California Energy Commission

CONSULTANT REPORT

North Coast and Upstate Fuel Cell Vehicle Readiness Project

Task 2.4 Site Readiness Report

Prepared for: **Redwood Coast Energy Authority**
Prepared by: **Schatz Energy Research Center**

California Energy Commission
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PREFACE

Assembly Bill (AB) 118 (Nüñez, Chapter 750, Statutes of 2007), created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The statute authorizes the California Energy Commission (Energy Commission) 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) re-authorizes the ARFVTP 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 Energy Commission has an annual program budget of approximately $100 million and provides financial support for projects that:

- Develop and improve alternative and renewable low-carbon fuels;
- Optimize alternative and renewable fuels for existing and developing engine technologies;
- Produce alternative and renewable low-carbon fuels in California;
- Decrease, on a full fuel cycle basis, the overall impact and carbon footprint of alternative and renewable fuels and increase sustainability;
- Expand fuel infrastructure, fueling stations, and equipment;
- Improve light-, medium-, and heavy-duty vehicle technologies;
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets;
- Expand infrastructure connected with existing fleets, public transit, and transportation corridors; and
- Establish workforce training programs, conduct public education and promotion, and create technology centers.

The California Energy Commission (Energy Commission) issued solicitation PON-14-607 to fund Zero Emission Vehicle (ZEV) Readiness activities. To be eligible for funding under PON- 14-607, the projects must also be consistent with the Energy Commission's ARFVT Investment Plan updated annually. In response to PON-14-607, the Redwood Coast Energy Authority (Recipient) submitted application number 11, which was proposed for funding in the Energy Commission's Notice of Proposed Awards on March 17th, 2015, and the agreement was executed as ARV-14-055 on May 8th, 2015.

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ABSTRACT

This report presents the results of micrositing work conducted for the *North Coast and Upstate Fuel Cell Vehicle Readiness Plan Project*. Micrositing work involves developing preliminary hydrogen fueling station designs, and identifying specific potential locations for hydrogen fueling stations. The micrositing work conducted for this report focuses on the greater Eureka and Redding areas. This report provides an overview of the state of the art of hydrogen fueling station design and current code and safety requirements, station design recommendations specifically for the focus areas, and a list of recommended potential locations for the installation of hydrogen fueling infrastructure based on specific criteria.

Keywords: hydrogen, fuel, cell, vehicle, FCEV, station, micrositing, hydrogen fueling infrastructure, planning, ARFVTP, AB 8, AB 118, NFPA 2, North Coast, Upstate, Eureka, Redding

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EXECUTIVE SUMMARY

While the roughly 3,300 FCEVs currently on the road in California[1] are concentrated in urban centers, hydrogen refueling opportunities in rural, destination communities will be critical to sustained FCEV adoption. The North Coast and Upstate FCEV Fuel Cell Electric Vehicle (FCEV) Readiness Plan aims to prepare eight of California's northernmost counties for the introduction of FCEVs. The counties of Del Norte, Siskiyou, Humboldt, Trinity, Shasta, Mendocino, Tehama, and Glenn were included in the planning effort. Lake and Colusa Counties were initially included as project partners, but were subsequently unable to participate. As a result, the project covered a region of eight rather than nine counties.

A primary goal of this planning effort was to identify three phases of geographic locations for hydrogen infrastructure buildout in the study region. The first phase focused on establishing "anchor sites" that will catalyze a hydrogen market in the region, while the second and third phases build out and connect these anchor sites to urban areas hosting established fueling infrastructure.

The first task of this planning effort identified key regional hydrogen hotspots to geographically identify where anchor sites should be located. These hotspots were identified by comparing the five census-designated micro- or metropolitan statistical areas within the project region to a set of qualitative criteria. Statistical areas were evaluated based on proximity to major corridors, distance from existing FCEV markets, consistency with the Federal Highway Administration's Alternative Fuel Corridor designation, and level of future hydrogen demand identified through the California Hydrogen Infrastructure Tool (CHIT) model[2]. The Redding-Red Bluff and Eureka-Arcata-Fortuna census-designated areas were identified as focus regions for these anchor sites.

This Site Readiness Report is a first step in identifying potential locations for installing a hydrogen fueling station anchor site in the two focus regions. Particular emphasis was given to the cities of Eureka and Redding. Included in this report are:

- A detailed review of the current state of the art of commercial public hydrogen fueling stations in California;
- A review of the National Fire Protection Association Hydrogen Technologies Code, 2016 Edition;

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1 Estimate of the number of FCEVs obtained from the Clean Vehicle Rebate Project, last update April 11th, 2018.

2 More information on the California Hydrogen Infrastructure Tool (CHIT) can be found on the California Air Resources Board website.

- Recommended station designs and features that consider anticipated regional demand and hydrogen sourcing constraints, and associated space and setback requirements; and
- A list of pre-screened potential locations that could host a station.

The information in this report is intended to reduce the amount of initial groundwork to identify viable development projects in the region and help attract private and/or public investment. It is also intended to inform key stakeholders such as permitting officials and fire marshals to streamline early station development discussions with the relevant agencies holding jurisdiction.

CHAPTER 1: Background

One of the goals of the *North Coast and Upstate Fuel Cell Vehicle Readiness Project* (Project) is to provide guidance for the implementation of fueling infrastructure to support fuel cell electric vehicles (FCEVs) in the North Coast and Upstate regions. Guidance is developed in a two-step process.

The first step, termed “macrositing”, provides high-level regional insight into where to focus fueling infrastructure development efforts for first-phase critical anchor sites that will kick-start the regional fuel supply. Furthermore, recommendations on key second and third phase connector sites are provided that will solidify a fueling network to support a robust early market. The macrositing work was completed by the Redwood Coast Energy Authority and the Local Government Commission, and combines local knowledge with state-level modeling results provided by the CARB-funded CHIT-CHAT model[3]. The results of this step are found in the *Regional Hydrogen Infrastructure Plan* developed for this Project under Task 2.1.

The second step, termed “micrositing”, translates the macrositing results into on-the-ground locations and designs that address the many nuanced variables that impact the feasibility of station development. This report discusses the micrositing analysis work completed under Task 2.4 of the Project.

The micrositing effort is further split into two steps. The first step involves site screening and evaluation for potential fuel station locations within the critical anchor site regions identified in the macrositing process. These regions are the City of Redding and the City of Eureka. This *Site Readiness Report* documents the results of this step.

The second micrositing step involves using this *Site Readiness Report* to reach out to two key stakeholder groups:

- Fuel suppliers, to communicate the status of station designs and costs, and to gauge their interest in considering investment in hydrogen fueling infrastructure.
- City planning and permitting officials, to communicate the results of this report, the status of station designs and related codes, and to obtain feedback on additional information that they could use.

The results of the second step in the micrositing process are documented in the *Micrositing Analysis Results Summary Report*, which is the second deliverable under Task 2.4 of this Project.

3 https://www.arb.ca.gov/msprog/zevprog/hydrogen/h2fueling.htm

CHAPTER 2: Analysis of State of the Art Station Design and Associated Costs

There has been an extensive amount of work accomplished by state and federal governments, national laboratories, hydrogen advocacy groups and public-private partnerships over the past five years to promote and accelerate the deployment of hydrogen fueling stations throughout the state of California. Four main resources offer invaluable design and cost information for reference and retail stations and were heavily relied on for this site readiness report. The first two resources, (Pratt et al., 2015) and (Hecht and Pratt, 2017) developed by Sandia National Laboratory, are used to develop reference station designs which are discussed in the first section below. The last two resources, (Baronas and Achtelik, 2017a) and (Baronas and Achtelik, 2017b) developed jointly by the California Energy Commission (CEC) and the California Air Resources Board (CARB), are used to analyze retail station designs that have been funded by the CEC. These are discussed in the second section below.

Reference Stations – Designs and Costs

The first resource is the Hydrogen Fueling Infrastructure Research and Station Technology Project (H2FIRST). Funded by the U.S. Department of Energy, H2FIRST was established to address key challenges of hydrogen infrastructure. In the first phase of the project (Reference Station Design Task), team members from Sandia National Laboratories, National Renewable Energy Laboratory and Argonne National Laboratory along with input from H2USA Hydrogen Fueling Station Working Group, California Fuel Cell Partnership, and the California Air Resources Board screened over 160 different station design permutations using the H2A Refueling Station Analysis Model (HRSAM). The model performed an economic analysis using information on design capacity, peak performance, number of hoses, fill configuration and hydrogen delivery method for each station. Based on the preliminary economic results, fifteen station concepts were selected. (Pratt et al., 2015)

In addition to the economic results, fueling market needs were investigated. Given the early stages of infrastructure development, the accepted method for rollout was a "cluster strategy", where stations are centered in areas where early FCEV adopters reside. In a 2014 report by the CARB, station classifications were developed based on different needs (low or high use commuter, and low intermittent) and were matched with screened station concepts. (California Air Resources Board, 2014)

(Pratt et al., 2015) provided publicly-available detailed station designs including piping and instrumentation diagrams and bills of materials. Several site-specific layouts for various target markets were analyzed using setbacks required by the National Fire

Protection Association Hydrogen Technologies Code (NFPA 2, 2011) and setbacks that significantly affected the ability to site a hydrogen station on greenfield and brownfield (existing gasoline stations) sites. (Pratt et al., 2015)

In Phase 2 of H2FIRST, Sandia National Labs expanded and updated the work performed in the first phase by including designs and economic analyses of factory-built modular stations and stations utilizing on-site generation. (Hecht and Pratt, 2017) The report provides a summary of the hydrogen costs from various sources including a detailed breakdown of costs of gas delivery of centrally-produced hydrogen to fueling stations.

Summary of Reference Station Results

There are three potential sources for providing hydrogen to the fueling station: centrally produced hydrogen and delivery, on-site production via steam methane reforming and on-site production via electrolysis. Each of these methods are described below and factors that impact the overall cost to supply fuel are identified. (Hecht and Pratt, 2017)

Centrally produced hydrogen and delivery

The overall cost for delivered hydrogen includes the cost of the produced hydrogen, the delivery of a tube-trailer, and the cost to lease the tube-trailer while sited at the station. With an approximate capacity of 300 kg, the time to consume a tube trailer and the frequency of deliveries can be calculated based on the station use. As station utilization increases, the number of deliveries will increase. The delivery cost is associated with the distance travelled and therefore distance between the production facility and station location will be a factor in the total cost of supplied hydrogen.

On-site production via Steam Methane Reforming (SMR)

Hydrogen production from on-site reformers require additional capital costs and ongoing operational and maintenance costs. Estimated capital costs as provided by manufacturers are $1.15M, $2.04M and $2.46M for 100, 200 and 300 kg/day units, respectively. Operating costs are estimated to be 3.9 kWh/kgH2 for electricity, 96 lH2O/kgH2 of water, and 3.5 kg NG/kg H2 of natural gas. Due to their high operating temperatures, startup and shutdown cycles should be limited to prevent loss of unit efficiency. This lack of flexible operation makes SMR more suitable for larger and mature stations where continuous operation is required.

On-site production via Electrolysis

As with SMR, there are additional capital costs and on-going operational and maintenance costs associated with hydrogen production via electrolysis. Capital costs for electrolyzers are estimated to be $800k, $1.2M, and $1.5M for the 100, 200, and 300 kg/day stations. These capital costs are lower than on-site reformers; however, electrolysis is energy intensive (approximately 62.4 kWh/kgH2) and the electrical operating cost will have a big impact on the cost of hydrogen production.

(Hecht and Pratt, 2017) analyzed five updated "reference station" designs that offer baseline concepts to assist in the development of site-specific station designs. The updated reference station designs are:

- Conventional station with delivered hydrogen
- Conventional station with on-site production from steam methane reforming
- Conventional station with on-site production through electrolysis
- Modular station with delivered hydrogen
- Modular station with on-site production through electrolysis

For each of these designs, 100, 200, and 300 kg/day stations were analyzed to estimate all project costs. These costs include the construction and operating costs and the costs for producing hydrogen on-site or having hydrogen produced at a centralized facility and delivered.

Some of the model inputs and assumptions used by (Hecht and Pratt, 2017) include:

- the cost of land procurement is neglected,
- installation cost is assumed to be 35% of capital cost for conventional stations and a flat cost of $60,000 for modular stations, and
- a flat $300,000 is assumed for site preparation, engineering & design, project contingency, and upfront permitting costs.

Graphical tools are also available to the station designer to correct for any differences in capital or installation costs in order to get a better estimate of hydrogen cost. Refer to (Hecht and Pratt, 2017) for additional model details and economic analysis.

There are two types of stations that are being constructed at present; conventional and modular. Conventional stations consist of on-site assembly of the equipment while modular stations are pre-assembled units where the equipment is mounted on a skid, trailer, or within a container at a factory and then shipped to the site. The equipment for either type is similar. The majority of fueling stations currently being installed are modular stations. These stations or "compressor modules" are assembled at a factory and consist of the complete hydrogen system and most auxiliary systems mounted to a skid or housed in a container. The equipment costs are similar to that of conventional station, however, the factory assembly allows for system operational and leak checking of the system prior to shipping to the site thus reducing installation labor costs.

The economic results for the module reference station designs for the 100 kg/day and 200 kg/day capacities are shown in Table 1 below. The higher capacity stations estimate a lower hydrogen cost than the lower capacity stations (as expected) and delivered hydrogen from a central production facility is less expensive than on-site production. The installed costs shown include the site preparation, engineering & design, permitting costs (assumed as a flat $300k), installation (assumed to be 35% of capital costs for the conventional stations and a flat $60k for the modular units) and the capital costs for the equipment and materials previously presented.

Table 1: Installed Cost and Hydrogen Cost for Modular Stations

Station Type	100 kg/day		200 kg/day	
	installed ($)	*H2 ($/kg)*	*installed ($)*	*H2 ($/kg)*
Delivered H2	$1.86M	$33.90	$1.86M	$19.16
Electrolysis H2	$2.74M	$43.03	$3.14M	$27.30

Credit*: (Hecht and Pratt, 2017)*

The estimated hydrogen costs are based on results of the economic analysis that used the installed costs and revenue based on a station utilization profile. The profile estimates 5% of station capacity will be utilized in 2017, and ramps up to a maximum of 80% in 2026. A 200 mile, gas delivery distance was used and the resulting hydrogen costs assumed to break even on investments in 7 years (Hecht and Pratt, 2017).

Retail Stations – Designs and Costs

The other main resource for current design and cost information is the annual joint agency staff report, *Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California,* prepared by the California Energy Commission and California Air Resources Board. The assessment is updated annually, the last two updates of which are discussed here. It provides an update on the status of hydrogen fueling station design and the hydrogen infrastructure fleet in the State of California.

In the 2016 report (Baronas and Achtelik, 2017a), information was provided on the development of the hydrogen refueling station network, vehicle deployment rate and need for fuel, and required time for a station to become operational from permitting to construction and commissioning. In addition to these annual reporting topics, the Energy Commission and partners identified and analyzed the following retail station types from the various designs submitted to the Alternative and Renewable Fuel and Vehicle Technology Program:

- System 1: 180 kg per day delivered gaseous
- System 2: 350 kg per day delivered liquid
- System 3: 130 kg per day electrolysis
- System 4: 180 kg per day delivered gaseous (this differs from System 1 by increased CEC funding of capital costs in order to increase the projected profitability)

Costs for the site engineering and design, permitting, construction, commissioning, project management and overhead costs along with total equipment costs are shown in Table 2.

Table 2: Total Costs for the Four Retail Systems

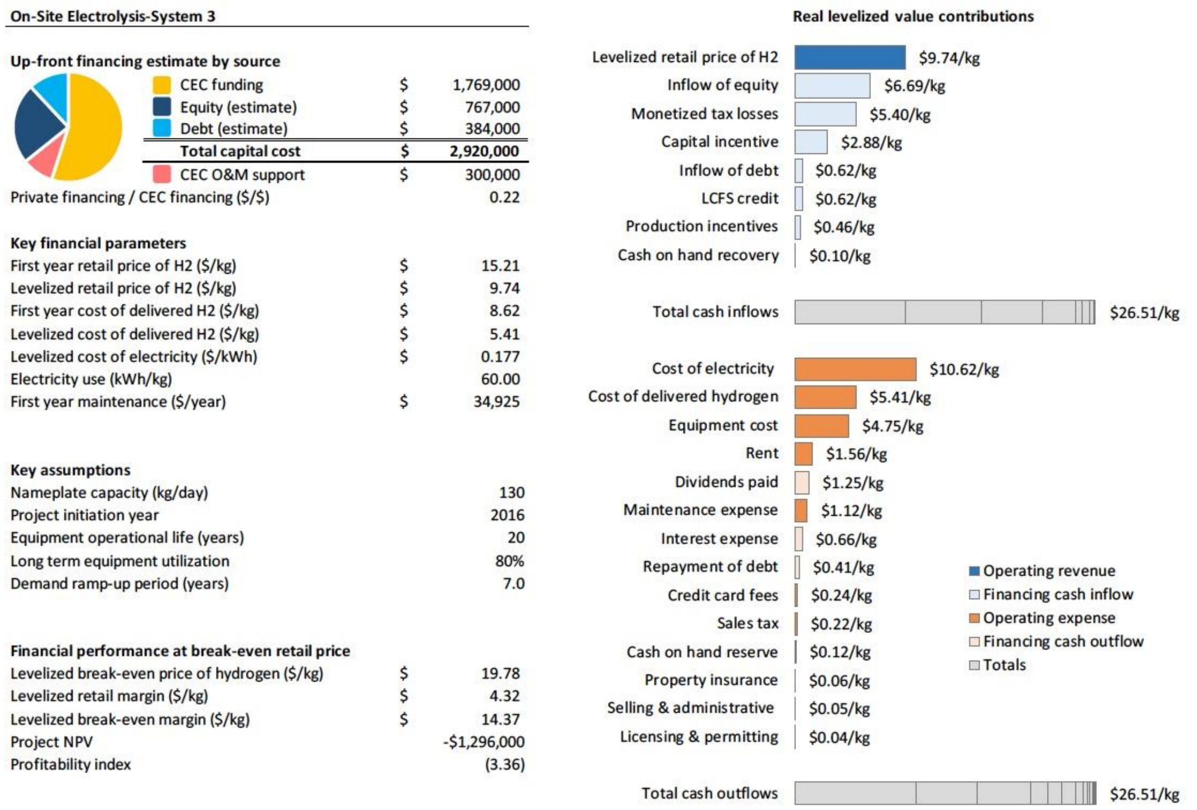
Activity	*System 1*	*System 2*	*System 3*	*System 4*
Site Engineering and Design	$55,800	$50,000	$50,000	$161,333
Permitting	$42,400	$31,000	$52,000	$55,684
Construction	$624,000	$599,000	$370,000	$507,312
Commissioning	$35,700	$76,000	$133,000	$28,751
Management and Overhead	$41,100	$117,000	$223,000	$100,000
Activity Subtotal	$799,000	$873,000	$828,000	$853,080
Total Equipment	$1,607,000	$1,930,000	$2,092,000	$1,552,146
Total Installed Cost	**$2,406,000**	**$2,803,000**	**$2,920,000**	**$2,405,226**

Credit: *(Baronas and Achtelik, 2017a) – reprint of Table F-10.*

For each system, a financial assessment was performed by the National Renewable Energy Laboratory (NREL) using the Hydrogen Financial Analysis Scenario Tool (H2FAST). Model input information was provided by station developers, CEC agreement files, invoices, and the NREL Data Collection Tool. The results from the model provided station capital costs, station O&M costs, upfront financing by source and other financing parameters and performance results in the form of scorecards. (Baronas and Achtelik, 2017a)

The scorecard for the On-Site Electrolysis – System 3 is shown below in Figure 1. The estimated total hydrogen station cost is $2,920,000 and the break-even hydrogen price is $19.78 per kg, with a retail price of hydrogen at $9.74 per kg. The high break-even point is due to the high cost of electricity and its large contribution ($10.62 per kg) to the cost of fuel. The break-even time horizon is 20 years.

Figure 1: Financial Scorecard for an On-Site Electrolysis System



On-Site Electrolysis-System 3		
Up-front financing estimate by source		
CEC funding	$	1,769,000
Equity (estimate)	$	767,000
Debt (estimate)	$	384,000
Total capital cost	**$**	**2,920,000**
CEC O&M support	$	300,000
Private financing / CEC financing ($/$)		0.22
Key financial parameters		
First year retail price of H2 ($/kg)	$	15.21
Levelized retail price of H2 ($/kg)	$	9.74
First year cost of delivered H2 ($/kg)	$	8.62
Levelized cost of delivered H2 ($/kg)	$	5.41
Levelized cost of electricity ($/kWh)	$	0.177
Electricity use (kWh/kg)		60.00
First year maintenance ($/year)	$	34,925
Key assumptions		
Nameplate capacity (kg/day)		130
Project initiation year		2016
Equipment operational life (years)		20
Long term equipment utilization		80%
Demand ramp-up period (years)		7.0
Financial performance at break-even retail price		
Levelized break-even price of hydrogen ($/kg)	$	19.78
Levelized retail margin ($/kg)	$	4.32
Levelized break-even margin ($/kg)	$	14.37
Project NPV		-$1,296,000
Profitability index		(3.36)

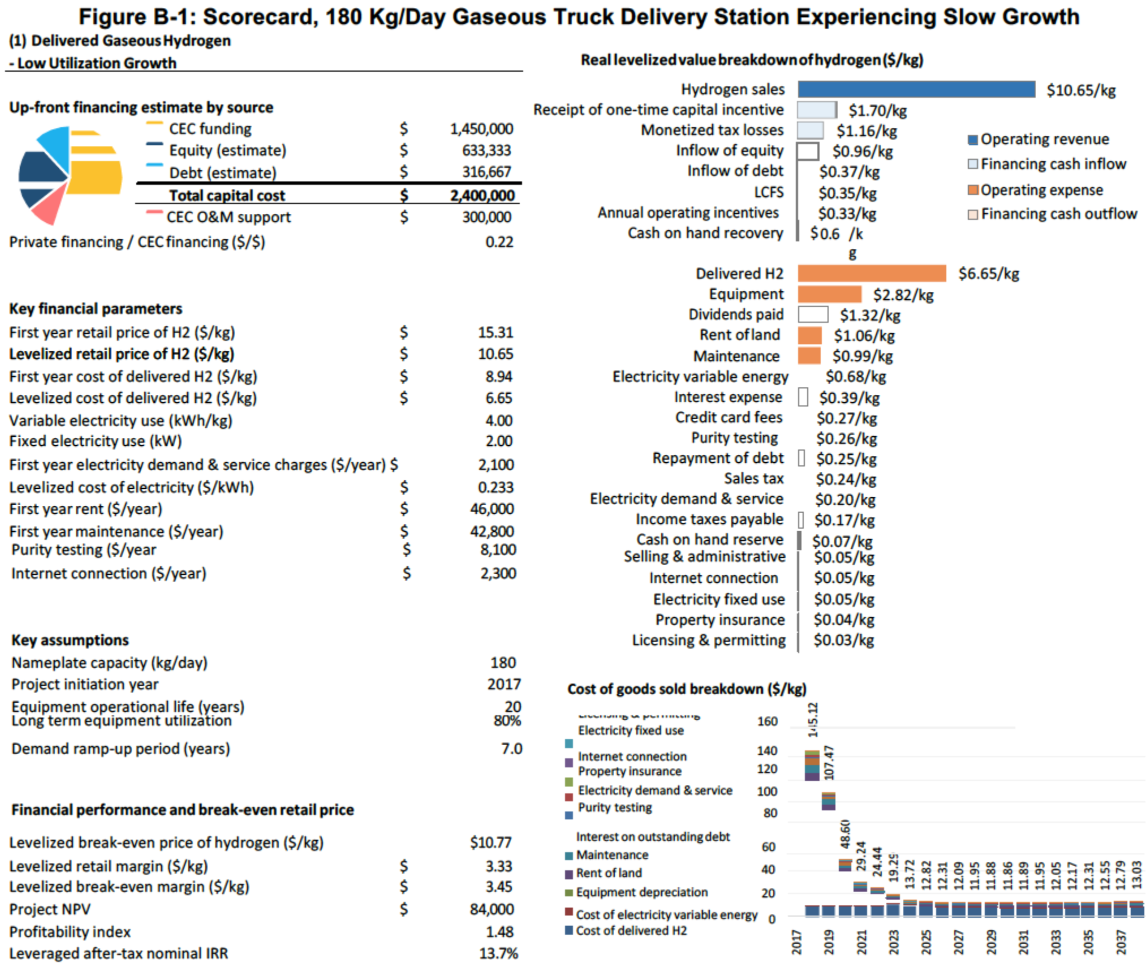
Source: NREL

Credit: *(Baronas and Achtelik, 2017a) - reprint of Figure F-3.*

In the more recent 2017 report (Baronas and Achtelik, 2017b), additional financial evaluations were conducted using more detailed cost data than the previous work. Scorecards were developed for two station types, one with gaseous hydrogen storage and one with liquid hydrogen storage. Each station was analyzed at two different utilization growth rates (a slow seven-year growth and a fast three-year growth) and with two different capacities (180 kg/day and 350 kg/day). It should be noted that an on-site hydrogen production station was not evaluated.

The scorecard for the 180 kg/day gaseous truck delivery station experiencing slow growth is shown below.

Figure 2: Financial Scorecard for a Delivered Gaseous Hydrogen Station



Source: NREL

Credit: *(Baronas and Achtelik, 2017b) - reprint of Figure B-1*

The total capital cost, which includes grant funding, developer match funding and debt financing is $2,400,000 with an additional $300,000 in O&M funding. Assuming station utilization reaches 80% in seven years, the results show a levelized retail price of hydrogen $10.65 per kilogram. Other details of the models' input and descriptions of the expenses can be found in Appendix B of the joint report. (Baronas and Achtelik, 2017b)

In comparison with a 180 kg/day Gaseous Delivered Hydrogen – System 1 scorecard presented in the 2016 report, the updated scorecard does not identify a specific station developer, nor does it provide information on the distance for the hydrogen delivery. The previous evaluation listed FirstElement Fuels Inc. as the developer and gave a round trip delivery distance of 95 miles for a 250 kg capacity tube trailer to a specific site. The results were similar with an estimated total hydrogen station cost of $2,406,000 and the break-even price of hydrogen would be $9.46 per kg.

CHAPTER 3: Review of Safety Code Requirements

This section reviews and summarizes some of the important safety code requirements. It reviews the latest edition of NFPA 2 Hydrogen Technologies Code.

Station Design – Safety and Hazard Mitigation Features

Stations are designed to meet all applicable building and fire safety codes, especially those dealing with the generation, compression, storage and dispensing of hydrogen as a vehicular fuel. The main reference code for designing a safe hydrogen fueling station is NFPA 2 Hydrogen Technologies Code 2016 Edition (National Fire Protection Association, 2016). Other important codes include the most recent versions of the California Fire Code, California Electrical and Mechanical Codes, and other international codes.

Chapter 10 Compressed Gaseous Hydrogen (GH_2) Vehicle Fueling Facilities of NFPA 2 has detailed code requirements that provide the basis for the safe design, installation and operation of a hydrogen fueling station. Some of the code-required and/or prudent design features for the various sections of a modular station are listed below.

<u>Compressor Module:</u>

- Walls are constructed of non-combustible materials with a minimal number of openings
- Designed with forced ventilation to prevent trapped gases
- Classified as a Class 1, Division 2 hazardous electrical area with all electrical equipment meeting proper standards to ensure that they cannot serve as an ignition source if a combustible gas mixture is present
- Equipped with safety devices that may include: flame detectors, smoke detectors, combustible gas detectors, vibration sensor, and emergency shutdown devices
- Designed for earthquake safety by ensuring plumbing between various components has strain relief that will allow components to move independently of one another without a resulting breach in the hydrogen plumbing
- Equipped with a vent stack to discharge hydrogen vent gas from automatic valves or relief valves at an elevated height to meet minimum separation distance from compressor module ventilation intake duct, and to prevent the vent outlets classified area from extending to ground level beyond the enclosure area

Storage Module:

- Tank array and plumbing designed for earthquake safety by ensuring plumbing has strain relief that will allow components to move independently of one another without a resulting breach in the hydrogen plumbing
- Vent gas from tank relief valves are directed to an individual vent stack or connected to a common vent stack with the compressor module

Enclosure or Structure

- Walls meant as fire barriers void of openings or penetrations unless protected with firestops
- Constructed with non-combustible materials with 2-hour fire resistance rating
- Designed for natural or forced ventilation depending on design to prevent accumulation of combustible gas mixtures
- Enclosure secured to prohibit unauthorized access to the equipment
- Buffer area between equipment and enclosure walls for safety and access purposes

Dispenser and Dispensing Area

- Electrical components within the dispenser enclosure are designed to meet Class 1, Division 1 hazardous area requirements
- Dispenser equipped with a combustible gas detector and vibration sensor that triggers an automatic shutdown when activated by an earthquake or vehicle collision
- Vent gas from automatic valves or relief valves directed subgrade back to enclosure area vent stack
- Dispensing area equipped with a hydrogen flame detector that watches over the dispensing area and initiates a system shutdown if a hydrogen flame is detected
- Dispenser protected by safety bollards

Code Separation Distances for Gaseous Hydrogen Stations

One of the main challenges in siting a hydrogen fueling station is meeting the separation distances requirements of NFPA 2. Understanding these requirements and other applicable codes is necessary in order to properly and safely install a hydrogen fueling station.

The critical setbacks for gaseous hydrogen systems are based on the connecting line size and pressure of the hydrogen storage system. Table 3 below lists the minimum separation distances for various exposures as listed in Chapter 7 Gaseous Hydrogen of NFPA 2 (2016 edition). These distances are based on a minimum pipe size of 7.16 mm internal diameter and a pressure greater than 7500 and less than or equal to 15000 psig. The most critical distances are the lot lines, air intakes and parked cars (shown in bold). With the exception of air intakes, NFPA states setbacks can be reduced by one-half if an appropriately designed 2-hour firewall is constructed between the pressurized gas and the exposure.

Table 3: NFPA Minimum Separation Distances for Outdoor Gaseous Hydrogen Systems

Exposures	*Minimum Distance (ft)*	*Reduced Minimum Distance (ft)*
Group I		
Lot lines	34	**17**
Air intakes (HVAC, compressors, other)	34	**34**
Operable openings in buildings and structures	34	17
Ignition sources (open flames, welding)	34	17
Group 2		
Exposed persons other than those servicing system	16	8
Parked cars	16	**8**
Group 3		
Buildings of noncombustible non-fire-rated construction	14	14
Buildings of combustible construction	14	14
Flammable gas storage systems above or below ground	14	14
Encroachment by overhead utilities	14	14
Additional exposures, see table in code	14	14

Credit:*(National Fire Protection Association, 2016)*

In addition to the above separation distances between the outdoor bulk gaseous hydrogen (GH_2) systems and various exposures, Chapter 7 of NFPA 2 shows the distances for outdoor gaseous hydrogen dispensing systems. The required separation between the dispensing equipment and the nearest important building, property line that can be built upon, ignition source, public street, or sidewalk is 10'.

It is extremely important for station owners and developers to work closely with zoning and permitting agencies to implement a safe design when integrating hydrogen into existing gasoline retail stations. The construction and installation of compressor and storage module enclosures has provided many benefits towards this effort. These enclosures have been designed to provide protection for the hydrogen equipment from vehicular damage, secure the equipment from the general public, and most importantly, reduce the risk of an accidental hydrogen release from reaching the exposures listed in the NFPA table. Based on the locations of the compressor and storage enclosures as seen in the images of the recent installations (Figure 5 through Figure 11), it appears that station developers have been able to work with the Authority Having Jurisdiction (AHJ) and demonstrate that these enclosures can safely be sited along lot lines adjacent to non-occupied lots or low-traffic areas (alleys). This approach may be necessary for promising locations that are space constrained.

CHAPTER 4: Analysis of Required Station Footprint

When considering whether hydrogen can be integrated into an existing site, it is important to have a good understanding of the space or “station footprint” that is needed to not only fit the hydrogen equipment, but also meet the local, state and federal safety code requirements. The following sections review the available hydrogen station planning work and take a close look at the designs and layouts of current hydrogen retail stations. This information is used to determine the required space to install different types of stations.

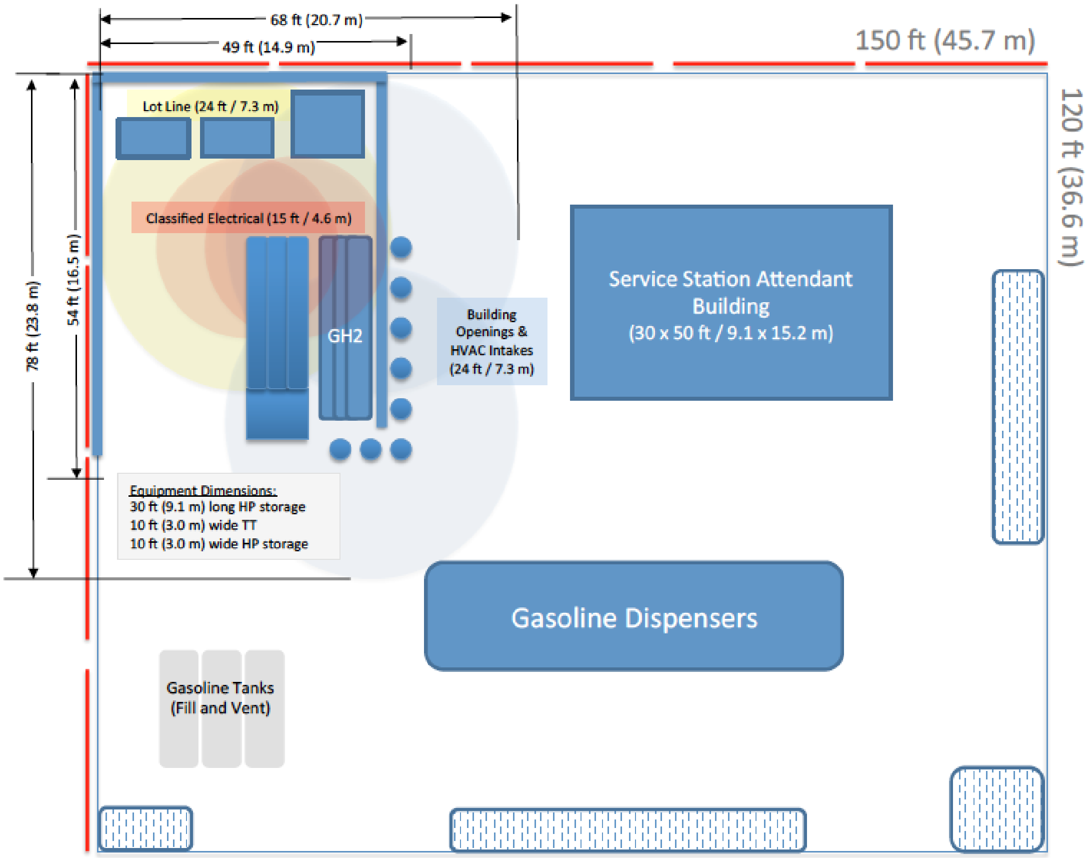
Station Footprint Analysis Studies

This section summarizes the station footprint analysis work reported by Sandia National Labs and the California Energy Commission over the past few years. This work shows the progress made by station developers, equipment manufacturers and permitting agencies to reduce the size of the equipment footprints, thus improving the chances of integrating hydrogen at more retail gas stations.

In a 2014 study, researchers at Sandia National Labs defined a new metric to characterize the impact and success in the development of codes relevant for hydrogen refueling stations as the “number of (gasoline) fueling stations that can readily accept hydrogen”. As noted in the study, a site can readily accept hydrogen when no statutory, regulatory or local ordinance barriers exist, and a viable business case can be made. (Harris et al., 2014)

Using the required safety separation distances listed in the 2011 edition of NFPA, the team developed two code-compliant reference hydrogen systems, a gaseous hydrogen system and liquid hydrogen system. The gaseous station had a 100 kg/day capacity with dimensions of 68’ x 78’ (including offset distances), which included an equipment footprint of 2,650 square feet and a total footprint of about 5,500 square feet with the addition of separation distances (Figure 3). The liquid station required significantly more space due to the restrictive safety separations distances for liquid hydrogen. Liquid stations are not considered in this report since the projected demand for hydrogen for the study area is relatively low and does not warrant the need for liquid hydrogen storage. Therefore, this reference station is not discussed here.

Figure 3: Gaseous Hydrogen Reference Station.



Separation Distances per NFPA 2 (2011). Credit: *Reprint of Figure 1 in (Harris et al., 2014)*

These reference station footprints were used to evaluate 70 retail gasoline stations in California's targeted market to determine if enough space was present to satisfy the code requirements to allow a hydrogen refueling station to the site. The process developed in this study is used in the micrositing analysis here as it provides a quick way to determine if a hydrogen station can be installed at an existing retail gasoline station. (Harris et al., 2014)

In 2016, the California Energy Commission staff collected footprint information provided by applicants for 38 stations proposed across three grant solicitations. As shown in Figure 4, the hydrogen refueling equipment footprint sizes ranged from 660 square feet to 4,300 square feet. Unlike the work in (Harris et al., 2014), this study did not include NFPA 2 setbacks.

Figure 4: Hydrogen Station Equipment Footprints

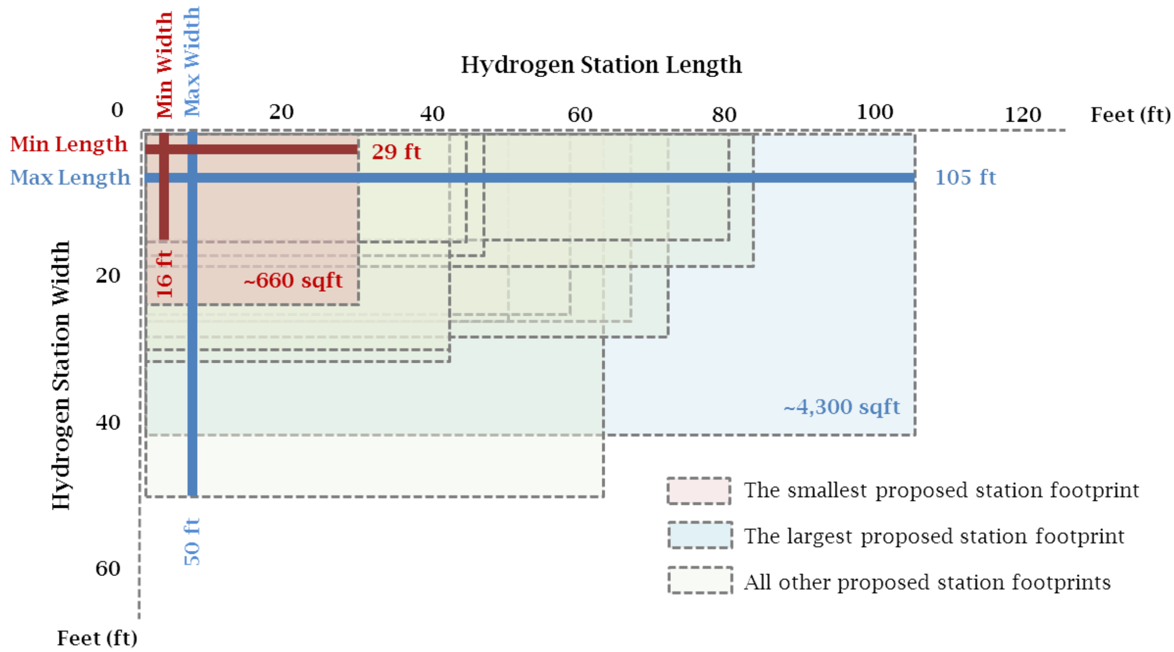


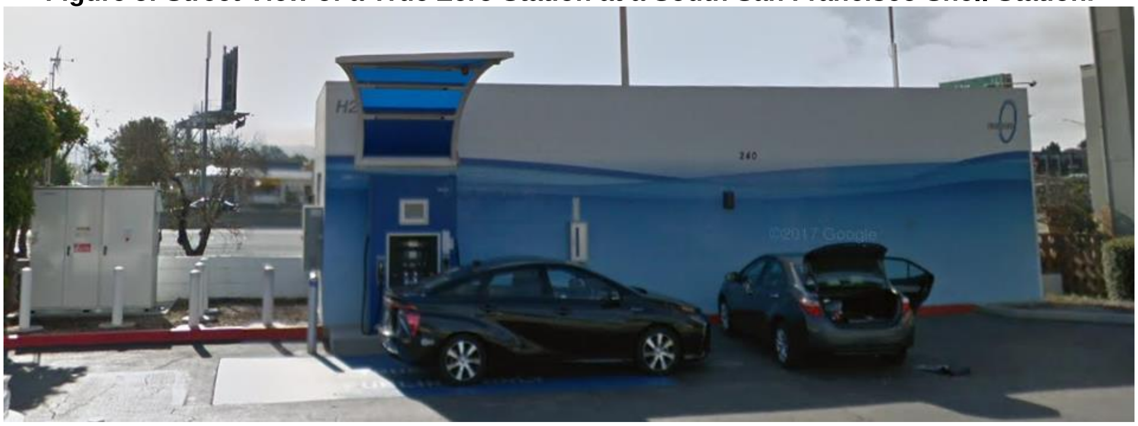
Image is comprised from a sampling of CEC proposals. Distances do NOT include NFPA 2 setbacks. Credit: *(Baronas and Achtelik, 2017a) – reprint of Figure E-2.*

The Energy Commission continued the station footprint analysis work in 2017 for the proposals submitted under GFO-15-605: Light Duty Vehicle Hydrogen Refueling Infrastructure. In general, they found that these recent designs moved the lower range bound to a size smaller than previous stations with sizes ranging from 300 square feet to just over 2,000 square feet. Some applicants included “project” footprints (remote dispenser) or “excavation” footprints (construction and trenching impacts) that moved the range from 500 to 2,500 square feet. A closer look at the two types of station designs funded through this solicitation show that one had an estimated footprint size of 670 square feet and the other 825 square feet, indicating that the higher scored designs had a relatively compact design. (Baronas and Achtelik, 2017b)

Design and Footprint Assessment of Retail Hydrogen Stations

Given that hydrogen equipment layouts can change from the proposal stage to the final installation, this report examines a few of the recently installed stations to understand the various layouts, footprints and mitigation measures implemented to address code separation distances from critical exposures. Figure 5 through Figure 11 provide overhead and street view images of four recent retail stations that show the station layout and the major hydrogen components: electrolyzer module (if applicable), compressor module, storage module, dispenser, and electrical equipment. Not all components are visible in each figure.

Figure 5: Street View of a True Zero Station at a South San Francisco Shell Station.



This shows the compact layout with the dispenser sited in front of the compressor and storage enclosure, and the electrical panel (far left) just outside the electrical classified area. Credit: *Google 2018. Image capture August 2017.*

Figure 6: Overhead View of a True Zero Station at a South San Francisco Shell Station.

The image illustrates the linear station design that has an overall complete station footprint, including dispenser and electrical equipment, of 1,071 square feet. Credit: *Google 2018.*

Figure 7: Street View of a True Zero Station at a Valero station in Fremont.

The image illustrates a dispersed layout with compressor / storage area (white module) in back center, dispenser (dark blue) under canopy, and electrical panel (gray cabinet with white bollards) on the right. Credit: *Google 2018. Image capture August 2017.*

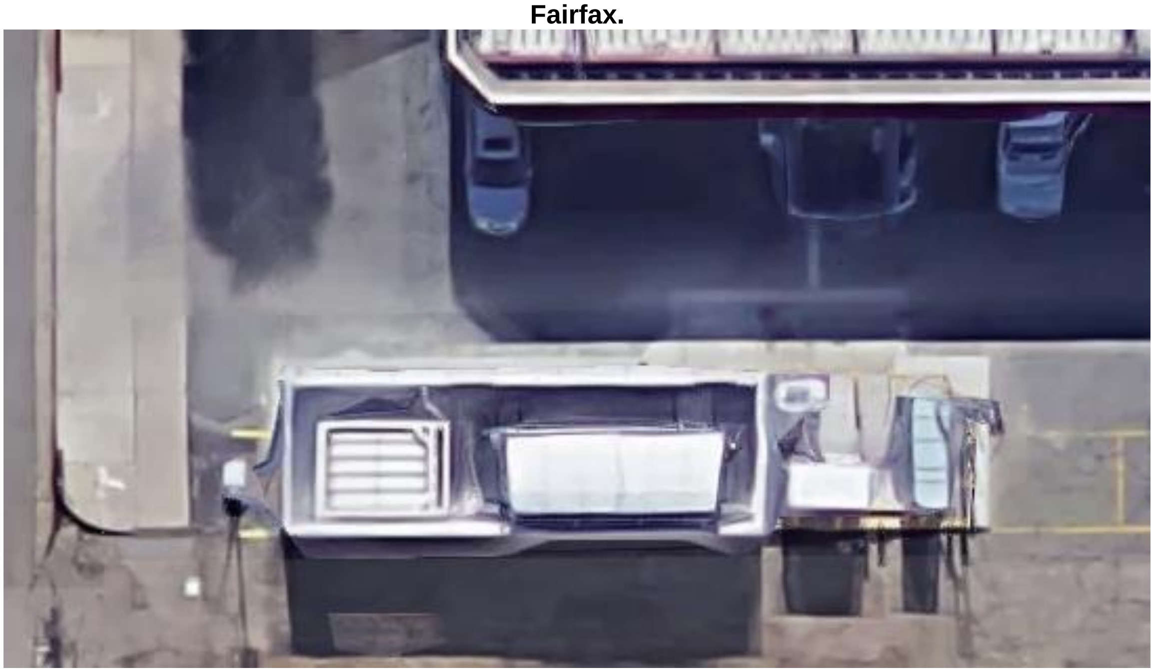
Figure 8: Overhead View of a True Zero Station at a Valero station in Fremont.

This image shows the compressor container and storage module in a side-by-side configuration. Credit: *Google 2018.*

Figure 9: Street View of an Air Products Hydrogen Fueling Station at a Chevron in Fairfax.

This image shows the secured hydrogen equipment enclosure with the dispenser and electrical panels at the far left. Credit: *Google 2018. Image capture February 2017.*

Figure 10: Overhead View of Air Products Hydrogen Fueling Station at a Chevron in Fairfax.



The perspective shows a linear design with an overall complete station footprint, including dispenser and electrical equipment, of 1,020 square feet. Credit: *Google 2018. Image capture February 2017.*

Figure 11: Overhead View of 76 Station in Ontario That Includes an On-Site Electrolyzer.

The image shows the electrolyzer module with roof-top cooling fans (center) and the gas storage area (left). The proposed location for the dispenser is under canopy. Credit: *Google 2018.*

The above images illustrate the various station layout options that are possible depending on the source of hydrogen (delivered or on-site generation) and the amount of available space. The main differences are the configuration of the compressor and storage modules (installed either in a side-by-side or an end-to-end configuration) and the location of the dispenser (installed adjacent to the equipment or located remotely). At the gas delivery stations, the compressor and storage modules are surrounded by an enclosure that provides safety and code benefits that allow the equipment to be installed within the constraints of the existing infrastructure. For the on-site generation station (Figure 11), the electrolyzer system is packaged in a modular, containerized system that is not completely enclosed by a perimeter structure, but has a (2-hour) fire wall along the side(s) where potential exposures may be an issue.

Google Earth was used to estimate the dimensions for some of the individual hydrogen equipment, and the associated stations that the dimensions were pulled from:

- electrolyzer module (height unknown) 10’ x 40’ (Ontario)
- compressor module (standard container size) 8’ x 20’ (True Zero-Fremont)
- storage module, nominally 9’ x 13’ (True Zero-Fremont)
- storage area 19’ x 35’ (Ontario)
- dispenser and dispensing area 15’ x 15’ (True Zero-San Francisco)
- electrical service panels 10’ x 10’ (True Zero-San Francisco)

At stations where the dispenser is installed remotely, the open area required to site a station is dependent on the footprint of the hydrogen equipment enclosure. These enclosures house the compressor and storage modules and for safety and maintenance purposes have a buffer between the modules and the enclosure wall. The enclosure footprint plus the footprint of the remote dispenser and electrical utility panel result in the overall station footprint.

Table 4 lists the dimensions and footprints for the enclosure, dispenser and utility panel, and the total station for these hydrogen stations.

Table 4: Estimated Dimensions (ft) and Footprints (ft^2) for Recent Installations

Station Location	*Fuel Source*	*Remote Dispenser*	*Enclosure Dimensions (Footprint)*	*Dispenser/Utility Dimensions (Footprint)*	*Station Dimensions (Footprint)*
True Zero South San Francisco	delivered	no	17 x 45 (765)	17 x 18 (306)	17 x 63 (1,071)
True Zero Fremont	delivered	yes	29 x 31 (899)	25 x 25 (325)	* (1,224)
Air Products Fairfax/LA	delivered	no	15 x 45 (675)	15 x 23 (345)	15 x 68 (1,020)
76 Ontario	electrolysis	yes	19 x 75 (1,425)	25 x 25 (325)	* (1,750)

*** For remote dispenser stations, the station dimensions are not shown. NFPA setbacks not included.** Credit: *SERC, 2018.*

The hydrogen equipment footprints for the three delivered hydrogen stations in Table 4 range from 675 to 899 square feet and are in the same size range as the footprints (670 and 825 square feet) identified in the California Energy Commission sampling of GFO-15-605 proposals. However, when the additional space needed for the dispenser and electrical equipment is considered, the overall station footprints range between 1,020 to 1,224 square feet.

The above observations show that it is best to screen potential fueling sites without incorporating the NFPA minimum code separation distances. This approach prevents potential site candidates from being prematurely screened out before station developers can communicate with the Authority Having Jurisdiction (AHJ) about potential mitigation measures that can address identified issues.

CHAPTER 5: Recommended Station Design Options

In this section, the reference and retail station design information will be used to develop station designs for Eureka and Redding. Given the rapidly evolving station designs and the potential changes in available hydrogen sources in the State, it will be difficult to determine what the “best” station design will be in the coming years. As stated in the CARB/CEC joint report, “identifying which stations are the right stations is not a static pursuit. The characteristics of the right station are not necessarily the same in every community, and they evolve with the growing market and new technologies.” (Baronas and Achtelik, 2017b)

The following steps are recommended to identify the most appropriate station designs for Eureka and Redding:

1. Determine the **station classification** and identify the capacity and performance capabilities as recommended by CARB.
2. Determine the most appropriate **source(s) of hydrogen** given the station location relative to a hydrogen production facility.
3. Identify the **station design options** from the reference or retail station work that are reasonable for the area.

Station Design Options - Eureka

According to the CARB station classifications, Eureka would be classified as an **intermittent destination station**. Given its remoteness, relatively low population and distance from the established fueling network, total utilization will be low until the fueling network and vehicle penetration is well established. Capacity and performance capabilities for an intermittent destination station per CARBs latest recommendations are 200+ kg/day capacity and a single fueling position (California Air Resources Board, 2017).

One of the main challenges in designing a fueling station in Eureka is determining the source of hydrogen. For the **centrally produced and delivery** option, the closest hydrogen production facility is Air Products & Chemicals, Inc. located in Sacramento. With a one-way driving distance of 300 miles, tube-trailer deliveries of hydrogen will be time consuming and expensive.

In addition to the long driving distance, there is a concern of reliable access to Eureka. Highway 101 and Highway 299 run through forested areas and sections of unstable hillsides that have a potential for wildfires in the summer months and landslides in the rainy, winter months that may result in road closures. In addition to the unreliable road conditions, there may be a concern with delivery truck size restrictions, although both routes have and are currently undergoing major road realignment to address this issue. The long distance and access issues make centrally produced and delivered gas from Sacramento a fuel reliability concern.

Given the delivery logistics and road access concerns for delivered hydrogen, **on-site hydrogen generation via electrolysis** should be considered as a viable option for sourcing hydrogen. It offers a more secure source of year-round fuel and as the market matures and utilization increases, gas deliveries would most likely not be able to keep up with local demand. On-site gas production is, however, more expensive both in terms of capital costs and the on-going production costs that will result in a high price per kg for fuel.

It is worth noting that some discussions have occurred regarding the use of inexpensive Trinity County hydroelectric power to generate hydrogen via electrolysis. If there were an industrial source of hydrogen in Redding this may make centrally produced and delivered hydrogen more cost competitive. However, this does not solve the challenges associated with road closures on Highway 299.

A review of the reference and retail station design options identified two current retail station design options that are recommended for Eureka: a **modular 180 kg/day system with delivered gaseous system or a modular 130 kg/day system using on-site hydrogen production via electrolysis.** Although the capacity for each system is below the minimum 200 kg/day as recommended by CARB, this is not expected to be an issue for many years given the destination station classification and the anticipated low utilization rate until the market matures.

Station Design Options - Redding

Given its relatively low population compared to the other core market areas, a station in Redding would be classified as an **intermittent destination station.** Although there is no current fueling network beyond state lines, it is an ideal location for a station to provide travel to the north into Oregon.

Centrally produced and delivery of gaseous hydrogen is the obvious choice for fuel supply to a station in Redding. Air Products & Chemicals, Inc., located in Sacramento, is 175 miles due south on Interstate 5, a driving time of a little over 3 hours.

Given its anticipated low utilization and somewhat close proximity to a gas supplier, a **modular 180 kg/day system with delivered gaseous system** is the recommended option for the first hydrogen refueling station in Redding.

Estimated Costs for Design Options

Total installed costs and the economic analyses results for the Sandia reference stations and the NREL retail station design options are summarized in Table 5 below. The table shows the levelized break-even fuel prices and analysis time horizon for each station type. The NREL retail station performance results are based on retail station design proposals and provide the best estimates of installation costs and fuel prices currently available for these two station types.

Table 5: Station Design Cost Data

Station Type	*Capacity (kg/day)*	*Installed Cost ($M)*	*Levelized Break-even Fuel Price ($/kg)*	*Break-even Time (yrs)*	*Source Information*
Delivered	100	1.9	33.90	7	Reference
	180	**2.4**	**10.77**	20	Retail
	200	1.9	19.16	7	Reference
Electrolysis	100	2.7	43.03	7	Reference
	130	**2.9**	**19.78**	20	Retail
	200	3.1	27.30	7	Reference

Credit: *Reference – (Hecht and Pratt, 2017), Retail – (Baronas and Achtelik, 2017a)*

For a Eureka station, one operating expense that will affect the fuel price is the cost of delivered hydrogen. As previously discussed, with Eureka 300 miles from the nearest gas supplier, the hydrogen delivery costs will have a significant impact on fuel price. Further investigation will be required to determine the actual cost.

Key Footprint Dimensions of Design Options

Using the method outlined in Chapter 4 for identifying the key dimensions for pre-screening a site, the three station layouts and the key dimensions (shown in bold below) used in the site screening evaluations are:

- a gas-delivered station with the compressor and storage modules in an end-to-end configuration: **15’ x 45’**
- a gas-delivered station with the compressor and storage modules in a side-by-side configuration: **29’ x 31’**
- an on-site generation station with a linear layout for the electrolyzer, compressor module, and storage module: **19’ x 75’**

Note that the dispenser and dispensing pad require an area approximately **15’ x 15’** and the electrical utility equipment will occupy a **10’x10’** area.

Layout Drawings of Design Options

Layout drawings are developed for the two identified design options: a modular hydrogen station with gas delivery and an on-site hydrogen generation station using electrolysis. These drawings have been created to provide a visual representation of the code setbacks and to assist in determining the overall space dimensions needed to site a station. In addition to the layout drawings, a side view drawing of a hydrogen system vent stack design is presented to illustrate how a good design can mitigate potential hazards. The layout drawings show the stations in a few different configurations and illustrate how the code setbacks affect the overall required space dimensions needed to install a station. All of the drawings provide a high-level look at some of the critical code requirements and do not provide the necessary detail to be used for final design purposes. A detailed site investigation and code analysis should be conducted by a qualified engineer or professional familiar with all applicable codes.

The overall space dimensions provided do not include the 34' air intake minimum distance requirement. A site investigation is needed to identify the location of nearby building intakes or onsite air compressors. Implementing this crucial distance can have an impact on where the station is located on the site or whether the site can even host a station. This may be a situation where an adjustment to a lot line setback can safely move the station footprint closer to the property line and outside the 34' setback.

The location of the dispenser/dispensing areas are arbitrary and can be on either the side or end of the station enclosure. For a remote dispenser, it can be located at a new dispensing area or at an existing gasoline fueling island.

Design Option 1: Modular Station with Gas Delivery

The first set of drawings shown in Figure 12 show a modular hydrogen station with gas delivery with two equipment layouts that are currently being used at new retail stations by two predominant developers in California: FirstElement and Air Products, Inc. Drawing 1 in Figure 12 is a station that has a parallel configuration. This side-by-side layout of the compressor and storage modules results in a square footprint that may fit into a corner of a lot. The overall space required for this layout is approximately **42' x 45'.**

Drawing 2 in Figure 12 illustrates a linear configuration with the compressor and storage modules positioned end to end. This layout could also be sited in a corner or along one of the property lot lines and has an estimated overall space requirement of **30' x 66'**.

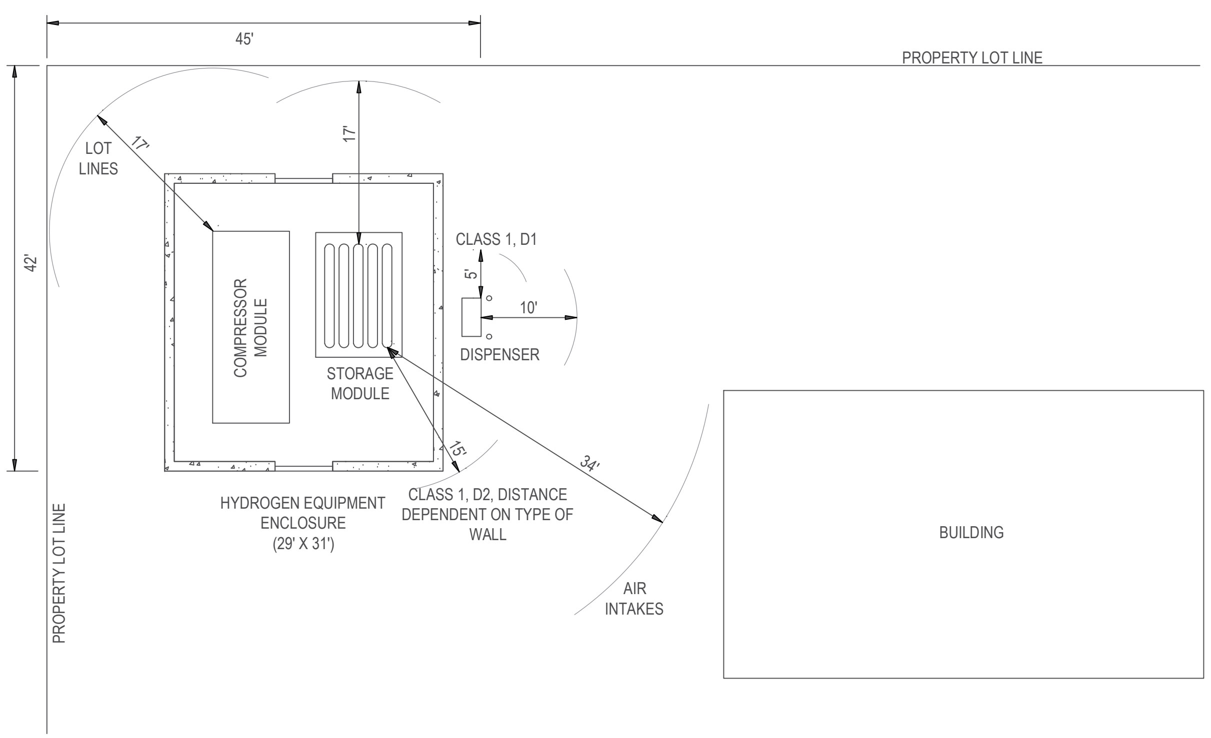
Drawing 4 in Figure 13 shows a side view of the compressor module which indicates the required height of the vent stack outlet for the compressor module.

Design Option 2: On-Site Hydrogen Generation Using Electrolysis

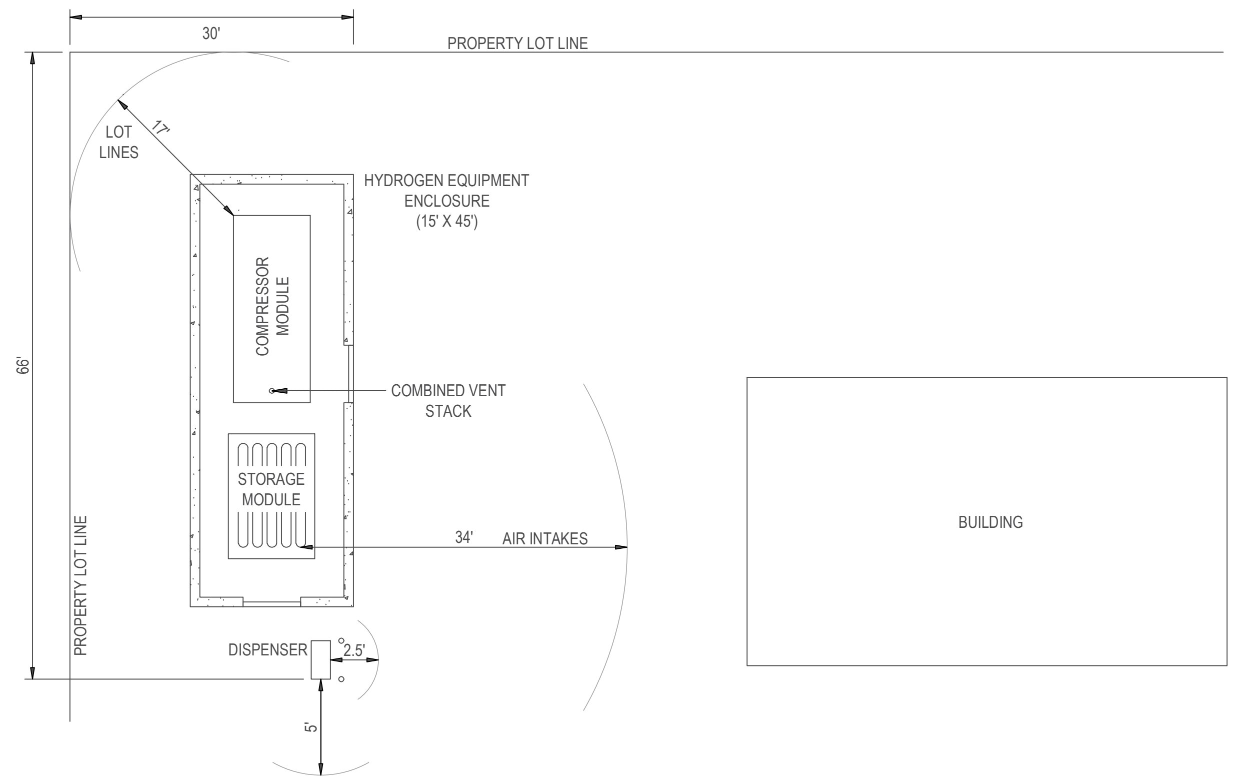
The second set of drawings shown in Figure 13 shows a station that has on-site hydrogen generation via electrolysis. Drawing 3 in Figure 13 shows one of many possible layouts, a linear configuration of the electrolyzer module and the compressor and equipment area. This equipment along with intermediate and high-pressure storage tanks are partially enclosed to mitigate any potential hazards. The Ontario fueling station (see Figure 11) was referenced for approximate dimensions and the equipment layout. Drawing 4 in Figure 13 shows a side view of the compressor module which indicates the required height of the vent stack outlet for the compressor module.

Figure 12: Design Option 1 - Modular Station with Gas Delivery

DRAWING 1:GAS-DELIVERED STATION WITH PARALLEL CONFIGURATION
OVERALL SPACE REQUIREMENT OF 42' X 45' INCLUDING THE DISPENSER



DRAWING 2: GAS-DELIVERED STATION WITH LINEAR CONFIGURATION
OVERALL SPACE REQUIREMENT OF 30' X 66' INCLUDING THE DISPENSER



DESIGN NOTES

IN THESE TWO LAYOUTS THE LOT LINE SETBACKS ARE IMPLEMENTED TO PROVIDE A CONSERVATIVE APPROACH FOR ESTIMATING THE TOTAL OPEN SPACE REQUIRED TO INSTALL THIS TYPE OF STATION. MODIFICATIONS TO ANY SETBACKS ARE AT THE DISCRETION OF THE AUTHORITY HAVING JURISDICTION (AHJ) AND IF IMPLEMENTED, MAY MAKE A SPACE-CONTRAINED SITE VIABLE FOR HYDROGEN INTEGRATION.

A SITE EVALUATION WILL BE REQUIRED TO DETERMINE HOW THE 34' AIR INTAKE DISTANCE AFFECTS THE REQUIRED SPACE.

- THIS ANALYSIS IS A HIGH-LEVEL LOOK AT CODE REQUIREMENTS, A MORE DETAILED INVESTIGATION BY A CODE EXPERT IS RECOMMENDED FOR SITE DESIGN
- ONLY CRITICAL NFPA 2 SEPARATION DISTANCES AND SOME ELECTRICAL AREA CLASSIFICATION DISTANCES ARE SHOWN
- ENCLOSURES ARE CONSTRUCTED OF NON-COMBUSTIBLE MATERIALS AND ARE DESIGNED TO PROVIDE ADEQUATE VENTILATION
- DISPENSER CAN BE SITED ADJACENT TO EITHER SIDE OF THE HYDROGEN EQUIPMENT ENCLOSURE OR REMOTELY AT A NEW DISPENSING LOCATION OR EXISTING GASOLINE DISPENSING ISLAND

SEPARATION DISTANCES FOR GASEOUS HYDROGEN SYSTEMS (NFPA 2, 2016)

- AIR INTAKES (HVAC AND COMPRESSORS, ETC.) 34'
- LOT LINES 17'
- OPERABLE OPENINGS IN BUILDINGS 17'
- PARKED CARS 8'
- BUILDINGS OF NONCOMBUSTIBLE OR COMBUSTIBLE MATERIALS, OVERHEAD UTILITIES 14'
- DISPENSER TO LOT LINE, IGNITION SOURCE, ETC. 10'
- APPROVAL AND MODIFICATIONS TO SETBACKS AT THE DISCRETION OF THE AUTHORITY HAVING JURISDICTION (AHJ)

ELECTRICAL AREA CLASSIFICATIONS - GH2 VEHICLE FUELING STATIONS (NFPA 2, 2016)

- ALL DISTANCES MEASURED SPHERICALLY FROM SOURCE POINT
- WITH STRATEGIC PLACEMENT AND HEIGHT OF THE RELIEF VALVE AND VENT STACK OUTLETS, THE ELECTRICAL CLASSIFICATION AREAS FROM THESE SOURCES SHOULD NOT EXTEND TO GROUND LEVEL OUTSIDE THE EQUIPMENT ENCLOSURE
- CLASS I, DIV. 1 WITHIN 5' OF DISPENSER ENCLOSURE
- CLASS I, DIV. 2 UP TO 15' FROM STORAGE EQUIPMENT, BUT SHALL NOT EXTEND PAST AN UNPIERCED WALL OR GASTIGHT PARTITION. ENCLOSURE DESIGN AND LOUVRE LOCATION(S) WILL DICTATE THE DIRECTION THIS ZONE EXTENDS.

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MODULAR HYDROGEN STATION - GAS DELIVERY - 180 KG/DAY

REFERENCE STATION DESIGN LAYOUTS FOR SPACE EVALUATION
FCEV HYDROGEN READINESS PROJECT

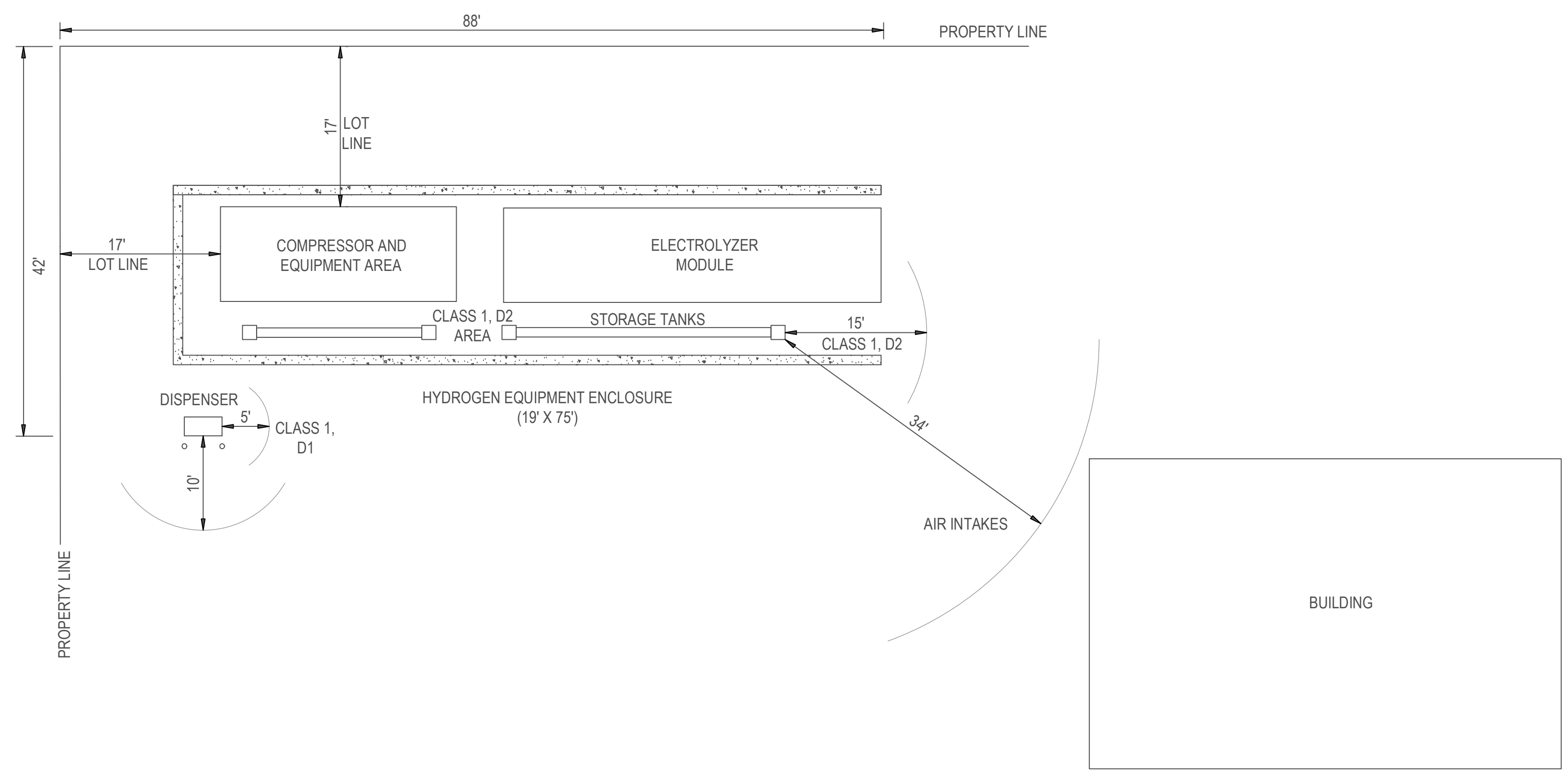
PHASE 1
DRWN: GC CHK:

SHEET 1

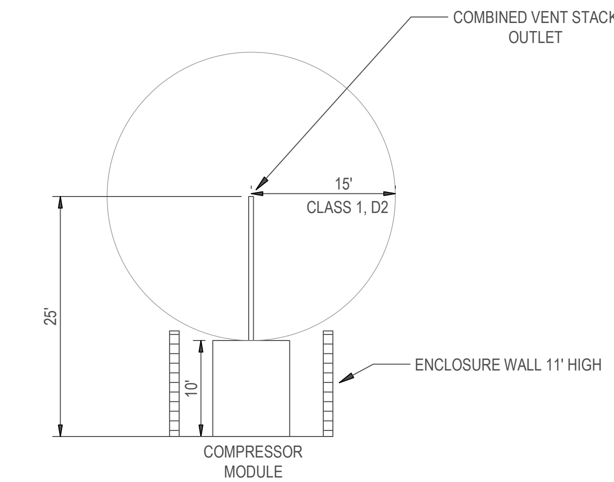
Credit: *SERC, 2018*

Figure 13: Design Option 2 - On-Site Hydrogen Generation Using Electrolysis

DRAWING 3: ON-SITE ELECTROLYSIS STATION WITH LINEAR CONFIGURATION
OVERALL SPACE REQUIREMENT OF 42' X 88' INCLUDING THE DISPENSER



DRAWING 4: SIDE VIEW OF VENT STACK EXTENDING
UPWARD FROM COMPRESSOR MODULE



THIS EXAMPLE SHOWS THAT WITH AN ENCLOSURE WALL HEIGHT OF 11' AND A VENT STACK OUTLET HEIGHT OF 25', THE CLASS 1, DIV 2 ELECTRICAL CLASSIFICATION ZONE DOES NOT EXTEND TO GROUND LEVEL.

ENCROACHMENT OF OVERHEAD UTILITIES SHOULD BE INVESTIGATED (14' PER NFPA 2)

DESIGN NOTES

IN THESE TWO LAYOUTS THE LOT LINE SETBACKS ARE IMPLEMENTED TO PROVIDE A CONSERVATIVE APPROACH FOR ESTIMATING THE TOTAL OPEN SPACE REQUIRED TO INSTALL THIS TYPE OF STATION. MODIFICATIONS TO ANY SETBACKS ARE AT THE DISCRETION OF THE AUTHORITY HAVING JURISDICTION (AHJ) AND IF IMPLEMENTED, MAY MAKE A SPACE-CONTRAINED SITE VIABLE FOR HYDROGEN INTEGRATION.

A SITE EVALUATION WILL BE REQUIRED TO DETERMINE HOW THE 34' AIR INTAKE DISTANCE AFFECTS THE REQUIRED SPACE.

- THIS ANALYSIS IS A HIGH-LEVEL LOOK AT CODE REQUIREMENTS, A MORE DETAILED INVESTIGATION BY A CODE EXPERT IS RECOMMENDED FOR SITE DESIGN
- ONLY CRITICAL NFPA 2 SEPARATION DISTANCES AND SOME ELECTRICAL AREA CLASSIFICATION DISTANCES ARE SHOWN
- ENCLOSURES ARE CONSTRUCTED OF NON-COMBUSTIBLE MATERIALS AND ARE DESIGNED TO PROVIDE ADEQUATE VENTILATION
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SEPARATION DISTANCES FOR GASEOUS HYDROGEN SYSTEMS (NFPA 2, 2016)

- AIR INTAKES (HVAC AND COMPRESSORS, ETC.) 34'
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- PARKED CARS 8'
- BUILDINGS OF NONCOMBUSTIBLE OR COMBUSTIBLE MATERIALS 14'
- DISPENSER TO LOT LINE, IGNITION SOURCE, ETC. 10'
- APPROVAL AND MODIFICATIONS TO SETBACKS AT THE DISCRETION OF THE AUTHORITY HAVING JURISDICTION (AHJ)

ELECTRICAL AREA CLASSIFICATIONS - GH2 VEHICLE FUELING STATIONS (NFPA 2, 2016)

- ALL DISTANCES MEASURED SPHERICALLY FROM SOURCE POINT
- WITH STRATEGIC PLACEMENT AND HEIGHT OF THE RELIEF VALVE AND VENT STACK OUTLETS, THE ELECTRICAL CLASSIFICATION AREAS FROM THESE SOURCES SHOULD NOT EXTEND TO GROUND LEVEL OUTSIDE THE EQUIPMENT ENCLOSURE
- CLASS I, DIV. 1 WITHIN 5' OF DISPENSER ENCLOSURE
- CLASS I, DIV. 2 UP TO 15' FROM STORAGE EQUIPMENT, BUT SHALL NOT EXTEND PAST AN UNPIERCED WALL OR GASTIGHT PARTITION. ENCLOSURE DESIGN AND LOUVRE LOCATION(S) WILL DICTATE THE DIRECTION THIS ZONE EXTENDS.

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MODULAR HYDROGEN STATION - ELECTROLYSIS GENERATION - 130 KG/DAY
MODULES IN A LINEAR CONFIGURATION

REFERENCE STATION DESIGN LAYOUTS FOR SPACE EVALUATION
FCEV HYDROGEN READINESS PROJECT

PHASE 1
DRWN: GC CHK:

SHEET 2

Credit: *SERC, 2018*

CHAPTER 6: Site Screening Evaluations

A site screening process similar to those used in past hydrogen integration studies was created to analyze the existing retail gasoline fueling stations and open parcels in the Eureka and Redding areas for possible hydrogen integration. The process steps are:

- Determine the open space required to install a hydrogen station: review available hydrogen station planning literature and current retail hydrogen station designs to quantify the space needed to install a hydrogen station.
- Define site screening criteria: develop the criteria that will be used to screen potential sites.
- Pre-screen retail gasoline stations: locate the retail gasoline stations identified from the macrositing task using Google Maps and conduct a preliminary screening based on available open space and proximity to the priority zone.
- Identify commercial parcels or open lots with available open space: survey the priority zone using Google Maps and identify commercial lots with available open space. Priority zones were developed in the macrositing task by overlaying the commercial zoning layer with CHIT capacity needs to identify the areas where station utilization may be the highest.
- Perform a basic site assessment of the potential sites: conduct an assessment of the potential sites and document general site information (business name, address, type of business) and a description of the land and surrounding area. Also, obtain images of the sites, measure the available space, and identify any site-specific issues that may make hydrogen integration difficult. Summarize this information in a Potential Sites List.
- Conduct site screening and select candidate sites: screen the potential sites using the developed criteria that will result in a short list of candidate sites.

In addition, the above process was applied to sites submitted to the project team through a public request for information (RFI). RCEA worked with project partners to distribute an RFI to solicit responses from public and private entities in the North Coast and Upstate regions.

Site Screening Criteria

The following mix of quantitative and qualitative criteria was developed by the project team to provide guidance in the site evaluation process:

- Sufficient Space for Delivered H2: for a site to accommodate a station that receives delivered gas, it must have an open area with dimensions of at least 15’ x 45’ or 29’ x 31’ for the hydrogen equipment. It is assumed that additional space will be available for the dispensing and electrical equipment. Note that these dimensions do not address NFPA or electrical classification requirements.

- Sufficient Space for On-site Generation: for a site to accommodate a station that generates gas on-site, it must have an open area with dimensions of at least 19' x 75'. It is assumed that additional space will be available for the dispensing and electrical equipment. Note that these dimensions do not address NFPA or electrical classification requirements.
- Proximity: an ideal site will be in close proximity to major regional highways and/or high-use traffic routes within city limits.
- Accessibility: sites must have convenient access to and from the site based on traffic patterns and in the case of delivered hydrogen, they must have sufficient space for a gas delivery truck to navigate the site safely.
- Visibility: ideal sites are located along high-use traffic routes.

The qualitative criteria (Proximity, Accessibility, and Visibility) will be judged by viewing the sites in Google Maps in relationship to the priority zone and surrounding traffic routes. The quantitative criteria (Sufficient Space) will provide a discreet metric in the process. If a site does not have sufficient open space to fit the equipment, the site is screened out.

Site Evaluations - Eureka

Sites for Eureka were screened using the following process:

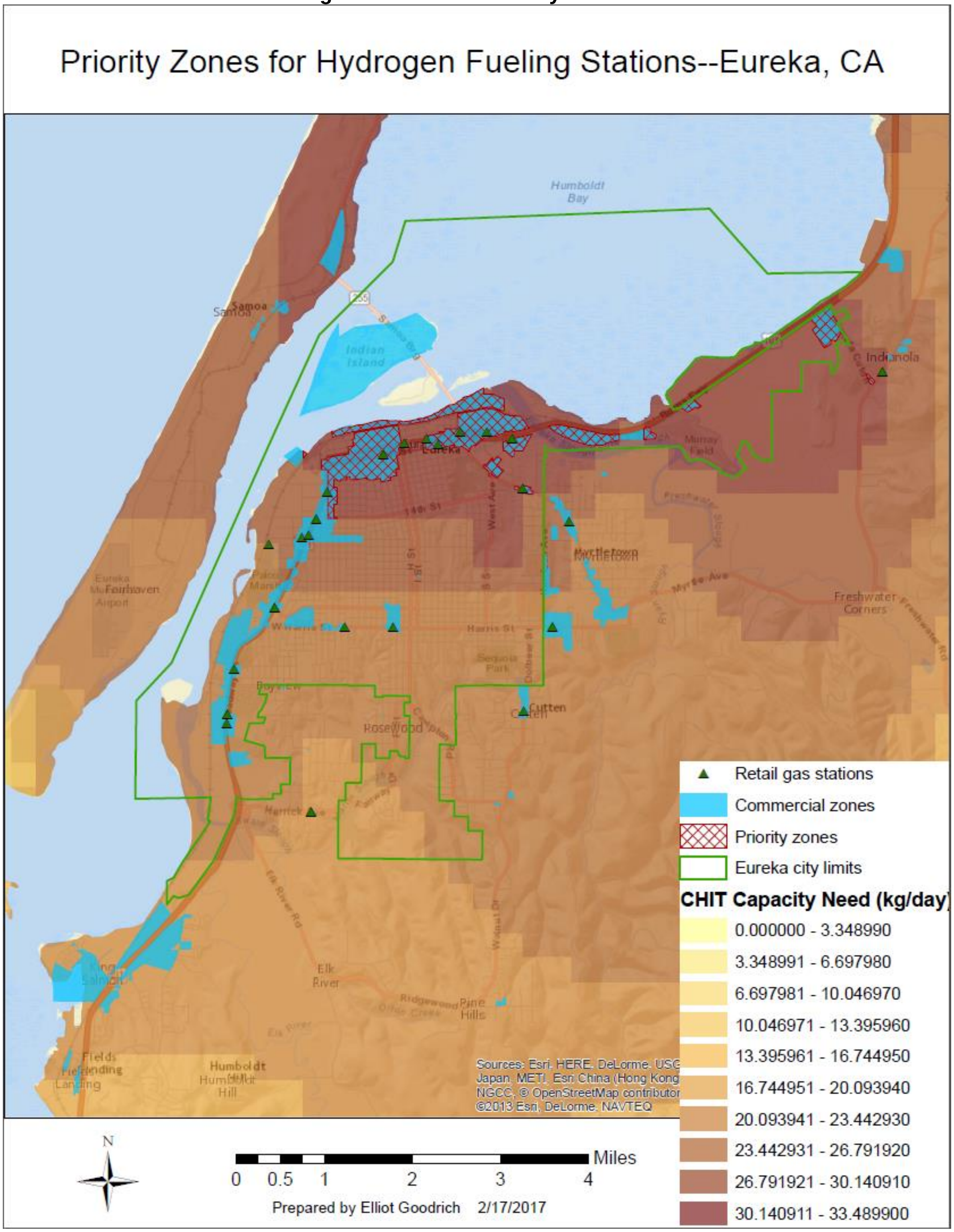
1. A list of Eureka retail gas stations was created by RCEA within the Eureka priority zones identified during the Task 2.1 macrositing effort (priority zones shown in Figure 14). A prescreening of these gas stations was conducted using the proximity and sufficient space criteria and inadequate sites were eliminated (Table 8). Of the twenty-four retail stations, 6 (25%) of the stations were found to meet these initial criteria.
2. A survey for open lots within the Eureka priority area, south along the main thoroughfare (Broadway Street), and at two Renner stations north of Eureka, resulted in 15 additional sites to be evaluated.
3. Basic site assessments were conducted for the 19 total sites and information and the captured images were collected and are available in Appendix A. A potential site list (Table 9) was also created that provides information such as: the type of business, whether it lies within the priority zone, the open space dimensions, and any issues that may make hydrogen integration difficult.
4. The screening process was carried out and results for each site can be seen in the screening rubric in (Table 10). The process resulted in the short list of 12 candidate sites shown in Table 6. In cases where the size or shape of a sites open space was questionable, but all other criteria were met, the team deemed the site viable. A

subsequent in-depth analysis of site layout may make these sites inadequate.

A few observations for the top candidate sites:

- Three sites are gas stations located at the north end of Eureka: Shell Station-Myrtle, Humboldt Plaza Chevron, and Renner Petroleum-North.
- Three sites (Cash & Carry, Bracut Industrial Park, and Humboldt Plaza Private lot) are in a prime location on Highway 101 between Eureka and Arcata and have sufficient space to host an on-site generation station. The intersections for accessing the Cash & Carry and Bracut sites do not have traffic lights and there are safety concerns for crossing traffic. CalTrans has plans to address the various ingress and egress points along the safety corridor. Further investigation into the plans is required.
- The two commercial sites (Pacific Outfitters and Target) may have some compatibility challenges with the existing business traffic and dispensing hydrogen.
- Shell/Pacific Pride and Broadway Gas - 76 stations have available open space and offer good visibility, but are located outside the priority zones.
- Renner Petroleum – South is off-the beaten path and has limited open space, however the owner may be interested in hosting a station.
- The W. 7th & Summer St. open lot has some unknowns, but owner engagement should occur before screening out this site.

Figure 14: Eureka Priority Zones



Credit: *Redwood Coast Energy Authority, 2017*

Table 6: Top Candidate Sites for Eureka

Business	*Type*	*Priority Zone*	*Space for Delivered Gas*	*Space for Onsite Generation*	*Comments/Concerns*
Shell Station - Myrtle	gas station	yes	yes	no	<1 mile south of Hwy 101 at the north end of Eureka
Humboldt Plaza Chevron	gas station	yes	possibly	no	good location, sewer access issues
Renner Petroleum Eureka North	gas station	yes	possibly	no	possible interested host, storm drain access issues
Cash & Carry	commercial	yes	yes	yes	ideal location, accessibility safety concerns
Bracut Industrial Park	commercial	yes	yes	yes	ideal location, accessibility safety concerns
Pacific Outfitters	commercial	yes	yes	no	good visibility, incompatible and loss of parking
Target	commercial	yes	yes	yes	difficult to work with large corporation
Humboldt Plaza Lot	parking lot	yes	yes	yes	large private lot, secluded location
Shell/Pacific Pride	gas station	no	yes	no	sufficient space, outside of priority zone
Broadway Gas 76	gas station	no	yes	no	open space, outside of priority zone
Renner Petroleum Eureka South	gas station	no	possibly	no	limited space, possible interested party
Undeveloped	empty lot	no	yes	no	outside of priority zone, ingress and egress concerns
Renner Arcata	gas station	no	possibly	possibly	constrained space, possible storm drainage issues
Renner McKinleyville	gas station	no	possibly	possibly	excellent space if open lot is developable. Otherwise space constrained. Long distance for Eureka and Arcata drivers

Credit: *SERC, 2018*

Site Evaluations - Redding

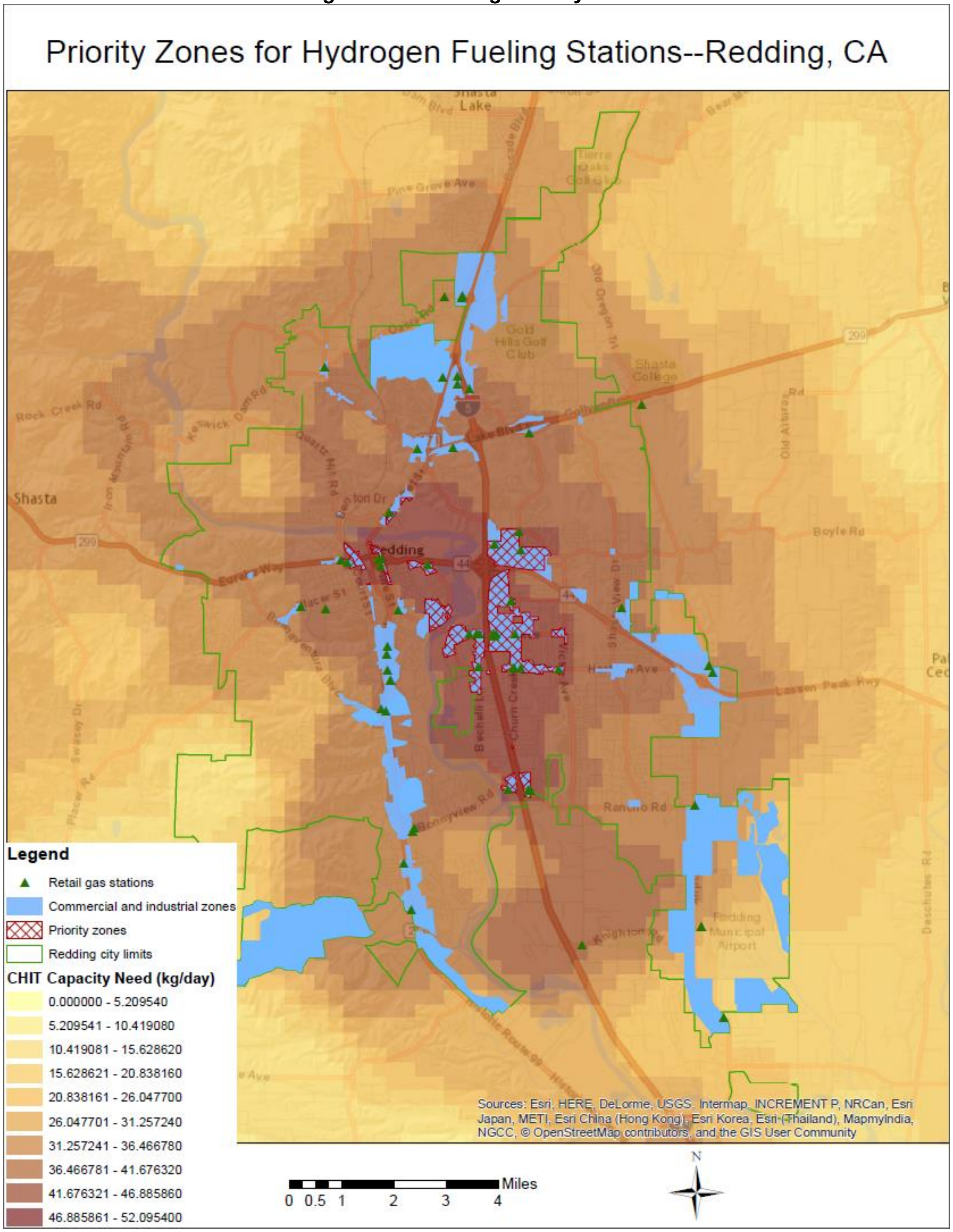
Sites for Redding were screened with the following modified process:

1. Given the high number of retail gas stations in Redding, the prescreening criteria were modified to filter out inadequate sites and improve the quality of stations evaluated in the next steps of the screening process. Instead of the proximity criterion, the station was required to be located within the priority zone (identified in the Task 2.1 Regional Hydrogen Infrastructure Plan, and shown in Figure 15). Once these priority zone stations were identified, they were screened for sufficient space. Of the sixty-four retail stations, 10 (~15%) of the stations were found to meet these initial criteria (Table 11).
2. Attempting to identify commercial parcels or open lots with sufficient space in the large Redding priority zone would be inefficient and a difficult task using Google Maps. The project team plans to work with partners in the Redding area to assist in this step.
3. Basic site assessments were conducted for the 10 retail stations and information and the captured images were collected and are available in Appendix B. A potential site list (Table 12) was also created that provides the open space dimensions, accessibility to major routes and any issues that may make hydrogen integration difficult.
4. The screening process was carried out and results for each site can be seen in the screening rubric in Table 7 (which is also repeated in Appendix B in Table 13). All 10 potential sites passed the screening process and are deemed viable sites.

A few observations from the screening process:

- All of the sites have sufficient space to site the hydrogen equipment, however, 7 of the 10 sites are space limited and may not meet the full lot line separation distance requirement. Authorization by the AHJ would be needed to reduce this distance to make installation possible.
- All of the sites have adequate to good visibility and are in close proximity to major highways.
- The available lots in the region identified as the priority zone are generally space constrained as the area has a relatively high density of built infrastructure. The limited available space and potential loss of parking spaces may be the most common reason for owners declining to host a hydrogen station at their site. Looking outside the priority zone may reveal many more options as the density of built infrastructure is lower.

Figure 15: Redding Priority Zones



Credit: *Redwood Coast Energy Authority, 2017*

Table 7:Top Candidate Sites Within the Priority Zone for Redding

Site #	*Business*	*Space for Delivered Gas*	*Proximity*	*Accessibility*	*Visibility*	*Comments Potential Concerns*
1	HILLTOP FOOD & FUEL	yes	at I-5 exit	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking
2	ARCO AM/PM #83205	yes	0.7 miles from I-5 exit	okay	okay	limited space - lot line separation issue loss of parking
3	TESORO #68192	yes	0.2 miles from I-5 exit	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking obstruction of traffic
4	BALL PARK 76	yes	1 mile from I-5 exit	okay	okay	limited space - lot line separation issue loss of parking
5	COLONIAL ENERGY CE 20110	yes	2 miles from I-5 exit	okay	good	open space
6	CHURN CREEK CHEVRON	yes	at I-5 exit	okay	good	open space
7	TURTLE BAY MINI MART	yes	at Hwy 44 exit 2 miles from I-5	yes	okay	sufficient space good location
8	TESORO #68194	yes	1 mile from I-5 exit	yes	okay	limited space - lot line separation issue loss of parking
9	SPEEDY VALERO	yes	on Hwy 299 < 3 miles from I-5	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking interference with handicap route
10	CHEVRON	yes	at I-5 exit	okay	good	limited space - lot line separation issue loss of parking incompatible with adjacent motel

Credit: *SERC, 2018*

Example Station Design Options at Two Candidate Sites

Two top candidate sites were chosen to illustrate how a hydrogen fueling station could be integrated at these sites. At the Myrtle Shell Station, we will present two images to show how safely adjusting the lot line setbacks could make hydrogen integration viable at a retail gas station. The other example layout in the Humboldt Plaza parking lot will illustrate that even a large, on-site hydrogen generation station can be safely sited if a suitable location is used.

Myrtle Shell Station – Modular System with Gas Delivery

A visual assessment of the shape and location of the open space at the Myrtle Shell gas station indicate that a gas-delivered hydrogen station with a linear configuration would be appropriate. Figure 16 shows a dimensioned layout for this station type at the east end of the property. The linear station is parallel to and 17' from the angled lot fence line. In this position, the hydrogen equipment enclosure and dispenser extend into the normal traffic flow path on the property presenting a safety hazard that may deem this site inappropriate for hydrogen integration.

Figure 16: Dimensionalized Layout of a Gas-delivered Station at Myrtle Shell

Station positioned 17' from lot line. Image – *Google Maps, 2018.* Overlay drawing – *SERC, 2018*

The dispenser could be relocated to the end of the enclosure or if space is available to the existing gas dispensing island. Even so, the top left corner of the enclosure may still be a safety issue. A lot line setback adjustment could possibly make for a safer layout and make hydrogen integration viable at this site. The adjacent property on southeast side of the station is steep and unoccupied land. With approval from the AHJ, a reduction in the lot line setback as shown in Figure 17, would move the hydrogen equipment enclosure and dispenser closer to the fence line and out of traffic flow path.

Figure 17: Station Layout Adjustment at Myrtle Shell

Station repositioned closer to lot line with unoccupied land. Credit: Image – *Google Maps, 2018.* Overlay drawing – *SERC, 2018*

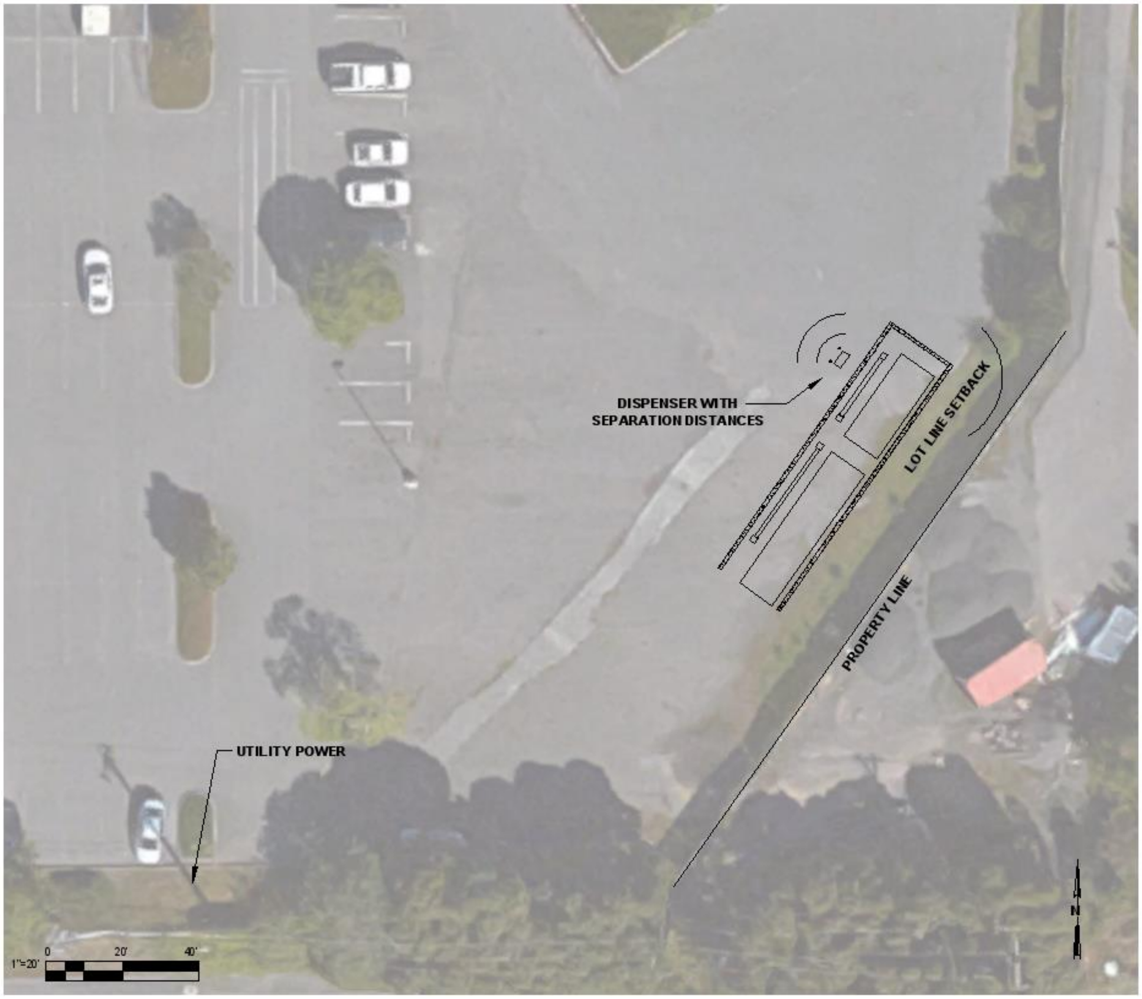
A detailed site investigation would be required to assess the property and determine if the 34' minimum air intake setback is met. Siting a station on this lot would require the relocation of the propane tank and associated refilling system, and would result in a loss of parking spaces. The lost handicapped parking space would need to be relocated to west side of store.

Humboldt Plaza Parking Lot – On-Site Generation Using Electrolysis

Based on a preliminary visual assessment of the Humboldt Plaza parking lot, the area in the southeast corner of the lot seems like a good location for an on-site hydrogen generation station. It is a flat area away from the normal traffic pathway through the parking lot and there is power available at the utility pole in the bottom left corner of the image. A site investigation would be required to identify the location of the water supply and storm drain systems needed for the electrolysis water treatment system.

Figure 18 shows a dimensioned layout of an on-site hydrogen generation along the angled fence line. The areas along the property line on either side of the layout are also suitable.

Figure 18: Dimensionalized Layout of an On-Site Generation Station at Humboldt Plaza



Credit: Image – *Google Maps, 2018.* Overlay drawing – *SERC, 2018*

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APPENDIX A: Details Regarding Sites Considered in Eureka

Eureka – Prescreening of Retail Gas Stations

Table 8: List of Prescreened Retail Gas Stations in Eureka Provided By RCEA

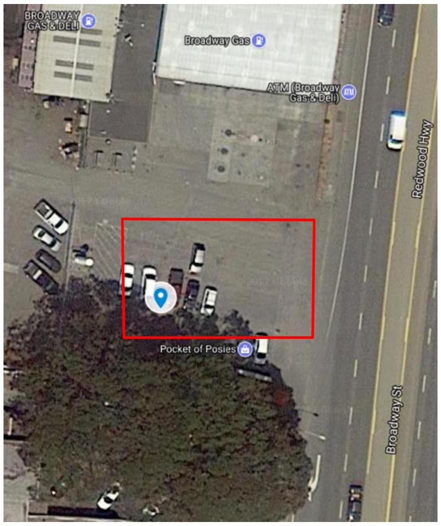
Station #	*Name*	*Address*	*Proximity*	*Sufficient Space*
1	GAS-N-GO PATRIOT	1711 4TH STREET	yes	no
2	PATRIOT GASOLINE	1679 MYRTLE AVE	no	yes
3	FAIRWAY MARKET (PATRIOT)	590 HERRICK AVE	no	yes
4	BROADWAY GAS & DELI	4050 BROADWAY	yes	yes
5	COSTCO GAS STATION #125	1006 W WABASH AVE	yes	no
6	PERFORMANCE FUELS (HP #1)	1125 4TH ST	yes	no
7	CUTTEN SHELL (HP #4)	3973 WALNUT DRIVE	no	yes
8	HARRIS STREET SHELL (HP #2)	111 W HARRIS STREET	yes	no
9	MYRTLE AVENUE SHELL (HP #5)	1434 MYRTLE AVE	yes	yes
10	SHELL PETRO MART (HP #9)	1310 5TH STREET	yes	no
11	BROADWAY TEXACO (HP #14)	1007 BROADWAY	yes	no
12	4TH STREET SHELL (HP#10)	2111 4TH ST	yes	no
13	HP #17 (SHELL)	3505 BROADWAY	yes	yes
14	INDIANOLA MARKET	7769 MYRTLE AVE	no	yes
15	NORTH EUREKA CHEVRON	2480 6TH STREET	yes	yes
16	EUREKA CHEVRON	2806 BROADWAY	yes	no
17	EUREKA EAST CARDLOCK	2600 HARRIS STREET	yes	no
18	EUREKA NORTH CARDLOCK	1976 5TH STREET	yes	yes
19	EUREKA SOUTH CARDLOCK	1176 W DEL NORTE ST	yes	yes
20	COURTHOUSE UNION 76	803 4TH STREET	yes	no
21	FAIRWAY PLUS TWO	1411 BROADWAY	yes	no
22	FAIRWAY PLUS (PATRIOT)	1723 BROADWAY	yes	no
23	HENDERSON CENTER PATRIOT	414 HARRIS STREET	yes	no
24	SOUTH BROADWAY PATRIOT	4175 BROADWAY	yes	no

(shaded) passed both prescreening criteria

Credit: *SERC, 2018*

Eureka - Site Assessment of Possible Hydrogen Station Locations

1. Broadway Gas – 76, 4050 Broadway St.



Credit: *Google Maps, 2018.*

- Paved parking lot
- Possible Issues:
    - Trees and building on adjacent property owner to the south
    - Propane tank on lot

2. Shell Station, 1434 Myrtle Ave

Credit: *Google Maps, 2018.*

- Available space
- 1 mile south of Hwy 101 N

3. Shell / Pacific Pride Gas Station 3505 Broadway St

Credit: *Google Maps, 2018.*

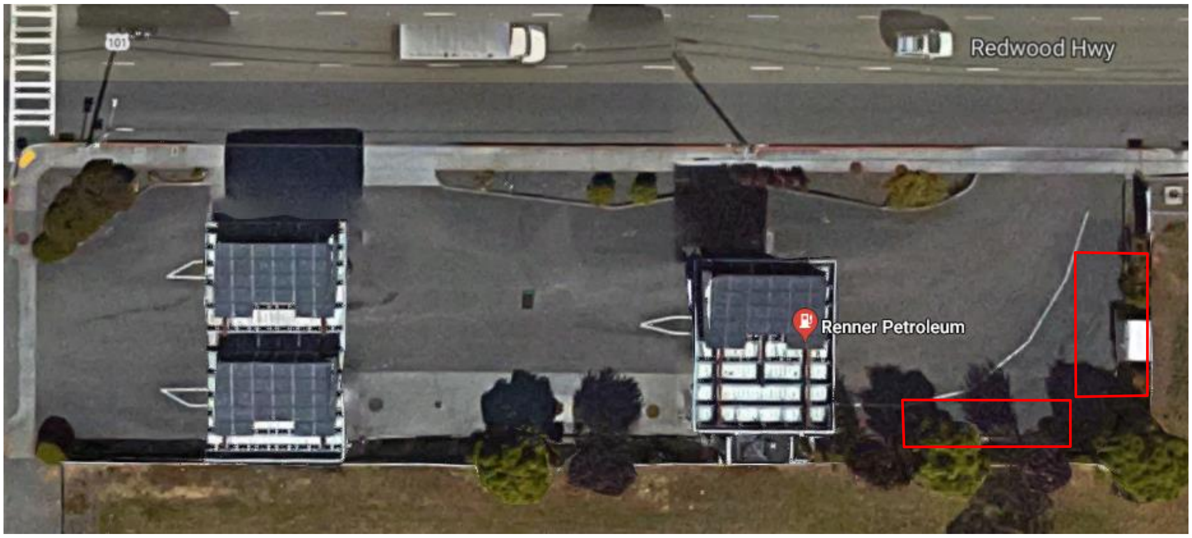
- Open space on southern portion of lot

4. Humboldt Plaza Chevron

Credit: *Google Maps, 2018.*

- no overhead electrical.
- Possible Issues:
  - an irregular lot which present a challenge with arranging equipment while maintaining setbacks traffic ingress / egress
  - loss of parking spaces
  - sewer pipes and access in grass area

5. Renner 1976 5th St



Credit: *Google Maps, 2018.*

- Ideal location, limited amount of open space
- Storm drain access at bottom corner of lot
- Possible interested party

6. Renner Petroleum W. Del Norte 1141 W Del Norte St:

Credit: *Google Maps, 2018.*

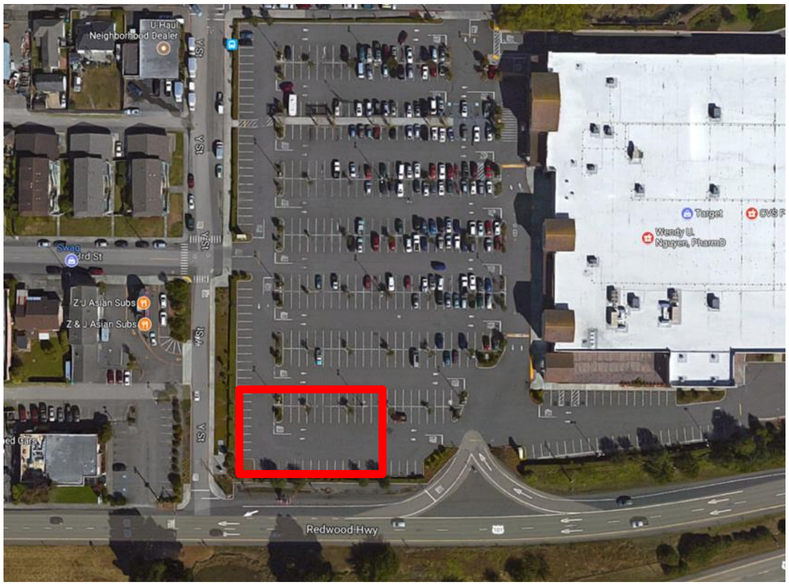
- Small corner of open area at SW corner
- Possible interested party
- Away from traffic routes
- Possible Issues:
    - traffic for existing gasoline dispensers and other on-site businesses

7. Pacific Outfitters - grass area at SW corner of 5th and R

Credit: *Google Maps, 2018.*

- No buildings nearby, no overhead electrical.
- Trapezoidal shaped grass area, limited parking
- Possible Issues:
    - irregular lot so may be challenging arranging equipment and associated setback requirements
    - potential loss of parking spaces

8. Target: Southeast corner of lot



Credit: *Google Maps, 2018.*

- Plenty of space, no nearby buildings, no overhead electrical.
- Possible Issues:
    - traffic ingress / egress – access through parking lot
    - loss of parking spaces

9. Humboldt Plaza Parking Lot

Credit: *Google Maps, 2018.*

- no overhead electrical.
- Possible Issues:
  - potential blockage of access to property to the east

10. W. 7th and Summer St: triangle corner empty lot

Credit: *Google Maps, 2018.*

- Small triangle, empty grass area
- Possible Issues:
  - corner of busy intersection
  - ingress and egress issues along with code setbacks (lot line)

11. 6th and B St: NW corner, S of and adjacent to Hertz

Credit: *Google Maps, 2018.*

- Owner unknown
- Near rental car agencies

12. **5th and O St: empty lot and commercial building**

Credit: *Google Maps, 2018.*

- Paved vacant parking lot, unknown business owner
- Possible Issues:
  - would occupy parking spaces for future tenants

13. SE corner of 3rd and J St.: empty lot behind Coast Central Credit Union

Credit: *Google Maps, 2018.*

- Possible Issues:
    - For Sale

14. 936 W. Hawthorne St

Credit: *Google Maps, 2018.*

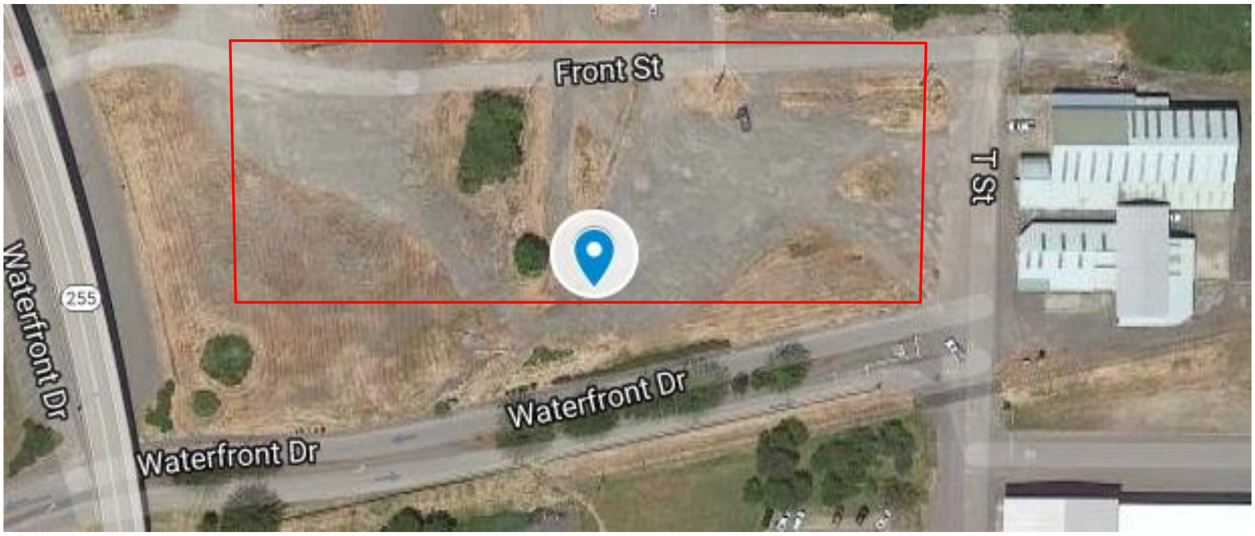
- Empty, unpaved lot
- adjacent property potentially code compatible
- Possible Issues:
    - Proximity to Chamber of Commerce parking lot

15. Building Material Distributor, 1200 W Del Norte St

Credit: *Google Maps, 2018.*

- Plenty of available space
- Possible Issues:
  - Owner may not want to tie up small portion of property with station

16. Eureka Waterfront property



Credit: *Google Maps, 2018.*

- Green fields
- Possible Issues:
  - new development currently in progress

17. Eureka Oxygen, 2810 Jacobs Ave.

Credit: *Google Maps, 2018.*

- Possible Issues: too many gas storage tanks/cylinders throughout property

18. Cash & Carry, 6700 N Highway 101

Credit: *Google Maps, 2018.*

- Access issues – crossing of Hwy 101 may be required
- Location good between Eureka and Arcata

19. Bracut Industrial Park, 4000 US-101

Credit: *Google Maps, 2018.*

- Plenty of open space
- Access issues – crossing of Hwy 101 may be required
- Location good between Eureka and Arcata

20. Renner Arcata, 5000 West End Road, Arcata

Credit: *Google Maps, 2018.*

- Restricted space
- Good access to 299 and 101
- Area along west end road has storm water drainage infrastructure

21. Renner McKinleyville, 2782 Central Ave

Credit: *Google Maps, 2018.*

- Excellent open space if empty lot can be used
- If empty lot cannot be used, primary open space is south end of gas station. There may not be sufficient space for hydrogen refill truck to sit while refilling.
- Good access to 101
- North of bay area may not be convenient for local drivers that do not live in McKinleyville.

Eureka - Potential Site List

Table 9: Potential Site List for Eureka Area

Site #	*Business*	*Address*	*Type*	*Priority Zone*	*Open Space (ft)*	*Issues*
1	Broadway Gas - 76	4050 Broadway St	gas station	no	70 x 35	limited open space trees and building on adjacent lot
2	Shell Station -Myrtle	1434 Myrtle Ave	gas station	yes	25 x 50	limited open space good visibility
3	Shell/Pacific Pride	3505 Broadway St	gas station	no	25 x 60	open space good visibility
4	Humboldt Plaza Chevron	2480 6th St	gas station	yes	30 x 100 x 70 trapezoid	small area, sewer pipes and access in grass area
5	Renner Petroleum Eureka-N	1976 5th. St	gas station	yes	15 x 30 10 x 30	storm drain access in north east corner of lot limits possible interested party
6	Renner Petroleum Eureka- S	1141 W Del Norte St	gas station	no	40 x 40 x 70	small corner area possible interested party
7	Pacific Outfitters	1600 5th St	commercial	yes	100 x 100	irregular shaped lot, difficult to site H2 equipment loss of parking
8	Target	2525 4th St	commercial	yes	large lot	large lot, good access, working with large corporation
9	Humboldt Plaza Lot	2500 6th St	parking lot	yes	30 x 100 x 70	large lot, secluded area
10	Undeveloped	W. 7th & Summer St	empty	no	75 x 75 x 110 triangle	small area, potential ingress and egress issues
11	Unknown	6th & B St	parking lot	yes	100 x 60	loss of parking potential compatibility issues with neighbors
12	Unknown	5th & O St	commercial	yes	100 x 20	loss of parking and use of existing building
13	Unknown	3rd & J St	commercial	no	110 x 110	For Sale - potentially expensive to acquire land and develop, not an appropriate site
14	Unknown	936 Hawthorne St	empty lot	no	180 x 120	unpaved, potentially compatible with one neighbor, other side is Chamber of Commerce
15	Building Materials Distributors	1200 W Del Norte St	industrial	no	300 x 300	large empty space
16	Eureka Waterfront	T & Waterfront St	multi-use	yes	multiple locations	large area, city development in progress
17	Eureka Oxygen	2810 Jacobs Ave	light industrial	yes	90 x 40	open area, site has hazardous gases, tanks and cylinders throughout
18	Cash & Carry	6700 N Highway 101	grocery store	yes	120 x 60	prime location access issue - crossing busy highway

19	Bracut Industrial Park	4000 US-101	commercial	yes	large parcel	prime location, access issue - crossing busy highway
20	Renner Arcata	5000 West End Rd, Arcata	gas station	no	90 x 30 20 x 50	Drainage on west edge of larger open space
21	Renner McKinleyville	2782 Central Ave., McKinleyville	gas station	no	100 x 200 15 x 80	Smaller open space may not have sufficient room for refill truck to sit while refilling

Credit: *SERC, 2018*

Eureka - Site Evaluation Rubric

Table 10: Eureka Area – Evaluation Rubric

Business	*Priority Zone*	*Space for Delivered Gas*	*Space for Onsite Generation*	*Proximity*	*Accessibility*	*Visibility*	*Comments Potential Concerns*
Broadway Gas - 76	no	yes	no	south end of town	yes	good	good visibility incompatible with neighbors
Shell Station -Myrtle	yes	yes	no	1 mile south of Hwy 101	yes	okay	limited open space okay proximity
Shell/Pacific Pride	no	yes	no	south end of town	yes	good	good site outside priority zone
Humboldt Plaza Chevron	yes	possibly	no	yes	convenient for Hwy 101 N	okay	good location sewer access issues
Renner Petroleum Eureka North	yes	possibly	no	yes	yes	good	possible interested host, storm drain access
Renner Petroleum Eureka South	no	possibly	no	west side of town	yes, remote location	poor	possible interested host, outside priority zone
Pacific Outfitters	yes	yes	no	yes	yes	good	good visibility incompatible/loss of parking
Target	yes	yes	yes	yes	yes	good	great location incompatible with owner
Humboldt Plaza Lot	yes	yes	yes	yes	from Hwy 101 N	poor	open space poor visibility
Undeveloped	no	yes	no	yes	yes	okay	ingress/egress concerns
6th & B St	yes	yes	yes	yes	yes	poor	loss of parking neighbor compatibility
5th & O St	yes	no	yes	yes	yes	good	loss of parking and use of building
3rd & J St	no	yes	yes	yes	yes	poor	For sale - incompatible with neighbors
936 Hawthorne St	no	yes	yes	south end of town	yes	poor	may be incompatible with neighbor
Building Materials Distributors	no	yes	yes	west side of town	yes, remote location	poor	long distance for Arcata drivers

Eureka Waterfront	yes	yes	yes	away from traffic	unknown	poor	development underway
Eureka Oxygen	yes	yes	no	yes	no	poor	good location hazardous gases
Cash & Carry	yes	yes	yes	yes	yes	good	ideal location accessibility safety concerns
Bracut Industrial Park	yes	yes	yes	yes	yes	good	ideal location accessibility safety concerns
Renner Arcata	no	possibly	possibly	yes	yes, convenient for 299 and 101	okay	constrained space, possible storm drainage issues
Renner McKinleyville	no	possibly	possibly	yes	maybe, convenient for 101	good	excellent space if open lot is developable. Otherwise space constrained. Long distance for Eureka and Arcata drivers

gas stations - passed	commercial - passed	did not pass

Credit: *SERC, 2018*

APPENDIX B: Details Regarding Sites Considered in Redding

Redding – Prescreening of Retail Gas Stations

Table 11: List of Prescreened Retail Gas Stations in Redding

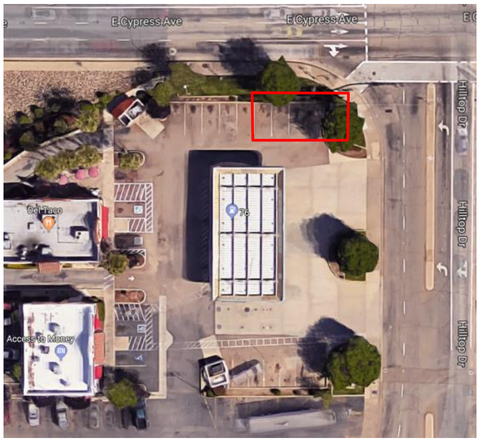
Station #	*Name*	*Address*	*In Priority Zone*	*Sufficient Space*
11	CIRCLE K/76 - HARTNELL	1015 HARTNELL AVE	yes	no
55	TESORO #68193	2998 CHURN CREEK RD	yes	no
45	SAFEWAY FUEL CENTER	1010 E. CYPRESS AVE	yes	no
61	VASU GAS & FOOD	1120 HARTNELL AVE	yes	maybe
18	CYPRESS CHEVRON	765 E. CYPRESS AVE	yes	maybe
30	HILLTOP FOOD & FUEL	2604 HILLTOP DRIVE	yes	yes
31	HILLTOP VALERO	722 E CYPRESS AVENUE	yes	maybe
2	ARCO #05797	2010 CHURN CREEK RD	yes	no
33	JINDRA'S AUTO SERVICE INC	482 E CYPRESS AVENUE	yes	no
36	LANE CHEVRON	510 EAST CYPRESS AVE	yes	no
4	ARCO AM/PM #83205	2951 BECHELLI LANE	yes	yes
54	TESORO #68192	382 E. CYPRESS AVENUE	yes	yes
5	BALL PARK 76	1275 CHURN CREEK RD	yes	yes
8	BROWNING ST MINI MART	1120 CHURN CREEK RD	yes	no
15	COLONIAL ENERGY CE 20110	1670 HARTNELL AVE	yes	yes
26	FOOD EXPRESS #5	5150 CHURN CREEK RD	yes	no
9	CHURN CREEK CHEVRON	4746 CHURN CREEK RD	yes	yes
27	FUELGOOD	1279 PINE STREET	yes	no
28	GAS 4 LESS	1409 PINE STREET	yes	no
48	SHASTA STREET VALERO	1220 SHASTA STREET	yes	no
58	TURTLE BAY MINI MART	1801 PARK MARINA DR	yes	yes
56	TESORO #68194	1233 HILLTOP DRIVE	yes	yes
6	BONNYVIEW CHEVRON	5001 BECHELLI LANE	yes	maybe
19	EUREKA WAY CHEVRON	1905 EUREKA WAY	yes	no
51	SPEEDY VALERO	2026 EUREKA WAY	yes	yes
49	SHASTA VIEW CHEVRON	2505 TARMAC ROAD	yes	no
	CHEVRON	1650 HILLTOP	yes	yes

(shaded) passed both prescreening criteria

Credit: *SERC, 2018*

Redding - Site Assessment of Possible Hydrogen Station Locations

1. **HILLTOP FOOD & FUEL – 2604 HILLTOP DRIVE 25' x 50'**



Credit: *Google Maps, 2018.*

- High visibility, great access to/from I-5
- Possible Issues:
    - Loss of parking spaces
    - Gasoline delivery truck and UG tanks prevent use of southern parking area

2. **ARCO AM/PM #83205 - 2951 BECHELLI LANE 25' x 85'**

Credit: *Google Maps, 2018.*

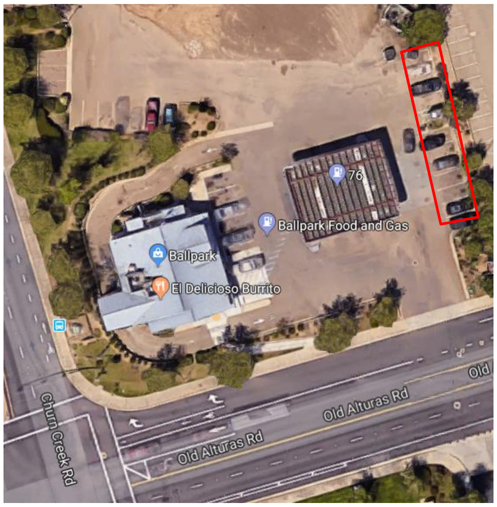
- High visibility, limited parking
- Possible Issues:
    - Loss of parking spaces
    - Store delivery truck may use area of interest

3. **TESORO #68192 - 382 E. CYPRESS AVENUE ~ 18' x 85'**

Credit: *Google Maps, 2018.*

- High visibility, I-5 on/off ramps on Cypress Ave
- Possible Issues:
    - Loss of parking spaces
    - Traffic flow to western most fueling island

4. **BALL PARK 76 - 1275 CHURN CREEK RD ~ 25' x 100'**



Credit: *Google Maps, 2018.*

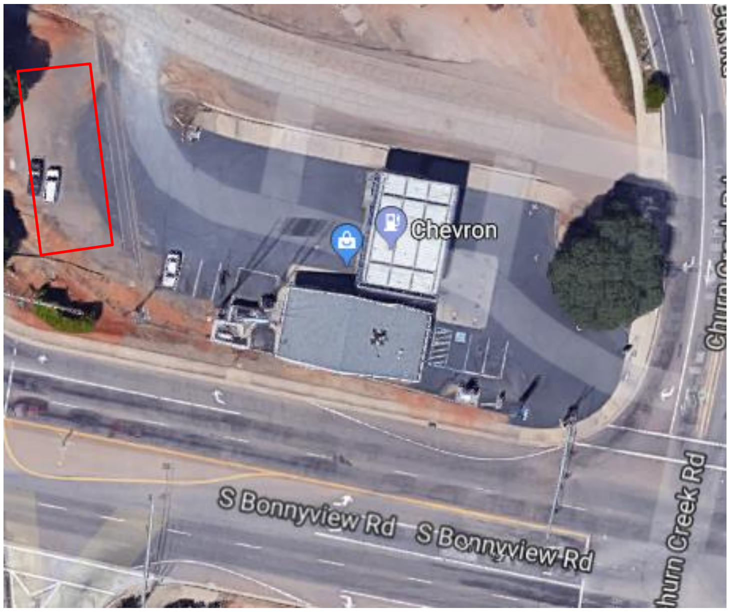
- High visibility, okay access from I-5
- Possible Issues:
    - Loss of parking spaces

5. COLONIAL ENERGY CE 20110 - 1670 HARTNELL AVE ~ 25' x 85'

Credit: *Google Maps, 2018.*

- Available space
- Possible Issues:
  - No I-5 on/off ramps for Hartnell Ave

6. CHURN CREEK CHEVRON - 4746 CHURN CREEK RD ~ 35' x 95'



Credit: *Google Maps, 2018.*

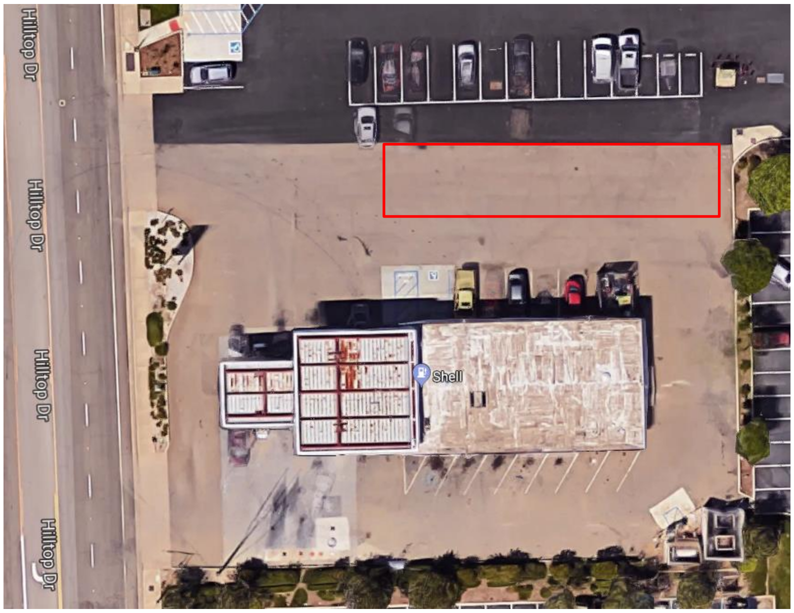
- Available space, great I-5 access

7. TURTLE BAY MINI MART - 1801 PARK MARINA Dr ~ 30' x 90'

Credit: *Google Maps, 2018.*

- Adjacent to Hwy 44 off-ramp, 2 miles west of I-5 intersect
- Open space

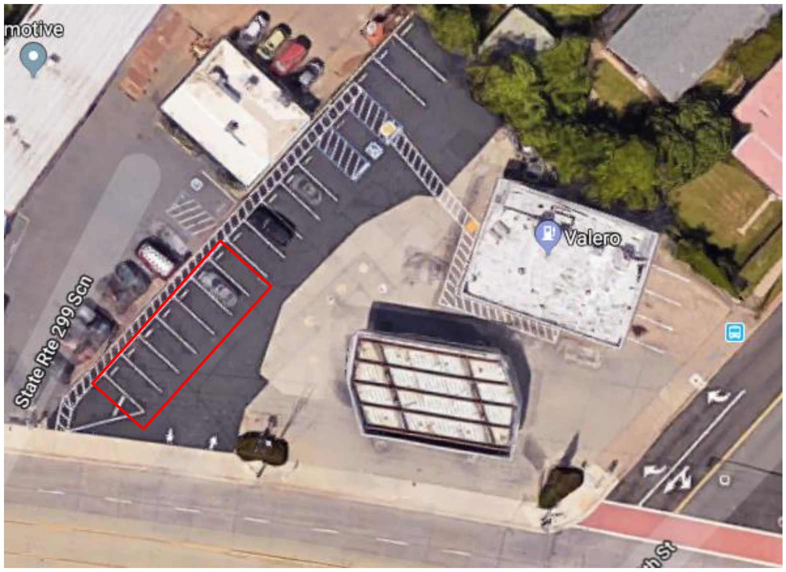
8. TESORO #68194 - 1233 HILLTOP DRIVE ~ 30' x 100'



Credit: *Google Maps, 2018.*

- Perimeter property space is narrow.
- Possible Issues:
    - loss of parking spaces

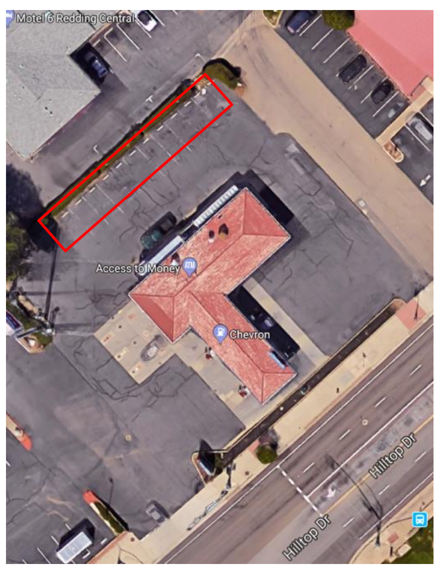
9. SPEEDY VALERO - 2026 EUREKA WAY 21' x 60'



Credit: *Google Maps, 2018.*

- High visibility, on Hwy 299
- Possible Issues:
  - Not enough space width
  - Obstruction of handicap access lane

10. CHEVRON - 1650 HILLTOP ~ 23' x 100'



Credit: *Google Maps, 2018.*

- Narrow open space
- Possible Issues:
  - Space borders Motel 6

Redding - Potential Site List

Table 12: Potential Site List for Redding

Site #	*Business*	*Address*	*Priority Zone*	*Approximate Open Space (ft)*	*Comments Issues*
1	HILLTOP FOOD & FUEL	2604 HILLTOP DRIVE	yes	25 x 50	high visibility, limited space loss of parking
2	ARCO AM/PM #83205	2951 BECHELLI LANE	yes	25 x 85	high visibility, limited space loss of parking
3	TESORO #68192	382 E. CYPRESS AVENUE	yes	18 x 85	high visibility, limited space loss of parking, obstruct traffic
4	BALL PARK 76	1275 CHURN CREEK RD	yes	25 x 100	high visibility, limited space loss of parking
5	COLONIAL ENERGY CE 20110	1670 HARTNELL AVE	yes	25 x 85	open space no direct access to I-5
6	CHURN CREEK CHEVRON	4746 CHURN CREEK RD	yes	35 x 95	open space great access to I-5
7	TURTLE BAY MINI MART	1801 PARK MARINA DR	yes	30 x 90	available space, good location great access to Hwy 44
8	TESORO #68194	1233 HILLTOP DRIVE	yes	30 x 100	limited space loss of parking
9	SPEEDY VALERO	2026 EUREKA WAY	yes	21 x 60	high visibility, limited space loss of parking, obstruction of handicap route
10	CHEVRON	1650 HILLTOP	yes	23 x 100	limited space, loss of parking incompatible-adjacent motel

Credit: *SERC, 2018*

Redding - Site Evaluation Rubric

Table 13: Redding – Evaluation Rubric

Site #	*Business*	*Space for Delivered Gas*	*Proximity*	*Accessibility*	*Visibility*	*Comments Potential Concerns*
1	HILLTOP FOOD & FUEL	yes	at I-5 exit	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking
2	ARCO AM/PM #83205	yes	0.7 miles from I-5 exit	okay	okay	limited space - lot line separation issue loss of parking
3	TESORO #68192	yes	0.2 miles from I-5 exit	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking obstruction of traffic
4	BALL PARK 76	yes	1 mile from I-5 exit	okay	okay	limited space - lot line separation issue loss of parking
5	COLONIAL ENERGY CE 20110	yes	2 miles from I-5 exit	okay	good	open space
6	CHURN CREEK CHEVRON	yes	at I-5 exit	okay	good	open space
7	TURTLE BAY MINI MART	yes	at Hwy 44 exit 2 miles from I-5	yes	okay	sufficient space good location
8	TESORO #68194	yes	1 mile from I-5 exit	yes	okay	limited space - lot line separation issue loss of parking
9	SPEEDY VALERO	yes	on Hwy 299 < 3 miles from I-5	limited space for hydrogen delivery	good	limited space - lot line separation issue loss of parking interference with handicap route
10	CHEVRON	yes	at I-5 exit	okay	good	limited space - lot line separation issue loss of parking incompatible with adjacent motel

Credit: *SERC, 2018*