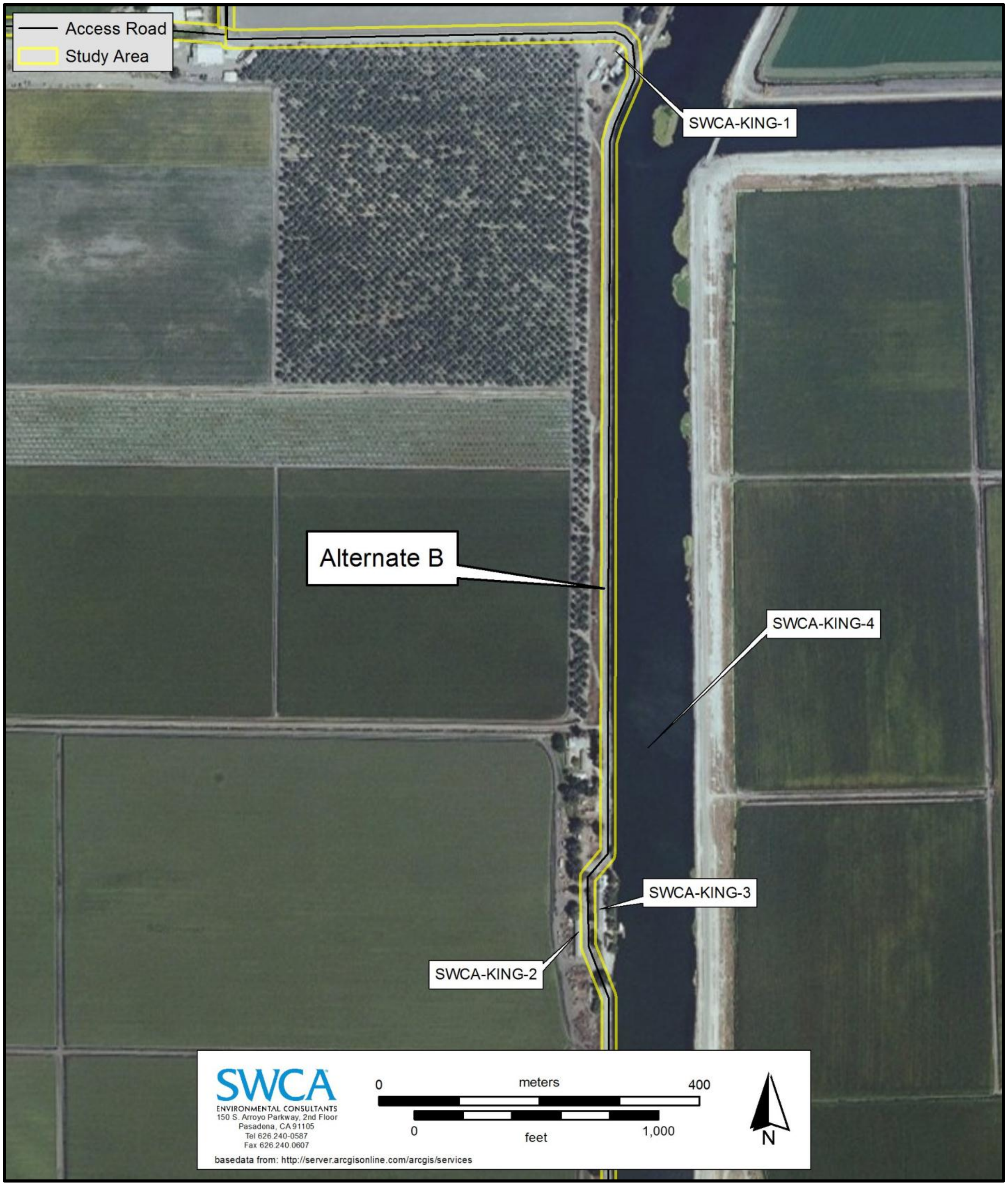

Figure 8. Potential cultural resources in relation to the study area.

DISCUSSION AND RECOMMENDATIONS

Discussion

The goal of this study is to identify cultural resources in the PG&E CAES King Island study area and provide management recommendations for those resources. The results of the records search indicate that a small portion of the study area was surveyed by qualified archaeologists in 1982. Although the records search also identified five previously recorded cultural resources within 1 mile of the APE, none were in the current study area or listed as eligible for the NRHP. Additionally, the NAHC Sacred Lands File search was negative for Native American cultural resources within 0.8 km (0.5 mile) of the APE.

SWCA cultural resources specialists identified four potential historic built resources as a result of the intensive-level survey (SWCA-KING-1, SWCA-KING-2, SWCA-KING-3, and SWCA-KING-4). They were not formally recorded or evaluated, and no determination of their significance was made at this time. However, visual inspection and initial research suggests that that they may be over 50 years old, and as a result, have the potential to be eligible for the NRHP.

Recommendations

The historical significance of the buildings and irrigation canal (SWCA-KING-1, SWCA-KING-2, SWCA-KING-3, and SWCA-KING-4), which are located along road Alternate B, was not determined as part of the current study. However, visual inspection and initial research using historic maps suggest they may be considered cultural resources. Until these resources are formally evaluated, SWCA recommends that they be treated as though they are significant, and that the project avoid impacting them. Alternate A would not have direct or indirect effects on these buildings or the canal, and SWCA recommends that the project use this access route, while avoiding the use of Alternate B. If it becomes necessary to use Alternate B, SWCA recommends that SWCA-KING-1, SWCA-KING-2, SWCA-KING-3, SWCA-KING-4 be formally evaluated to determine their significance before any construction activities begin.

Although SWCA did not identify any additional cultural resources, ground disturbance associated with the proposed project could impact previously unrecorded cultural resources. SWCA recommends that the following measures be taken to identify additional cultural resources in the study area to prevent or reduce the significance of project-related impacts to cultural resources and to satisfy the requirements of Section 106 and CEQA.

Inadvertent Discovery of Cultural Resources

In the event that cultural resources are exposed during ground-disturbing activities, construction activities (e.g., grading, grubbing, or vegetation clearing) should be halted in the immediate vicinity of the discovery. An archaeologist who meets the Secretary of the Interior’s Professional Qualifications Standards (National Park Service 1983) should then be retained to evaluate the find’s significance under CEQA. If the discovery proves to be significant, additional work, such as data recovery excavation, may be warranted and should be discussed in consultation with the lead agency.

Inadvertent Discovery of Human Remains

The discovery of human remains is always a possibility during ground disturbances; State of California Health and Safety Code Section 7050.5 addresses these findings. This code section states that no further disturbance shall occur until the county coroner has made a determination of origin and disposition pursuant to PRC Section 5097.98. The coroner must be notified of the find immediately. If the human remains are determined to be prehistoric, the coroner will notify the NAHC, which will determine and notify a most likely descendant. The most likely descendant shall complete the inspection of the site within 48 hours of notification and may recommend scientific removal and nondestructive analysis of human remains and items associated with Native American burials.

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A515: Kings Island BCA Final

North State Resources, Inc.

Date: October 12, 2012 **PG&E Order #:** 8105484

To: Land and Environmental Management—Catalina Reyes, Biologist

From: North State Resources, Inc.— John W. Hunt, Biologist

Project: PG&E Compressed Air Energy Storage Sites–Proposed Investigative Geologic Core Sampling at the King Island Piacentine Well.

Subject: Final Biological Constraints Analysis of the King Island Piacentine Well, San Joaquin County, California

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Introduction and Summary

Mr. John W. Hunt, NSR Biologist, conducted a biological constraints analysis for the proposed Geologic Core Sampling Phase of the Pacific Gas and Electric Company (PG&E) Compressed Air Energy Storage Project (project) at the proposed King Island Piacentine natural gas well pad expansion area and associated access roads (project area). The survey area consists of all areas within 20 feet of proposed access roads and all areas within 250 feet of the existing well pad and the proposed well pad expansion area (Figure 1, Appendix A). The objective of the project is to expand and utilize the existing footprint of the Piacentine natural gas well site to stage geological core sampling equipment. The geological core sampling will be used to determine the suitability of the project vicinity for compressed air storage within depleted subterranean natural gas reservoirs.

A field reconnaissance was conducted on August 20, 2012 with Ms. Catalina Reyes, PG&E Biologist. The project area includes all proposed access roads, existing well pad and staging area, and well pad expansion area identified by PG&E technical staff during the field review on August 20, 2012 (Figure 2, Appendix A).

Giant garter snake, listed as threatened under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA); Swainson’s hawk, listed as threatened under CESA; loggerhead shrike, designated as California species of special concern (SC); and white-tailed kite, a state fully protected (FP) species, have the potential to be adversely affected or impacted by the project This document provides Avoidance and Minimization Measures (AMMs) that will avoid effects on these species.

The irrigation ditches within the project area appear to meet wetland criteria and are considered to qualify as potential waters of the United States. The existing access roads, the existing well pad, and the proposed well pad expansion area do not appear to meet wetland criteria and are not considered to qualify as potential waters of the United States. All determinations concerning waters of the United States should be considered preliminary and tentative unless verified in writing by the U.S. Army Corps of Engineers.

The proposed project will receive federal funding from the U.S. Department of Energy (USDOE). As such, the USDOE is required under section 7 of the federal Endangered Species Act to determine whether the proposed project may affect federally listed and proposed species or proposed or designated critical habitat. If the USDOE determines that the project may affect federally listed species or critical habitat, consultation with the U.S. Fish and Wildlife Service and/or National Marine Fisheries Services is required.

Project Description

The objective of the project is to collect approximate 10-inch diameter geological core samples from the subsurface natural gas formation at depth approximately 4,000-5,000 feet. Cores will be used to determine the suitability of the subsurface formation for compressed air storage. Compressed air energy storage involves utilizing appropriate geological formations (e.g., depleted natural gas reservoirs) to store surplus energy in the form of compressed air during periods of low electric demand. This stored energy can then be utilized during periods of higher electric demand, improving the efficiency of energy distribution through the power grid.

The project area is located approximately 5 miles northwest of the city of Stockton in northwestern San Joaquin County, California. It is situated immediately north of West 8 Mile Road between White Slough and Bishop Cut, and can be accessed from Interstate 5 via West 8 Mile Road at approximately 38.082284°, -121.421892° (Figure 2, Appendix A). For project construction, the preferred site access (preferred access) is from the southwest along an unnamed dirt road. The dirt road is graded and well-maintained, and is surfaced with gravel. The alternative site access (alternative access) is from the southeast along the King Island Road.

Given that existing access roads are available, no road construction is necessary for project construction. Improvements to the existing access roads from the ranch yard to approximately 900 feet north will be limited to light graveling of the unnamed dirt road if determined to be necessary (e.g., work to occur during the wet season) with the assumption no additional grading will be required. If grading is required, it will be limited to the existing road and will not extend beyond the compacted surface. All vehicle traffic will be on the existing access roads and all staging will be contained within the southeast portion of the existing well pad. Water trucks will be used as necessary to reduce dust during site access and other construction activities. Approximately 28 truck trips will be required to import well pad material to the site. An additional five truck trips will be required to remove drill cuttings and associated material from the site. If well pad expansion area is restored to pre-project conditions, an additional 28 truck trips will be required to remove temporary well pad expansion materials, which will total 61 truck trips. Best Management Practices (BMPs) and AMMs will be implemented to avoid impacts on potential waters of the United States.

The well pad expansion area will occupy an approximately 0.18-acre area (80 x 100 feet) that abuts the existing Piacentine well pad and access road. Approximately 5–6 rows of walnut trees (approximately 4 inches diameter at breast height) and intercropped safflower will be cleared in order to accommodate the well pad expansion. After clearing the vegetation, approximately 1 foot of crushed rock will be placed within the cleared area and compacted with a roller. If necessary, woven geotextile fabric will be placed as an underlayment for the overlying gravel fill. Final pad dimensions will be 220 (east-west) by 140 feet (north-south).

After the well pad expansion area has been established (i.e., cleared of vegetation, compacted and surfaced with gravel), well drilling equipment will be moved onto the expansion area. The primary equipment includes the drill rig, mud and water tanks and pumps, shaker tanks, electric generators, diesel fuel tanks, and drill pipe racks. Geologic sampling will consist of drilling a 10 inch diameter well to a depth of approximately 4,000-5,000 feet and extracting a geological core sample not greater than 4 inches in diameter. All sections of the core sample will be removed offsite for analysis and storage. All peripheral material (e.g., cuttings and drilling mud) removed during the coring process will be immediately placed in proper storage receptacles and removed offsite for disposal at an authorized facility. The drilling crew, plus engineers, temporary workers and site visitors, will consist of an average of approximately 12 workers per shift, with three shifts per day. A maximum of 20 workers may be present during various operations. In addition to worker vehicles, service and delivery vehicles will access the site during the drilling phase including equipment trucks for all aspects of the effort. All drilling activities will be completed in compliance with the County Gas and Oil Well Improvement Plan approval.

Once the core sample is obtained and the remaining hole is plugged and abandoned per California Division of Oil Gas and Geothermal Resources (DOGGR) and Environmental Protection Agency (EPA) standards, the drilling equipment will be dismantled and demobilized from the site. Construction equipment similar to that used during well pad development will be used to remove the pad materials and return the site to near pre-project conditions. This includes spreading of any surface vegetation or roots stockpiled during site preparation. All removed material will be disposed of at suitable landfills or recycled consistent with county grading or other permit requirements. However, the property owner may elect to retain the pad for farm equipment staging and storage.

Well pad construction and improvements to access roads will occur over a two-week period commencing as early as October 2012. Drilling activities will occur virtually continuously for up to approximately six weeks. If elected to remove the well pad, restoration of the site will take up to two weeks.

Habitat and Affected Environment

The project area is situated in a landscape that currently supports active agricultural operations, an existing natural gas well site, access roads, a farmhouse, and appurtenant facilities/equipment (e.g., farm equipment, staging area, and barn). The project area is located within the “Delta Islands”. The Delta Islands are areas of former marshlands of the Sacramento–San Joaquin Delta that were historically reclaimed for agricultural use by the construction of levees/dikes and draining to enable farming.

Habitats within the project area (Figure 3-1 through 3-4 and Figure 4, Appendix A) include flood irrigated row crops (e.g., corn, asparagus, onions, safflower) and walnut orchards intercropped with safflower. Some of the cornfields adjacent to the access roads in the project area were being flood irrigated during the August 20, 2012 field reconnaissance. The proposed well pad expansion area is entirely within a young walnut orchard intercropped with safflower and is disked on an annual rotation. With the exception of asparagus crops in the westernmost portion of the project area, all agricultural habitats within the project area are disked and cropped on an annual rotation. All fields are actively farmed and regularly disked, harvested and/or disturbed to the edge of the existing access road.

A series irrigation ditches parallel the entire length of the preferred access route to its junction with the graveled Piacentine well access road approximately 550 feet west of the Piacentine well. The irrigation ditches and their appear to be subject to regular vegetation management using both mechanical and chemical techniques. Habitat within the channel is predominantly open water. In addition to the open water habitat, intermittent patches of floating aquatic and emergent vegetation including water primrose (*Ludwigia* sp.), cattails (*Typha* sp.), smartweed (*Persicaria* sp.), mosquito fern (*Azolla* sp.) and water hyacinth (*Eichhornia crassipes*) are present within the channel. Ruderal herbaceous species occurring along the banks and adjacent road shoulders include common mallow (*Malva neglecta*), poison hemlock (*Conium maculatum*), Johnson grass (*Sorghum halepense*), redroot pigweed (*Amaranthus retroflexus*) and common knotweed (*Polygonum aviculare*).

Methods

The determination of the potential for the project area to support habitat for special-status species, waters of the United States, and other sensitive biological resources was established through desktop review and a field reconnaissance. The desktop review was completed using a series of database searches and a review of pertinent resources (Appendix B). Special-status species[1] listed in the U.S. Fish and Wildlife (USFWS) species list for San Joaquin County and species reported in the CNDDB to occur within a 5-mile radius of the project area were considered in the evaluation (e.g., listed shrimp, valley elderberry longhorn beetle, giant garter snake) (Appendix B). Additionally, special-status species not included in the USFWS species list or CNDDB records were considered due to their known geographic range and/or the presence of potential habitat (e.g., white-tailed kite, loggerhead shrike, ringtail). Special-status species shown in the USFWS and CNDDB queries (Appendix B) that are not included in Table 1 lack habitat within the project area or the project area is not within the range of the species. These species are not analyzed further in this document.

Following completion of the field reconnaissance, an assessment of local, state, and federal permitting requirements was conducted to determine if the proposed project requires permits or authorizations from the local government or state and federal regulatory agencies. No local, state, or federal permits addressing biological resources are anticipated to be required.

Special-Status Species and Potential Impacts

The project area contains potentially suitable habitat for eleven special-status plant species including: watershield (*Brasenia schreberi*), bristly sedge (*Carex comosa*), woolly rose-mallow (*Hibiscus lasiocarpus* var. *occidentalis*), Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), Mason's lilaeopsis (*Lilaeopsis masonii*), Delta mudwort (*Limosella subulata*), eel-grass pondweed (*Potamogeton zosteriformis*), Sanford's arrowhead (*Sagittaria sanfordii*), marsh skullcap (*Scutellaria galericulata*), side-flowering skullcap (*Scutellaria lateriflora*), and Suisun marsh aster (*Symphyotrichum lentum*). The potentially suitable habitat for these species is located within the irrigation ditches that are present within the project area. The proposed project will not result in disturbance to the irrigation ditches. Therefore, the proposed project will not result in impacts on special-status plant species.

Special-status animal species that were determined to have the potential to occur in or near the project area, and that could be adversely affected by the proposed project, include giant garter snake (*Thamnophis gigas*), Swainson’s hawk (*Buteo swainsoni*), white-tailed kite (*Elanus leucurus*), and loggerhead shrike (*Lanius ludovicianus*) (Table 1).

Within the project vicinity the perennial irrigation ditches and the nearby slough, Bishop Cut and associated uplands, provide potential suitable habitat for giant garter snake (GGS). The perennial irrigation ditches are located immediately adjacent to the preferred access road and the Bishop Cut is located adjacent to the alternate access road, King island Road (Figure 3-1 through 3-4). The CNDDB contains reported GGS occurrences from marsh habitat within Coldani Marsh less than 0.5 mile from the project. If GGS are present within the project area during the inactive season (i.e., October 1 to May 1), when work is anticipated to occur, adverse impacts (e.g., injury or death) on GGS could result from vehicular traffic or ground disturbance associated with project activities.

Although, vegetation is actively managed along ditches, emergent vegetation persists and may provide suitable habitat for GGS. Because these aquatic habitats (ditches) appear to be subject to regular vegetation management using both mechanical and chemical technique, these aquatic habitats offer poor to marginal habitat to GGS. Additionally, no fish or amphibians which serve as prey items were observed in these ditches during the August 20, 2012 field survey.

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[1] Special-status species: Listed, candidate, or proposed for listing as threatened or endangered under the Endangered Species Act, or California Endangered Species Act, California Native Plant Protection Act, California Species of Special Concern, and California Fully Protected Species. Special-status plants include California rare plant rank (RPR) 1A, 1B and 2.

Burrows and other underground refuge are important to GGS during summer and winter to escape unfavorable winter cold temperatures or excessive summer heat. The GGS recovery plan states that wintering habitat can be up to 250 meters (820 feet) from the edge of marsh habitat (Miller, Hornaday et al. 1999). An irrigation ditch with perennial flow is located approximately 400 feet west of the potential well pad expansion area could provide dispersal habitat for juvenile GGS and the uplands in the project area may provide wintering habitat. Typically, the USFWS defines upland habitat as all areas occurring within 200 feet of aquatic habitat (White 1997). Because the proposed well pad expansion area is greater than 200 feet from potential GGS aquatic habitat, the risk of encountering GGS out of its burrow is greatly reduced. The highest potential of adverse impacts on GGS is most likely to occur from project activities along the access roads since they are located within 200 feet of aquatic habitat and provide potential habitat for winter burrows. If burrows are located under the access roads project activities can result in the collapse of burrows and snakes can become entombed.

Despite the presence of vegetated irrigation ditches that may support dispersal of GGS, these provide marginal to poor habitat. Based on landscape habitat use analysis of studies conducted by Wylie et al (Wylie, Graham et al. 1995; Wylie, Casazza et al. 1997; Wylie, Casazza et al. 2002; Wylie, Casazza et al. 2002) provided in the Solano Multispecies Habitat Conservation Plan (Solano HCP), low quality ditch habitat associated with rice fields provided an artificial marsh habitat that provides the essential components (e.g., appropriate cover, high food availability, and upland refuge) to support GGS. Alternatively, studies conducted in high quality marsh habitat surrounded by fallow fields did not locate GGS or found them at very low densities. Based on these results, areas supporting marginal to poor habitat or small, isolated patches of good habitat are presumed to not support GGS due to lack of surrounding aquatic habitat (Solano County Water Agency 2009). In the case of the project area, the surrounding aquatic habitat is of marginal to poor quality and thus, it is unlikely that GGS would use these for dispersal.

The upland habitat that the project area provides (i.e. upland habitat along access routes and within well pad expansion area) is also poor to marginal habitat for GGS. As part of existing agricultural activities, potential upland habitat for GGS within and immediately around proposed project area are extensively disked, tilled and planted with row crops to the edge of the existing well pad and likely precludes occupation of burrowing mammals that would provide refugia for GGS. Additionally, no burrows or other refugia were observed around the existing well pad, in the pad expansion area, or along the Piacentine well access roads (alternative or primary), and no ground squirrel activity was observed during the field reconnaissance on August 20, 2012 in these areas. Based on the observation of low quality habitat (i.e. distance from moderate to poor quality dispersal habitat provided by the primary irrigation ditches (greater than 200 feet), documented lack of use in non-rice agricultural lands, the lack of upland habitat including burrows or other refugia, and the lack of ground squirrel activity near the well pad expansion area, the primary irrigation ditches and the associated farmed upland provide low quality habitat and the likelihood for GGS to occur within the pad expansion area is very low.

To minimize potential adverse effects on GGS along the access roads, a survey for burrows shall be conducted 24 hours prior to any modifications to access roads (i.e., grading or addition of gravels). If burrows are observed during the inactive period, they shall be flagged and grading or addition of gravel along the shoulder shall avoid all burrows. In addition, all vehicles will travel in the road center and speed limit of 10 mph will be maintained which will also minimize potential impact on this species.

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name **Scientific Name**	**Listing Status[1] (Fed/State)**	**Habitat Requirements**	**Potential for Significant Impact**	**Avoidance and Minimization Measures**
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	T/—	Elderberry shrubs associated with riparian forests which occur along rivers and streams.	None. No elderberry shrubs were observed within the project area.	None required
Delta smelt *Hypomesus transpacificus* **Critical habitat**	T/T	Estuarine systems in the Sacramento-San Joaquin Delta.	None. The irrigation ditches and Bishop Cut occurring within the project area and along the access roads provide potential habitat for this species and are connected to higher quality habitat (marshes and sloughs) occurring outside of the project area. However, all potential habitat for this species occurs outside of planned activity areas (i.e., access roads, existing well pads, and well pad expansions areas) and no impacts or modifications to potential habitat are expected.	None required
Sacramento splittail Pogonichthys macrolepidotus	—/SC	Shallow, dead-end sloughs with submerged vegetation.	None. The irrigation ditches and Bishop Cut occurring within the project area and along the access roads provide potential habitat for this species and are connected to higher quality habitat (marshes and sloughs) occurring outside of the project area. However, all potential habitat for this species occurs outside of planned activity areas (i.e., access roads, existing well pads, and well pad expansions areas) and no impacts or modifications to potential habitat are expected.	None required
Longfin smelt Spirinchus thaleichthys	—/SC	Sloughs of Suisun Bay and Delta.	None. The irrigation ditches and Bishop Cut occurring within the project area and along the access roads provide potential habitat for this species and are connected to higher quality habitat (marshes and sloughs) occurring outside of the project area. However, all potential habitat for this species occurs outside of planned activity areas (i.e., access roads, existing well pads, and well pad expansions areas) and no impacts or modifications to potential habitat are expected.	None required

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Common Name Scientific Name	Listing Status[1] (Fed/State)	Habitat Requirements	Potential for Significant Impact	Avoidance and Minimization Measures
California red-legged frog *Rana draytonii*	T/SC	Require aquatic habitat for breeding, also uses a variety of other habitat types including riparian and upland areas. Adults prefer dense, shrubby or emergent vegetation associated with deep-water pools with fringes of cattails and dense stands of overhanging vegetation. This species also breeds in ephemeral ponds that support little or no vegetation.	None . This species is outside the current known range (CWHR) and there are no occurrences within 5 miles of the project area. Additionally, the San Joaquin County Multispecies Habitat Conservation and Open Space Plan (SJMHCP) concludes that CRLF is extirpated from the valley floor (San Joaquin County 2000). This species is not expected to occur in the project area.	None required.
Giant garter snake *Thamnophis gigas*	T/T	Freshwater marshes and low gradient streams with emergent vegetation. Adapted to drainage canals and irrigation ditches with mud substrate.	Low. The irrigation ditches and associated uplands within the project area provide potential habitat. A known extant population of GGS occurs within the Coldani Marsh-White Slough area approximately 0.5 mile to the northeast of the project area. The location of this population is hydrologically connected to irrigation ditches within the project area. Ground disturbance activities that disrupt burrows within the project area could adversely affect this species.	Pre construction surveys Biological monitor Water quality BMPs

Table 1. Special-Status Species with Potential to Occur in the Project Area, Impacts Analysis, and Avoidance and Minimization Measures

Common Name Scientific Name	Listing Status[1] (Fed/State)	Habitat Requirements	Potential for Significant Impact	Avoidance and Minimization Measures
Western pond turtle *Emys marmorata*	--/SC	Slow water aquatic habitat with available basking sites. Hatchlings require shallow water with dense submergent or short emergent vegetation. Requires an upland oviposition site in the vicinity of the aquatic site.	None. Although ditches in the project area are perennial, and contain fresh emergent vegetation, the banks are steep and do not contain available basking sites. Ditches are actively maintained and likely preclude the occupation of pond turtles. Additionally, upland breeding sites are unavailable in the cropland habitat around the well expansion site and access roads. Due to lack of basking habitat and upland oviposition sites, the potential for pond turtles to occur in the project area is unlikely.	None required.
California black rail *Laterallus jamaicensis coturniculus*	—/T, FP	Coastal and inland marsh habitat.	None. The irrigation ditches occurring within the project area provide poor to no potential habitat for this species and are connected to higher quality habitat (marshes and sloughs) occurring outside of the project area. However, potential habitat for this species occurs outside of planned activity areas (i.e., access roads, existing well pads, and well pad expansions areas) and no impacts or modifications to potential habitat are expected.	None required
Swainson's hawk *Buteo swainsoni*	--/T	Breeds in stands with few trees in juniper-sage flats, riparian areas, and oak savannah; forages in adjacent livestock pasture, grassland or grain fields.	Moderate. Larger trees and stands of trees occurring within 0.5 mile of the project area provide potential nesting habitat for Swainson's hawk. There are sixteen recorded CNDDB occurrences of nesting Swainson's hawk within 5 miles of the project area with the nearest approximately 2 miles west of the project area. Noise generated by project activities could disrupt nesting behavior and nest success if Swainson's hawks are nesting within 0.5 mile of the project area.	If work is expected to occur during nesting season (March 1 to July 31), Swainson' hawk nesting surveys will be performed following CDFG protocol developed by the Swainson's Hawk Technical Advisory Committee.

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Common Name Scientific Name	Listing Status[1] (Fed/State)	Habitat Requirements	Potential for Significant Impact	Avoidance and Minimization Measures
White-tailed kite *Elanus leucurus*	—/FP	Nests in tall shrubs and trees, forages in grasslands, agricultural fields and marshes.	Low. Isolated trees and shrubs near proposed access roads and existing farm facilities provide potential nesting habitat for this species.	Nesting bird surveys required within the breeding season (February 15-August 31).
Loggerhead shrike *Lanius ludovicianus*	—/SC	Nests in tall shrubs and dense trees, forages in grasslands, marshes, and ruderal habitats.	Low. Isolated trees and shrubs near proposed access roads and existing farm facilities provide potential nesting habitat for this species.	Nesting bird surveys required within the breeding season (February 15-August 31).

[1] Status Codes: : Federal and State Codes: T = Threatened; SC = Species of Special Concern (State), FP = Fully Protected (State)

However, if construction occurs during the GGS active period, the likelihood of encountering a snake along or within access roads bordering GGS aquatic habitat greatly increases. Due to the aquatic habitat along the unnamed dirt road and King Island Road (Figure 2), if construction activities, occurs during the active period, a biological monitor will drive in front of heavy construction vehicles (i.e. dump trucks, drill rigs, etc.) on all dirt roads during entry/exit of project site. The biologist will lead vehicles at a maximum speed of 10 mph, watch for signs of snakes, and stop and investigate the road if there are any concerns. The preferred access road will be likely used; however, if the alternate route along King Island Road is used, all AMMs developed for dirt roads will be implemented.

Because of the proximity of a known population 0.5 miles northeast of the project and the availability of moderate to high quality marsh aquatic habitat in larger canals 900 feet north of the proposed well pad expansion area, AMM's are provided in this document to avoid potential impacts on GGS.

Potential nesting habitat (e.g., trees, power poles/towers) for Swainson's hawk occurs within the project area and within 0.5 mile of the project area. Noise generated by expanding the pad, exploration drilling, site restoration, and other construction activities could adversely affect this species if active nests are located within 0.5 mile. Project implementation is expected to commence as early as October 2012 and extend for a total of four to six weeks, which is outside of the nesting season for these species. If project implementation is confined to this period, the proposed project will not result in adverse effects on this species. However, if work will occur during the nesting season (i.e., March 1–July 31), protocol -level surveys for Swainson's hawk will be required. If active nests are detected within 0.5 mile of project activities, construction activity will stop immediately and will not resume until PG&E Biologist or Land Planner contacts USFWS and California Department of Fish and Game (CDFG) Biologists to discuss possible AMM's, which could include avoidance buffers, reconsidering access routes, and additional surveys.

Walnut orchards within the proposed area of expansion do not provide foraging habitat for Swainson's hawks and removal of approximately 0.18 acre of this crop to expand the well pad would not affect available foraging habitat for Swainson's hawks.

Nesting habitat for loggerhead shrike and white-tailed kite occur in the trees and shrubs adjacent to the project area. As with the Swainson's hawk, construction activities could have adverse impacts on nesting success for these species depending on the timing of the work. Disturbance to vegetation and removal of existing crops (i.e., walnut orchards and safflower) for well pad expansion should be conducted outside of the nesting season (i.e., between August 31-February 15) in order to avoid potential effects on nesting birds. If work is to occur during the nesting season for these species (February 15–August 31), nesting bird surveys will occur 72 hours prior to the start of construction to determine if birds are nesting in the area. If nesting birds are found PG&E will halt work and consult with CDFG and USFWS to establish AMM's to protect nest (i.e. establish buffers).

Waters of the United States and Potential Impacts

An assessment for potential waters of the United States was conducted during the August 20, 2012 field reconnaissance. The irrigation ditches adjacent to roadways within the project area were observed to support a prevalence of hydrophytic vegetation, and some reaches of the irrigation ditches contained flowing or ponded water. Water is generally pumped in or out of White Slough depending on need to irrigate farmland or to pump out water to keep the area from flooding. The irrigation ditches within the project area drain into or are adjacent (separated by a berm) to White Slough, which qualifies as waters of the United States. Given that the irrigation ditches support hydrophytic vegetation, are subject to extended inundation and/or saturation, and are tributary to waters of the United States, the features are considered as potential waters of the United States. The Bishop Cut is a navigable water and is subject to

USACE jurisdiction. The project will not result in any physical disturbance of irrigation ditches or Bishop Cut within the project area; thus, the proposed project would not result in direct impacts on the irrigation ditches. AMMs have been incorporated into the proposed project to avoid the potential for indirect impacts.

Although the USFWS National Wetlands Inventory identifies the entire project area as farmed wetlands, the existing access roads, the existing well pad, and the proposed well pad expansion area do not appear to currently meet wetland criteria. The existing access roads and the existing well pad consist of compacted surfaces that are graded and unvegetated; and do not exhibit evidence of long-duration ponding or saturation, or exhibit other indications of wetland hydrology. The proposed well pad expansion area currently supports a leveled and routinely disked agricultural field that is planted with a young walnut orchard intercropped with safflower. Field inspection of this area did not identify the presence of hydrophytic vegetation or evidence of soil inundation/saturation unrelated to routine irrigation. Based on observation of the water level in ponded portions of the irrigation ditch, the surface of the agricultural field appeared to be several feet above the water table. Given the lack of hydrophytic vegetation and an absence of indications of a current wetland hydrology, the existing access roads, the existing well pad, and the proposed well pad expansion area are not considered to qualify as potential waters of the United States.

It is important to note that the field assessment did not involve a formal delineation using U.S. Army Corps of Engineers (USACE) methodology and no detailed investigations for wetland hydrology were conducted. The entire project area was historically Sacramento–San Joaquin Delta marshland prior to dikes/draining and conversion to agricultural production. Areas of agricultural production that were formerly wetlands may still qualify as jurisdictional wetlands if hydrological characteristics remain to the extent that hydrophytic vegetation would return if the agricultural activities ceased. The determinations provided in this document concerning wetland hydrology are based on a single visual assessment conducted on August 20, 2012. Definitive documentation of the status of wetland hydrology generally cannot be provided by a single visual assessment during the dry season. Therefore, all determinations provided in this document concerning waters of the United States should be considered preliminary and tentative unless verified in writing by the USACE.

Other Sensitive Biological Resources

Migratory birds and raptors (i.e., birds of prey) protected under the federal Migratory Bird Treaty Act and the California Department of Fish and Game Code may nest on open ground, vegetation, or structures within the project area. Construction activities could have adverse impacts on nesting success for birds nesting near the construction site. If disturbance to vegetation and removal of existing crops (i.e., walnut orchards and safflower) for well pad expansion is conducted outside of the nesting season, then no impacts to nesting birds are expected to result from well pad expansion activities. If work is to occur during the nesting season for these species (February 15–August 31), nesting bird surveys will be occur 72 hours prior to the start of construction required to determine if birds are nesting in the area. If nesting birds are found PG&E will halt work and consult with CDFG and USFWS to establish AMM’s to protect nest (i.e. establish buffers).

Avoidance and Minimization Measures (22 total):

1. Prior to working on-site, all workers shall be provided with Environmental Awareness Training by a qualified biologist approved by USFWS and CDFG. The training shall address the identification and general ecology of GGS, Swainson’s hawk, nesting birds and other special-status species that have potential to occur in the project area, and the AMMS to be implemented in order to avoid impacts on these resources. Areas to be avoided shall also be addressed in the

training. Please contact project biologist, Catalina Reyes (925-808-8811) two weeks prior to construction to schedule the training.

2. Prior to construction, all work areas (e.g., vehicle access, parking, staging) needed to complete the project shall be identified in coordination with the on-site biologist. Due to the presence of sensitive resources, some work areas may need to be adjusted. All work areas shall be limited to the minimum area necessary to complete work.

3. If practicable, ground disturbing activity (e.g. vegetation removal, compaction, and placement of gravel fill) at all the well pad site shall be conducted during the active season for giant garter snake (GGS) (i.e., between May 1 and October 1). If ground-disturbing activity cannot be conducted during the GGS active season, preconstruction surveys for potential GGS wintering sites (i.e., burrows and soils crevices) shall be conducted within two weeks by a qualified biologist approved by USFWS and CDFG to determine the if potential GGS habitat is present within proposed areas of ground disturbing activity (e.g., the well pad expansion site, road work, application of gravel) and again within 24 hours prior to ground disturbing activity which includes any modification to access roads.

4. All burrows or potential refuge habitat shall be flagged and avoided. If work is suspended for a period of five days or greater, than the project area must be resurveyed. If it is determined that potential GGS wintering habitat (e.g., burrows and crevices) is present within areas planned for ground disturbance, ground-disturbing activities shall be postponed until the GGS active season (i.e., between May 1 and October 1). If GGS is encountered at any time during the project, work will stop immediately and the USFWS and CDFG will be contacted before work proceeds.

5. A biological monitor shall be on site during all phases of construction to direct access and construction work around irrigation ditches and other sensitive habitats capable of supporting GGS. If any GGS are observed within the project area during work activities, work shall cease and the on-site project manager shall immediately contact the project biologist, Catalina Reyes (925-808-8811) prior to resuming work. The biological monitor has the authority to stop construction to resolve any biological concerns.

6. Access to well pads shall be confined to existing roads, road shoulders, and other compacted areas. Travel along roads shall be restricted to the centerline. If placement of gravel or grading on access roads is necessary, the placement shall be limited to the existing road surface. No gravel shall be placed on ditch banks or other areas that may support burrows that could be used by GGS. No grading shall occur along segments of existing roads that may support burrows that could be used by GGS.

7. The irrigation ditches and Bishop Cut will be designated as environmentally sensitive areas and physical disturbance to ditches will be avoided during construction.

8. If deemed necessary, an exclusionary fence shall be erected to protect potentially sensitive habitat adjacent to the existing well pad. To ensure that GGS does not become trapped or entangled, no wattles with plastic monofilament netting are permitted. Burlap or coconut wattles are appropriate substitutes.

9. A qualified biologist approved by USFWS and CDFG shall perform a general pre-construction survey within 72 hours of the start of project construction.

10. Provide escape ramps at a 45 degree angle or less for any excavations that are greater than one foot that are left open overnight. For smaller holes, cover so that no gaps occur and inspect each morning for wildlife. Inspect prior to filling any trenches or holes. If special-status wildlife becomes entrapped, work shall stop and the PG&E project biologist, Catalina Reyes, shall be notified immediately to determine next steps.

11. All construction personnel shall visually check for snakes and other wildlife under vehicles and equipment prior to moving them.

12. Construction equipment will be maintained to prevent leaks of fuels, lubricants or other pollutants into aquatic habitats.

13. Whenever possible, refueling and maintenance of vehicles shall occur offsite. In cases when this is not possible, refueling and maintenance of vehicles and equipment will be conducted over drip pans and at least 100 feet from any waterway.

14. Open ends of pipes, conduits or other materials stored onsite will be covered to exclude wildlife and will be inspected prior to use.

15. Vehicular speed within the project area shall be limited to 10 miles per hour in order avoid impacts on wildlife that may be located on or near roadways. If construction activities, including addition of gravel, occurs during the active period, a biological monitor will drive in front of heavy construction vehicles (i.e. dump trucks, drill rigs, etc.) on all dirt roads during entry/exit of project site. Biologist will lead vehicles at a minimum speed of 10 mph, watch for signs of snakes, and stop and investigate the road if there are any concerns.

16. Watering of roads during dry season work shall be performed as necessary (approximately 3–4 times a day) in order to reduce potential dust resulting from project associated traffic.

17. All potential nesting substrate (e.g., shrubs and trees) that requires removal to construct the project should be removed before the onset of the nesting season (i.e., prior to February 15), if feasible. This will help preclude nesting and substantially decrease the likelihood of direct impacts on nesting birds. If this is not feasible then a nesting bird survey of potential nesting substrate will be performed 72 hours prior to its removal.

18. Surveys for nesting raptors and migratory birds (including Swainson’s hawk) shall be required if project construction is to occur during the nesting season (February 15–August 31; March 1-July 31 for Swainson’s hawk). Surveys shall be conducted by a qualified biologist approved by USFWS and CDFG.

    Surveys for Swainson’s hawk shall follow the California Department of Fish and Game protocol developed by the Swainson’s Hawk Technical Advisory Committee (see Appendix C).

    Surveys for other nesting birds, surveys will consist of performing an initial survey after February 15, 2013 or within a month of the start of project date if project is to begin later in the nesting bird season. A second nesting bird survey shall be performed within 72 hours of the start of construction. The surveys shall be repeated if work is suspended for five days or more. Please contact project biologist, Catalina Reyes (925-808-8811) two weeks prior to construction schedule surveys.

19. Caution shall be used when handling and/or storing chemicals (fuel, hydraulic fluid, etc.). As part of standard PG&E Best Management Practices (BMPs), crews shall have appropriate materials on site to provide secondary containment and prevent and manage spills. If groundwater is encountered, contact PG&E Environmental Specialist Bryon Nicholson (415-990-0139).

20. Crews shall implement all standard PG&E BMPs outlined in the Good Housekeeping Activity Specific Erosion and Sediment Control Plan (January 2011) as needed.

21. If the scope of work or project location changes, contact project biologist Catalina Reyes (925-808-8811) prior to commencing work. The project biologist or Land Planner (Ernie Ralston, 515-973-3215) will contact the USFWS Bay-Delta Fish & Wildlife Office ESA/Regulatory Division and the Dept. of Fish & Game-Bay Delta Region upon notice of any such changes.

22. Remove construction related trash from the site daily and upon work completion and return site to near pre-construction contours and conditions upon project completion.

Attachment 1. Desktop Review Results

Source	Results
County	San Joaquin
USGS Quadrangle	Terminous, California (Unsectioned Wetlands of the Empire Tract)
Aerial Photographs – Google Earth 2012 & Bing Aerial Imagery 2012	Row crop region on Delta Island. Preferred Access Road: runs north for approximately 1.0 mile, turning east for approximately 1.2 miles, then turns north to parallel secondary access road for 0.6 mile to entrance of Piacentine Well site (along west bank of unnamed irrigation ditch). Total of 2.7 miles along east and south bank of large (approximately 40 foot wide) irrigation ditch to entrance of Piacentine Well site. Irrigation ditch supports patches of emergent vegetion. Alternate Access Road: approximately 1.85 miles long. Runs north along west bank of Bishop Cut (large Delta channel) for approximately 1.0 mile, then jogs west between vineyard and (maybe) orchards for approximately 0.3 mile, then turns north for 0.6 mile, joining proposed primary access road along east bank of unnamed irrigation ditch. Piacentine Well: Approximately 0.12 mile of raised gravel access road going to well pad. Well pad access and associated well pad access road entirely within orchard.
Land Ownership California Protected Areas Database (CPAD)	None. Private Ownership.
USFWS official list	Attached.
Federally Designated Critical Habitat (within 5-mile radius)	Within Delta Smelt Critical Habitat.
CNDDB-5-mile radius	Attached.
CNDDB owl viewer	Not within range of Spotted Owl.
CNPS-9 quad search	Attached.
PG&E Raptor Concentration Zones (RCZ)	Within RCZ.
National Audubon Society Important Bird Areas (IBA)	Within Sacramento-San Joaquin IBA.
U.S. Department of Agriculture (USDA) Web Soil Survey	Project area within organic muck over alluvium: Kingile muck, Kingile-Ryde complex, and Ryde-Peltier complex.
USFWS National Wetlands Inventory	Entire project area included within farmed wetlands (Pf) in USFWS NWI.
PG&E San Joaquin HCP or other HCPs, NCCPs	Within PG&E San Joaquin HCP and San Joaquin County Multispecies HCP.
Known Swainson's Hawk, golden or bald eagle nest sites	CNDDB Swainson's hawk nesting record within 5 miles of project area. Nearest CNDDB occurrence is 0.4 mile south of the project area. No golden or bald eagle occurrences within 5 miles.
PG&E VELB Conservation Program Range	Within PG&E VELB Conservation Program Range.
CWHR (California Wildlife Habitat Relations) species.	Potential giant garter snake habitat is found in association with the irrigation ditches and associated uplands within the project area. Potential nesting habitat for Swainson's hawk occurs in several areas within 0.5 mile of the project area.

References

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP). Stockton, CA. Available online at - http://www.sjcog.org/programs-projects/Habitat_files/SJMSCP%20Document%20and%20Appendixes/San%20Joaquin%20Multi%20Species%20Habitat%20Conservation%20and%20Open%20Space%20Plan.pdf

Miller, K. J., K. Hornaday, et al. 1999. Draft recovery plan for the giant garter snake (Thamnophis gigas), U.S. Fish and Wildlife Service: 192.

Solano County Water Agency (2009). Solano Multispecies Habitat Conservation Plan Final Administrative Draft.

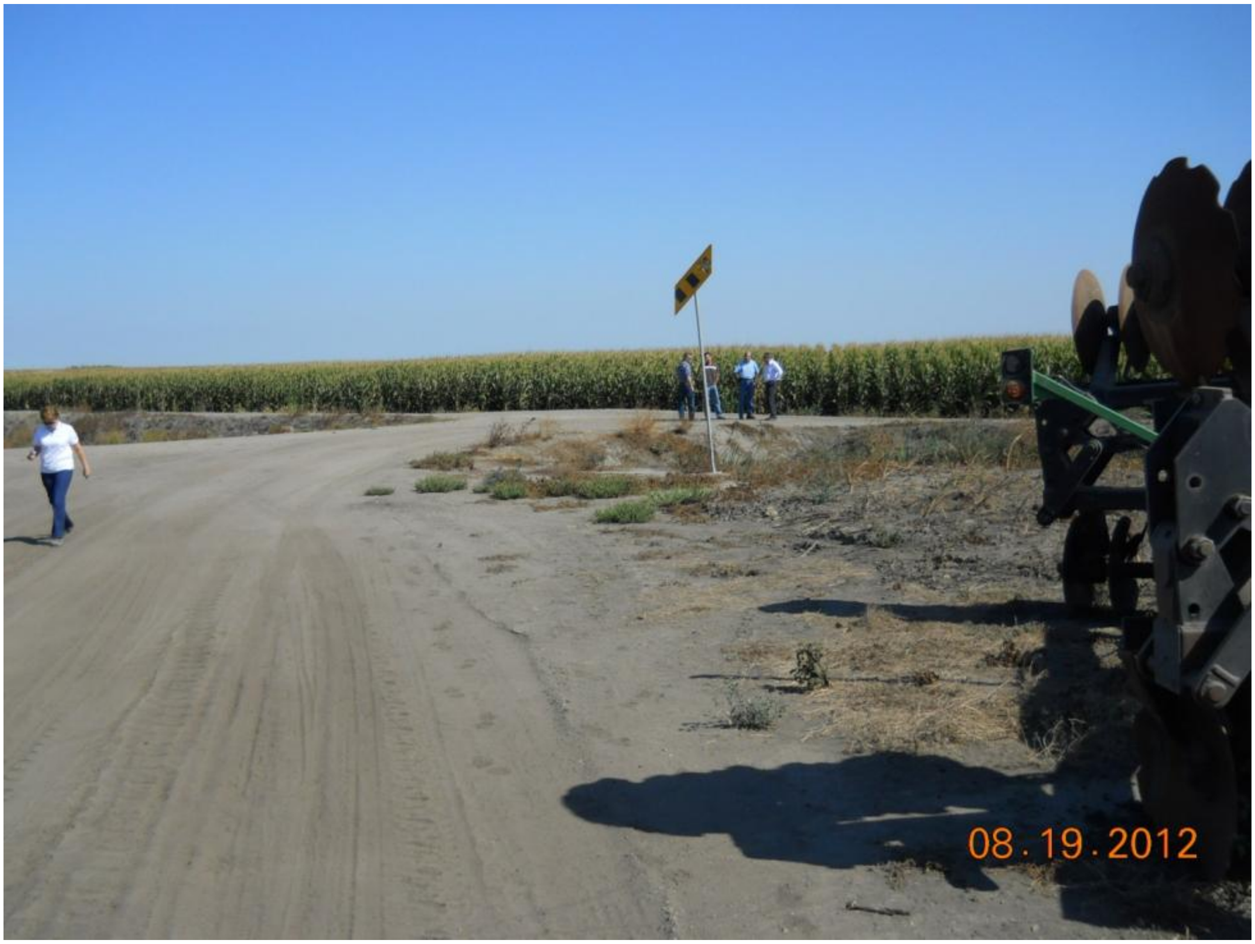
Wylie, G. D., M. L. Casazza, et al. 1997. 1996 Progress report for giant garter snake study. Unpublished report. Dixon, CA, USGS Biological Resources Division Dixon Research Station.

Wylie, G. D., M. L. Casazza, et al. 2002. The distribution of giant garter snakes and their habtiat in the Natomas Basin. Dixon, CA, USGS, Western Ecological Research Center, Dixon Field Station.

Wylie, G. D., M. L. Casazza, et al. 2002. Monitoring giant garter snakes at Colusa National Wildlife Refuge: 2002 progress report. Prepared for U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation. Dixon, CA, USGS Western Ecological Research Center, Dixon Field Station.

Wylie, G. D., T. Graham, et al. 1995. National biological service giant garter snake study progress report for the 1995 field season. Unpublished report. Dixon, CA, USGS Biological Resources Division, Dixon Research Station.

Photograph 1. View north along irrigation ditch and preferred access road from junction of preferred access with West 8 Mile Road. Photograph shows (from left to right) existing corn crops, graded levees road (with no burrows or crevices in surface), unnamed ditch (with bankside vegetation and patches of floating aquatic vegetation), another levee road, and asparagus crops.



Photograph 2. View north toward preferred access road crossing of existing ditch structures showing ruderal vegetation along edge of road bed and well-graded road bed with no burrows or crevices.

Photograph 3. View west along ditch and east–west portion of preferred access road. Photograph shows (from left to right) harvested and disked row crops (safflower), preferred access road (with no burrows or crevices in surface), unnamed ditch (with ruderal bankside vegetation, floating aquatic vegetation and patches of emergent vegetation), another levee road, and flood-irrigated corn crops.

Photograph 4. View west along irrigation ditch and east–west portion of preferred access road. Photograph shows (from left to right) harvested and disked row crops (safflower), preferred access road (with no burrows or crevices in surface), unnamed ditch (with ruderal bankside vegetation.

Photograph 5. View north along unnamed irrigation ditch and preferred access road from farm facilities. Photograph shows (from left to right) unnamed graded levee road, unnamed ditch (with patches of ruderal vegetation and dense patches of emergent vegetation), preferred access road (with no burrows or crevices in surface), young walnut orchard intercropped with safflower.

Photograph 6. View west along graveled access road to King Island Piacentine well pad. Well pad is shown on left and will be expanded into the adjacent cropland. No burrows or crevices were observed in the road surface (young walnut orchard intercropped with safflower shown in background).

Photograph 7. View northeast of existing King Island Piacentine Well pad, natural gas facilities and staged agricultural supplies. No burrows or crevices were observed in the existing well pad (young walnut orchard intercropped with safflower shown in background).

Photograph 8. View east of existing King Island Piacentine well and staged agricultural supplies. No burrows or crevices were observed in the existing well pad (young walnut orchard intercropped with safflower shown in background).

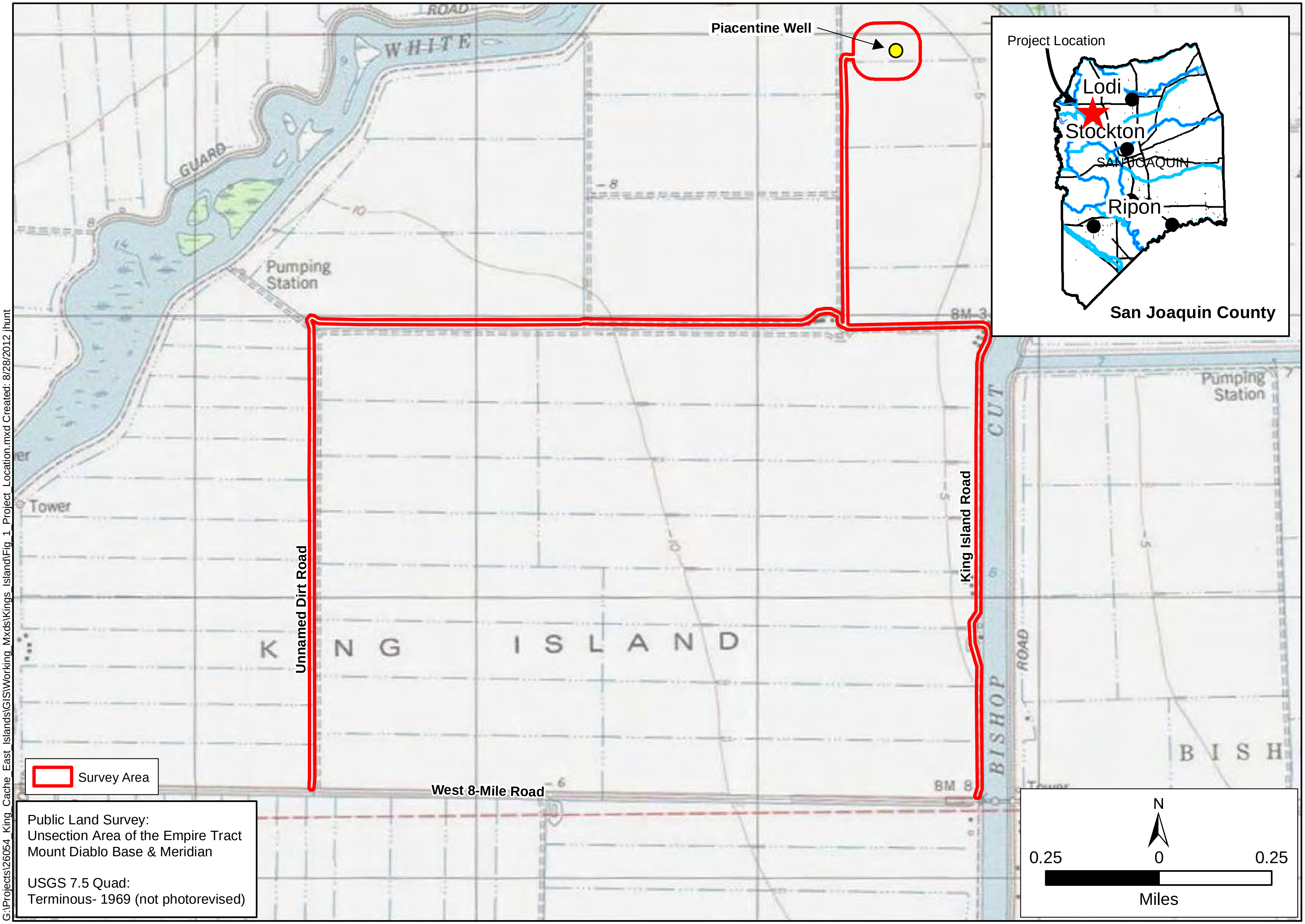
Photograph 9. View north toward proposed King Island Piacentine well pad expansion area showing young walnut orchard intercropped with safflower characteristic of proposed expansion area (staged agricultural equipment on existing Piacentine well pad in foreground).

Photograph 10. View of existing agricultural facility staging area at junction of preferred and alternate access roads.

Photograph 11. View of south along King Island Road. Photograph shows (from left to right) the open water of Bishop Cut, rip-rapped banks and ruderal vegetation, King Island Road with fringing ruderal vegetation, and mature walnut orchards.

APPENDIX A

Figures



Public Land Survey:
Unsection Area of the Empire Tract
Mount Diablo Base & Meridian

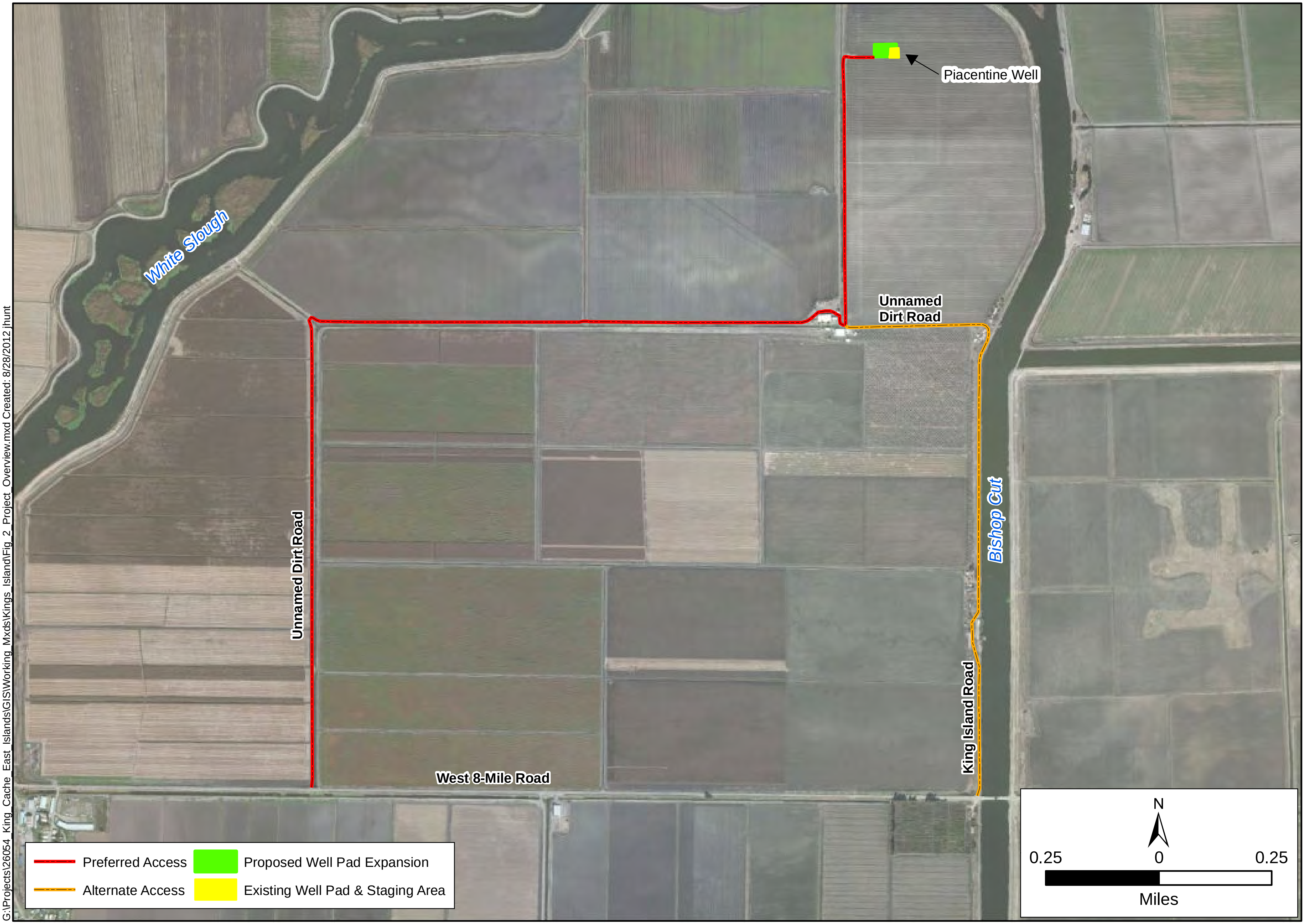
USGS 7.5 Quad:
Terminous- 1969 (not photorevised)

G:\Projects\26054 King Cache East Islands\GIS\Working Mxds\Kings Island\Fig 1 Project Location.mxd Created: 8/28/2012 jhunt

North State Resources, Inc.

King Island, San Joaquin County, California

Figure 1. Project Location and Vicinity Map



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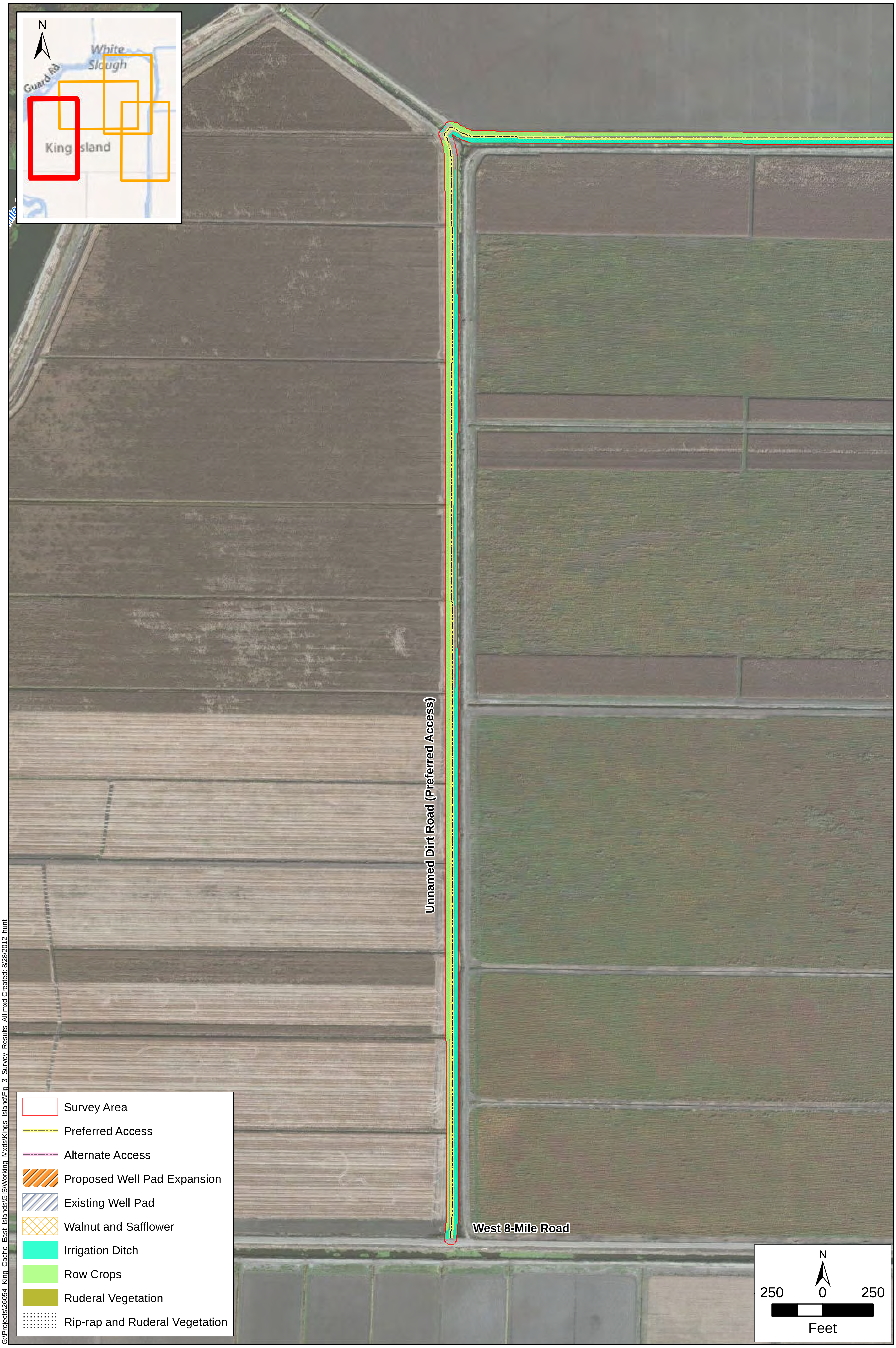
North State Resources, Inc.

King Island, San Joaquin County, California

Figure 2. Project Area



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North State Resources, Inc.

King Island, San Joaquin County, California

Figure 3-1. Survey Results

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North State Resources, Inc.

King Island, San Joaquin County, California

Figure 3-2. Survey Results

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North State Resources, Inc.

King Island, San Joaquin County, California

Figure 3-3. Survey Results

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King Island, San Joaquin County, California

North State Resources, Inc.

Figure 3-4. Survey Results

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North State Resources, Inc.

King Island, San Joaquin County, California

Figure 4. Survey Results - Well Pad Expansion Area

APPENDIX B

USFWS, CNDDB, and CNPS Queries

U.S. Fish & Wildlife Service

Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 120816041228

Database Last Updated: September 18, 2011

Quad Lists

Listed Species

Invertebrates

- *Branchinecta lynchi*
  - vernal pool fairy shrimp (T)
- *Desmocerus californicus dimorphus*
  - valley elderberry longhorn beetle (T)
- *Lepidurus packardi*
  - vernal pool tadpole shrimp (E)

Fish

- *Acipenser medirostris*
  - green sturgeon (T) (NMFS)
- *Hypomesus transpacificus*
  - Critical habitat, delta smelt (X)
  - delta smelt (T)
- *Oncorhynchus mykiss*
  - Central Valley steelhead (T) (NMFS)
  - Critical habitat, Central Valley steelhead (X) (NMFS)
- *Oncorhynchus tshawytscha*
  - Central Valley spring-run chinook salmon (T) (NMFS)
  - winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

- *Ambystoma californiense*
  - California tiger salamander, central population (T)
- *Rana draytonii*
  - California red-legged frog (T)

Reptiles

- *Thamnophis gigas*
  - giant garter snake (T)

Mammals

- *Sylvilagus bachmani riparius*
  - riparian brush rabbit (E)

Quads Containing Listed, Proposed or Candidate Species:

TERMINOUS (479C)

County Lists

San Joaquin County

Listed Species

Invertebrates

Branchinecta conservatio
- Conservancy fairy shrimp (E)
- Critical habitat, Conservancy fairy shrimp (X)

Branchinecta longiantenna
- longhorn fairy shrimp (E)

Branchinecta lynchi
- Critical habitat, vernal pool fairy shrimp (X)
- vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
- valley elderberry longhorn beetle (T)

Elaphrus viridis
- delta green ground beetle (T)

Lepidurus packardi
- Critical habitat, vernal pool tadpole shrimp (X)
- vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris
- green sturgeon (T) (NMFS)

Hypomesus transpacificus
- Critical habitat, delta smelt (X)
- delta smelt (T)

Oncorhynchus mykiss
- Central Valley steelhead (T) (NMFS)
- Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
- Central Valley spring-run chinook salmon (T) (NMFS)
- Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
- Critical habitat, winter-run chinook salmon (X) (NMFS)
- winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
- California tiger salamander, central population (T)
- Critical habitat, CA tiger salamander, central population (X)

Rana draytonii
- California red-legged frog (T)
- Critical habitat, California red-legged frog (X)

Reptiles

Masticophis lateralis euryxanthus
- Alameda whipsnake [=striped racer] (T)

Critical habitat, Alameda whipsnake (X)

Thamnophis gigas
giant garter snake (T)

Birds

Rallus longirostris obsoletus
California clapper rail (E)

Vireo bellii pusillus
Least Bell's vireo (E)

Mammals

Neotoma fuscipes riparia
riparian (San Joaquin Valley) woodrat (E)

Sylvilagus bachmani riparius
riparian brush rabbit (E)

Vulpes macrotis mutica
San Joaquin kit fox (E)

Plants

Amsinckia grandiflora
Critical habitat, large-flowered fiddleneck (X)
large-flowered fiddleneck (E)

Arctostaphylos myrtifolia
Ione manzanita (T)

Castilleja campestris ssp. succulenta
Critical habitat, succulent (=fleshy) owl's-clover (X)
succulent (=fleshy) owl's-clover (T)

Cordylanthus palmatus
palmate-bracted bird's-beak (E)

Lasthenia conjugens
Critical habitat, Contra Costa goldfields (X)

Orcuttia viscida
Critical habitat, Sacramento Orcutt grass (X)
Sacramento Orcutt grass (E)

Tuctoria greenei
Greene's tuctoria (=Orcutt grass) (E)

Candidate Species

Birds

Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

Key:

(E) *Endangered* - Listed as being in danger of extinction.
(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.
(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.
(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.
Critical Habitat - Area essential to the conservation of a species.
(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.
(C) *Candidate* - Candidate to become a proposed species.
(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.
(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.
- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be November 14, 2012.

Count of ELMCODE CNAME	SNAME	FEDLIST	CALLIST	RPLANTRANK	SRANK	Total
burrowing owl	**Athene cunicularia**	None	**None**	(blank)	S2	1
California black rail	**Laterallus jamaicensis coturniculus**	None	**Threatened**	(blank)	S1	6
Coastal and Valley Freshwater Marsh	**Coastal and Valley Freshwater Marsh**	None	**None**	(blank)	S2.1	7
Delta mudwort	**Limosella subulata**	None	**None**	2.1	S2.1	8
Delta smelt	**Hypomesus transpacificus**	Threatened	**Endangered**	(blank)	S1	3
Delta tule pea	**Lathyrus jepsonii var. jepsonii**	None	**None**	1B.2	S2.2	4
giant garter snake	**Thamnophis gigas**	Threatened	**Threatened**	(blank)	S2S3	5
great blue heron	**Ardea herodias**	None	**None**	(blank)	S4	1
Mason's lilaeopsis	**Lilaeopsis masonii**	None	**Rare**	1B.1	S2	18
side-flowering skullcap	**Scutellaria lateriflora**	None	**None**	2.2	S1	2
Suisun Marsh aster	**Symphyotrichum lentum**	None	**None**	1B.2	S2	25
Swainson's hawk	**Buteo swainsoni**	None	**Threatened**	(blank)	S2	25
Valley Oak Woodland	**Valley Oak Woodland**	None	**None**	(blank)	S2.1	1
vernal pool tadpole shrimp	**Lepidurus packardi**	Endangered	**None**	(blank)	S2S3	1
watershield	**Brasenia schreberi**	None	**None**	2.3	S2	1
western pond turtle	**Emys marmorata**	None	**None**	(blank)	S3	11
white-tailed kite	**Elanus leucurus**	None	**None**	(blank)	S3	1
woolly rose-mallow	**Hibiscus lasiocarpos var. occidentalis**	None	**None**	1B.2	S2.2	28
Grand Total						**148**

CNPS Inventory of Rare and Endangered Plants

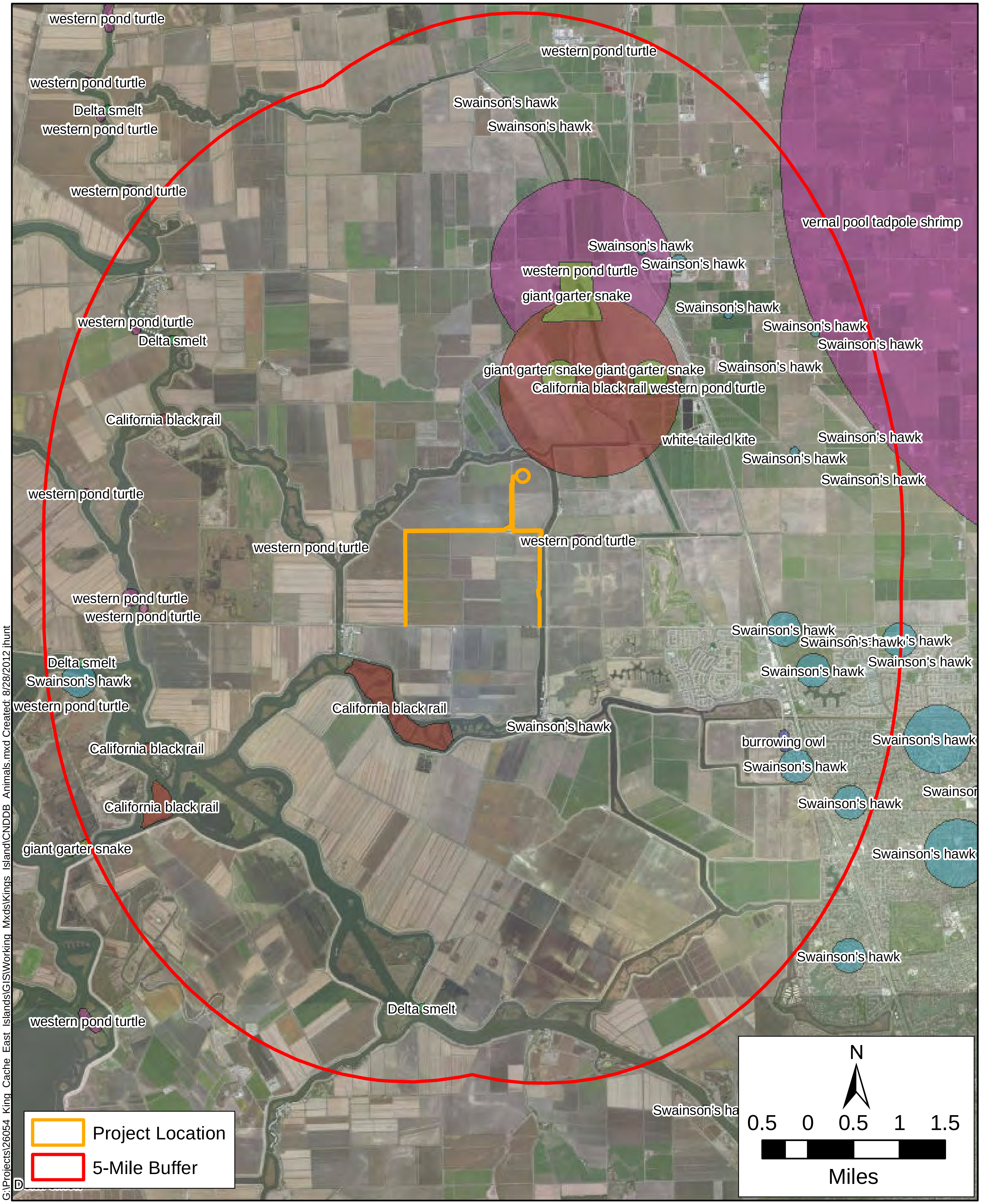
Status: Plant Press Manager window with 21 items - Fri, Aug. 17, 2012 18:17 c

Reformat list as: Standard List - with Plant Press controls ▾

ECOLOGICAL REPORT

scientific	family	life form	blooming	communities	elevation	CNPS
Astragalus tener var. tener	Fabaceae	annual herb	Mar-Jun	•Playas (Plyas) •Valley and foothill grassland (VFGrs) (adobe clay) •Vernal pools (VnPls)/alkaline	1 - 60 meters	List 1B.2
Atriplex cordulata var. cordulata	Chenopodiaceae	annual herb	Apr-Oct	•Chenopod scrub (ChScr) •Meadows and seeps (Medws) •Valley and foothill grassland (VFGrs) (sandy)/saline or alkaline	0 - 560 meters	List 1B.2
Atriplex joaquinana	Chenopodiaceae	annual herb	Apr-Oct	•Chenopod scrub (ChScr) •Meadows and seeps (Medws) •Playas (Plyas) •Valley and foothill grassland (VFGrs)/alkaline	1 - 835 meters	List 1B.2
Blepharizonia plumosa	Asteraceae	annual herb	Jul-Oct	•Valley and foothill grassland (VFGrs)/Usually clay.	30 - 505 meters	List 1B.1
Brasenia schreberi	Cabombaceae	perennial rhizomatous herb aquatic	Jun-Sep	•Marshes and swamps (MshSw)/freshwater	30 - 2200 meters	List 2.3
California macrophylla	Geraniaceae	annual herb	Mar-May	•Cismontane woodland (CmWld) •Valley and foothill grassland (VFGrs)/clay	15 - 1200 meters	List 1B.1
Carex comosa	Cyperaceae	perennial rhizomatous herb	May-Sep	•Coastal prairie (CoPrr) •Marshes and swamps (MshSw) (lake margins) •Valley and foothill grassland (VFGrs)	0 - 625 meters	List 2.1
Chloropyron palmatum	Orobanchaceae	annual herb hemiparasitic	May-Oct	•Chenopod scrub (ChScr) •Valley and foothill grassland (VFGrs)/alkaline	5 - 155 meters	List 1B.1
Eryngium racemosum	Apiaceae	annual/perennial herb	Jun-Oct	•Riparian scrub (RpScr)(vernally mesic clay depressions)	3 - 30 meters	List 1B.1

Hibiscus lasiocarpos var. occidentalis	Malvaceae	perennial rhizomatous herb emergent	Jun-Sep	•Marshes and swamps (MshSw) (freshwater)	0 - 120 meters	List 1B.2
Juglans hindsii	Juglandaceae	perennial deciduous tree	Apr-May	•Riparian forest (RpFrs) •Riparian woodland (RpWld)	0 - 440 meters	List 1B.1
Lathyrus jepsonii var. jepsonii	Fabaceae	perennial herb	May-Jul(Sep), Months in parentheses are uncommon.	•Marshes and swamps (MshSw) (freshwater and brackish)	0 - 4 meters	List 1B.2
Legenere limosa	Campanulaceae	annual herb	Apr-Jun	•Vernal pools (VnPls)	1 - 880 meters	List 1B.1
Lilaeopsis masonii	Apiaceae	perennial rhizomatous herb	Apr-Nov	•Marshes and swamps (MshSw) (brackish or freshwater) •Riparian scrub (RpScr)	0 - 10 meters	List 1B.1
Limosella subulata	Scrophulariaceae	perennial stoloniferous herb	May-Aug	•Marshes and swamps (MshSw)	0 - 3 meters	List 2.1
Potamogeton zosteriformis	Potamogetonaceae	annual herb aquatic	Jun-Jul	•Marshes and swamps (MshSw) (assorted freshwater)	0 - 1860 meters	List 2.2
Sagittaria sanfordii	Alismataceae	perennial rhizomatous herb emergent	May-Oct	•Marshes and swamps (MshSw) (assorted shallow freshwater)	0 - 650 meters	List 1B.2
Scutellaria galericulata	Lamiaceae	perennial rhizomatous herb	Jun-Sep	•Lower montane coniferous forest (LCFrs) •Meadows and seeps (Medws) (mesic) •Marshes and swamps (MshSw)	0 - 2100 meters	List 2.2
Scutellaria lateriflora	Lamiaceae	perennial rhizomatous herb	Jul-Sep	•Meadows and seeps (Medws) (mesic) •Marshes and swamps (MshSw)	0 - 500 meters	List 2.2
Symphyotrichum lentum	Asteraceae	perennial rhizomatous herb	May-Nov	•Marshes and swamps (MshSw) (brackish and freshwater)	0 - 3 meters	List 1B.2
Tropidocarpum capparideum	Brassicaceae	annual herb	Mar-Apr	•Valley and foothill grassland (VFGrs) (alkaline hills)	1 - 455 meters	List 1B.1



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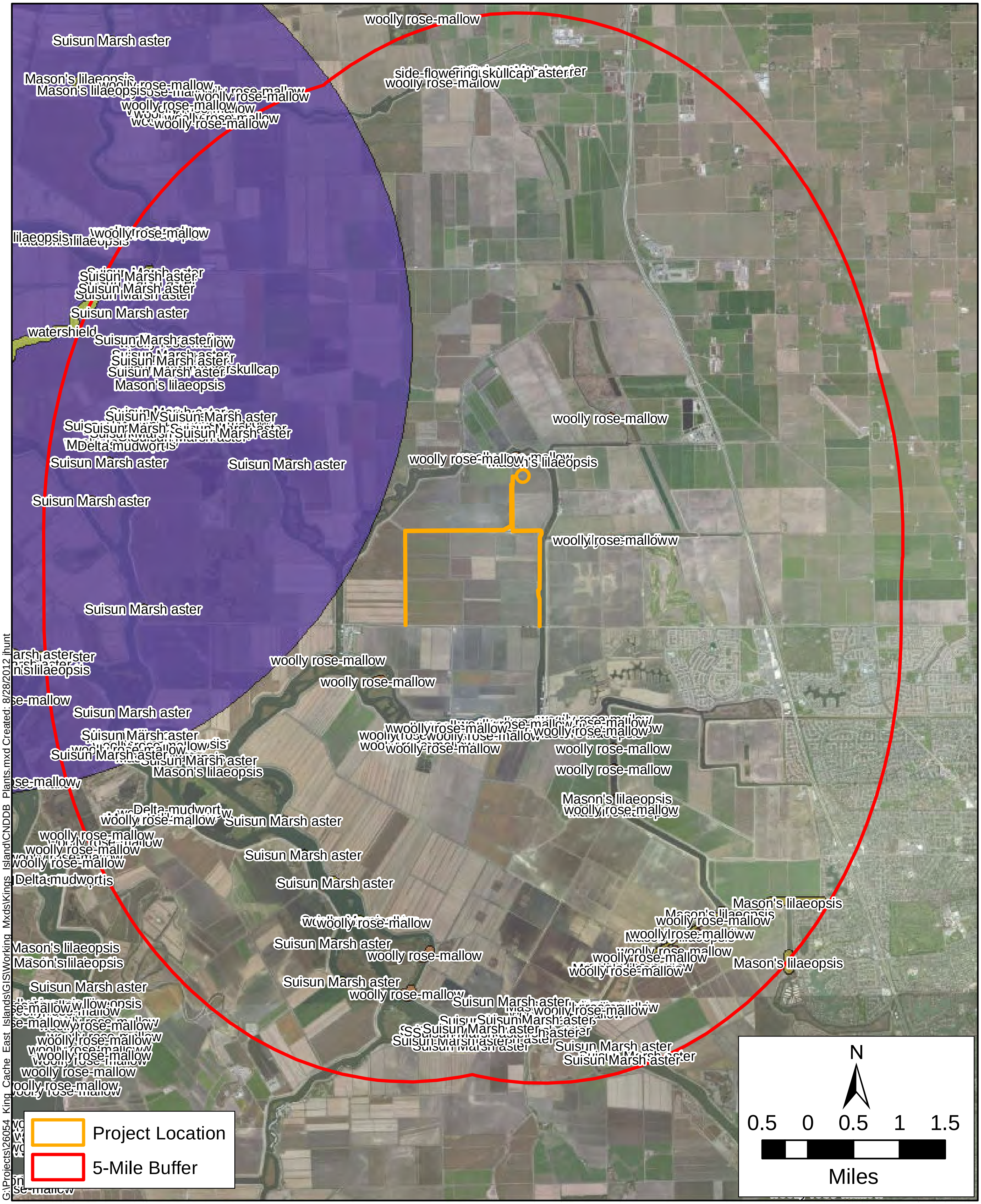
Kings Island, San Joaquin County, California

North State Resources, Inc.

Animal CNDDB Results



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North State Resources, Inc.

Kings Island, San Joaquin County, California

Plants CNDDB Results

APPENDIX C

Swainson's Hawk Survey Protocol

RECOMMENDED TIMING AND METHODOLOGY
FOR SWAINSON'S HAWK NESTING SURVEYS
IN CALIFORNIA'S CENTRAL VALLEY

Swainson’s Hawk Technical Advisory Committee
May 31, 2000

This set of survey recommendations was developed by the Swainson’s Hawk Technical Advisory Committee (TAC) to maximize the potential for locating nesting Swainson’s hawks, and thus reducing the potential for nest failures as a result of project activities/disturbances. The combination of appropriate surveys, risk analysis, and monitoring has been determined to be very effective in reducing the potential for project-induced nest failures. As with most species, when the surveyor is in the right place at the right time, Swainson’s hawks may be easy to observe; but some nest sites may be very difficult to locate, and even the most experienced surveyors have missed nests, nesting pairs, mis-identified a hawk in a nest, or believed incorrectly that a nest had failed. There is no substitute for specific Swainson’s hawk survey experience and acquiring the correct search image.

METHODOLOGY

Surveys should be conducted in a manner that maximizes the potential to observe the adult Swainson’s hawks, as well as the nest/chicks second. To meet the California Department of Fish and Game’s (CDFG) recommendations for mitigation and protection of Swainson’s hawks, surveys should be conducted for a ½ mile radius around all project activities, and if active nesting is identified within the ½ mile radius, consultation is required. In general, the TAC recommends this approach as well.

Minimum Equipment

Minimum survey equipment includes a high-quality pair of binoculars and a high quality spotting scope. Surveying even the smallest project area will take hours, and poor optics often result in eye-strain and difficulty distinguishing details in vegetation and subject birds. Other equipment includes good maps, GPS units, flagging, and notebooks.

Walking vs Driving

Driving (car or boat) or “windshield surveys” are usually preferred to walking if an adequate roadway is available through or around the project site. While driving, the observer can typically approach much closer to a hawk without causing it to fly. Although it might appear that a flying bird is more visible, they often fly away from the observer using trees as screens; and it is difficult to determine from where a flying bird came. Walking surveys are useful in locating a nest after a nest territory is identified, or when driving is not an option.

Angle and Distance to the Tree

Surveying subject trees from multiple angles will greatly increase the observer’s chance of detecting a nest or hawk, especially after trees are fully leafed and when surveying multiple trees in close proximity. When surveying from an access road, survey in both directions. Maintaining a distance of 50 meters to 200 meters from subject trees is optimal for observing perched and flying hawks without greatly reducing the chance of detecting a nest/young: Once a nesting territory is identified, a closer inspection may be required to locate the nest.

Speed
Travel at a speed that allows for a thorough inspection of a potential nest site. Survey speeds should not exceed 5 miles per hour to the greatest extent possible. If the surveyor must travel faster than 5 miles per hour, stop frequently to scan subject trees.

Visual and Aural Ques
Surveys will be focused on both observations and vocalizations. Observations of nests, perched adults, displaying adults, and chicks during the nesting season are all indicators of nesting Swainson's hawks. In addition, vocalizations are extremely helpful in locating nesting territories. Vocal communication between. hawks is frequent during territorial displays; during courtship and mating; through the nesting period as mates notify each other that food is available or that a threat exists; and as older chicks and fledglings beg for food.

Distractions
Minimize distractions while surveying. Although two pairs of eyes may be better than one pair at times, conversation may limit focus. Radios should be off, not only are they distracting, they may cover a hawk's call.

Notes and Species Observed
Take thorough field notes. Detailed notes and maps of the location of observed Swainson's hawk nests are essential for filling gaps in the Natural Diversity Data Base; please report all observed nest sites. Also document the occurrence of nesting great homed owls, red-tailed hawks, red-shouldered hawks and other potentially competitive species. These species will infrequently nest within 100 yards of each other, so the presence of one species will not necessarily exclude another.

TIMING

To meet **the minimum level** of protection for the species, surveys should be completed for **at least** the two survey periods immediately prior to a project's initiation. For example, if a project is scheduled to begin on June 20, you should complete 3 surveys in Period III and 3 surveys in Period V. However, it is always recommended that surveys be completed in Periods II, III and V. **Surveys should not be conducted in Period IV.**

The survey periods are defined by the timing of migration, courtship, and nesting in a "typical" year for the majority of Swainson's hawks from San Joaquin County to Northern Yolo County. Dates should be adjusted in consideration of early and late nesting seasons, and geographic differences (northern nesters tend to nest slightly later, etc). If you are not sure, contact a TAC member or CDFG biologist.

Survey dates **Survey time** **Number of Surveys**
Justification and search image

I. *January-March 20 (recommended optional)* *All day* *1*

Prior to Swainson’s hawks returning, it may be helpful to survey the project site to determine potential nest locations. Most nests are easily observed from relatively long distances, giving the surveyor the opportunity to identify potential nest sites, as well as becoming familiar with the project area. It also gives the surveyor the opportunity to locate and map competing species nest sites such as great homed owls from February on, and red-tailed hawks from March on. After March 1, surveyors are likely to observe Swainson’s hawks staging in traditional nest territories.

II. *March 20 to April 5* *Sunrise to 1000*
1600 to sunset *3*

Most Central Valley Swainson’s hawks return by April 1, and immediately begin occupying their traditional nest territories. For those few that do not return by April 1, there are often hawks (“floaters”) that act as place-holders in traditional nest sites; they are birds that do not have mates, but temporarily attach themselves to traditional territories and/or one of the site’s “owners.” Floaters are usually displaced by the territories’ owner(s) if the owner returns.

Most trees are leafless and are relatively transparent; it is easy to observe old nests, staging birds, and competing species. The hawks are usually in their territories during the survey hours, but typically soaring and foraging in the mid-day hours. Swainson’s hawks may often be observed involved in territorial and courtship displays, and circling the nest territory. Potential nest sites identified by the observation of staging Swainson’s hawks will usually be active territories during that season, although the pair may not successfully nest/reproduce that year.

III. *April 5 to April 20* *Sunrise to 1200*
1630 to Sunset ***3***

Although trees are much less transparent at this time, ‘activity at the nest site increases significantly. Both males and females are actively nest building, visiting their selected site frequently. Territorial and courtship displays are increased, as is copulation. The birds tend to vocalize often, and nest locations are most easily identified. This period may require a great deal of “sit and watch” surveying.

IV. *April 21 to June 10* *Monitoring known nest sites only*
Initiating Surveys is not recommended

Nests are extremely difficult to locate this time of year, and even the most experienced surveyor will miss them, especially if the previous surveys have not been done. During this phase of nesting, the female Swainson’s hawk is in brood position, very low in the nest, laying eggs, incubating, or protecting the newly hatched and vulnerable chicks; her head may or may not be visible. Nests are often well-hidden, built into heavily vegetated sections of trees or in clumps of mistletoe, making them all but invisible. Trees are usually not viewable from all angles, which may make nest observation impossible.

Following the male to the nest may be the only method to locate it, and the male will spend hours away from the nest foraging, soaring, and will generally avoid drawing attention to the nest site. Even if the observer is fortunate enough to see a male returning with food for the female, if the female determines it is not safe she will not call the male in, and he will not approach the nest; this may happen if the observer, or others, are too close to the nest or if other threats, such as rival hawks, are apparent to the female or male.

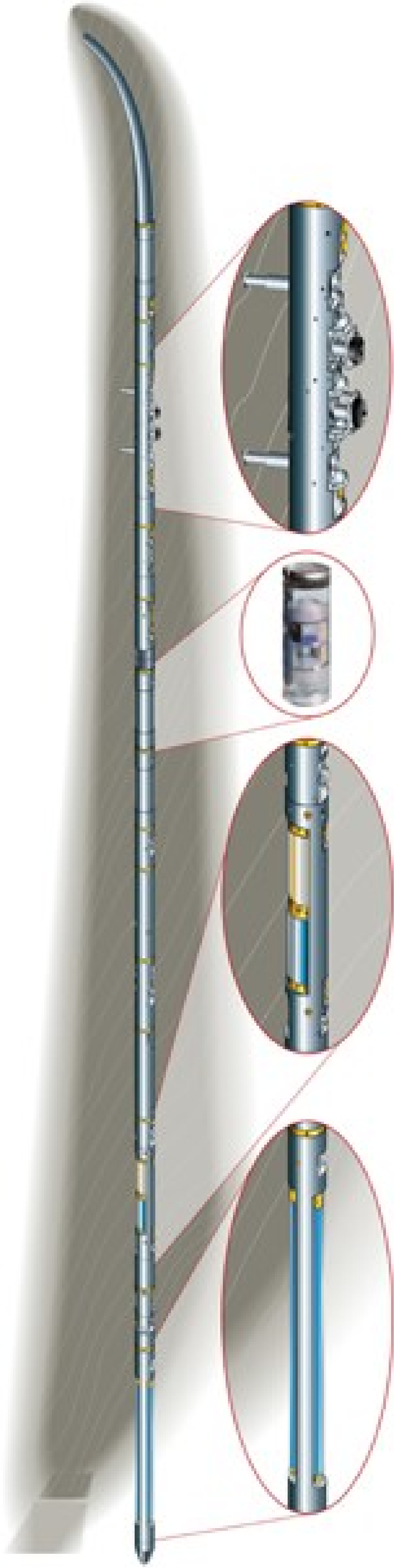
V. ***June 10 to JuIy 30 (post-fledging)*** ***Sunrise to 1200*** ***3***
1600 to sunset

Young are active and visible, and relatively safe without parental protection. Both adults make numerous trips to the nest and are often soaring above, or perched near or on the nest tree. The location and construction of the nest may still limit visibility of the nest, young, ‘and adults.

DETERMINING A PROJECT’S POTENTIAL
FOR IMPACTING SWAINSON'S HAWKS

LEVEL OF RISK	REPRODUCTIVE SUCCESS (Individuals)	LONGTERM SURVIVABILITY (Population)	NORMAL SITE CHARACTERISTICS (Daily Average)	NEST MONI-TORING
HIGH	Direct physical contact with the nest tree while the birds are on eggs or protecting young. (Helicopters in close proximity)	Loss of available foraging area. Loss of nest trees.	Little human-created noise, little human use: nest is well away from dwellings, equipment yards, human access areas, etc. *Do not include general cultivation practices in evaluation.*	MORE
	Loss of nest tree after nest building is begun prior to laying eggs.	Loss of potential nest trees.		
	Personnel within 50 yards of nest tree (out of vehicles) for extended periods while birds are on eggs or protecting young that are < 10 days old.	Cumulative: Multi-year, multi-site projects with substantial noise/personnel disturbance.		
	Initiating construction activities (machinery and personnel) within 200 yards of the nest after eggs are laid and before young are > 10 days old.	Cumulative: Single-season projects with substantial noise/personnel disturbance that is greater than or significantly different from the daily norm.		
	Heavy machinery only working within 50 yards of nest.			
	Initiating construction activities within 200 yards of nest before nest building begins or after young > 10 days old.		Substantial human-created noise and occurrence: nest is near roadways, well-used waterways, active airstrips, areas that have high human use. *Do not include general cultivation practices in evaluation.*	
LOW	All project activities (personnel and machinery) greater than 200 yards from nest.	Cumulative: Single-season projects with activities that “blend” well with site’s “normal’ activities.		LESS

A516: MORAIS 16-2 RDT Transient Pressures



RDT Pressure Transient Analysis

Client: PG&E
Well: Morais_16-2
Field: EAST ISLAND GAS
Rig: PAUL GRAHAM NO. 4

Country: USA

Logged: 04/12/13

Date: 04/12/13

HALLIBURTON

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Test Summary

PRESSURE TEST SUMMARY

Test Identification				Hydrostatic Pres.		Eq. Mud Wt.		Test Pressures - Temperatures					Test Times		Remarks
Test No.	File No.	MD (ft)	TVD (ft)	Phyds1 (psia)	Phyds2 (psia)	EqFmMw (lbs/gal)	EqBhMw (lbs/gal)	Psdd (psia)	Pedd (psia)	Pstop (psia)	dPob (psia)	Temp (degF)	dTdd (sec)	dTbu (sec)	
1.1	2-3.1	4762.01	4762.01	2462.82	2461.31	8.12	9.94	2010.63	1972.65	2010.50	450.81	124.50	1.25	118.50	Excellent Buildup Stability
2.1	2-4.1	4752.02	4752.02	2455.37	2454.23	8.12	9.93	2006.35	1765.76	2006.37	447.86	124.80	1.00	140.44	Excellent Buildup Stability
3.1	2-5.1	4740.00	4740.00	2447.90	2446.64	8.12	9.93	2001.55	1967.67	2001.47	445.17	125.30	1.50	88.31	Excellent Buildup Stability
4.1	2-6.1	4735.00	4735.00	2443.81	2442.62	8.12	9.92	1999.47	1920.31	1999.45	443.16	125.80	2.25	92.69	Excellent Buildup Stability
5.1	2-7.1	4730.01	4730.01	2439.86	2438.60	8.12	9.91	1997.37	1965.13	1997.34	441.25	126.00	1.00	130.68	Excellent Buildup Stability
6.1	2-8.1	4718.02	4718.02	2431.29	2431.70	8.12	9.91	1995.46	1437.96	1992.61	439.09	126.10	0.75	89.44	Excellent Buildup Stability
7.2	2-9.2	4704.00	4704.00	2422.87	2423.96	8.12	9.91	1986.34	1954.10	1986.81	437.15	127.50	0.75	76.61	Excellent Buildup Stability
8.1	2-10.1	4696.00	4696.00	2418.71	2418.81	8.12	9.91	1983.65	1957.37	1983.61	435.20	128.30	1.75	80.56	Excellent Buildup Stability
9.2	2-11.2	4685.01	4685.01	2412.33	2412.26	8.12	9.90	1979.17	1849.19	1979.05	433.21	128.00	1.25	100.00	Fair Buildup Stability
10.1	2-12.1	4583.02	4583.02	2362.08	2360.77	8.22	9.91	1959.14	1747.24	1959.51	401.27	124.60	1.50	92.32	Excellent Buildup Stability
11.1	2-13.1	4566.01	4566.01	2350.97	2351.07	8.22	9.90	1952.73	1907.01	1952.65	398.42	125.60	8.77	114.27	Excellent Buildup Stability
12.1	2-14.1	4550.00	4550.00	2342.26	2342.18	8.23	9.90	1946.23	1843.41	1946.15	396.02	125.80	1.00	93.68	Fair Buildup Stability

Legend:

Phyds1: Initial Hydrostatic Pressure

Phyds2: Final Hydrostatic Pressure

EqFmMw:Equivalent Formation Mud Weight (Pstop / (TVD * Constant))

EqBhMw: Equivalent Borehole Mud Weight (Phyds2 / (TVD * Constant))

Psdd: Initial Drawdown Pressure

Pedd: Final Drawdown or End Drawdown Pressure

Pstop: Final Buildup Pressure

Temp: Final Temperature

dTdd= Tedd-Tsdd: Tedd - End of Drawdown Time; Tsdd - Initial Drawdown Time

dTbu=Tstop - Tedd:Buildup Time, Tedd - End of Drawdown Time, Tstop - Final Buildup Time

dPob= Phyds2 - Pstop: Over Balance

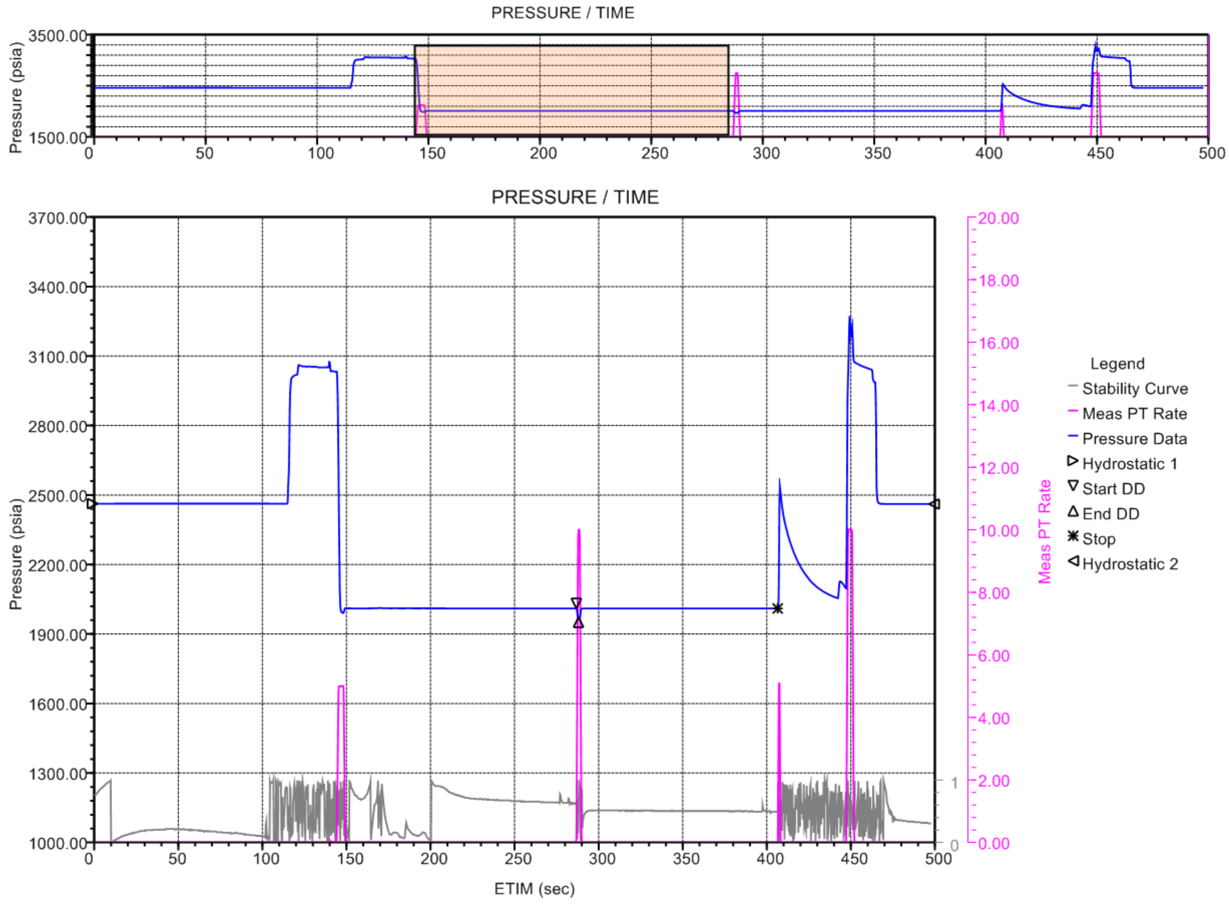
PRESSURE TRANSIENT SUMMARY										
Test Identification				**Buildup Stability**		**PTA Pressure**		**PTA Mobilities**		**Remarks**
Test No.	**File No.**	**MD (ft)**	**TVD (ft)**	**Stability (psia/min)**	**Stability (degF/min)**	**Pexact (psia)**	**Pstdev (psia)**	**Mexact (md/cp)**	**Msdd (md/cp)**	
1.1	2-3.1	4762.01	4762.01	-0.010		2010.50	0.01	255	294	Excellent Buildup Stability
2.1	2-4.1	4752.02	4752.02	0.022		2006.37	0.02	2.96	4.25	Excellent Buildup Stability
3.1	2-5.1	4740.00	4740.00	-0.020	0.300	2001.47	0.01	84.1	165	Excellent Buildup Stability
4.1	2-6.1	4735.00	4735.00	-0.001		1999.45	0.01	153	172	Excellent Buildup Stability
5.1	2-7.1	4730.01	4730.01	-0.021		1997.34	0.01	179	297	Excellent Buildup Stability
6.1	2-8.1	4718.02	4718.02	0.063	0.299	1992.61	0.02	5.05	9.69	Excellent Buildup Stability
7.2	2-9.2	4704.00	4704.00	0.001	0.337	1986.81	0.01	83.5	185	Excellent Buildup Stability
8.1	2-10.1	4696.00	4696.00	-0.034		1983.61	0.02	563	762	Excellent Buildup Stability
9.2	2-11.2	4685.01	4685.01	-0.091		1979.05	2.88	10.3	75.9	Fair Buildup Stability
10.1	2-12.1	4583.02	4583.02	-0.056		1959.51	0.04	35.5	79.7	Excellent Buildup Stability
11.1	2-13.1	4566.01	4566.01	-0.002		1952.65	0.00	182	193	Excellent Buildup Stability
12.1	2-14.1	4550.00	4550.00	0.002		1946.18	5.58	2.97	35.5	Fair Buildup Stability

Legend:
Pexact: Projected formation pressure based on exact model.
Pstdev: Standard deviation of actual pressures from exact model
Mexact: Spherical Mobility based on exact model
Msdd: Spherical Drawdown Mobility

Plots

Test No. 1.0; MD: 4762.01 ft; TVD: 4762.01 ft

RDT Test File # 2-3.0 Date: 12-Apr-13 10:38:29



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4762.01	2462.82	2461.31							

CONSTANTS - SPHERICAL FLOW

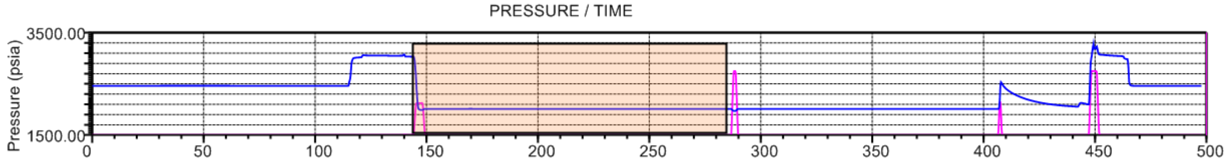
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
7.26	5.81	0.66	0.25	6.13e-004	180.00

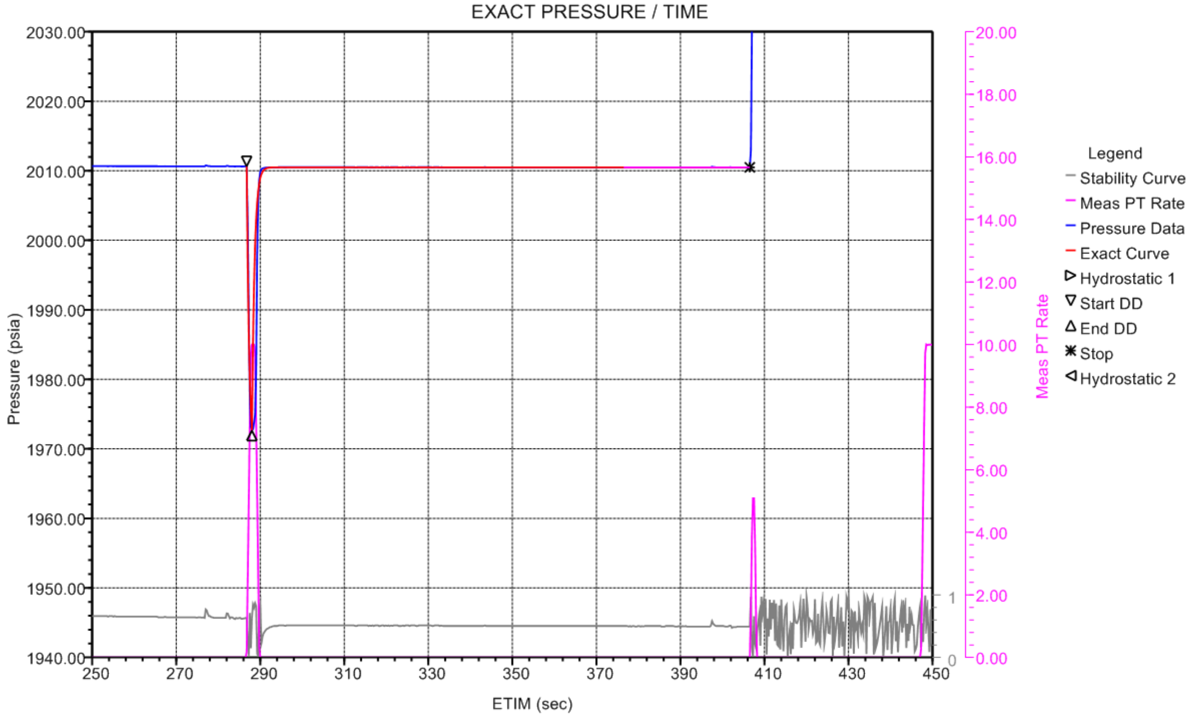
REMARKS

Excellent Buildup Stability

Test No. 1.1; MD: 4762.01 ft; TVD: 4762.01 ft

RDT Test File # 2-3.1 Date: 12-Apr-13 10:38:29

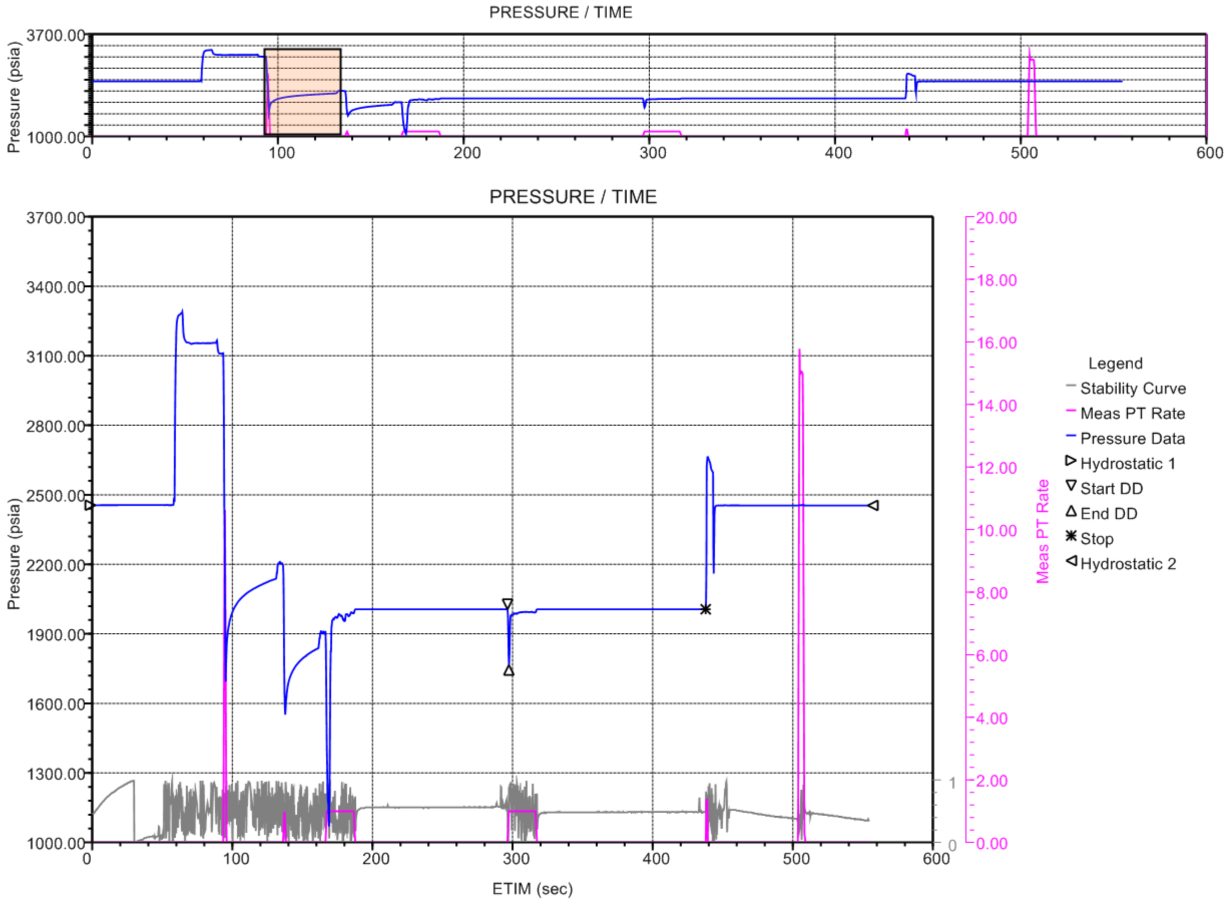




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4762.01	4762.01	1972.65	2010.50	2010.50	255
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
7.26	5.81	0.66	0.25	6.13e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 2.0; MD: 4752.02 ft; TVD: 4752.02 ft

RDT Test File # 2-4.0 Date: 12-Apr-13 10:48:06



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(ft)</th><th>Phyds1
(psia)</th><th>Phyds2
(psia)</th><th>Psdd
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(psia)</th><th>Tsdd
(sec)</th><th>Tedd
(sec)</th><th>Tstop
(sec)</th><th>Mdd
(md/cp)</th></tr>
<tr><td>4752.02</td><td>2455.37</td><td>2454.23</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="10">CONSTANTS - SPHERICAL FLOW</th></tr>
<tr><th colspan="2">Volume (cc)</th><th>Rate
(cc/sec).</th><th colspan="2">Rsnorkel (in)</th><th colspan="2">Porosity (fraction)</th><th>Ct
(1/psia)</th><th colspan="2">Flow-line Storage (cc)</th></tr>
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<tr><th colspan="10">REMARKS</th></tr>
<tr><td colspan="10">Excellent Buildup Stability</td></tr>
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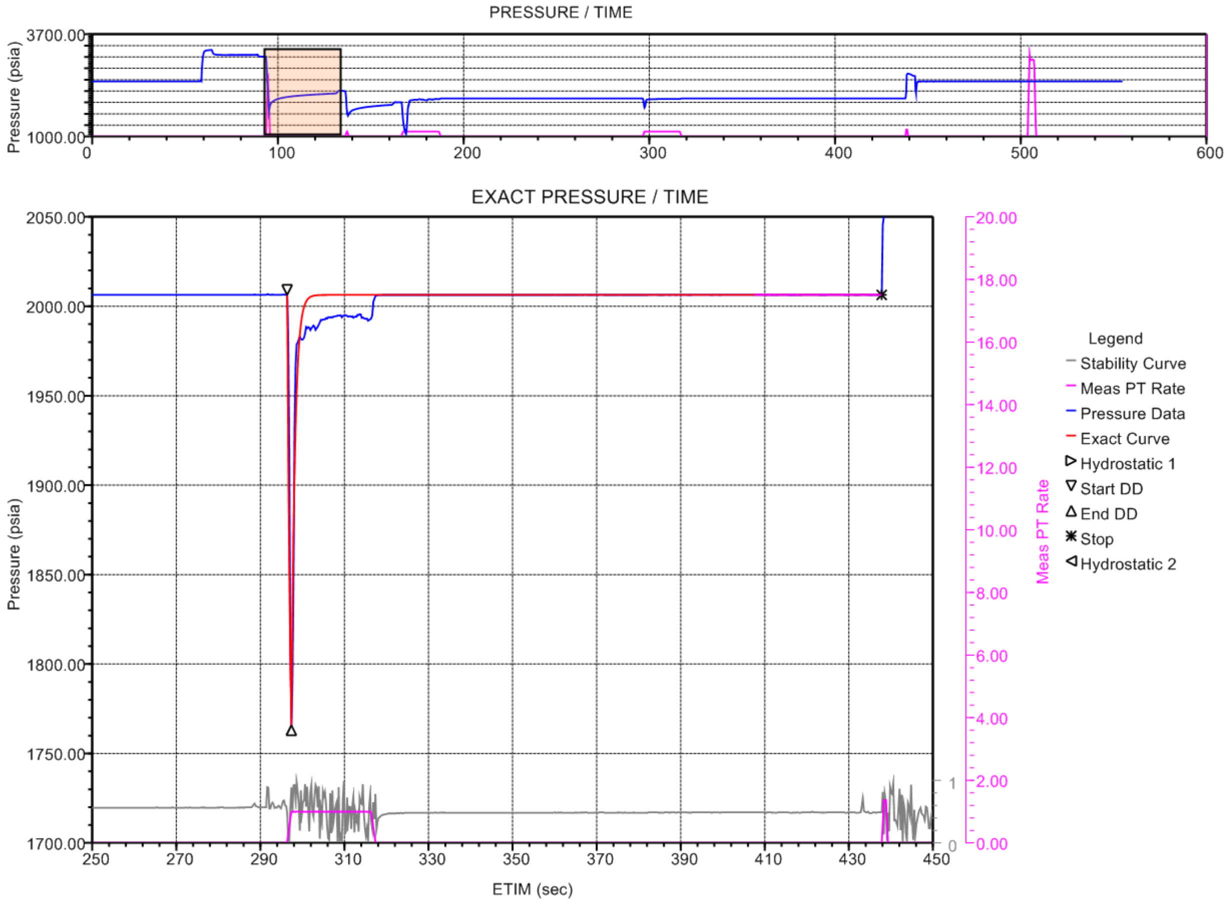
Test No. 2.1; MD: 4752.02 ft; TVD: 4752.02 ft

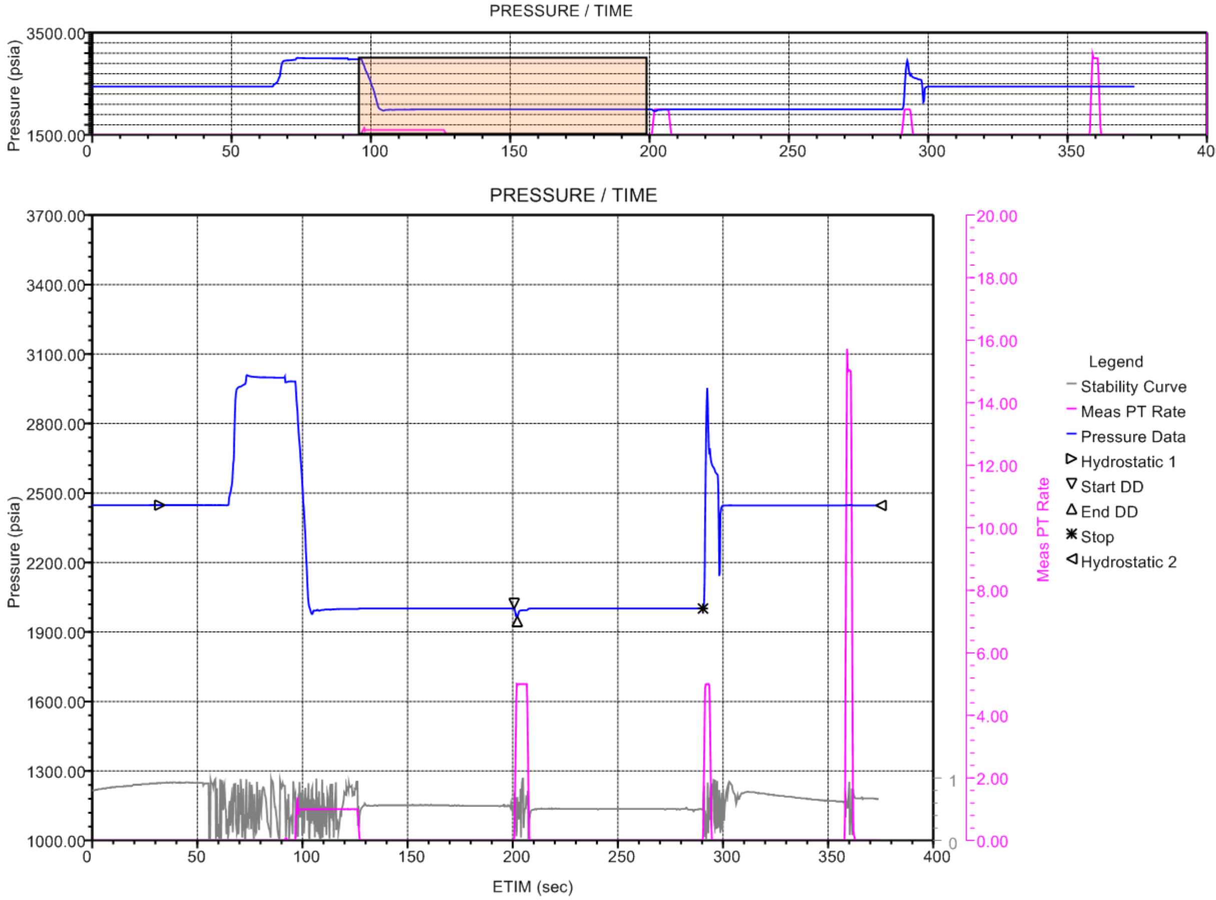
RDT Test File # 2-4.1 Date: 12-Apr-13 10:48:06



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4752.02	4752.02	1765.76	2006.37	2006.37	2.96
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
0.53	0.53	0.66	0.25	6.75e-006	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.02	0.02	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 3.0; MD: 4740.00 ft; TVD: 4740.00 ft

RDT Test File # 2-5.0 Date: 12-Apr-13 11:00:34



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4740.00	2447.90	2446.64							

CONSTANTS - SPHERICAL FLOW

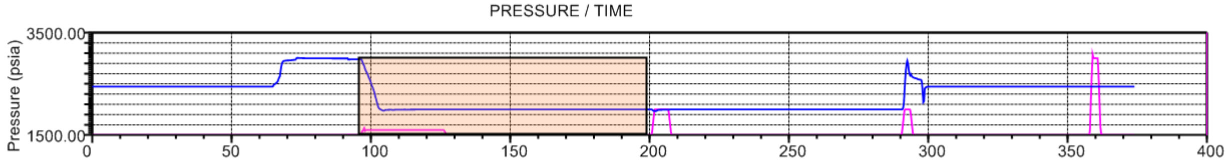
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
4.38	2.92	0.66	0.25	3.00e-004	180.00

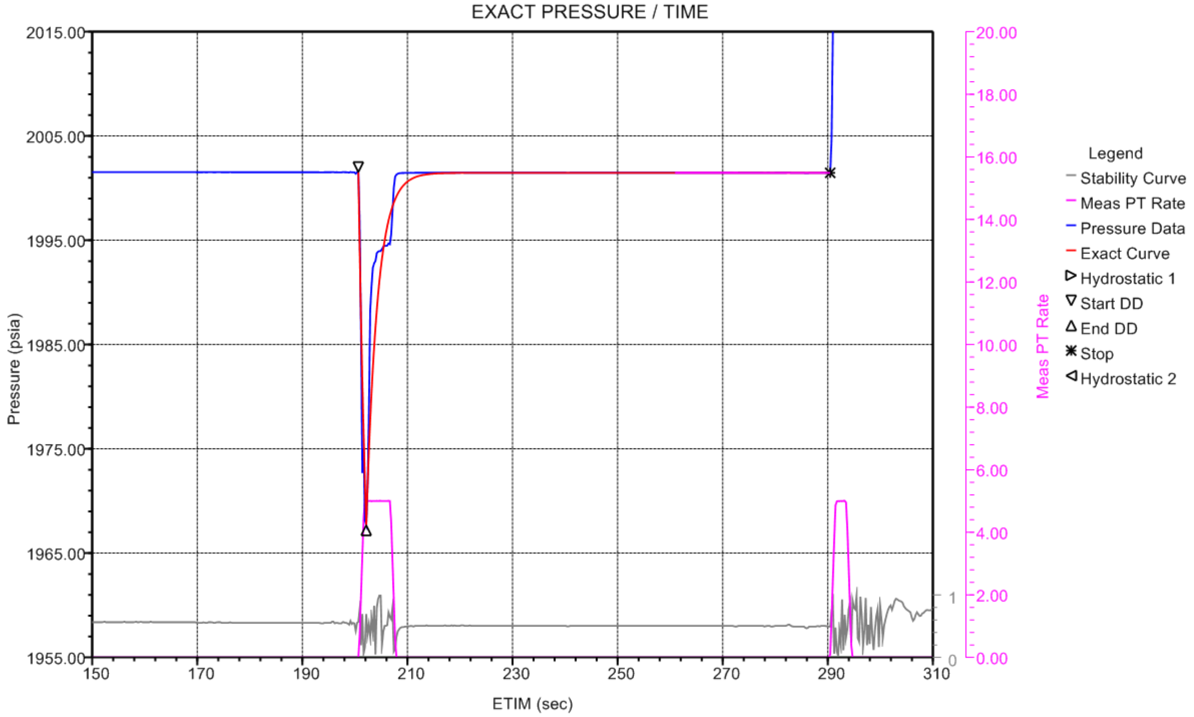
REMARKS

Excellent Buildup Stability

Test No. 3.1; MD: 4740.00 ft; TVD: 4740.00 ft

RDT Test File # 2-5.1 Date: 12-Apr-13 11:00:34

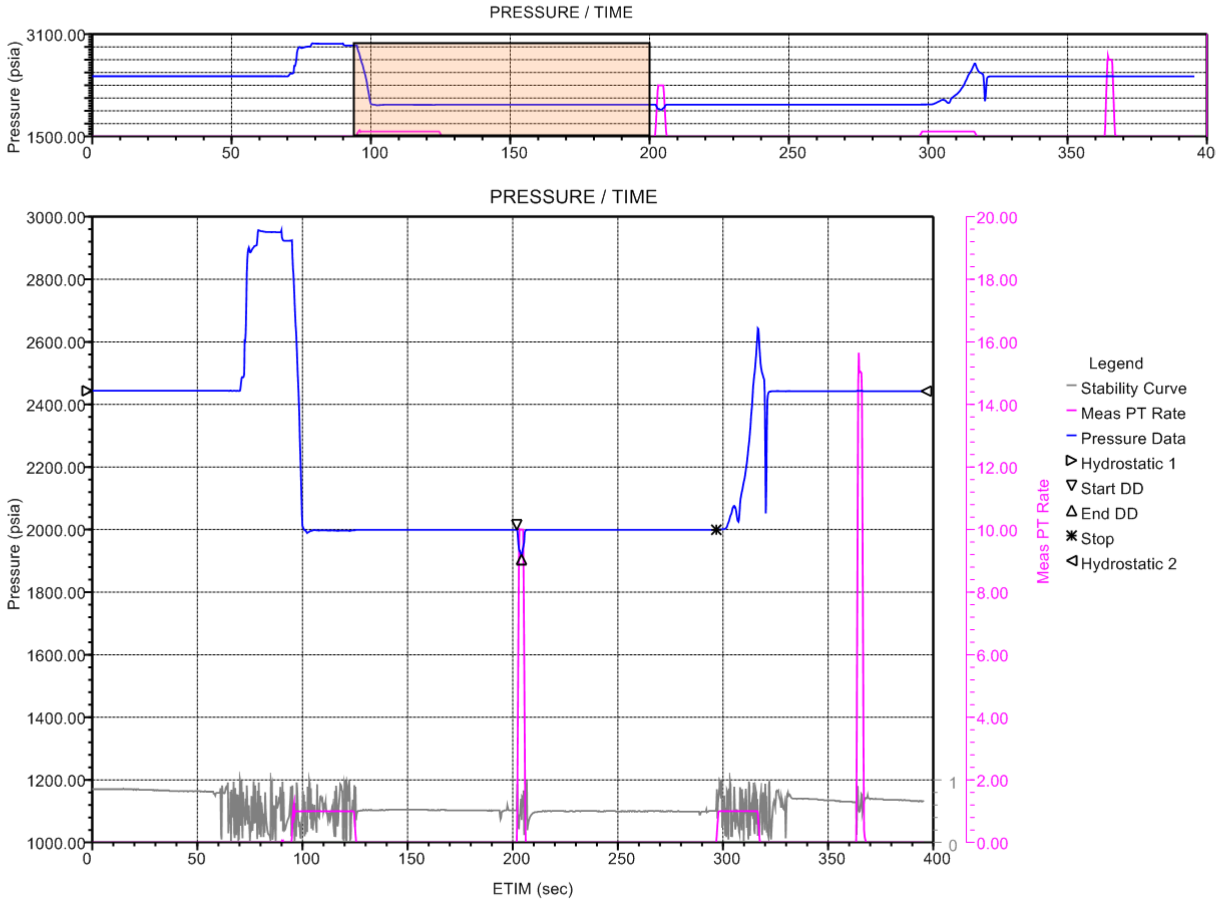




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4740.00	4740.00	1967.67	2001.47	2001.47	84.1
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
4.38	2.92	0.66	0.25	3.00e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.02	0.30			
REMARKS					
Excellent Buildup Stability					

Test No. 4.0; MD: 4735.00 ft; TVD: 4735.00 ft

RDT Test File # 2-6.0 Date: 12-Apr-13 11:09:19



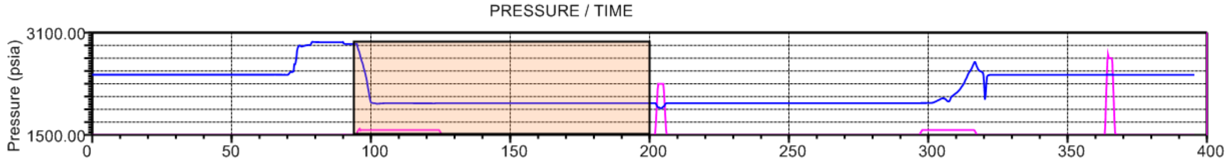
PRESSURE/TIME PLOT SUMMARY									
Depth	**Hydrostatic**		**Pretest Pressures**			**Pretest Times**			**Mobility**
MD (ft)	**Phyds1 (psia)**	**Phyds2 (psia)**	**Psdd (psia)**	**Pedd (psia)**	**Pstop (psia)**	**Tsdd (sec)**	**Tedd (sec)**	**Tstop (sec)**	**Mdd (md/cp)**
4735.00	2443.81	2442.62							

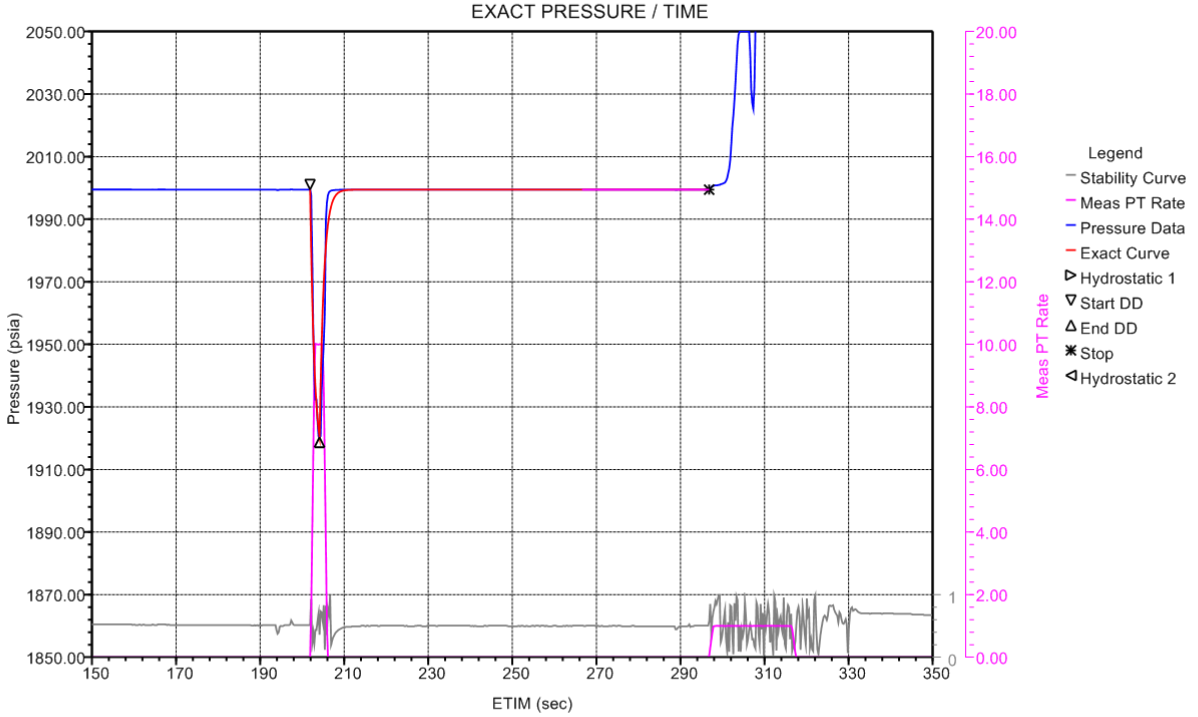
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
15.92	7.08	0.66	0.25	4.31e-004	180.00

REMARKS
Excellent Buildup Stability

Test No. 4.1; MD: 4735.00 ft; TVD: 4735.00 ft

RDT Test File # 2-6.1 Date: 12-Apr-13 11:09:19

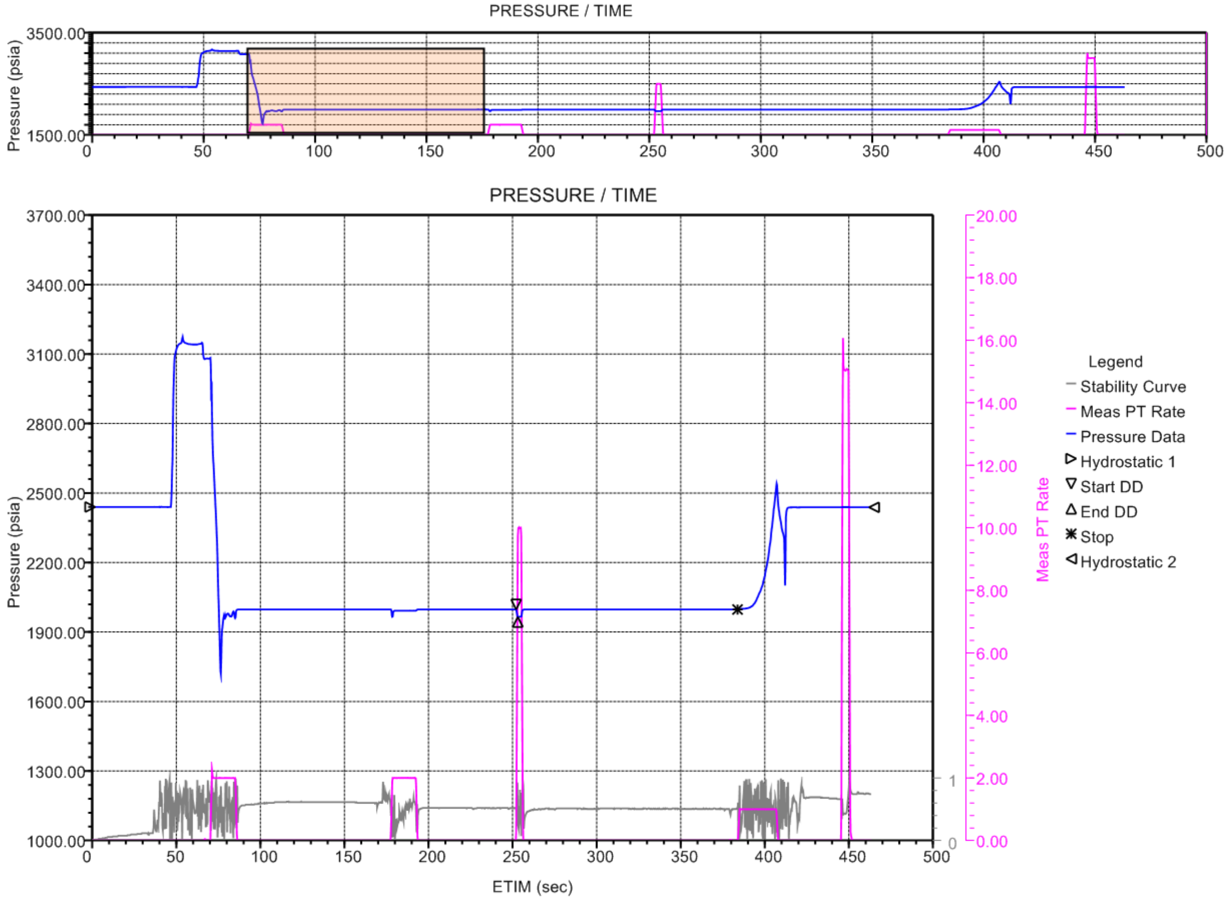

PRESSURE / TIME


EXACT PRESSURE / TIME

EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4735.00	4735.00	1920.31	1999.45	1999.45	153
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
15.92	7.08	0.66	0.25	4.31e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.00	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 5.0; MD: 4730.01 ft; TVD: 4730.01 ft

RDT Test File # 2-7.0 Date: 12-Apr-13 11:17:27



PRESSURE/TIME PLOT SUMMARY									
Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4730.01	2439.86	2438.60							

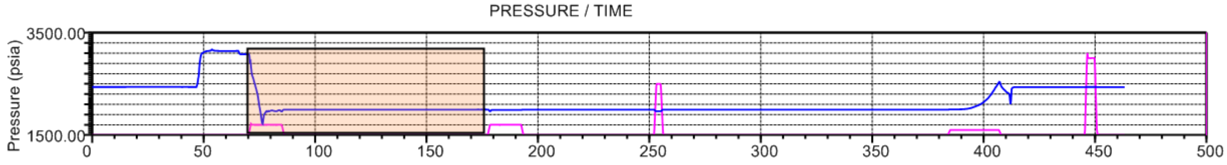
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
4.98	4.99	0.66	0.25	6.12e-004	180.00

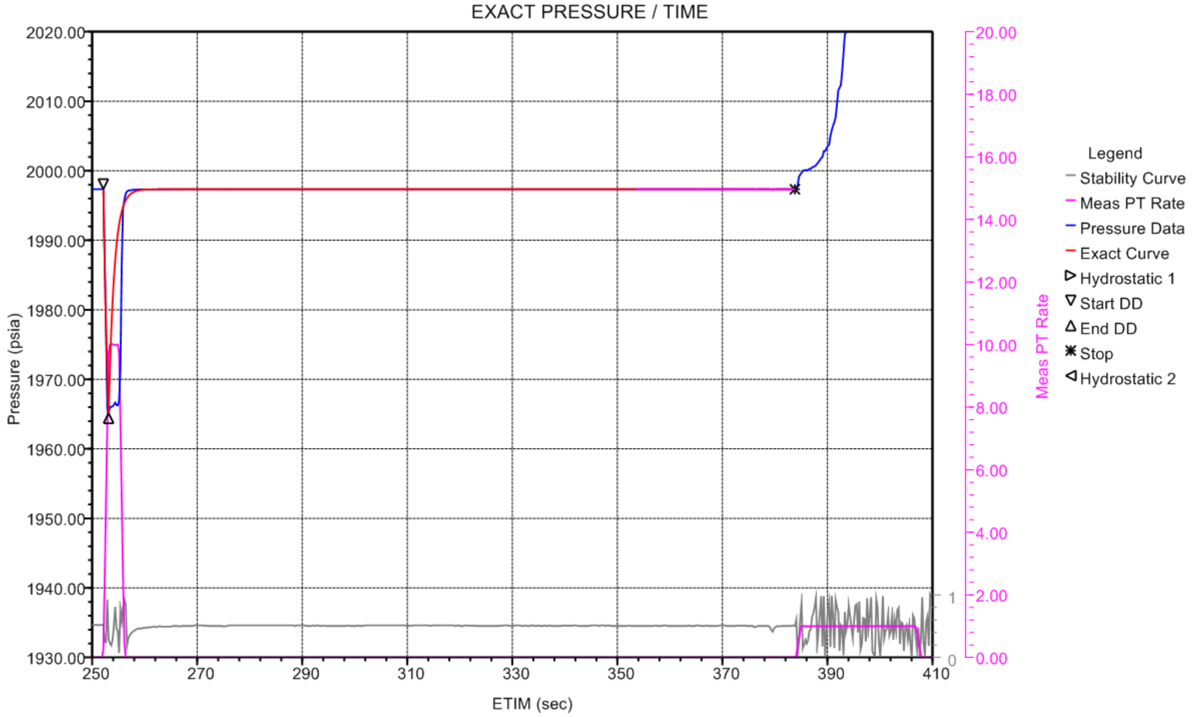
REMARKS

Excellent Buildup Stability

Test No. 5.1; MD: 4730.01 ft; TVD: 4730.01 ft

RDT Test File # 2-7.1 Date: 12-Apr-13 11:17:27





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<tr><th colspan="6">EXACT PRESSURE / TIME PLOT SUMMARY</th></tr>
<tr><th>MD (ft)</th><th>TVD (ft)</th><th>Pedd (psia)</th><th>Pstop (psia)</th><th>Pexact (psia)</th><th>Mexact(md/cp)</th></tr>
<tr><td>4730.01</td><td>4730.01</td><td>1965.13</td><td>1997.34</td><td>1997.34</td><td>179</td></tr>
<tr><th colspan="6">CONSTANTS - SPHERICAL FLOW</th></tr>
<tr><th>Volume (cc)</th><th>Rate (cc/sec).</th><th>Rsnorkel (in)</th><th>Porosity (fraction)</th><th>Ct (1/psia)</th><th>Flow-line Storage (cc)</th></tr>
<tr><td>4.98</td><td>4.99</td><td>0.66</td><td>0.25</td><td>6.12e-004</td><td>180.00</td></tr>
<tr><th colspan="6">TEST CONDITIONS & STATUS</th></tr>
<tr><th>+/- stdev (psia)</th><th>Stability (psi/min).</th><th>Stability (deg/min).</th><th>Pump Status</th><th>Exposure Time (hr).</th><th>Tool Face (deg).</th></tr>
<tr><td>0.01</td><td>-0.02</td><td>0.00</td><td></td><td></td><td></td></tr>
<tr><th colspan="6">REMARKS</th></tr>
<tr><td colspan="6">Excellent Buildup Stability</td></tr>
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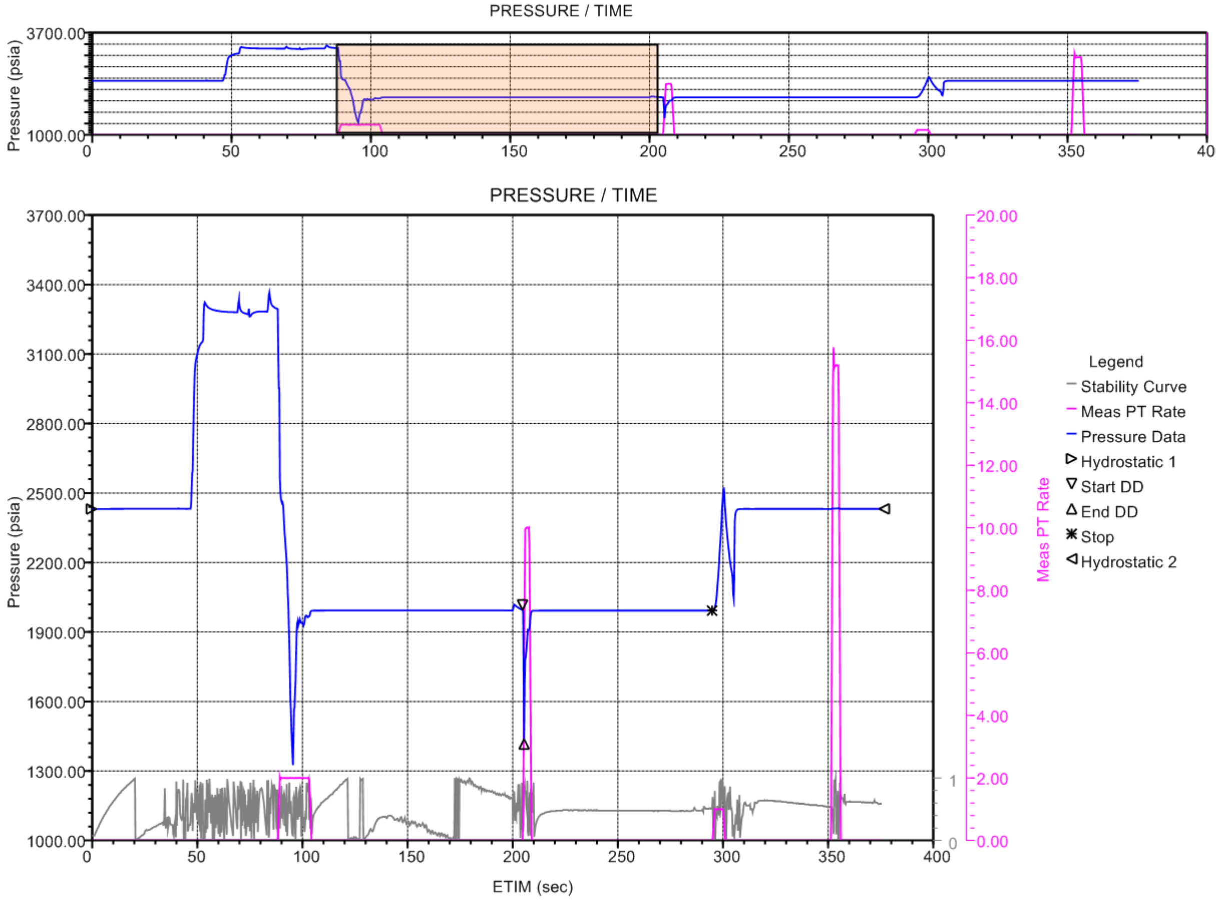
Test No. 6.0; MD: 4718.02 ft; TVD: 4718.02 ft

RDT Test File # 2-8.0 Date: 12-Apr-13 11:27:17



<table>
<tr><th colspan="10">PRESSURE/TIME PLOT SUMMARY</th></tr>
<tr><th>Depth</th><th colspan="2">Hydrostatic</th><th colspan="3">Pretest Pressures</th><th colspan="3">Pretest Times</th><th>Mobility</th></tr>
<tr><th>MD (ft)</th><th>Phyds1 (psia)</th><th>Phyds2 (psia)</th><th>Psdd (psia)</th><th>Pedd (psia)</th><th>Pstop (psia)</th><th>Tsdd (sec)</th><th>Tedd (sec)</th><th>Tstop (sec)</th><th>Mdd (md/cp)</th></tr>
<tr><td>4718.02</td><td>2431.29</td><td>2431.70</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="10">CONSTANTS - SPHERICAL FLOW</th></tr>
<tr><th colspan="2">Volume (cc)</th><th>Rate (cc/sec).</th><th colspan="2">Rsnorkel (in)</th><th colspan="2">Porosity (fraction)</th><th>Ct (1/psia)</th><th colspan="2">Flow-line Storage (cc)</th></tr>
<tr><td colspan="2">2.09</td><td>2.80</td><td colspan="2">0.66</td><td colspan="2">0.25</td><td>1.26e-005</td><td colspan="2">180.00</td></tr>
<tr><th colspan="10">REMARKS</th></tr>
<tr><td colspan="10">Excellent Buildup Stability</td></tr>
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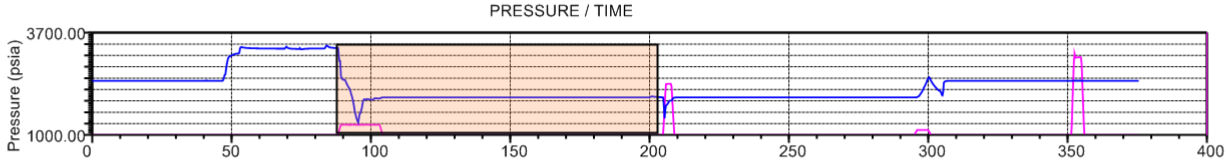
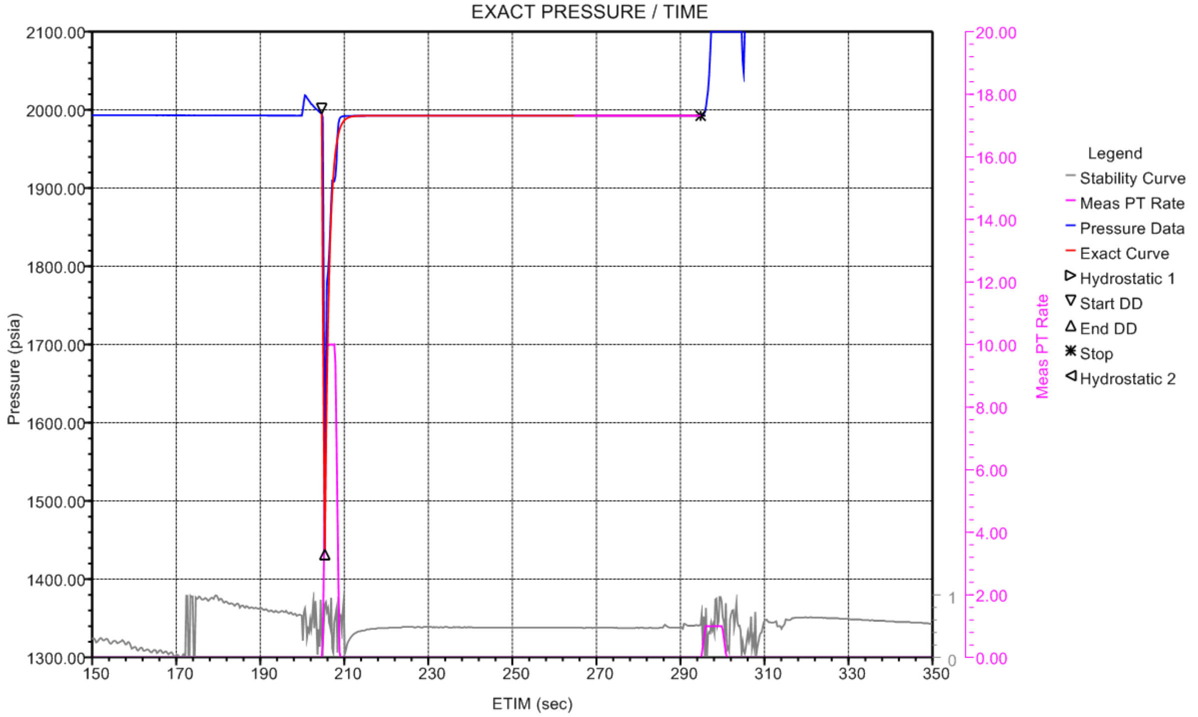
Test No. 6.1; MD: 4718.02 ft; TVD: 4718.02 ft

RDT Test File # 2-8.1 Date: 12-Apr-13 11:27:17

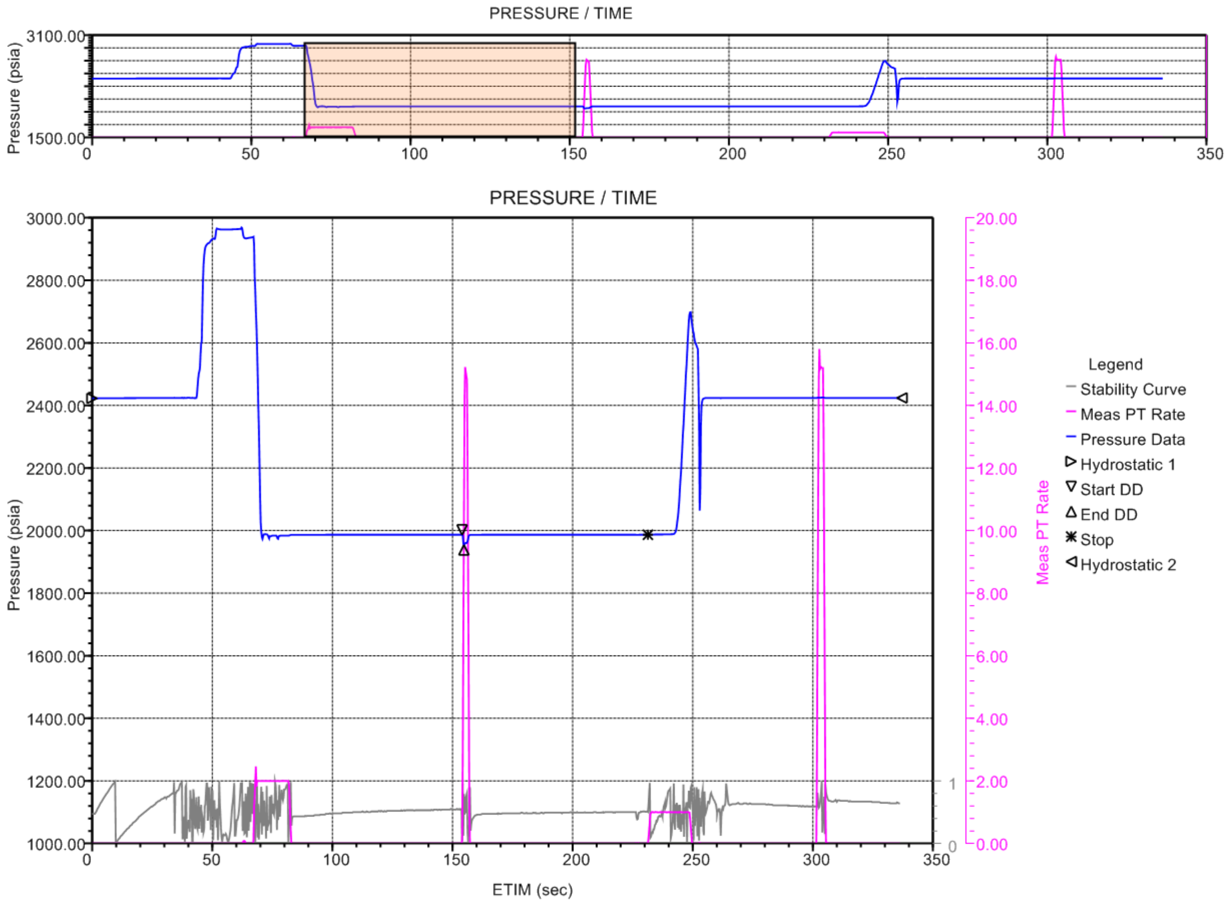




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4718.02	4718.02	1437.96	1992.61	1992.61	5.05
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
2.09	2.80	0.66	0.25	1.26e-005	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.02	0.06	0.30			
REMARKS					
Excellent Buildup Stability					

Test No. 7.0; MD: 4704.00 ft; TVD: 4704.00 ft

RDT Test File # 2-9.0 Date: 12-Apr-13 11:34:52



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4704.00	2422.87	2423.96							

CONSTANTS - SPHERICAL FLOW

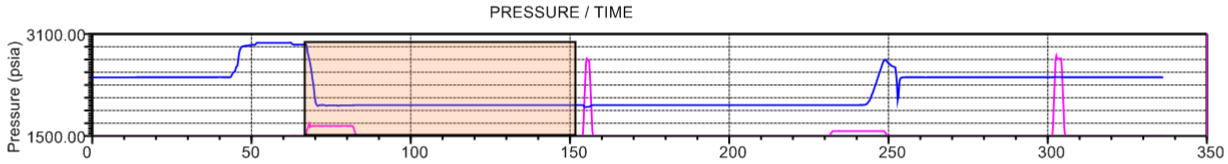
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
2.37	3.15	0.66	0.25	1.77e-004	180.00

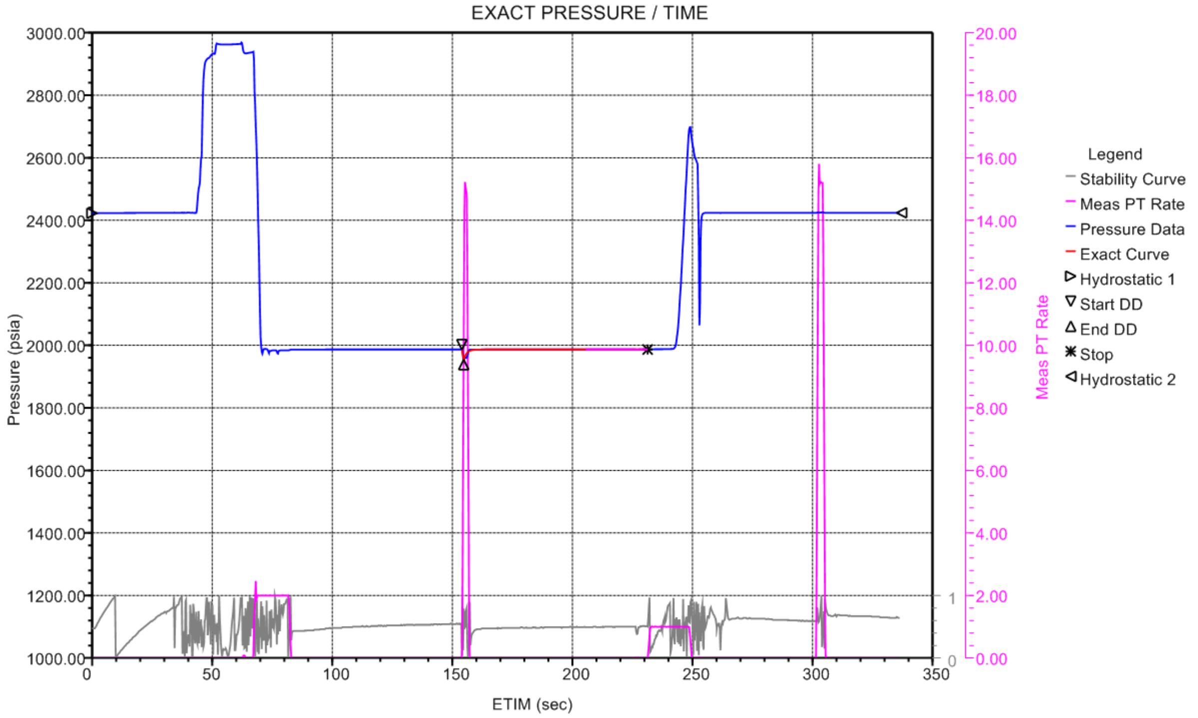
REMARKS

Excellent Buildup Stability

Test No. 7.1; MD: 4704.00 ft; TVD: 4704.00 ft

RDT Test File # 2-9.1 Date: 12-Apr-13 11:34:52

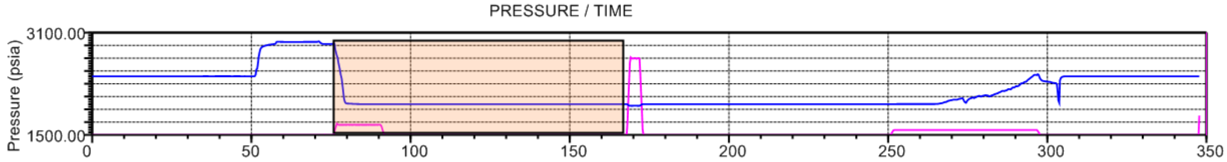


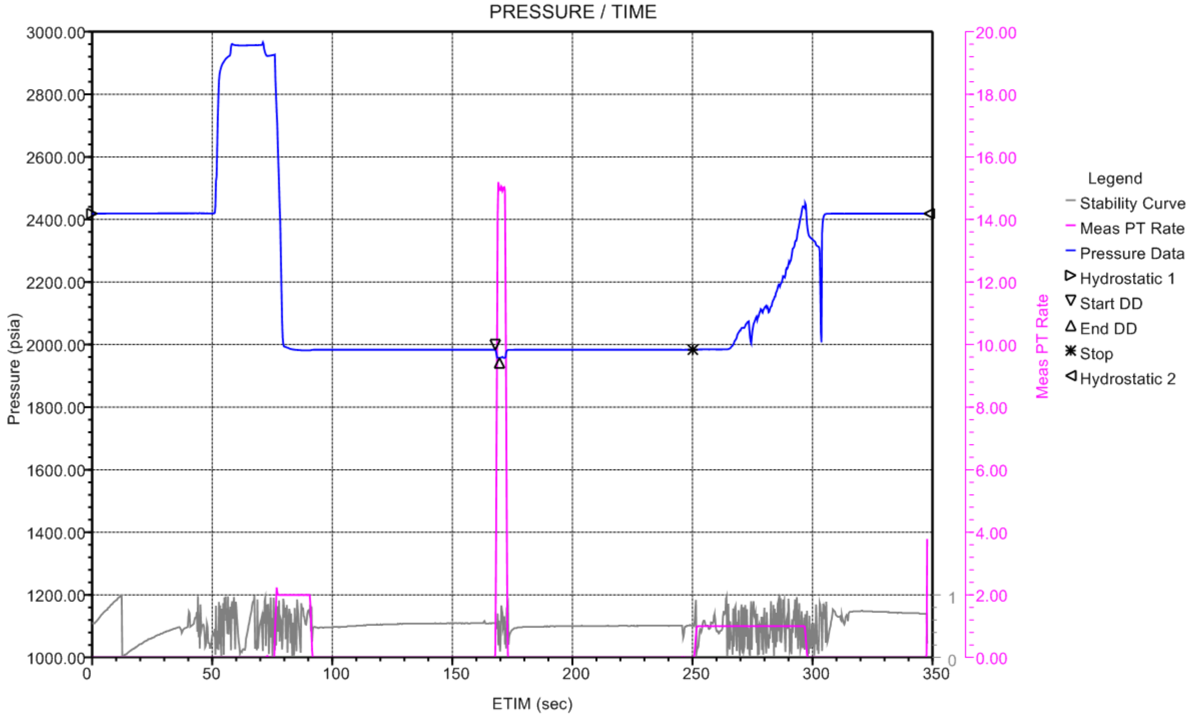


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4704.00	4704.00	1954.10	1986.81	1986.81	83.5
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
2.37	3.15	0.66	0.25	1.77e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	0.00	0.34			
REMARKS					
Excellent Buildup Stability					

Test No. 8.0; MD: 4696.00 ft; TVD: 4696.00 ft

RDT Test File # 2-10.0 Date: 12-Apr-13 11:41:29





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4696.00	2418.71	2418.81							

CONSTANTS - SPHERICAL FLOW

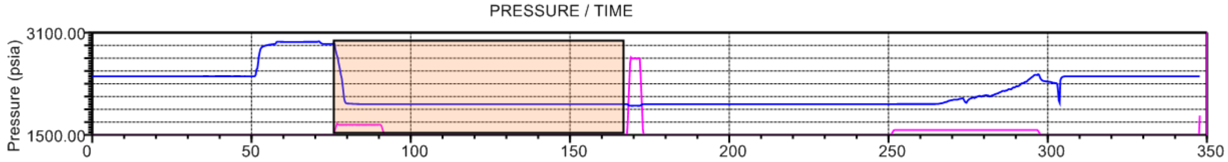
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
18.21	10.40	0.66	0.25	1.43e-003	180.00

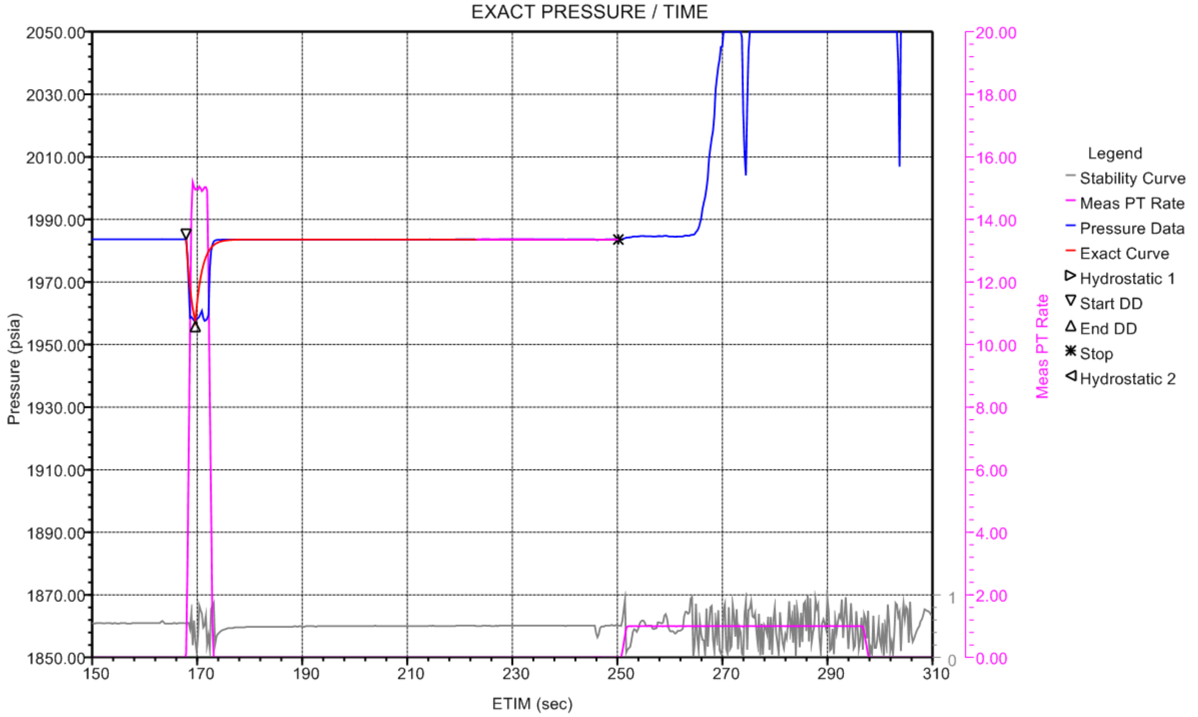
REMARKS

Excellent Buildup Stability

Test No. 8.1; MD: 4696.00 ft; TVD: 4696.00 ft

RDT Test File # 2-10.1 Date: 12-Apr-13 11:41:29

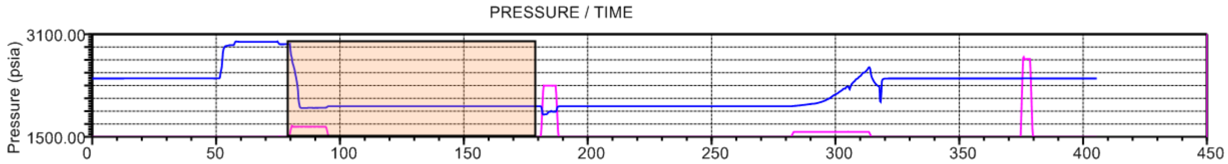


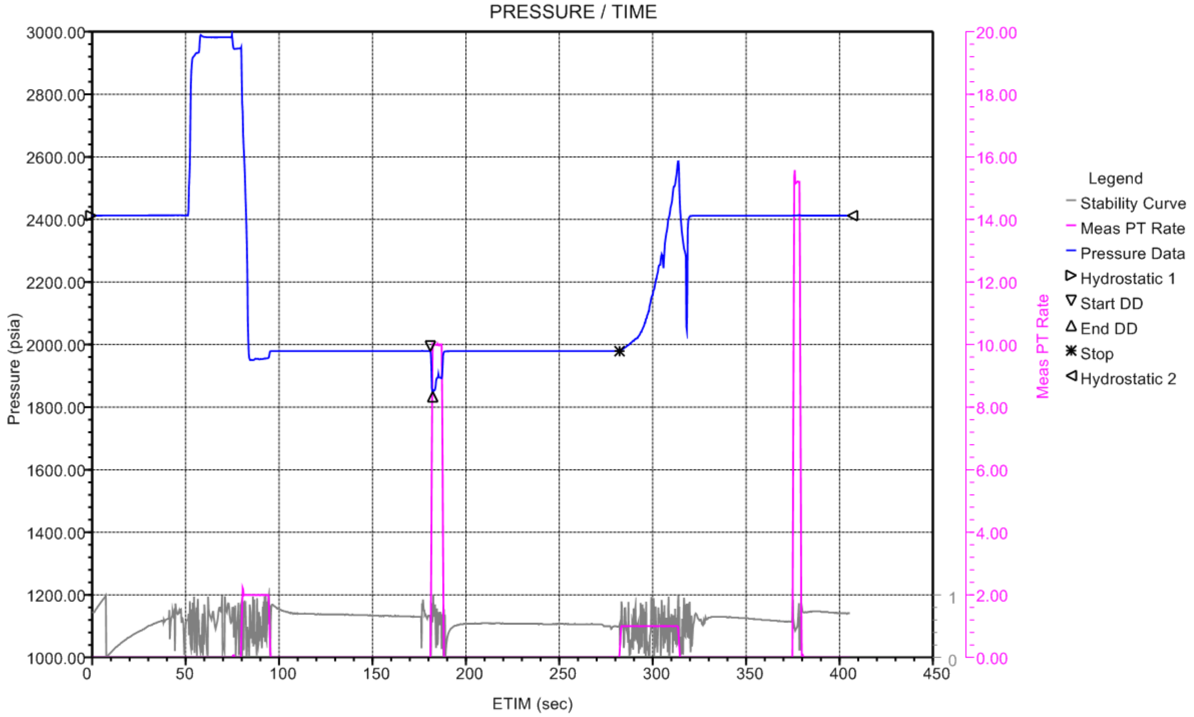


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4696.00	4696.00	1957.37	1983.61	1983.61	563
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
18.21	10.40	0.66	0.25	1.43e-003	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.02	-0.03	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 9.0; MD: 4685.01 ft; TVD: 4685.01 ft

RDT Test File # 2-11.0 Date: 12-Apr-13 11:49:24





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4685.01	2412.33	2412.26							

CONSTANTS - SPHERICAL FLOW

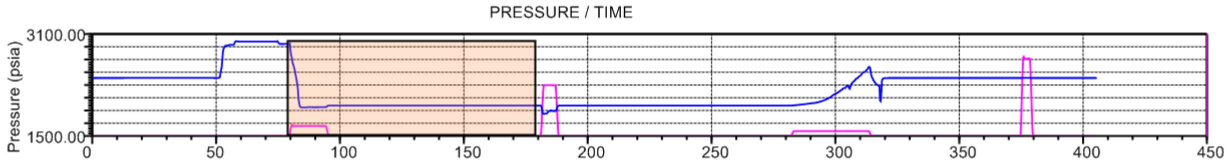
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
6.41	5.13	0.66	0.25	1.10e-004	180.00

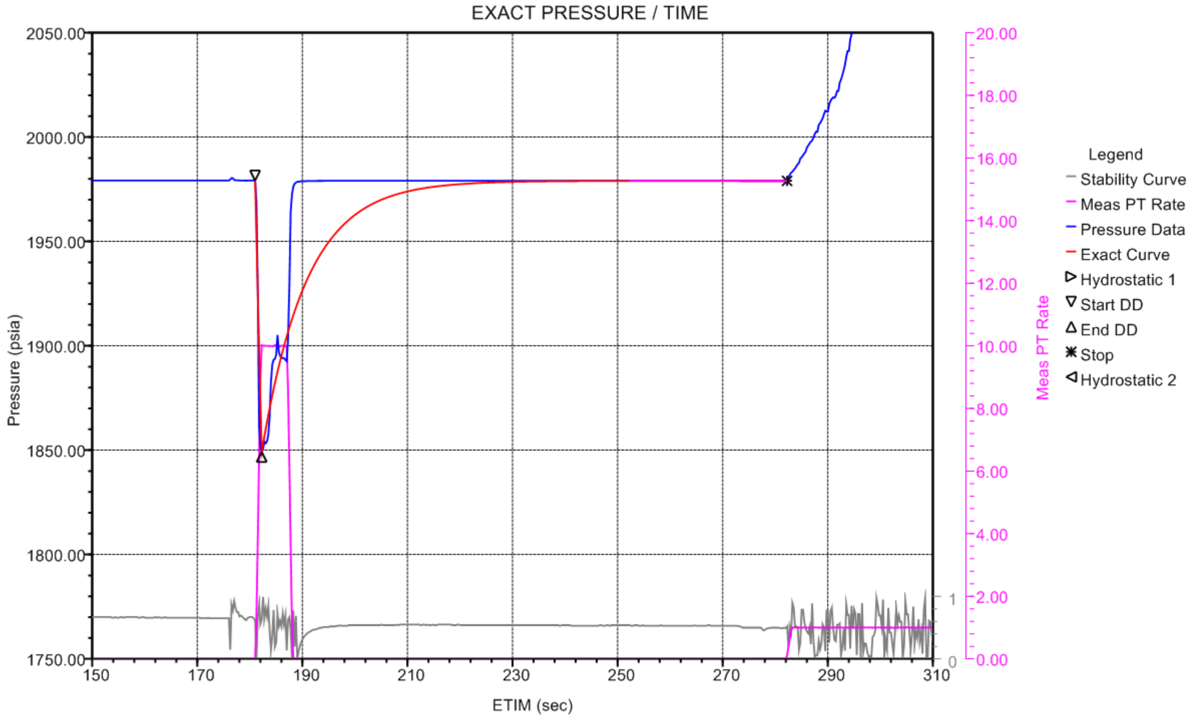
REMARKS

Fair Buildup Stability

Test No. 9.2; MD: 4685.01 ft; TVD: 4685.01 ft

RDT Test File # 2-11.2 Date: 12-Apr-13 11:49:24

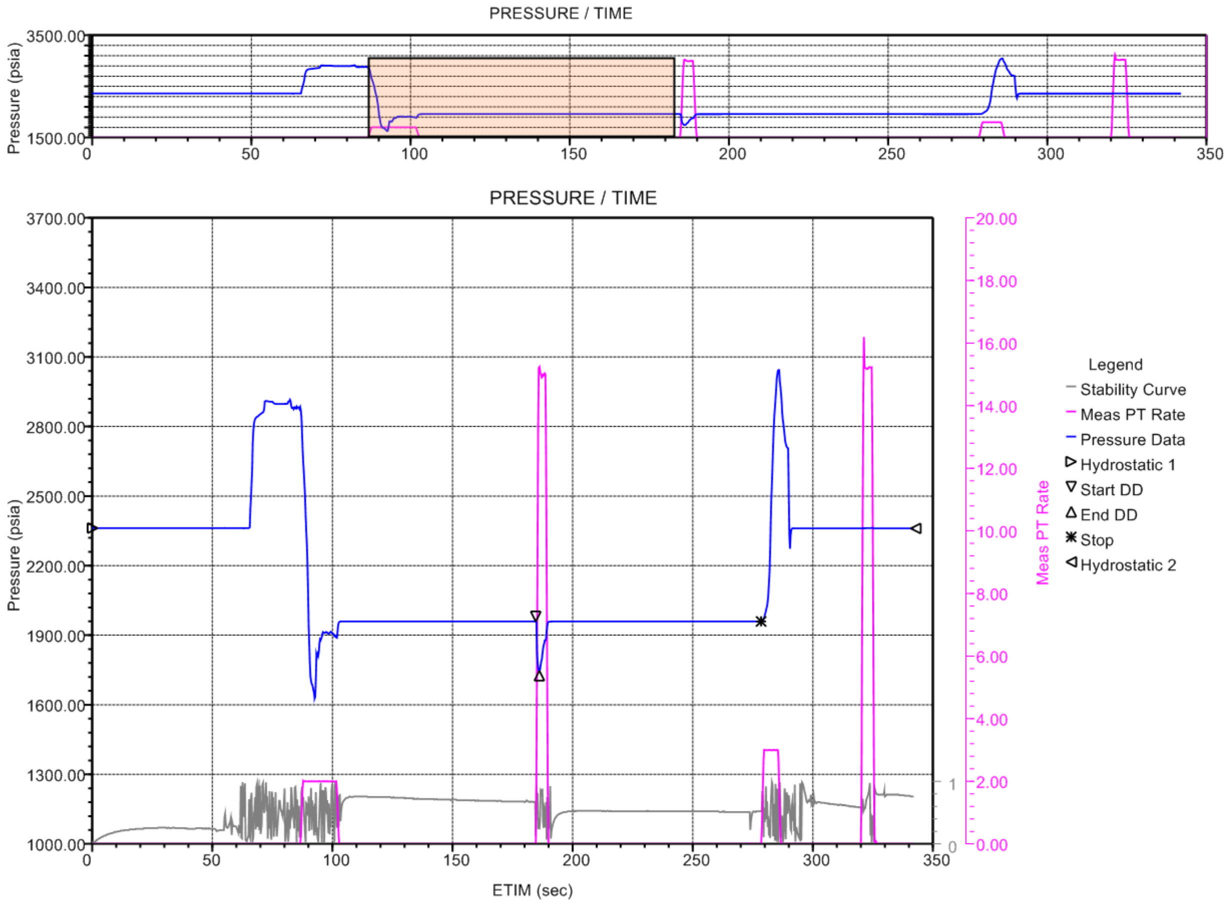




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4685.01	4685.01	1849.19	1979.05	1979.05	10.3
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
6.41	5.13	0.66	0.25	1.10e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
2.88	-0.09	0.00			
REMARKS					
Fair Buildup Stability					

Test No. 10.0; MD: 4583.02 ft; TVD: 4583.02 ft

RDT Test File # 2-12.0 Date: 12-Apr-13 12:00:20



<table>
<tr><th colspan="10">PRESSURE/TIME PLOT SUMMARY</th></tr>
<tr><th>Depth</th><th colspan="2">Hydrostatic</th><th colspan="3">Pretest Pressures</th><th colspan="3">Pretest Times</th><th>Mobility</th></tr>
<tr><th>MD
(ft)</th><th>Phyds1
(psia)</th><th>Phyds2
(psia)</th><th>Psdd
(psia)</th><th>Pedd
(psia)</th><th>Pstop
(psia)</th><th>Tsdd
(sec)</th><th>Tedd
(sec)</th><th>Tstop
(sec)</th><th>Mdd
(md/cp)</th></tr>
<tr><td>4583.02</td><td>2362.08</td><td>2360.78</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="10">CONSTANTS - SPHERICAL FLOW</th></tr>
<tr><th colspan="2">Volume (cc)</th><th>Rate
(cc/sec).</th><th colspan="2">Rsnorkel (in)</th><th colspan="2">Porosity (fraction)</th><th>Ct
(1/psia)</th><th colspan="2">Flow-line Storage (cc)</th></tr>
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<tr><th colspan="10">REMARKS</th></tr>
<tr><td colspan="10">Excellent Buildup Stability</td></tr>
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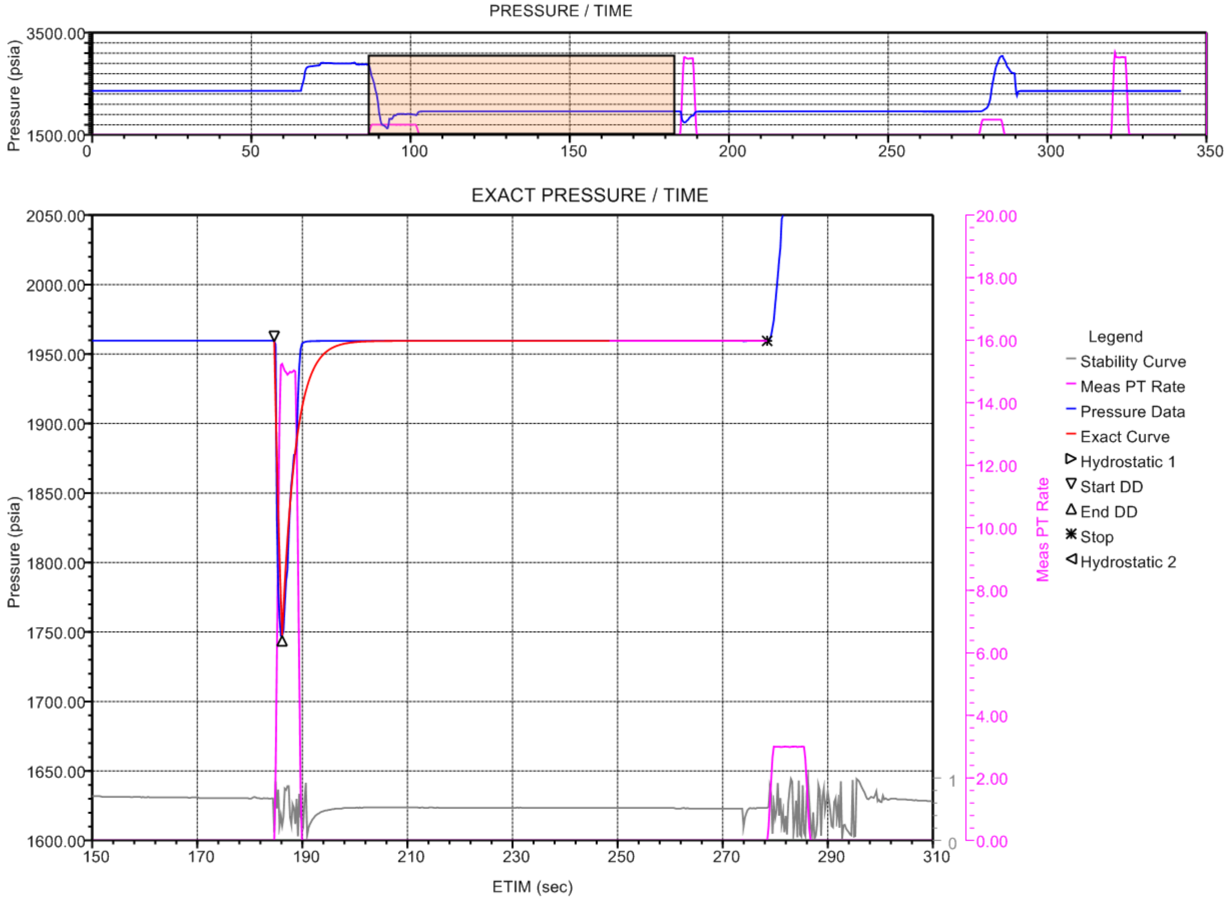
Test No. 10.1; MD: 4583.02 ft; TVD: 4583.02 ft

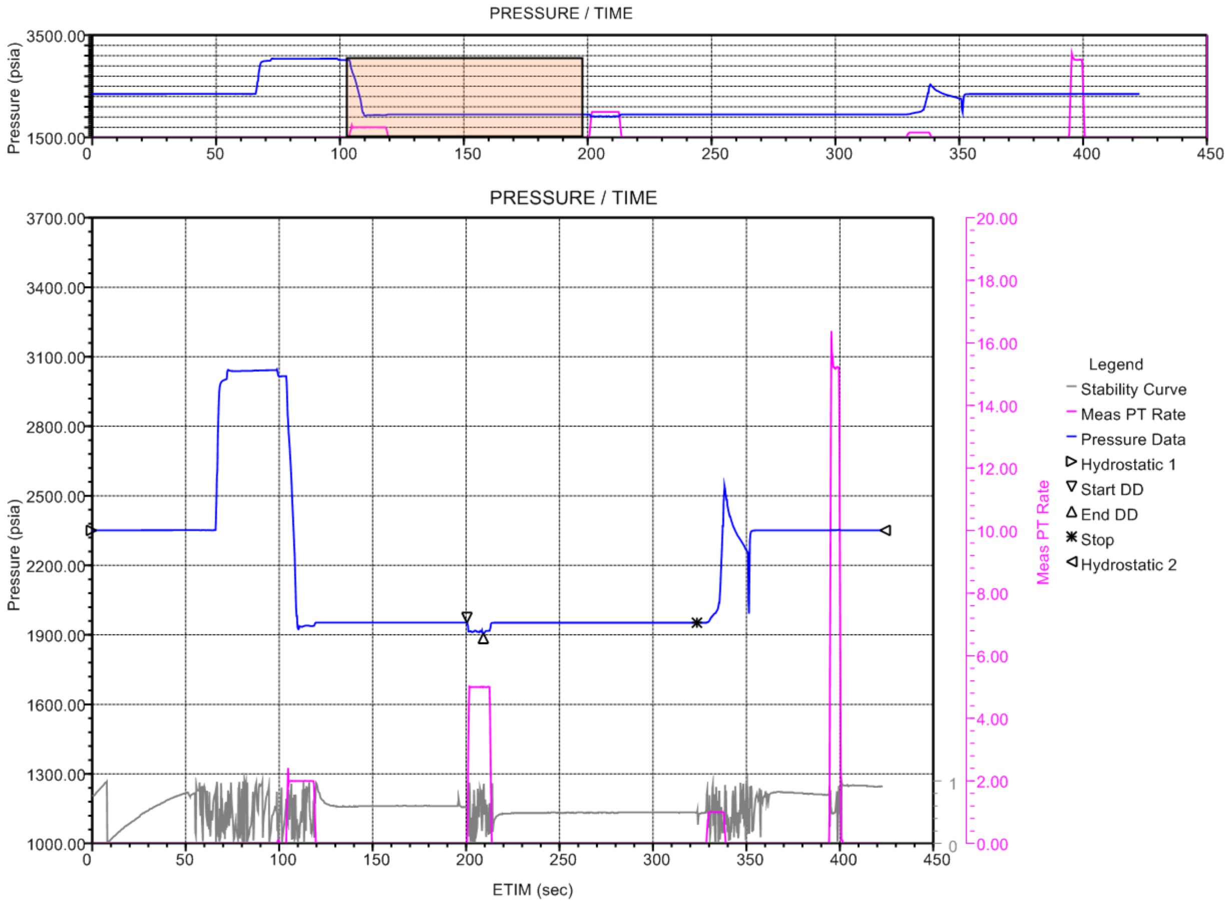
RDT Test File # 2-12.1 Date: 12-Apr-13 12:00:20



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4583.02	4583.02	1747.24	1959.51	1959.51	35.5
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
13.20	8.79	0.66	0.25	9.67e-005	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.04	-0.06	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 11.0; MD: 4566.01 ft; TVD: 4566.01 ft

RDT Test File # 2-13.0 Date: 12-Apr-13 12:07:42



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4566.01	2350.97	2351.07							

CONSTANTS - SPHERICAL FLOW

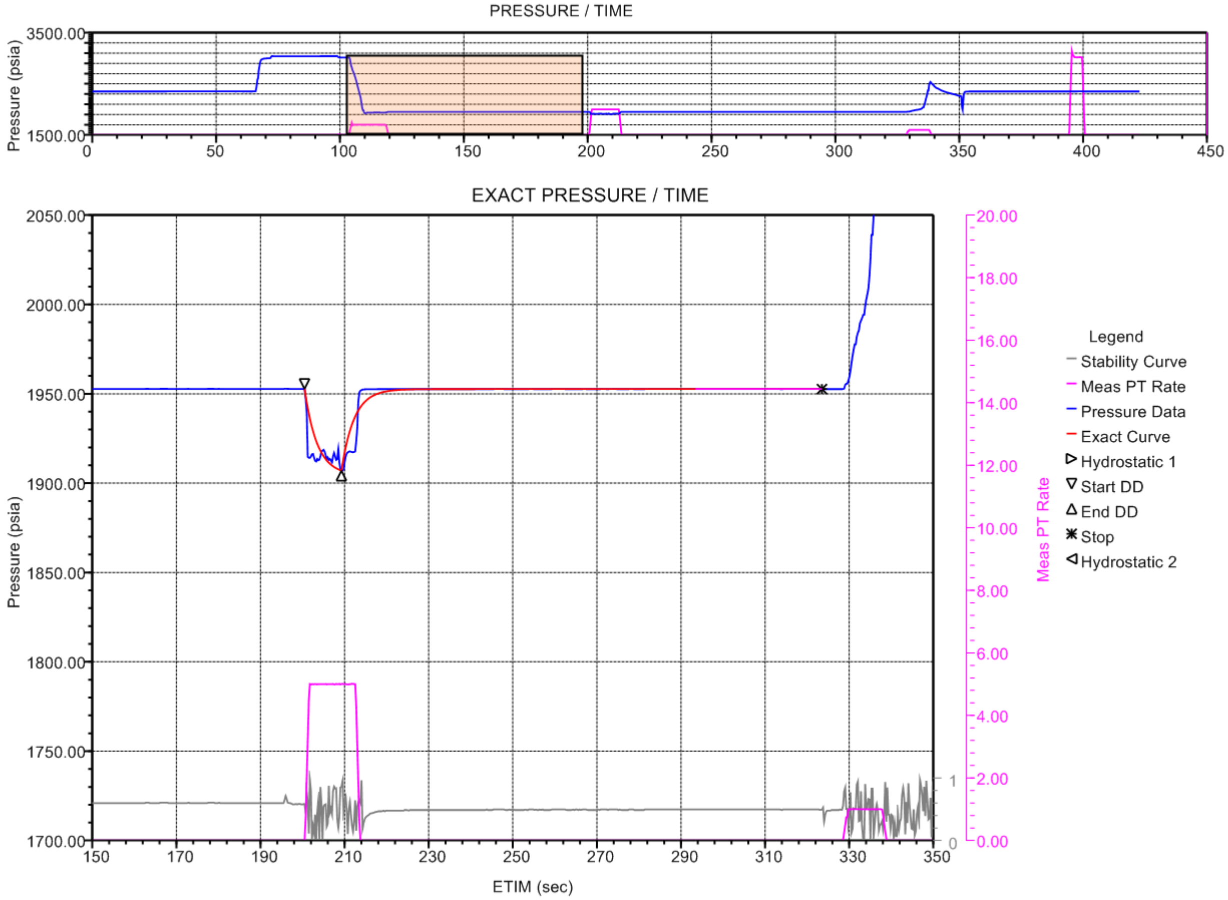
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
40.21	4.59	0.66	0.25	2.54e-004	180.00

REMARKS

Excellent Buildup Stability

Test No. 11.1; MD: 4566.01 ft; TVD: 4566.01 ft

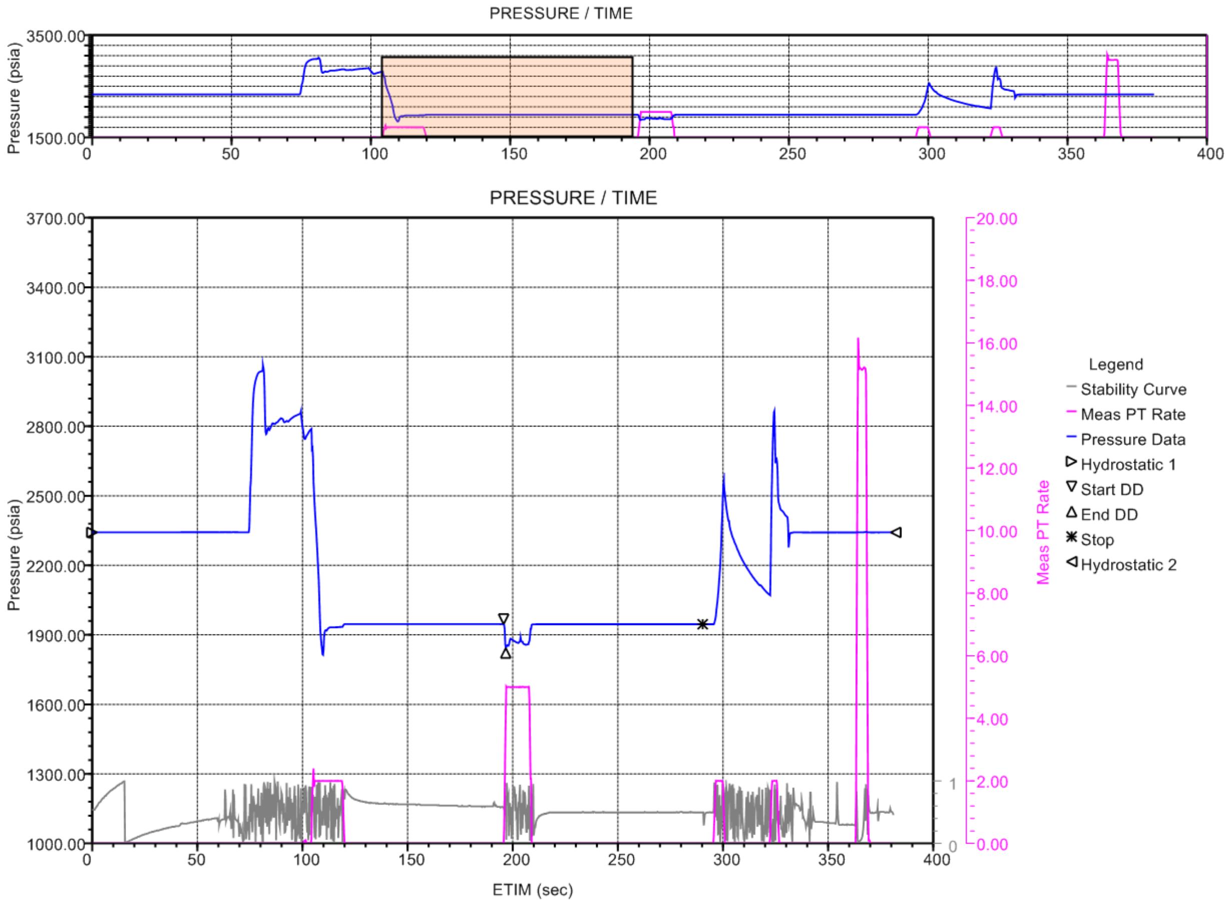
RDT Test File # 2-13.1 Date: 12-Apr-13 12:07:42



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4566.01	4566.01	1907.01	1952.65	1952.65	182
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
40.21	4.59	0.66	0.25	2.54e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.00	-0.00	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 12.0; MD: 4550.00 ft; TVD: 4550.00 ft

RDT Test File # 2-14.0 Date: 12-Apr-13 12:15:58



PRESSURE/TIME PLOT SUMMARY									
Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4550.00	2342.26	2342.18							

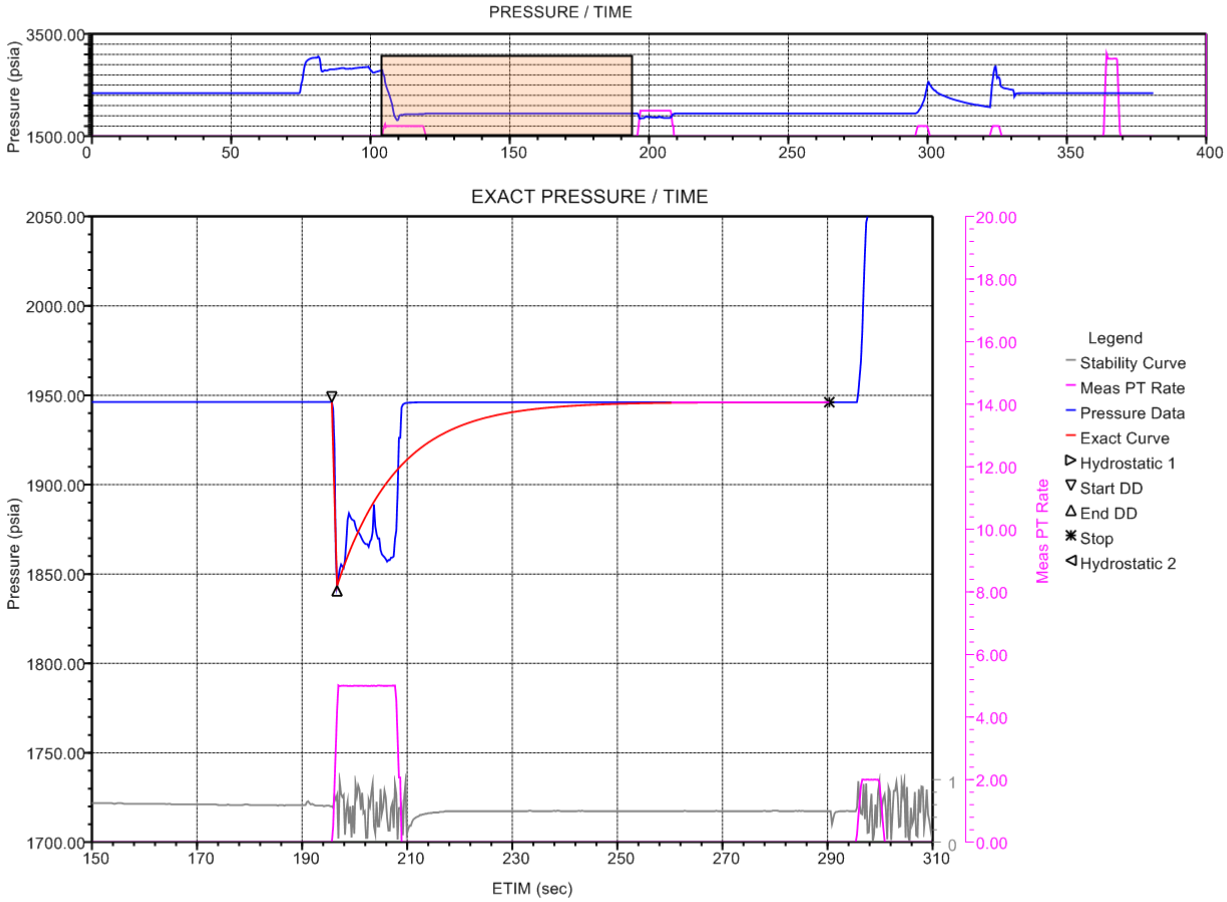
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
1.90	1.90	0.66	0.25	4.47e-005	180.00

REMARKS

Fair Buildup Stability

Test No. 12.1; MD: 4550.00 ft; TVD: 4550.00 ft

RDT Test File # 2-14.1 Date: 12-Apr-13 12:15:58



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4550.00	4550.00	1843.41	1946.15	1946.18	2.97
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
1.90	1.90	0.66	0.25	4.47e-005	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
5.58	0.00	0.00			
REMARKS					
Fair Buildup Stability					

Disclaimer

DATA, RECOMMENDATIONS, INTERPRETATIONS LIMITATIONS

Because of the uncertainty of variable well conditions the necessity of relying on facts and supporting services furnished by others, Halliburton IS UNABLE TO GUARANTEE THE EFFECTIVENESS OF THE PRODUCTS, SUPPLIES OR MATERIALS, NOR THE RESULTS OF ANY TREATMENT OR SERVICE, NOR THE ACCURACY OF ANY CHART INTERPRETATION, RESEARCH ANALYSIS, JOB RECOMMENDATION OR OTHER DATA FURNISHED BY Halliburton. Halliburton personnel will use their best efforts in gathering such information and their best judgment in interpreting it, but Customer agrees that Halliburton shall not be liable for and Customer SHALL RELEASE, DEFEND AND INDEMNIFY Halliburton against any damages or liability arising from the use of such information even if such damages are contributed to or caused by the negligence, fault or strict liability of Halliburton.

A517: Morais 16-2 Well Summary Report 4-15-2013

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

WELL SUMMARY REPORT

API NO. **077-20737**

Operator
PG&E

Well
Morais #16-2

Field
East Island Gas

County
San Joaquin

Sec.	T.	R.	B.&M.
16	**3N**	**5E**	**M.D..**

Location (Give surface location from property or section corner, street center line)
X= 1731921, Y= 585372

Elevation of ground above sea level
-4'

California Coordinates (if known): **Lat: 38.10394898 Long: 121.4327195**

Was the well directionally drilled? ☒ Yes ☐ No If yes, show coordinates at total depth. **408' North, 416' West of surface hole location at 4,548' TVD, 4,648' MD.**

Commenced drilling (date)
4/1/13

Completed drilling (date)
4/15/13

Commenced production/injection (date)

Total depth		
(1st hole)	(2nd)	(3rd)
4,993' MD		

Present effective depth **4,993'**

Junk
none

Production mode: ☐ Flowing ☐ Pumping ☐ Gas lift

Name of production/injection zone(s)

Depth measurements taken from top of: ☐ Derrick Floor ☐ Rotary Table ☒ Kelly Bushing
Which is **12** feet above ground

GEOLOGICAL MARKERS	DEPTH

Formation and age at total depth
Meganos Channel Sand

Base of fresh water
150'

▨	Clean Oil (bbl per day)	API Gravity (clean oil)	Percent Water (including emulsion)	Gas (Mcf per day)	Tubing Pressure	Casing Pressure
Initial Production						
Production After 30 days						

CASING AND CEMENTING RECORD (Present Hole)

Size of Casing (API)	Top of Casing	Depth of Shoe	Weight of Casing	Grade and Type of Casing	New (N) or Used (U)	Size of Hole Drilled	Number of Sacks or Cubic Feet of Cement	Depth of Cementing (if through perforations)	Top(s) of Cement in Annulus
9-5/8"	Surface	577'	36.0#	K-55, LT&C SMLS	N	12-1/4	235 sx	Shoe	Surface
5-1/2"	Surface	4,968'	15.5#	K-55, LT&C USS	N	8-1/2"	1290 sx	Shoe	Surface

PERFORATED CASING (Size, top, bottom, perforated intervals, size and spacing of perforations, and method.)

Logs/surveys run? ☒ Yes ☐ No If yes, list type(s) and depth(s).
Mudlog from 4993'-3010'; ACTR/SD/Caliper/Neutron from 4985'-527'; SP from 4985'-527'; Sidewall from 4830'-4674'; RCBL/NL/GR from 4904'-surface.

In compliance with Sec. 3215, Division 3, of the *Public Resources Code*, the information given herewith is a complete and correct record of the present condition of the well and all work done thereon, so far as can be determined from all available records.

Name
PG&E

Title
Petroleum Engineer

Address
375 North Wiget Ln., #250 Walnut Creek, CA 94598

City/State
Walnut Creek, CA

Zip Code
94598

Telephone Number
925-974-4151

Signature

Date
5/21/13

OG100 (1/98/GSR/1M)
Printed on recycled paper.

SUBMIT IN DUPLICATE

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

HISTORY OF OIL OR GAS WELL

Operator PG&E Field East Island County San Joaquin

Well Morais 16-2 Sec. 16 T. 3N R. 5E M.D. B.&M.

A.P.I. No. 04-077-20737 Name Irani Engineering (Person submitting report) Title Petroleum Engineer (President, Secretary, or Agent)

Date 4/26/13 (Month, day, year)

Signature

Address 375 North Wiget Ln., #250 Walnut Creek, CA 94598 Telephone Number (925) 974-4151

History must be complete in all detail. Use this form to report all operations during drilling and testing of the well or during redrilling or altering the casing, plugging, or abandonment, with the dates thereof. Include such items as hole size, formation test details, amounts of cement used, top and bottom of plugs, perforation details, sidetracked junk, bailing tests, and initial production data.

Date
2013

3/31 Rig idle

4/01 Held safety meeting, finished rigging up on Morais 16-2. Took on water. Unloaded and measured 9 5/8" J-55 36# STC Casing. Welded on conductor and equalizer tube on half rounds. Mixed spud mud. Picked up and made up bottom hole assembly. Held safety meeting. Spud in, drilled 12 1/4" surface hole from 40' to 616'. Average ROP is 88' hour.

4/02 Continued to drill 12 ¼" surface hole from 40' to 616'. Average ROP is 88' hour. Circulated and conditioned mud. Wiped hole to bit (free of drag). Circulated and conditioned mud. POOH to rig up and run casing. Held safety meeting with crews, rigged up casing crews. Rigged up and ran 15 joi nts of 9 5/8" 36 #, J-55, STC casing to 579'. Shoe set at 577' with insert float set at 540' (two bad joints of surface casing, collars were bad). Held safety meeting, serviced rig. Finished running 9 5/8" casing.

<u>Set 9 5/8" casing @ 579'</u>. Rigged up Halliburton, circulated through Halliburton with rig pumps. Held safety meeting. Cemented casing as follows: Mixed and pumped 120 sacks, 208 cubic feet, 37 bbl of lead cement with a density of 13.1 ppg with a yield of 1.73. Followed by 100 sacks 143 cubic feet, 26 bbl of tail cement with a density of 14.5 ppg and a yield of 1.43. Dropped top plug and displaced cement with 41.5 bbl of H2O. Bumped plug at 500 psi over pumping pressure 793 psi. Floats held, had full returns throughout job with 5 bbl of cement to surface. Rigged up and pump for top job, pumped 15 bbl of 14.5 ppg tail cement. 10 bbl of cement to surface. CIP @ 10:40. Waited on cement. Tear out rig floor. Cut conductor and casing, dressed casing and landed 11' well head. Welded well head and tested to 500 psi. Landed BOP. Held safety meeting, serviced rig. Nippled up all BOPE.

4/03 Held safety meeting, serviced rig. Nippled up all BOPE. Picked up and made up new BHA. Tested for DOG representative Gary Ngo. Drilled out Insert float and shoe, drilled to 686'. Wipers on 4 to 6 hour intervals. Held safety meeting, serviced rig. Drilled 8 1/2" hole from 686' to 1022'. Average ROP 112'/hour. Circulated and conditioned mud. Surveyed at 1022', 1 degree NNE 55 Corrected. Wiped hole from 1022' to 500' (free of drag). Drilled 8 1/2" hole from 1022' to 1567', average ROP of 99'/hour. Circulated and Conditioned mud. Wiped hole to shoe, 10K hole drag. Drilled 8 1/2" hole from 1567' to 1725', average ROP 79'/hr.

4/04 Held safety meeting, serviced rig. Drilled 8 1/2" hole from 1725' to 1978', average ROP 101'/hour. Circulated and conditioned mud. Surveyed at 1978', 1 degree NNE 25 corrected. Wiped hole to shoe, 10K hole drag. Wiped hole to shoe. Wipers on 4 to 6 hour intervals. Drilled 8 1/2" hole from 1977' to 2063', average ROP 57'/hour. Held safety meeting, serviced rig. Drilled 8 1/2" hole from 2063' to 2233'. Average ROP 68'/hr. Circulated and conditioned mud, wiped hole to 1591', 10K hole drag. Drilled 8 1/2" hole from 2233' to 2450'. Average ROP was 62'/hr. Kick off point at 2450'. Held safety meeting, serviced rig. Circulated and conditioned mud. POOH. Laid down bottom hole assembly. Picked up directional bottom hole assembly. Scribed directional tools and set MWD tool. RIH to shoe. Slipped 60' of drilling line.

4/05 Held safety meeting, serviced rig. Slipped 60' of drilling line. Replaced liner on pump #1. Code 8 repaired rig. Ran in hole, tested tools at shoe, 1500'. Directional drilled 8 1/2" hole from 2450' to 2525', average ROP 75'/hour. Directional drilled 8 1/2" hole from 2450' to 2600', average ROP 75'/hour. Held safety meeting, serviced rig. Wipers on 6 hour intervals. Directional drilled 8 1/2" hole from 2600' to 2696', average ROP/190' hour. RCR= 300 psi at 60 stks. Circulated and wiped hole to 2050', free of drag. Directional drilled 8 1/2" hole from 2696' to 3043', average ROP 69'/hr. Circulated and conditioned mud. Held safety meeting, serviced rig. Wiped hole from 3043' to 2435', free of drag. Directional drilled 8 1/2" hole from 3043' to 3357', average ROP 52'/hr. Circulated and wiped hole to 2435', 10K spot drag.

4/06 Continued to circulate and wipe hole to 2435', 10K spot drag. Directional drilled from 3357' to 3452'. Average ROP 47'/hr. Circulated, worked on 31 pump (Code 8). Directional drilled 8 1/2" hole from 3452' to 3560', average ROP 54'/hr. Directional drilled 8 1/2" hole from 3500' to 3642', average ROP 71'/hr. Average ROP 75'/hr. Held safety meeting, serviced rig. Wipers on 6 to 7 hour intervals. Circulated and wiped hole to 3003', 10-20K hole drag. RCR= 300 psi at 60 stks. Directional drilled 8 1/2" hole from 3642' to 3958', average ROP 52'/ hour. Circulated and conditioned mud. Held safety meeting, serviced rig. Wiped hole from 3958' to 3317', free of drag. Directional drilled 8 1/2" hole from 3958' to 4401', average ROP 63'/hr. Circulated and conditioned mud.

4/07 Held safety meeting, serviced rig. Wiped hole from 4401' to 3730', free of drag. Directional drilled 8 1/2" hole from 4401' to 4600', average ROP 44' hr. At 6 am, depth 4600'. Directional drilled 8 1/2" hole from 4510' to 4608', average ROP 49'/hr. Coring point. Held safety meeting, service rig. Circulated and conditioned mud, wiped hole to 2300'. Circulated and conditioned mud. Directional drilled 8 1/2" hole from 4608' to 4648'. Average ROP 40'/hr. New coring point. Circulated and conditioned mud. POOH to lay down directional BHA. Held safety meeting, serviced rig. POOH and laid down bottom hole assembly, rigged down sperry. Picked up and made up coring tools. RIH to 1415', broke Kelly, installed ball valve for Coring.

4/08 Held safety meeting, serviced rig. Run in hole to 4648'. Circulated and conditioned mud. Cored from 4648' to 4673'. Circulated hole clean. Pulled out of hole with first core. At 6 am, depth of 4673'. Pulled out of hole with core barrel, cored from 4648' to 4674'. Cored 26', recovered 25'. Held safety meeting, serviced rig. POOH with core. Waited at shoe for 1 hour for core to equalize pressure. POOH with core. Broke bit. Laid down core barrel, picked up new core barrel. Held safety meeting, serviced rig. Rigged up new core barrel. RIH, loaded ball in upper kelly. Circulated and conditioned mud. Cored from 4674' to 4704'. Circulated and conditioned mud. POOH with core barrel.

4/09 POOH, installed safety valve, held blow out drill. Held safety meeting, serviced rig. Waited at shoe for 1 hour to equalize pressure in core barrel. Pulled out of hole with core barrel, laid down core barrel. At 6 am, depth was 4704'. Laid down core barrel, picked up new core barrel. Held safety meeting, serviced rig. Made up bit, RIH to shoe and added ball to upper Kelly. Slipped drilling line 15'. Ran in hole. Held safety meeting, serviced rig. RIH. Circulated and conditioned mud. Cored from 4704' to 4734'. Circulated and conditioned mud. POOH with core.

4/10 Held safety meeting, serviced rig. POOH with core. Waited one hour to let core equalize pressure. Pulled out of hole with core. 6 am depth 4734'. Laid down core barrel, picked up new core barrel. Held safety meeting, serviced rig. RIH to shoe. Added ball to upper Kelly. RIH to 2356', filled pipe. Run In Hole. Circulated and conditioned mud. Cored from 4734' to 4764'. Recovered 30' of core. Circulated and conditioned mud. Held safety meeting, serviced rig. POOH with core. Held safety meeting, serviced rig.

4/11 Pulled out of hole with core, laid down core barrel. Tore out core equipment. Dressed bit with 3-13's, 1-14 jets. Made up Bit and BHA. Run in hole. Held safety meeting, serviced rig. Drilled 8 1/2" hole from 4764' to 4960'. Circulated and repaired rotary motor (radiator hose). Drilled 8 1/2" hole from 4960' to 4993'. Circulated and conditioned mud. Held safety meeting, serviced rig. Wiped hole from 4993' to 4764'. Wiped new hole to check trip gas. Released mud loggers after wiper trip (needed room for Halliburton logging truck). Circulated and conditioned mud, increased mud volume. Wiped hole to shoe, 10-20K spot drag. Slipped 35' of drilling line. Cut 105' of drilling line. Ran in hole.

4/12 Ran in hole to 4993'. Held safety meeting, serviced rig. Circulated and conditioned mud. POOH for logs. Rigged up Halliburton loggers.
Ran ACTR, SD, Caliper, Neutron logs from 4985' to 527'. Held safety meeting, serviced rig.
Ran SP logs from 4985' to 527'.
Ran Sidewall logs from 4830' to 4674'. Held safety meeting, serviced rig. Tore out Halliburton. Made up bit, RIH to shoe. RIH to 4993'. Circulated and conditioned mud. Rigged up lay down equipment. Laid down 4 1/2" drill pipe.

4/13 Held safety meeting, serviced rig. Laid down 4 1/2" drill pipe. Broke kelly, laid down HWDP. Rigged up casing tongs, held safety meeting. Serviced rig. Ran 5 1/2" 15.5#, K-55 LTC to 4971' Shoe set at 4968' with Dif. Collar set at 4923'. Flag joint placed at 4963'. Centralizers placed on the second joint through the sixty first joint (60 centralizers).
Set 5 ½" casing @ 4971'. Rigged up circulating head, circulated with rig pump. Laid down casing tongs. Circulated and conditioned mud. Rigged up cementers. Held safety meeting with crews, dropped ball.
Cemented casing as follows: Pressure tested lines to 3000 psi. Dropped bottom plug, pumped 20 bbl of mud flush 111 followed by 20 bbl of tuned spacer. Mixed and pumped 980 sacks, 209.5 bbl, 1176 cubic feet of lead cement with a weight of 14.5 ppg. Followed by 310 sacks, 64 bbl, 359 cubic feet of tail cement mixed at a weight of 16.0 ppg. Dropped top plug and displaced with 117 bbl of Water, pumped plug with 500 psi over circulation pressure 2577 psi. Had full returns throughout cement job with 20 bbl of cement to surface. CIP at 21:30. Tore out cementers. Nippled down BOPE. Set casing slips with 30K on slips. Nippled down BOPE.

4/14 Held safety meeting, serviced rig. Nippled down BOPE. Tore out floor, pulled BOPE. Cut and dressed 5 1/2" casing, landed 3k Tubing head. Nippled up Tubbing Head. Tested Tubbing head to 3000 psi. Cleaned mud pits. Tore out rig, cleaned mud pits. Released rig at 10:00 am. Tear out rig for road move. Rig Idle.

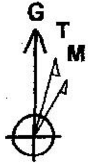
4/15 Loaded out all third party equipment.

5/6 Conducted safety meeting, filled out JSA. Rigged up Halliburton to run Radial cement bond, NL/GR log. Ran in the hole to 4904.0' and tagged (PB 4923.0')
Ran RCBL, NL/GR logs from 4904.0' to surface. Rigged out wireline.

Pacific Gas & Electric
_Morais 16-2 - Survey #1

MD	Inc	Azimuth	TVD	Subsea	Latitude	Northings	Departure	Eastings	Vert Sec	Dogleg
0.00	0.00	0.00	0.00	8.00	0.00	585372.00	0.00	1731921.00	0.00	0.00
650.00	0.50	237.87	649.99	-641.99	-1.51	585370.49	-2.40	1731918.60	0.66	0.08
1149.00	0.68	47.88	1148.98	-1140.98	-0.68	585371.32	-2.05	1731918.95	0.99	0.24
1717.00	0.57	191.53	1716.97	-1708.97	-1.19	585370.81	-0.11	1731920.89	-0.75	0.21
2382.00	0.47	155.81	2381.94	-2373.94	-6.92	585365.08	0.34	1731921.34	-5.09	0.05
2414.00	0.40	138.50	2413.94	-2405.94	-7.12	585364.88	0.47	1731921.47	-5.32	0.46
2445.00	1.19	336.52	2444.94	-2436.94	-6.91	585365.09	0.41	1731921.41	-5.13	5.08
2477.00	3.77	325.91	2476.91	-2468.91	-5.73	585366.27	-0.31	1731920.69	-3.79	8.15
2540.00	4.58	326.42	2539.74	-2531.74	-1.92	585370.08	-2.86	1731918.14	0.70	1.29
2604.00	4.54	325.06	2603.54	-2595.54	2.29	585374.29	-5.72	1731915.28	5.69	0.18
2667.00	5.28	321.97	2666.31	-2658.31	6.61	585378.61	-8.94	1731912.06	11.01	1.25
2730.00	6.35	322.62	2728.98	-2720.98	11.67	585383.67	-12.84	1731908.16	17.33	1.70
2794.00	7.41	322.84	2792.52	-2784.52	17.77	585389.77	-17.48	1731903.52	24.92	1.66
2856.00	8.63	323.04	2853.91	-2845.91	24.67	585396.67	-22.69	1731898.31	33.48	1.97
2919.00	9.75	319.21	2916.10	-2908.10	32.49	585404.49	-29.02	1731891.98	43.47	2.02
2982.00	10.73	317.26	2978.10	-2970.10	40.83	585412.83	-36.49	1731884.51	54.64	1.65
3045.00	11.43	318.09	3039.92	-3031.92	49.79	585421.79	-44.64	1731876.36	66.73	1.14
3107.00	12.52	319.27	3100.57	-3092.57	59.45	585431.45	-53.12	1731867.88	79.55	1.80
3170.00	13.70	317.47	3161.93	-3153.93	70.12	585442.12	-62.62	1731858.38	93.81	1.98
3233.00	14.99	317.56	3222.97	-3214.97	81.63	585453.63	-73.16	1731847.84	109.40	2.05
3296.00	15.36	314.43	3283.77	-3275.77	93.49	585465.49	-84.62	1731836.38	125.88	1.43
3360.00	16.56	313.67	3345.30	-3337.30	105.72	585477.72	-97.27	1731823.73	143.47	1.90
3422.00	17.18	312.55	3404.63	-3396.63	118.01	585490.01	-110.41	1731810.59	161.46	1.13
3486.00	17.95	313.14	3465.65	-3457.65	131.15	585503.15	-124.57	1731796.43	180.77	1.23
3549.00	19.46	314.58	3525.32	-3517.32	145.15	585517.15	-139.13	1731781.87	200.97	2.51
3612.00	19.86	314.22	3584.65	-3576.65	159.98	585531.98	-154.27	1731766.73	222.16	0.66
3676.00	20.17	313.14	3644.78	-3636.78	175.11	585547.11	-170.11	1731750.89	244.06	0.75
3739.00	20.51	313.42	3703.85	-3695.85	190.12	585562.12	-186.06	1731734.94	265.96	0.56

3803.00	20.54	312.48	3763.79	-3755.79	205.41	585577.41	-202.48	1731718.52	288.39	0.52
3866.00	20.95	313.40	3822.71	-3814.71	220.61	585592.61	-218.81	1731702.19	310.70	0.83
3929.00	20.95	313.01	3881.54	-3873.54	236.03	585608.03	-235.23	1731685.77	333.22	0.22
3992.00	20.93	313.02	3940.38	-3932.38	251.39	585623.39	-251.70	1731669.30	355.72	0.03
4055.00	20.53	312.05	3999.30	-3991.30	266.47	585638.47	-268.13	1731652.87	378.01	0.84
4119.00	20.60	312.82	4059.22	-4051.22	281.64	585653.64	-284.72	1731636.28	400.48	0.44
4182.00	20.49	312.67	4118.22	-4110.22	296.65	585668.65	-300.96	1731620.04	422.58	0.19
4245.00	20.34	312.24	4177.26	-4169.26	311.48	585683.48	-317.17	1731603.83	444.54	0.34
4308.00	20.11	312.19	4236.38	-4228.38	326.11	585698.11	-333.30	1731587.70	466.30	0.37
4371.00	20.30	315.13	4295.50	-4287.50	341.13	585713.13	-349.03	1731571.97	488.05	1.64
4434.00	19.94	314.86	4354.66	-4346.66	356.46	585728.46	-364.36	1731556.64	509.72	0.59
4498.00	20.04	314.09	4414.80	-4406.80	371.78	585743.78	-379.97	1731541.03	531.60	0.44
4550.00	20.25	315.53	4463.62	-4455.62	384.40	585756.40	-392.67	1731528.33	549.51	1.04
4580.00	19.93	315.30	4491.79	-4483.79	391.74	585763.74	-399.91	1731521.09	559.81	1.10
4648.00	19.93	315.30	4555.72	-4547.72	408.22	585780.22	-416.21	1731504.79	582.99	0.00



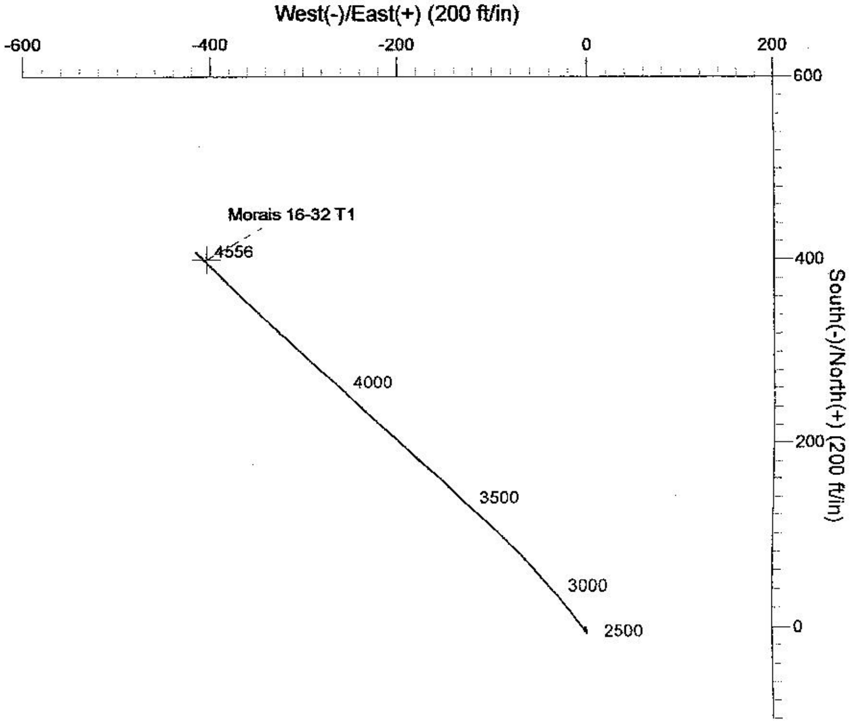
Azimuths to Grid North
True North: 0.57°
Magnetic North: 14.51°

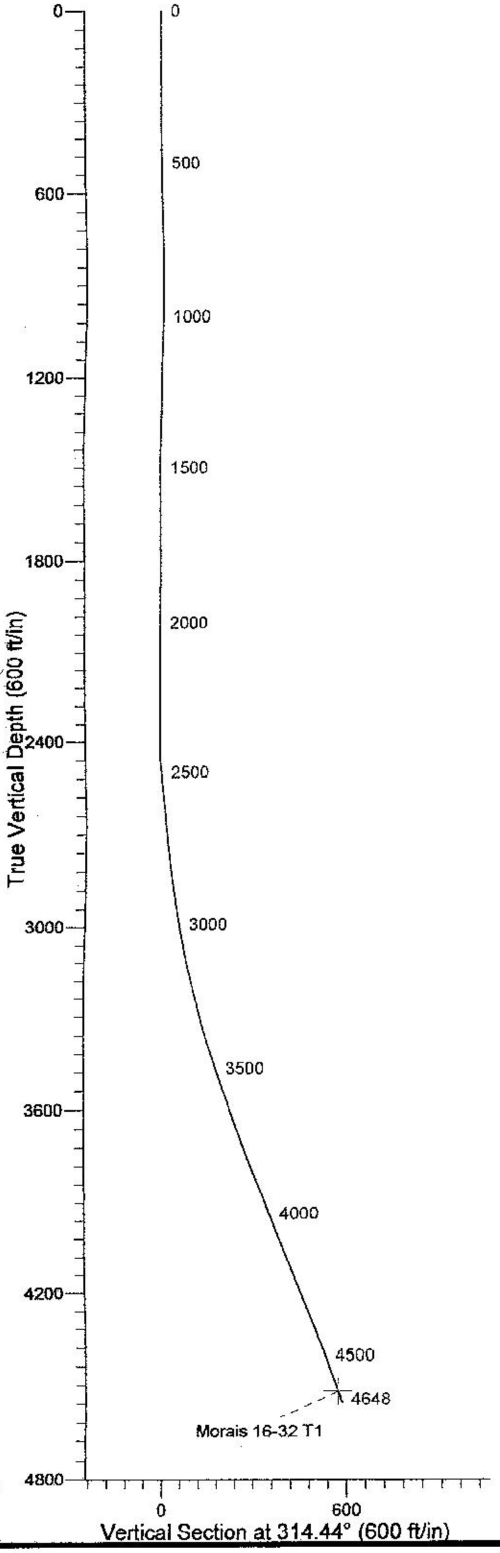
Magnetic Field
Strength: 49163.2nT
Dip Angle: 61.73°
Date: 12/17/2012
Model: IGRF2010

Pacific Gas & Electric

Project: Section 16, T 3N, R 5E
Site: San Joaquin
Well: _Morais 16-2
API# 040772073700
Design: API# 040772073700

HALLIBURTON
Sperry Drilling Services





_Morais 16-2
NAD 1927 (NADCON CONUS)
California III 403
Grid
rkbe (f) @ 8.00ft (Paul Graham 4)
Northing: 585372.00
Easting: 1731921.00

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814-3530
Phone:(916) 322-1110 Fax:(916) 322-1201

No. T **613-0009**

REPORT ON OPERATIONS

Ms Linda Y. H. Cheng
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Sacramento, California
April 26, 2013

Your operations at well **"Morais" 16-2**, A.P.I. No. **077-20737**, Sec. **16**, T. **03N**, R. **05E**, **MD** B.&M., **East Islands Gas** field, in **San Joaquin** County, were witnessed on **4/3/2013**, by **Gary Ngo**, a representative of the supervisor.

The operations were performed for the purpose of **testing the blowout prevention equipment and installation**.

DECISION: **APPROVED**

DEFICIENCIES NOTED AND CORRECTED: None noted.

GN/jc

Tim Kustic
State Oil and Gas Supervisor

X Michael L. Woods

Michael L. Woods
District Deputy

OG109 (Rev. 10/2011)

API No. 077-20737 DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES T 613-0009

BLOWOUT PREVENTION EQUIPMENT MEMO

Operator Pacific Gas & Electric Co. Well “Morais” 16-2 Sec. 16 T. 3N R. 5E
Field East Islands Gas County San Joaquin Spud Date 04/01/2013

VISITS:	Date	Engineer	Time	Operator’s Rep.	Title
1st	04/03/2013	Gary Ngo	(0400 to 0800)	Ted Coffee	Company Man
2nd			(to)		

Contractor Paul Graham Rig # 4 Contractor’s Rep. & Title Chuck Johnson (TP)
Casing record of well: 9-5/8” cem 578’. TD 616’

OPERATION: Testing (inspecting) the blowout prevention equipment and installation. Critical well? Y ☐ N ☒
DECISION: The blowout prevention equipment and its installation on the 8- 5/8 “ casing are approved.

Proposed Well Opns: Drill . MACP: psi
Hole size: 12-1/4 “ fr. 0 ‘ to 616 ‘ , “ to ‘ & “ to ‘

REQUIRED BOPE CLASS:
III B 3M

CASING RECORD OF BOPE ANCHOR STRING					Cement Details	Top of Cement	
Size	Weight(s)	Grade(s)	Shoe at	CP at		Casing	Annulus
9-5/8	36#	J-55	578’		Lead: 37 bbls; 120 sx; 13.1 ppg; 208 cf; 1.43 yield	578’	Surface
					Tail: 26 bbls; 100 sx; 14.5 ppg; 143 cf; 1.43 yield		
					3 bbls returned to surface		

BOP STACK							TEST DATA						
API Symb.	Ram Size (in.)	Manufacturer	Model or Type	Vert. Bore Size (in.)	Press. Rtg.	Date Last Overhaul	Gal. to Close	Recov. Time (Min.)	Calc. GPM Output	psi Drop to Close	Secs. to Close	Test Date	Test Press.
A	CSO	Hydril	GK	10	3000		6.32					04/03	1000
Rd	4.5"	Shaffer	Pipe	11	5000		4.20					04/03	1000
Rd	CSO	Shaffer	CSO	11	5000		4.20					rpt	1500

ACTUATING SYSTEM

Accumulator Unit(s) Working Pressure 3000 psi
Total Rated Pump Output gpm Fluid Level
Distance from Well Bore 50 ft. OK

	Accum. Manufacturer	Capacity	Precharge
1	Koomey	40 gal.	1000 psi
2		gal.	psi

	CONTROL STATIONS	Elec.	Hyd.	Pneu.
X	Manifold at accumulator unit	X	X	
X	Remote at Driller’s station			X
	Other:			

	EMERG. BACKUP SYSTEM			Press.	Wkg.Fluid
X	N2 Cylinders	1	L= 55 “	2400	8.0 gal.
	Other:	2	L= 55 “	2500	9.0 gal.
		3	L= 55 “	2500	9.0 gal.
		4	L=55 “	2500	9.0 gal.
		5	L= “		gal.
		6	L= “		gal.
				TOTAL: 35.0	gal.

TOTAL:

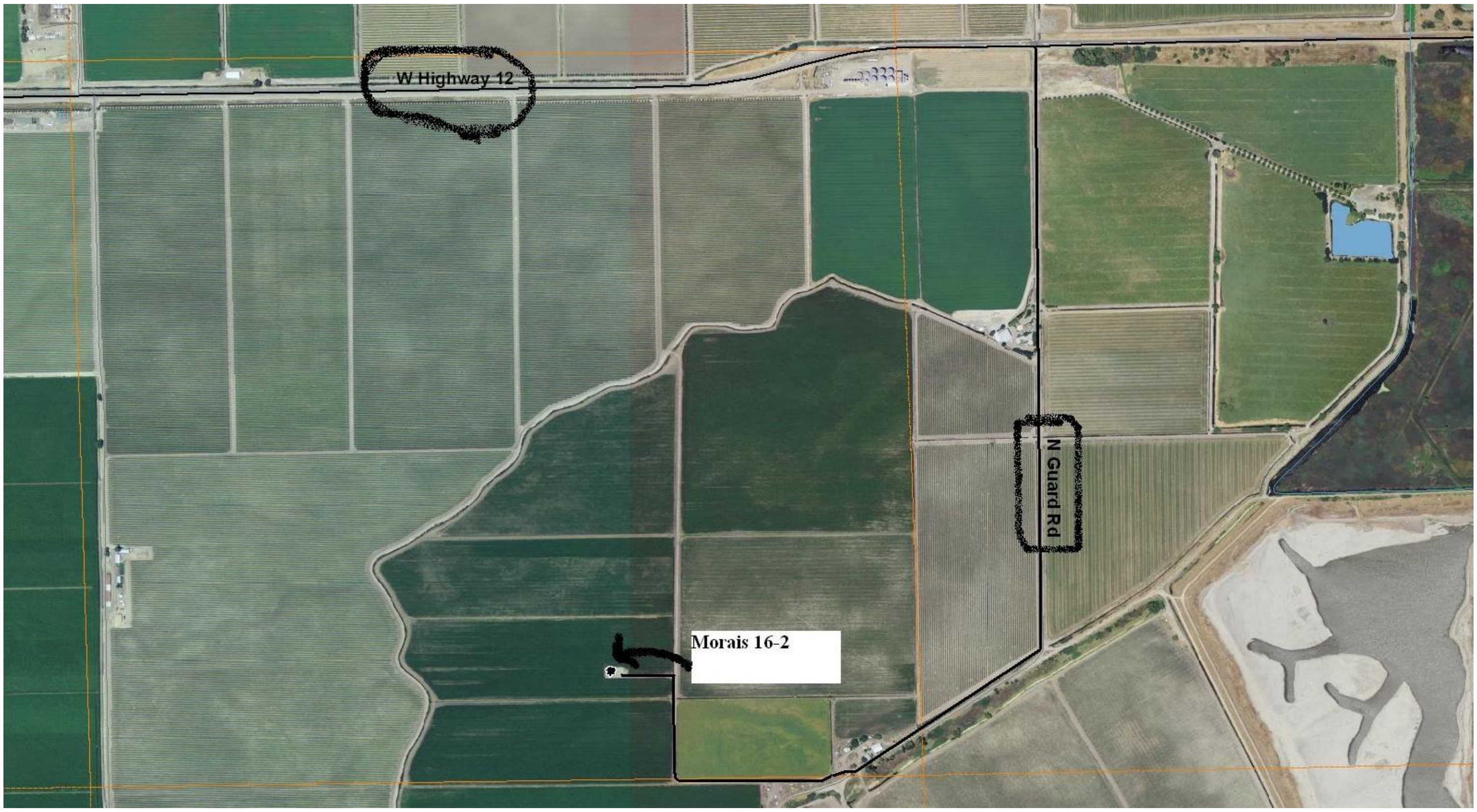
	AUXILIARY EQUIPMENT				Connections			
		No.	Size (in.)	Rated Press	Weld	Flange	Thread	Test Press.
X	Fill-up Line							
X	Kill Line		2"	3M			X	1000
X	Control Valve(s)	1		3M		X		1000
X	Check Valve(s)	1		3M		X		1000
X	Aux. Pump Cnnct.			3M			X	1000
X	Choke Line		3"	3M			X	1000
X	Control Valve(s)	7		3M		X		1000
X	Pressure Gauge						X	
X	Adjstble Choke(s)	2	2”	3M			X	1000
X	Bleed Line		3"				X	
X	Upper Kelly Cock							1000
---	Lower Kelly Cock		------	------				
X	Standpipe Valve							1000
X	Stndpipe Pres. Gau.							
X	Pipe Safety Valve		4.5”	3M				1000
X	Internal Preventer		4.5”	3M				1000

	HOLE FLUID MONITORING EQUIPMENT	Alarm Type		
		Audible	Visual	Class
X	Calibrated Mud Pit	X	X	A
X	Pit Level Indicator	X	X	B
X	Pump Stroke Counter	X	X	
	Pit Level Recorder			C
	Flow Sensor			
	Mud Totalizer			
	Calibrated Trip Tank			
	Other:			

Hole Fluid Type	Weight	Storage Pits (Type & Size)
Mud	10.1	350 bbls

REMARKS AND DEFICIENCIES:

OGD9 (9/06)


W Highway 12
N Guard Rd
Morais 16-2

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814 - 3530

No. P 612-0397

	Old	New
FIELD CODE	--	225
AREA CODE	--	00
POOL CODE	--	32

PERMIT TO CONDUCT WELL OPERATIONS

Sacramento, California
December 11, 2012

Ms Linda Y. H. Cheng, Agent
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Your proposal to **Drill** well **"Morais" 16-2**, A.P.I. No. **077-20737**, Section **16**, T. **03N**, R. **05E**, **MD** B. & M., **East Islands Gas** field, **--** area, **Meganos Canyon** pool, **San Joaquin** County, dated **12/3/2012**, received **12/7/2012** has been examined in conjunction with records filed in this office.

THE PROPOSAL IS APPROVED PROVIDED:

1. Blowout prevention equipment, as defined by this Division's publication No. M07, shall be installed and maintained in operating condition and meet the following minimum requirements:
   a. Class **III B 3M** on the **9 5/8"** casing.
   b. A **3M lubricator** for **wire line** operations.
2. The **9 5/8""** casing is cemented with sufficient cement to fill behind the casing to at least 100' above the base of freshwater zone.
3. Hole fluid of a quality and in sufficient quantity to control all subsurface conditions in order to prevent blowouts shall be used.
4. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.
5. No program changes are made without prior Division approval.
6. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.

THIS DIVISION SHALL BE NOTIFIED TO:

1. Witness a pressure test of the **9 5/8"** casing.
2. Witness a test of the installed blowout prevention equipment prior to drilling out the shoe of the **9 5/8"** casing. Prior to notifying the Division engineer to witness the test, the blind rams must be tested. Information on the blind rams test must be entered on the tour sheet along with the signature of the person in charge.

NOTE:

1. The base of the freshwater zone should be encountered at **300'+/-'**±. A final determination must be made from the well logs after the well is drilled.

Blanket Bond

Tim Kustic, State Oil and Gas Supervisor

Engineer Baxter Tackett
Office (916) 322-1110

By Original signed by
Michael L. Woods, *District Deputy*

BT/sh

A copy of this permit and the proposal must be posted at the well site prior to commencing operations. Records for work done under this permit are due within 60 days after the work has been completed or the operations have been suspended. Issuance of this permit does not affect the Operator's responsibility to comply with other applicable state, federal, and local laws, regulations, and ordinances.

OIL-GAS [illegible]
RECEIVED
2012 DEC -7 AM 8:56

OIL-GAS [illegible]
RECEIVED
2012 NOV 37 AM 9:55

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

FOR DIVISION USE ONLY			
Bond	Forms		
	OGD114	OGD121	

NOTICE OF INTENTION TO DRILL NEW WELL

Detailed instructions can be found at: www.conservation.ca.gov/dog/

In compliance with Section 3203, Division 3, Public Resources Code, notice is hereby given that it is our intention to drill well Morais 16-2, well type Core Well, API No. 077-20737 (Assigned by Division)

Sec. 16, T.3N, R. 5E, MD B.&M., East Islands Field, San Joaquin County.

Legal description of mineral-right lease, consisting of 123 acres (attach map or plat to scale), is as follows:

Do mineral and surface leases coincide? Yes☒ No☐. If answer is no, attach legal description of both surface and mineral leases, and map or plat to scale.

Location of well 693 feet North (Direction) along section ☒ / property ☐ (Check one) line and 2148 feet West (Direction) at right angles to said line from the Southwest corner of section ☒ / property ☐ (Check one) 16 and Lat./Long. in decimal degrees, to six decimal places, NAD 83 format: Latitude: 38.103882 Longitude: -121.433012

If well is to be directionally drilled, show proposed coordinates (from surface location) and true vertical depth at total depth: 1000 feet North (Direction) and 2250 feet West (Direction). Estimated true vertical depth 5000'. Elevation of ground above sea level -4.5 feet. All depth measurements taken from top of KB (Derrick Floor, Rotary Table, or Kelly Bushing) that is 12 feet above ground.

Is this a critical well as defined in the California Code of Regulations, Title 14, Section 1720(a) (see next page)? Yes☐ No☒

Is a California Environmental Quality Act (CEQA) document required by a local agency? Yes☐ No☒ If yes, see next page.

PROPOSED CASING PROGRAM

SIZE OF CASING (Inches API)	WEIGHT	GRADE AND TYPE	TOP	BOTTOM	CEMENTING DEPTHS	FORMATION PRESSURE (Estimated Maximum)	CALCULATED FILL BEHIND CASING (Linear Feet)
16"	109	K-55	0	60'	60'		
9 5/8"	36	J-55	0	600'	600'		

(Attach a complete drilling program including wellbore schematics in addition to the above casing program.)

Estimated depth of base of fresh water: 300' Anticipated geological markers: Meganos Channel Island (4570') (Name, depth)

Intended zone(s) of completion: (Name, depth and expected pressure) Estimated total depth: 5000'

The Division must be notified immediately of changes to the proposed operations. Failure to provide a true and accurate representation of the well and proposed operations may cause rescission of the permit.

Name of Operator
PG&E

Address	City/State	Zip Code
6121 Bollinger Canyon Rd.	San Ramon CA	94583

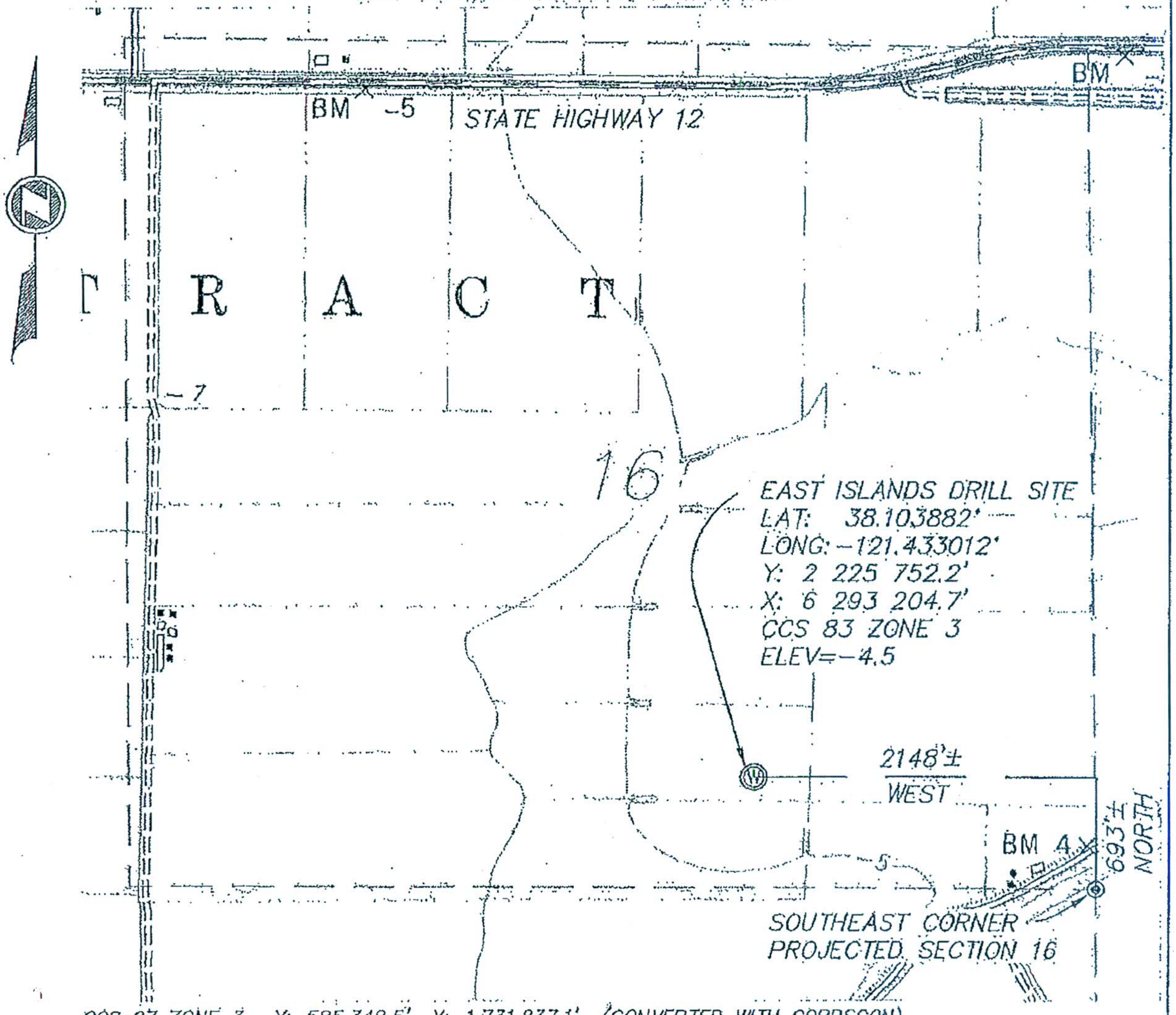
Name of Person Filing Notice	Telephone Number:	Signature	Date
Joe Chan	925-244-3207		12/03/2012

Individual to contact for technical questions:	Telephone Number:	E-Mail Address:
Joe Chan	925-244-3207	jcc4@pge.com

This notice and an indemnity or cash bond shall be filed, and approval given, before drilling begins. If operations have not commenced within one year of the Division's receipt of the notice, this notice will be considered cancelled.

SKETCH OF WELL LOCATION

WELL LOCATED 693'± FT. NORTH; 2148'± FT. WEST FROM
THE SOUTHEAST CORNER OF PROJECTED SECTION 16,
T. 3 N., R. 5 E, M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA



EAST ISLANDS DRILL SITE
LAT: 38.103882'
LONG: -121.433012'
Y: 2 225 752.2'
X: 6 293 204.7'
CCS 83 ZONE 3
ELEV=-4.5

SOUTHEAST CORNER
PROJECTED SECTION 16

CCS 27 ZONE 3, Y: 585,348.5' X: 1,731,837.1' (CONVERTED WITH CORPSCON)

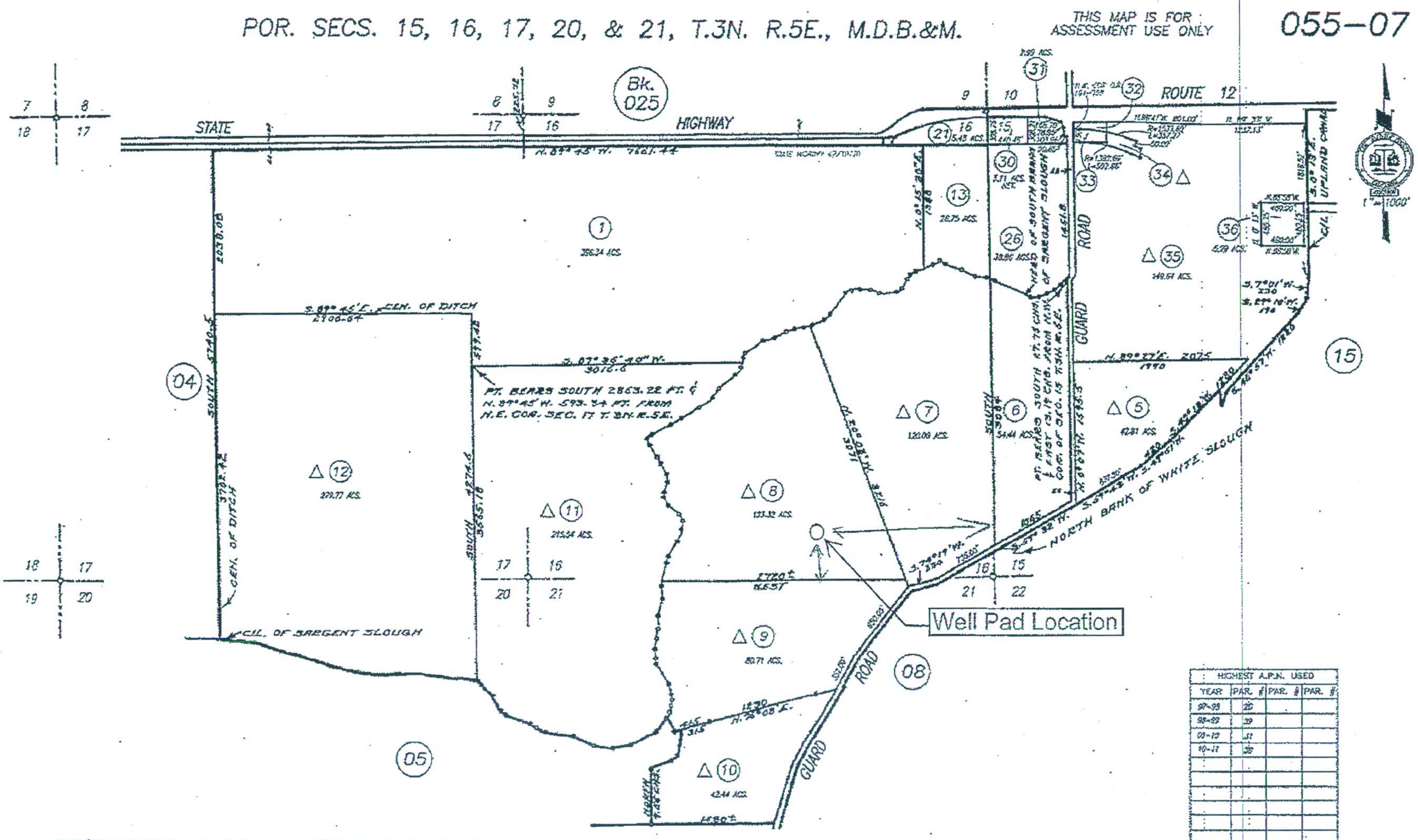
LICENSED LAND SURVEYOR
CHRISTOPHER W. LERCH
10-22-12
L.S. 7906
STATE OF CALIFORNIA

EXHIBIT-"A-1"
EAST ISLANDS
DRILL SITE
WELL NAME

LAUGENOUR AND MEIKLE
CIVIL ENGINEERING · LAND SURVEYING · PLANNING
608 COURT STREET, WOODLAND, CALIFORNIA 95695 · PHONE: (530) 662-1755
P.O. BOX 828, WOODLAND, CALIFORNIA 95776 · FAX: (530) 662-4602

SCALE: 1" = 1000" DATE: 10/22/12

JOB No. 3462-3



PG&E CAES Project Core Well Permit Application

Figure 2 - East Island Assessor's Map

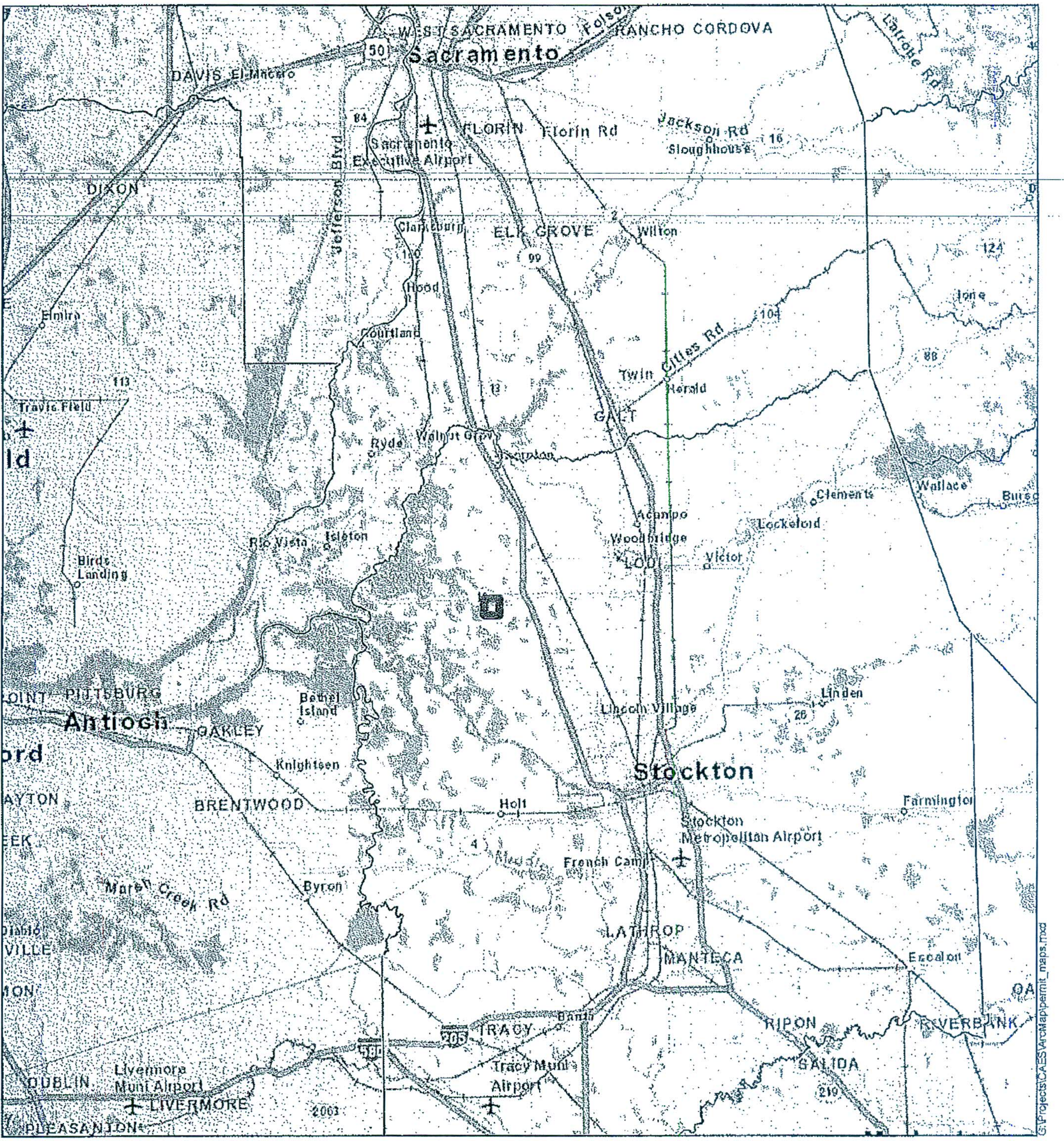


Figure 1 - East Island Vicinity Map

☐ East Island Proposed Core Well Pad

PG&E CAES Project Core Well Permit Application

0 5 10 15 Miles

11/27/2012

IRANI ENGINEERING
PETROLEUM ENGINEER
2625 FAIR OAKS BLVD., SUITE 10
SACRAMENTO, CALIFORNIA 95864
916-482-2847
FAX 916-482-7514

PG&E
East Islands Core Well

Location: 1200′ North and 2200′ West from Southeast corner of
Section 16, T 3N, R 5E, MDB&M, San Joaquin County., California.
Elevation: -5′ ground. +7′ KB (assume 12' KB)

Take all measurements from KB Which is 12'above ground.
Keep hole full at all times.

Drilling and Abandonment Program (Drill Pipe: 5″, 19.5#, 4-1/2″ IF thread)

Building Location, Set Conductor, Rat Hole, Mouse Hole

1. Build location. Pilings might be required to stabilize the rig.

2. 6'X6′ diameter cellar will be constructed. Rat hole and mouse hole for the rig will be dug by a water well driller.

3. 16" conductor will be cemented at 60' using a water well driller.

Rig Move, Drill 12-1/4″ hole to ~600′+, Cement 9-5/8″ casing, Install BOE.

1. Move in drilling rig. Rig up. Install riser and flow line on 16" conductor. Install mud cleaners and centrifuge. Have a full water tank before spud. In addition have a frac tank on location and fill it with water.

2. Run 12-1/4″ rental bit, 3-16/32" jets, 2-DC,s, HW and drill to 600′. Use both pumps with 6" liners.

3. Do not log surface hole.

4. Cement 9-5/8″, 36″, J-55, ST&C casing at ~600′ with 120 sacks of Class G cement premixed 6% gel and 3% CaCl2 followed with 100 Class G cement premixed 3% CaCl2. Displace cement with freshwater. Tack weld and Bakerlok bottom 4 collars, weld shoe solid. Run float shoe and insert 40' above shoe. Run a centralizer 15' above shoe. Use top rubber plug only and plug holding head. Bump plug on insert. Pressure test to 500 psig. Perform 60 sacks top job using cement premixed 3% CaCl2.
   Note: The cement volume is calculated at 70% excess.

5. After 2 hours WOC, land casing. Weld casing head (have welders on the hook). Test weld 500 psig. Install Series 900 dual hydraulic control gate and Hydril GK. Test according to Standing Orders. Notify DOG to witness. Pressure test casing to 1000 psig.

Change hole to Cypan mud System. Drill 8-1/2″ hole to 4520′.

1. Drill out the shoe of 9-5/8″ casing. Change hole to Cypan mud system with low PH. Use the following BHA: 8-1/2″ new long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 5" drill pipe. Drill to 4520′. Use both pumps with 6" liners. Have an additional mill tooth bit on location.

2. Wipe hole every 4 to 8 hours. Wipe hole to shoe on the first three wiper runs after that 10 stands will suffice. Wipe hole to shoe every 50 to 60 hours.

3. Install mud loggers at 3000'.

4. Have 9.8 ppg mud weight by 3000'.

5. Mud loggers report any unusual gas readings to the company man immediately.

6. Check for flow before coming out of hole.

7. Drift survey every 1000'.

8. Keep pipe moving at all times.

Core well from 4520′ to 4720′.

1. Pick up 8-1/2″X3″ core bit with 6-1/2″X3″X30′ barrel Continuous Wireline Coring System, 4 drill collars with stabilizers, 5″ drill pipe. Cut 3″ core from 4520′ to 4720′. Have Core Lab on location to collect cores per core handling instruction attached to this program. Pull out. Lay down core BHA.

Drill 8-1/2″ hole to TD at 5000′.

1. Use the following BHA: 8-1/2″ RR long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 5" drill pipe. Drill to Total Depth of 5000′. Use both pumps with 6" liners.

Condition Hole before Logging.

1. Wipe hole to shoe. Circulate and condition mud. Pull out.

Logging Program

1. Run DIL/Sonic/GR/Neutron/Density from 600′ to TD. Run EMI from 4000′ to 5000′. If ordered take formation water samples using RFT tool.

Mud logging Program

1. Install mud loggers at 3000′. Circulate as necessary for evaluation. Open hole tests will not be run. Take one set W&D samples every 30′. E-mail daily log copies to PG&E, Worleyparsons, and Irani. Watch pit level monitor closely at all times. Keep 3 spliced log copies in trailer.

Mud Program.

Cypan mud system with low PH from 600′ to TD.

Depth	Weight	Viscosity	Water Loss
0'- 600′	Spud mud	65 sec.	NC
600′-3000'	9.0-9.8 ppg.	35-45 sec.	6cc/30 min
3000'- TD	9.8-10.0 ppg.	35-45 sec.	6cc/30 min

Have sufficient mud material on location to raise mud weight .66 ppg. Adjust mud weight to maintain mud log base line below 30 units and to stabilize shale

Abandonment Program

TD ~5000′ MD, BFW at ~400′.
Surface Casing: 9-5/8″ 36″ set at ~600′
Hole size: 8-1/2″ hole at 5000′, MW=10 ppg
Note: This is a straight hole.

1. Run open-ended drill pipe to 4720′.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% NaCl at 4700′. Pull up to 4000′. Wait on cement for 6 hours. Locate top Of cement plug which must be above 4470′. Notify DOG to witness.

2. Pull up drill pipe to 700′.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% CaCl2 at 700′. Pull up to surface. Wait on cement for 6 hours. Locate top Of cement plug which must be above 300′. Notify DOG to witness.

3. Cut casing 5′ below ground. Plug casing with 25 lineal feet of cement. Weld steel plate on stub. Notify DOG to witness.

Rig down and move out the drilling rig.

1. Make sure the rat hole and mouse hole are covered and red taped during the rig move. Place a fence around the cellar as soon as the rig has moved off.

Geological Prognosis

Anticipated Formation Tops

Depth	DEPTH
Base of USDW	~400'
Top of Meganos Channel Sand	4570'
Total Depth	5000'

A518: PG&E EQ Interim Action Memorandum
King-East-Cache

NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA
U.S. DEPARTMENT OF ENERGY

MEMORANDUM FOR DISTRIBUTION

FROM: FRED E. POZZUTO F.E.P. 11-16-2012
ENVIRONMENTAL MANAGER / NEPA COMPLIANCE OFFICER
ENVIRONMENTAL COMPLIANCE DIVISION

TO: LISA A. KUZNAIR
CONTRACTING OFFICER
ACQUISITION AND ASSISTANCE DIVISION

SUBJECT: **Interim Action within the scope of an ongoing Environmental Assessment (DOE/EA-1752) prior to issuance of a finding of no significant impacts (FONSI) for the Pacific Gas and Electric Company's (PG&E) Project DE-OE0000198, Recovery Act Smart Grid - Advanced Underground Compressed Air Energy Storage (CAES)**

In accordance with criteria established by the Council on Environmental Quality in its regulations implementing the procedural provisions of the National Environmental Policy Act (NEPA)(40 CFR Parts 1500-1508), DOE's NEPA implementing regulations (10 CFR Part 1021), which rely on those criteria, and DOE Order 451.1B, *National Environmental Policy Act Compliance Program*, our office has reviewed PG&E's Environmental Questionnaire (NETL Form 451.1-1/3) and found it acceptable in order to proceed with the requisite subsurface investigation.

PG&E has selected up to three sites to conduct core sampling. These three sites are the East Island site, the King Island site, and the Cache Slough site. Wells will be drilled into the formation caprock and further into the porous rock formation of the potential storage zone. After conducting down hole and laboratory analysis on each of these wells, an evaluation will be made to determine viability of pressure testing the formation for use in Compressed Air Energy Storage (CAES). The Environmental Assessment (EA) will address the pressure testing of the selected well site.

All three construction locations are in active agriculture or other disturbed areas and the proposed activity will not affect any habitats. Biological Assessments prepared by PG&E's consultant (*North State Resources*) document that no listed or sensitive species will be affected. Cultural Resource Surveys conducted by PG&E's consultant (*SWCA Environmental Consultants*) concluded no historic or prehistoric resources would be affected by the core drilling activities.

Although the activities discussed in the above paragraph would take place prior to DOE's completion of the EA (DOE/EA-1752) for the entire project (*wherein a more thorough and extensive review will be conducted*), DOE has determined this subsurface geological exploration activity would not have an adverse environmental impact; or would limit the choice of reasonable alternatives for the project. Activities of this nature would normally be covered by Categorical

Exclusion (CX) B3.7 (*New Terrestrial infill exploratory and experimental wells*), however the determination for the need of an EA for the compression testing and other potential environmental impacts of this project, requires the need for this Interim Action, in-lieu of a Categorical Exclusion.

The activities associated with this interim action will still need to be documented and included in the upcoming EA, as will all of the other work proposed to be undertaken with the pressure testing.

Please direct any questions regarding this Interim Action to Fred Pozzuto at (304) 285-5219.

DISTRIBUTION:
M. D. Hampton, 830
K. R. Nuhfer, 530
Original to NEPA File (451.1)

A519: Morais 16-2 - Permit to Conduct Well Operations

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814 - 3530

PERMIT TO CONDUCT WELL OPERATIONS

No. P 612-0397

Old	New	
--	225	FIELD CODE
--	00	AREA CODE
--	32	POOL CODE

Sacramento, California
December 11, 2012

Ms Linda Y. H. Cheng, Agent
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Your proposal to **Drill** well **"Morais" 16-2**, A.P.I. No. **077-20737**, Section **16**, T. **03N**, R. **05E**, **MD** B. & M., **East Islands Gas** field, **--** area, **Meganos Canyon** pool, **San Joaquin** County, dated **12/3/2012**, received **12/7/2012** has been examined in conjunction with records filed in this office.

THE PROPOSAL IS APPROVED PROVIDED:

1. Blowout prevention equipment, as defined by this Division's publication No. M07, shall be installed and maintained in operating condition and meet the following minimum requirements:
   a. Class **III B 3M** on the **9 5/8”** casing.
   b. A **3M lubricator** for **wire line** operations.
2. The **9 5/8”**” casing is cemented with sufficient cement to fill behind the casing to at least 100’ above the base of freshwater zone.
3. Hole fluid of a quality and in sufficient quantity to control all subsurface conditions in order to prevent blowouts shall be used.
4. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.
5. No program changes are made without prior Division approval.
6. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.

THIS DIVISION SHALL BE NOTIFIED TO:

1. Witness a pressure test of the **9 5/8"** casing.
2. Witness a test of the installed blowout prevention equipment prior to drilling out the shoe of the **9 5/8"** casing. Prior to notifying the Division engineer to witness the test, the blind rams must be tested. Information on the blind rams test must be entered on the tour sheet along with the signature of the person in charge.

NOTE:

1. The base of the freshwater zone should be encountered at **300’+/-'**±. A final determination must be made from the well logs after the well is drilled.

Blanket Bond

Tim Kustic, State Oil and Gas Supervisor

Engineer Baxter Tackett
Office (916) 322-1110

By Original signed by
Michael L. Woods, *District Deputy*

BT/sh

A copy of this permit and the proposal must be posted at the well site prior to commencing operations. Records for work done under this permit are due within 60 days after the work has been completed or the operations have been suspended. Issuance of this permit does not affect the Operator's responsibility to comply with other applicable state, federal, and local laws, regulations, and ordinances.

A520: Piacentene 2-27 - Permit to Conduct Well Operations

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814 - 3530

No. P 612-0396

Old	**New**	
--	**351**	FIELD CODE
--	**00**	AREA CODE
--	**10**	POOL CODE

PERMIT TO CONDUCT WELL OPERATIONS

Sacramento, California
December 11, 2012

Ms Linda Y. H. Cheng, Agent
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Your proposal to **Drill** well **"Piacentine" 2-27**, A.P.I. No. **077-20736**, Section **27**, T. **03N**, R. **05E**, **MD** B. & M., **King Island Gas** field, **--** area, **Mokelumne River** pool, **San Joaquin** County, dated **12/3/2012**, received **12/7/2012** has been examined in conjunction with records filed in this office.

THE PROPOSAL IS APPROVED PROVIDED:

1. Blowout prevention equipment, as defined by this Division's publication No. M07, shall be installed and maintained in operating condition and meet the following minimum requirements:
   a. Class **III B 3M** on the **9 5/8"** casing.
   b. A **3M lubricator** for **wire line** operations.
2. The **9 5/8"**" casing is cemented with sufficient cement to fill behind the casing to at least 100' above the base of freshwater zone.
3. Hole fluid of a quality and in sufficient quantity to control all subsurface conditions in order to prevent blowouts shall be used.
4. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.
5. No program changes are made without prior Division approval.
6. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.

THIS DIVISION SHALL BE NOTIFIED TO:

1. Witness a pressure test of the **9 5/8"** casing.
2. Witness a test of the installed blowout prevention equipment prior to drilling out the shoe of the **9 5/8""** casing. Prior to notifying the Division engineer to witness the test, the blind rams must be tested. Information on the blind rams test must be entered on the tour sheet along with the signature of the person in charge.

NOTE:

1. The base of the freshwater zone should be encountered at **150 +/-'**±. A final determination must be made from the well logs after the well is drilled.

Blanket Bond

Tim Kustic, State Oil and Gas Supervisor

Engineer Baxter Tackett
Office (916) 322-1110

By Original signed by
Michael L. Woods, *District Deputy*

BT/sh

A copy of this permit and the proposal must be posted at the well site prior to commencing operations. Records for work done under this permit are due within 60 days after the work has been completed or the operations have been suspended. Issuance of this permit does not affect the Operator's responsibility to comply with other applicable state, federal, and local laws, regulations, and ordinances.

A521: Piacentine 2-27 Drilling Program

IRANI ENGINEERING
PETROLEUM ENGINEER
2625 FAIR OAKS BLVD., SUITE 10
SACRAMENTO, CALIFORNIA 95864
916-482-2847
FAX 916-482-7514

February 20, 2013

PG&E
Piacentine No. 2-27

Location: X= 1734574, Y 577271, Nad 27, Zone 3
Section 27, T 3N, R 5E, MDB&M, San Joaquin County., California.
Elevation: -6′ ground. +6′ KB (assume 12' KB)
Lat: 38.08155572 Long: 121.422162329
API: 077-20736
Take all measurements from KB Which is 12' above ground.
Keep hole full at all times.
Comply with Standing Orders attached.

Drilling and running 5-1/2″ casing Program (Drill Pipe: Drill Pipe: 4-1/2", 16.6#, XH)

Building Location, Set Conductor, Rat Hole, Mouse Hole

1. Build location. Pilings might be required to stabilize the rig.

2. 8'X8′ diameter cellar will be constructed. Rat hole and mouse hole for the rig will be dug by a water well driller.

3. 16" conductor will be cemented at 60' using a water well driller.

Rig Move, Drill 12-1/4″ hole to ~600′+, Cement 9-5/8″ casing, Install BOE.

1. Move in drilling rig. Rig up. Install riser and flow line on 16" conductor. Install mud cleaners and centrifuge. Have a full water tank before spud. In addition have a frac tank on location and fill it with water.

2. Run 12-1/4″ rental bit, 3-16/32" jets, 2-DC,s, HW and drill to 600′. Use both pumps with 6" liners.

3. Do not log surface hole.

4. Cement 9-5/8″, 36″, J-55, ST&C casing at ~600′ with 120 sacks of VERSACEM lead cement premixed with 2% CaCl2 and 0.2% Versaset (13.1 ppg, 1.72 yield) followed with 100 ECONOCEM tail cement premixed 5% Salt-Interpid-Moab Fine (1.42 ppg, 1.42 yield). Displace cement with freshwater. Tack weld and Bakerlok bottom 4 collars, weld shoe solid. Run float shoe and insert 40' above shoe. Run a centralizer 15' above shoe. Use top rubber plug only and plug holding head. Bump plug on insert. Pressure test to 500 psig. Perform 60 sacks top job using cement premixed 3% CaCl2.
   Note: The cement volume is calculated at 85% excess.

5. After 2 hours WOC, land casing. Weld casing head (have welders on the hook). Test weld 500 psig. Install Series 900 dual hydraulic control gate and Hydril GK. Test according to Standing Orders. Notify DOG to witness. Pressure test casing to 1000 psig.

Change hole to Cypan mud System. Drill 8-1/2″ hole to 4640′.

1. Drill out the shoe of 9-5/8″ casing. Change hole to Cypan mud system with Neural PH. Use the following BHA: 8-1/2″ new long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 4-1/2" drill pipe. Drill to 4640′. Use both pumps with 6" liners. Have an additional mill tooth bit on location.

2. Wipe hole every 4 to 8 hours. Wipe hole to shoe on the first three wiper runs after that 10 stands will suffice. Wipe hole to shoe every 50 to 60 hours.

3. Install mud loggers at 4200'.

4. Have 9.8 ppg mud weight by 3000'.

5. Mud loggers report any unusual gas readings to the company man immediately.

6. Check for flow before coming out of hole.

7. Drift survey every 1000'.

8. Keep pipe moving at all times.

Core well from 4641′ to 4821′.

1. Pick up Baker 8-1/2″X4″ core bit with Baker HydroLift Full Closer Catcher System, with 6.75″X4″X30′ barrel, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's 4-1/2″ drill pipe. Cut 4″ core from 4641′ to 4821′. Use Baker Lay-Down Shuttle to lower the core barrel from derrick. Have Core Lab on location to collect cores per core handling instruction attached to this program

Drill 8-1/2″ hole to TD at 4970′.

1. Use the following BHA: 8-1/2″ RR long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 4-1/2" drill pipe. Drill to Total Depth of 4970′. Use both pumps with 6" liners.

Condition Hole before Logging.

1. Wipe hole to shoe. Circulate and condition mud. Pull out.

Logging Program

1. Run DIL/Sonic/GR/Neutron/Density/SP?Caliper logs from 600′ to TD. Run EMI from 3800′ to 4970′. CMR logging tool might be run. If ordered take formation water samples using RFT tool.

Mud logging Program

1. Install mud loggers at 4200′. Circulate as necessary for evaluation. Open hole tests will not be run. Take one set W&D samples every 30'. E-mail daily log copies to PG&E, Worleyparsons, and Irani. Watch pit level monitor closely at all times. Keep 3 spliced log copies in trailer.

Mud Program, Baroid

Aquagel/Polyac Plus mud system with Neutral PH from 600′ to TD.

Depth	Weight	Viscosity	Water Loss
0'- 600′	Spud mud	65 sec.	NC
600′-3000'	9.0-9.8 ppg.	35-45 sec.	6cc/30 min
3000'- TD	9.8-10.0 ppg.	35-45 sec.	6cc/30 min

Have sufficient mud material on location to raise mud weight .66 ppg. Adjust mud weight to maintain mud log base line below 30 units and to stabilize shale.

IRANI ENGINEERING
PETROLEUM ENGINEER
2625 FAIR OAKS BLVD., SUITE 10
SACRAMENTO, CALIFORNIA 95864
916-482-2847
FAX 916-482-7514

STANDING ORDERS, DRILLING

Operator PG&E Well No. Piacentine No. 2-27

Contractor Paul Graham Drilling Rig No. 7

*1. Prior to drilling out the surface casing, the blowout preventers and all associated equipment shall be pressure tested to 50% of the rated working pressure (Bag preventer to 40%). Equipment to be tested separately are: Pipe rams, blind rams, bag preventer, kelly cock, standpipe valve, kill line (stop valve, check valve) and blow down line (each valve, choke and bean). Blow down manifold shall have at least one operating pressure gage of a range at least 1000 psig higher than blowout preventer rated working pressure. DOG to witness.
*2. Blowout preventers on protection and production casing shall be tested as above to 70% of rated pressure (Bag to 50%).
*3. Each drilling crew is to have at least one blowout drill weekly.
*4. Before tripping, check the ditch for flow with pumps off.
*5. Daily record the one-half pump stroke standpipe pressure.
6. Measure drill pipe on first trip after installing mud loggers.
7. All casing run shall be carefully visually inspected for pipe body and thread defects as it is unloaded. Casing shall not be permitted to drop from trucks, roll it off on ramps.
8. All casing shall have threads "bright" cleaned and a teflon pipe dope (Bakerseal, TF-17) liberally applied.
9. Keep hole full at all times.
*10. Check operation of BOE each round trip.
11. Take all measurements from KB.
12. Drilling rig mud pits shall have a calibrated tank to gage mud used to fill the hole on trips.

Each 60′ stand of 4-1/2″ drill pipe takes 0.38 barrels.

*Shall be entered on tour sheet and signed by person in responsible charge.
Date: February 20, 2013

Core Handling Procedures

Use Baker Lay-Down Shuttle to lower the core barrel from derrick. Core Laboratories personnel will catch and handle core.

Drill holes in the core barrel and pump resin in the core barrel to stabilize the core, after that, the core barrel (aluminum liner) will be cut into 3 ft. lengths and capped on both ends. For the caprock, be sure the barrels are full before capping. For each 3 ft segment, the top and bottom should be labeled and footages marked on barrel. Core boxes labeled appropriately.

The core should be stored at ambient temperature and then transported to Core Labs facility in Bakersfield at completion of coring. Should ambient temperature exceed 70°F, then core should be kept cool.

The portions of caprock to analyze for threshold pressure testing will be identified from the e-log by PG&E personnel before any core is slabbed. These intervals are not to be slabbed but set aside for shipment to the lab that will test the core.

The core will be slabbed 2/3rd; 1/3rd. The 2/3rd portion will be used for sampling; the 1/3rd portion for core description.

Routine core analysis for P&P will be one per foot. Samples for special core analysis and petrography will be selected after those tests are completed. The P&P analyses need to be completed as soon as possible.

Samples for sieve analysis should be selected as the core is plugged for P&P. Those analyses should be conducted as soon as possible.

Core Labs will store the core in cool condition until PG&E requests otherwise.

Casing and Cementing Program

TD 4970′, BFW at ~150′.
Surface Casing: 9-5/8″, 36#, J-55 cemented at ~600′.
Hole Size: 8-1/2″ Drilled to 4970′, MW= ~10 ppg

1. **Run 5-1/2″, 15.5#, J-55, ST&C casing to 4970′-.**
2. **Run guide shoe. Run Differential cementing collar on top of shoe joint.**
3. **Place a flag joint around 4670′.**
4. **Please prepare tally sheets for the casing using dark ink. Last joint in the hole should be on the first sheet. E-mail the tally to Irani Engineering.**
5. **Give Halliburton 16 hours notice. Need two pump trucks.**
6. **Use ? Tongs to run casing. Clean threads. Visually inspect casing. Please bring back up on tongs and elevators. Put a welder on the hook for cutting casing. Apply Bakerseal to the casing on the rack.**
7. **Shaffer has the tubinghead. Notify Shaffer.**
8. **Place centralizers on top of 2nd , 3rd, 4th , 5th, 6th, 7th, 8th, 9th, and 10th. (9 8-1/2″ X 5-1/2″ centralizers)**
9. **Bakerlok shoe and differential collar.**
10. **Have two lines to cementing head. Top and bottom plugs. Flush lines before displacing cement.**
11. **Have two Vacuum trucks full of water on location.**
12. **Cement Mix: Pump 20 Bbl of mud flush ahead of 20 Bbl of 11.0 ppg Tuned Spacer III and cement casing shoe at 4970′ with 820 sacks 50/50 Poz/Premium Plus cement with 3% KCl, 0.75% Halad-322, 0.2% Halad-344 and 0.5% D-Air 3000 (14.5 ppg, 1.20 ft^3/sk, 5.21 gal/sk water) followed with 310 sacks of Class G cement with 2% CaCl2, 0.75% Halad-322, 0.2% Halad-344 and 0.15% SuperCBL (16.0 ppg, 1.14 ft^3/sk, 4.75 gal/sk water). Ramp up cement density for the tail cement from 15.8 ppg to 16.2 ppg. Flush lines. Launch top plug for displacement (total displacement volume is 117 Bbls). Displace with water as fast as possible with two trucks. Bump top plug. Test casing to 2000 psig.**

Note: **The cement volume is calculated based on theoretical volume of cement to surface plus 15% excess. The actual cement volume will be based on the Caliper log plus 10% excess**

Land 5-1/2″ casing, Install tubing head.

1. **Shaffer land 5-1/2″ casing with slip & packing with 30,000# tension. Cut casing. Install 3000# tubing head with secondary seal. Test to 3000 psig.**

2. **Install a blind flange on top of tubing head.**

Rig down and move out the drilling rig.

1. **Make sure the rat hole and mouse hole are covered and red taped during the rig move. Place a fence around the cellar as soon as the rig has moved off.**

Geological Prognosis

Anticipated Formation Tops

Depth	DEPTH
Base of Fresh Water	~150'
Top of Domengine	3920'
Top of Capay	4590′
Top of Mokelumne	4670′
MR2	4910′
Total Depth	4970′

Daily distribution list

1. **Daily drilling report should be e-mailed to PG&E, Worleyparsons, and Irani.**

Contact e-mails and phone numbers

PG&E contact: Mike Medeiros MJML@Pge.com 415-265-9316
Joe Sutton JMSK@pge.com 415-516-9115
Trent Holsey TXHT@pge.com 916-225-4432
Charlie Stinson Cstinson@csenergyventures.com 503-307-6654

Worlyparsons: Mike Tietze Mtietze@jacobsonjames.com 916-872-7293
Mark Ausburn Mausburn@gmail.com 360-320-1029

Irani Engineering:

Saeed Irani: Airani1234@Gmail.com
Work: 916-482-2847
Cell: 916-715-6493
Iraj Irani: Iraj_Irani@Yahoo.com 916-716-3422
Mary Halpin: mhalpin98@yahoo.com
Jayne Buchannan: Jayneb123@yahoo.com

A522: Piacentine 2-27 Well Summary Report 3-11-2013

DISTRICT 6 - WELL RECORDS CHECKLIST

API# 077-20736 **WELL ID:** "PIACENTINE" 2-27

NOTICE FOR: ✓ drill _____ rd _____ rw _____ abd

P-number(s) 612-0396 & _____

RECORDS RECEIVED	**Date Rec'd**	**Records Ok**	**NORD**	**121 entry**	**Remarks**
Well Summary (OG100)	7/18/2913	✓	✓		Entered into CalWims
History (OG103)	7/18/2013	✓	✓		7-18-2013
Directional Survey					
E-logs (2")	7/1/2013	✓	✓		recd elec. 8/12/13
E-logs (5")					
MUD Logs	7/1/2103	✓	✓		recd elec. 8/12/13
CBL	7/1/2013	✓	✓		recd elec. 8/12/13
Other					

_____ **CONFIDENTIAL**

RELEASE DATE _____

STATUS

Producing-gas _____

Idle-gas _____

Abandoned-gas _____

Drilling-Idle _____

Abandoned-dry hole _____

Observation _____

Water Disposal _____

Other ✓

Date Work Completed _____

Remarks Well drilled under a DG permit as a core hole/research well for air storage.

ABANDONMENT

_____ NEEDS Surface Inspection

_____ MAP MADE for Surface Inspection

Surface Inspection COMPLETED by _____

DATE _____

_____ FINAL LETTER

_____ FINAL LETTER NTS

Final Letter Completed by: _____ **Date** _____

RECORDS APPROVED

BY: bgt DATE: 8/12/2013

DIGITAL RECORDS APPROVED

BY: bgt DATE: 10/14/2013

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

WELL SUMMARY REPORT

API NO. **077-20736**

Operator **PG&E**	Well **Piacentine #2-27**				
Field **King Island Gas**	County **San Joaquin**	Sec. **27**	T. **3N**	R. **5E**	B.&M. **M.D..**

Location (Give surface location from property or section corner, street center line)
X= 1734574, Y= 577271

California Coordinates (if known): **Lat: 38.08155572 Long: 121.422162329**

Elevation of ground above sea level
-6'

Was the well directionally drilled? ☐ Yes ☒ No If yes, show coordinates at total depth.

Commenced drilling (date)
3/11/13

Completed drilling (date)
3/29/13

Commenced production/injection (date)

Total depth (1st hole)	(2nd)	(3rd)
4,970' MD		

Present effective depth **4,970'**

Depth measurements taken from top of: ☐ Derrick Floor ☐ Rotary Table ☒ Kelly Bushing

Which is **12'** feet above ground

Production mode: ☒ Flowing ☐ Pumping ☐ Gas lift

Name of production/injection zone(s)

Junk
none

GEOLOGICAL MARKERS	DEPTH

Formation and age at total depth
Mokelumne

Base of fresh water
150'

	Clean Oil (bbl per day)	API Gravity (clean oil)	Percent Water (including emulsion)	Gas (Mcf per day)	Tubing Pressure	Casing Pressure
Initial Production						
Production After 30 days						

CASING AND CEMENTING RECORD (Present Hole)

Size of Casing (API)	Top of Casing	Depth of Shoe	Weight of Casing	Grade and Type of Casing	New (N) or Used (U)	Size of Hole Drilled	Number of Sacks or Cubic Feet of Cement	Depth of Cementing (if through perforations)	Top(s) of Cement in Annulus
9-5/8"	Surface	614'	36.0#	K-55, LT&C	N	12-1/4	280 sx	Shoe	Surface
5-1/2"	Production	4,969'	15.5#	K-55 SMLS, LT&C	N	8-1/2"	1180 sx	Shoe	Surface

PERFORATED CASING (Size, top, bottom, perforated intervals, size and spacing of perforations, and method.)

Logs/surveys run? ☒ Yes ☐ No If yes, list type(s) and depth(s).
Mudlog 4,200'-4,970'; DIL/ Sonic/ GR/ Neutron/ Density/ Caliper log from 4,960'-613'; CS natural gamma from 4,878'- 613'; XRMI from 4960'-3800'; MRIL from 4957'-3800'; RDT-A log at 4970'; Side Wall Core from 4809'-4640'; RCBL NL/GR from 4868'-surface.

In compliance with Sec. 3215, Division 3, of the *Public Resources Code,* the information given herewith is a complete and correct record of the present condition of the well and all work done thereon, so far as can be determined from all available records.

Name **PG&E**	Title **Petroleum Engineer**	
Address **375 North Wiget Ln., #250 Walnut Creek, CA 94598**	City/State **Walnut ~~Creek, CA~~**	Zip Code **94598**
Telephone Number **925-974-4151**	Signature	Date **5/21/13**

OG100 (1/98/GSR/1M)
Printed on recycled paper.

SUBMIT IN DUPLICATE

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

HISTORY OF OIL OR GAS WELL

Operator PG&E Field King Island Gas County San Joaquin
Well Piacentine 2-27 Sec. 27 T. 3N R. 5E M.D. B.&M.
A.P.I. No. 04-077-20736 Name Irani Engineering Title Petroleum Engineer
(Person submitting report) (President, Secretary, or Agent)
Date 4/26/13
(Month, day, year)
Signature
Address 375 North Wiget Ln., #250 Walnut Creek, CA 94598 Telephone Number (925) 974-4151

History must be complete in all detail. Use this form to report all operations during drilling and testing of the well or during redrilling or altering the casing, plugging, or abandonment, with the dates thereof. Include such items as hole size, formation test details, amounts of cement used, top and bottom of plugs, perforation details, sidetracked junk, bailing tests, and initial production data.

Date
2013

3/10 Rigged up Paul Graham Drilling #4. Raised and secured derrick. Made up swivel and Kelly hose. Took on water. Welded on conductor. Unloaded 9 5/8" casing. Built spud mud. Changed out pump liners and heads from 5 1/2" to 6" (Pump #1 and pump #2).

3/11 Serviced rig. Changed out pump liners and heads from 5 1/2" to 6" (pump #1 and pump #2). Picked up and made up BHA. Drilled surface hole from 40' to 200', average ROP 64'/hr. 6:00 am Depth 200'. Drilled surface hole from 200' to 255'. Average ROP 27.5'/hr. Serviced rig. Drilled surface hole from 255' to 610'. Average ROP 47'/hr. Drilled surface hole from 610' to 617' TD. Average ROP 14'/hr. Circulated hole clean. Serviced rig. Wiped hole to bit, 5k spot drag. Circulated and wiped hole to conductor, free of drag. Circulated and POOH to run 9 5/8" casing. Laid down BHA, held safety meeting with crews and casing crews. Rigged up casing crews.
Ran 16 joints of 9 5/8" J-55 STC 36# casing to 614'. Shoe set at 614' with insert float set at 577'. Rigged down casing tongs, rig up cementers.

3/12 Circulated and conditioned mud, held safety meeting with crews. Cemented casing as follows: pumped 2 bbl of water to fill lines, pressure tested to 2000 psi, pumped 10 bbl of water ahead of 37 bbl, 120 sacks, 208 cubic feet of lead cement mixed at 13.10 of ppg. Followed with 25 bbl, 100 sacks, 143 cubic feet mixed at 14.5 ppg of tail cement. Dropped plug and displaced with 44.5 bbl of water. Bumped plug, had full returns throughout job with 15 bbl of cement to surface. Pumped 60 sacks top job with tail cement mixed at 14.5 ppg. Waited on cement. Tore out rig floor. Cut off conductor. Cut and dressed 9 5/8" casing. Landed and welded 11" x 3M well head. Landed and welded up 11" x 3M well head. Held safety meeting with crews, serviced rig (tested well head to 500 psi, good test). Landed mud cross. Nippled up all BOPE. Held safety meeting, picked up and landed Hydril (bag). Held orientation for PG&E with new crew, Mike Tietze J/J&A, Mark J/J&A, Patrick the Biologist. Held safety meeting, nippled up Hydrill. Held safety meeting, function tested BOPE. Hammered up lines, function tested BOP.

3/13 Serviced rig, HSM (held safety meeting), pretested blind rams. HSM (held safety meeting), picked up and made up BHA. HSM, Run in hole to 500'. HSM, Pretested pipe rams and Hydril. Function tested all surface equipment (BOPE) for DOG rep Gary. Tests passed. RIH to 577', tagged insert. Drilled out shoe track (plug, insert, and shoe). Wipers on 4-6 hour intervals. Held safety meeting, serviced rig. Drilled out shoe. Circulated and conditioned mud, changed over spud mud to Cypan mud. Circulated and leveled rig. Drilled 8 1/2" hole from 617' to 1004', average ROP 96'/hr. Circulated for wiper, rigged up wire line for survey. Held safety meeting, rigged up survey tool. Ran survey at 1004'. Serviced rig. Wiped hole to shoe, 10K hole drag. Drilled 8 1/2" hole from 1004' to 1330', average ROP 65'/hr.

3/14 Serviced rig, circulated for wiper. Wiped hole to shoe (free of drag). Drilled from 1330' to 1900'. Average ROP 126'/hr. Drilled from 1900' to 2015', average ROP 115'/hr. Wipers on 6 hour intervals. Circulated and conditioned mud, surveyed at 2015'. RCR = 350 psi at 60 stks. Pump #1 and #2. Wiped hole to shoe, 10K hole drag. HSM, serviced rig. Drilled 8 1/2" hole from 2015' to 2518', average ROP 111'/ hr. HSM, circulated and fix dog nut (cable clamp on drilling line). Serviced rig. Slipped 100' drilling line. Wiped hole to 1847', 10K spot drag. Drilled 8 1/2" hole from 2518' to 2925', average ROP 81'/hr.

3/15 Held safety meeting, serviced rig. Drilled 8 1/2" hole from 2925' to 3021', average ROP 96'/hr. Circulated, surveyed at 3021'. Wiped hole from 3021' to 2350', 10-20K spot drag. Drilled 8 1/2" hole from 3021' to 3225', average ROP 81'/hr. Drilled 8 1/2" hole from 3225' to 3333', average ROP 43'/hr. Wipers on 6 hour intervals. Circulated, HSM, serviced rig.

Fixed Dog Nut, cable clamp on drilling line. Pulled out of hole to shoe. Changed out drilling line. Fixed standpipe valve. HSM, adjusted brakes. Serviced rig. Run in hole. Drilled 8 1/2" hole from 3530' to 3594', average ROP 44'/hr.

3/16 HSM, serviced rig. Drilled 8 1/2" hole from 3530' to 3594', average ROP 44'/hr. Circulated and wiped hole from 3594' to 2992', 10-20K hole drag with little swabbing. Drilled 8 1/2" hole from 3594' to 3800', average ROP 58'/hr. Drilled 8 1/2" hole from 3837' to 3913', average ROP 61'/hr. Wipers on 6 hour intervals. Circulated, HSM, serviced rig. Surveyed at 3913'. Wiped hole to 3204', 20K hole drag with some swabbing. Mud weight at 9.8 ppg. Drilled 8 1/2" hole from 3913' to 4165', average ROP 45'/hr. Held safety meeting. Circulated and serviced rig. Wiped hole to 4165'. Increased mud weight to 10.2 ppg for hole drag (free with no swabbing). Drilled 8 1/2" hole from 4165' to 4417', average ROP 42'/hr.

3/17 Circulated and wiped hole to 3746', free. HSM, Service rig. Drilled 8 1/2" hole from 4417' to 4640', average ROP 55'/hr. Coring Point. Drilled to 4641'. Circulated, HSM. Surveyed, Serviced rig. POOH, coring point. HSM, serviced rig. Laid Down BHA. Made up BHA and core barrel. Made up BHA. RIH with heavy weight drill pipe (HWDP). Placed insert valve in upper kelly. Circulated, RIH to 1831'. Reamed from 1831' to 2075'. RIH to 3200'. Filled pipe. Circulated and conditioned mud. Cored from 4641' to 4650'.

3/18 HSM, serviced rig. Cored from 4650' to 4666'. Dropped 1 1/4" ball to close core barrel, circulated. POOH, slowed to 3-4 minutes per stand. POOH. HSM, serviced rig. POOH. Unloaded and loaded core barrel. Made up bit, made up BHA. Unloaded jars, RIH, made up Jars. Loaded 1" ball in upper Kelly. Replaced Jerk Line on tongs (Code 8). HSM, serviced rig. Run in Hole (RIH), measured pipe on the way in. 4664' pipe and tools, 2' Kelly, 4666' hole depth correction. Circulated and conditioned mud. Cored from 4666' to 4669'.

3/19 HSM, serviced rig. Cored from 4669' to 4685'. Cored from 4685' to 4687'. POOH, laid down core barrel. Received 18.5' out of 21' cored. HSM, serviced rig. Loaded core barrel. Made up core tools. RIH, filled pipe at 2500'. Run in hole to 4687'. Circulated and conditioned mud. Cored from 4687' to 4701', 14' cored.

3/20 HSM, serviced rig. Laid down pup joints and single drill pipe. POOH 3 minutes a stand 4701' to 1500'. 1500' to 500' at 4 minutes a stand, 500' to surface at 10 minutes a stand. Laid down core. Cored 14' and recovered 13.85'. Laid down core, loaded core barrel. RIH, loaded 1 1/4" ball in upper kelly. HSM, serviced rig. RIH to 4701'. Circulated and conditioned mud. Cored from 4701' to 4731'. Cored 30'. Circulated and conditioned mud.

3/21 POOH to 580'. Held safety meeting, serviced rig. POOH, break bit. HSM, laid down core barrel. Cored 30' from 4701' to 4731' and recovered 28.2'. Serviced rig, held safety meeting. Loaded core barrel, made up bit. RIH with BHA. HSM with crews. Broke kelly, loaded 1 1/4" Ball in upper Kelly. RIH, (held blow out drill). HSM, serviced rig. Circulated and conditioned mud. Cored from 4731' to 4761'. Circulated and conditioned mud. POOH.

3/22 POOH. Break bit, HSM, serviced rig. Laid down core barrel. Loaded core barrel, make up bit. RIH with BHA, loaded 1 1/4" ball in upper Kelly. Made up kelly, RIH. Cored 30' from 4731' to 4761'. Recovered 32' of Core. 2 feet from 4729' to 4731'. 30' from 4731' to 4761'. RIH, Filled pipe at 2500' (HSM). Circulated and conditioned mud. Cored from 4761' to 4791', cored 30' and recovered 28.85'. Circulated and conditioned mud. POOH with core barrel. Serviced rig, HSM. POOH, laid down core barrel. Repaired rig (replaced chain on Hydromatic). Made up core barrel. RIH with core barrel, loaded 1 1/4" ball in upper Kelly. Run In Hole.

3/23 Continued to RIH. Circulated and conditioned mud. Cored from 4791' to 4816', 25' cored. POOH. HSM, serviced rig. POOH. Laid down core barrel and tools. TD with Coring Assembly. Cored from 4791' to 4816', 25' Cored. Recovered 27', 2' from previous Core and 25' from this Coring run. Measured new BHA. HSM, serviced rig. Picked up and made up new BHA. RIH to 4815'. Circulate and conditioned mud. Drilled 8 1/2" Hole from 4816' to 4970' TD.

3/24 Continued to drill 8 1/2" Hole from 4816' to 4970' TD. Circulated and conditioned mud. Wiped hole to shoe, free. HSM, serviced rig. Adjusted brakes. RIH. HSM, Serviced rig. Run In Hole. Circulated and conditioned mud. Wiped hole to 3690', free. Circulated and conditioned mud. Wiped hole to 4000', free. Had to wait for Halliburton. Circulated and conditioned mud. HSM, serviced rig, circulated and conditioned mud. Halliburton on site at 20:30. Pulled out of hole for logs. HSM with loggers and crews.
Ran Quad Combo Pack, DIL/ Sonic / GR / Neutron / Density / Caliper Log from 4960' to 613'.
Ran compensated spectral natural gamma logs from 4878'-613'.

3/25 HSM with loggers and with crews.
Ran 2nd set of logs XRMI from 4960' to 3800'. Hole in good shape, no over pulls and both sets of logs went to bottom. Laid down logs, HSM. Run logs (XRMI). HSM, serviced rig .
Ran MRIL log from 4957' to 3800'. Laid down logs. RIH, filled pipe at 2500'. HSM, Serviced rig. Run In Hole. Circulated and conditioned mud, (circulated hole clean). Pulled out of hole (free). Rig up Halliburton for Logs, HSM.
Ran RDT-A log at 4970'.

3/26 HSM, serviced rig.

Ran Side Wall Core logs from 4809'-4640'. HSM, serviced rig. Laid down loggers. RIH to shoe, 600'. Slipped and cut 60' of drilling line. RIH. HSM, serviced rig. RIH to 4970'. Circulated and conditioned mud, rigged up lay down equipment. Wiped hole to 3648', free (wait on cementers). Circulated and conditioned mud. Laid down 4 1/2" drill pipe.

3/27 HSM, Serviced rig. Laid down 4 1/2" drill pipe. HSM with all crews. Rigged up casing crew, **Ran 5 1/2" 15.5 #, J-55 LTC 8 round casing to 4969'.** Shoe set at 4967' with Diff. Collar set at 4723'. HSM, serviced rig. Rigged down casing crew. Made up circulating swedge. Circulated hole clean. 2 hours waiting on Halliburton, only 2 pump trucks on location. HSM with all crews. Cemented casing as follows: Mixed and pumped 20 bbl of mud flush ahead of 20 bbl of 11 ppg Tuned Spacer 111 followed by 870 sacks (1044 cubic feet) at 14.5# 186 bbl of lead cement. Followed with 310 sacks (356.5 cubic feet) at 15.8 ppg ramped up to 16.2 ppg, 64 bbl. Flushed and cleaned lines, dropped top plug and displaced with 112 bbl of H2O, bumped plug at 2000 psi over circulating pressure. Had full returns throughout cement job with 10 bbl of cement to surface. CIP @ 20:13. HSM, Rigged down Halliburton. Landed casing slips with 30K over string weight.

3/28 Nippled down all BOPE. Cut off and dressed casing to fit tubing head. Landed and Nippled up Tubing head. Tested to 3000 psi (Good). Cleaned mud pits. HSM. Release rig at 14:00 hours. Tear out rig for road move. Rig idle, wait on daylight to finish tearing out rig. Loaded out rig, took 8 loads to Morais location. The other loads to yard. Put fence around cellar and plate on rat hold. Wait on daylight to finish bringing in rig.

5/6 Conducted safety meeting, filled out JSA. Rigged up Halliburton to run Radial cement bond NL/GR log. Ran in the hole to 4868.0' and tagged (PB 4920.0').
Ran RCBL, NL/GR logs from 4868.0' to surface. Top of good cement at 612.0'. Poor bonding from 612.0' to surface. Rigged out wireline.

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814-3530
Phone:(916) 322-1110 Fax:(916) 322-1201

No. T **613-0008**

REPORT ON OPERATIONS

Ms Linda Y. H. Cheng
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Sacramento, California
April 01, 2013

Your operations at well **"Piacentine" 2-27**, A.P.I. No. **077-20736**, Sec. **27**, T. **03N**, R. **05E**, **MD** B.&M., **King Island Gas** field, in **San Joaquin** County, were witnessed on **3/11/2013**, by **Gary Ngo**, a representative of the supervisor.

The operations were performed for the purpose of **testing the blowout prevention equipment and installation**.

DECISION: **APPROVED**

DEFICIENCIES NOTED AND CORRECTED: None noted.

GN/jc

Tim Kustic
State Oil and Gas Supervisor

X Michael L. Woods

Michael L. Woods
District Deputy

OG109 (Rev. 10/2011)

API No. 077-20736 DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES T 613-0008

BLOWOUT PREVENTION EQUIPMENT MEMO

Operator Pacific Gas & Electric Co. Well "Piacentine" 2-27 Sec. 27 T. 3N R. 5E
Field King Island Gas County San Joaquin Spud Date 3/11/2013

VISITS:	Date	Engineer	Time		Operator's Rep.	Title
1st	3/13/2013	Gary Ngo	(0600	to 0630)	Ted Coffey	Company Man
2nd			(	to)		

Contractor Rig # Contractor's Rep. & Title Charlie Parker (TP)
Casing record of well: 9-5/8" cem 614'. TD 617' (standing cemented)

OPERATION: Testing (inspecting) the blowout prevention equipment and installation. Critical well? Y ☐ N ☒
DECISION: The blowout prevention equipment and its installation on the 9-5/8 " casing are approved.

Proposed Well Opns: Drill . MACP: psi
Hole size: 12-1/4 " fr. 0 ' to 617 ' , " to ' & " to '

REQUIRED BOPE CLASS:
III B 3M

CASING RECORD OF BOPE ANCHOR STRING					Cement Details	Top of Cement	
Size	Weight(s)	Grade(s)	Shoe at	CP at	Lead: 208 cf	Casing	Annulus
9-5/8	36#	J-55	617'		Tail: 143 cf	614'	Surface
					60 sx top job; 14.5 ppg		

BOP STACK							**TEST DATA**						
API Symb.	Ram Size (in.)	Manufacturer	Model or Type	Vert. Bore Size (in.)	Press. Rtg.	Date Last Overhaul	Gal. to Close	Recov. Time (Min.)	Calc. GPM Output	psi Drop to Close	Secs. to Close	Test Date	Test Press.
A	CSO	Hydril	A	11"	3000		6.32					3/13	800
Rd	4.5"	Shaffer	PIPE	11"	3000		1.75					3/13	1000
Rd	CSO	Shaffer	CSO	11"	3000		8.23					rpt	1200

TOTAL: 16.3

ACTUATING SYSTEM

Accumulator Unit(s) Working Pressure 3000 psi
Total Rated Pump Output gpm Fluid Level
Distance from Well Bore 50 ft. OK

	Accum. Manufacturer	Capacity	Precharge
1	Koomey	60 gal.	1000 psi
2		gal.	psi

	CONTROL STATIONS	Elec.	Hyd.	Pneu.
X	Manifold at accumulator unit	X	X	
X	Remote at Driller's station			X
	Other:			

	EMERG. BACKUP SYSTEM				Press.	Wkg.Fluid
X	N_2 Cylinders	1	L= 55	"	2400	8.39 gal.
	Other:	2	L= 55	"	2400	8.39 gal.
		3	L= 55	"	2400	8.39 gal.
		4	L= 55	"	2400	8.39 gal.
		5	L=	"		gal.
		6	L=	"		gal.
					TOTAL: 33.56	gal.

	AUXILIARY EQUIPMENT	No.	Size (in.)	Rated Press	Connections Weld	Flange	Thread	Test Press.
X	Fill-up Line							
X	Kill Line		2"	3M			X	1000
X	Control Valve(s)	1		3M		X		1000
X	Check Valve(s)	1		3M		X		1000
X	Aux. Pump Cnnct.			3M			X	1000
X	Choke Line		3"	3M			X	1000
X	Control Valve(s)	10		3M		X		1000
X	Pressure Gauge						X	
X	Adjstble Choke(s)	2	2"	3M			X	1000
X	Bleed Line		3"				X	
X	Upper Kelly Cock							1000
---	Lower Kelly Cock		------	------				1000
X	Standpipe Valve							1000
X	Stndpipe Pres. Gau.							
X	Pipe Safety Valve		4.5"	3M				1000
X	Internal Preventer		4.5"	3M				1000

	HOLE FLUID MONITORING EQUIPMENT	Alarm Type Audible	Visual	Class
X	Calibrated Mud Pit	X	X	A
X	Pit Level Indicator	X	X	B
X	Pump Stroke Counter	X	X	
	Pit Level Recorder			
	Flow Sensor			C
	Mud Totalizer			
	Calibrated Trip Tank			
	Other:			

Hole Fluid Type	Weight	Storage Pits (Type & Size)
Mud	10.0	350 bbls

REMARKS AND DEFICIENCIES:

OGD9 (9/06)


Piacentine
2-27
King Is
W Eight Mile Rd

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES
801 K Street, MS 20-22 Sacramento, CA 95814 - 3530

PERMIT TO CONDUCT WELL OPERATIONS

No. P 612-0396

	Old	New
FIELD CODE	--	351
AREA CODE	--	00
POOL CODE	--	10

Sacramento, California
December 11, 2012

Ms Linda Y. H. Cheng, Agent
Pacific Gas & Electric Co. (P0300)
77 Beale Street, 24th Flr., MC B24W
San Francisco, CA 94105

Your proposal to **Drill** well **"Piacentine" 2-27**, A.P.I. No. **077-20736**, Section **27**, T. **03N**, R. **05E**, **MD** B. & M., **King Island Gas** field, **--** area, **Mokelumne River** pool, **San Joaquin** County, dated **12/3/2012**, received **12/7/2012** has been examined in conjunction with records filed in this office.

THE PROPOSAL IS APPROVED PROVIDED:

1. Blowout prevention equipment, as defined by this Division's publication No. M07, shall be installed and maintained in operating condition and meet the following minimum requirements:
    a. Class **III B 3M** on the **9 5/8"** casing.
    b. A **3M lubricator** for **wire line** operations.
2. The **9 5/8"**" casing is cemented with sufficient cement to fill behind the casing to at least 100' above the base of freshwater zone.
3. Hole fluid of a quality and in sufficient quantity to control all subsurface conditions in order to prevent blowouts shall be used.
4. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.
5. No program changes are made without prior Division approval.
6. The Division will monitor the monthly production of this well for a period of six months and if anomalous water production is indicated, remedial action will be ordered.

THIS DIVISION SHALL BE NOTIFIED TO:

1. Witness a pressure test of the **9 5/8"** casing.
2. Witness a test of the installed blowout prevention equipment prior to drilling out the shoe of the **9 5/8""** casing. Prior to notifying the Division engineer to witness the test, the blind rams must be tested. Information on the blind rams test must be entered on the tour sheet along with the signature of the person in charge.

NOTE:

1. The base of the freshwater zone should be encountered at **150 +/-'**±. A final determination must be made from the well logs after the well is drilled.

Blanket Bond

Tim Kustic, State Oil and Gas Supervisor

Engineer Baxter Tackett
Office (916) 322-1110

By Original signed by
Michael L. Woods, *District Deputy*

BT/sh

A copy of this permit and the proposal must be posted at the well site prior to commencing operations. Records for work done under this permit are due within 60 days after the work has been completed or the operations have been suspended. Issuance of this permit does not affect the Operator's responsibility to comply with other applicable state, federal, and local laws, regulations, and ordinances.

OIL, GAS & GEOTHERMAL

NATURAL RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

2012 Dec 7 9:29

FOR DIVISION USE ONLY			
	Forms		
Bond	OGD114	OGD121	

NOTICE OF INTENTION TO DRILL NEW WELL

Detailed Instructions can be found at: www.conservation.ca.gov/dog/

In compliance with Section 3203, Division 3, Public Resources Code, notice is hereby given that it is our intention to drill well Piacentine 2-27, well type Core Well, API No. ________ (Assigned by Division),

Sec. 27, T.3N, R. 5E, M.D. B.&M., King Island Field, San Joaquin County.

Legal description of mineral-right lease, consisting of 204 acres (attach map or plat to scale), is as follows:

Do mineral and surface leases coincide? Yes☒ No☐. If answer is no, attach legal description of both surface and mineral leases, and map or plat to scale.

Location of well 2007 feet South (Direction) along section ☒ / property ☐ (Check one) line and 846 feet East (Direction)

at right angles to said line from the Northwest corner of section ☒ / property ☐ (Check one) 27 and

Lat./Long. in decimal degrees, to six decimal places, NAD 83 format: Latitude: 38.081985 Longitude: -121.422202

If well is to be directionally drilled, show proposed coordinates (from surface location) and true vertical depth at total depth:

________ feet ________ (Direction) and ________ feet ________ (Direction). Estimated true vertical depth ________. Elevation of ground above sea level -5.0 feet. All depth measurements taken from top of KB (Derrick Floor, Rotary Table, or Kelly Bushing) that is 12 feet above ground.

Is this a critical well as defined in the California Code of Regulations, Title 14, Section 1720(a) (see next page)? Yes☐ No☒

Is a California Environmental Quality Act (CEQA) document required by a local agency? Yes☐ No☒ If yes, see next page.

PROPOSED CASING PROGRAM

SIZE OF CASING (Inches API)	WEIGHT	GRADE AND TYPE	TOP	BOTTOM	CEMENTING DEPTHS	FORMATION PRESSURE (Estimated Maximum)	CALCULATED FILL BEHIND CASING (Linear Feet)
16"	109	K-55	0	60'	60'		
9 5/8"	36	J-55	0	600	600'		

(Attach a complete drilling program including wellbore schematics in addition to the above casing program.)

Estimated depth of base of fresh water: 300' Anticipated geological markers: Capay (4598') Mokelume (4695') MR2 (4917') (Name, depth)

Intended zone(s) of completion: ________ (Name, depth and expected pressure) Estimated total depth: 5000'

The Division must be notified immediately of changes to the proposed operations. Failure to provide a true and accurate representation of the well and proposed operations may cause rescission of the permit.

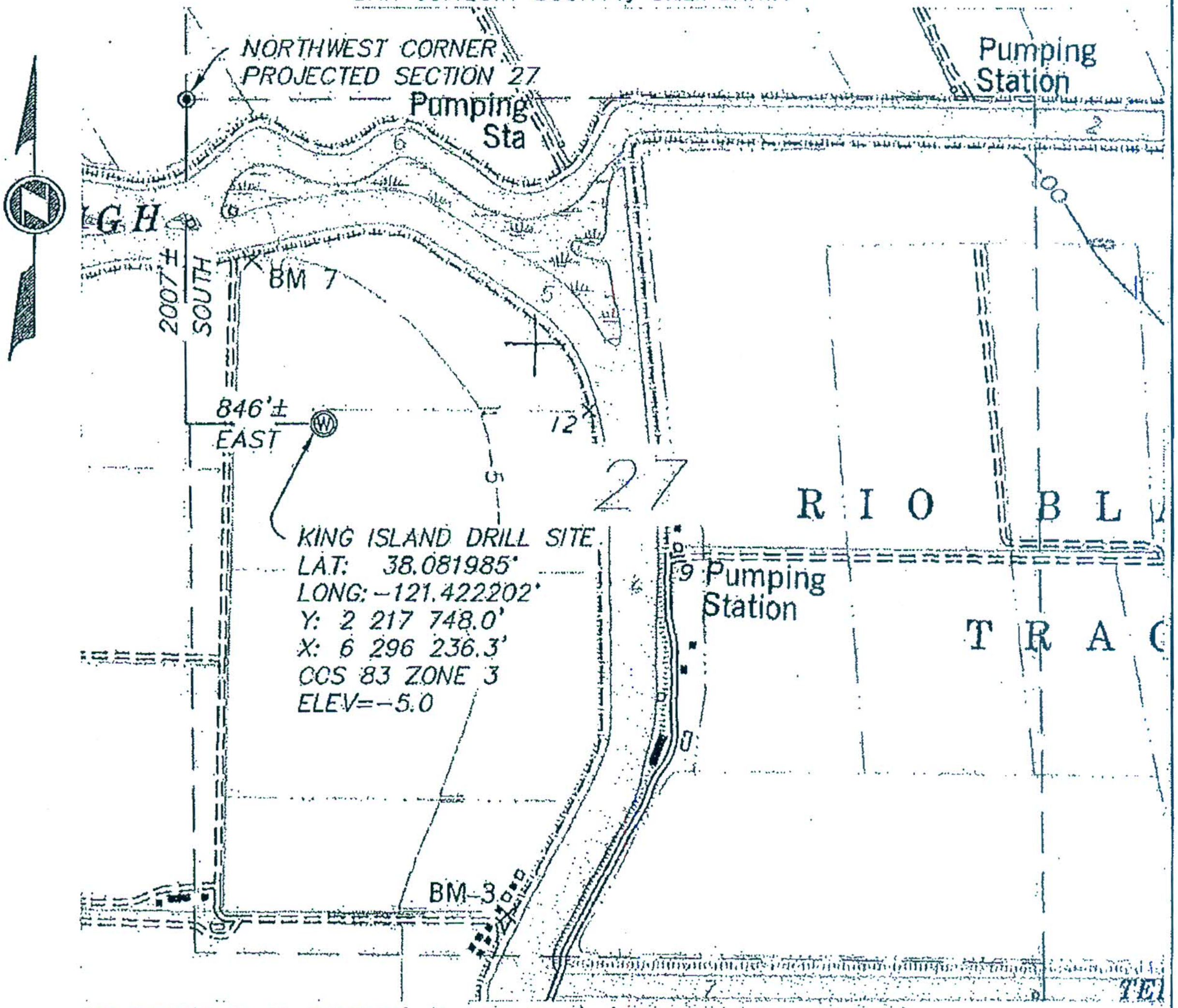
Name of Operator PG&E			
Address 6121 Bollinger Canyon Rd.		City/State San Ramon CA	Zip Code 94583
Name of Person Filing Notice Joe Chan	Telephone Number: 925-244-3207	Signature	Date 12/03/2012
Individual to contact for technical questions: Joe Chan	Telephone Number: 925-244-3207	E-Mail Address: jcc4@pge.com	

This notice and an indemnity or cash bond shall be filed, and approval given, before drilling begins. If operations have not commenced within one year of the Division's receipt of the notice, this notice will be considered cancelled.

OG105 (08/09)

SKETCH OF WELL LOCATION

WELL LOCATED 2007'± FT. SOUTH; 846'± FT. EAST FROM
THE NORTHWEST CORNER OF PROJECTED SECTION 27,
T. 3 N., R. 5 E, M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA



KING ISLAND DRILL SITE
LAT: 38.081985°
LONG: -121.422202°
Y: 2 217 748.0'
X: 6 296 236.3'
CCS 83 ZONE 3
ELEV=-5.0

CCS 27 ZONE 3, Y: 577,344.2' X: 1,734,868.8' (CONVERTED WITH CORPSCON)

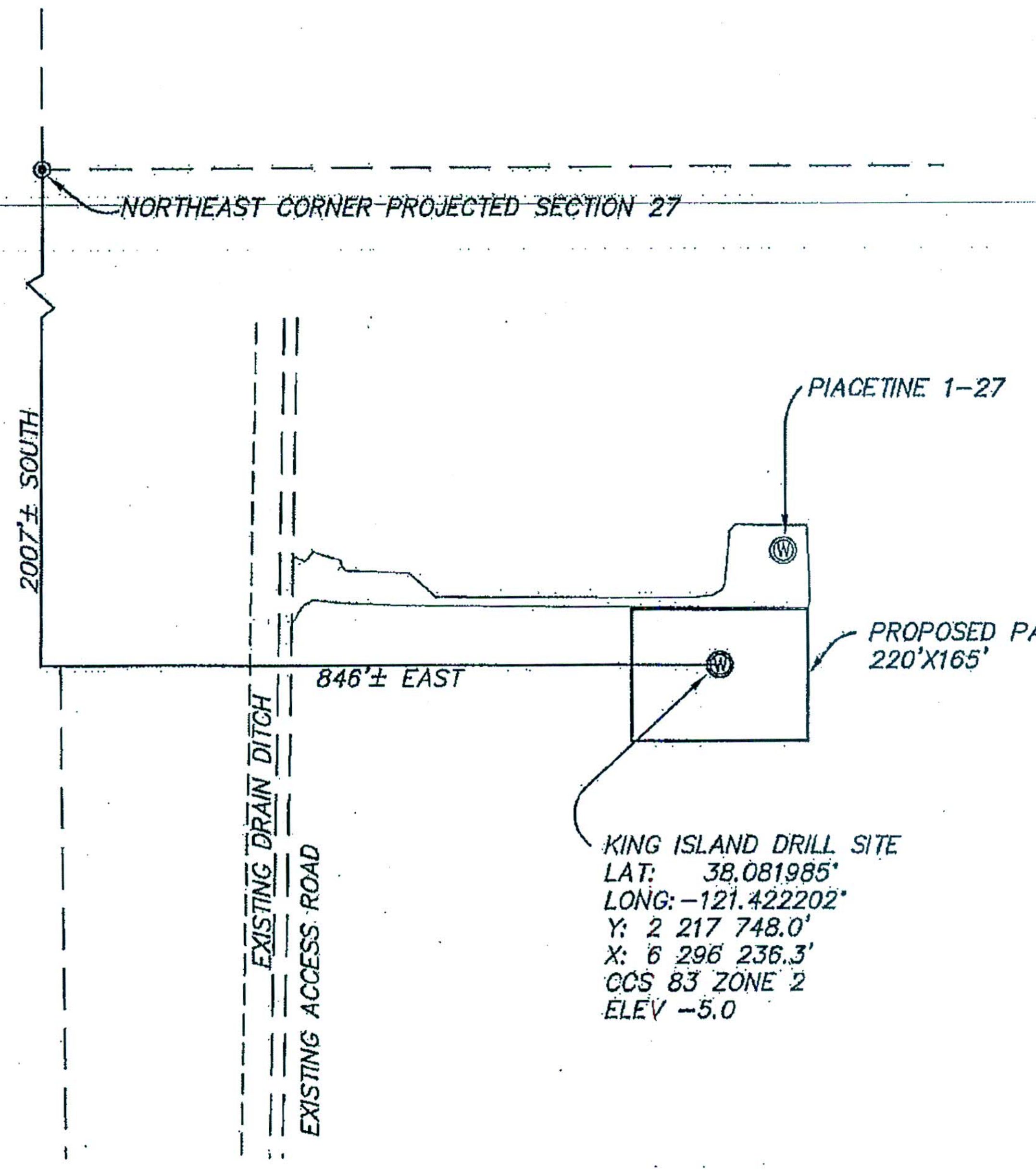
LICENSED LAND SURVEYOR
CHRISTOPHER W. LERCH
10-22-12
L.S. 7906
STATE OF CALIFORNIA

EXHIBIT-"A"
KING ISLAND
DRILL SITE
WELL NAME

LM LAUGENOUR AND MEIKLE
CIVIL ENGINEERING · LAND SURVEYING · PLANNING
608 COURT STREET, WOODLAND, CALIFORNIA 95695 ·PHONE: (530) 662-1755
P.O. BOX 828, WOODLAND, CALIFORNIA 95776 ·FAX: (530) 662-4602

SCALE: 1" = 1000" DATE: 10/22/12

JOB No. 3462-2



CCS 27 ZONE 3, Y: 577,344.2' X: 1,734,868.8' (CONVERTED WITH CORPSCON)

LICENSED LAND SURVEYOR
CHRISTOPHER W. LERCH
11-13-12
L.S. 7906
STATE OF CALIFORNIA

SCALE 1"= 200'

EXHIBIT-"A"
KING ISLAND DRILL SITE

PROJECTED SECTION 27,
T.3 N., R.5 E., M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA
SHEET 1 OF 1

#3462-2

LM LAUGENOUR AND MEIKLE
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P.O. BOX 828, WOODLAND, CALIFORNIA 95776 · FAX: (530) 662-4602

revised
11-13-12

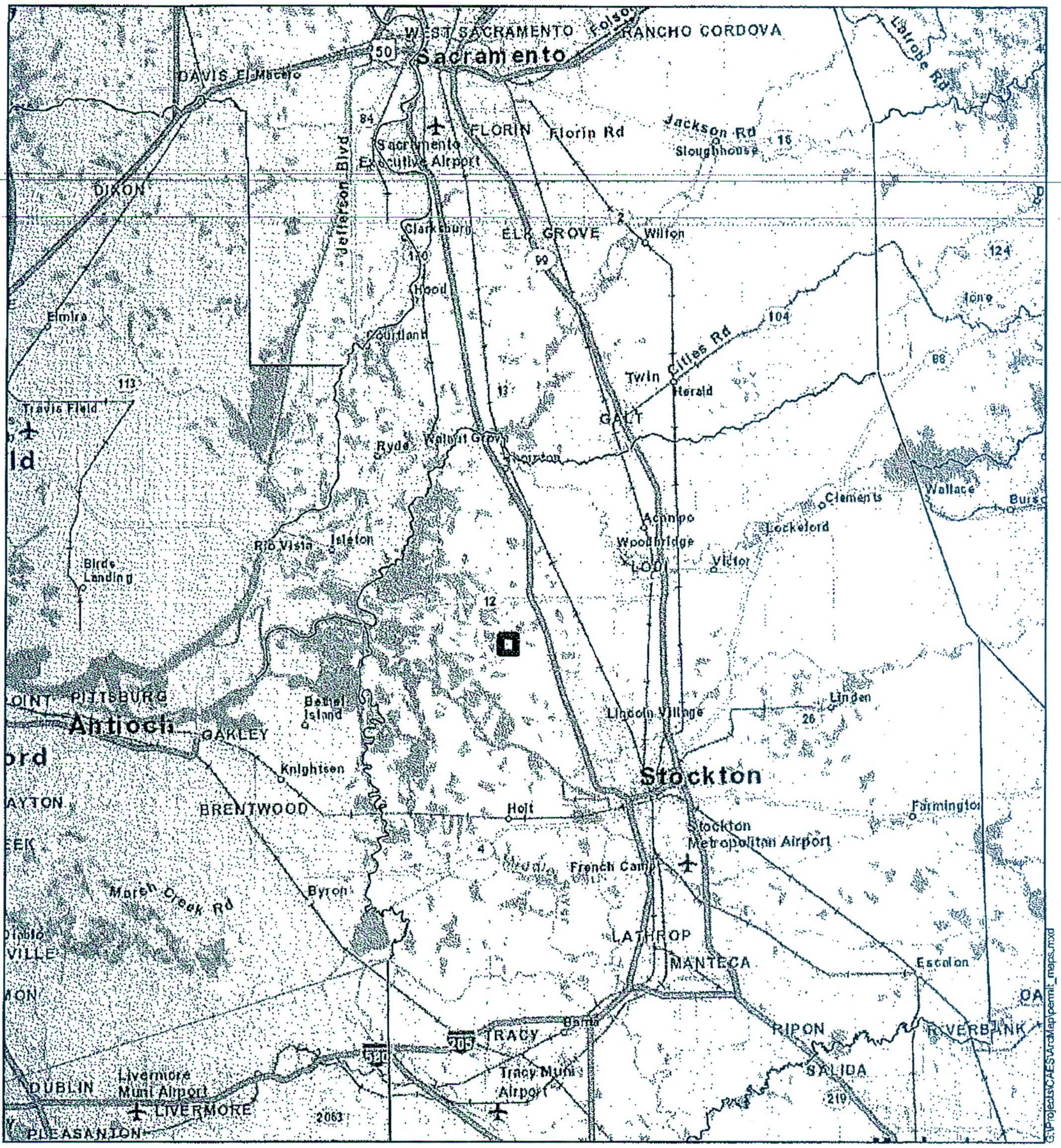


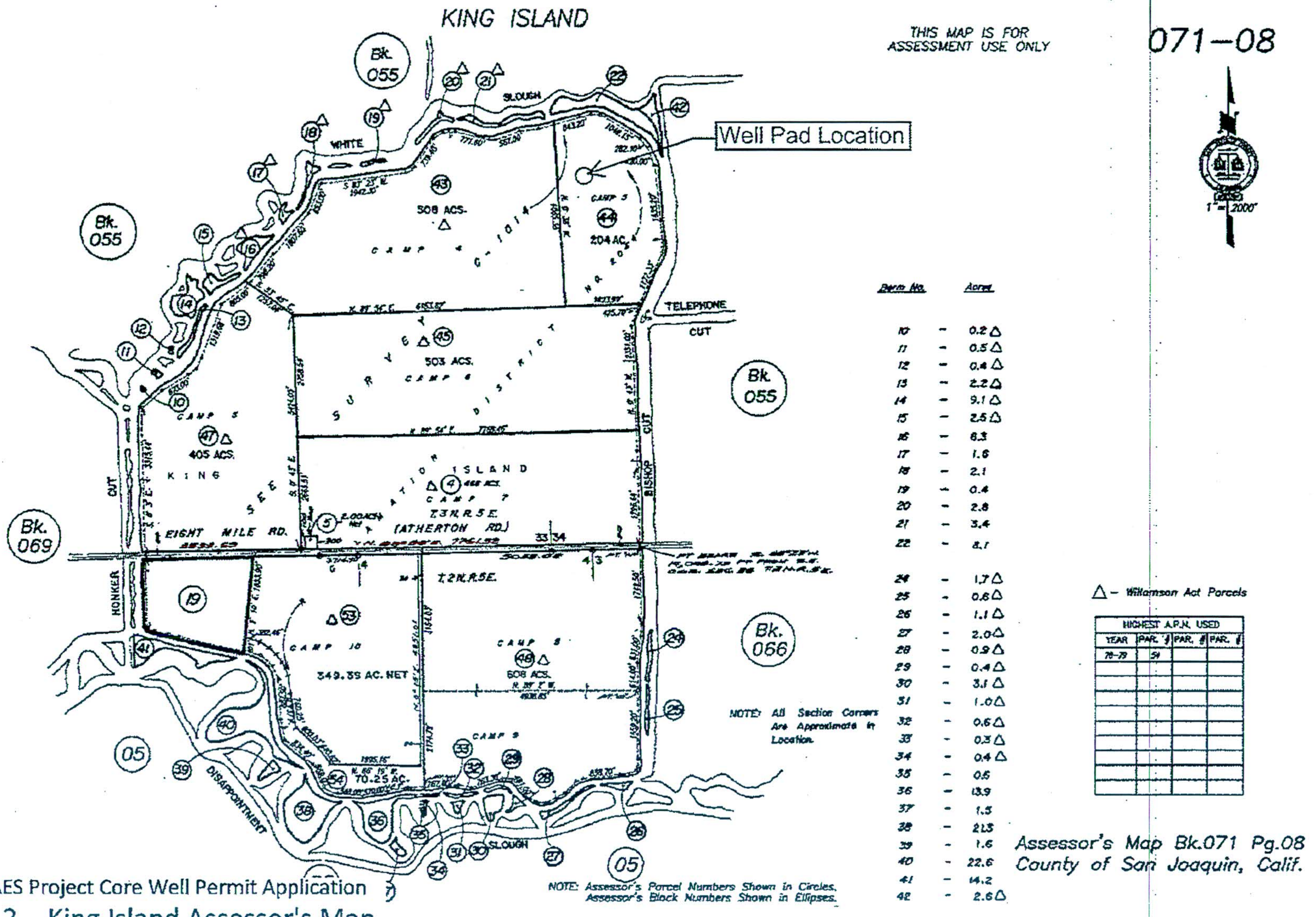
Figure 1 - King Island Vicinity Map

☐ King Island Proposed Core Well Pad

PG&E CAES Project Core Well Permit Application

0 5 10 15 Miles

11/27/2012



Berm No.		Acres
10	-	0.2 △
11	-	0.5 △
12	-	0.4 △
13	-	2.2 △
14	-	9.1 △
15	-	2.5 △
16	-	8.3
17	-	1.6
18	-	2.1
19	-	0.4
20	-	2.8
21	-	3.4
22	-	8.1
24	-	1.7 △
25	-	0.6 △
26	-	1.1 △
27	-	2.0 △
28	-	0.9 △
29	-	0.4 △
30	-	3.1 △
31	-	1.0 △
32	-	0.6 △
33	-	0.3 △
34	-	0.4 △
35	-	0.5
36	-	13.9
37	-	1.5
38	-	21.3
39	-	1.6
40	-	22.6
41	-	14.2
42	-	2.6 △

△ - Williamson Act Parcels

HIGHEST A.P.N. USED			
YEAR	PAR. #	PAR. #	PAR. #
78-79	54		

Assessor's Map Bk.071 Pg.08
County of San Joaquin, Calif.

PG&E CAES Project Core Well Permit Application

Figure 2 - King Island Assessor's Map

IRANI ENGINEERING
PETROLEUM ENGINEER
2625 FAIR OAKS BLVD., SUITE 10
SACRAMENTO, CALIFORNIA 95864
916-482-2847
FAX 916-482-7514

PG&E
King Island Core Well

Location: 2055′ South and 285′ West from Northeast corner of
Section 28, T 3N, R 5E, MDB&M, San Joaquin County., California.
Elevation: -5′ ground. +7′ KB (assume 12' KB)

Take all measurements from KB Which is 12'above ground.
Keep hole full at all times.

Drilling and Abandonment Program (Drill Pipe: 5″, 19.5#, 4-1/2″ IF thread)

Building Location, Set Conductor, Rat Hole, Mouse Hole

1. Build location. Pilings might be required to stabilize the rig.

2. 6'X6′ diameter cellar will be constructed. Rat hole and mouse hole for the rig will be dug by a water well driller.

3. 16" conductor will be cemented at 60' using a water well driller.

Rig Move, Drill 12-1/4″ hole to ~600′+, Cement 9-5/8″ casing, Install BOE.

1. Move in drilling rig. Rig up. Install riser and flow line on 16" conductor. Install mud cleaners and centrifuge. Have a full water tank before spud. In addition have a frac tank on location and fill it with water.

2. Run 12-1/4″ rental bit, 3-16/32" jets, 2-DC,s, HW and drill to 600′. Use both pumps with 6" liners.

3. Do not log surface hole.

4. Cement 9-5/8″, 36″, J-55, ST&C casing at ~600′ with 120 sacks of Class G cement premixed 6% gel and 3% CaCl2 followed with 100 Class G cement premixed 3% CaCl2. Displace cement with freshwater. Tack weld and Bakerlok bottom 4 collars, weld shoe solid. Run float shoe and insert 40' above shoe. Run a centralizer 15' above shoe. Use top rubber plug only and plug holding head. Bump plug on insert. Pressure test to 500 psig. Perform 60 sacks top job using cement premixed 3% CaCl2.
   Note: The cement volume is calculated at 70% excess.

5. After 2 hours WOC, land casing. Weld casing head (have welders on the hook). Test weld 500 psig. Install Series 900 dual hydraulic control gate and Hydril GK. Test according to Standing Orders. Notify DOG to witness. Pressure test casing to 1000 psig.

Change hole to Cypan mud System. Drill 8-1/2″ hole to 4640′.

1. Drill out the shoe of 9-5/8″ casing. Change hole to Cypan mud system with low PH. Use the following BHA: 8-1/2″ new long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 5" drill pipe. Drill to 4640′. Use both pumps with 6" liners. Have an additional mill tooth bit on location.
2. Wipe hole every 4 to 8 hours. Wipe hole to shoe on the first three wiper runs after that 10 stands will suffice. Wipe hole to shoe every 50 to 60 hours.
3. Install mud loggers at 4200'.
4. Have 9.8 ppg mud weight by 3000'.
5. Mud loggers report any unusual gas readings to the company man immediately.
6. Check for flow before coming out of hole.
7. Drift survey every 1000'.
8. Keep pipe moving at all times..

Core well from 4640′ to 4859′.

1. Pick up 8-1/2″X3″ core bit with 6-1/2″X3″X30′ barrel Continuous Wireline Coring System, 4 drill collars with stabilizers, 5″ drill pipe. Cut 3″ core from 4640′ to 4859′. Have Core Lab on location to collect cores per core handling instruction attached to this program. Pull out. Lay down core BHA.

Drill 8-1/2″ hole to TD at 5000′.

1. Use the following BHA: 8-1/2″ RR long tooth mill tooth bit with 4-13/32" jets (check hydraulics), bit sub, 2-6" DC, 8-1/2″ stab, Bumper sub, 30 Hw's, 5" drill pipe. Drill to Total Depth of 5000′. Use both pumps with 6" liners.

Condition Hole before Logging.

1. Wipe hole to shoe. Circulate and condition mud. Pull out.

Logging Program

1. Run DIL/Sonic/GR/Neutron/Density from 600′ to TD. Run EMI from 3800′ to 5000′. If ordered take formation water samples using RFT tool.

Mud logging Program

1. Install mud loggers at 4200'. Circulate as necessary for evaluation. Open hole tests will not be run. Take one set W&D samples every 30'. E-mail daily log copies to PG&E, Worleyparsons, and Irani. Watch pit level monitor closely at all times. Keep 3 spliced log copies in trailer.

Mud Program.

Cypan mud system with low PH from 600' to TD.

Depth	Weight	Viscosity	Water Loss
0'- 600'	Spud mud	65 sec.	NC
600'-3000'	9.0-9.8 ppg.	35-45 sec.	6cc/30 min
3000'- TD	9.8-10.0 ppg.	35-45 sec.	6cc/30 min

Have sufficient mud material on location to raise mud weight .66 ppg. Adjust mud weight to maintain mud log base line below 30 units and to stabilize shale.

Abandonment Program

TD ~5000' MD, BFW at ~400'.
Surface Casing: 9-5/8" 36" set at ~600'
Hole size: 8-1/2" hole at 5000', MW=10 ppg
Note: This is a straight hole.

1. Run open-ended drill pipe to 4850'.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% NaCl at 4850'. Pull up to 4000'. Wait on cement for 6 hours. Locate top Of cement plug which must be above 4595'. Notify DOG to witness.
2. Pull up drill pipe to 700'.
   Equalize 180 sacks (500 lineal feet) of cement premixed 3% CaCl2 at 700'. Pull up to surface. Wait on cement for 6 hours. Locate top Of cement plug which must be above 300'. Notify DOG to witness.
3. Cut casing 5' below ground. Plug casing with 25 lineal feet of cement. Weld steel plate on stub. Notify DOG to witness.

Rig down and move out the drilling rig.

1. Make sure the rat hole and mouse hole are covered and red taped during the rig move. Place a fence around the cellar as soon as the rig has moved off.

Geological Prognosis

Anticipated Formation Tops

Depth	DEPTH
Base of USDW	~400'
Top of Domengine	3925'
Top of Capay	4598'
Top of Mokelumne	4695'
MR2	4917'
Total Depth	5000'

D6

SAN JOAQUIN COUNTY
COMMUNITY DEVELOPMENT DEPARTMENT

1810 E. HAZELTON AVE., STOCKTON, CA 95205-6232
PHONE: 209/468-3121 FAX: 209/468-3163

RECEIVED
JAN 07 2013
BY: DOC/OGER

January 3, 2013

State of California
Dept Conservation - Administration
801 K Street, #Flr-24
Sacramento, CA 95814-3528

Gentlemen:

RE: IMPROVEMENT PLAN NUMBER: PA-1200261 (Improvement Plan)

On January 3, 2013, the San Joaquin County Community Development Department approved an Application No. PA-1200261, to drill a Geological Core Sample Well (piacentine 2-27) to a depth of 4,000-5,000 feet. The sample will be analyzed to determine the geological suitability for a future project to store compressed gas as an energy surplus during low electric demand periods, on property located at Lat: 38.081985 / Long: 121.422202, well located 2,007 feet south, 846 feet east from the northeast corner of projected section 27, T. 3N. R. 5E., M.D.B. & M.,, San Joaquin County, on a private road, on the north side of Eight Mile Road and Bishop Cut, on King Island, west of Stockton.

The property is owned by Ashley Lane LP and the applicant is Environmental Planning.

Improvement plans are processed as ministerial projects by San Joaquin County.

If you have any questions, please do not hesitate to contact this office.

Sincerely,

CHUCK FARANO
COUNTER MANAGER

CF:vb
Attachments: Conditions of Approval & Map

cc: Environmental Health Division
Bureau of Fire Prevention
Ashley Lane LP
Department of Public Works
Environmental Planning, Ernie Ralston

IMPROVEMENT PLAN CONDITIONS
FOR
GAS AND OIL

APPLICATION NO: PA-1200261 (Improvement Plan)
DATE APPROVED: January 3, 2013

1. There must be proof that the applicant has posted the surety bond as required by the State of California Division of Oil and Gas.

2. An application for a drilling permit for test holes shall be submitted to the San Joaquin Environmental Health Division before drilling commences. The application shall contain a map showing test hole location, depth, and method of test hole destruction.

3. The site plan shall show all structures, equipment, sumps, and access roads.

4. The project shall conform to the approved site plan.

5. The permit shall become void should the use of the property become a nuisance as defined by Section 9-3113 of the Planning Title.

6. Unattended sumps shall be enclosed by a six-foot (6') high chain link fence.

7. Secure encroachment permits for any access points to the public right-of-way from the Department of Public Works.

8. The permit shall expire eighteen (18) months after the date of approval unless all permits necessary to complete the project have been secured and actual drilling shall be diligently pursued to completion, or the permit shall be come void. Any cessation for one-hundred-eighty (180) days or more shall void this permit.

9. This permit may be transferred provided:

   a. The transferee provides the Planning Division with proof of a surety bond, as required by the California Division of Oil and Gas, two weeks prior to the transfer.

   b. The transferee complies with all conditions of the approved permit.

10. Provide sanitary facilities for all employees, as required by the California Occupational Safety and Health Administration.

11. Provide a potable water supply approved by the San Joaquin County Environmental Health Services for all employees.

12. All unused or abandoned holes shall be filled with bentonite or other approved grout material as specified in San Joaquin County Ordinance 1862, and the surface is to be left in its original condition.

13. All gas or oil drilling operations shall be performed in accordance with the rules and regulations set forth by the California Division of Oil and Gas.

14. Adequate fire fighting equipment shall be maintained on the premises in conformity with all State and local regulations.

15. Mud and wastes from the drilling and production shall be disposed of at a site approved by the San Joaquin County Environmental Health Division.

16. Any derricks shall be removed within ninety (90) days of completion or abandonment of the well unless a greater time is approved by the Planning Director in writing, based on a showing of good cause.

17. The surety bond shall remain in force until drilling is completed and the site is restored. On completion or abandonment of the well, all sumps shall be filled to natural grade and site restored to its original condition.

18. Secure a permit from the San Joaquin County Bureau of Fire Prevention before drilling commences.

APPLICATION – IMPROVEMENT PLAN
GAS & OIL WELL

SAN JOAQUIN COUNTY COMMUNITY DEVELOPMENT DEPARTMENT
FILE NUMBER IP - ____________

TO BE COMPLETED BY THE APPLICANT PRIOR TO FILING THE APPLICATION

Owner Information	**Applicant Information**
Name: Ashley Lane, LP	Name: Ernie Ralston, PG&E Environmental Permitting
Address: 8601 West Eight Mile Rd. Stockton, CA 95219	Address: PO Box 770000 – N10A San Francisco, CA 94177
Phone:	Phone: 415-973-3215

PROJECT DESCRIPTION

Proposal

Description of the proposed project:

The objective of the project is to collect a 4-inch diameter geological core sample from the subsurface natural gas formation at depth approximately 4,000-5,000 feet. The core rock would be analyzed to determine the geologic suitability of the subsurface formation for compressed air storage. Compressed air energy storage involves utilizing appropriate geological formations (e.g., depleted natural gas reservoirs) to store surplus energy in the form of compressed air during periods of low electric demand. This stored energy can then be utilized during periods of higher electric demand to augment gas-fired electrical generators, improving the efficiency of energy distribution through the power grid.

No new road construction is necessary for project construction. Improvements to the existing dirt access roads will be limited to light graveling if determined to be necessary for work to occur during the wet season. The well pad expansion area will occupy an approximately 0.84-acre area (165 x 220 feet) that abuts the existing well pad and access road. Up to 7 rows of walnut trees (approximately 4 inches diameter at breast height) and intercropped safflower will be cleared in order to accommodate the well pad expansion. After clearing the vegetation, approximately 1 foot of crushed rock will be placed within the cleared area and compacted with a roller. If necessary, geotextile fabric will be placed as an underlayment for the gravel fill.

After the well pad expansion area has been established, well drilling equipment will be moved onto the pad. The primary equipment includes the drill rig, mud and water tanks and pumps, shaker tanks, electric generators, diesel fuel tanks, and drill pipe racks. Geologic sampling will consist of drilling to a depth of approximately 4,000-5,000 feet and extracting a geologic core sample of the cap rock and porous rock formation. The drilling crew, plus engineers, temporary workers and site visitors, will consist of an average of approximately 12 workers per shift, with three shifts per day. A maximum of 20 workers may be present during various operations. In addition to worker vehicles, service and delivery vehicles will access the site during the drilling phase.

Once the core sample is obtained, the well hole may be plugged and abandoned per California Division of Oil, Gas and Geothermal Resources (DOGGR) standards or retained for potential future use as a monitoring well should the project proceed. The drilling equipment will be dismantled and demobilized from the site. Construction equipment similar to that used during well pad development will be used to remove the pad materials and return the site to near pre-project conditions. All removed material will be disposed of at suitable landfills or recycled consistent with county grading or other permit requirements. However, the property owner may elect to retain the pad for farm equipment staging and storage.

Well pad construction and improvements to access roads will occur over a two to three-week period commencing as early as January 2013. Drilling activities will occur virtually continuously for up to approximately six weeks. If elected to remove the well pad, restoration of the site will take up to two weeks.

APPLICATION – IMPROVEMENT PLAN
GAS & OIL WELL

SAN JOAQUIN COUNTY COMMUNITY DEVELOPMENT DEPARTMENT
FILE NUMBER IP - ____________________

Employees/Customers per Work Shift

Shift Hours	Days of the week	Employees (Number)	Customers per Shift	Vehicle Trips per Shift
3x8	7	12	0	20

Materials/Equipment Used

Describe equipment used in the project (include number of automobiles and trucks)

Standard gas well drilling rig and support equipment

Describe materials produced, stored or used (all hazardous materials should be identified)

Drilling mud and additives, diesel fuel and lubricants.

PROPERTY AND VICINITY DESCRIPTION

Property Information

Assessor's Parcel Number(s)	Property Size	Number of Parcels	Project Size	Williamson Act Contract
071-080-44	204 ac	1	0.84 acre	Yes

Property Address: 8601 West Eight Mile Road

Existing Land Uses

On-Site Uses (Include ag crops) Young walnut orchard with safflower intercropped.

Uses to the North: Row Crop

Uses to the East: Row Crop

Uses to the South: Row Crop

Uses to the West: Row Crop

BUILDINGS AND STRUCTURES

(This information may be shown on the Improvement Plan)

Structure Number*	Proposed Use**	Ground Floor Area	Highest Floor	Overall Height (in feet)
No structures proposed				

SITE IMPROVEMENTS AND SERVICES

Water

Public Water Proposed ☐ Existing ☐	Service Provider	Annex-Formation Required	Distance to Public Water (Ft)
	N/A – Water trucked to site		

Private Water ☐ Existing Well ☐ New Well ☐ Well Replacement ☐

Sewage Disposal

Public Sewage Disposal Proposed ☐ Existing ☐	Service Provider	Annex-Formation Required	Distance to Public Sewer Facility
	N/A – Chemical toilets provided		

On-site Sewage Disposal ☐ Existing Septic System ☐ New Septic System ☐ Other ☐

APPLICATION – IMPROVEMENT PLAN
GAS & OIL WELL

SAN JOAQUIN COUNTY COMMUNITY DEVELOPMENT DEPARTMENT
FILE NUMBER IP - ___________________

Storm Drainage				
Public Storm Drainage Proposed ☐ Existing ☐	Service Provide (if Public)	Annex-Formation Required	Terminal Drainage to:	Detention-Retention Pond
	N/A			
Private Storm Drainage ☐	On-site Retention Pond(s) ☐	Natural Drainage/No Change ☐	Other ☐	

Electricity		**Telephone Service**	
Service Provider	Distance to Service	Service Provider	Distance to Service
N/A		N/A	

School Service		**Fire Protection Service**	
Service Provider	Distance to Elem School	Service Provider	Distance to Fire Station
Lodi Unified	N/A	Woodbridge	9 miles

Existing Roads				
Road/Street Name	R.O.W. Width	Pavement Width	Curb/Gutter	Sidewalks
Nearest Public Road - West Eight Mile	40 feet	24 feet	Yes ☐ No ☒	Yes ☐ No ☒
			Yes ☐ No ☐	Yes ☐ No ☐

AUTHORIZATION SIGNATURES

ONLY THE OWNER OF THE PROPERTY OR AN AUTHORIZED AGENE MAY FILE AND APPLICATION

I, the Owner/Agent agree, to defend, indemnify, and hold harmless the County and its agents, officers and employees from any claim, action or proceeding against the County arising from the Owner/Agent's project.

I further certify, under penalty of perjury that I am (check one):

☐ Legal property owner (owner includes partner, trustee, trustor, or corporate officer) of the property(s) involved in this application.

☒ Legal agent (attach proof of owner's consent to the application of the property's involved in this application and have been authorized to file on their behalf, and that the foregoing application statements are true and correct.

Print Name: Ernie Ralston, PG&E Signature: ____________ Date: 12-6-12

Print Name: ____________ Signature: ____________ Date: ________

Print Name: ____________ Signature: ____________ Date: ________

COUNTY OF SAN JOAQUIN
OFFICE OF EMERGENCY SERVICES
2101 E. Earhart Avenue, Suite 300
Stockton, CA 95206
Telephone (209) 953-6200
FAX (209) 953-6268

RONALD E. BALDWIN
DIRECTOR OF
EMERGENCY OPERATIONS

HAZARDOUS MATERIALS DISCLOSURE SURVEY

Please read the information on the reverse side before completing this survey form. A separate survey for each business name and/or address in San Joaquin County is required.

Business Name: Pacific Gas & Electric Co. – King Island CAES Core Well Project

Business Owner(s) Name: Ernie Ralston, Energy Supply Permitting Telephone: 415-973-3215

Business Address: 8601 West Eight Mile Rd, Stockton, CA 95219 (Drill Pad Location: APN 071-080-44)

Mailing Address (if different from above): PO Box 770000, N10A, San Francisco, CA 94177

Nature of Business: Gas & Electric Utility Fire District: Woodbridge

Q1. ☐Yes ☑No Does your business handle a hazardous material in any quantity at any one time in the year? See the definition of hazardous material on the back of this form. If your answer is "no", go to Question 4.

Q2. ☐Yes ☐No Does your business handle a hazardous material, or a mixture containing a hazardous material in a quantity equal to or greater than 55 gallons, 500 pounds, or 200 cubic feet at any one time in a year?

If "Yes", how long have you handled these materials at your business? ____________

If "Yes", check any of the following conditions that apply to your business.

☐A. The hazardous materials handled by this business are contained solely in a consumer product, packaged for direct distribution to, and use by, the general public.

☐B. This business is a health care facility (doctor, dentist, veterinary, etc.) and uses only medical gasses.

☐C. This business operates a farm for purposes of cultivating the soil, raising, or harvesting an agricultural or horticultural commodity.

Q3. ☐Yes ☐No Does your business handle an acutely hazardous material? See definition on reverse side of this form.

Q4. ☐Yes ☑No Is your business within 1,000 feet of the outer boundary of a school (grades K-12)?

I have read the information on this form and understand my requirements under Chapter 6.95 of the California Health and Safety Code. I understand that if I own a facility or property that is used by tenants, that it is my responsibility to notify the tenants of the requirements which must be met prior to issuance of a Certificate of Occupancy or beginning of operations. I declare under the penalty of perjury that the information provided on this disclosure survey is true and accurate to the best of my knowledge.

Owner or Authorized Agent

X Ernie Ralston Date: 12-6-12
Print Name

X Title: Principal Planner, PG&E Environmental Management, Energy Supply Projects
Signature

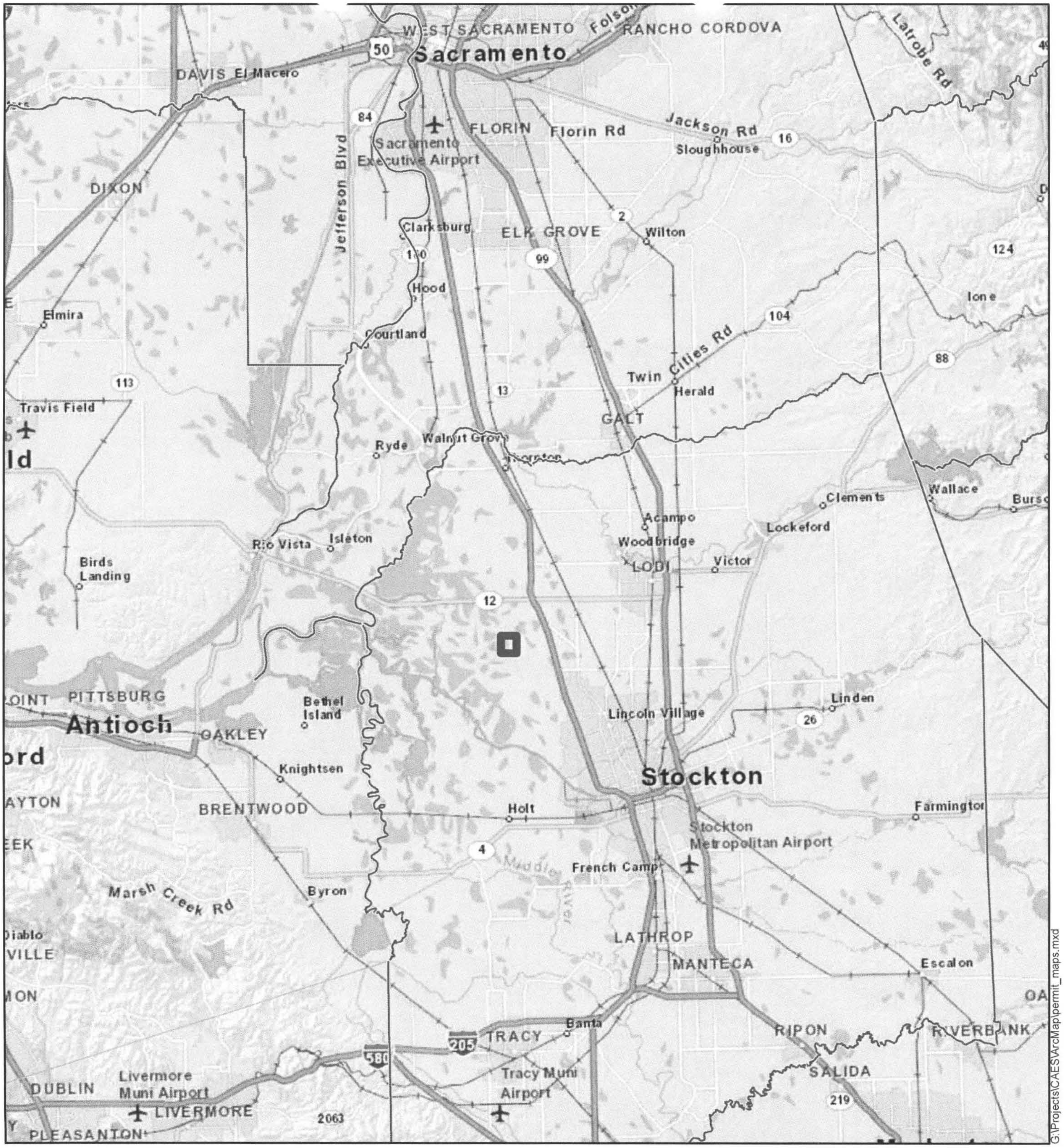


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Figure 1 - King Island Vicinity Map

▭ King Island Proposed Core Well Pad

PG&E CAES Project Core Well Permit Application

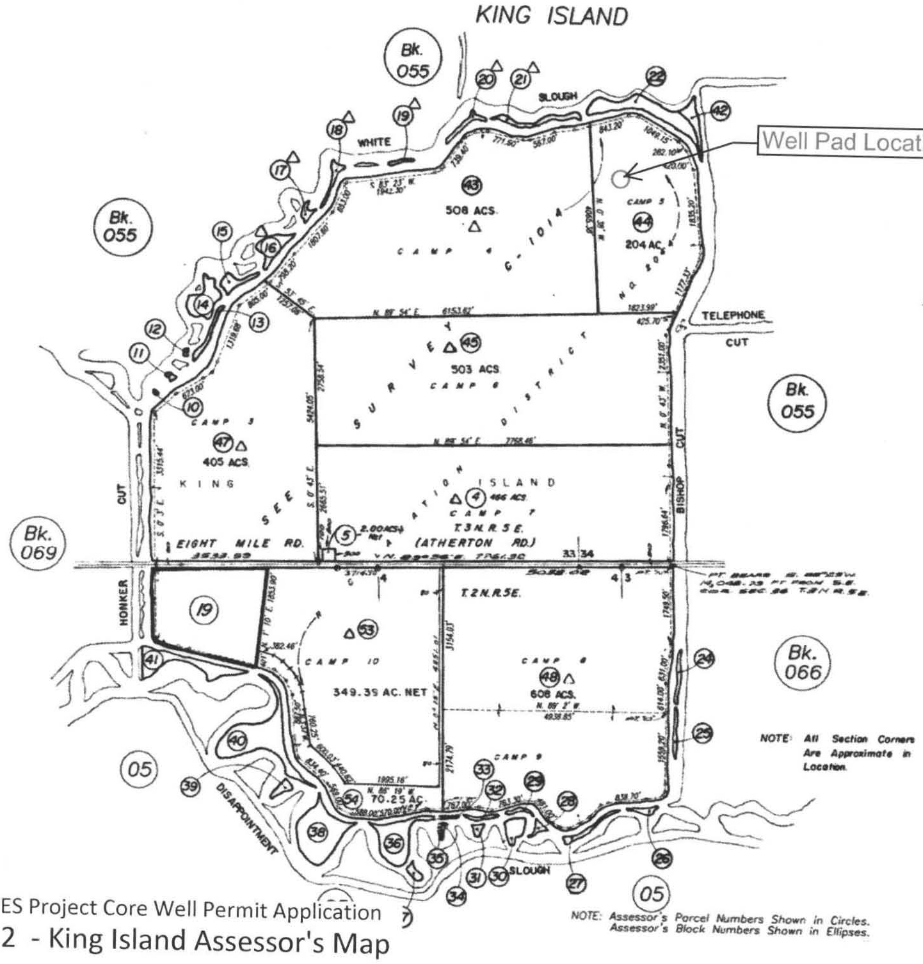
N

0 5 10 15 Miles

11/27/2012

THIS MAP IS FOR
ASSESSMENT USE ONLY

071–08



NOTE: All Section Corners Are Approximate in Location.

NOTE: Assessor's Parcel Numbers Shown in Circles.
Assessor's Block Numbers Shown in Ellipses.

1" = 2000'

Berm No.		Acres
10	-	0.2 △
11	-	0.5 △
12	-	0.4 △
13	-	2.2 △
14	-	9.1 △
15	-	2.5 △
16	-	6.3
17	-	1.6
18	-	2.1
19	-	0.4
20	-	2.8
21	-	3.4
22	-	8.1
24	-	1.7 △
25	-	0.6 △
26	-	1.1 △
27	-	2.0 △
28	-	0.9 △
29	-	0.4 △
30	-	3.1 △
31	-	1.0 △
32	-	0.6 △
33	-	0.3 △
34	-	0.4 △
35	-	0.6
36	-	13.9
37	-	1.5
38	-	21.3
39	-	1.6
40	-	22.6
41	-	14.2
42	-	2.6 △

△ – Willamson Act Parcels

HIGHEST A.P.N. USED			
YEAR	PAR. #	PAR. #	PAR. #
78-79	54		

Assessor's Map Bk.071 Pg.08
County of San Joaquin, Calif.

PG&E CAES Project Core Well Permit Application
Figure 2 - King Island Assessor's Map

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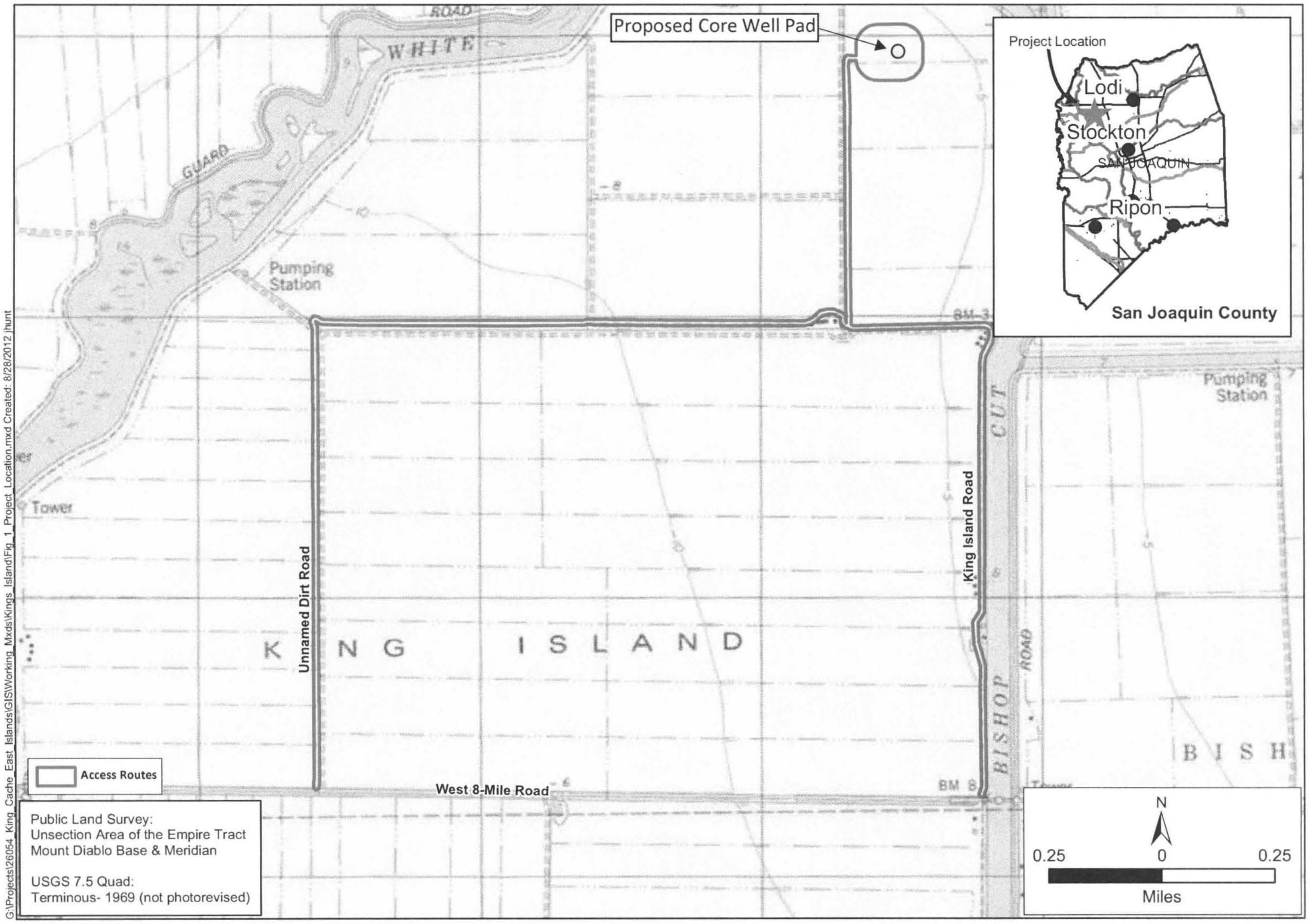
PG&E CAES Project Core Well Permit Application
Figure 3 - King Island Site Plan

0 500 1,000 1,500 Feet

12/7/2012



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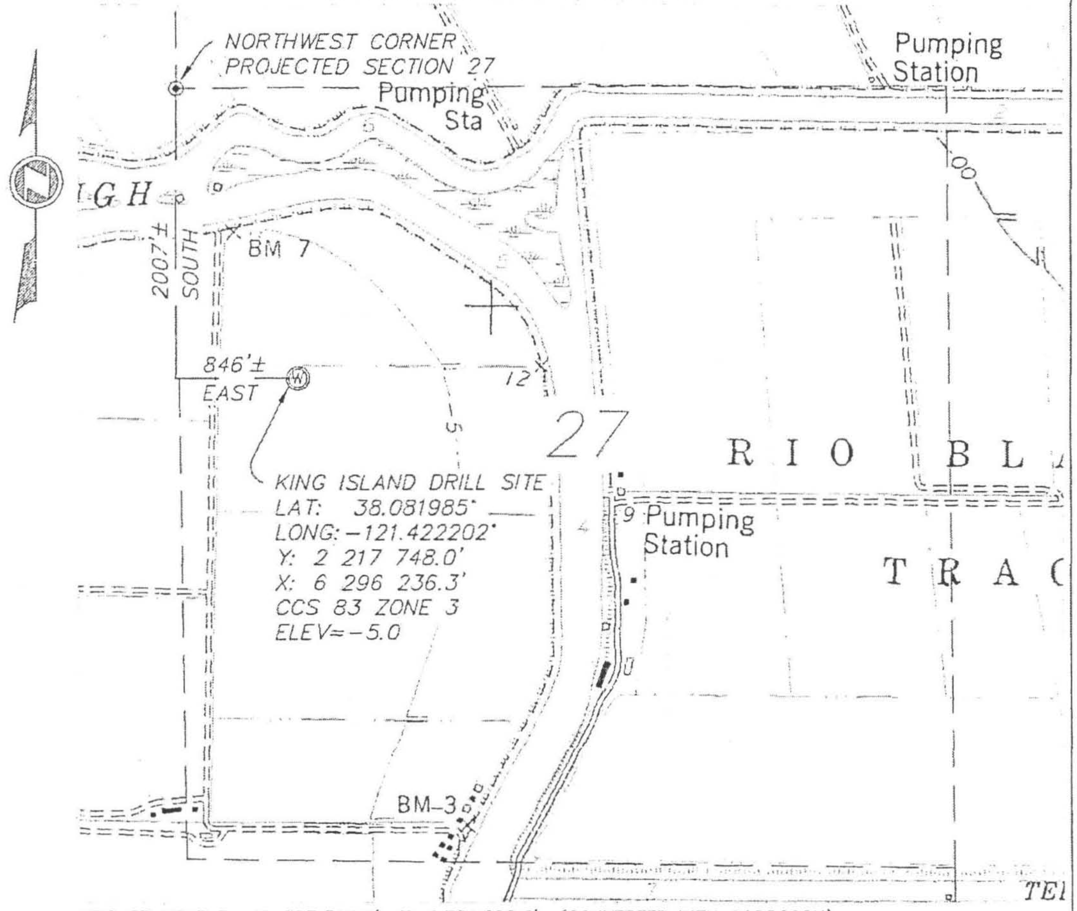
North State Resources, Inc.

King Island, San Joaquin County, California

Figure 4 - King Island Alternate Access Routes

SKETCH OF WELL LOCATION

WELL LOCATED 2007'± FT. SOUTH; 846'± FT. EAST FROM
THE NORTHWEST CORNER OF PROJECTED SECTION 27,
T. 3 N., R. 5 E, M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA



CCS 27 ZONE 3, Y: 577,344.2' X: 1,734,868.8' (CONVERTED WITH CORPSCON)

LICENSED LAND SURVEYOR
CHRISTOPHER W. LERCH
10-22-12
L.S. 7906
STATE OF CALIFORNIA

EXHIBIT-"A"
KING ISLAND
DRILL SITE
WELL NAME

LM LAUGENOUR AND MEIKLE
CIVIL ENGINEERING · LAND SURVEYING · PLANNING
608 COURT STREET, WOODLAND, CALIFORNIA 95695 · PHONE: (530) 662-1755
P.O. BOX 828, WOODLAND, CALIFORNIA 95776 · FAX: (530) 662-4602

SCALE: 1" = 1000"
DATE: 10/22/12

JOB No. 3462-2

RECORDING REQUESTED BY:

WHEN RECORDED MAIL TO:
Ben Jordan
Pacific Gas & Electric
245 Market Street, Ste. 1058A
San Francisco, CA 94105

Doc #: 2012-173091
12/26/2012 01:23:24 PM
Page: 1 of 6 Fee: $29.00
Kenneth W Blakemore
San Joaquin County Recorders
Paid By: SHOWN ON DOCUMENT

SPACE ABOVE THIS LINE FOR RECORDER'S USE

DRILL SITE ASSIGNMENT

THIS DRILL SITE ASSIGNMENT is made this 19 day of November 2012 from King Island Gas Storage, LLC hereinafter called "Assignor" to Pacific Gas & Electric Company, hereinafter called "Assignee".

For and in consideration of Ten Dollars the receipt of which is hereby acknowledged, Assignor does hereby assign to Assignee a portion of Assignor's right title and interest in and to those certain, Oil, Gas and Mineral Leases, contained in Document No. 2012-148291 as recorded in the office of the Recorder, San Joaquin California County on November 13, 2012. This Assignment is limited to the Drill Sites only as delineated on a Plat Map attached hereto as Exhibit 'A" and "A-1". This Assignment is made for a specific purpose expressly precluding the production of natural gas or the injection of air or natural gas into the strata underlying the land delineated on the Exhibit "A' and 'A-1" attached hereto. Activities shall be limited to building the drill sites and drilling, coring and casing and cementing to surface one well at each of the drill sites to a depth not to exceed 5,500 feet in depth in accordance with the specifications referenced in an unrecorded document of even date herewith.

THIS ASSIGNMENT IS MADE WITHOUT THE ASSIGNOR'S EXPRESS OR IMPLIED WARRANTY OR REPRESENTATION AS TO THE MERCHANTABILITY OF TITLE OR THE FITNESS FOR ANY PURPOSE, AND WITHOUT ANY OTHER REPRESENTATIONS WHATSOEVER, EXPRESS OR IMPLIED. ASSIGNEE SHALL BE THE RESPOSIBLE PARTY TO PAY ANY AND ALL TAXES, ASSESSED , AND ASSOCIATED WITH THE DRILLING OF WELLS AND ANY AND ALL OTHER IMPROVEMENTS ON LANDS AS DESCRIBED HEREIN AND ATTACHED HERETO TO INCLUDE ALL LAND REQUIRED FOR INGRESS AND EGRESS, (LAND).

IT IS UNDERSTOOD AND AGREED THAT ASSIGNEE SHALL HAVE INSPECTED THE DRILL SITES, AND LAND, INCLUDING THE PROPERTY AND PREMISES, AND HAS SATISFIED ITSELF AS TO THEIR PHYSICAL CONDITION, BOTH SURFACE AND SUBSURFACE AND THAT ASSIGNEE SHALL ACCEPT ALL OF THE SAME IN THEIR "AS IS-WHERE IS" CONDITION WITH NO PERFORMANCE REQUIRED BY ASSIGNEE.

Assignee shall indemnify, hold harmless and defend Assignor from and against any and all claims, liabilities, lawsuits, causes of action, demands ("claims") from any governmental agency, including but not limited to the United States federal government, State of California, County of San Joaquin and any Landowner or any other Party or entity affected by the drilling of said Wells on the Land arising from activities and obligations incurred subsequent to the effective date of this Assignment. This Assignment may not be assigned in whole part without the Assignees express written permission.

Assignee agrees it shall be fully responsible for applying for, obtaining and maintaining any permits, licenses, insurance, bonds, right of ways, easements, crop damage or any other agreements needed to effect this Assignment. This assignment shall expire and become null and void on September 30th 2013 for each drill site where no well has been drilled per the provisions of that certain unrecorded document between the Parties of even date herewith.

ASSIGNOR:

KING ISLAND GAS STORAGE, LLC

By: Robert D. Montella
Robert D. Montella, Manager

ASSIGNEE:

PACIFIC GAS & ELECTRIC COMPANY

By:
ZACK ANAWALT

CERTIFICATE OF ACKNOWLEDGMENT
OF NOTARY PUBLIC

STATE OF CALIFORNIA)
) ss
COUNTY OF SAN FRANCISCO)

On December 20, 2012, before me, Steve McClure, Notary Public, personally appeared Zack Anawalt, who proved to me on the basis of satisfactory evidence to be the person~~(s)~~ whose name~~(s)~~ is/~~are~~ subscribed to the within instrument, and acknowledged to me that he/~~she/they~~ executed the same in his/~~her/their~~ authorized capacity~~(ies)~~, and that by his/~~her/their~~ signature(s) on the instrument the person~~(s)~~, or the entity upon behalf of which the person~~(s)~~ acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Notary Public

(Seal)

STEVE MCCLURE
Commission # 1921571
Notary Public - California
San Francisco County
My Comm. Expires Jan 13, 2015

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of California

County of ______________________

On ______________ before me, ______________________________________,
Date — Here Insert Name and Title of the Officer

personally appeared ______________________________________
Name(s) of Signer(s)

____,

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Place Notary Seal and/or Stamp Above

Signature: ______________________________
Signature of Notary Public

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached Document

Title or Type of Document: ______________________________

Document Date: ______________________ Number of Pages: __________

Signer(s) Other Than Named Above: ______________________________

Capacity(ies) Claimed by Signer(s)

Signer's Name: ______________________

- ☐ Corporate Officer — Title(s): ______________
- ☐ Individual
- ☐ Partner — ☐ Limited ☐ General
- ☐ Attorney in Fact
- ☐ Trustee
- ☐ Guardian or Conservator
- ☐ Other: ______________

Signer Is Representing: __________

RIGHT THUMBPRINT OF SIGNER

Top of thumb here

Signer's Name: ______________________

- ☐ Corporate Officer — Title(s): ______________
- ☐ Individual
- ☐ Partner — ☐ Limited ☐ General
- ☐ Attorney in Fact
- ☐ Trustee
- ☐ Guardian or Conservator
- ☐ Other: ______________

Signer Is Representing: __________

RIGHT THUMBPRINT OF SIGNER

Top of thumb here

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of California

County of San Diego

On 11-19-2012 before me, F MAHMOUDI A NOTARY PUBLIC
Date Here Insert Name and Title of the Officer

personally appeared Robert D Montello
Name of Signer(s)

Who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies) and that by his/her/their signature(s) on the instrument the person(s) or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

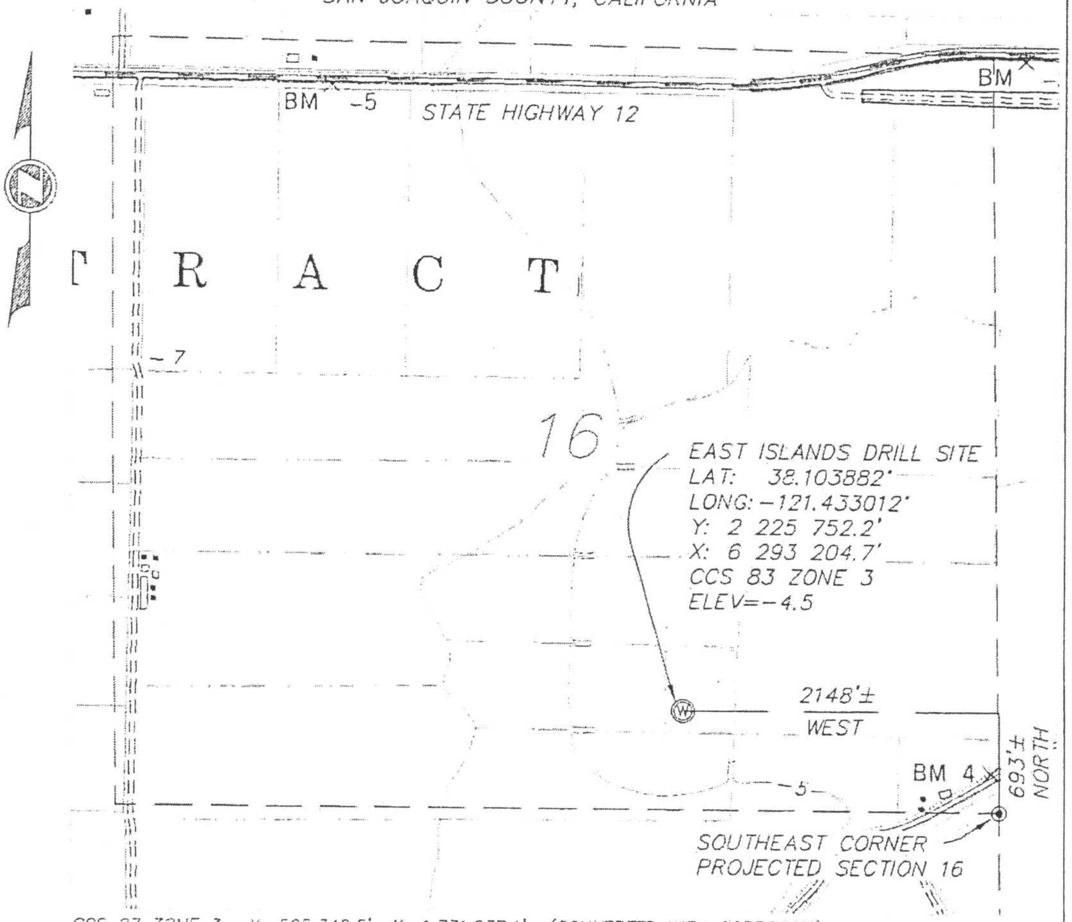
Place Notary Seal and/or Stamp Above

Signature:
Signature of Notary Public

F. MAHMOUDI
Commission # 1953100
Notary Public - California
San Diego County
My Comm. Expires Oct 19, 2015

SKETCH OF WELL LOCATION

WELL LOCATED 693'± FT. NORTH; 2148'± FT. WEST FROM
THE SOUTHEAST CORNER OF PROJECTED SECTION 16,
T. 3 N., R. 5 E, M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA



EAST ISLANDS DRILL SITE
LAT: 38.103882'
LONG: -121.433012'
Y: 2 225 752.2'
X: 6 293 204.7'
CCS 83 ZONE 3
ELEV=-4.5

CCS 27 ZONE 3, Y: 585,348.5' X: 1,731,837.1' (CONVERTED WITH CORPSCON)

CHRISTOPHER W. LERCH
10-22-12
L.S. 7906

LM LAUGENOUR AND MEIKLE
CIVIL ENGINEERING · LAND SURVEYING · PLANNING
608 COURT STREET, WOODLAND, CALIFORNIA 95695 · PHONE: (530) 662-1755
P.O. BOX 828, WOODLAND, CALIFORNIA 95776 · FAX: (530) 662-4602

EXHIBIT-"A-1"
EAST ISLANDS DRILL SITE

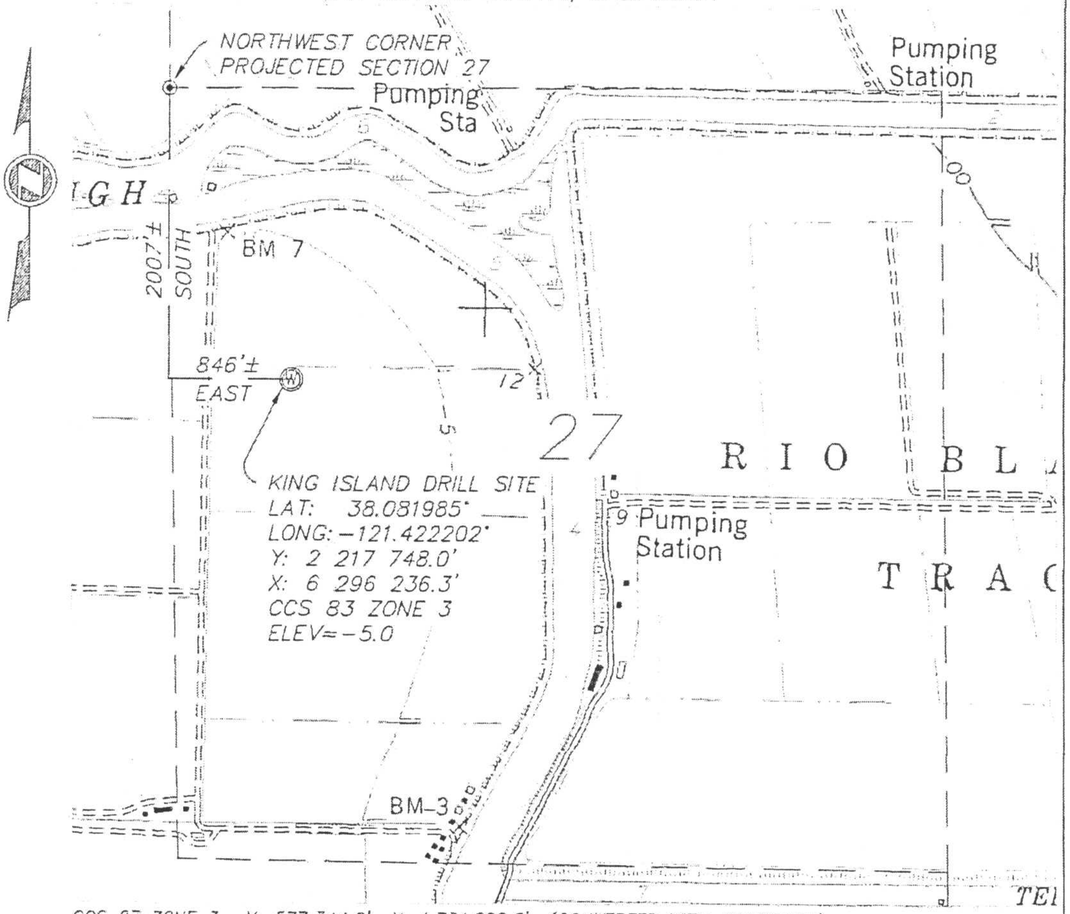
WELL NAME

SCALE: 1" = 1000"   DATE: 10/22/12

JOB No. 3462-3

SKETCH OF WELL LOCATION

WELL LOCATED 2007'± FT. SOUTH; 846'± FT. EAST FROM
THE NORTHWEST CORNER OF PROJECTED SECTION 27,
T. 3 N., R. 5 E, M.D.B.&M.
SAN JOAQUIN COUNTY, CALIFORNIA



CCS 27 ZONE 3, Y: 577,344.2' X: 1,734,868.8' (CONVERTED WITH CORPSCON)

LICENSED LAND SURVEYOR
CHRISTOPHER W. LERCH
10-22-12
L.S. 7906
STATE OF CALIFORNIA

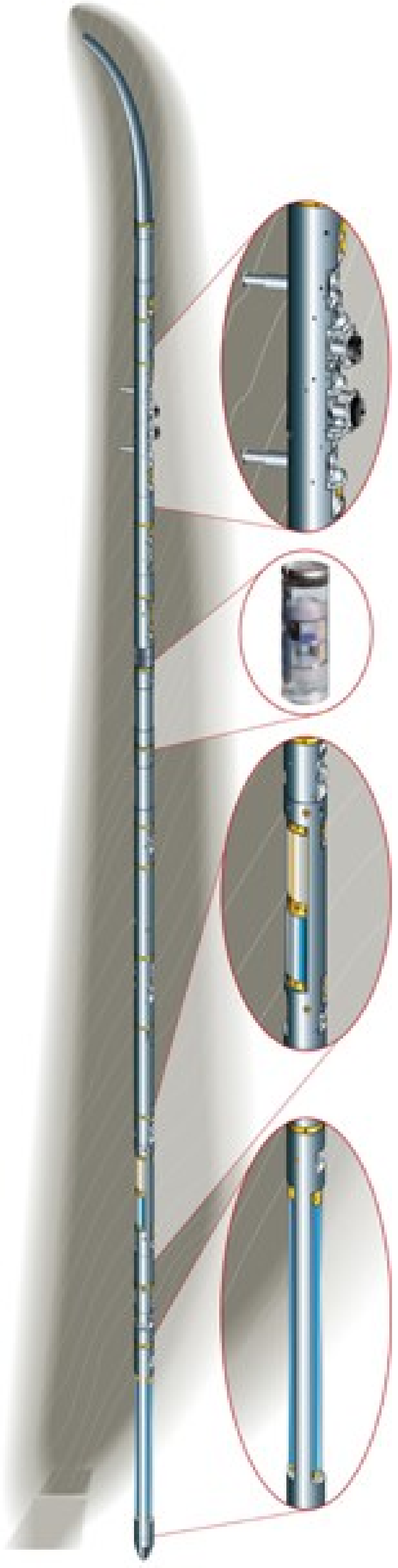
EXHIBIT-"A"
KING ISLAND
DRILL SITE
WELL NAME

LM LAUGENOUR AND MEIKLE
CIVIL ENGINEERING · LAND SURVEYING · PLANNING
608 COURT STREET, WOODLAND, CALIFORNIA 95695 · PHONE: (530) 662-1755
P.O. BOX 828, WOODLAND, CALIFORNIA 95776 · FAX: (530) 662-4602

SCALE: 1" = 1000" DATE: 10/22/12

JOB No. 3462-2

A523: PIACENTINE_2-27 RDT Survey Pressures



RDT Pressure Transient Analysis

Client: PG&E
Well: PIACENTINE 2-27
Field: KING ISLANDS
GAS
Rig:
Country: USA

Logged:

Analyst: C. HARRELL
Date: 03/26/13

HALLIBURTON

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  Test No. 2.2; MD: 4695.01 ft; TVD: 4695.00 ft 12

  Test No. 2.2; MD: 4695.01 ft; TVD: 4695.00 ft 13

  Test No. 3.0; MD: 4720.04 ft; TVD: 4720.04 ft 14

  Test No. 3.1; MD: 4720.04 ft; TVD: 4720.04 ft 15

  Test No. 4.0; MD: 4754.05 ft; TVD: 4754.05 ft 16

  Test No. 4.1; MD: 4754.05 ft; TVD: 4754.05 ft 17

  Test No. 5.0; MD: 4762.00 ft; TVD: 4762.00 ft 18

  Test No. 5.1; MD: 4762.00 ft; TVD: 4762.00 ft 19

  Test No. 6.0; MD: 4774.01 ft; TVD: 4774.01 ft 20

  Test No. 6.1; MD: 4774.01 ft; TVD: 4774.01 ft 21

  Test No. 7.0; MD: 4788.02 ft; TVD: 4788.02 ft 22

  Test No. 7.1; MD: 4788.02 ft; TVD: 4788.02 ft 23

  Test No. 8.0; MD: 4793.99 ft; TVD: 4793.99 ft 24

  Test No. 8.1; MD: 4793.99 ft; TVD: 4793.99 ft 25

  Test No. 9.0; MD: 4804.00 ft; TVD: 4804.00 ft 26

  Test No. 9.1; MD: 4804.00 ft; TVD: 4804.00 ft 27

  Test No. 10.0; MD: 4810.02 ft; TVD: 4810.02 ft 28

  Test No. 10.1; MD: 4810.02 ft; TVD: 4810.02 ft 29

  Test No. 11.0; MD: 4880.01 ft; TVD: 4880.01 ft 30

  Test No. 11.1; MD: 4880.01 ft; TVD: 4880.01 ft 31

Test No. 12.0; MD: 4890.02 ft; TVD: 4890.02 ft....................32

Test No. 12.1; MD: 4890.02 ft; TVD: 4890.02 ft....................33

Test No. 13.0; MD: 4774.00 ft; TVD: 4774.00 ft....................34

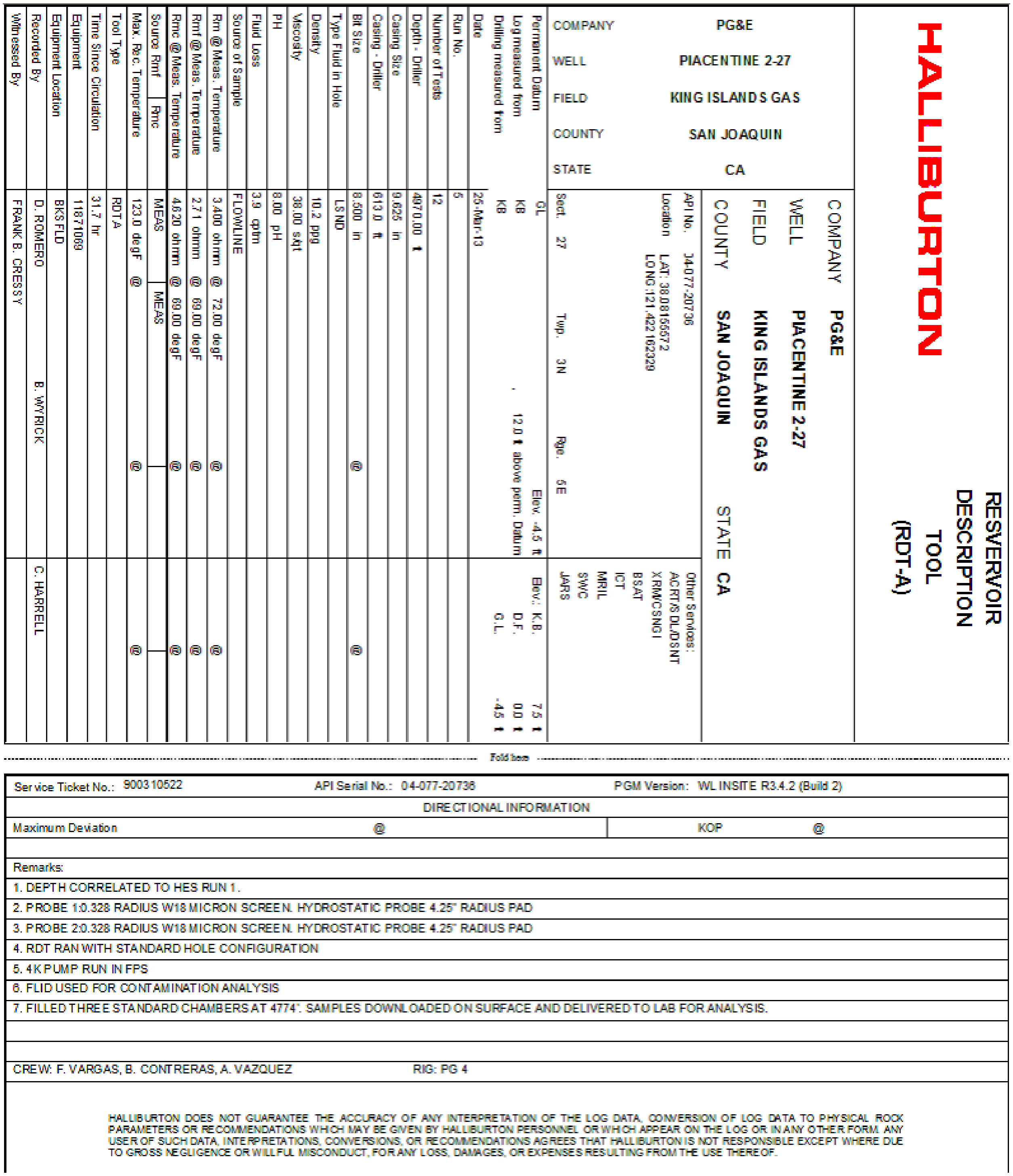
Test No. 13.1; MD: 4774.00 ft; TVD: 4774.00 ft....................35

Disclaimer....................36

Overview

At the request of PG&E, the RDT tool was run in the PIACENTINE 2-27 well, KING ISLANDS GAS field, USA in a 8.5 in. hole for formation pressures and establishes gradients in various formations.

Log Header



HALLIBURTON

RESVERVOIR
DESCRIPTION
TOOL
(RDT-A)

COMPANY	PG&E
WELL	PIACENTINE 2-27
FIELD	KING ISLANDS GAS
COUNTY	SAN JOAQUIN
STATE	CA

COMPANY **PG&E**
WELL **PIACENTINE 2-27**
FIELD **KING ISLANDS GAS**
COUNTY **SAN JOAQUIN** STATE **CA**

API No. 04-077-20736
Location LAT: 38.08155572
LONG:121.422162329

Other Services:
ACRT/SDL/DSNT
XRMI/CSNGI
BSAT
ICT
MRIL
SWC
JARS

Sect. 27 Twp. 3N Rge. 5E

Permanent Datum	GL	Elev. -4.5 ft	Elev.: K.B. 7.5 ft
Log measured from	KB	, 12.0 ft above perm. Datum	D.F. 0.0 ft
Drilling measured from	KB		G.L. -4.5 ft
Date	25-Mar-13		
Run No.	5		
Number of Tests	12		
Depth - Driller	4970.00 ft		
Casing Size	9.625 in		
Casing - Driller	613.0 ft		
Bit Size	8.500 in	@	@
Type Fluid in Hole	LSND		
Density	10.2 ppg		
Viscosity	38.00 s/qt		
PH	8.00 pH		
Fluid Loss	3.9 cptm		
Source of Sample	FLOWLINE		
Rm @ Meas. Temperature	3.400 ohmm @ 72.00 degF	@	@
Rmf @ Meas. Temperature	2.71 ohmm @ 69.00 degF	@	@
Rmc @ Meas. Temperature	4.620 ohmm @ 69.00 degF	@	@
Source Rmf | Rmc	MEAS | MEAS		
Max. Rec. Temperature	123.0 degF @	@	@
Tool Type	RDTA		
Time Since Circulation	31.7 hr		
Equipment	11871069		
Equipment Location	BKSFLD		
Recorded By	D. ROMERO	B. WYRICK	C. HARRELL
Witnessed By	FRANK B. CRESSY		

Fold here

Service Ticket No.: 900310522 API Serial No.: 04-077-20736 PGM Version: WL INSITE R3.4.2 (Build 2)

DIRECTIONAL INFORMATION

Maximum Deviation @ KOP @

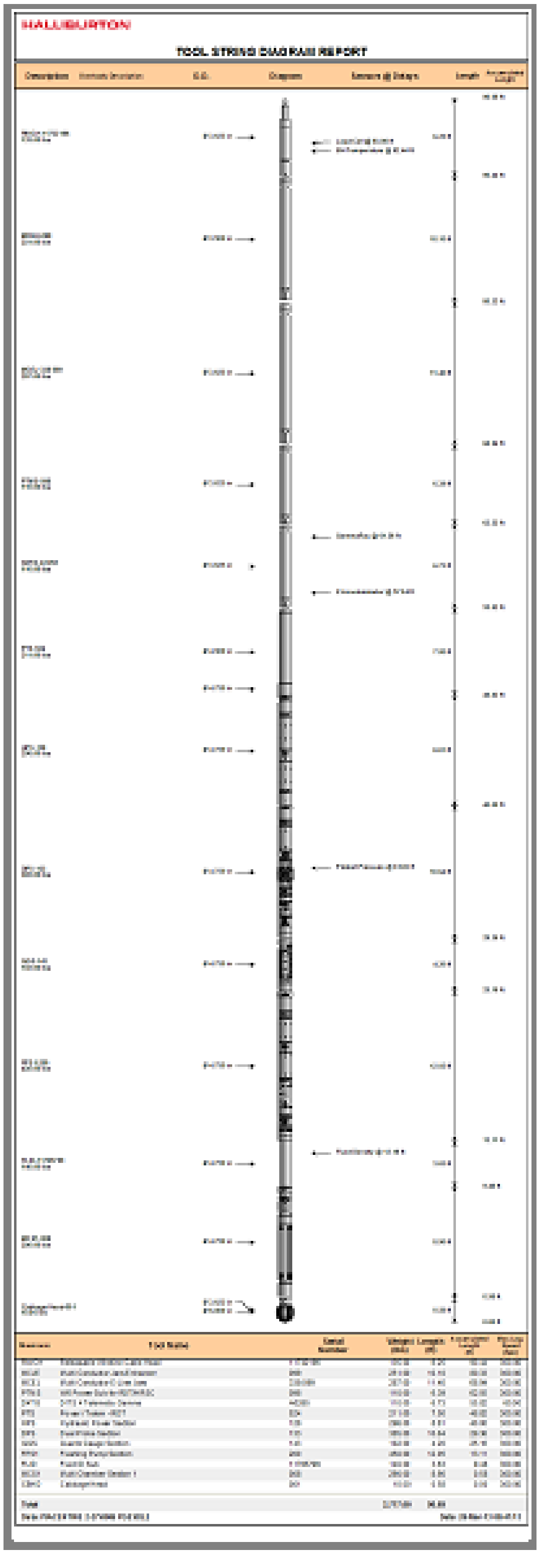
Remarks:

1. DEPTH CORRELATED TO HES RUN 1.
2. PROBE 1:0.328 RADIUS W18 MICRON SCREEN. HYDROSTATIC PROBE 4.25" RADIUS PAD
3. PROBE 2:0.328 RADIUS W18 MICRON SCREEN. HYDROSTATIC PROBE 4.25" RADIUS PAD
4. RDT RAN WITH STANDARD HOLE CONFIGURATION
5. 4K PUMP RUN IN FPS
6. FLID USED FOR CONTAMINATION ANALYSIS
7. FILLED THREE STANDARD CHAMBERS AT 4774'. SAMPLES DOWNLOADED ON SURFACE AND DELIVERED TO LAB FOR ANALYSIS.

CREW: F. VARGAS, B. CONTRERAS, A. VAZQUEZ RIG: PG 4

HALLIBURTON DOES NOT GUARANTEE THE ACCURACY OF ANY INTERPRETATION OF THE LOG DATA, CONVERSION OF LOG DATA TO PHYSICAL ROCK PARAMETERS OR RECOMMENDATIONS WHICH MAY BE GIVEN BY HALLIBURTON PERSONNEL OR WHICH APPEAR ON THE LOG OR IN ANY OTHER FORM. ANY USER OF SUCH DATA, INTERPRETATIONS, CONVERSIONS, OR RECOMMENDATIONS AGREES THAT HALLIBURTON IS NOT RESPONSIBLE EXCEPT WHERE DUE TO GROSS NEGLIGENCE OR WILLFUL MISCONDUCT, FOR ANY LOSS, DAMAGES, OR EXPENSES RESULTING FROM THE USE THEREOF.

Tool String Diagram



HALLIBURTON

TOOL STRING DIAGRAM REPORT

Test Summary

PRESSURE TEST SUMMARY															
Test Identification				**Hydrostatic Pres.**		**Eq. Mud Wt.**		**Test Pressures - Temperatures**					**Test Times**		**Remarks**
Test No.	**File No.**	**MD (ft)**	**TVD (ft)**	**Phyds1 (psia)**	**Phyds2 (psia)**	**EqFmMw (lbs/gal)**	**EqBhMw (lbs/gal)**	**Psdd (psia)**	**Pedd (psia)**	**Pstop (psia)**	**dPob (psia)**	**Temp (degF)**	**dTdd (sec)**	**dTbu (sec)**	
1.1	5-4.1	4630.06	4630.06	2523.76	2521.43	8.40	10.47	2023.08	1999.73	2021.65	499.79	118.50	1.00	105.62	Excellent Buildup Stability
2.1	5-5.1	4695.01	4695.00	2557.33	2555.31	7.82	10.47	1908.98	1852.09	1908.98	646.33	118.80	0.75	82.35	Excellent Buildup Stability
3.1	5-6.1	4720.04	4720.04	2570.71	2568.03	7.82	10.46	1919.21	1731.42	1920.06	647.97	119.20	1.50	118.64	Good Buildup Stability
4.1	5-7.1	4754.05	4754.05	2587.26	2585.76	7.83	10.46	1934.58	1915.42	1934.50	651.26	119.60	0.75	83.31	Excellent Buildup Stability
5.1	5-8.1	4762.00	4762.00	2590.06	2589.16	7.83	10.46	1937.93	1907.49	1937.94	651.22	120.00	4.25	82.75	Excellent Buildup Stability
6.1	5-16.1	4774.00	4774.00	2599.36	2574.01	7.83	10.37	1943.91	1935.19	1943.78	630.23	129.60	0.50	36.50	Excellent Buildup Stability
7.1	5-9.1	4774.01	4774.01	2596.45	2597.04	7.83	10.46	1943.22	1909.36	1943.08	653.95	120.20	2.00	82.05	Excellent Buildup Stability
8.1	5-10.1	4788.02	4788.02	2606.30	2604.60	7.83	10.46	1949.24	1914.98	1949.21	655.39	120.50	2.00	90.82	Excellent Buildup Stability
9.1	5-11.1	4793.99	4793.99	2607.17	2607.07	7.83	10.46	1951.93	1939.84	1951.75	655.32	121.20	1.00	93.25	Excellent Buildup Stability
10.1	5-12.1	4804.00	4804.00	2612.65	2612.16	7.83	10.46	1956.23	1910.19	1956.14	656.02	121.50	1.50	91.25	Excellent Buildup Stability
11.1	5-13.1	4810.02	4810.02	2615.83	2614.84	7.83	10.45	1958.87	1945.29	1958.78	656.06	121.60	2.00	97.35	Excellent Buildup Stability
12.1	5-14.1	4880.01	4880.01	2655.59	2653.02	7.84	10.45	1989.55	1942.30	1989.77	663.26	122.40	1.50	108.37	Excellent Buildup Stability
13.1	5-15.1	4890.02	4890.02	2660.62	2659.93	7.84	10.46	1994.03	1952.88	1994.05	665.88	122.70	1.75	89.33	Excellent Buildup Stability

Legend:
Phyds1: Initial Hydrostatic Pressure
Phyds2: Final Hydrostatic Pressure
EqFmMw:Equivalent Formation Mud Weight (Pstop / (TVD * Constant))
EqBhMw: Equivalent Borehole Mud Weight (Phyds2 / (TVD * Constant))
Psdd: Initial Drawdown Pressure
Pedd: Final Drawdown or End Drawdown Pressure
Pstop: Final Buildup Pressure
Temp: Final Temperature
dTdd= Tedd-Tsdd: Tedd - End of Drawdown Time; Tsdd - Initial Drawdown Time
dTbu=Tstop - Tedd:Buildup Time, Tedd - End of Drawdown Time, Tstop - Final Buildup Time
dPob= Phyds2 - Pstop: Over Balance

PRESSURE TRANSIENT SUMMARY

Test Identification				Buildup Stability		PTA Pressure		PTA Mobilities		Remarks
Test No.	**File No.**	**MD (ft)**	**TVD (ft)**	**Stability (psia/min)**	**Stability (degF/min)**	**Pexact (psia)**	**Pstdev (psia)**	**Mexact (md/cp)**	**Msdd (md/cp)**	
1.1	5-4.1	4630.06	4630.06	-0.005		2021.65	0.01	72.5	228	Excellent Buildup Stability
2.1	5-5.1	4695.01	4695.00	0.039		1908.98	0.04	17.4	57.4	Excellent Buildup Stability
3.1	5-6.1	4720.04	4720.04	0.362		1920.06	0.14	16.6	36.2	Good Buildup Stability
4.1	5-7.1	4754.05	4754.05	-0.011		1934.50	0.02	82.4	381	Excellent Buildup Stability
5.1	5-8.1	4762.00	4762.00	-0.006		1937.94	0.01	533	533	Excellent Buildup Stability
6.1	5-16.1	4774.00	4774.00	-0.001		1943.78	0.01	323	1160	Excellent Buildup Stability
7.1	5-9.1	4774.01	4774.01	-0.020		1943.08	0.01	283	337	Excellent Buildup Stability
8.1	5-10.1	4788.02	4788.02	-0.014		1949.21	0.01	400	405	Excellent Buildup Stability
9.1	5-11.1	4793.99	4793.99	-0.013		1951.75	0.01	226	793	Excellent Buildup Stability
10.1	5-12.1	4804.00	4804.00	0.001		1956.14	0.09	82.2	266	Excellent Buildup Stability
11.1	5-13.1	4810.02	4810.02	-0.025		1958.78	0.06	713	984	Excellent Buildup Stability
12.1	5-14.1	4880.01	4880.01	0.010		1989.77	0.02	101	135	Excellent Buildup Stability
13.1	5-15.1	4890.02	4890.02	-0.022		1994.05	0.01	333	339	Excellent Buildup Stability

Legend:
Pexact: Projected formation pressure based on exact model.
Pstdev: Standard deviation of actual pressures from exact model
Mexact: Spherical Mobility based on exact model
Msdd: Spherical Drawdown Mobility

SAMPLE SUMMARY

Sample Identification				Conditions					Fluid Properties*			Pumpout - Anisotropy**			Remarks
Sample Test	File No.	MD (ft)	Event	Ts (sec)	Ps (psia)	Pop (psia)	Vs (cc)	Temp (degF)	Density (sg)*	B.P. (psia)	Com. (1/psia)	Mposph (md/cp)	Mpoh (md/cp)	ANISO (Kv/Kh)	
6.1	5-16.1	4774.00	OpenSc	48398.25	1930.98	2612.30		129.20	0.98			50.60			SN 1498 STANDARD CHAMBER
6.2	5-16.2	4774.00	OpenSc	56245.50	1925.96	2624.86		129.40	0.98			2282.31			SN 1500 STANDARD CHAMBER
6.3	5-16.3	4774.00	OpenSc	57006.00	1926.25	2623.39		129.50	0.99			2343.43			SN 1507 STANDARD CHAMBER

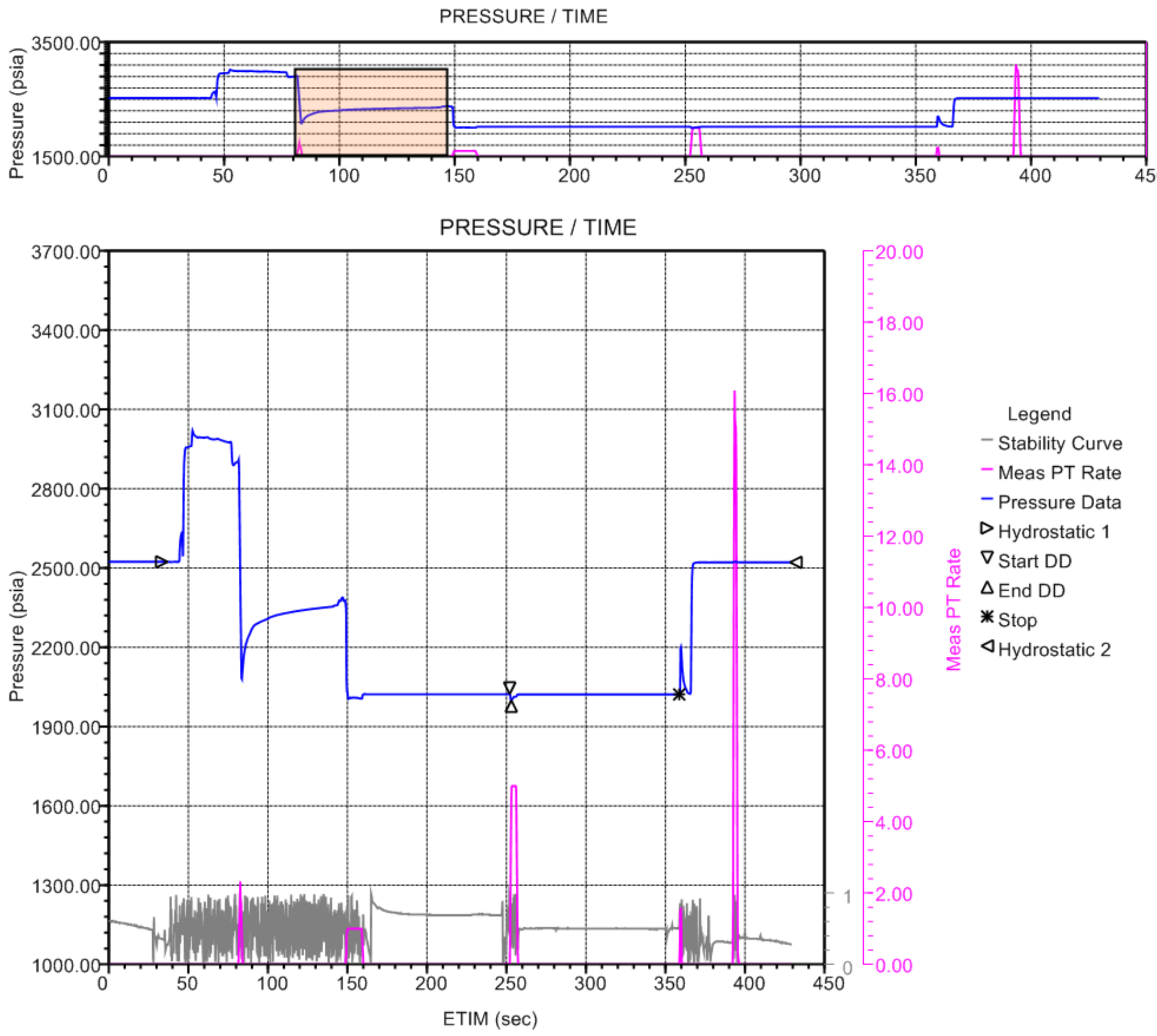
Legend:
Ts: Time Sample Taken
Ps: Pressure of Sample
B.P.:Bubble Point Pressure
Temp: Pretest Temperature
Com.: Compressibility
Density: Density
Pop: Over Pressure
Vs: Sample Volume
Mposph: Pump out Spherical Mobility
Mpoh: Pump out Horizontal Mobility
ANISO: Anisotropy, Kv/Kh

Options:
*: Fluid density available with advanced fluid properties tool option
**: Permeability - Mposph, Mpoh is available with pump-out and advanced fluid properties option

Plots

Test No. 1.0; MD: 4630.06 ft; TVD: 4630.06 ft

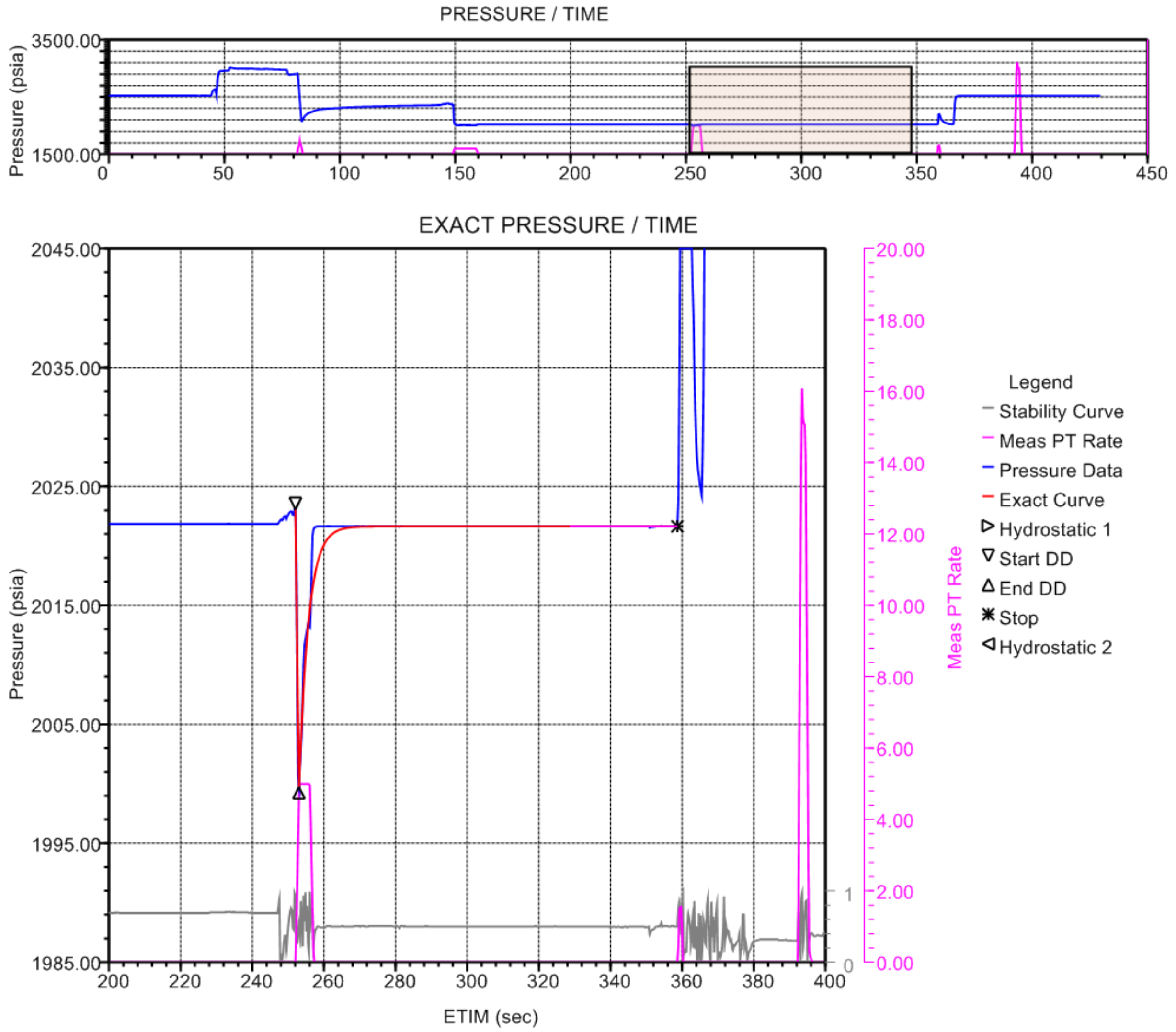
RDT Test File # 5-4.0 Date: 26-Mar-13 00:44:45



<table>
<tr><th colspan="10">PRESSURE/TIME PLOT SUMMARY</th></tr>
<tr><th>Depth</th><th colspan="2">Hydrostatic</th><th colspan="3">Pretest Pressures</th><th colspan="3">Pretest Times</th><th>Mobility</th></tr>
<tr><th>MD
(ft)</th><th>Phyds1
(psia)</th><th>Phyds2
(psia)</th><th>Psdd
(psia)</th><th>Pedd
(psia)</th><th>Pstop
(psia)</th><th>Tsdd
(sec)</th><th>Tedd
(sec)</th><th>Tstop
(sec)</th><th>Mdd
(md/cp)</th></tr>
<tr><td>4630.06</td><td>2523.42</td><td>2521.43</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="10">CONSTANTS - SPHERICAL FLOW</th></tr>
<tr><th colspan="2">Volume (cc)</th><th>Rate
(cc/sec).</th><th colspan="2">Rsnorkel (in)</th><th colspan="2">Porosity (fraction)</th><th>Ct
(1/psia)</th><th colspan="2">Flow-line Storage (cc)</th></tr>
<tr><td colspan="2">2.60</td><td>2.60</td><td colspan="2">0.66</td><td colspan="2">0.25</td><td>3.28e-004</td><td colspan="2">180.00</td></tr>
<tr><th colspan="10">REMARKS</th></tr>
<tr><td colspan="10">Excellent Buildup Stability</td></tr>
</table>

Test No. 1.1; MD: 4630.06 ft; TVD: 4630.06 ft

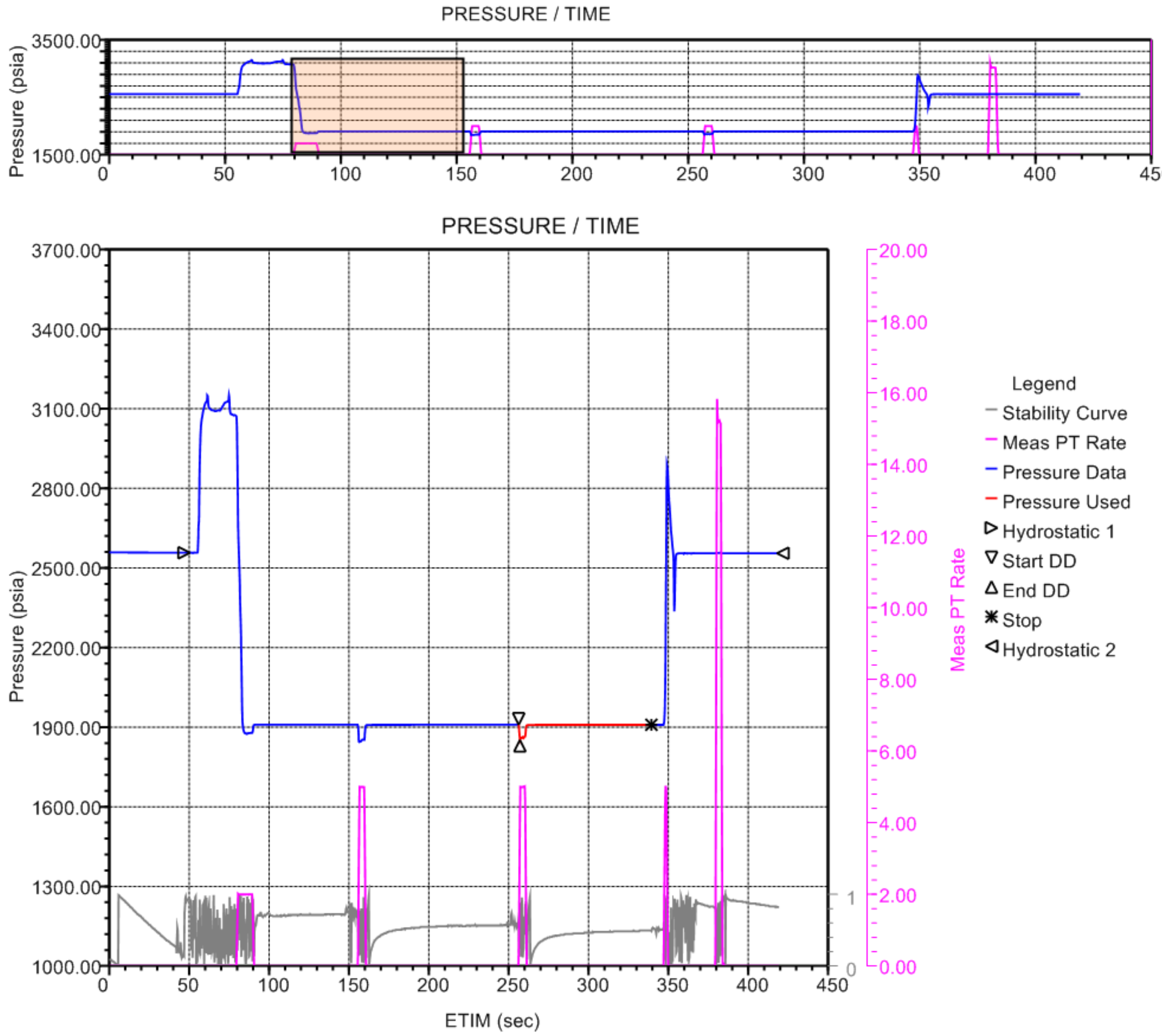
RDT Test File # 5-4.1 Date: 26-Mar-13 00:44:45



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4630.06	4630.06	1999.73	2021.65	2021.65	72.5
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
2.60	2.60	0.66	0.25	3.28e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 2.2; MD: 4695.01 ft; TVD: 4695.00 ft

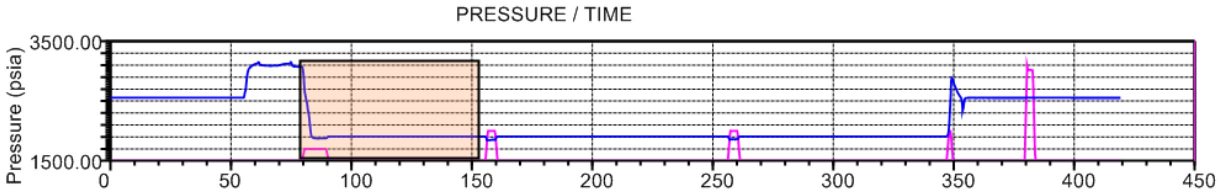
RDT Test File # 5-5.2 Date: 26-Mar-13 00:56:29

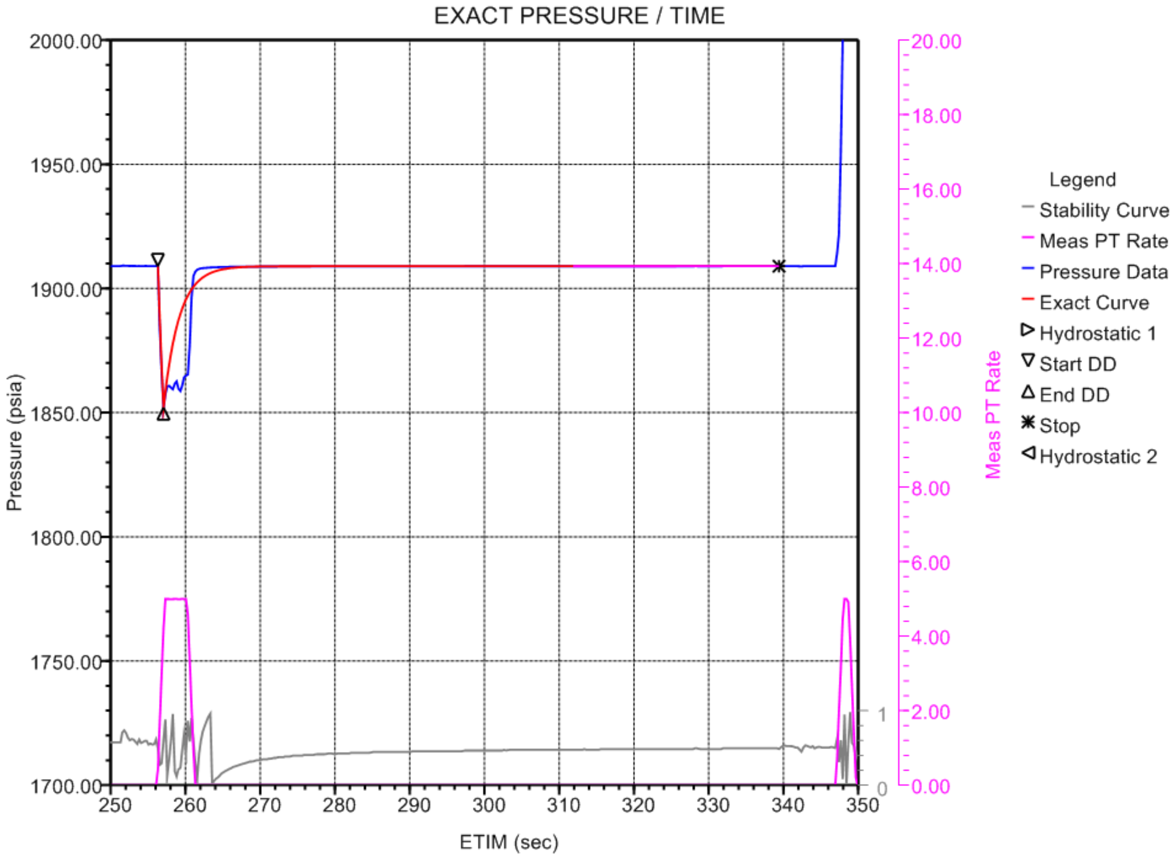


PRESSURE/TIME PLOT SUMMARY									
Depth	**Hydrostatic**		**Pretest Pressures**			**Pretest Times**			**Mobility**
MD (ft)	**Phyds1 (psia)**	**Phyds2 (psia)**	**Psdd (psia)**	**Pedd (psia)**	**Pstop (psia)**	**Tsdd (sec)**	**Tedd (sec)**	**Tstop (sec)**	**Mdd (md/cp)**
4695.01	2557.33	2555.32	1908.98	1852.09	1908.98	256.31	257.06	339.40	57.4
CONSTANTS - SPHERICAL FLOW									
Volume (cc)		**Rate (cc/sec).**	**Rsnorkel (in)**		**Porosity (fraction)**		**Ct (1/psia)**	**Flow-line Storage (cc)**	
1.28		1.70	0.66		0.25		9.37e-005	180.00	
REMARKS									
Excellent Buildup Stability									

Test No. 2.2; MD: 4695.01 ft; TVD: 4695.00 ft

RDT Test File # 5-5.2 Date: 26-Mar-13 00:56:29

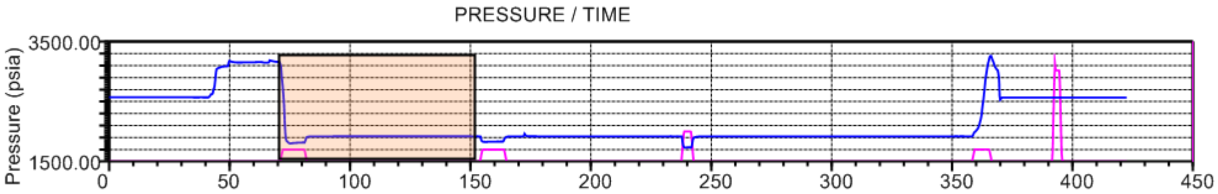


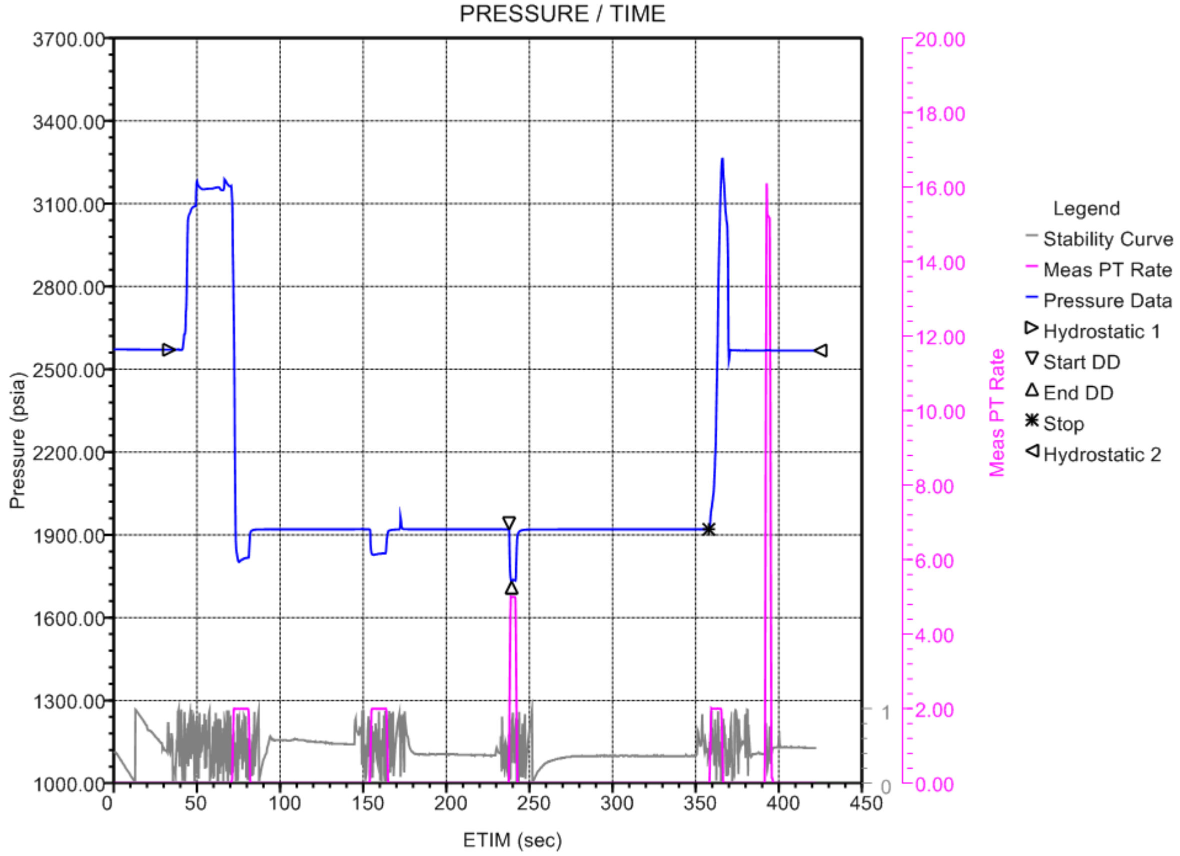


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4695.01	4695.00	1852.09	1908.98	1908.98	17.4
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
1.28	1.70	0.66	0.25	9.37e-005	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.04	0.04	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 3.0; MD: 4720.04 ft; TVD: 4720.04 ft

RDT Test File # 5-6.0 Date: 26-Mar-13 01:06:31





PRESSURE/TIME PLOT SUMMARY									
Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4720.04	2570.71	2568.03							

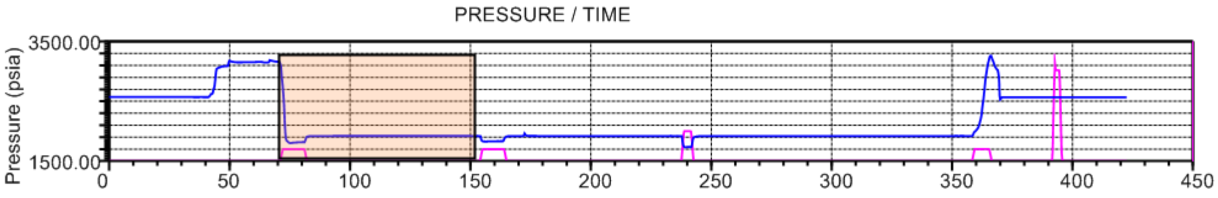
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
5.33	3.55	0.66	0.25	5.53e-005	180.00

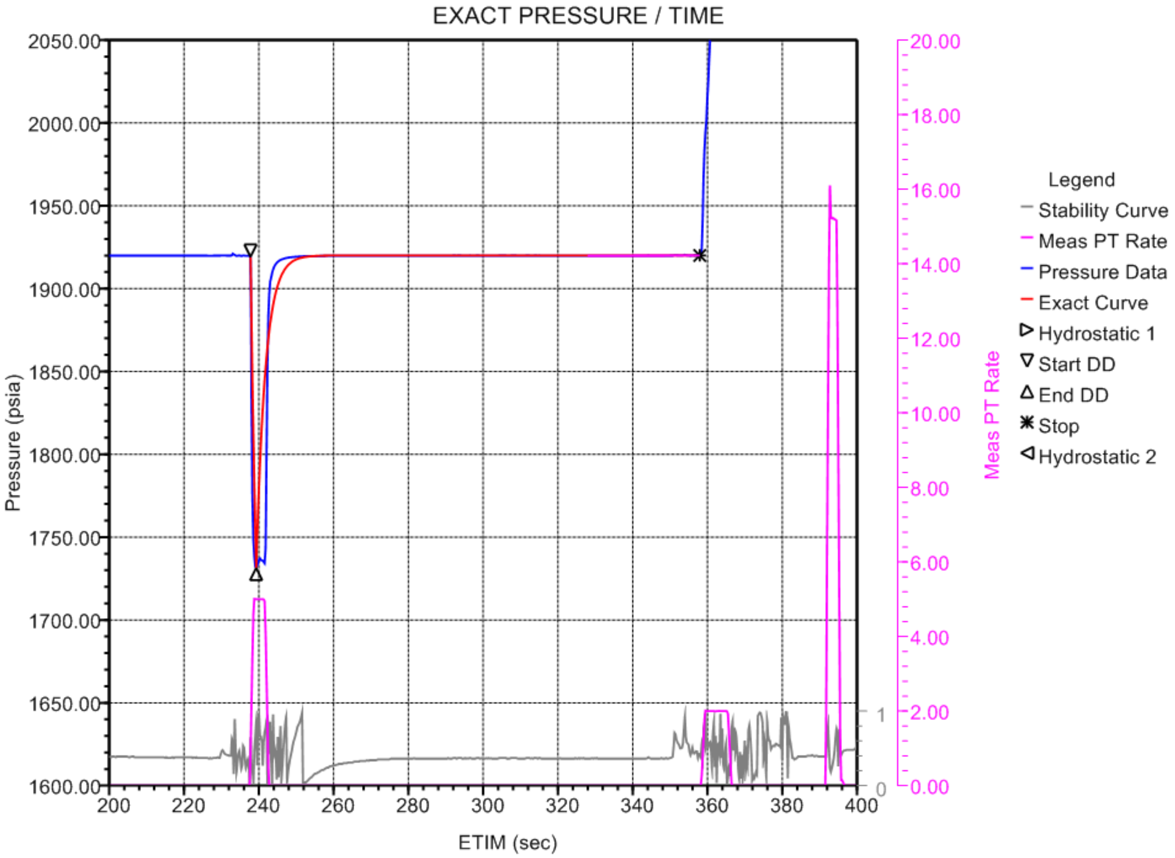
REMARKS

Good Buildup Stability

Test No. 3.1; MD: 4720.04 ft; TVD: 4720.04 ft

RDT Test File # 5-6.1 Date: 26-Mar-13 01:06:31

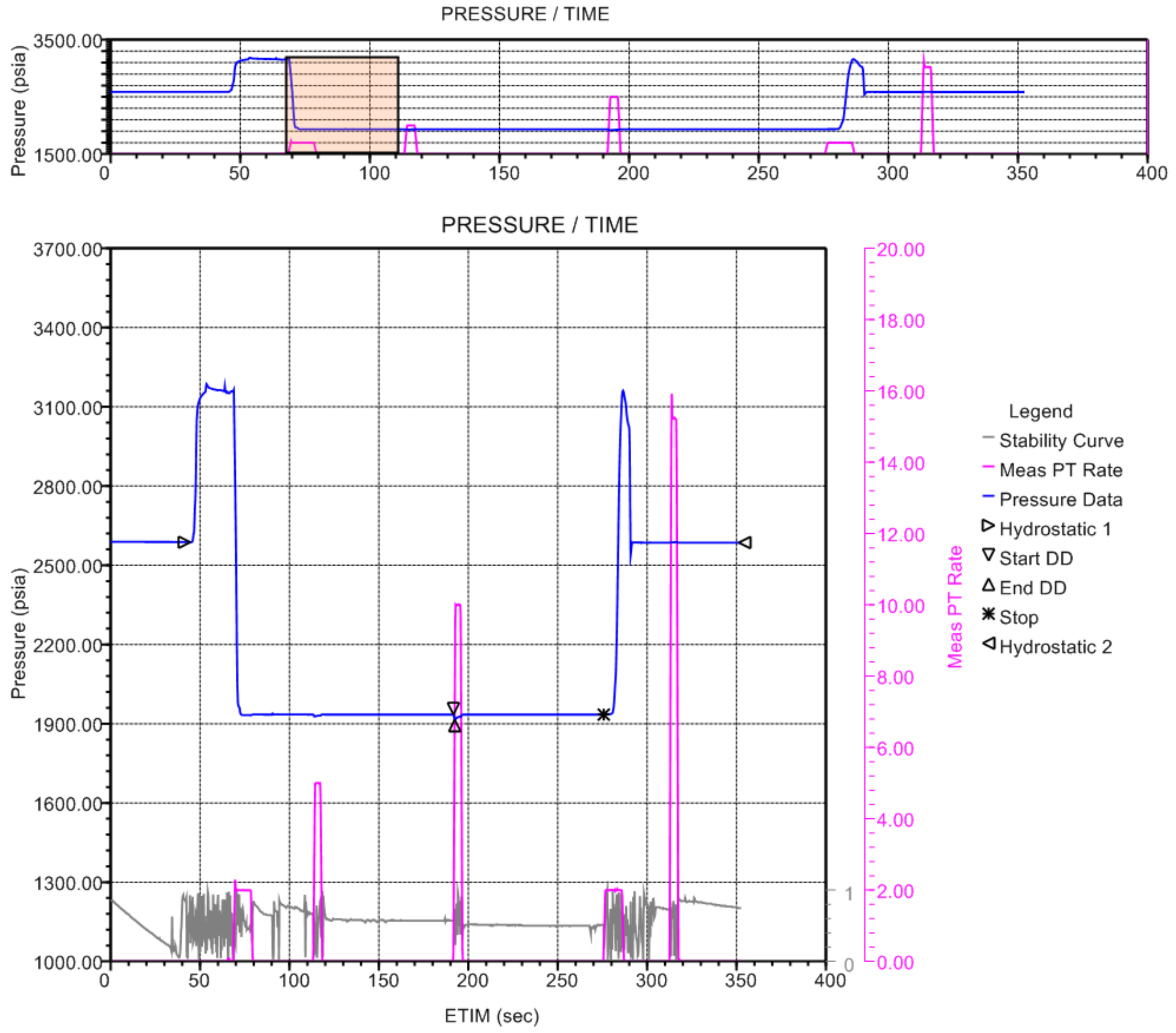




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4720.04	4720.04	1731.42	1920.06	1920.06	16.6
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
5.33	3.55	0.66	0.25	5.53e-005	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.14	0.36	0.00			
REMARKS					
Good Buildup Stability					

Test No. 4.0; MD: 4754.05 ft; TVD: 4754.05 ft

RDT Test File # 5-7.0 Date: 26-Mar-13 01:17:09



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4754.05	2587.26	2585.76							

CONSTANTS - SPHERICAL FLOW

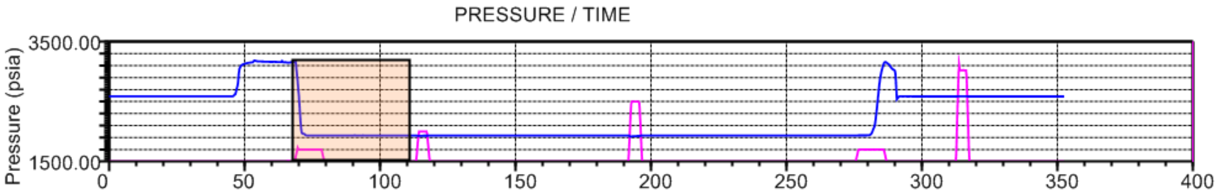
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
2.84	3.78	0.66	0.25	4.10e-004	180.00

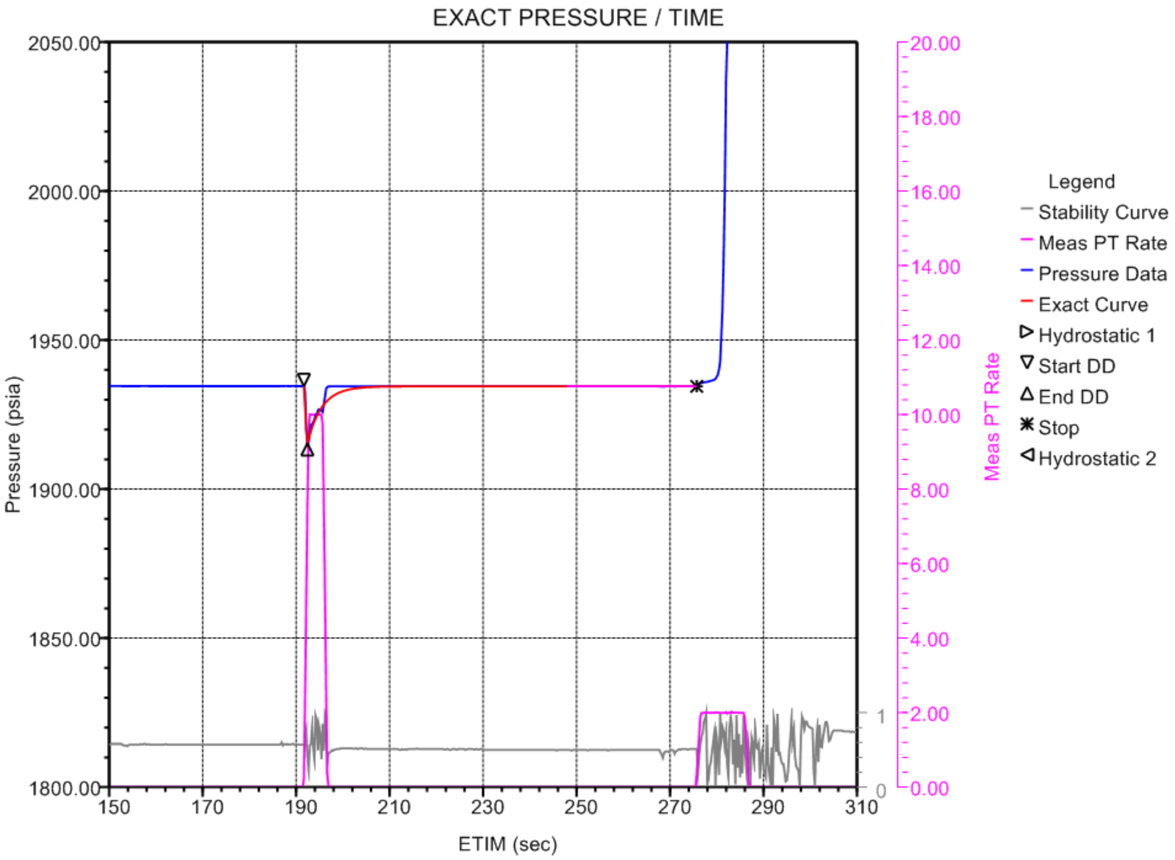
REMARKS

Excellent Buildup Stability

Test No. 4.1; MD: 4754.05 ft; TVD: 4754.05 ft

RDT Test File # 5-7.1 Date: 26-Mar-13 01:17:09

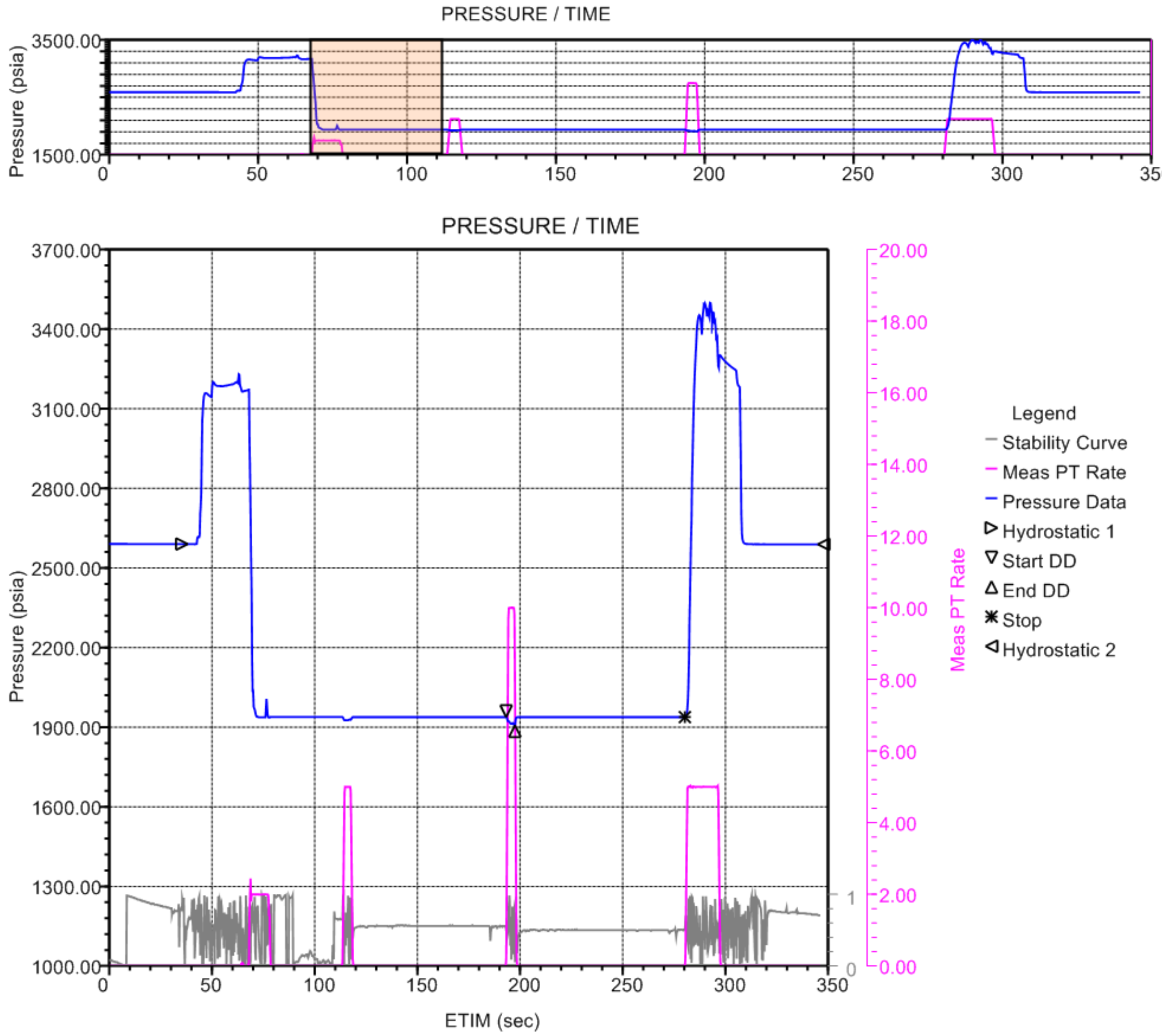




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4754.05	4754.05	1915.42	1934.50	1934.50	82.4
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
2.84	3.78	0.66	0.25	4.10e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.02	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 5.0; MD: 4762.00 ft; TVD: 4762.00 ft

RDT Test File # 5-8.0 Date: 26-Mar-13 01:25:20



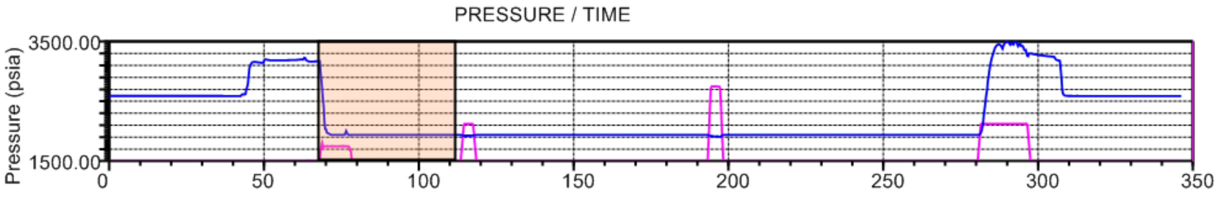
PRESSURE/TIME PLOT SUMMARY									
Depth	**Hydrostatic**		**Pretest Pressures**			**Pretest Times**			**Mobility**
MD (ft)	**Phyds1 (psia)**	**Phyds2 (psia)**	**Psdd (psia)**	**Pedd (psia)**	**Pstop (psia)**	**Tsdd (sec)**	**Tedd (sec)**	**Tstop (sec)**	**Mdd (md/cp)**
4762.00	2590.06	2589.16							

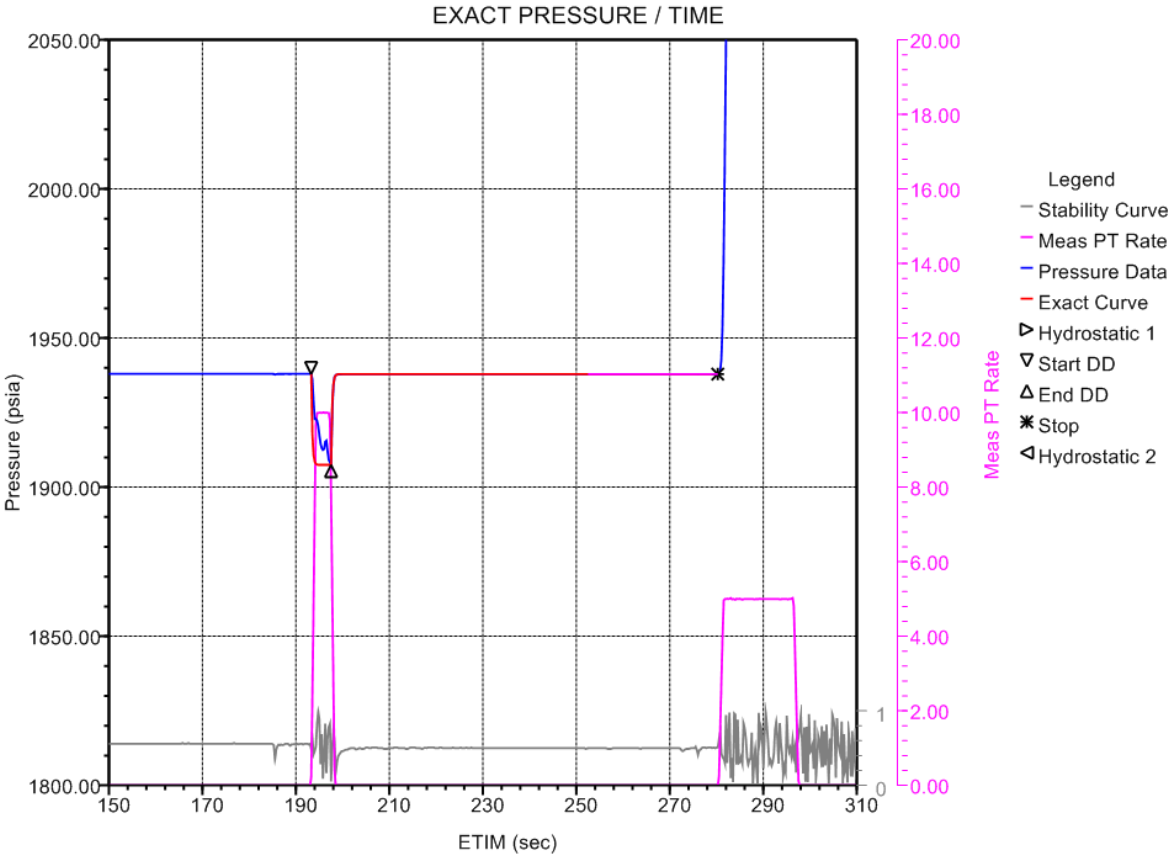
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
35.92	8.45	0.66	0.25	1.63e-003	180.00

REMARKS
Excellent Buildup Stability

Test No. 5.1; MD: 4762.00 ft; TVD: 4762.00 ft

RDT Test File # 5-8.1 Date: 26-Mar-13 01:25:20

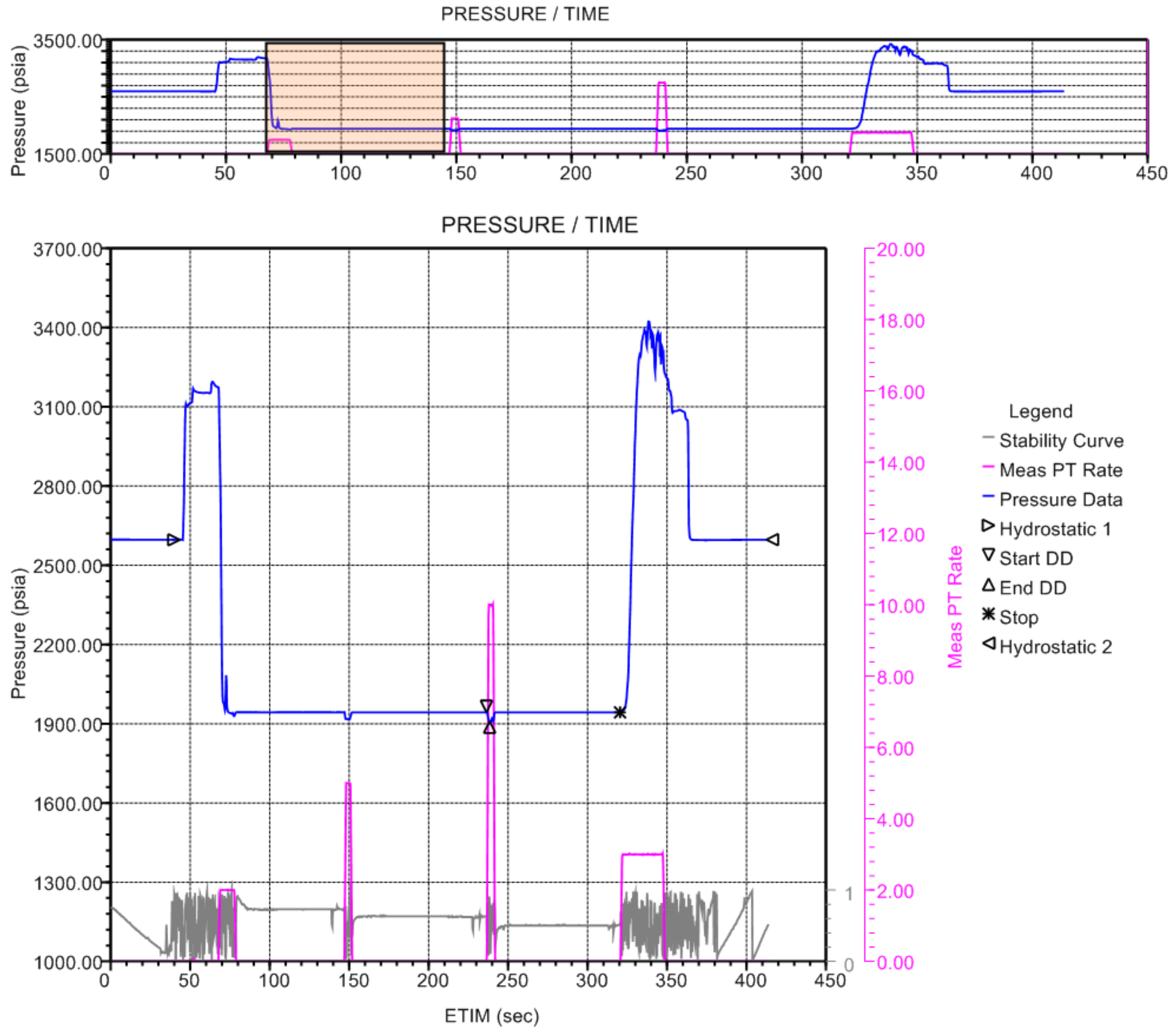




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4762.00	4762.00	1907.49	1937.94	1937.94	533
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
35.92	8.45	0.66	0.25	1.63e-003	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 6.0; MD: 4774.01 ft; TVD: 4774.01 ft

RDT Test File # 5-9.0 Date: 26-Mar-13 01:32:53

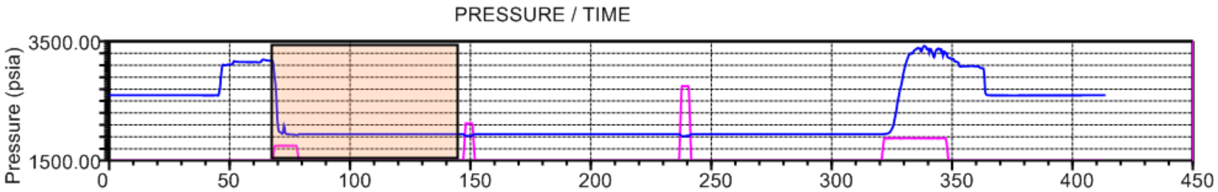


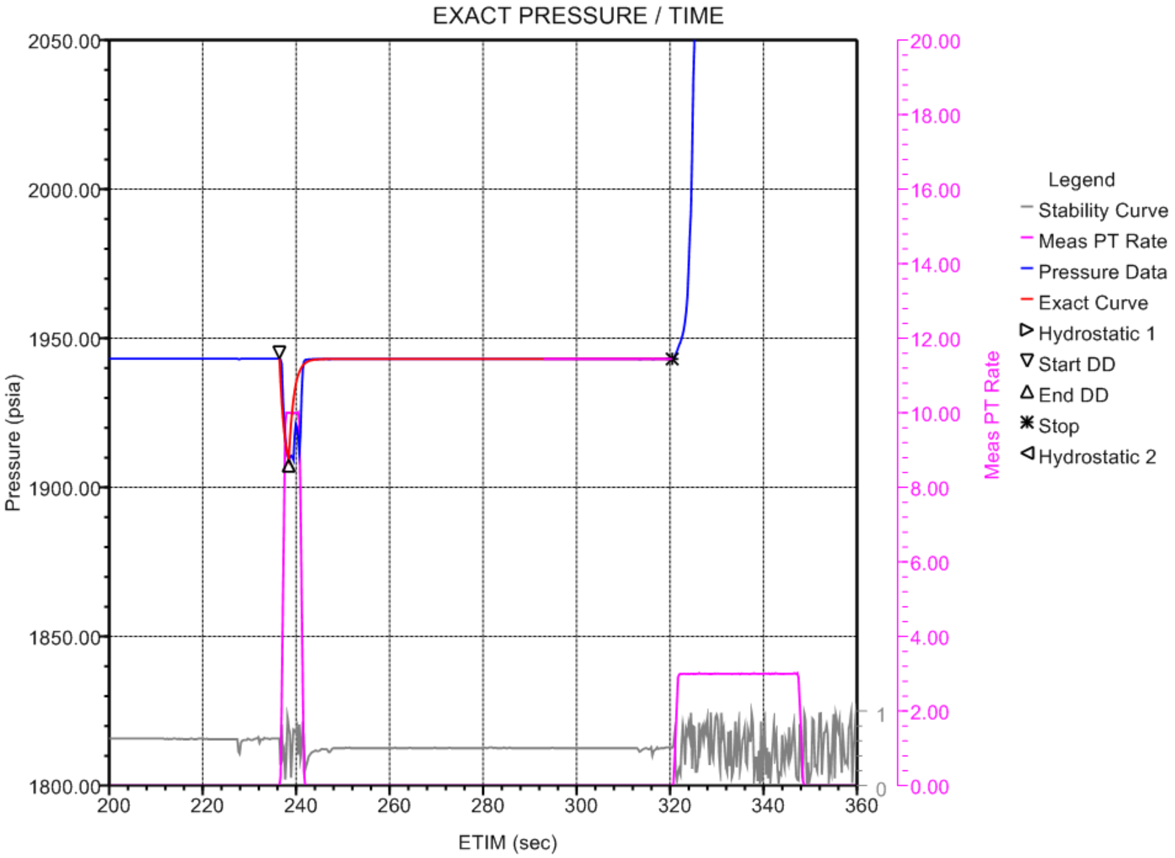
PRESSURE/TIME PLOT SUMMARY									
Depth	**Hydrostatic**		**Pretest Pressures**			**Pretest Times**			**Mobility**
MD (ft)	**Phyds1 (psia)**	**Phyds2 (psia)**	**Psdd (psia)**	**Pedd (psia)**	**Pstop (psia)**	**Tsdd (sec)**	**Tedd (sec)**	**Tstop (sec)**	**Mdd (md/cp)**
4774.01	2596.45	2597.04							

CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
11.85	5.92	0.66	0.25	7.19e-004	180.00
REMARKS					
Excellent Buildup Stability					

Test No. 6.1; MD: 4774.01 ft; TVD: 4774.01 ft

RDT Test File # 5-9.1 Date: 26-Mar-13 01:32:53

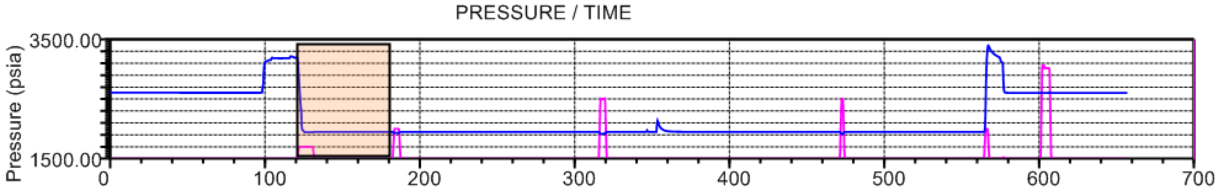


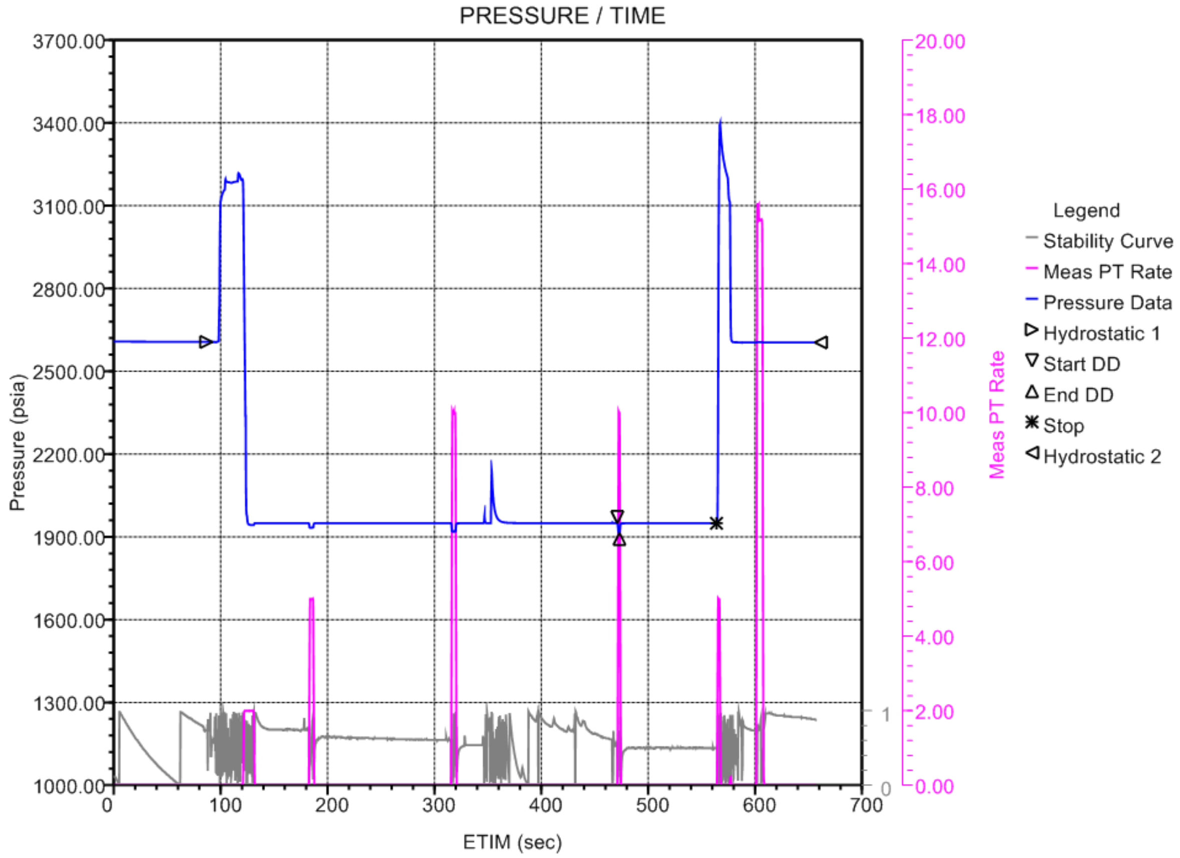


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4774.01	4774.01	1909.36	1943.08	1943.08	283
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
11.85	5.92	0.66	0.25	7.19e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.02	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 7.0; MD: 4788.02 ft; TVD: 4788.02 ft

RDT Test File # 5-10.0 Date: 26-Mar-13 01:41:34





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4788.02	2606.30	2604.60							

CONSTANTS - SPHERICAL FLOW

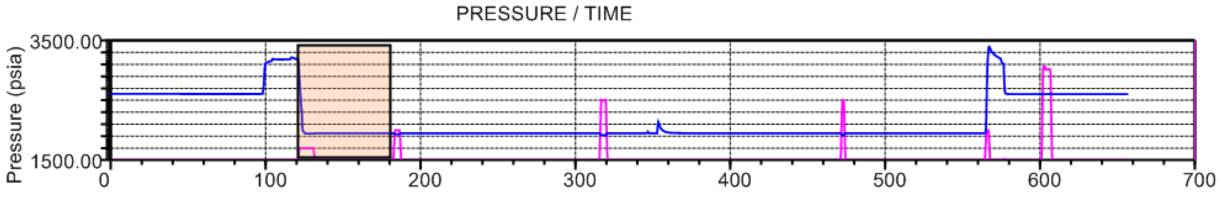
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
14.46	7.22	0.66	0.25	6.55e-004	180.00

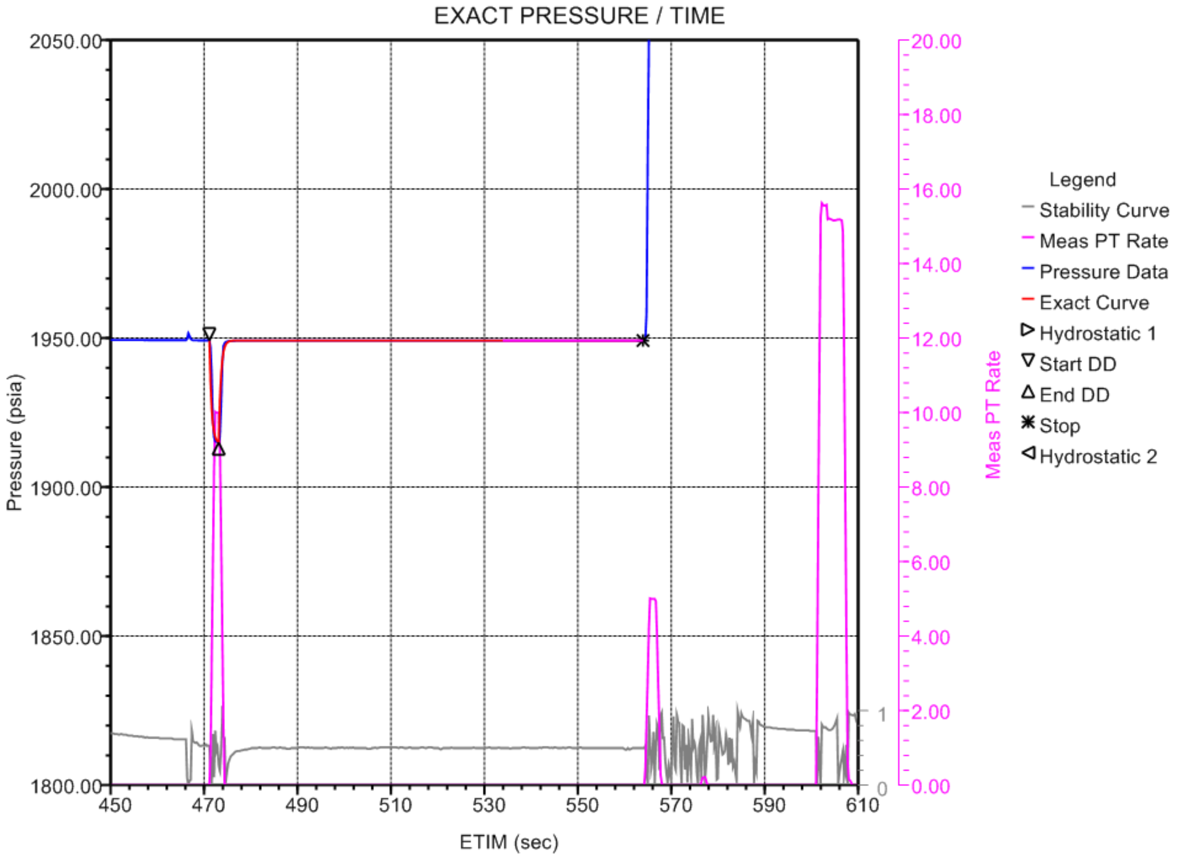
REMARKS

Excellent Buildup Stability

Test No. 7.1; MD: 4788.02 ft; TVD: 4788.02 ft

RDT Test File # 5-10.1 Date: 26-Mar-13 01:41:34

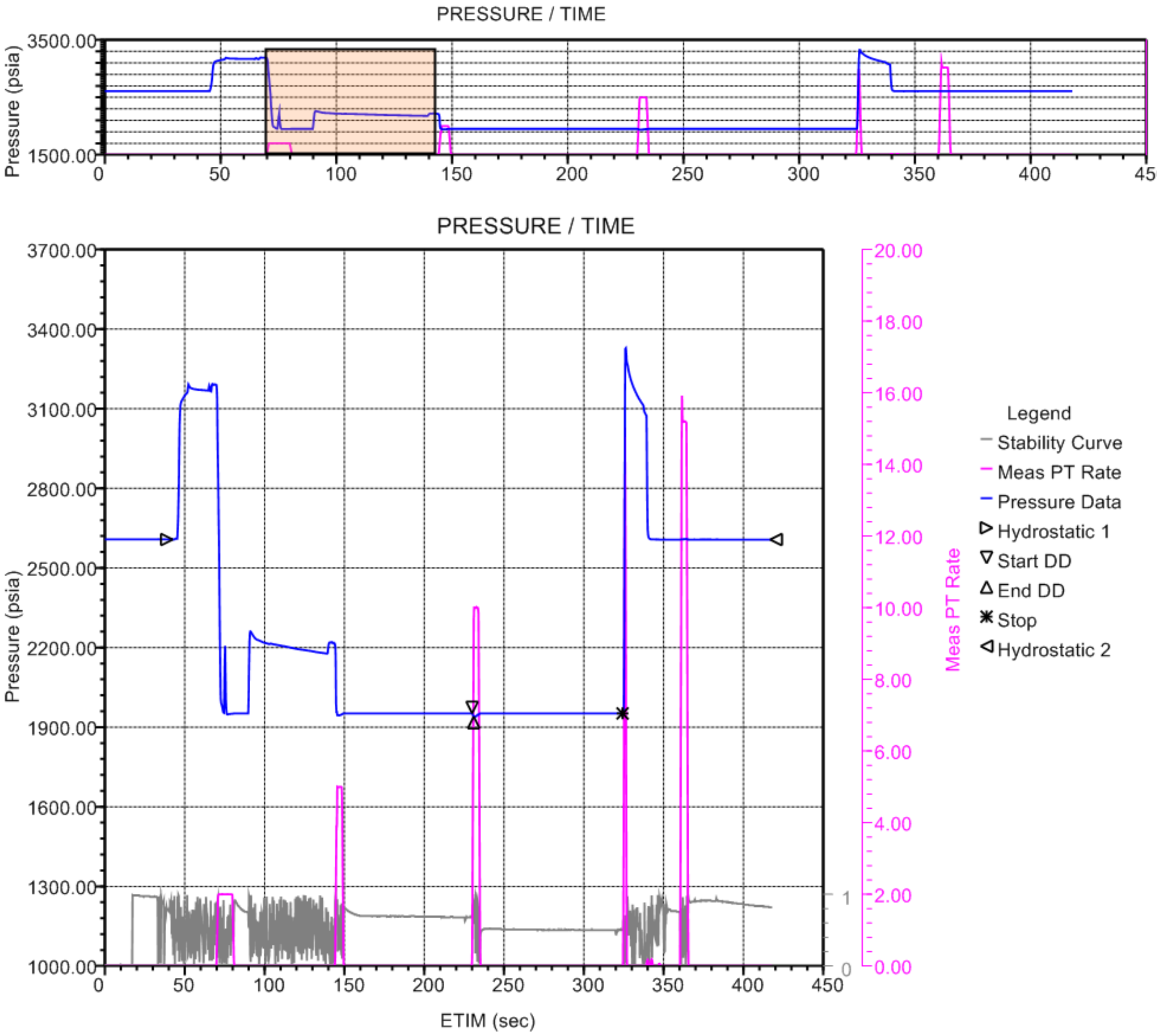




EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4788.02	4788.02	1914.98	1949.21	1949.21	400
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
14.46	7.22	0.66	0.25	6.55e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 8.0; MD: 4793.99 ft; TVD: 4793.99 ft

RDT Test File # 5-11.0 Date: 26-Mar-13 01:56:15



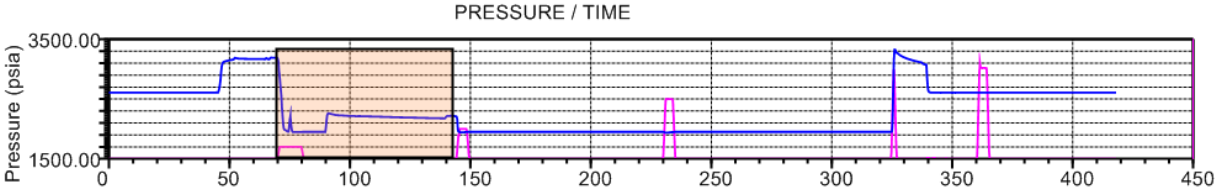
PRESSURE/TIME PLOT SUMMARY									
Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4793.99	2607.17	2607.07							

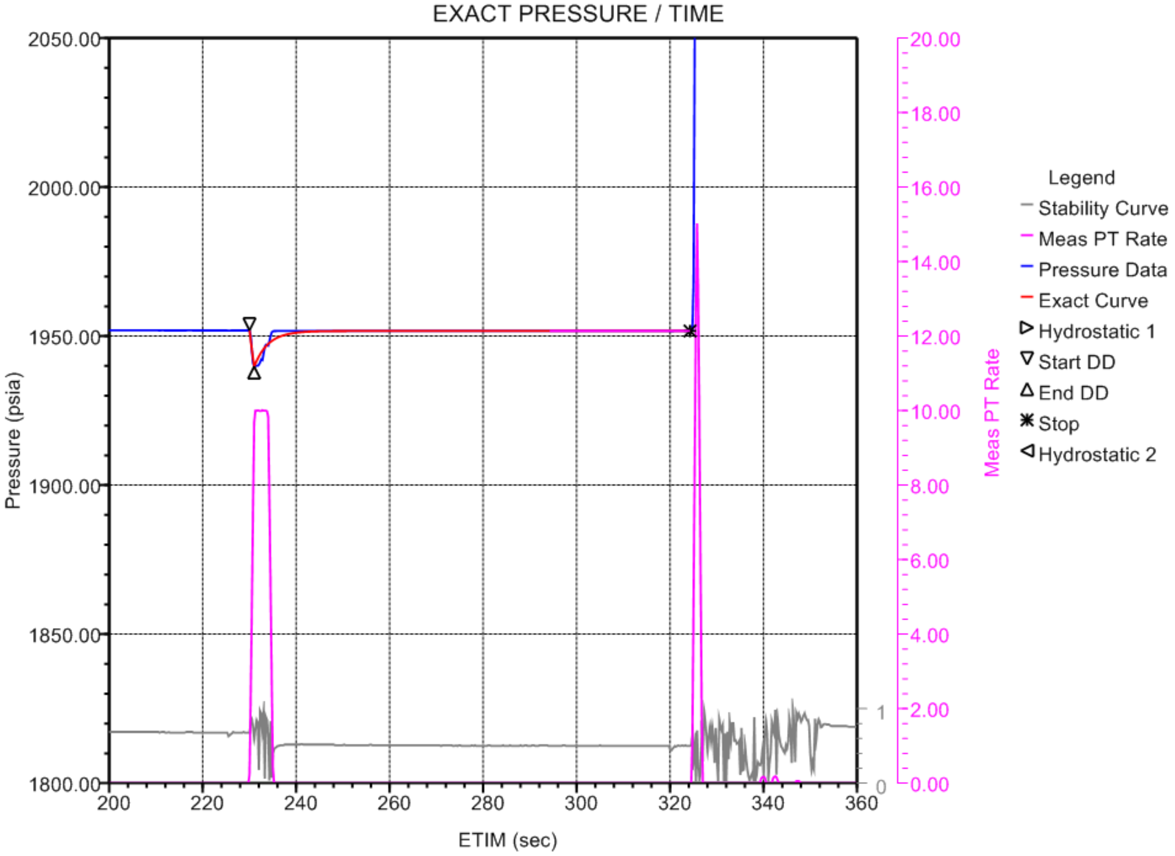
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
4.91	4.91	0.66	0.25	1.37e-003	180.00

REMARKS
Excellent Buildup Stability

Test No. 8.1; MD: 4793.99 ft; TVD: 4793.99 ft

RDT Test File # 5-11.1 Date: 26-Mar-13 01:56:15

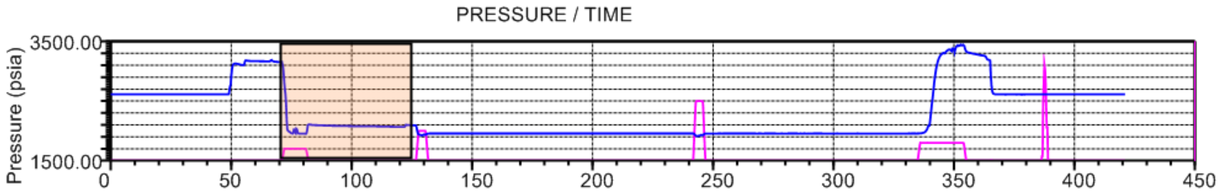


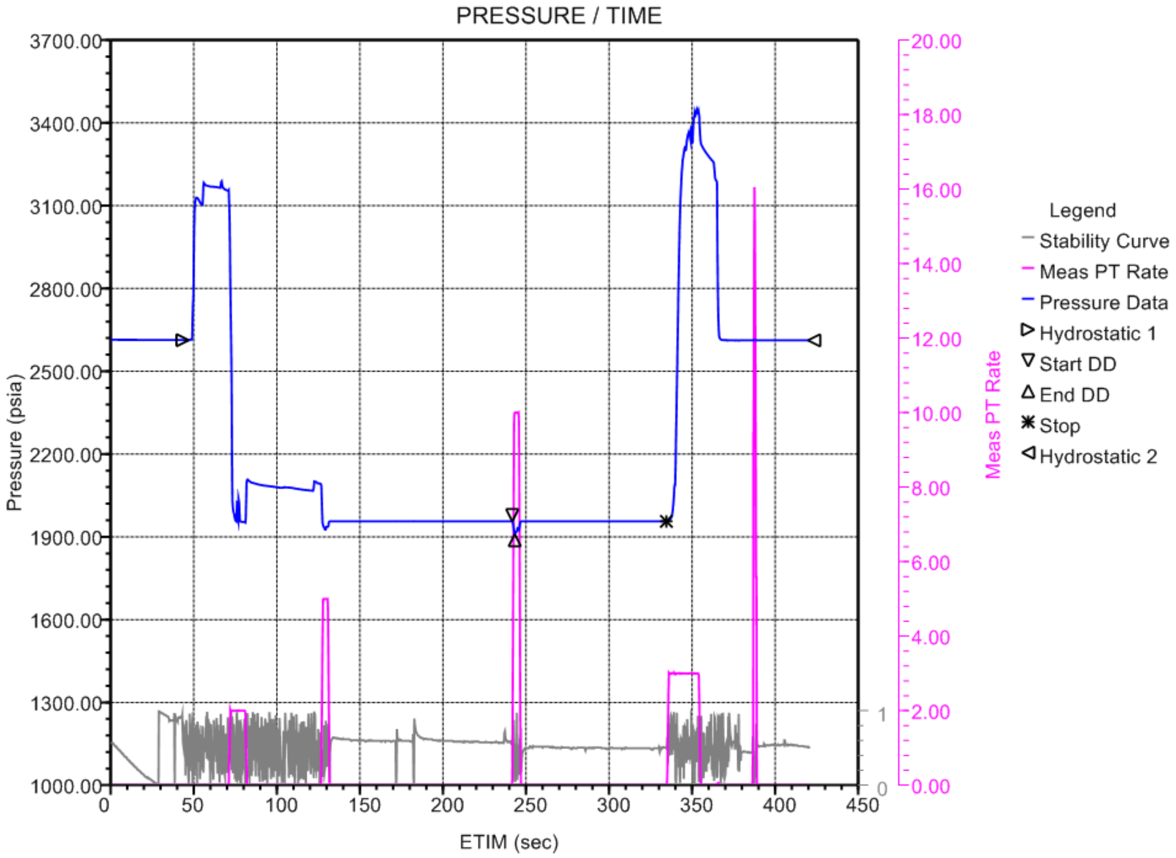


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4793.99	4793.99	1939.84	1951.75	1951.75	226
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
4.91	4.91	0.66	0.25	1.37e-003	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 9.0; MD: 4804.00 ft; TVD: 4804.00 ft

RDT Test File # 5-12.0 Date: 26-Mar-13 02:04:40





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4804.00	2612.65	2612.16							

CONSTANTS - SPHERICAL FLOW

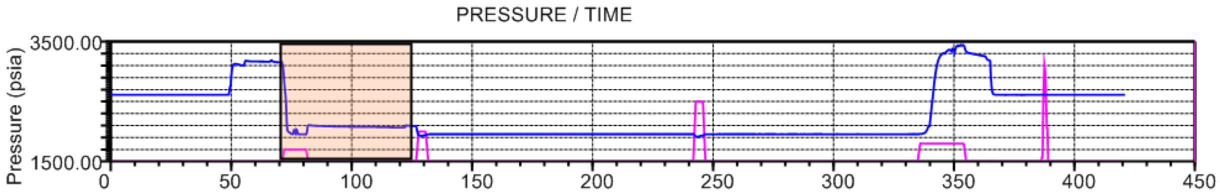
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
9.56	6.37	0.66	0.25	7.46e-004	180.00

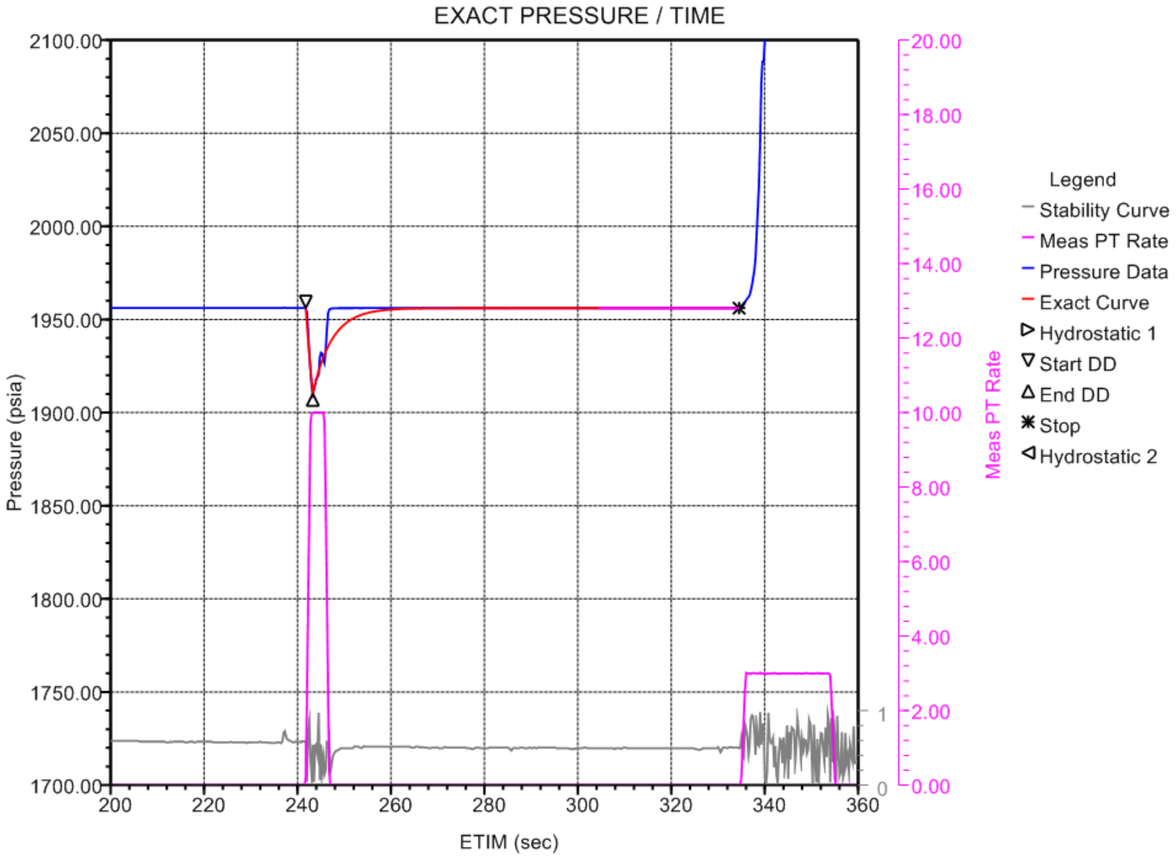
REMARKS

Excellent Buildup Stability

Test No. 9.1; MD: 4804.00 ft; TVD: 4804.00 ft

RDT Test File # 5-12.1 Date: 26-Mar-13 02:04:40

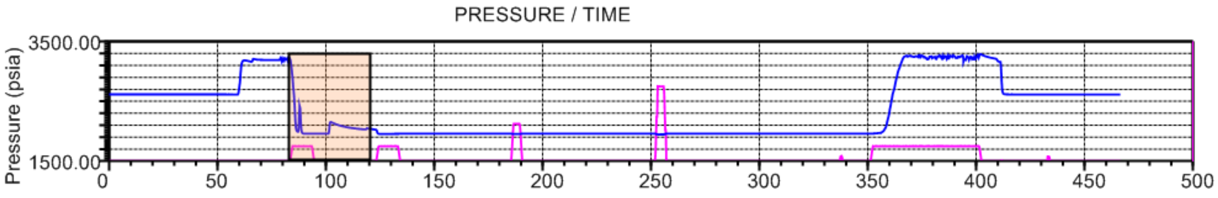


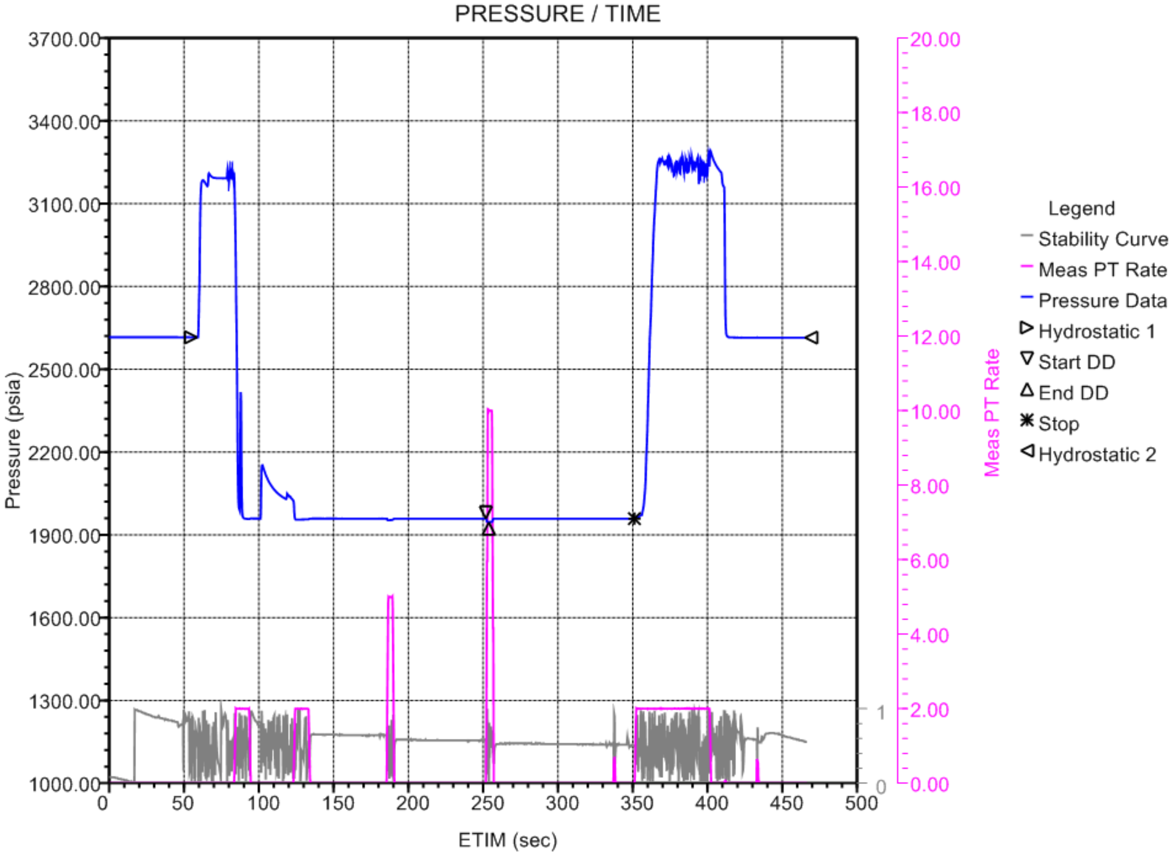


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4804.00	4804.00	1910.19	1956.14	1956.14	82.2
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
9.56	6.37	0.66	0.25	7.46e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.09	0.00	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 10.0; MD: 4810.02 ft; TVD: 4810.02 ft

RDT Test File # 5-13.0 Date: 26-Mar-13 02:13:11





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4810.02	2615.83	2614.84							

CONSTANTS - SPHERICAL FLOW

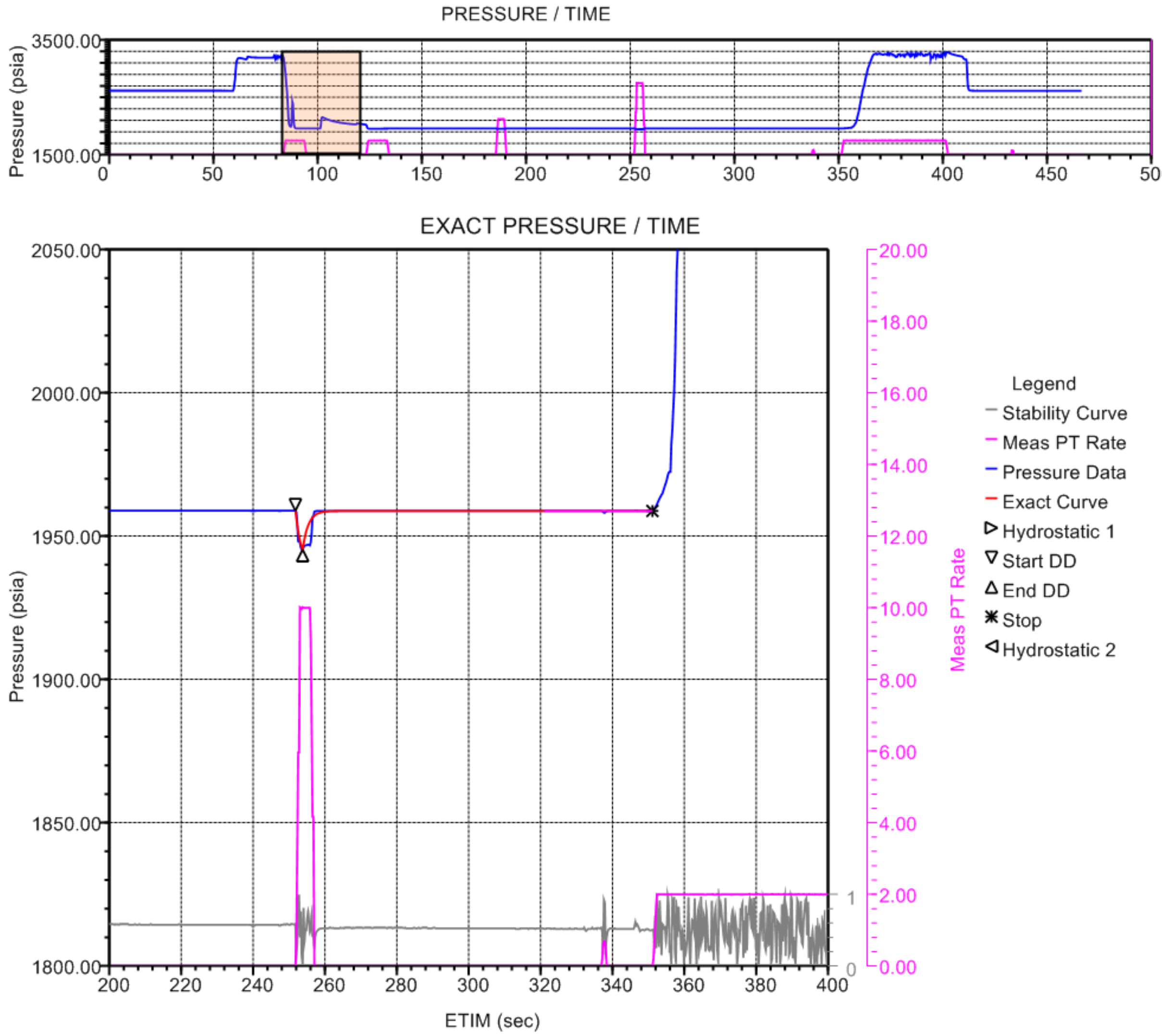
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
13.83	6.91	0.66	0.25	1.52e-003	180.00

REMARKS

Excellent Buildup Stability

Test No. 10.1; MD: 4810.02 ft; TVD: 4810.02 ft

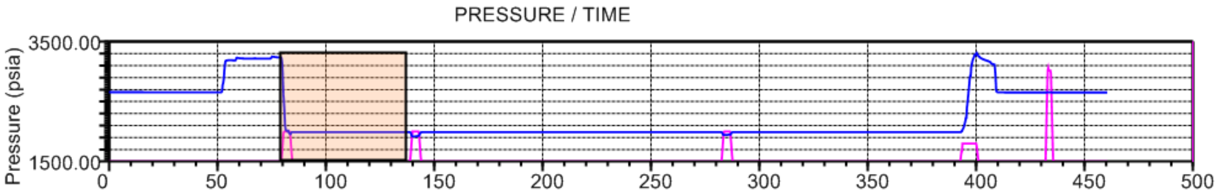
RDT Test File # 5-13.1 Date: 26-Mar-13 02:13:11

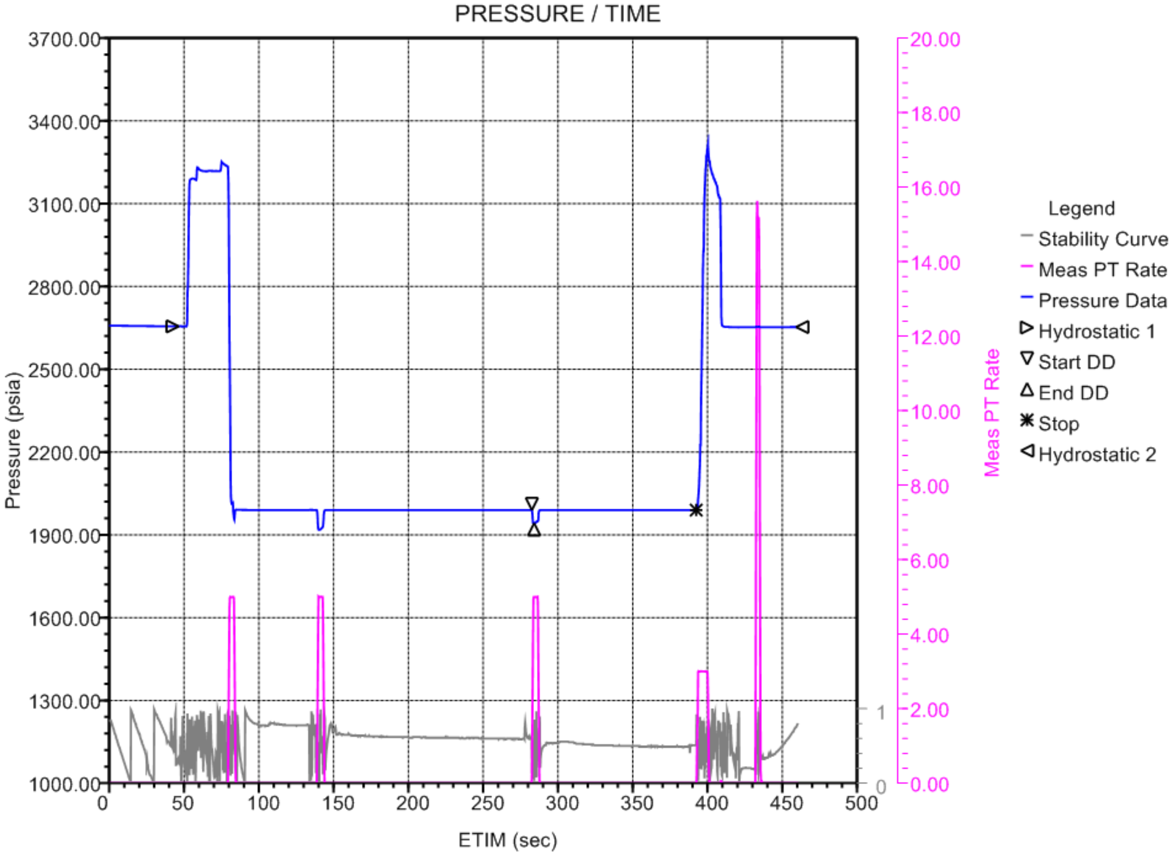


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4810.02	4810.02	1945.29	1958.78	1958.78	713
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
13.83	6.91	0.66	0.25	1.52e-003	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.06	-0.02	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 11.0; MD: 4880.01 ft; TVD: 4880.01 ft

RDT Test File # 5-14.0 Date: 26-Mar-13 02:23:17





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4880.01	2655.59	2653.02							

CONSTANTS - SPHERICAL FLOW

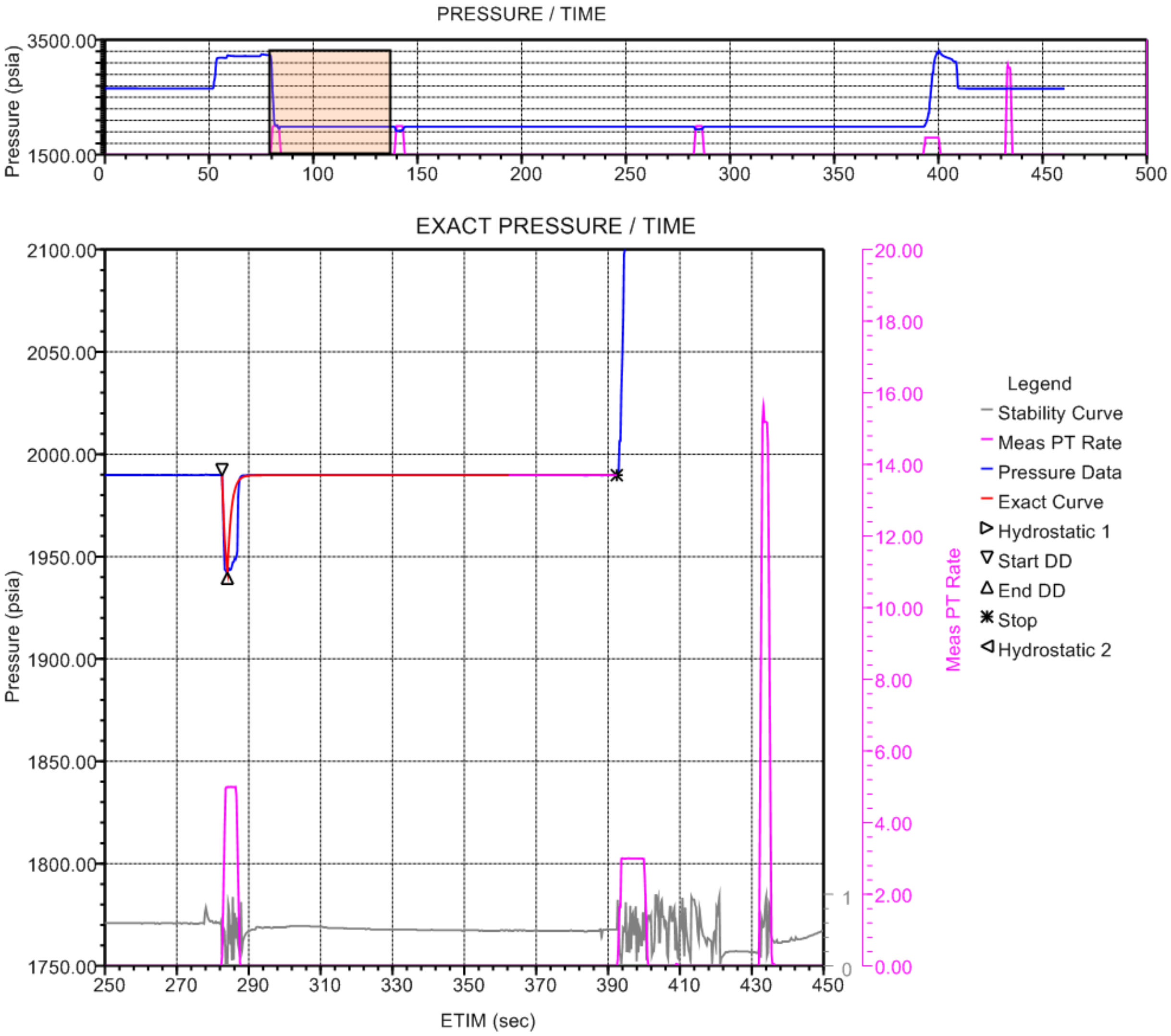
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
5.01	3.34	0.66	0.25	2.23e-004	180.00

REMARKS

Excellent Buildup Stability

Test No. 11.1; MD: 4880.01 ft; TVD: 4880.01 ft

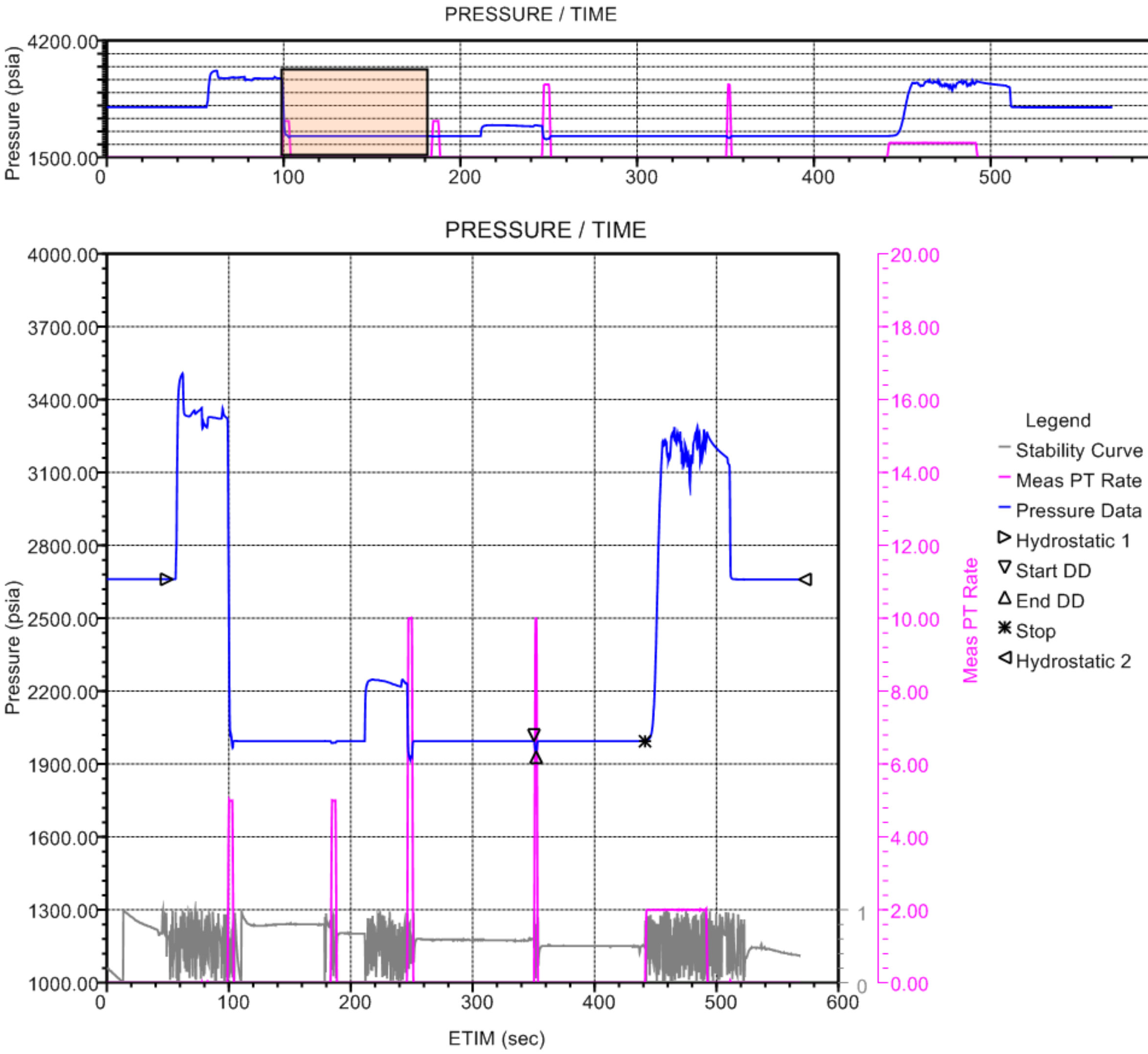
RDT Test File # 5-14.1 Date: 26-Mar-13 02:23:17



EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4880.01	4880.01	1942.30	1989.77	1989.77	101
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
5.01	3.34	0.66	0.25	2.23e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.02	0.01	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 12.0; MD: 4890.02 ft; TVD: 4890.02 ft

RDT Test File # 5-15.0 Date: 26-Mar-13 02:32:40



PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4890.02	2660.62	2659.93							

CONSTANTS - SPHERICAL FLOW

Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
12.72	7.26	0.66	0.25	6.99e-004	180.00

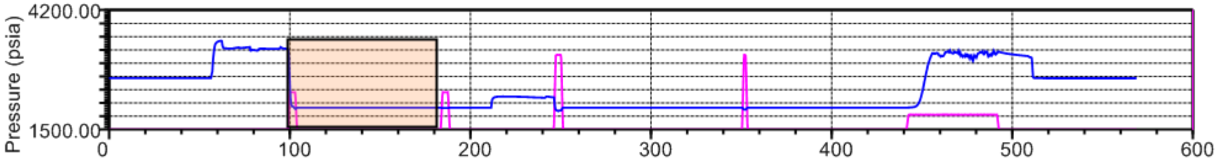
REMARKS

Excellent Buildup Stability

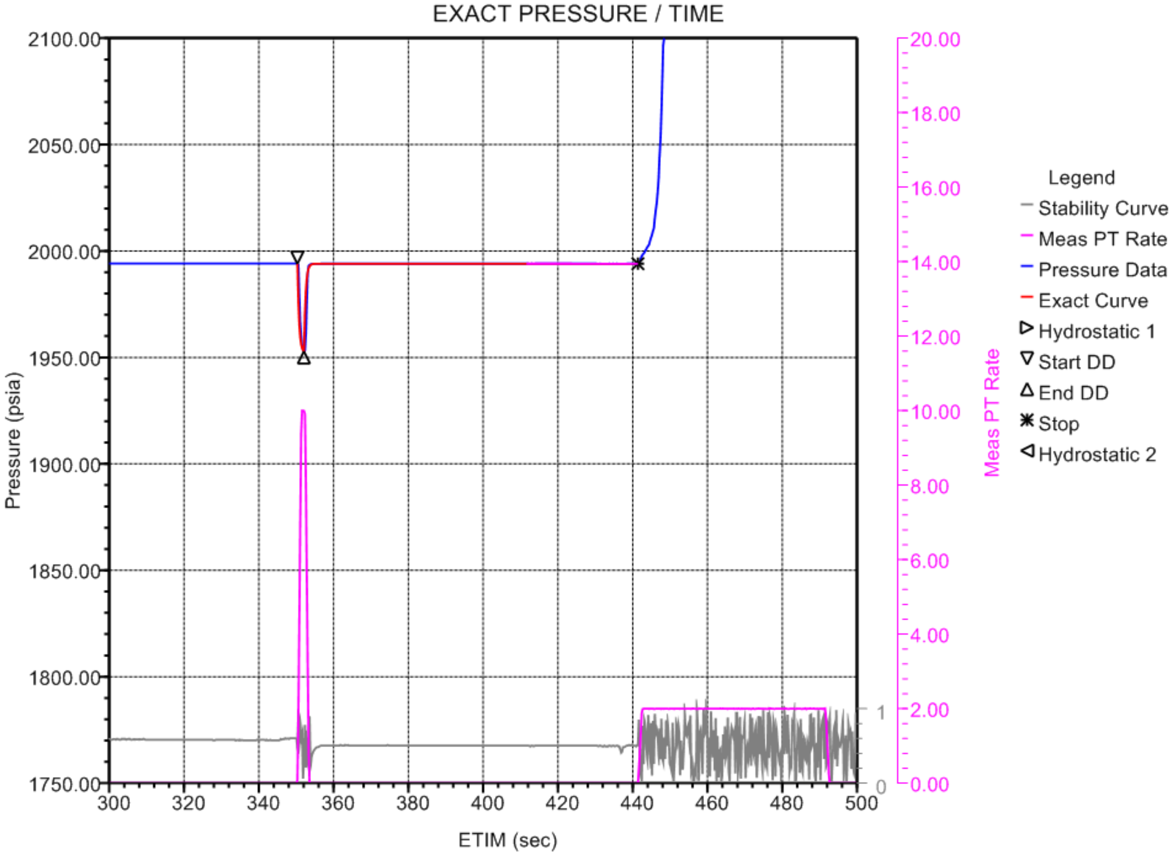
Test No. 12.1; MD: 4890.02 ft; TVD: 4890.02 ft

RDT Test File # 5-15.1 Date: 26-Mar-13 02:32:40

PRESSURE / TIME



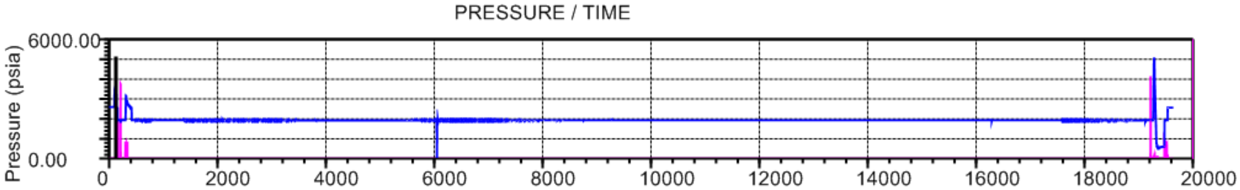
EXACT PRESSURE / TIME

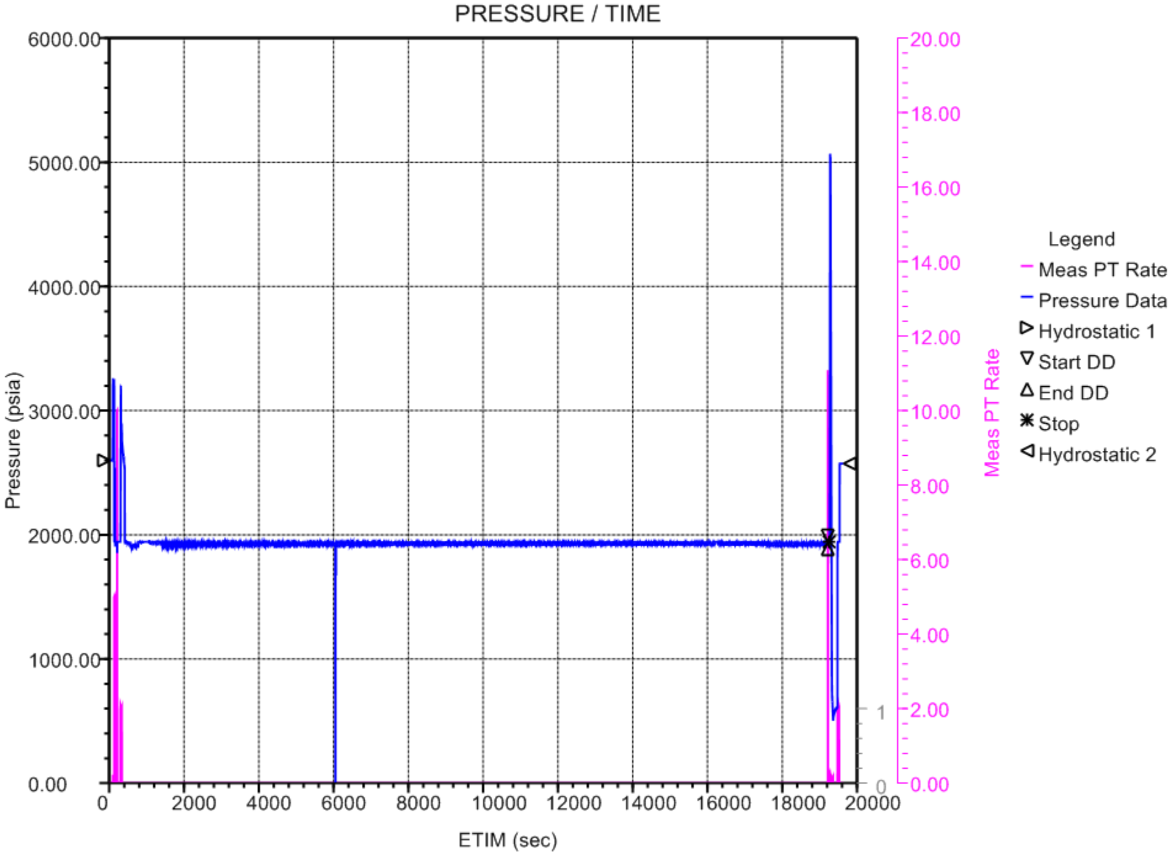


EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4890.02	4890.02	1952.88	1994.05	1994.05	333
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
12.72	7.26	0.66	0.25	6.99e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.02	0.00			
REMARKS					
Excellent Buildup Stability					

Test No. 13.0; MD: 4774.00 ft; TVD: 4774.00 ft

RDT Test File # 5-16.0 Date: 26-Mar-13 02:47:46





PRESSURE/TIME PLOT SUMMARY

Depth	Hydrostatic		Pretest Pressures			Pretest Times			Mobility
MD (ft)	Phyds1 (psia)	Phyds2 (psia)	Psdd (psia)	Pedd (psia)	Pstop (psia)	Tsdd (sec)	Tedd (sec)	Tstop (sec)	Mdd (md/cp)
4774.00	2599.36	2574.01							

CONSTANTS - SPHERICAL FLOW

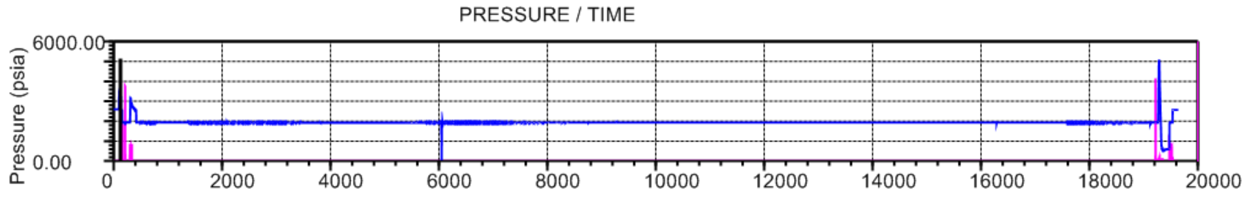
Volume (cc)	Rate (cc/sec).	Rsnorkel (in)	Porosity (fraction)	Ct (1/psia)	Flow-line Storage (cc)
2.60	5.20	0.66	0.25	9.70e-004	180.00

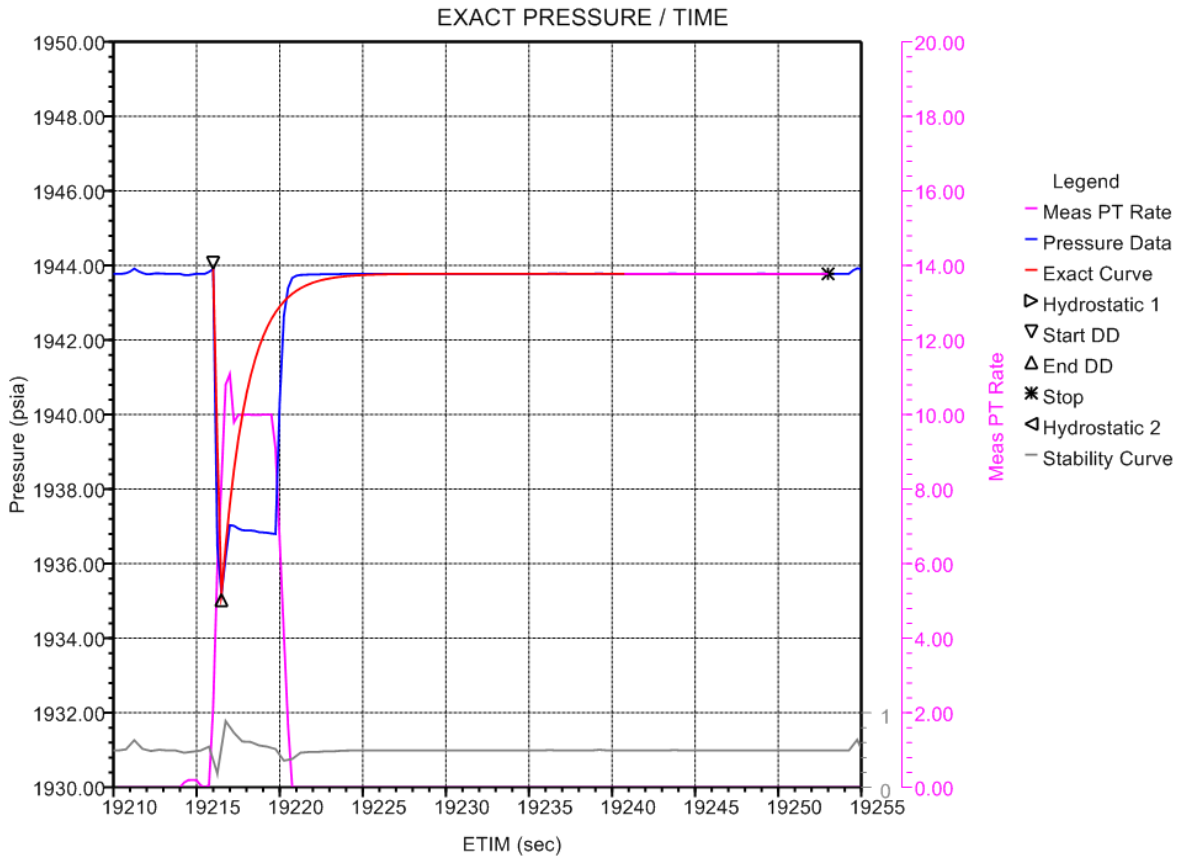
REMARKS

Excellent Buildup Stability

Test No. 13.1; MD: 4774.00 ft; TVD: 4774.00 ft

RDT Test File # 5-16.1 Date: 26-Mar-13 02:47:46





EXACT PRESSURE / TIME PLOT SUMMARY					
MD (ft)	**TVD (ft)**	**Pedd (psia)**	**Pstop (psia)**	**Pexact (psia)**	**Mexact(md/cp)**
4774.00	4774.00	1935.19	1943.78	1943.78	323
CONSTANTS - SPHERICAL FLOW					
Volume (cc)	**Rate (cc/sec).**	**Rsnorkel (in)**	**Porosity (fraction)**	**Ct (1/psia)**	**Flow-line Storage (cc)**
2.60	5.20	0.66	0.25	9.70e-004	180.00
TEST CONDITIONS & STATUS					
+/- stdev (psia)	**Stability (psi/min).**	**Stability (deg/min).**	**Pump Status**	**Exposure Time (hr).**	**Tool Face (deg).**
0.01	-0.00	0.00			
REMARKS					
Excellent Buildup Stability					

Disclaimer

DATA, RECOMMENDATIONS, INTERPRETATIONS LIMITATIONS

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A524: Summary logging and coring program_ 2Fields_ACTUAL

Logging and Coring Program Summary

				Depth Range (ft MD)	
Logging / Coring Program		**Halliburton Tool**	**Primary Purpose**	**East Islands Morias #16-2**	**King Island Piacentine #2-27**
Open-hole	Conventional Coring	N/A (Baker-Hughes)	Reservoir parameters	4649' - 4764'	4641' - 4816'
	Sidewall coring (SWC)	Percussion Sidewall Coring Tool	Reservoir parameters. Compare results to those from coventional core and relate to future well SWC results.	4674' - 4830'	4640' - 4809'
	Mud Log	N/A (Geolog)	lithology, rate of penetration, gas shows	3010' - 4993'	4200' - 4970'
	Spontaneous Potential (SP) log	Spontaneous Potential (SP)	Sand layer definition, formation water salinity	527' - 4985'	613' - 4960'
	Dual induction log (DIL)	Array Compensated True Resistivity (ACRt)	Formation water salinity, hydrocarbon indicator, water/hydrocarbon saturation (with porosity measurements)		
	Micro-resistivity Tool (MRT)	Micro Log (ML)	Flushed and invaded zone resistivity, permeability indicator		
	Gamma Ray (GR) log	Gamma Ray (GR)	Shale indicator		
	Formation Density Compensated (FDC) log	Spectral Density Log (SDL)	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)		
	Compensated Neutron Log (CNL)	Dual Spaced Neutron Log (DSN)	Porosity measurement, water/hydrocarbon saturation (with resistivity measurements)		
	Sonic log (SL)	Borehole Compensated Sonic Array (BSAT)	Formation velocity, synthetic seismograms. Can be used for porosity determination, though usually inferior to TLD/CNL.		
	Caliper log (CAL)	ICT Multi-arm Caliper	Show variations in borehole size and geometry		
	Electrical Micro Imaging (EMI) log	Extended Range Micro-imager (XRMI)	Formation texture, sedimentary features, fractures, thin-bed and lamination characterization		3800' - 4960'
	Nuclear Magetic Resonance (NMR)	Magnetic Resonance Imaging Logging (MRIL)	Clay-bound, capillary-bound and movable water; free-fluid, effective and total porosity.		3800' - 4957'
	Repeat Formation Tester (RFT)	Reservoir Description Tool (RDT)	Depth-discrete water sampling, pressure measurement, permeability determination. Identification of USDWs, and the USDW base. Estimated six water samples with Multi-sample Module (MRMS).		Ran 13 pressure tests between 4630' - 4890'; and collected water sample (in 3 cylinders) at 4774'
Cased-hole	Cement bond log (CBD)	Radial cement bond log (RCBL) NL/GR	Evaluate integrity of annular cement seal and identify channels that might allow fluids to migrate between formations	Surface to 4904'	Surface to 4868'