CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Citrus Heights Hydrogen Station

Prepared for: California Energy Commission

Prepared by: Equilon Enterprises LLC (dba Shell Oil Products US)

Gavin Newsom, Governor

February 2021 | CEC-600-2021-003

California Energy Commission

Julia DiPalma, Omar Shkeir
Primary Authors

Equilon Enterprises LLC (dba Shell Oil Products US)
650 California Street, Suite 2250
San Francisco, CA 94108
Company Website (www.shell.com/hydrogen)

Contract Number: ARV-17-001

Mark Johnson
Commission Agreement Manager

Mark Wenzel
Office Manager
ADVANCED VEHICLE INFRASTRUCTURE OFFICE

Hannon Rasool
Deputy Director
FUELS AND TRANSPORTATION

Drew Bohan
Executive Director

ACKNOWLEDGEMENTS

At Shell Hydrogen, we are focused on making hydrogen fuel a mainstream and competitive option for zero-emission transportation. Developing the network of hydrogen fueling stations under this grant funding opportunity has accomplished significant progress for fuel cell electric vehicle customers in California, including the fastest delivery of new stations to date in California for improving coverage and capacity in the fueling network, two fueling positions at each station for improving customer service, station reliability through two entirely redundant systems at each station, and integration under the canopy alongside other fuels for safety of traffic flow, convenience, shelter, and the normalcy of refueling. We would like to thank the following individuals and business partners for significant contributions to this success:

- The California Energy Commission (CEC) Lead Transportation Commissioner, Patty Monahan, who provided visionary leadership and direction for the hydrogen mobility in the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program, CEC Hydrogen Unit Supervisor, Jean Baronas, who provided diligent program administration with helpful attention to detail and direct engagement, as well as the various commission agreement managers and officers who provided thoughtful and constructive oversight of the Citrus Heights station delivery.
- AU Energy, which is a high-quality and forward-thinking owner and operator of the Shell retail stations in California. Varish Goyal, Sunny Goyal, and Kpish Goyal are important business partners for their successful introduction of hydrogen fuel in California and represent the model of family business in California.
- The leading manufacturers of fuel cell electric vehicles, Craig Scott with Toyota Motors North America, and Robert Bienenfeld and Stephen Ellis with American Honda. They are important business partners for their direct financial contributions to these stations as well as their dedication to the introduction of fuel cell electric vehicles. Their ongoing collaboration ensures the highest quality of customer service.
- The NEL service and operations teams, who are important business partners for increasing the quality and capacity of hydrogen fueling station equipment in these stations and ongoing partnership in the successful operation and maintenance of the stations.
- The Fiedler Group Team, who was instrumental in managing the permitting process, which often entailed the challenging task of introducing jurisdictions to hydrogen refueling stations. Fiedler Group

also managed the detailed design and construction on site, drawing from their deep expertise in the retail refueling business.

- The team at Fastech Inc., who did an exceptional job with the construction of the site and was on the front line of managing the daily hazardous aspects of construction. Their careful work and planning resulted in no injuries to personnel, asset, or the environment.
- The local authorities having jurisdiction for the stations – Sacramento, San Francisco, Berkeley, Walnut Creek, and San Jose – who worked collaboratively throughout the evaluation and permitting of these stations, and in doing so have continued to expand upon the base of experience that will enable continued expansion of the hydrogen fueling network that is an important component of the infrastructure to transition to zero emission transportation.

PREFACE

Assembly Bill (AB) 118 (Nùñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. AB 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the Energy Commission allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of approximately $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued grant funding opportunity GFO-15-605 to grant funds to expand the network of publicly accessible hydrogen fueling stations that serve California's light duty fuel cell electric vehicles. In response to GFO-15-605, the recipient submitted an application which was proposed for funding in the CEC's Notice of Proposed Awards dated February 17, 2017, and the agreement was executed as ARV-17-001 on August 10, 2017.

ABSTRACT

Equilon Enterprises LLC (dba Shell Oil Products US) designed, engineered, permitted, constructed, and made operational a hydrogen refueling station at 6141 Greenback Lane, Citrus Heights, California. The station consists of a concrete reinforced block compound that encloses hydrogen storage, compression, and cooling equipment; two dispensers with one fueling hose each; and two customer payment point-of-sale terminals. Hydrogen dispensers are co-located with gasoline dispensers under the canopy of an existing Shell gas station.

Keywords: California Energy Commission, Citrus Heights, Equilon Enterprises, Shell Oil Products, fuel cell electric vehicles, hydrogen refueling station, infrastructure, FCEV

Author(s) Shkeir, Omar; DiPalma, Julia; Leighty, Wayne; Hoban, Michael; Wiens, Richard. Equilon Enterprises, LLC dba Shell Oil Products US. 2019. *Citrus Heights Hydrogen Station*. California Energy Commission. Publication Number: CEC-600-2021-003.

TABLE OF CONTENTS

Page

Acknowledgements i
Preface iii
Abstract iv
Table of Contents v
List of Figures v
List of Tables vi
Executive Summary 1
CHAPTER 1: Introduction 3
Objectives 3
Approach 3
Activities Performed 3
CHAPTER 2: Station Design, Construction and Startup 4
Major Activities and Timeline 4
Commissioning and Startup (October 12, 2018 to December 6, 2018) 13
Operational Station (December 18, 2018) 13
Open Retail Station (December 18, 2018) 13
List of Subcontractors and Value 16
CHAPTER 3: Data Collection and Analysis 18
Data Reporting 18
Economic Impact 18
Environmental Impact 19
CHAPTER 4: Statement of Future Intent 20
CHAPTER 5: Findings, Conclusions, and Recommendations 21
Glossary 23

LIST OF FIGURES

Page

Figure 1: Preliminary Site Plan 6
Figure 2: Site Plan Approved by the Planning Department 9
Figure 3: Site Plan for Construction 10

Figure 4: Field Assembly of Storage Module 11
Figure 5: Two Compressor Modules 11
Figure 6: View of the Completed Station 12
Figure 7: Fenced Equipment Compound 12
Figure 8: First Fueling of an FCEV (Honda Clarity owned by project team member on December 6, 2018) 13
Figure 9: Hydrogen Fuel Quality Report (November 8, 2018) 14
Figure 10: Screen Shot of the SOSS Web Page with Citrus Heights Listed as a New Station 15

LIST OF TABLES

Page

Table 1: List of Equipment Suppliers and the Value of Their Contracts 16
Table 2: List of Subcontractors and the Value of Their Subcontracts 16
Table 3: Total Project Cost and Total Energy Commission Cost Share 17

EXECUTIVE SUMMARY

Equilon Enterprises LLC (dba Shell Oil Products US) built a hydrogen fueling station at its existing gasoline station located at 6141 Greenback Lane, Citrus Heights, California, 95621. Under Grant Funding Opportunity-15-605, the CEC funded 58.9 percent of the total cost of the station while Shell provided the balance for a total station cost of $3,971,700. The CEC contributed $2,337,500.

The hydrogen station has a refueling capacity of 400 kilograms per day, dispensed via two single-hose dispensers that are located under the canopy, in the same fueling lanes that gasoline cars use for refueling.

Shell's project team comprised of Fiedler Group as engineer of record, NEL Hydrogen as the equipment vendor, installer and operations and maintenance contractor, and Fueling and Service Technologies as the general contractor.

The hydrogen station equipment, supplied by NEL Hydrogen, attained an Underwriter Laboratories Certificate of Compliance on October 25, 2018.

The station took less than 17 months to achieve an open retail status, from the time when Fiedler Group initiated preapplication meetings with the authorities having jurisdiction to the open retail date of December 18, 2018. The first fueling of a fuel cell electric vehicle was on December 6, 2018.

Shell initiated site acquisition negotiations with AU Energy, the joint owner and operator for the Citrus Heights Shell gasoline station. A complete agreement was executed on August 17, 2016.

Fiedler Group initiated the first of three rounds of preapplication meetings with the authority having jurisdiction in March 2017. An entitlement application package was submitted to the Citrus Heights Planning department in August 2017 and was approved in October 2017. A submission to the building department for construction permit was made in early December 2017 and conditional approval was obtained on December 28, 2017. Final approval of the construction permit was obtained on March 8, 2018.

Shell initiated equipment procurement with NEL Hydrogen in April 2017. On-site delivery and installation of the equipment was completed in October 2018.

After a competitive bidding process, Shell awarded Fastech the contract for civil construction. Construction of the station began on April 23, 2018. The station, with all equipment installed, was ready for a pre-startup safety review on October 12, 2018.

Precommissioning activities began on October 12, 2018, and the first fuel cell electric vehicle was filled on December 6, 2018, after obtaining a certificate of

accuracy for the dispensers, issued on November 11, 2018, by California Department of Food and Agriculture, Division of Measurement Standards.

Shell collected one year of operational data, which was submitted to the CEC. This includes quarterly reporting of all fueling, maintenance, operations data; four hydrogen quality reports; and two reports of dispensed renewable hydrogen. If one average hydrogen fuel cell electric vehicle takes one average gasoline mid-sized sedan off the road, the amount of gasoline displaced due to Citrus Heights operation using one year of data (December 2018 to December 2019) would equal nearly 23,265 gallons displaced per year.

Shell plans to operate the Sacramento station for at least the next ten years and plans to operate up to 56 other light-duty stations in California in addition to heavy -duty stations. Shell is a committed participant and supporter of California's vision for the hydrogen refueling station network.

CHAPTER 1:
Introduction

Objectives

The Citrus Heights station is one of seven stations that Equilon Enterprises LLC (dba Shell Oil Products US) designed and constructed under awards from the California Energy Commission (CEC), granted under its grant funding opportunity, GFO-15-605. The objective of this project was to design, build, commission and open a retail hydrogen service station co-located at an existing Shell gasoline station at 6141 Greenback Lane, Citrus Heights, California, 95621.

Approach

Shell's overall approach to the development of its hydrogen refueling station infrastructure has the following key elements:

- Make the customers refueling experience as similar as possible to that of refueling gasoline powered vehicles. This is achieved by co-locating hydrogen dispensers and associated point of sale (POS) terminals with the gasoline dispensers under the canopy of its branded gas stations.
- Employ standardized equipment design and performance characteristics across all its hydrogen refueling stations.
- Employ modular equipment with the smallest possible footprint to permit installation in existing stations that are space constrained. Such stations are typically located in urban, densely developed sites. This allows Shell to bring hydrogen refueling stations to city centers.
- Team with engineering firms, equipment manufacturers, and construction contractors with proven records of designing and building service stations.

Activities Performed

Shell performed the following activities:

- Site Acquisition
- Preliminary Investigations
- Equipment Procurement
- Entitlements
- Design and Permitting
- Bid Solicitation
- Construction
- Commissioning and Startup
- Operational and Open Retail Station
- Data Collection and Analysis

CHAPTER 2:
Station Design, Construction and Startup

Major Activities and Timeline

Construction of the Citrus Heights station required many activities that are listed and described below along with an approximate timeline for their execution. Shell negotiated site acquisition agreement and procured the hydrogen station equipment.

Shell retained Fiedler Group (FG) to prepare documents required for design, entitlements, permitting, bid solicitation and construction services. FG implemented its phased approach to accomplish the preparation of the documents, exhibits and attain a permit ready to issue status. The project team comprised of Shell, NEL hydrogen (NEL), FG and the construction contractor, Fueling and Service Technologies Inc. (Fastech), executed the following phases to achieve an open retail station:

- Site Acquisition
- Preliminary Investigations
- Equipment Procurement
- Entitlements
- Design and Permitting
- Bid Solicitation
- Construction
- Commissioning and Startup
- Operational and Open Retail Station

Site Acquisition (August 2016)

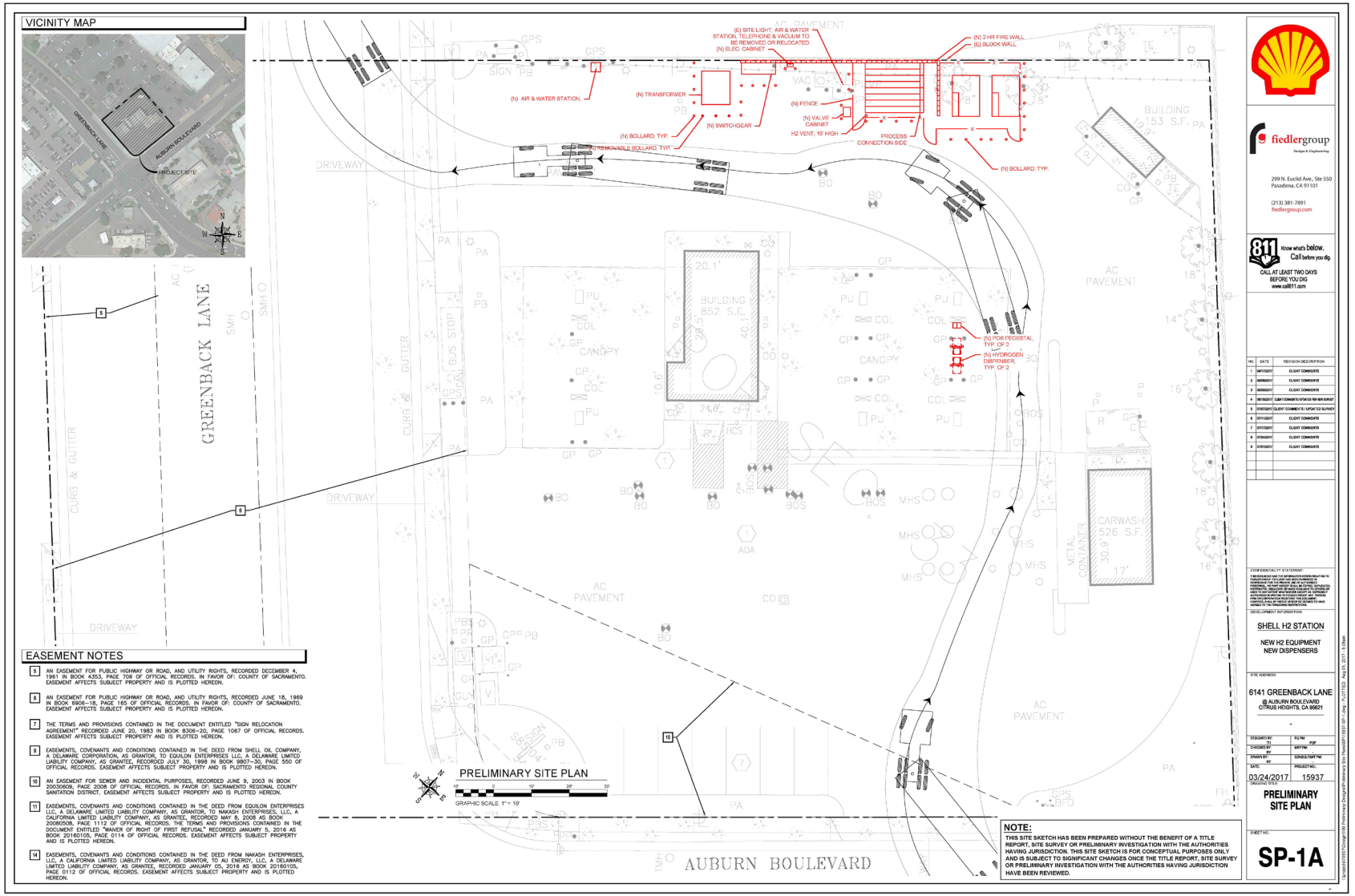
The Citrus Heights station is at an existing Shell branded station operated by AU Energy (AUE). The site is jointly owned by Shell and AUE. Shell and AUE entered into negotiations to build a hydrogen station, and the completed agreement was executed on August 17, 2016.

Preliminary Investigations (March 2017 to June 1, 2017)

FG investigated the requirements of government agencies and utilities. This entailed discovery of requirements, codes, ordnances and regulations that impact entitlements, permitting, and design criteria. A site investigation report was developed based on agency contact. Shell contacted the following agencies: City of Citrus Heights Planning, Building and Public Works Departments; Sacramento County Business Environmental Resource Center (BERC), Sacramento Metro Fire, and Sacramento Municipal Utility District (SMUD). Shell prepared a preliminary

site plan based on Shell's design requirements, agency findings and site visit. Figure 1 illustrates the preliminary site plan.

Figure 1: Preliminary Site Plan



Source: Fiedler Group

Equipment Procurement (April 10, 2017 to December 18, 2018)

Shell selected NEL, to supply the hydrogen station equipment. Shell contracted with NEL to supply, install, and commission all equipment necessary to achieve an operational hydrogen station. NEL supplied the following major hydrogen station equipment: station module (containing compressor and hydrogen cooling system), storage module and associated valve panels, supply cabinet and associated human machine interface, hydrogen dispensers and all interconnecting mechanical pipe and tubing between the equipment. Equipment delivery was timed to synchronize with the construction schedule. All the equipment was delivered to the site and installed on October 12, 2018.

Shell purchased the POS terminals from COMDATA.

Entitlement Process (August 3, 2017 to October 2, 2017)

FG submitted the entitlements drawing package to the authorities having jurisdiction (AHJ) on August 3, 2017. The planning department verified that the project meets the zoning requirements and approved aesthetic, landscaping and other details that are important to the community. Two sets of plan-check comments were received and addressed. Approval was received on October 2, 2017. Figure 2 illustrates the site plan approved by the planning department.

Site Design and Permitting (completed on March 8, 2018)

FG submitted the first design drawing package to the city of Citrus Heights on December 5, 2017. Two sets of plan check comments were received and addressed. Conditional approval was obtained on December 28, 2017. Shell received final approval of the construction permit on March 8, 2018. Figure 3 illustrates the site plan permitted for construction.

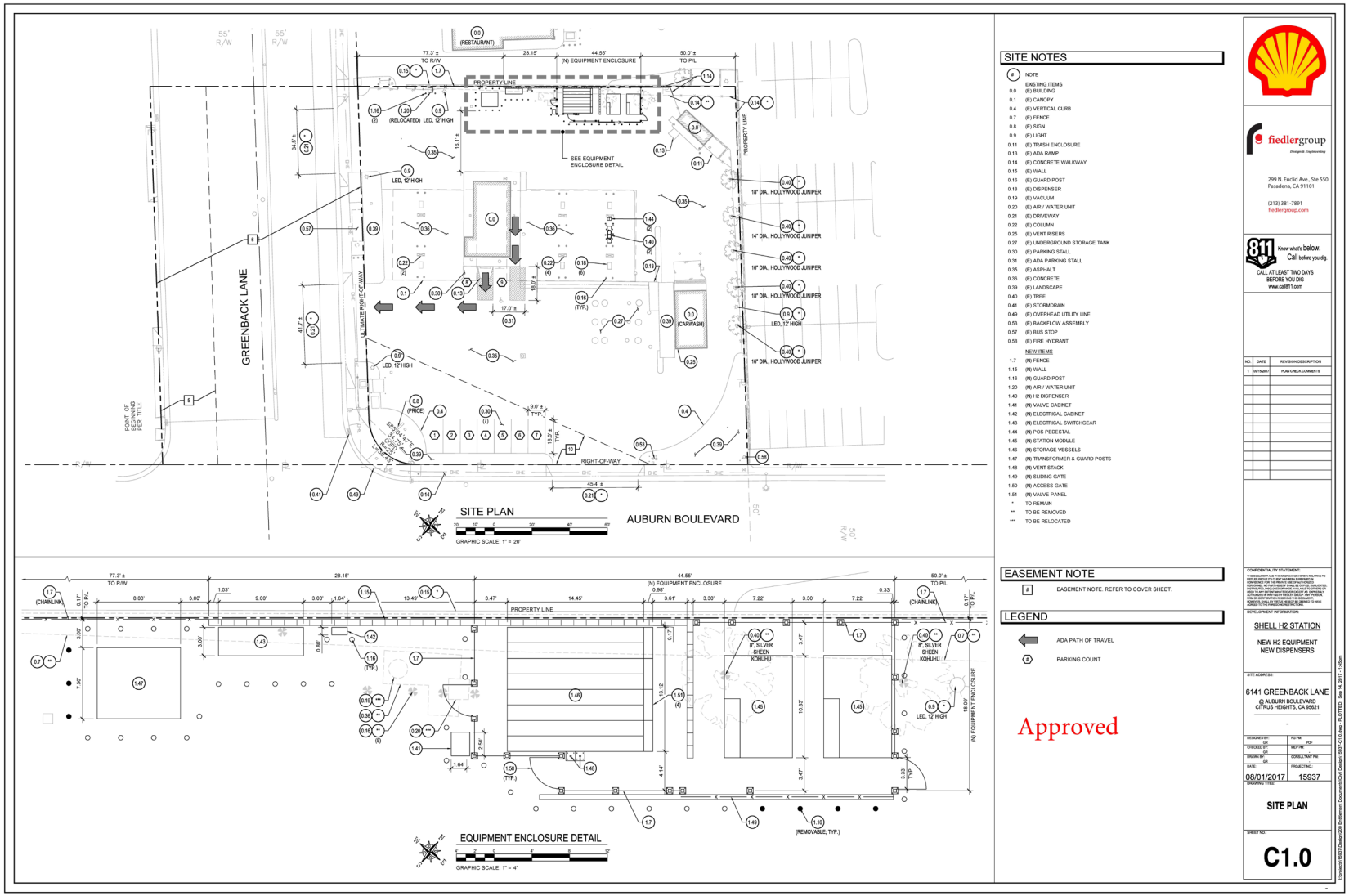
Bid Solicitation (February 1, 2018 to March 23, 2018)

FG prepared a bid solicitation package consisting of the drawing set, technical documents, and project manual. Shell invited four prequalified general contractors to bid. Two contractors declined to bid, citing workload constraints and unavailability for the planned mobilization date of April 2, 2018. Shell invited each contractor to attend a one-on-one prebid meeting. Shell received two bids and evaluated them against an engineer's independent cost estimate. In addition to cost, prior similar experience and current capability, safety performance, financial strength, and ability to mobilize and complete construction per the required schedule were also evaluated. Shell awarded a construction contract to FASTECH on March 23, 2018.

Construction (April 23, 2018 to October 12, 2018)

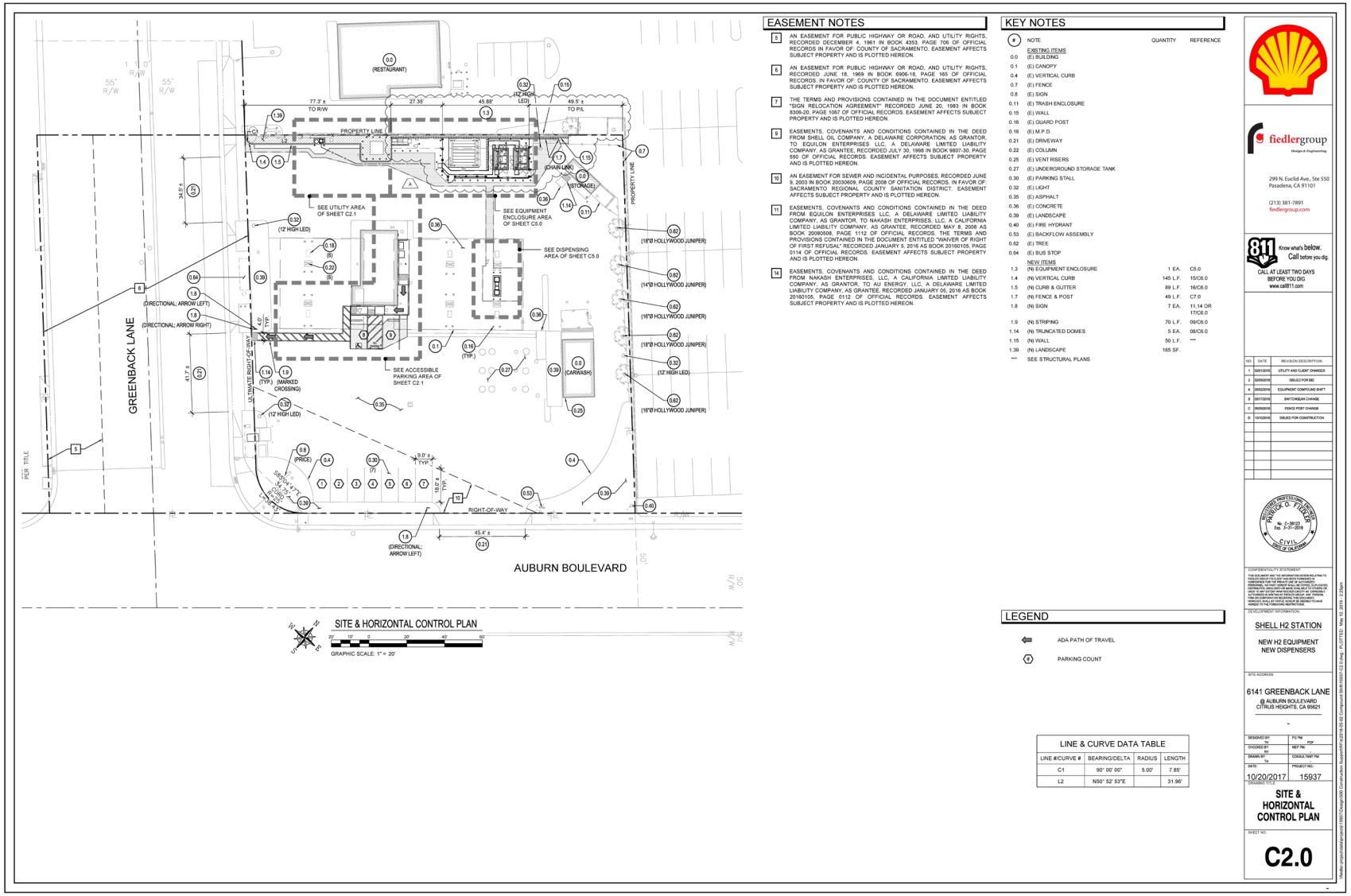
FASTECH mobilized to the site on April 23, 2018. All station equipment was installed on October 12, 2018. The utility service was energized on October 2, 2018. The prestart up safety review (PSSR) was conducted on October 12, 2018, and a check list of actions was developed. Figure 4 and Figure 5 illustrate assembly of the storage module and two compressor modules set on their foundation. Figure 6 and Figure 7 illustrate the completed hydrogen station.

Figure 2: Site Plan Approved by the Planning Department



Source: Fiedler Group

Figure 3: Site Plan for Construction



EASEMENT NOTES

5 AN EASEMENT FOR PUBLIC HIGHWAY OR ROAD, AND UTILITY RIGHTS, RECORDED DECEMBER 4, 1961 IN BOOK 4353, PAGE 709, OF OFFICIAL RECORDS IN FAVOR OF: COUNTY OF SACRAMENTO. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

6 AN EASEMENT FOR PUBLIC HIGHWAY OR ROAD, AND UTILITY RIGHTS, RECORDED JUNE 18, 1969 IN BOOK 6906-18, PAGE 165 OF OFFICIAL RECORDS, IN FAVOR OF: COUNTY OF SACRAMENTO. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

7 THE TERMS AND PROVISIONS CONTAINED IN THE DOCUMENT ENTITLED "SIGN RELOCATION AGREEMENT" RECORDED JUNE 20, 1983 IN BOOK 8306-20, PAGE 1067 OF OFFICIAL RECORDS. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

9 EASEMENTS, COVENANTS AND CONDITIONS CONTAINED IN THE DEED FROM SHELL OIL COMPANY, A DELAWARE CORPORATION, AS GRANTOR, TO EQUILON ENTERPRISES LLC, A DELAWARE LIMITED LIABILITY COMPANY, AS GRANTEE, RECORDED JULY 30, 1998 IN BOOK 9807-30, PAGE 550 OF OFFICIAL RECORDS. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

10 AN EASEMENT FOR SEWER AND INCIDENTAL PURPOSES, RECORDED JUNE 9, 2003 IN BOOK 20030609, PAGE 2008 OF OFFICIAL RECORDS. IN FAVOR OF: SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

11 EASEMENTS, COVENANTS AND CONDITIONS CONTAINED IN THE DEED FROM EQUILON ENTERPRISES LLC, A DELAWARE LIMITED LIABILITY COMPANY, AS GRANTOR, TO NAKASH ENTERPRISES, LLC, A CALIFORNIA LIMITED LIABILITY COMPANY, AS GRANTEE, RECORDED MAY 9, 2008 AS BOOK 20080508, PAGE 1112 OF OFFICIAL RECORDS. THE TERMS AND PROVISIONS CONTAINED IN THE DOCUMENT ENTITLED "WAIVER OF RIGHT OF FIRST REFUSAL" RECORDED JANUARY 5, 2016 AS BOOK 20160105, PAGE 0114 OF OFFICIAL RECORDS. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

14 EASEMENTS, COVENANTS AND CONDITIONS CONTAINED IN THE DEED FROM NAKASH ENTERPRISES, LLC, A CALIFORNIA LIMITED LIABILITY COMPANY, AS GRANTOR, TO AU ENERGY, LLC, A DELAWARE LIMITED LIABILITY COMPANY, AS GRANTEE, RECORDED JANUARY 05, 2016 AS BOOK 20160105, PAGE 0112 OF OFFICIAL RECORDS. EASEMENT AFFECTS SUBJECT PROPERTY AND IS PLOTTED HEREON.

KEY NOTES

#	NOTE	QUANTITY	REFERENCE
	EXISTING ITEMS		
0.0	(E) BUILDING		
0.1	(E) CANOPY		
0.4	(E) VERTICAL CURB		
0.7	(E) FENCE		
0.8	(E) SIGN		
0.11	(E) TRASH ENCLOSURE		
0.15	(E) WALL		
0.16	(E) GUARD POST		
0.18	(E) M.P.D.		
0.21	(E) DRIVEWAY		
0.22	(E) COLUMN		
0.25	(E) VENT RISERS		
0.27	(E) UNDERGROUND STORAGE TANK		
0.30	(E) PARKING STALL		
0.32	(E) LIGHT		
0.35	(E) ASPHALT		
0.36	(E) CONCRETE		
0.39	(E) LANDSCAPE		
0.40	(E) FIRE HYDRANT		
0.53	(E) BACKFLOW ASSEMBLY		
0.62	(E) TREE		
0.64	(E) BUS STOP		
	NEW ITEMS		
1.3	(N) EQUIPMENT ENCLOSURE	1 EA.	C5.0
1.4	(N) VERTICAL CURB	145 L.F.	15/C6.0
1.5	(N) CURB & GUTTER	89 L.F.	16/C6.0
1.7	(N) FENCE & POST	49 L.F.	C7.0
1.8	(N) SIGN	7 EA.	11,14 OR 17/C6.0
1.9	(N) STRIPING	70 L.F.	09/C6.0
1.14	(N) TRUNCATED DOMES	5 EA.	08/C6.0
1.15	(N) WALL	50 L.F.	***
1.39	(N) LANDSCAPE	165 SF.	
***	SEE STRUCTURAL PLANS		

LEGEND

ADA PATH OF TRAVEL

PARKING COUNT

LINE & CURVE DATA TABLE			
LINE #/CURVE #	BEARING/DELTA	RADIUS	LENGTH
C1	90° 00' 00"	5.00'	7.85'
L2	N50° 52' 53"E		31.96'

fiedlergroup
Design & Engineering
299 N. Euclid Ave., Ste 550
Pasadena, CA 91101
(213) 381-7891
fiedlergroup.com

811 Know what's below. Call before you dig.
CALL AT LEAST TWO DAYS BEFORE YOU DIG
www.call811.com

NO.	DATE	REVISION DESCRIPTION
1	02/01/2016	UTILITY AND CLIENT CHANGES
2	02/05/2016	ISSUED FOR BID
A	05/02/2016	EQUIPMENT COMPOUND SHIFT
B	09/17/2016	SWITCHGEAR CHANGE
C	05/22/2018	FENCE POST CHANGE
D	10/15/2018	ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
PATRICK O. FIEDLER
No. C-39123
Exp. 2-31-2019
CIVIL
STATE OF CALIFORNIA

CONFIDENTIALITY STATEMENT

THIS DOCUMENT AND THE INFORMATION HEREIN RELATING TO THE PROJECT ARE THE PROPERTY OF SHELL AND ARE CONFIDENTIAL FOR THE PRIVATE USE OF AUTHORIZED PERSONNEL ONLY. THIS DOCUMENT IS NOT TO BE COPIED, DISTRIBUTED, DISCLOSED OR MADE AVAILABLE TO OTHERS OR USED TO ANY EXTENT WHATSOEVER EXCEPT AS EXPRESSLY AUTHORIZED IN WRITING BY SHELL. BY ACCEPTING THIS DOCUMENT, YOU OR COMPANY OR BUILDING THIS SOLELY FOR SHELL AGREE TO THE FOREGOING RESTRICTIONS AND AGREE TO HONOR THE FOREGOING RESTRICTIONS.

DEVELOPMENT INFORMATION

SHELL H2 STATION

NEW H2 EQUIPMENT
NEW DISPENSERS

SITE ADDRESS

6141 GREENBACK LANE
@ AUBURN BOULEVARD
CITRUS HEIGHTS, CA 95621

DESIGNED BY:	TH	FG TM PDF
CHECKED BY:	MEP TM	
DRAWN BY:	TH	CONSULTANT PM
DATE:		PROJECT NO.:
10/20/2017		15937

DRAWING TITLE

SITE & HORIZONTAL CONTROL PLAN

SHEET NO.:

C2.0

Source: Fiedler Group

Figure 4: Field Assembly of Storage Module

Source: Fiedler Group

Figure 5: Two Compressor Modules

Source: Fiedler Group

Figure 6: View of the Completed Station

Source: Shell Hydrogen

Figure 7: Fenced Equipment Compound

Source: Shell Hydrogen

Commissioning and Startup (October 12, 2018 to December 6, 2018)

PSSR actions that were deemed prerequisite for introduction of hydrogen into the system were completed on October 24, 2018. Hydrogen was introduced into the system on October 26, 2018. California Department of Food and Agriculture, Division of Measurement Standards (DMS) certified dispenser accuracy on November 11, 2018. Commissioning and startup activities continued until December 6, 2018, when the first fuel cell electric vehicle (FCEV) was filled. Figure 8 illustrates fueling of the first FCEV at the station, which was a Honda Clarity that was owned by a member of the project team and was used to prove fueling capabilities. Figure 9 illustrates results of the hydrogen purity test.

Operational Station (December 18, 2018)

The first retail customer was served on December 18, 2018. The station was deemed operational on the same date. Connection to the Station Operational Status System (SOSS) network went live on December 18, 2018. Figure 10 illustrates the SOSS status of the new Citrus Heights Station.

Open Retail Station (December 18, 2018)

The first retail customer was served on December 18, 2018. The station was deemed open on the same date.

Figure 8: First Fueling of an FCEV (Honda Clarity owned by project team member on December 6, 2018)

Source: Shell Hydrogen

Figure 9: Hydrogen Fuel Quality Report (November 8, 2018)

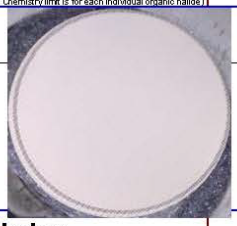
www.SmartChemistry.com

SAE J2719

Sampling Date: 11/08/2018 and 10/31/2018

Shell Citrus Height H70

SUMMARY	SAE J2719 Limits - µmol/mol	SMART CHEMISTRY Detection Limits - µmol/mol	Concentration (µmol/mol)
H_2O (ASTM D7849)	5	1	**3.7**
Total Hydrocarbons -C_1 Basis (ASTM D7892)	2		**0.12**
Methane			0.094
Acetone			0.014
Ethanol			0.013
O_2 (ASTM D7840)	5	2	< 2
He (ASTM D7948)	100	10	< 10
N_2 & Ar (ASTM D7840)	100		
N_2		5	< 5
Ar		0.4	< 0.4
CO_2 (ASTM D7840)	2	0.05	< 0.05
CO (ASTM D5466)	0.2	0.0005	**0.0032**
Total S (ASTM D7652)	0.004		**0.000087**
Hydrogen Sulfide		0.000002	**0.0000089**
Carbonyl Sulfide		0.000002	**0.0000223**
Methyl Mercaptan (MTM)		0.00001	< 0.00001
Ethyl Mercaptan (ETM)		0.00001	< 0.00001
Dimethyl Sulfide (DMS)		0.00001	< 0.00001
Carbon Disulfide		0.000001	**0.0000269**
Isopropyl Mercaptan (IPM)		0.00001	< 0.00001
Tert-Butyl Mercaptan (TBM)		0.00001	< 0.00001
n-Propyl Mercaptan		0.00001	< 0.00001
Thiophene		0.00001	< 0.00001
Diethyl Sulfide		0.00001	< 0.00001
n-Butyl Mercaptan		0.00001	< 0.00001
Dimethyl Disulfide (DMDS)		0.00001	< 0.00001
Tetrahydrothiophene (THT)		0.00001	**0.0000292**
Formaldehyde (ASTM D7892)	0.01	0.005	< 0.005
Formic Acid (ASTM D5466)	0.2	0.0005	< 0.0005
Ammonia (ASTM D5466)	0.1	0.005	< 0.005
Total Halogenates	0.05		< 0.01
Cl_2 (ASTM D5466)		0.0002	< 0.0002
HCl (ASTM D5466)		0.001	< 0.001
HBr (ASTM D5466)		0.0005	< 0.0005
Total Organic Halides (32 compounds in red and bold listed in "Non-Methane Hydrocarbons") (ASTM D7892, Smart Chemistry limit is for each individual organic halide)		0.001	< 0.001
Particulate Concentration (ASTM D7651)	1 mg/kg		**0.027 mg/kg**
Particulates Found & Size (ASTM D7596)			**There are total 17 particulates found (sizes in micrometer) - 187, 147, 130, 75, 71, 67, 59, 56, 51, 32 (3), 25, 20 (2), 12 (2).**
Hydrogen Fuel Index	99.97%		**99.999613%**



Source: SmartChemistry

Figure 10: Screen Shot of the SOSS Web Page with Citrus Heights Listed as a New Station

Source: California Fuel Cell Partnership (https://m.cafcp.org/)

List of Subcontractors and Value

Table 1 and Table 2 list the equipment suppliers and subcontractors and the value of their contracts. Table 3 shows the total project cost and the total CEC cost share.

Table 1: List of Equipment Suppliers and the Value of Their Contracts

Equipment Supplier	Description	CEC Grant	Shell Match	Total
NEL Hydrogen, San Leandro, CA	Hydrogen station equipment -- supply, install and commission the station	$2,288,806.00	$573,729.00	$2,862,535.00
COMDATA, Brentwood, TN	Supply (POS) terminals for recording sale transactions	$34,338.37	$0.00	$34,338.37
Benfield, White Plains, NY	Supply switchgear for power distribution	$14,354.00	$11,596.00	$25,950.00
Equipment Total		**$2,337,498.37**	**$585,325.00**	**$2,922,823.37**

Source: Fiedler Group

Table 2: List of Subcontractors and the Value of Their Subcontracts

Subcontractor	Description	CEC Grant	Shell Match	Total
Fiedler Group, Pasadena, CA	Engineering, procurement, construction management contractor	$0.00	$305,019.00	$305,019.00
Fastech, Buena Park, CA	General contractor for civil construction	$0.00	$743,869.00	$743,869.00
Subcontracts Total		**$0.00**	**$1,048,888.00**	**$1,048,888.00**

Source: Fiedler Group

Table 3: Total Project Cost and Total CEC Cost Share

Category	CEC Grant	Shell Match	Total
Equipment Total	$2,337,498.37	$585,325.00	$2,922,823.37
Subcontracts Total	$0.00	$1,048,888.00	$1,048,888.00
Grand Total	**$2,337,498.37**	**$1,634,213.00**	**$3,971,711.37**
Total CEC Cost Share	**58.9%**	**N/A**	**N/A**

Source: Fiedler Group

CHAPTER 3:
Data Collection and Analysis

Data Reporting

Shell collected one year of operational data and submitted to the CEC. This includes four quarterly reportings of all fueling, maintenance, operations data; four hydrogen quality reports; and two reports of dispensed renewable hydrogen.

Economic Impact

The project required construction and high-tech firms to build and maintain the Citrus Heights station. The funding was awarded predominantly to California construction and technology firms that had the expertise and qualifications. The workers and firms developed hydrogen dispensing expertise during the construction and support of the refueling station, which was valuable, and will be directly transferable to other hydrogen refueling station developers in California and abroad for the foreseeable future.

The on-site jobs to handle the initial construction for the Citrus Heights station included roughly 25 full-time temporary positions including local engineering resources, masonry and electrical workers, pipefitters, welders, truck drivers, environmental engineers, and others. Internally, Shell created two full-time permanent roles to manage the construction and project phase of the development of the station, and one full-time permanent role to maintain the stations, collect and report the technical data, and support the operations. Shell also created one full-time role to develop future hydrogen refueling station growth within California.

Shell estimates the funding awarded to California-based companies and employees to be about $750,000 for the Citrus Heights station. The California-based companies that Shell contracted with included NEL and Air Products and Chemicals, Inc. NEL supplied critical fueling dispenser and equipment for the station and established full-time positions solely to prepare market expansion and provision of equipment for California. The team consists of California-based technicians who are qualified and trained to conduct maintenance as well as any advanced station repair. Air Products and Chemicals Inc. supplies and transports the hydrogen fuel to the Citrus Heights station and manufactures the hydrogen fuel predominantly from California-based operations.

The generation of California taxes is a direct and immediate economic benefit. These taxes can be utilized to provide government services to the disadvantaged communities, which can provide a direct benefit to the community. These taxes

were generated upon launch of the project and continues through with the operation of the station. The estimated California taxes collected over five years is valued at $3,446,516.

Environmental Impact

If one average hydrogen FCEV takes one average gasoline mid-sized sedan off the road, the amount of gasoline displaced due to Citrus Heights operation using one year of data (2019) would equal 23,265 gallons displaced per year.

The resulting air emissions reduction, using the assumptions above, would equal 206 metric tons of CO2e per year. The assumptions used to calculate this emissions reduction are below.

- Average mileage of a mid-sized hydrogen FCEV is 312 miles per tank, and one tank is on average 5 kilograms of hydrogen.
- Average mileage of a mid-sized gasoline sedan is 434 miles per tank, and one tank is on average 12 gallons of gasoline.
- The amount of CO2e for a hydrogen FCEV is 145 grams of CO2e per mile.
- The amount of CO2e for a gasoline vehicle is 390 grams of CO2e per mile.
- Both of these CO2e values are simulated per the GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model
- The calculation does not account for any offsets using greenhouse gas credits.

Carbon Intensity Value

The carbon intensity value for the supply chain for Citrus Heights is 138.4 gCO2 per megajoule. The energy efficiency ratio for light-duty passenger vehicles is 2.5.

Energy Efficiency Measures

While a Title 24 report was not required for the Citrus Heights station, Shell monitors and manages energy use and efficiency for continuous improvement and the global greenhouse gas emission inventory is subject to independent assurance.

CHAPTER 4:
Statement of Future Intent

Shell plans to operate the Citrus Heights Station for at least the next ten years. Shell has further subcontracted with the equipment vendor, NEL, for the operation, maintenance, and repairs of the system. NEL has local maintenance and engineering capability and staff in northern California. The system is outfitted with remote monitoring and automatic alarm communication systems that send alerts to designated Shell, and NEL personnel.

Shell is a committed participant and supporter of California's hydrogen refueling station network. To this end, Shell has matched funds with CEC for the construction of six other hydrogen refueling stations in Northern California. Shell's commitment is further demonstrated with its match share for the construction of a heavy-duty vehicle fueling station at the Port of Long Beach, Wilmington, and Ontario, as well as the GFO-19-602 proposed award to build 50 additional light-duty stations in California.

CHAPTER 5:
Findings, Conclusions, and Recommendations

The Citrus Heights station was built at a record-breaking pace. The time elapsed from the signing of the grant agreement to the first fill was 16 months.

Establishing new power service is time-consuming and can very easily become the critical path for a project's completion. Early engagement with the utility to obtain a detailed understanding of their process, procedures, inspection milestones, and their timeline is recommended.

A key learning from the construction process was that a thorough security and safety assessment is needed for the site to anticipate the challenges of performing construction on an operational site in a heavily trafficked area. Vehicles entering and exiting the site were a significant hazard to the workers and were likely the biggest risk that required active management. Spotters were deployed to manage the flow and speed of traffic. Speed bumps were installed at all the entrances to the site. Demarcation that the site was in construction helped alert motorists and encouraged them to slow down. There was heavy pedestrian traffic at the site as well, which increased the risk of vandalism. Special cameras, motion-activated lights, and devices that called the authorities in case of a break-in were deployed to protect the valuables and personnel on site.

The National Fire Protection Association – Hydrogen Technologies Code (NFPA 2) is a critical tool for working with permit agencies. The code clearly defines fire safety guidelines that enable local jurisdictions and builders to reach common ground while ensuring safety via the rigorous NFPA code writing process. For this project, the station siting and set back decisions were based on the Performance Based Analysis provisions of the NFPA 2 code. This is an important tool in NFPA-2 that makes the construction of hydrogen stations in an urban environment practical and feasible.

The Citrus Heights station has contributed towards the fulfillment of the goals of CEC's Clean Transportation Program and specifically towards the goals of GFO-15-605. Insights gained from the project are invaluable and will be applied to future projects to further the success of hydrogen refueling stations. Some recommendations for changes in future projects include extensively testing the POS system and its integration with the dispenser for a flawless customer experience, as well as adding visual signage aids to guide customers to the hydrogen dispensers, especially if they are located in the forecourt between

other gasoline dispensers. Improvements to the project management process, include starting the permitting process with the utility companies as soon as possible, given that it is often the critical path on projects, as well as finding ways to optimize the commissioning process and lessen the time it takes to perform DMS certification, Hydrogen Station Equipment Performance (HyStEP) testing, and automaker approval. Technical improvements are reviewed continuously throughout the lifecycle of the project and operational phases, however one notable technical improvement that was observed throughout the Citrus Heights project was to introduce a pressure differential alarm that detects leaks in the system throughout remote monitoring.

GLOSSARY

Alternative and Renewable Fuels and Vehicle Technology Program (ARFVTP) – Created by Assembly Bill 118 (Nunez, Chapter 750, Statutes of 2007), the program with an annual budget of about $100 million supports projects that develop and improve alternative and renewable low-carbon fuels, improve alternative and renewable fuels for existing and developing engine technologies, expand transit and transportation infrastructures, and establishing workforce training programs, conduct public education and promotion, and create technology centers, among other tasks.

AU Energy (AUE) – a fuel wholesaler and retailer which owns and operates Shell retail stations in California.

Authority Having Jurisdiction (AHJ) – An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

Business Environmental Resource Center (BERC) – a free, confidential, non-regulatory, and business retention resource established by the Sacramento County Board of Supervisors in response to requests for more compliance assistance with existing and expanding business and business startups.

California Division of Measurement Standards (DMS) – Enforcement of California weights and measures laws and regulations is the responsibility of the Division of Measurement Standards. The Division works closely with county sealers of weights and measures who, under the supervision and direction of the Secretary of Food and Agriculture, carry out the vast majority of weights and measures enforcement activities at the local level. Ensuring fair competition for industry and accurate value comparison for consumers are the primary functions of the county/state programs.

Carbon Dioxide Equivalent (CO_2e) – A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)" or "million short tons of carbon dioxide equivalents (MSTCDE)" The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. MMTCDE= (million metric tons of a gas) * (GWP of the gas) For example, the GWP for methane is 24.5. This means that emissions of one million metric tons of methane is equivalent to emissions of 24.5 million metric tons of carbon dioxide. Carbon may also be used as the reference and other greenhouse gases may be converted to carbon equivalents. To convert carbon to carbon dioxide, multiply

the carbon by 44/12 (the ratio of the molecular weight of carbon dioxide to carbon). (EPA)

Fiedler Group (FG) – the engineer of record for the Citrus Heights hydrogen refueling station.

Fuel Cell Electric Vehicle (FCEV) – A zero-emission vehicle that runs on compressed hydrogen fed into a fuel cell "stack" that produces electricity to power the vehicle.

Human-Machine Interface (HMI) – the hardware or software through which an operator interacts with a controller. An HMI can range from a physical control panel with buttons and indicator lights to an industrial PC with a color graphics display running dedicated HMI software.

Hydrogen Station Equipment Performance (HyStEP) device – a device that has been designed to carry out the test methods of CSA HGV 4.3 to measure that stations follow the fueling protocols standard SAE International J2601.

Kilogram (kg) – The base unit of mass in the International System of Units that is equal to the mass of a prototype agreed upon by international convention and that is nearly equal to the mass of 1000 cubic centimeters of water at the temperature of its maximum density.

National Fire Protection Association (NFPA) – is a global self-funded nonprofit organization, established in 1896, devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards.

Pre-startup safety review (PSSR) – a safety review conducted prior to startup of a new or modified facility to ensure that installations meet the original design or operating intent to catch and re-assess any potential hazard due to changes during the detailed engineering construction phase of a project.

Ready to issue (RTI) – The permit application is ready to be issued once the building permit issuance fees are paid.

Sacramento Municipal Utility District (SMUD) – an electric utility serving the greater Sacramento, California, region.

Station Online Status System (SOSS) – a mobile-friendly website that shows station availability and provides other station information such as hours of operation, address, and the hydrogen station operator and developer.