



California Integrated Waste  
Management Board

February 2009

Contractor's Report  
To The Board

## Detecting Waste Tire Piles Using High-Resolution Remotely Sensed Imagery

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# Table of Contents

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Executive Summary ..... 1

Background ..... 1

Scope of Work ..... 2

Imagery Acquisition..... 2

    Study Area Requests ..... 3

Results..... 6

Future Study Areas ..... 20

Methodology Development ..... 21

Future Improvements ..... 23

Abbreviations and Acronyms ..... 25

Appendix A: Detailed Results ..... 26

Appendix B: Detailed maps of requested areas with possible waste tire piles identified by satellite..... 40

Appendix C: Notes for Inspectors..... 42

Appendix D: Illegal Dumping..... 53

Bibliography ..... 57

Source Reference Notes ..... 59

# Executive Summary

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In 2006, the California Integrated Waste Management Board (Board) awarded a grant to San Francisco State University to continue previous research and further develop a tire identification methodology using satellite imagery to a scale practical for regular use by the Board. Study sites in Marin County, Sonoma County, and along the California/Mexico border were analyzed via QuickBird imagery through visual analysis and the use of the TIRe model, an algorithm previously developed during a Board-initiated pilot project. A total of 264 sites were targeted for inspection: excluding 22 previously known sites and 17 sites that were inaccessible by inspectors, 82 percent of identified sites were correctly identified by the analyst, 64 percent of which contained tires. Improvements to the methodology developed during the project included refinement of analyst's skills, the utilization of pan-sharpened imagery, the production of Google Earth-compatible files to reduce location error, and the analyst's production of snapshots to help inspectors pinpoint possible waste tire pile sites.

## Background

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California drivers generated more than 40 million tires in 2004, which once used, were reused, recycled, disposed legally into landfills, or illegally stockpiled<sup>1</sup>. Approximately 8 million waste tires are illegally landfilled or stockpiled annually<sup>2</sup>. These stockpiles pose a fire threat and subsequent environmental and human health risks; as well, standing water in tires provides a breeding ground for mosquitoes, which potentially carry diseases like West Nile Virus, encephalitis, and dengue fever<sup>3</sup>.

State-regulated legal waste tire piles are required to provide firefighting equipment and water, limit tire pile size, and provide fire lanes for safety<sup>4</sup>. Illegal waste tire sites often do not comply with these regulations. Additionally, once an illegal site becomes established, it likely attracts others to perpetuate the dumping<sup>5</sup>. In the past, the State of California has monitored legal tire stockpiles by commissioning the California Highway Patrol to aerially photograph sites using a 35 mm camera, then georeference the piles internally<sup>6</sup>. The Board also provides grants to local law enforcement to identify waste tire piles and assist with enforcement of regulations<sup>7</sup>.

In 2004, the Board's Special Waste Division initiated a proof-of-concept project investigating the use of high-resolution satellite imagery for locating and mapping waste tire disposal sites in the Sonoma and San Bernardino regions of California<sup>8</sup>. IKONOS imagery was used to develop a methodology that included the TIRe model and visual analysis to target sites with possible waste tire piles. In all four study sites, the TIRe model and subsequent visual analysis identified the 13 target waste tire sites the Board used for testing the methodology. Two new sites containing tires were identified as well. The TIRe model produced false positives at each study site. False-positives were commonly attributed to shadows, water, debris piles, and features with tire material content such as black tarps, polyethylene tubing, and parking lots.

# Scope of Work

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To improve the methodology and determine the feasibility of using satellite imagery to find waste tire disposal sites, the Board partnered with San Francisco State University to identify sites in Sonoma County, Marin County, and along the California/Mexico border. QuickBird imagery was selected for analysis for its cost effectiveness and higher spatial resolution. This required some alterations to the TIRe model and raised the effectiveness of the visual analysis phase, but the steps in the methodology remained the same as in the pilot project.

## Imagery Acquisition

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Despite the wide range of imagery available from public and private organizations, only a few products can meet both technical and budgetary needs. A number of products were examined at the onset of this project and only two possibilities appeared feasible: IKONOS and QuickBird. The pilot project was conducted with IKONOS imagery, which had a spatial resolution coarser than the QuickBird imagery chosen for the current contract. Though QuickBird was the first choice for the pilot, pricing was much better for IKONOS imagery in low volumes. However, QuickBird imagery was purchased for the current contract due to its finer resolution and better pricing with higher volumes.

For best results during the image analysis phase, ideal imagery would be 100 percent cloud-free and collected on or after the date of request. We must, however, balance costs and needs.

**Table 1. QuickBird Imagery Pricing<sup>9</sup>**

	<b>Retail price</b>	<b>Government/ Educational price</b>	<b>Our price after volume discount</b>
New collection	\$28/km <sup>2</sup>	\$24/km <sup>2</sup>	\$22.68/km <sup>2</sup>
Archived imagery	\$24/km <sup>2</sup>	\$20/km <sup>2</sup>	\$9/km <sup>2</sup>

Archived imagery within two years of the request date was purchased when possible. New collections were purchased for areas where no imagery was already available. In all cases, a maximum of 20 percent cloud cover was designated. Because less imagery is available with a guaranteed 0 percent cloud cover, a purchase with a much greater proportion of the imagery as new collection would be required, increasing the purchase price significantly. The acquired QuickBird imagery has been of excellent quality overall, and has had much less than 20 percent cloud cover. However, in a few cases, tire piles were unable to be detected that were encountered during inspection due to atmospheric conditions. In most cases, redundant images have mitigated

this problem. Finally, all imagery was purchased in large blocks at the time of the Board's requests. This strategy has allowed the project to take advantage of volume discounts as well as government rates. Requests for imagery purchase and analysis came in three phases.

### **Study Area Requests**



**Figure 1. NASA pilot study sites and Board requests.**

**Request: Portions of Sonoma and Marin Counties, 09/06**

The Board requested a satellite survey of the northern portion of Marin County and all of Sonoma County. The terrain is hilly with a mixture of land uses. Agriculture is the primary land use, mostly devoted to grazing. There are a few forests and many scattered smaller stands of trees. Tire piles are primarily found in gullies in this area.

- Imagery order complete: 11/06
- First analysis including maps and locations submitted: 01/07
- Second analysis including maps and locations submitted: 02/07
- First inspections conducted (Board and San Francisco State): 02/07
- Second inspections conducted (Board and San Francisco State): 01/08
- Partial results submitted (inspection was not able to be completed in 01/08 due to weather): 01/08
- Snapshots provided for third inspection: 02/08
- Third inspection (Board): 03/08
- Final results submitted: 05/08
- Imagery DVDs turned over to Board: 05/08

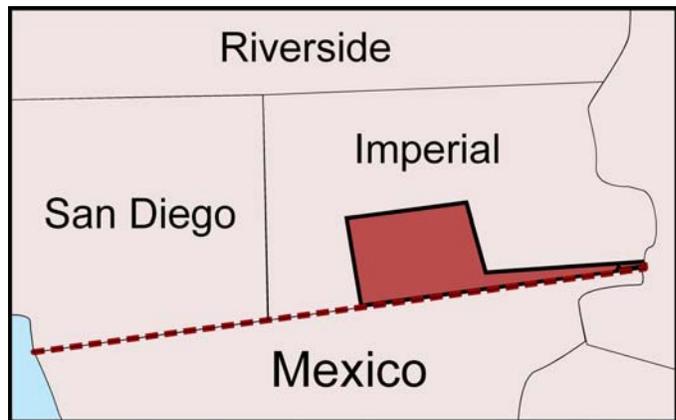


**Figure 2. Sonoma and Marin County requested area**

**Request: California/Mexico Border Region 1, 10/06**

The requested area lies entirely within Imperial County along the U.S.-Mexico border and incorporating inhabited and agricultural areas surrounding El Centro. Tire piles were often associated with agricultural operations.

- Imagery order complete: 12/06
- Analysis including maps and locations submitted: 07/07
- Inspections (Board): 08/07
- Results and response to inspector’s report submitted: 10/07
- Imagery DVDs turned over to Board: 05/08



**Figure 3. California/Mexico Border Region 1**

**Request: California/Mexico Border Region 2, 10/07**

In its western portion, the requested area straddles the U.S.-Mexico border and surrounds the cities of Tijuana and Mexicali. In its eastern portion, the area surrounds the lands surveyed in the request for California/Mexico Border Region 1 and extends south into Mexico to encompass the area around Guadalupe Victoria. At its northern apex, imagery was acquired to cover the agricultural lands that surround the southern end of the Salton Sea. Most of the possible tire piles are located in desert areas near settlements, though many tires are also used as fences.

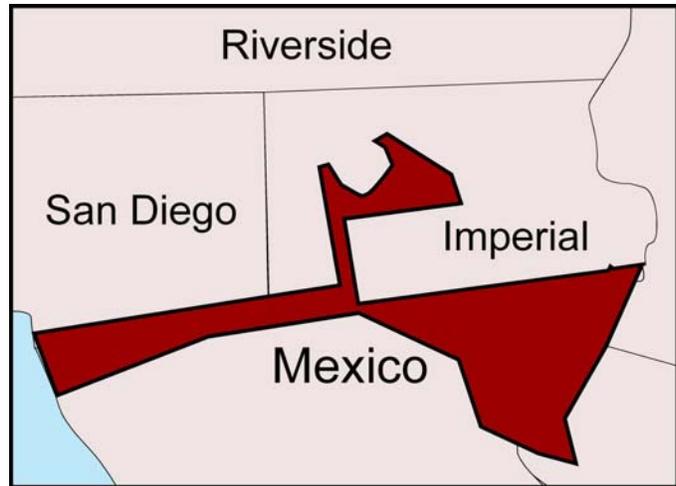
Imagery order complete: 12/07

Analysis including maps, snapshots and locations submitted: 05/08

Inspections (San Diego State University): 02/09

Results submitted: 04/09

Imagery DVDs turned over to Board: 05/08



**Figure 4. California/Mexico Border Region 2**

**Table 2: Imagery purchases**

Location	Area (km <sup>2</sup> )	Area (mi <sup>2</sup> )	Cost (Dollars)
Sonoma and Marin counties	6,887	2,659	61,377.00
Sonoma and Marin counties (supplemental)	72	28	623.00
California/Mexico Border Region 1	4,377	1,690	41,558.04
California/Mexico Border Region 1 (supplemental)	329	127	2,961.00
California/Mexico Border Region 2	8,498	3,281	81,064.80

# Results

The summary of results (Table 3) does not include waste tire disposal sites that the analyst knew of before analysis. Additionally, sites that inspectors were unable to observe because of a physical barrier, like a wall or fence, are not included in the results table. For instance, in California/Mexico Border Region 2, 89 sites were identified by the analyst as possible waste tire piles. Two sites were known by the analyst to be large waste tire storage facilities<sup>10</sup>. The analyst used these sites to calibrate the TIRe model for the surrounding area. There were 11 sites which inspectors were unable to access due to walls or fences. These exclusions left the 76 sites which are included in the results table.

The results included fall into three categories. “Correctly identified sites” means that what the analyst described as present at the location was, indeed, there when the inspectors arrived. “Sites incorrectly identified due to presence of dark object” means that the inspector found something at the location that the analyst did not identify. Examples include scrap metal, shadows, black plastic, or a water body, all of which can look similar to tires on satellite imagery. “Uncertain” is a catch-all category of sites that cannot be placed in the correct or incorrect categories. Causes include location error; inspectors may have failed to find the designated location. Another cause for inclusion in the “uncertain” category is limited access; the inspector found the correct property and was able to look inside, but was unable to see tires. In these cases, it was impossible to identify if the inspector was able to observe the exact location of the possible waste tire pile.

**Table 3: Summary of results**

Location	Correctly identified sites	Sites incorrectly identified due to presence of dark object	Uncertain
Sonoma County	14 (82%)	0	3 (18%)
Marin County	7 (70%)	1 (10%)	2 (20%)
California/Mexico Border Region 1	92 (76%)	10 (9%)	19 (16%)
California/Mexico Border Region 2	66 (87%)	3 (4%)	7 (9%)
Total	200 (82%)	14 (6%)	31 (13%)

The following table (Table 4) shows a breakdown of the “correctly identified sites” category from Table 3. These results show both a difference in the storage of waste tires between regions and a progression of the analyst’s ability to identify possible waste tire piles. Sonoma and Marin counties were the first areas to be analyzed and were well surveyed and cleaned before the commencement of this project. As a result, all sites containing tires had previously been identified, were known to the analyst before analysis and were not included in the results table. Those sites correctly identified in Marin and Sonoma counties did not contain tires. These results

greatly contrast with those found in California/Mexico Border Region 2, the last area to be analyzed and inspected. In addition to an improvement in the analyst’s ability to distinguish between tires and other dark objects in imagery, the disposal of tires in the region differs greatly from Sonoma and Marin counties. The vast majority of sites identified for inspection in California/Mexico Border Region 2 were in Mexico and most were unregulated tire piles; only two sites were in the United States.

**Table 4: Breakdown of correctly identified sites**

Location	Containing tires	Containing no tires
Sonoma County	0	14 (100%)
Marin County	0	7 (100%)
California/Mexico Border Region 1	48 (52%)	44 (48%)
California/Mexico Border Region 2	66 (100%)	0
Total	114 (64%)	65 (36%)

Complete tables of tire sites are compiled in Appendix A and can be seen individually below. Additionally, detailed maps of each requested area can be found in Appendix B.

In the following tables, the analyst has hypothesized what object the inspector will find at the target site in the “analyst’s notes” section. The “inspector’s notes” and “analyst’s notes after inspection” columns show what objects were found at the site upon inspection. If the two columns are a match, we have highlighted them in **green**. If they are not a match, they are highlighted in **red**. **Yellow** shows an indefinite conclusion.

Sonoma and Marin counties were inspected between February 2007 and March 2008. The region covered 2,687 square miles and there were 12 known sites in the area. In Sonoma County, excluding known tire sites, 82 percent of targets were correctly identified by analysis, and three sites were unidentifiable in the imagery purchased due to atmospheric conditions, so no description was provided to inspectors. In Marin County, 70 percent of targets were correctly identified by the analyst; only three sites were not correctly identified.

In six cases, inspectors and California Highway Patrol found tires that were not detected by San Francisco State. Upon review, only one of these sites was plainly tires in the satellite imagery. One site was re-visited by a second inspector, and no tires were found. In two cases, the only image available was not of high enough quality to indicate tires. One site was evident on the imagery, but the analyst was not able to identify tires due to shadow coverage. Finally, one tire pile cannot be seen on the imagery.

**Table 5. Marin County, California**

Site	Analyst's notes	Latitude	Longitude	Analyst's notes after inspection
30	Shadow or silage pile	38.2528748967391	-122.854788809089	silage pile
31	Shadow or pond	38.2348097325803	-122.851895497453	shadow
32	known tire pile	38.1098059766318	-122.751398117949	Analyst error - shadow
33	tire pile, shadow or water body	38.1638521561933	-122.811097276539	shadow
34	Pond	38.1690212314193	-122.858326329165	pond
35	Unknown	38.1826716096215	-122.839623990405	shadow
36	Dairy yard	38.2108128889264	-122.834169356770	dairy yard
37	Tire pile or shadow	38.1783107241582	-122.824951722819	shadow
38	burn scar or pond	38.0902501343753	-122.814297416653	shadow
39	rock or shadow	38.1061042763605	-122.746949770890	basalt and shadow

**Table 6. Sonoma County, California**

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	Gully	38.6932425290002	-123.164701460173	gully
2	Pond	38.6636340823973	-123.076077889372	pond
3	Pond	38.5806724981016	-123.193884860412	gully
4	Pond	38.7971344234739	-122.765710396900	holding tank
5	tree shadow	38.7261357759836	-122.813369129519	tree shadow
6	asphalt pile or black plastic covered dirt	38.6514131343094	-122.858162782811	black plastic on dirt piles
7	asphalt pile or black plastic covered dirt	38.6513715184580	-122.857847374511	black plastic on dirt piles
8	Pond	38.6260175714666	-122.681954627700	pond
9	Pond	38.5372190453941	-122.777624296870	pond
10	Pond	38.5372320977171	-122.777365596688	pond
11	House	38.5128038947178	-122.681411243819	house
12	building shadow	38.4294044149071	-122.890326850812	building shadow
13	Dairy yard	38.3547014165200	-122.952823695118	dairy yard
14	tree shadow	38.3456865247729	-122.853942989926	tree shadow
15	Known	38.3115896203021	-122.840781619377	cleaned up
16	Known	38.3106898999377	-122.840343628048	cleaned up
17	Known	38.3108951234627	-122.839903218381	cleaned up
18	Gully	38.2395224062524	-122.559071598915	gully and shadow

19	Unknown	38.2122145272323	-122.607114457512	shadow or vegetation surrounding tank
20	known tire pile - near raceway	38.1609911112522	-122.484596468992	known
21	known tire pile - near raceway	38.1597116658243	-122.487186217285	known
22	known tire pile - near raceway	38.1566662637299	-122.489727159558	known
23	known tire pile - near raceway	38.1563075350664	-122.490166532390	known
24	Unknown	38.1545257365149	-122.512284969135	brush
25	known tire pile	38.2005531575770	-122.526865588057	known
26	known tire pile	38.1987735159218	-122.526566258546	known
27	known tire pile - near raceway	38.1627130633612	-122.485890194774	known
28	known tire pile	38.2490346628565	-122.550007550232	known
29	known tire pile	38.2452025597952	-122.550921047171	known

In California/Mexico Border Region 1, excluding eight previously known waste tire piles and six sites that were unable to be inspected, 76 percent of the sites were correctly identified in imagery analysis over an area of 1,817 square miles. The yellow cells indicate sites that appear to have changed since the satellite image was taken and those with location errors. The location errors during this inspection led to improvements in the methodology outlined later in this report. The red cells indicate sites incorrectly identified. Asphalt, wire, burned areas, and black plastic covering soil were common reasons for errors. Because of the photographic communication between the analyst and the inspectors, the analyst was able to improve her ability to identify these objects. Analysis of California/Mexico Border Region 2 reflected these improvements.

**Table 7. California/Mexico Border Region 1**

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	Scattered	32 52' 1.451" N	115 43' 46.892" W	We found over 200 waste tires and plastic tubes
2	junk pile or scrap	32 51' 4.005" N	115 42' 30.717" W	Tire pile (20-25 tires) near large debris pile. Tires in trailer under tree to W
3	equipment yard	32 50' 53.910" N	115 44' 3.663" W	Metal extensions for cows
4	Industrial farm	32 50' 56.152" N	115 44' 15.975" W	Metal tin sheets
5	agricultural staging area	32 50' 6.378" N	115 44' 40.865" W	We found only a subsoiler, no tires
6	deep gully	32 50' 34.678" N	115 43' 8.936" W	No tires. Rusted wire and tree stumps

8	shadow, agricultural equip	32 51' 28.112" N	115 40' 24.037" W	No tires. Field grader, wooden box, tractor.
9	possible tire pile	32 51' 27.379" N	115 40' 45.487" W	No tires. Black NRA clay shooting stand.
10	gully, scrub	32 51' 31.376" N	115 40' 46.574" W	One tractor tire plus dead brush
11	gully, scrub	32 51' 46.529" N	115 40' 54.055" W	No tires. Burnt trees/grass and metal culvert pipe.
12	gully, scrub	32 51' 6.313" N	115 41' 12.197" W	No tires at placemark (dead brush). 11 scattered tires to SW 300 ft and illegal dumpsite (30 tires) 200 ft to north
13	gully, scrub	32 51' 3.091" N	115 40' 35.236" W	No tires. Dead brush.
14	3 possible WTPs or scrub	32 50' 43.146" N	115 41' 24.175" W	No tires at placemark (dead brush). 10 tires plus illegal dumping approx 200 yards to east.
15	Unknown	32 50' 21.106" N	115 41' 4.628" W	No tires. Piles of ground asphalt and concrete. U.S. Gov. property.
16	Dumpsite	32 50' 44.580" N	115 41' 37.263" W	No tires. Concrete. Scattered tires to south approx 100 yards at illegal dumpsite.
17	Dumpsite	32 49' 37.265" N	115 41' 52.764" W	No tires. Black ag plastic (Five tires scattered in illegal dumpsite to NW)
18	Junkyard	32 47' 59.657" N	115 40' 2.869" W	There were tires six months ago, now clean
19	equipment yard	32 47' 31.858" N	115 41' 2.537" W	No tires. Black tarp.
20	multiple possible WTPs	32 47' 23.297" N	115 41' 46.915" W	We found 20 tires and black asphalt
21	parts/equipment yard	32 46' 54.026" N	115 41' 19.447" W	We found over 100 waste tire pile
22	4 piles in a NNW line	32 52' 48.829" N	115 42' 33.859" W	We found brown bushes with one tire
23	equipment yard	32 49' 21.848" N	115 42' 31.929" W	No tires. Dead brush in small gully.
24	tires or scrub	32 47' 32.197" N	115 41' 57.484" W	Pile of dead brush
25	equipment yard	32 47' 30.663" N	115 42' 31.636" W	200-300 tires cleaned about 6 mo. ago
26	tires or scrub	32 48' 6.156" N	115 44' 12.588" W	No tires. Hay dump. Few used oil filters/hoses near placemark.

27	3 possible WTPs or scrub	32 48' 56.249" N	115 46' 50.214" W	Brown twigs and concrete pipes
28	equipment/junk yard	32 46' 43.112" N	115 42' 10.077" W	We found a waste tire pile with more than 250 tires.
29	7 possible WTPs or scrub	32 44' 39.651" N	115 45' 5.205" W	Piles of concrete and burnt hay.
30	Unknown	32 45' 46.453" N	114 41' 2.908" W	<b>SITE INACCESSIBLE BY VEHICLE</b>
31	multiple possible WTPs or scrub	32 44' 33.026" N	114 39' 19.359" W	Brush pile. Two passenger tires in vicinity.
32	Possible WTP or burn	32 44' 49.046" N	114 38' 31.439" W	<b>SITE NOT VISITED</b>
33	multiple possible WTPs or scrub	32 43' 56.267" N	114 37' 23.038" W	No tires. Brush pile.
34	tire/agricultural equip	32 43' 47.032" N	114 37' 9.153" W	No tires. Burn pile for greenwaste.
35	tire/junkyard	32 44' 27.354" N	114 35' 56.144" W	Waste tire pile (approx. 200 tires)
36	Equipment yard	32 44' 42.085" N	114 34' 33.602" W	No tires. Farm equipment and possible bales of wire.
37	3 possible WTPs or shrub	32 54' 1.198" N	115 40' 56.863" W	We found tree trunks
38	property w/waste	32 53' 30.696" N	115 39' 17.685" W	Around 28 tires, cars at dumpsite
39	Equipment yard	32 51' 51.360" N	115 44' 27.889" W	Waste tires in large pile (over 1000 tires) at Bullfrog Farms
40	tires or scrub	32 50' 34.832" N	115 43' 13.991" W	No tires. Rolls of wire fencing, dried palm branches, metal debris.
41	1 linear pile	32 50' 48.245" N	115 40' 44.665" W	No tires. Object removed. (Bee boxes with black tarp covering present on 07/24)
42	junkyard/equipment	32 50' 56.637" N	115 40' 25.315" W	No tires, irrigation pipe.
43	junkyard/equipment	32 50' 54.016" N	115 40' 28.329" W	Few scattered tires and junk debris
44	tires or scrub	32 52' 34.207" N	115 38' 47.364" W	No tires. Brush pile. Four tires and concrete dumped on bank to east.
45	gully NE of junk	32 52' 29.331" N	115 39' 16.179" W	Burn ash. Two scattered tires in area. Large illegal dumpsite to northwest.
46	junkyard/agricultural yard	32 52' 27.306" N	115 39' 21.323" W	Eight passenger tires in abandoned pile of equipment and appliances

47	Junk	32 52' 14.584" N	115 39' 19.026" W	No tires. Equipment.
48	agricultural staging N, S	32 52' 12.209" N	115 39' 54.435" W	No tires. Fencing, brush
49	tires or burn	32 52' 46.310" N	115 42' 31.845" W	Four tires, telephone poles and wire
50	Tires or scrub	33 0' 56.373" N	115 28' 3.101" W	I found a red bush by the canal
51	several piles	33 0' 20.462" N	115 28' 0.396" W	Black plastic pipes for irrigation
135	Equipment yard	32 45' 5.003" N	114 47' 12.144" W	Black water storage tank and few tires long west side of mobile home at other end of property.
134	multiple poss. WTPs /equipment yard	32 45' 44.222" N	115 14' 12.034" W	SITE INACCESSIBLE
133	tire or scrub	32 45' 56.586" N	115 22' 40.416" W	Pile of brush at marked location. Five scattered tires closer to road.
132	tire or scrub	32 48' 1.232" N	115 22' 12.465" W	No tires. Old wood pens with brush
131	Dumpsite	32 48' 22.487" N	115 22' 44.625" W	Equip storage area. Approx 5 tractor tires and 2 or 3 passenger tires.
130	Equipment yard	32 50' 22.367" N	115 22' 44.866" W	We found waste tractor tire pile
53	Dumpsite	32 59' 35.609" N	115 27' 56.498" W	Site cleaned April 2007, but 353 tires were present at illegal dumpsite
54	Equipment yard	32 59' 12.905" N	115 27' 50.110" W	I found a bunch of dry bushes and dirt, looks like it was cleaned
55	possible WTP near trailer	32 59' 8.639" N	115 28' 0.720" W	I found three farm tractors lined up, looks like it was cleaned
56	equipment yard with many possible WTPs	32 58' 6.285" N	115 27' 44.932" W	At the verification point there were no tires, but nearby we found 350 tires
57	1 possible WTP on the N end of an equipment yard, 2 to the south	32 57' 26.318" N	115 27' 49.266" W	No tires. Illegal dumping with burn ash and trash pushed over bank.
58	1 possible WTP N of the target, one S	32 57' 18.682" N	115 27' 48.289" W	No tires. Hay burn pile.
59	agricultural staging	32 57' 58.041" N	115 23' 21.010" W	Approx. 30 tires plus irrigation tubing
60	parts yard	32 58' 30.476" N	115 23' 22.333" W	20 tractor tires, 16 trac tires

61	Equipment yard	33 0' 4.488" N	115 24' 38.559" W	Two vehicles at point, over 800 partial tires close by
62	1 possible WTP	33 0' 5.796" N	115 23' 24.298" W	We found nothing at the verification spot, farm tractor to the left hand side
63	One possible WTP SE in an equipment yard, 2 NE	33 0' 58.120" N	115 25' 20.708" W	We found a waste tire pile and farm equipment
64	1 possible WTP or scrub	33 0' 30.541" N	115 26' 56.685" W	Two tractor tires + 1 passenger tire
65	dumpsite to E	32 55' 51.771" N	115 23' 16.514" W	No tires. Brush pile. Recent cleanup
66	Junkyard	32 54' 33.594" N	115 27' 54.579" W	Waste tire pile along drainage ditch/old feedyard. 200-250
67	Possible WTPs and a junkpile	32 51' 47.177" N	115 26' 23.501" W	Fifty tires + large pile of irrigation tubing. Ash present in trash pile also.
68	Equipment yard	32 52' 6.543" N	115 18' 10.004" W	No tires at coordinates (maybe once). Tire stacks, West end Texeira Farms.
70	1 large possible WTP	32 50' 52.549" N	115 19' 8.075" W	No tires. Burn ash/brush pile (500 tires removed in 2006 per Danny)
71	small possible WTPs	32 50' 17.065" N	115 16' 49.493" W	No tires. Possible tamarisk burn pile.
72	1 oblong	32 50' 5.973" N	115 16' 52.551" W	No tires. Black plastic over dirt pile.
73	1E, 1SW, 1W, 2NW	32 48' 54.260" N	115 15' 29.726" W	SITE INACCESSIBLE
74	2E, 2W	32 46' 39.434" N	115 16' 2.042" W	SITE INACCESSIBLE
75	Dumpsite	32 41' 4.086" N	115 41' 33.459" W	We found black and grey alfafa ashes (few stacked tires were at property)
76	2 possible WTP or burn	32 58' 40.931" N	115 40' 2.296" W	We found a burned charred house
77	2 possible WTP	32 58' 37.405" N	115 40' 0.470" W	We found 6 scattered tires and large piles of wood, dead brush, and metal
78	Equipment yard	32 59' 10.629" N	115 36' 54.766" W	Approx 200 tires in two piles plus large pile of rusted scrap metal.
79	Equipment yard	32 59' 13.854" N	115 35' 16.104" W	No tires. Irrigation tubing piled among farm equipment/machinery
80	Equipment yard	32 58' 1.330" N	115 37' 30.327" W	We found row tubing, no tires

81	2 possible WTPs	32 56' 21.406" N	115 35' 16.945" W	We found black rubber pot planters
82	agricultural yard	32 56' 8.870" N	115 36' 35.611" W	Fifty tractor tires in pile.
83	deep gully	32 52' 30.164" N	115 37' 33.100" W	Deep gully with one passenger tire
84	Poss. WTP, trailer front	32 48' 25.740" N	115 34' 0.193" W	Approx. 65 waste tires in a pile
85	2 poss. WTPs or scrub	32 45' 34.170" N	115 35' 7.501" W	No tires. Pile of black plastic.
86	gully, brush	32 44' 19.321" N	115 38' 2.468" W	No tires. Burned brush. Some illegal dumping in ravine to NE.
87	equipment yard	32 43' 51.700" N	115 34' 8.893" W	Equipment repair operation. May have been tires present in past.
88	tire or agricultural supplies	32 42' 7.169" N	115 38' 28.991" W	We found 32 waste tires in a pile, oil drums, oil filters, mobile home
89	gully dumpsite	32 41' 51.651" N	115 34' 37.261" W	Approx. 50 tires (mixed sizes) at illegal dumpsite. Black plastic also present.
90	Mexico? junkyards	32 39' 32.248" N	115 34' 37.172" W	SITE IN MEXICO
91	parts/junk	32 40' 42.307" N	115 38' 28.240" W	We found ashes at the verification point. 2 WTPs 30 ft and 50 ft away.
92	Junkyard	32 59' 45.208" N	115 31' 20.515" W	Nothing at verification point, but manager stated that it was cleaned
93	Dumpsite	32 59' 40.676" N	115 32' 27.373" W	No waste tires, just large tree trunks
94	dump/ag supplies	32 58' 4.228" N	115 32' 50.591" W	Black corrugated plastic pipes
95	Dumpsite	32 56' 46.904" N	115 34' 19.076" W	WTP of 50 tires, junk cars
96	equipment/junk yard	32 56' 54.136" N	115 32' 14.908" W	No tires. Coiled drain tile pipe.
97	equipment/junk yard	32 56' 28.939" N	115 30' 28.374" W	No tires. Site has been cleaned
98	agricultural staging	32 55' 25.450" N	115 29' 22.172" W	Found 75 tires (mixed)
99	Dumpsite	32 54' 41.818" N	115 30' 49.395" W	We found over 1000 waste tire pile
100	car parts yard	32 54' 30.246" N	115 32' 1.105" W	There were 25 tires in a pile
101	equipment yard	32 53' 47.320" N	115 32' 1.893" W	No tires. Allied Waste company. Possible containers, bins with plastic.

102	large linear pile	32 53' 12.397" N	115 31' 48.746" W	<b>SITE INACCESSIBLE</b>
103	possible waste tires along fence	32 53' 0.536" N	115 32' 5.253" W	Four or six tractor tires stacked in farm equip. and supplies.
105	Poss. WTP or shadow	32 49' 37.608" N	115 33' 30.618" W	No tires. Wood pallet. Earthworks.
106	Poss. tires along fence	32 47' 4.194" N	115 32' 16.202" W	We found over 76 tractor tires stacked
107	possible shadow	32 47' 30.940" N	115 32' 8.688" W	Billboard sign and a smaller sign
108	transportation yard	32 47' 24.227" N	115 31' 54.058" W	Shredded tire pile of about 12 tires
109	Equipment yard	32 48' 7.698" N	115 30' 32.808" W	We found black corrugated tubes
111	Equipment yard	32 48' 10.757" N	115 29' 39.805" W	Scrap metal -Edman Steel
112	multiple possible waste tires in equipment yard	32 48' 37.168" N	115 26' 28.022" W	We found around 12 waste tires and old farm machinery
113	Equipment yard	32 48' 29.673" N	115 23' 43.732" W	We found over 250 tires in a pile
114	possible tires in eq yard	32 48' 33.954" N	115 23' 7.800" W	Twenty tires and old farm implements
115	Equipment yard	32 48' 11.357" N	115 23' 54.703" W	> 500 tires, piled, stacked
116	Dumpsite	32 47' 11.401" N	115 23' 33.459" W	Approx. 10 tractor tires
117	Equipment/junkyard	32 44' 57.773" N	115 30' 59.580" W	Irrigation tubes
118	2 possible WTP	32 42' 34.751" N	115 32' 15.029" W	Asphalt at Pyramid Construction yard
119	Poss. WTPs, NE corner	32 41' 29.851" N	115 32' 40.868" W	No tires. Rolls of wired fencing.
121	Dumpsite	32 40' 38.727" N	115 32' 13.296" W	Illegal dumpsite. 200-400 tires, but not at marked location. Dead brush.
122	Equipment yard	32 41' 38.829" N	115 23' 54.799" W	Burned pile of debris, 32 tractor tires 75 feet north of placemark
123	1 possible WTP	33 0' 32.188" N	115 40' 27.941" W	Pile of black wire and 4 scattered tires
124	Poss. tires along fence	33 0' 51.943" N	115 37' 16.652" W	We found black tarp covering wood
125	junk/equipment yard	33 0' 50.155" N	115 35' 46.346" W	We found 25 tires in a pile
126	Equipment yard	33 1' 5.265" N	115 31' 7.698" W	We found black irrigation tubes
128	tires or scrub	33 1' 35.286" N	115 31' 3.724" W	No tires. Pile of dry brush. Rusted scrap metal, one appliance to N

129	Equipment yard	32 50' 37.883" N	115 19' 46.249" W	Found 100-150 tires in pile
7	Known S 11	32 51' 43.672" N	115 40' 12.263" W	Six tires, dead brush on upper bank. Approx. 500 tires in adjacent gully.
120	Known S 37	32 41' 0.235" N	115 32' 34.011" W	No tires. Dead brush at bottom of ravine. Illegal dumpsite.
137	Known S 38	32 41' 25.893" N	115 32' 41.417" W	Found 200-250 passenger tires on slope
110	Known S35	32 48' 9.461" N	115 29' 50.039" W	The location was clean but nearby there were over 200 tires in a pile
52	Known S21	33 0' 6.486" N	115 27' 52.579" W	We found over 600 waste tires piled
127	Known S22	33 1' 14.040" N	115 28' 20.806" W	Three big tire piles
104	Known S17	32 52' 27.240" N	115 33' 52.859" W	Over 900 tires stacked and machinery
69	Known S29	32 51' 13.669" N	115 19' 12.330" W	Around 100 waste tires (truck and passenger). Also an illegal dumpsite.

87 percent of sites in the 3,281 square miles of California/Mexico Border Region 2 were correctly identified and contained tires. Two sites were previously known to the analyst and 11 sites were inaccessible to inspectors and were not included in these results. Uncertain sites included sites with limited access and sites that have changed since the satellite image was taken but still include tires or evidence of tire burning.

**Table 8. California/Mexico Border Region 2**

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	construction with much waste, high turnover, many possible piles	32 27' 17.814" N	117 0' 48.059" W	INACCESSIBLE
2	3 possible WTP on a N/S line, high turnover	32 23' 44.154" N	117 2' 47.687" W	Waste transfer area, 50-100 tires plus slope stabilization with tires
3	3 large piles with others scattered	32 20' 27.516" N	117 1' 55.254" W	500-1000 tires in 2+piles
4	possible WTP	32 29' 41.927" N	116 55' 49.966" W	Tire business, may/may not be waste
5	possible WTP	32 29' 25.653" N	116 55' 33.457" W	INACCESSIBLE
6	possible WTP or burn on farm	32 21' 15.070" N	117 0' 8.091" W	Farm with tire or burn
7	equipment yard	32 34' 53.190" N	116 38' 1.632" W	Limited access - uncertain if target area was observed.
8	equipment yard	32 33' 22.821" N	116 32' 28.025" W	INACCESSIBLE

9	possible WTP	32 34' 7.232" N	116 31' 34.728" W	INACCESSIBLE
10	possible WTP	32 33' 55.902" N	116 28' 0.149" W	INACCESSIBLE
11	Transport storage w/ tires	32 38' 33.887" N	116 13' 39.023" W	Tires present in towing yard.
12	possible WTP	32 37' 55.778" N	115 40' 26.282" W	Found 500-1000 tires along dirt road
13	possible WTP or vegetation	32 37' 26.608" N	115 40' 10.447" W	150-200 tires plus burning
14	possible WTP, all along track	32 37' 12.868" N	115 40' 8.962" W	Found 50-100 tires. Similar piles in area
15	possible WTP, under power lines	32 37' 5.407" N	115 40' 19.659" W	Found 50-100 tires at GPS point plus burn.
16	tires along N/S track crossing wash	32 36' 38.404" N	115 40' 0.092" W	Found 1000-2000 tires along dirt road
17	possible WTP	32 36' 33.139" N	115 40' 8.587" W	Few tires at GPS point. Site may have changed. Tires in nearby sites
18	huge system of tire dumps, wide area	32 36' 36.574" N	115 41' 24.020" W	INACCESSIBLE
19	smaller WTPs scattered along road	32 35' 37.567" N	115 41' 40.898" W	<50 tires at GPS point plus burn
20	possible WTP	32 35' 44.726" N	115 40' 53.398" W	Found 300-500 tires.
21	WTP, known to have been cleaned up	32 35' 54.902" N	115 40' 5.565" W	KNOWN
22	WTP, known tire disposal site	32 35' 27.926" N	115 40' 5.944" W	KNOWN
23	dumpsite/equipment site for agriculture	33 10' 13.458" N	115 34' 16.908" W	Found 50-100 tires at ag equipment dump
24	WTPs adjacent to race track	32 35' 14.285" N	115 36' 44.890" W	INACCESSIBLE
25	multiple possible WTP on supply yard	32 35' 0.680" N	115 36' 17.774" W	Limited access - uncertain if target area was observed.
26	possible WTP, high turnover	32 35' 18.448" N	115 35' 46.111" W	Evidence of tire burning
27	burns with possible WTPs	32 33' 1.120" N	115 31' 57.359" W	Evidence of tire and waste burning in several areas. 50-100 in largest pile.
28	tires or vegetation	32 32' 27.376" N	115 31' 53.087" W	>50,000 tires, 100x20 m area
29	possible WTP or asphalt on private lot	32 38' 41.631" N	115 30' 15.316" W	INACCESSIBLE
30	3 possible WTPs	32 27' 29.791" N	115 24' 8.432" W	100-200 tires at construction dump
31	possible WTP in equipment yard	32 36' 14.228" N	115 25' 35.864" W	WTP on private lot
32	4 small possible WTPs	32 38' 35.246" N	115 24' 9.150" W	Burn area
33	possible WTP in equipment yard	32 34' 59.466" N	115 22' 15.054" W	WTP on private lot

34	tire art or paintball range?	32 24' 52.381" N	115 21' 10.198" W	150-300 tires as barriers in private paintball range
35	possible WTP along desert road	32 24' 40.866" N	115 22' 3.074" W	300 tires in three piles along desert road
36	possible WTP in burn sites, also look to the south	32 24' 30.698" N	115 21' 35.846" W	1000 tires dispersed in construction waste dumpsite
37	possible WTP	32 23' 35.931" N	115 21' 21.225" W	10x10m tire burn area plus <50 dispersed tires
38	possible WTP	32 23' 21.708" N	115 21' 15.616" W	<50 tires and burn. Site appears to have changed since satellite image
39	possible scattered tires	32 21' 34.965" N	115 20' 6.222" W	Construction waste. Site appears to have changed since satellite image
40	dumpsite/burnsite, also look to the east	32 21' 19.401" N	115 20' 15.652" W	40x30m tire burning site. +<50 tires.
41	2 probable WTP, on private lots	32 17' 27.214" N	115 19' 22.555" W	1500-3000 tires dumped across street from tire fix and sell.
42	at shooting range	32 38' 30.694" N	115 17' 29.267" W	300-500 tires at shooting range
43	possible WTPs in agricultural yard	32 39' 54.852" N	115 18' 30.420" W	100-300 tires on rural lots, some making fences
44	probable WTP on private property	32 37' 40.783" N	115 12' 15.522" W	300-500 tires
45	possible WTP	32 37' 55.657" N	115 11' 10.713" W	300-500 tires as piles and fences
46	2 possible WTP in desert	32 39' 13.288" N	115 7' 40.823" W	burned tires +<50 dispersed tires
47	possible WTPs in equipment yard	32 39' 24.719" N	115 2' 25.831" W	Limited access - uncertain if target area was observed.
48	possible WTP or vegetation	32 37' 24.016" N	115 3' 53.346" W	50-1000 tires on private property
49	3 possible WTP	32 36' 31.672" N	115 3' 28.586" W	300-500 tires used as fence. Site changed since image
50	possible WTP in industrial yard	32 23' 18.243" N	115 3' 44.694" W	300-500 tires in ag yard
51	possible WTP on private property	32 20' 59.498" N	115 3' 50.796" W	50-100 tires in abandoned lot.
52	possible WTP used as a crash barrier	32 17' 39.090" N	115 4' 11.912" W	1000-3000 tires as a crash barrier
53	possible WTP on private property	32 13' 53.190" N	115 5' 5.535" W	Burns. Site changed since image
54	possible WTP on private property	32 36' 51.177" N	115 0' 57.941" W	Tire burning +<50 tires
55	possible WTP or burn	32 37' 50.956" N	115 1' 2.910" W	<50 tires and possible burn.

56	possible WTP or burn, high turnover	32 39' 35.334" N	114 59' 56.188" W	300-500 tires
57	possible WTP on edge of fields	32 31' 28.841" N	114 58' 17.775" W	<50 tires and burnt tires.
58	junkyard with tires	32 30' 18.445" N	114 55' 35.079" W	junkyard with <50 tires
59	equipment yard with tires	32 16' 50.163" N	114 58' 1.973" W	300-500 tires inside equipment yard.
60	possible WTP	32 14' 20.245" N	114 53' 11.423" W	INACCESSIBLE
61	equipment yard	32 19' 19.821" N	114 53' 22.620" W	Vacant lot with 50-100 tires. Site has changed since image.
62	probable WTP	32 19' 2.809" N	114 53' 23.578" W	100-300 tires with other waste on vacant lot
63	large monument under construction, tires in base of cross, also look to the northeast in the dove, may also be vegetation	32 20' 0.362" N	114 51' 56.153" W	INACCESSIBLE
64	WTP disposal site	32 21' 40.633" N	114 50' 59.906" W	<50 tires and tire burning.
65	probable WTP on equipment yard	32 24' 56.710" N	114 52' 47.813" W	50-100 tires in equipment yard
66	junkyard	32 37' 40.022" N	114 52' 44.037" W	Limited access. <50 tires observed. Spilled oil and used motors.
67	few waste tires in quarry, small pile and scattered tires	32 41' 1.605" N	114 48' 37.143" W	Limited access 50-100 tires observed
68	junkyard with tires, check nearby lots	32 27' 59.677" N	114 48' 48.974" W	Scrap steel company
69	possible WTP on private property	32 27' 44.695" N	114 49' 18.992" W	300-500 tires on vacant city lot
70	possible WTP, look in a wide area	32 25' 40.370" N	114 49' 18.508" W	300-500 tires at point.
71	possible WTP used to construct walls, many walls made of tires in this area	32 25' 46.114" N	114 48' 28.765" W	50-100 tires used for wall construction plus scattered tires.
72	possible WTPs on private lot, west of target also	32 25' 31.226" N	114 48' 15.164" W	300-500 tires in private lot
73	small WTP and scattered, look to the northwest also	32 25' 27.934" N	114 47' 56.322" W	50-100 tires on lot. Many other lots like this in area
74	junkyard, look to the northeast also	32 25' 31.452" N	114 47' 31.587" W	100-300 stacked tires in junkyard
75	possible WTP	32 26' 1.444" N	114 46' 30.224" W	1000-2000 tires
76	2 junkyards	32 26' 1.333" N	114 46' 8.408" W	Recycling company on two lots. Tires observed, limited access.

77	possible WTP on private property	32 25' 16.895" N	114 47' 10.524" W	300-500 tires as fencing
78	possible WTP	32 24' 52.732" N	114 46' 36.727" W	50-100 tires in a private lot
79	multiple small possible WTP	32 24' 45.214" N	114 46' 23.076" W	50-100 tires as fence + scattered
80	tires scattered along desert road	32 24' 36.537" N	114 47' 15.349" W	50-100 tires as fencing. Site has changed since image.
81	possible WTP	32 24' 42.571" N	114 46' 58.843" W	50-100 tires
82	scattered small WTP along desert road	32 24' 24.623" N	114 46' 44.061" W	Scattered waste tires along dirt road. 50-100 tires near GPS point.
83	look all the way to road end, also look along the road to the south	32 23' 50.379" N	114 45' 38.014" W	Municipal landfill. Hundreds of tires observed. Estimate thousands present.
84	WTPs inside yard	32 24' 20.822" N	114 45' 42.235" W	INACCESSIBLE
85	small WTPs on empty lot, and around	32 25' 26.563" N	114 45' 2.171" W	50-100 tires scattered and as fencing
86	possible WTPs on empty lot	32 24' 59.826" N	114 44' 40.662" W	<50 tires inside lot. Site has changed since image
87	small WTPs on empty lot	32 24' 42.260" N	114 45' 2.552" W	50-100 tires scattered and as fencing
88	dumpsites with tires	32 24' 8.994" N	114 44' 46.612" W	500-1000 tires piled and as fencing
89	dumpsite in desert	32 32' 30.701" N	114 42' 52.122" W	100-300 waste tires at dumpsite in desert. Includes other wastes.

## Future Study Areas

While the general methodology is valid for all but the forested areas of California, further methodology development will be necessary for verdant areas like Northern California. In the desert and agricultural areas, the methodology is working as expected. California and Mexico waste tire conditions differ. In areas of Mexico, a majority of property lines appear to be delineated with tires, whereas few California locations appear to use tires in this way. As a result of these and other varying conditions, the analyst and inspectors may have different standards for designation of an actionable waste tire pile. These standards should be reviewed and made clear to all involved upon the designation of a new study area.

Additionally, the imagery purchased and the methodology can be used to identify and monitor other features of interest to the State like illegal dumpsites. See Appendix D for more detail.

# Methodology Development

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The major improvements in methodology during the project include refinement of analyst's skills, the utilization of pan-sharpened imagery, the production of Google Earth-compatible files to reduce location error, and the analyst's production of snapshots to help inspectors pinpoint possible waste tire pile sites.

The analyst's skills have been refined throughout the course of the project. Objects that once may have been mistaken for tires, such as black plastic agricultural equipment, asphalt, and burns are much less likely to be misidentified today. Additionally, experience in model refinement has reduced the amount of time needed to tailor the model for each new study area. The model itself must be tailored for each region attempted, due to imagery collection conditions. Model tailoring should be considered only one step in the overall methodology.

Improvements that have greatly increased the positive identification of features include pan-sharpening of all imagery. This adds to the time needed for imagery analysis, but it can greatly reduce the time needed to map and visit possible waste tire piles and can reduce the number of sites that are visited but contain no tires. With the California/Mexico Border Region 2 inspections, we saw evidence of this improvement.

While no formal training has occurred with Board staff, we are continually improving communication between the San Francisco State analyst and Board inspectors. San Francisco State has tailored deliverables to the needs of inspectors to reduce errors in locating sites along with instructions for how to use the tools. An example of the detailed instructions provided to inspectors can be seen in Appendix C: Notes to Inspectors.

The analyst now provides files compatible with Google Earth and portable GPS units. The inspectors appear to prefer the use of Google Earth to provide maps and directions to possible waste tire pile locations; this tool allows them to use their own local knowledge in addition to the information provided by the analyst. Because tire inspectors vary in experience and jurisdiction, variation is to be expected in the level of expertise with GPS units. The compatible files reduce the likelihood of typographical errors during the transfer of locations from the analyst to Google Earth and to GPS units. Therefore, inspectors are more likely to find the location targeted by the analyst.

Another innovation to improve the communication between the analyst and inspector is the analyst's production of snapshots for each possible waste tire pile. The snapshots consist of imagery with the possible waste tire pile circled, the latitude and longitude of the target and a description of the site or pile. The inspector can use his Google Earth map to get to the location, and then use the snapshot to pinpoint the target. If there are other tires in the scene, the inspector can circle the location and take a photograph to aid identification. In the past, inspectors have

been within 300 feet from the target and have photographed an object other than the target. The pictures below illustrate how location errors can impede inspection. In the satellite image (Figure 1), vegetation appears red. The inspector's picture (Figure 2) may have been taken from the location indicated by the square. The target area, indicated by the circle, is less than 100 yards away, behind some brush. We feel that the snapshots will reduce the likelihood of such mistakes.



**Figure 5. QuickBird image showing target area (circle) and possible location of misidentified area (square) (DigitalGlobe, 2006).**



**Figure 6. Photograph of misidentified location (Silva, 2007).**

# Future Improvements

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Inspectors in Southern California commented that this methodology is unable to distinguish between legal and illegal waste tire piles. This is true on the most basic level, but if the legal tire piles have been mapped in the past, the methodology could be altered to delineate which of the found tire piles are known or legal. This will require further cooperation between the Board and San Francisco State, but may save some field time for inspectors. We have also updated the format in which we report analysis results with more extensive descriptions and promptings for inspectors to fill out. This will assure that the most useful information is passed between the Board and San Francisco State to avoid miscommunication and unnecessary repetition of inspections.

It is unknown if the use of satellite imagery in identification of waste tire piles in California is more cost-effective than the use of helicopter surveys. A brief overview would indicate that helicopter surveys may be less expensive (Table 9), but there are many assumptions made in the construction of this table and all benefits and limitations are not evident here. Assumptions in the satellite analysis cost include an imagery price comparable to the price acquired on this project. Pricing can change according to current availability of satellite imagery. Additionally, the cost of analysis at a contractor rate of \$75/hr. includes ground-truthing travel and travel for final presentation. Helicopter costs were calculated with a rate of \$500/hr. for the helicopter and \$134.43/hr. for each of two officers. It was assumed that the helicopter could adequately cover 250 square miles in 2.5 hours of flying over the target area and could document one tire pile per 100 square miles. Pricing for the helicopter does not include any flight time to or from the target area.

**Table 9. Methodology cost comparison**

	per sq mi	500 sq mi	1000 sq mi	5000 sq mi
Satellite analysis	\$31.92	\$15,960	\$31,920	\$159,600
Helicopter	\$15.38	\$7,690	\$15,380	\$76,900

All assumptions made for helicopter and analysis costs apply to the time to delivery under ideal circumstances. In addition, the times given in Table 10 are weather and schedule dependant for both methods. Helicopter surveys require the 2.5 hours of flying to have an adequate visibility to cover 250 square miles during the flight on every day of the ideal times set forth below. Satellite image times assume that archived imagery is available for the covered area. A three-day window has been added for delivery time of satellite imager to the analyst.

**Table 10. Days to delivery under ideal circumstances**

	500 sq mi	1000 sq mi	5000 sq mi
Satellite analysis	9	15	63
Helicopter	2	4	20

Benefits to helicopter surveys include real-time data and immediate verification of complaints. Benefits to satellite surveys include the ability to keep satellite imagery over time. The analyst has more time available over each site to analyze the image than would be available in one fly-over with the helicopter. Additionally with the current method of finding waste tire piles with satellite imagery, the analyst has the benefit of computer-assisted identification, whereas the helicopter survey is only able to make use of the human eye. Satellite imagery, once purchased, is perpetually available to the State for use in identifying other objects of concern. It can be used to track the status of invasive plant species, to monitor disposal sites of wastes other than tires, even to document land-use changes over time.

Because these benefits are not easily quantified in Table 9 and because many assumptions have been made but not verified, a future comparative study between the use of helicopters and satellite imagery for the identification of waste tire piles is needed.

# Abbreviations and Acronyms

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Ag – Agricultural

Board – California Integrated Waste Management Board

E – East

N – North

S – South

SFSU – San Francisco State University

TIRe – Tire Identification through Reflectance

W – West

WTP – Waste Tire Pile

# **Appendix A**

## **Detailed Results**



In the following tables, the analyst has hypothesized what object the inspector will find at the target site in the “analyst’s notes” section. The “inspector’s notes” and “analyst’s notes after inspection” columns show what objects were found at the site upon inspection. If the two columns are a match, we have highlighted them in **green**. If they are not a match, they are highlighted in **red**. **Yellow** shows an indefinite conclusion.

### Marin County, California

Site	Analyst's notes	Latitude	Longitude	Analyst's notes after inspection
30	Shadow or silage pile	38.2528748967391	-122.854788809089	silage pile
31	Shadow or pond	38.2348097325803	-122.851895497453	shadow
32	known tire pile	38.1098059766318	-122.751398117949	Analyst error - shadow
33	tire pile, shadow or water body	38.1638521561933	-122.811097276539	shadow
34	Pond	38.1690212314193	-122.858326329165	pond
35	unknown	38.1826716096215	-122.839623990405	shadow
36	dairy yard	38.2108128889264	-122.834169356770	dairy yard
37	tire pile or shadow	38.1783107241582	-122.824951722819	shadow
38	burn scar or pond	38.0902501343753	-122.814297416653	shadow
39	rock or shadow	38.1061042763605	-122.746949770890	basalt and shadow

### Sonoma County, California

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	gully	38.6932425290002	-123.164701460173	gully
2	pond	38.6636340823973	-123.076077889372	pond
3	pond	38.5806724981016	-123.193884860412	gully
4	pond	38.7971344234739	-122.765710396900	holding tank
5	tree shadow	38.7261357759836	-122.813369129519	tree shadow
6	asphalt pile or black plastic covered dirt	38.6514131343094	-122.858162782811	black plastic on dirt piles
7	asphalt pile or black plastic covered dirt	38.6513715184580	-122.857847374511	black plastic on dirt piles
8	pond	38.6260175714666	-122.681954627700	pond
9	pond	38.5372190453941	-122.777624296870	pond
10	pond	38.5372320977171	-122.777365596688	pond
11	house	38.5128038947178	-122.681411243819	house
12	building shadow	38.4294044149071	-122.890326850812	building shadow
13	dairy yard	38.3547014165200	-122.952823695118	dairy yard
14	tree shadow	38.3456865247729	-122.853942989926	tree shadow
15	known	38.3115896203021	-122.840781619377	cleaned up
16	known	38.3106898999377	-122.840343628048	cleaned up

17	known	38.3108951234627	-122.839903218381	cleaned up
18	gully	38.2395224062524	-122.559071598915	gully and shadow
19	unknown	38.2122145272323	-122.607114457512	shadow or vegetation surrounding tank
20	known tire pile - near raceway	38.1609911112522	-122.484596468992	known
21	known tire pile - near raceway	38.1597116658243	-122.487186217285	known
22	known tire pile - near raceway	38.1566662637299	-122.489727159558	known
23	known tire pile - near raceway	38.1563075350664	-122.490166532390	known
24	unknown	38.1545257365149	-122.512284969135	brush
25	known tire pile	38.2005531575770	-122.526865588057	known
26	known tire pile	38.1987735159218	-122.526566258546	known
27	known tire pile - near raceway	38.1627130633612	-122.485890194774	known
28	known tire pile	38.2490346628565	-122.550007550232	known
29	known tire pile	38.2452025597952	-122.550921047171	known

#### California/Mexico Border Region 1

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	scattered	32 52' 1.451" N	115 43' 46.892" W	We found over 200 waste tires and plastic tubes
2	junk pile or scrap	32 51' 4.005" N	115 42' 30.717" W	Tire pile (20-25 tires) near large debris pile. Tires in trailer under tree to west.
3	equipment yard	32 50' 53.910" N	115 44' 3.663" W	Metal extensions for cows
4	industrial farm	32 50' 56.152" N	115 44' 15.975" W	Metal tin sheets
5	agricultural staging	32 50' 6.378" N	115 44' 40.865" W	We found a subsoiler, no tires
6	deep gully	32 50' 34.678" N	115 43' 8.936" W	No tires. Rusted wire and tree stumps
8	shadow, agricultural equip	32 51' 28.112" N	115 40' 24.037" W	No tires. Field grader, wooden box, and old tractor.
9	possible tire pile	32 51' 27.379" N	115 40' 45.487" W	No tires. Black NRA clay shooting stand.
10	gully, scrub	32 51' 31.376" N	115 40' 46.574" W	One tractor tire plus dead brush
11	gully, scrub	32 51' 46.529" N	115 40' 54.055" W	No tires. Burned trees/grass and metal culvert pipe.
12	gully, scrub	32 51' 6.313" N	115 41' 12.197" W	No tires at placemark (dead brush). 11 scattered tires to SW 300 ft. and illegal dumpsite (30 tires) 200 ft. to north.

13	gully, scrub	32 51' 3.091" N	115 40' 35.236" W	No tires. Dead brush.
14	3 possible WTPs or scrub	32 50' 43.146" N	115 41' 24.175" W	No tires at placemark (dead brush). Ten tires plus illegal dumping approx 200 yards to east.
15	unknown	32 50' 21.106" N	115 41' 4.628" W	No tires. Piles of ground asphalt and concrete. U.S. Gov. property.
16	dumpsite	32 50' 44.580" N	115 41' 37.263" W	No tires. Concrete. Scattered tires to south approx 100 yds. at illegal dumpsite.
17	dumpsite	32 49' 37.265" N	115 41' 52.764" W	No tires. Black ag plastic (5 tires scattered in illegal dumpsite to NW)
18	junkyard	32 47' 59.657" N	115 40' 2.869" W	There were tires six months ago, now clean
19	equipment yard	32 47' 31.858" N	115 41' 2.537" W	No tires. Black tarp.
20	multiple possible WTPs	32 47' 23.297" N	115 41' 46.915" W	We found 20 tires and black asphalt
21	parts/equipment yard	32 46' 54.026" N	115 41' 19.447" W	We found over 100 waste tire pile
22	4 piles in a NNW line	32 52' 48.829" N	115 42' 33.859" W	We found brown bushes with one tire
23	equipment yard	32 49' 21.848" N	115 42' 31.929" W	No tires. Dead brush in small gully.
24	tires or scrub	32 47' 32.197" N	115 41' 57.484" W	Pile of dead brush
25	equipment yard	32 47' 30.663" N	115 42' 31.636" W	200-300 tires cleaned about six months ago
26	tires or scrub	32 48' 6.156" N	115 44' 12.588" W	No tires. Hay dump. Few used oil filters/hoses near placemark.
27	3 possible WTPs or scrub	32 48' 56.249" N	115 46' 50.214" W	Brown twigs and concrete pipes
28	equipment/junk yard	32 46' 43.112" N	115 42' 10.077" W	We found a waste tire pile of over 250
29	7 possible WTPs or scrub	32 44' 39.651" N	115 45' 5.205" W	Piles of concrete and burned hay.
30	unknown	32 45' 46.453" N	114 41' 2.908" W	SITE INACCESSIBLE
31	multiple possible WTPs or scrub	32 44' 33.026" N	114 39' 19.359" W	Brush pile. Two passenger tires in vicinity.
32	Possible WTP or burn	32 44' 49.046" N	114 38' 31.439" W	SITE NOT VISITED
33	multiple possible WTPs or scrub	32 43' 56.267" N	114 37' 23.038" W	No tires. Brush pile.
34	tire/agricultural equip	32 43' 47.032" N	114 37' 9.153" W	No tires. Burn pile for greenwaste.
35	tire/junkyard	32 44' 27.354" N	114 35' 56.144" W	Waste tire pile (approx. 200 tires)

36	equipment yard	32 44' 42.085" N	114 34' 33.602" W	No tires. Farm equipment and possible bales of wire.
37	3 possible WTPs or shrub	32 54' 1.198" N	115 40' 56.863" W	We found tree trunks
38	property w/waste	32 53' 30.696" N	115 39' 17.685" W	We found around 28 tires, abandoned cars and a dumpsite
39	equipment yard	32 51' 51.360" N	115 44' 27.889" W	Waste tires in large pile (over 1000 tires) at Bullfrog Farms
40	tires or scrub	32 50' 34.832" N	115 43' 13.991" W	No tires. Rolls of wire fencing, dried palm branches, and metal debris.
41	1 linear pile	32 50' 48.245" N	115 40' 44.665" W	No tires. Object removed. (Bee boxes with black tarp covering present on 07/24)
42	junkyard/equipment	32 50' 56.637" N	115 40' 25.315" W	No tires. Black irrigation tile pipe.
43	junkyard/equipment	32 50' 54.016" N	115 40' 28.329" W	Few scattered tires and junk debris
44	tires or scrub	32 52' 34.207" N	115 38' 47.364" W	No tires. Brush pile. Four tires and concrete dumped on bank to east.
45	gully NE of junk	32 52' 29.331" N	115 39' 16.179" W	Burn ash. Two scattered tires in area. Large illegal dumpsite to northwest.
46	junkyard/agricultural yard	32 52' 27.306" N	115 39' 21.323" W	8 passenger tires in abandoned pile of equipment and appliances
47	junk	32 52' 14.584" N	115 39' 19.026" W	No tires. Equipment.
48	agricultural staging N, S	32 52' 12.209" N	115 39' 54.435" W	No tires. Fencing rolls and brush
49	tires or burn	32 52' 46.310" N	115 42' 31.845" W	4 tires, telephone poles and wire
50	Tires or scrub	33 0' 56.373" N	115 28' 3.101" W	I found a red bush by the canal
51	several piles	33 0' 20.462" N	115 28' 0.396" W	Black plastic pipes for irrigation
135	equipment yard	32 45' 5.003" N	114 47' 12.144" W	Black water storage tank and few tires long west side of mobile home at other end of property.
134	multiple possible WTPs/equipment yard	32 45' 44.222" N	115 14' 12.034" W	<b>SITE INACCESSIBLE BY VEHICLE</b>
133	tire or scrub	32 45' 56.586" N	115 22' 40.416" W	Pile of brush at marked location. Five scattered tires closer to road.
132	tire or scrub	32 48' 1.232" N	115 22' 12.465" W	No tires. Old wood pens with brush
131	dumpsite	32 48' 22.487" N	115 22' 44.625" W	Equipment storage area. Approx five tractor tires and two or three passenger tires.
130	equipment yard	32 50' 22.367" N	115 22' 44.866" W	We found waste tractor tire pile

53	dumpsite	32 59' 35.609" N	115 27' 56.498" W	Site cleaned April 2007, but 353 tires were present at illegal dumpsite
54	equipment yard	32 59' 12.905" N	115 27' 50.110" W	I found a bunch of dry bushes and dirt, looks like it was cleaned
55	possible WTP near trailer	32 59' 8.639" N	115 28' 0.720" W	I found three farm tractors lined up, looks like it was cleaned
56	equipment yard with many possible WTPs	32 58' 6.285" N	115 27' 44.932" W	At the verification point there were no tires, but nearby we found 350 tires
57	1 possible WTP on the N end of an equipment yard, 2 to the south	32 57' 26.318" N	115 27' 49.266" W	No tires. Illegal dumping with burn ash and trash pushed over bank.
58	1 possible WTP to the N of the target, one S	32 57' 18.682" N	115 27' 48.289" W	No tires. Hay burn pile.
59	agricultural staging	32 57' 58.041" N	115 23' 21.010" W	Approx. 30 tires plus irrigation tubing
60	parts yard	32 58' 30.476" N	115 23' 22.333" W	20 tractor tires and 16 trac tires
61	equipment yard	33 0' 4.488" N	115 24' 38.559" W	Two vehicles at the verification point, but close by were over 800 partial tires
62	1 possible WTP	33 0' 5.796" N	115 23' 24.298" W	We found nothing at the verification spot, farm tractor to the left hand side
63	One possible WTP to the SE in an equipment yard, 2 to the NE	33 0' 58.120" N	115 25' 20.708" W	We found a waste tire pile and farm equipment
64	1 possible WTP or scrub	33 0' 30.541" N	115 26' 56.685" W	Two tractor tires + one passenger tire
65	dumpsite to E	32 55' 51.771" N	115 23' 16.514" W	No tires. Brush. Recent cleanup
66	junkyard	32 54' 33.594" N	115 27' 54.579" W	Waste tire pile along drainage ditch/old feedyard. Approx. 200-250
67	Possible WTPs and a junkpile	32 51' 47.177" N	115 26' 23.501" W	50 tires + large pile of irrigation tubing. Ash present in trash pile also.
68	equipment yard	32 52' 6.543" N	115 18' 10.004" W	No tires east side of property at coordinates (maybe once). Tire stacks, W end of Teixeira Farms.
70	1 large possible WTP	32 50' 52.549" N	115 19' 8.075" W	No tires. Burn ash/brush pile (500 tires removed in 2006 per Danny)
71	small possible WTPs	32 50' 17.065" N	115 16' 49.493" W	No tires. Possible tamarisk burn pile.

72	1 oblong	32 50' 5.973" N	115 16' 52.551" W	No tires. Black plastic over dirt pile.
73	1E, 1SW, 1W, 2NW	32 48' 54.260" N	115 15' 29.726" W	SITE INACCESSIBLE
74	2E, 2W	32 46' 39.434" N	115 16' 2.042" W	SITE INACCESSIBLE
75	dumpsite	32 41' 4.086" N	115 41' 33.459" W	We found black and grey alfafa ashes (a few stacked tires were at property)
76	2 possible WTP or burn	32 58' 40.931" N	115 40' 2.296" W	We found a burned charred house.
77	2 possible WTP	32 58' 37.405" N	115 40' 0.470" W	We found six scattered tires and large piles of wood, dead brush, and metal
78	equipment yard	32 59' 10.629" N	115 36' 54.766" W	Approx. 200 tires in two piles plus large pile of rusted scrap metal.
79	equipment yard	32 59' 13.854" N	115 35' 16.104" W	No tires. Irrigation tubing piled among farm equipment/machinery
80	equipment yard	32 58' 1.330" N	115 37' 30.327" W	We found row tubing, no tires
81	2 possible WTPs	32 56' 21.406" N	115 35' 16.945" W	We found black rubber pot planters
82	agricultural yard	32 56' 8.870" N	115 36' 35.611" W	Fifty tractor tires in pile.
83	deep gully	32 52' 30.164" N	115 37' 33.100" W	Deep gully; one passenger tire
84	Poss. WTP, trailer front	32 48' 25.740" N	115 34' 0.193" W	Approx 65 waste tires in a pile
85	2 poss. WTPs or scrub	32 45' 34.170" N	115 35' 7.501" W	No tires. Pile of black plastic.
86	gully, brush	32 44' 19.321" N	115 38' 2.468" W	No tires. Burned brush. Some illegal dumping in ravine to NE.
87	equipment yard	32 43' 51.700" N	115 34' 8.893" W	Equipment repair operation. May have been tires present in past.
88	tire or agricultural supplies	32 42' 7.169" N	115 38' 28.991" W	We found 32 waste tires in a pile, oil drums, oil filters, mobile home
89	gully dumpsite	32 41' 51.651" N	115 34' 37.261" W	Approx. 50 tires (mixed sizes) at illegal dumpsite. Black plastic also present.
90	Mexico? junkyards	32 39' 32.248" N	115 34' 37.172" W	SITE IN MEXICO
91	parts/junk	32 40' 42.307" N	115 38' 28.240" W	We found ashes at the verification point. 2 WTPs 30 ft and 50 ft away.
92	junkyard	32 59' 45.208" N	115 31' 20.515" W	Nothing at verification point, but manager stated that it was cleaned
93	dumpsite	32 59' 40.676" N	115 32' 27.373" W	No waste tires, just large tree trunks
94	dump/ag supplies	32 58' 4.228" N	115 32' 50.591" W	Black corrugated plastic pipes

95	dumpsite	32 56' 46.904" N	115 34' 19.076" W	WTP of 50 tires, junk cars
96	equipment/junk yard	32 56' 54.136" N	115 32' 14.908" W	No tires. Coiled drain tile pipe.
97	equipment/junk yard	32 56' 28.939" N	115 30' 28.374" W	No tires. Site has been cleaned
98	agricultural staging	32 55' 25.450" N	115 29' 22.172" W	We found 75 tires (mixed)
99	dumpsite	32 54' 41.818" N	115 30' 49.395" W	We found over 1000 waste tire pile
100	car parts yard	32 54' 30.246" N	115 32' 1.105" W	There were 25 tires in a pile
101	equipment yard	32 53' 47.320" N	115 32' 1.893" W	No tires. Allied Waste company. Possible containers, bins with plastic.
102	large linear pile	32 53' 12.397" N	115 31' 48.746" W	SITE INACCESSIBLE
103	possible waste tires along fence	32 53' 0.536" N	115 32' 5.253" W	Four or six tractor tires stacked in farm equip. and supplies.
105	Poss. WTP or shadow	32 49' 37.608" N	115 33' 30.618" W	No tires. Wood pallet. Earthworks.
106	Poss. tires along fence	32 47' 4.194" N	115 32' 16.202" W	We found over 76 tractor tires stacked
107	possible shadow	32 47' 30.940" N	115 32' 8.688" W	Billboard sign and a smaller sign
108	transportation yard	32 47' 24.227" N	115 31' 54.058" W	Shredded tire pile of about 12 tires
109	equipment yard	32 48' 7.698" N	115 30' 32.808" W	We found black corrugated tubes
111	equipment yard	32 48' 10.757" N	115 29' 39.805" W	Scrap metal only (Edman Steel)
112	multiple possible waste tires in equipment yard	32 48' 37.168" N	115 26' 28.022" W	We found around 12 waste tires and old farm machinery
113	equipment yard	32 48' 29.673" N	115 23' 43.732" W	We found over 250 tires in a pile
114	possible tires in eq yard	32 48' 33.954" N	115 23' 7.800" W	20 tires and old farm implements
115	equipment yard	32 48' 11.357" N	115 23' 54.703" W	Over 500 tires in a pile and stacked
116	dumpsite	32 47' 11.401" N	115 23' 33.459" W	Approx. 10 tractor tires present
117	equipment/junkyard	32 44' 57.773" N	115 30' 59.580" W	We found long irrigation tubes
118	2 possible WTP	32 42' 34.751" N	115 32' 15.029" W	Asphalt at Pyramid Const. yard
119	Poss. WTPs, NE corner	32 41' 29.851" N	115 32' 40.868" W	No tires. Rolls of wired fencing.
121	dumpsite	32 40' 38.727" N	115 32' 13.296" W	Illegal dumpsite. 200-400 tires, but not at marked location. Dead brush.
122	equipment yard	32 41' 38.829" N	115 23' 54.799" W	Burned pile of debris, 32 tractor tires 75 feet north of placemark
123	1 possible WTP	33 0' 32.188" N	115 40' 27.941" W	Pile of black wire;4 scattered tires
124	Poss. tires along fence	33 0' 51.943" N	115 37' 16.652" W	We found black tarp covering wood

125	junk/equipment yard	33 0' 50.155" N	115 35' 46.346" W	We found 25 tires in a pile
126	equipment yard	33 1' 5.265" N	115 31' 7.698" W	We found black irrigation tubes
128	tires or scrub	33 1' 35.286" N	115 31' 3.724" W	No tires. Pile of dry brush. Rusted scrap metal and one appliance to N
129	equipment yard	32 50' 37.883" N	115 19' 46.249" W	100-150 tires in pile
7	Known S 11	32 51' 43.672" N	115 40' 12.263" W	Six tires and dead brush on upper bank. Approx. 500 tires in adjacent gully.
120	Known S 37	32 41' 0.235" N	115 32' 34.011" W	No tires. Dead brush at bottom of ravine. Illegal dumpsite.
137	Known S 38	32 41' 25.893" N	115 32' 41.417" W	200-250 passenger tires on slope
110	Known S35	32 48' 9.461" N	115 29' 50.039" W	The location was clean but nearby there were over 200 tires in a pile
52	Known S21	33 0' 6.486" N	115 27' 52.579" W	We found over 600 waste tires piled
127	Known S22	33 1' 14.040" N	115 28' 20.806" W	Three big tire piles
104	Known S17	32 52' 27.240" N	115 33' 52.859" W	Over 900 tires stacked and machinery
69	Known S29	32 51' 13.669" N	115 19' 12.330" W	Around 100 waste tires (truck and passenger). Also an illegal dumpsite.

### California/Mexico Border Region 2

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	construction with much waste, high turnover, many possible piles	32 27' 17.814" N	117 0' 48.059" W	INACCESSIBLE
2	3 possible WTP on a N/S line, high turnover	32 23' 44.154" N	117 2' 47.687" W	Waste transfer area, 50-100 tires plus slope stabilization with tires
3	3 large piles with others scattered	32 20' 27.516" N	117 1' 55.254" W	We found 500-1000 tires in 2+piles
4	possible WTP	32 29' 41.927" N	116 55' 49.966" W	Tire business, may/may not be waste
5	possible WTP	32 29' 25.653" N	116 55' 33.457" W	INACCESSIBLE
6	possible WTP or burn on farm	32 21' 15.070" N	117 0' 8.091" W	Farm with tire or burn
7	equipment yard	32 34' 53.190" N	116 38' 1.632" W	Limited access - uncertain if target area was observed.
8	equipment yard	32 33' 22.821" N	116 32' 28.025" W	INACCESSIBLE
9	possible WTP	32 34' 7.232" N	116 31' 34.728" W	INACCESSIBLE
10	possible WTP	32 33' 55.902" N	116 28' 0.149" W	INACCESSIBLE
11	Transport storage w/ tires	32 38' 33.887" N	116 13' 39.023" W	Tires present in towing yard.

12	possible WTP	32 37' 55.778" N	115 40' 26.282" W	500-1000 tires along dirt road
13	possible WTP or vegetation	32 37' 26.608" N	115 40' 10.447" W	150-200 tires plus burning
14	possible WTP, all along track	32 37' 12.868" N	115 40' 8.962" W	50-100 tires. Similar piles in area
15	possible WTP, under power lines	32 37' 5.407" N	115 40' 19.659" W	50-100 tires at GPS point plus burn.
16	tires along N/S track crossing wash	32 36' 38.404" N	115 40' 0.092" W	1000-2000 tires along dirt road
17	possible WTP	32 36' 33.139" N	115 40' 8.587" W	Few tires at GPS point. Site may have changed. Tires in nearby sites
18	huge system of tire dumps, wide area	32 36' 36.574" N	115 41' 24.020" W	INACCESSIBLE
19	smaller WTPs scattered along road	32 35' 37.567" N	115 41' 40.898" W	<50 tires at GPS point plus burn
20	possible WTP	32 35' 44.726" N	115 40' 53.398" W	300-500 tires.
21	WTP, known to have been cleaned up	32 35' 54.902" N	115 40' 5.565" W	KNOWN
22	WTP, known tire disposal site	32 35' 27.926" N	115 40' 5.944" W	KNOWN
23	dumpsite/equipment site for agriculture	33 10' 13.458" N	115 34' 16.908" W	50-100 tires at ag equipment dump
24	WTPs adjacent to race track	32 35' 14.285" N	115 36' 44.890" W	INACCESSIBLE
25	multiple possible WTP on supply yard	32 35' 0.680" N	115 36' 17.774" W	Limited access - uncertain if target area was observed.
26	possible WTP, high turnover	32 35' 18.448" N	115 35' 46.111" W	Evidence of tire burning
27	burns with possible WTPs	32 33' 1.120" N	115 31' 57.359" W	Evidence of tire and waste burning in several areas. 50-100 in largest pile.
28	tires or vegetation	32 32' 27.376" N	115 31' 53.087" W	>50,000 tires, 100x20 m area
29	possible WTP or asphalt on private lot	32 38' 41.631" N	115 30' 15.316" W	INACCESSIBLE
30	3 possible WTPs	32 27' 29.791" N	115 24' 8.432" W	100-200 tires at construction dump
31	possible WTP in equipment yard	32 36' 14.228" N	115 25' 35.864" W	WTP on private lot
32	4 small possible WTPs	32 38' 35.246" N	115 24' 9.150" W	Burn area
33	possible WTP in equipment yard	32 34' 59.466" N	115 22' 15.054" W	WTP on private lot
34	tire art or paintball range?	32 24' 52.381" N	115 21' 10.198" W	150-300 tires as barriers in private paintball range
35	possible WTP along desert road	32 24' 40.866" N	115 22' 3.074" W	300 tires in 3 piles along desert road
36	possible WTP in burn sites, also look to the south	32 24' 30.698" N	115 21' 35.846" W	1000 tires dispersed in construction waste dumpsite

37	possible WTP	32 23' 35.931" N	115 21' 21.225" W	10x10m tire burn area plus <50 dispersed tires
38	possible WTP	32 23' 21.708" N	115 21' 15.616" W	<50 tires and burn. Site appears to have changed since satellite image
39	possible scattered tires	32 21' 34.965" N	115 20' 6.222" W	Construction waste. Site appears to have changed since satellite image
40	dumpsite/burnsite, also look to the east	32 21' 19.401" N	115 20' 15.652" W	40x30m tire burning site. +<50 tires.
41	2 probable WTP, on private lots	32 17' 27.214" N	115 19' 22.555" W	1500-3000 tires dumped across street from tire fix and sell.
42	at shooting range	32 38' 30.694" N	115 17' 29.267" W	300-500 tires at shooting range
43	possible WTPs in agricultural yard	32 39' 54.852" N	115 18' 30.420" W	100-300 tires on rural lots, some making fences
44	probable WTP on private property	32 37' 40.783" N	115 12' 15.522" W	300-500 tires
45	possible WTP	32 37' 55.657" N	115 11' 10.713" W	300-500 tires as piles and fences
46	2 possible WTP in desert	32 39' 13.288" N	115 7' 40.823" W	Burned tires +<50 dispersed tires
47	possible WTPs in equipment yard	32 39' 24.719" N	115 2' 25.831" W	Limited access - uncertain if target area was observed.
48	possible WTP or vegetation	32 37' 24.016" N	115 3' 53.346" W	50-1000 tires on private property
49	3 possible WTP	32 36' 31.672" N	115 3' 28.586" W	300-500 tires used as fence. Site changed since image
50	possible WTP in industrial yard	32 23' 18.243" N	115 3' 44.694" W	300-500 tires in ag yard
51	possible WTP on private property	32 20' 59.498" N	115 3' 50.796" W	50-100 tires in abandoned lot.
52	possible WTP used as a crash barrier	32 17' 39.090" N	115 4' 11.912" W	1000-3000 tires as a crash barrier
53	possible WTP on private property	32 13' 53.190" N	115 5' 5.535" W	Burns. Site changed since image
54	possible WTP on private property	32 36' 51.177" N	115 0' 57.941" W	Tire burning +<50 tires
55	possible WTP or burn	32 37' 50.956" N	115 1' 2.910" W	<50 tires and possible burn.
56	possible WTP or burn, high turnover	32 39' 35.334" N	114 59' 56.188" W	300-500 tires
57	possible WTP on edge of fields	32 31' 28.841" N	114 58' 17.775" W	<50 tires and burnt tires.
58	junkyard with tires	32 30' 18.445" N	114 55' 35.079" W	Junkyard with <50 tires
59	equipment yard with tires	32 16' 50.163" N	114 58' 1.973" W	300-500 tires inside equipment yard.
60	possible WTP	32 14' 20.245" N	114 53' 11.423" W	INACCESSIBLE
61	equipment yard	32 19' 19.821" N	114 53' 22.620" W	Vacant lot with 50-100 tires. Site has changed since image.

62	probable WTP	32 19' 2.809" N	114 53' 23.578" W	100-300 tires with other waste on vacant lot
63	large monument under construction, tires in base of cross, also look to the northeast in the dove, may also be vegetation	32 20' 0.362" N	114 51' 56.153" W	INACCESSIBLE
64	WTP disposal site	32 21' 40.633" N	114 50' 59.906" W	<50 tires and tire burning.
65	probable WTP on equipment yard	32 24' 56.710" N	114 52' 47.813" W	50-100 tires in equipment yard
66	junkyard	32 37' 40.022" N	114 52' 44.037" W	Limited access. <50 tires observed. Spilled oil and used motors.
67	few waste tires in quarry, small pile and scattered tires	32 41' 1.605" N	114 48' 37.143" W	Limited access 50-100 tires observed
68	junkyard with tires, check nearby lots	32 27' 59.677" N	114 48' 48.974" W	Scrap steel company
69	possible WTP on private property	32 27' 44.695" N	114 49' 18.992" W	300-500 tires on vacant city lot
70	possible WTP, look in a wide area	32 25' 40.370" N	114 49' 18.508" W	300-500 tires at point.
71	possible WTP used to construct walls, many walls made of tires in this area	32 25' 46.114" N	114 48' 28.765" W	50-100 tires used for wall construction plus scattered tires.
72	possible WTPs on private lot, west of target also	32 25' 31.226" N	114 48' 15.164" W	300-500 tires in private lot
73	small WTP and scattered, look to the northwest also	32 25' 27.934" N	114 47' 56.322" W	50-100 tires on lot. Many other lots like this in area
74	junkyard, look to the northeast also	32 25' 31.452" N	114 47' 31.587" W	100-300 stacked tires in junkyard
75	possible WTP	32 26' 1.444" N	114 46' 30.224" W	1000-2000 tires
76	2 junkyards	32 26' 1.333" N	114 46' 8.408" W	Recycling company on two lots. Tires observed, limited access.
77	possible WTP on private property	32 25' 16.895" N	114 47' 10.524" W	300-500 tires as fencing
78	possible WTP	32 24' 52.732" N	114 46' 36.727" W	50-100 tires in a private lot
79	multiple small possible WTP	32 24' 45.214" N	114 46' 23.076" W	50-100 tires as fence + scattered
80	tires scattered along desert road	32 24' 36.537" N	114 47' 15.349" W	50-100 tires as fencing. Site has changed since image.
81	possible WTP	32 24' 42.571" N	114 46' 58.843" W	50-100 tires
82	scattered small WTP along desert road	32 24' 24.623" N	114 46' 44.061" W	Scattered waste tires along dirt road. 50-100 tires near GPS point.

83	look all the way to road end, also look along the road to the south	32 23' 50.379" N	114 45' 38.014" W	Municipal landfill. Hundreds of tires observed. Estimate thousands present.
84	WTPs inside yard	32 24' 20.822" N	114 45' 42.235" W	INACCESSIBLE
85	small WTPs on empty lot, and around	32 25' 26.563" N	114 45' 2.171" W	50-100 tires scattered and as fencing
86	possible WTPs on empty lot	32 24' 59.826" N	114 44' 40.662" W	<50 tires inside lot. Site has changed since image
87	small WTPs on empty lot	32 24' 42.260" N	114 45' 2.552" W	50-100 tires scattered and as fencing
88	dumpsites with tires	32 24' 8.994" N	114 44' 46.612" W	500-1000 tires piled and as fencing
89	dumpsite in desert	32 32' 30.701" N	114 42' 52.122" W	100-300 waste tires at dumpsite in desert. Includes other wastes.

## **Appendix B**

### **Detailed maps of requested areas with possible waste tire piles identified by satellite**

(Actual map images are not included within this document, but can be accessed by selecting links shown on Page 41).

# Suspected Waste Tire Sites

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[Marin County](#) (Adobe PDF, 12.2 MB)

[Sonoma County](#) (Adobe PDF, 18.2 MB)

[Southern California Border Region, Sub-Map 1](#) (Adobe PDF, 50.4 MB)

[Southern California Border Region, Sub-Map 2](#) (Adobe PDF, 50.1 MB)

[Southern California Border Region, Sub-Map 3](#) (Adobe PDF, 57 MB)

[Southern California Border Region, Sub-Map 4](#) (Adobe PDF, 53.7 MB)

[Southern California Border Region, Sub-Map 5 \(Western California-Mexico Border\)](#) (Adobe PDF, 86 KB)

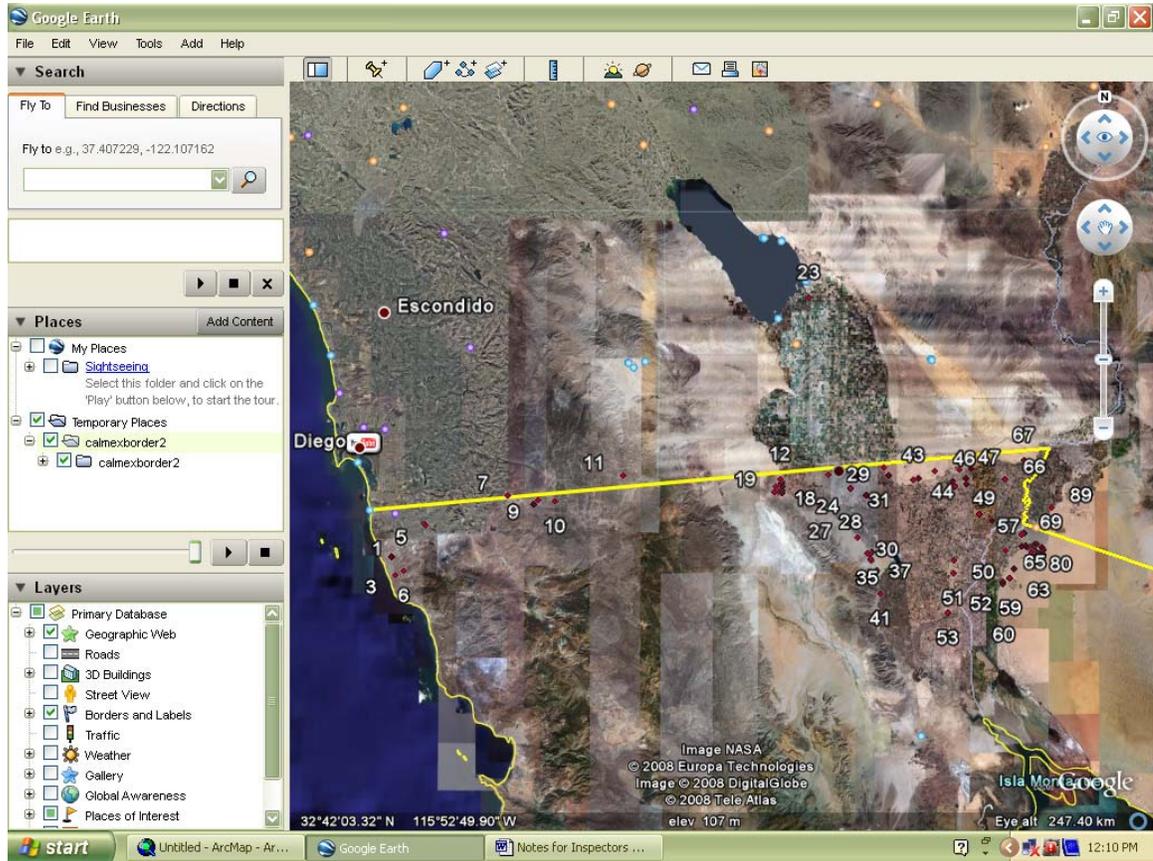
[Southern California Border Region, Sub-Map 6 \(Eastern Mexico Region\)](#) (Adobe PDF, 261 KB)

# **Appendix C**

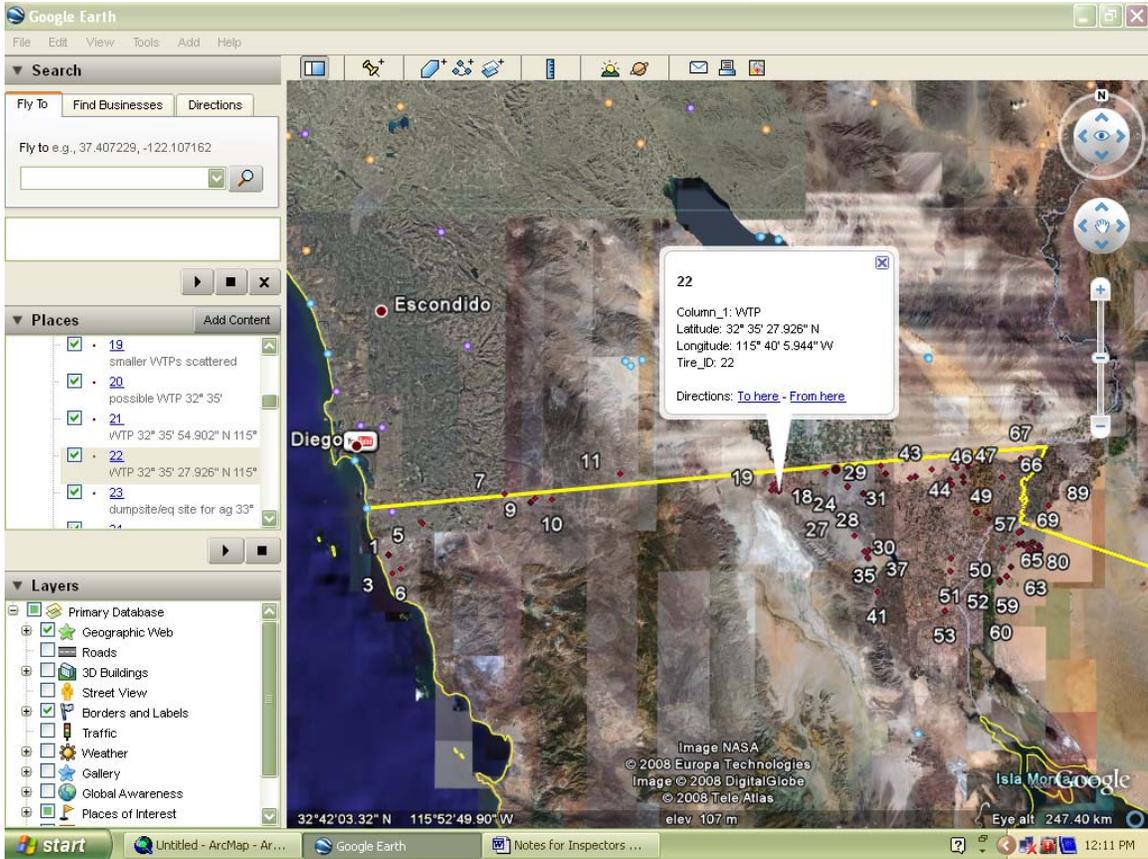
## **Notes for Inspectors**

The tools that have been provided are calmexborder2.xls, snapshots.doc and calmexborder2.kmz. All examples in this document are for site 22 in California – Mexico Border Region 2 unless otherwise noted.

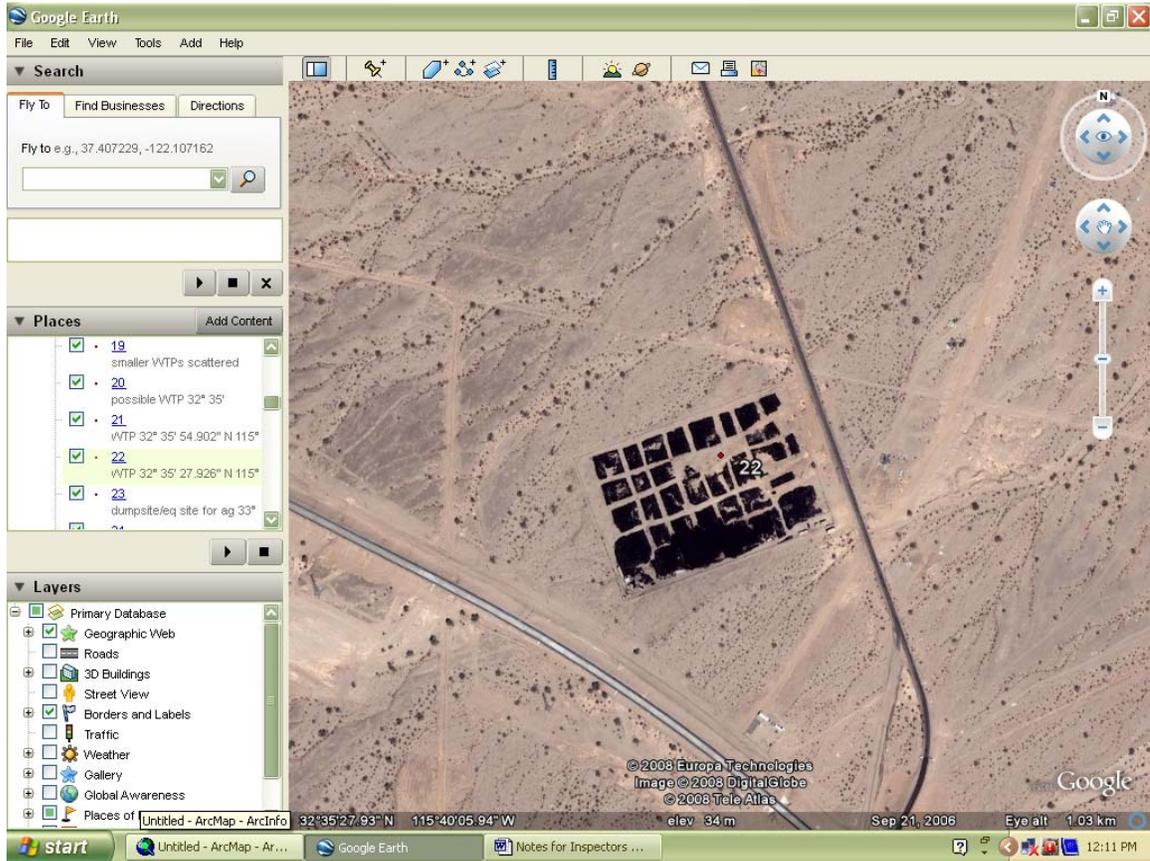
Calmexborder2.kmz file can be used in Google Earth to find possible waste tire piles (WTP). Simply open Google Earth, then open the .kmz file by clicking File>Open, and select “calmexborder2.kmz”. Google Earth should show an image that looks like this:



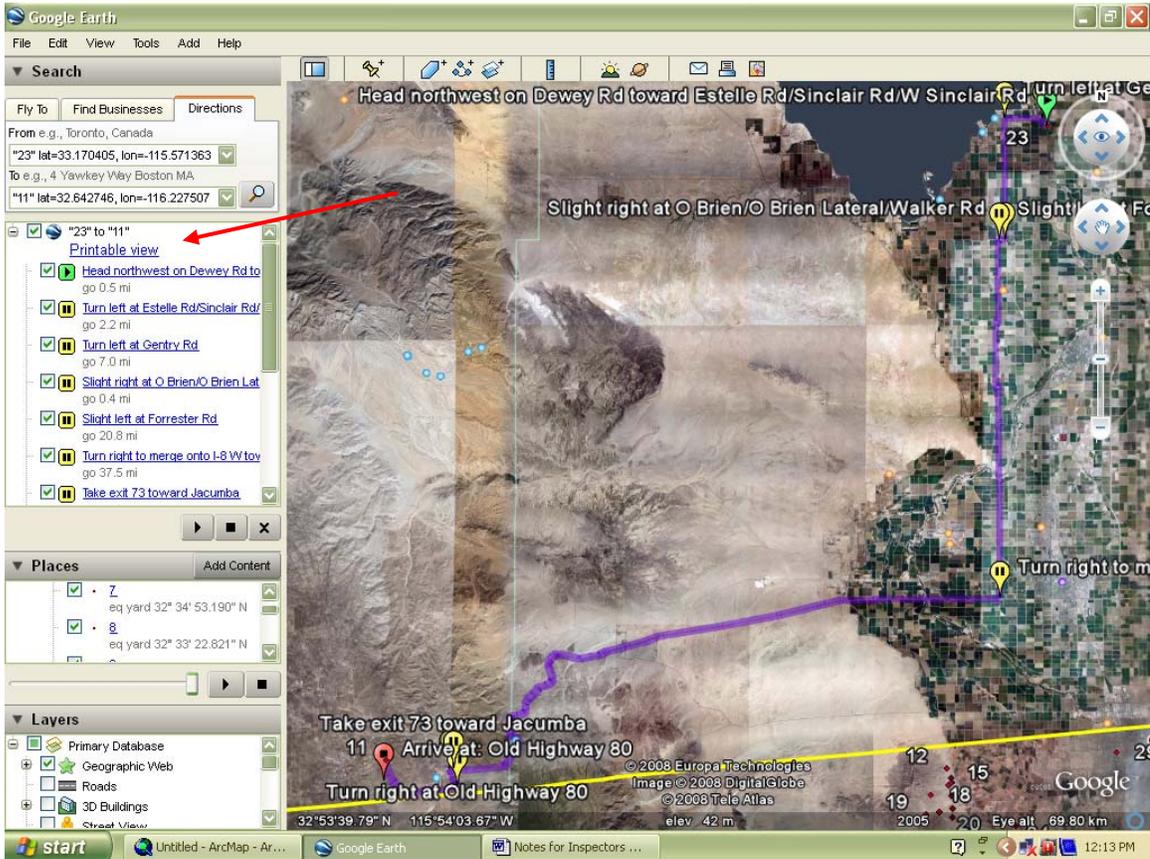
By expanding the calmexborder2.kmz folder in the Places menu and clicking on a site, a description of the site, the latitude and longitude, and any notes the analyst has provided are displayed.



By double-clicking on the site number, Google Earth will zoom into the location.

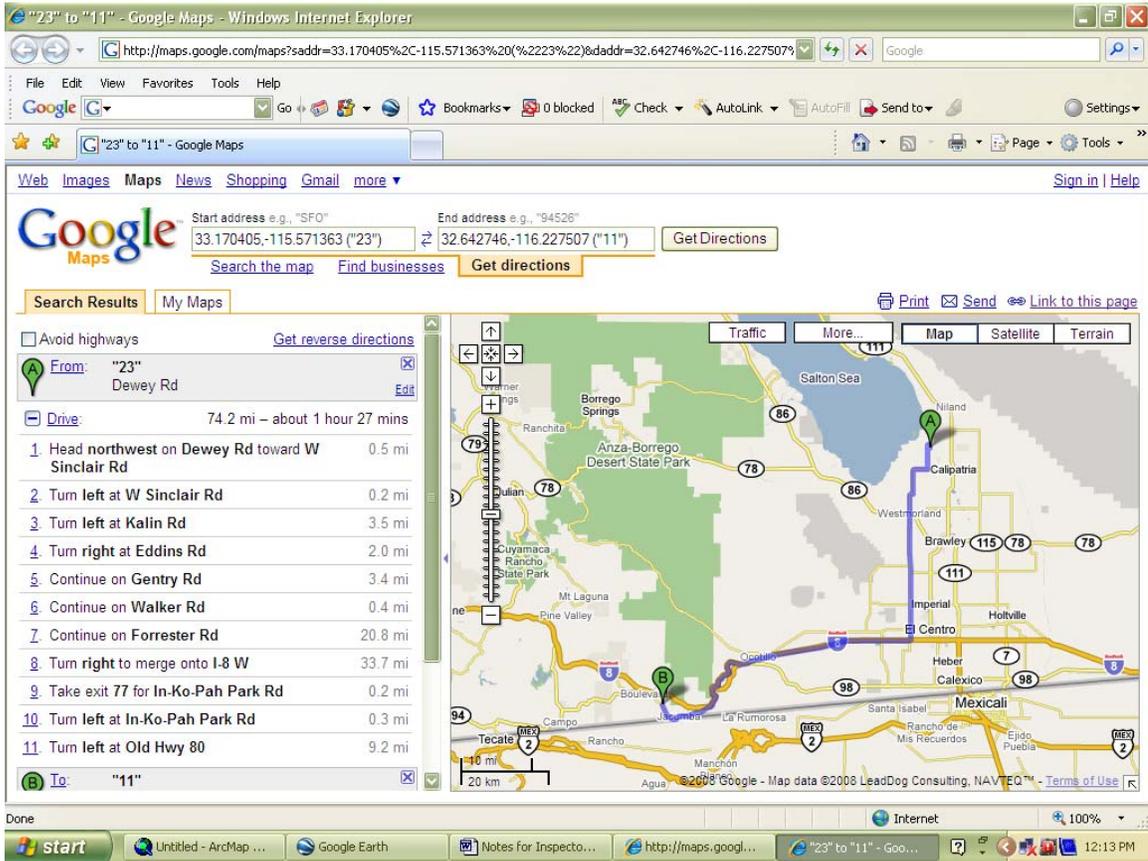


Road directions and maps for field work can be created in Google Earth. In the United States (and any other area where Google Earth has enabled it), click on a site to open the information box. In the box, there is an option “Get Directions: to here, from here.” In this case, I clicked “to here” for Site 11, and “from here” for Site 23. Google automatically searches for directions and displays the following:

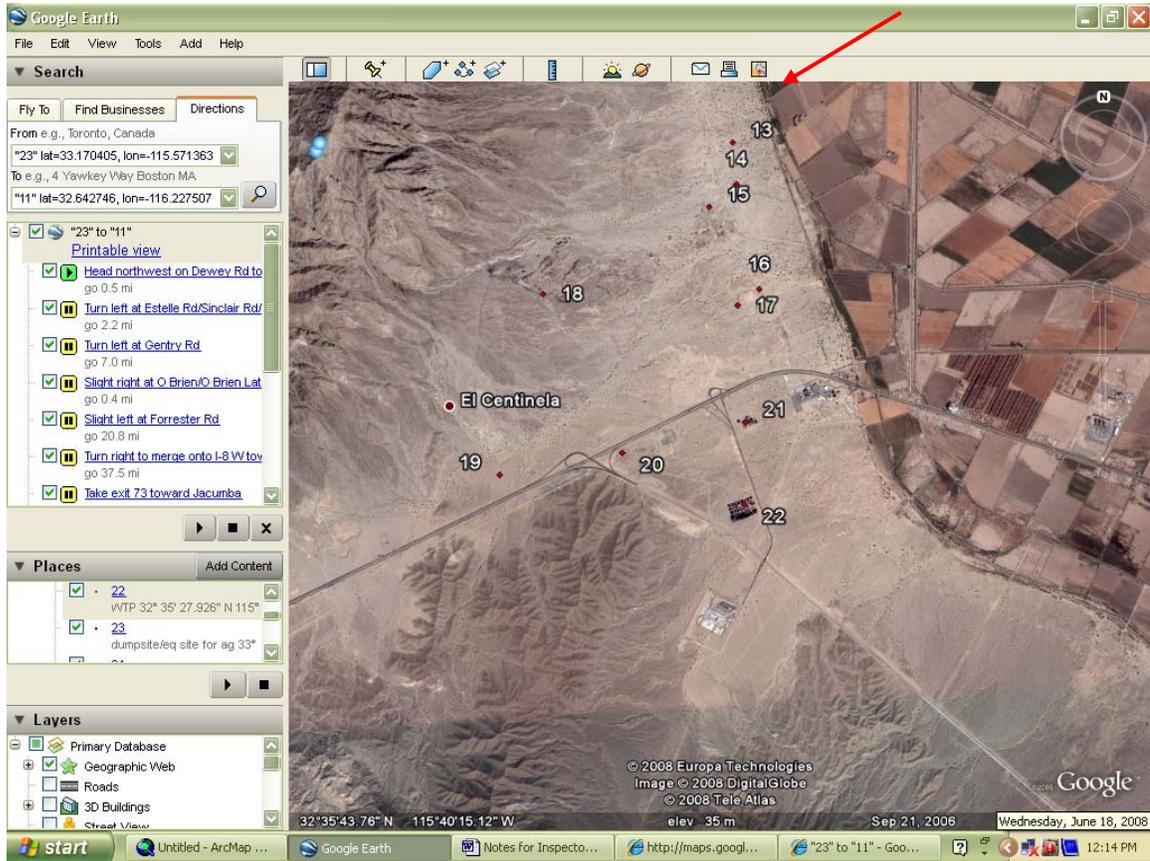


The directions appear at the right, and there is an option for a printable view (indicated by the red arrow).

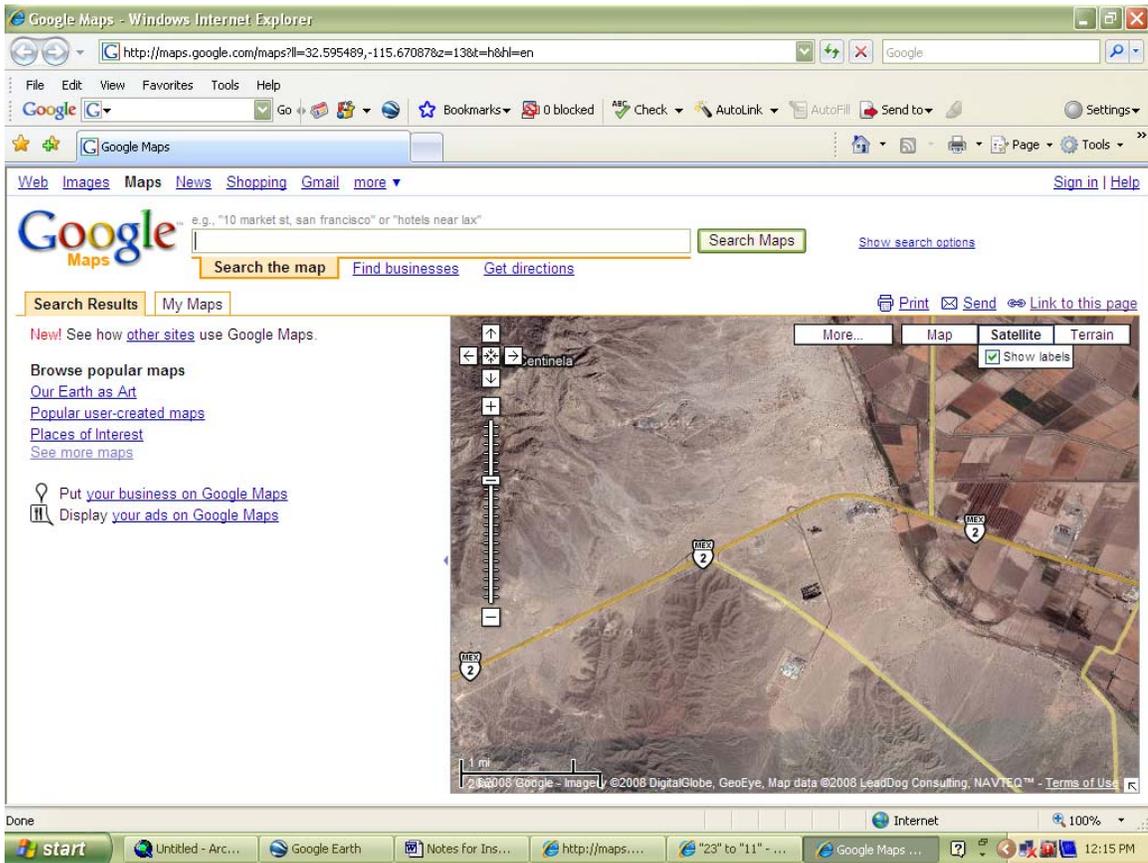
When you click on this option, you'll see:



In some areas (at this time, most of Mexico), this option is not available. You can, however, opt to see the scene in Google Maps by zooming to the area you would like to map and clicking the icon along the upper bar that is indicated by the red arrow:

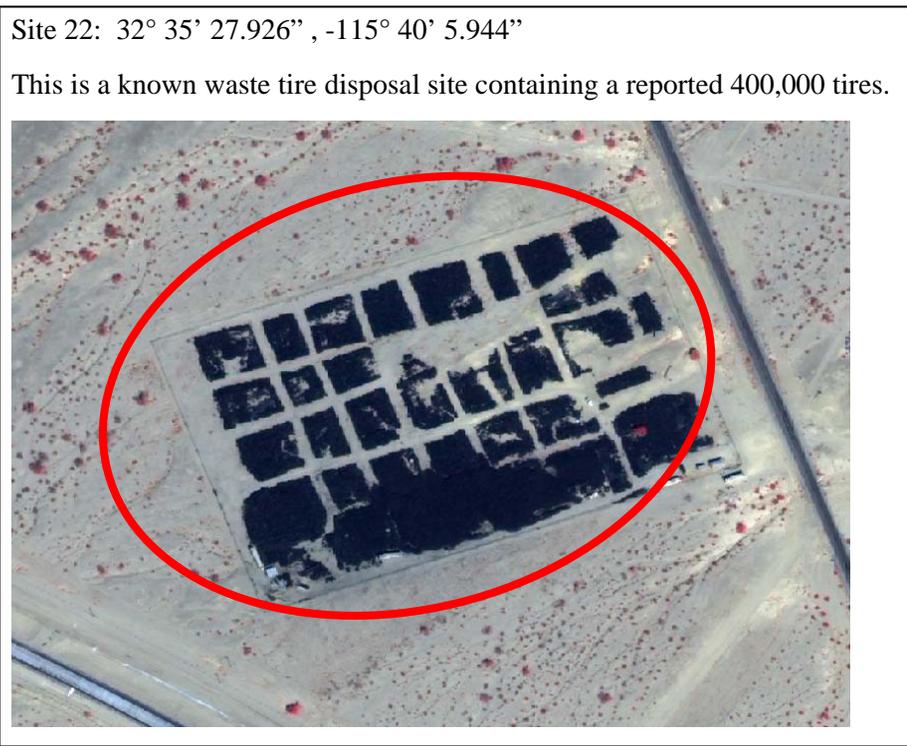


When you have clicked the icon to view the scene in Google Maps, you will see the following:



If you have Google Earth Plus (\$20) or Google Earth Pro (\$400), the .kmz file can be transferred to your GPS unit. This will help eliminate any typographical errors or read errors in finding the location.

Once you arrive at the approximate location, refer to snapshots.doc to guide you to the specific possible WTP. Site 22's snapshot looks like this:



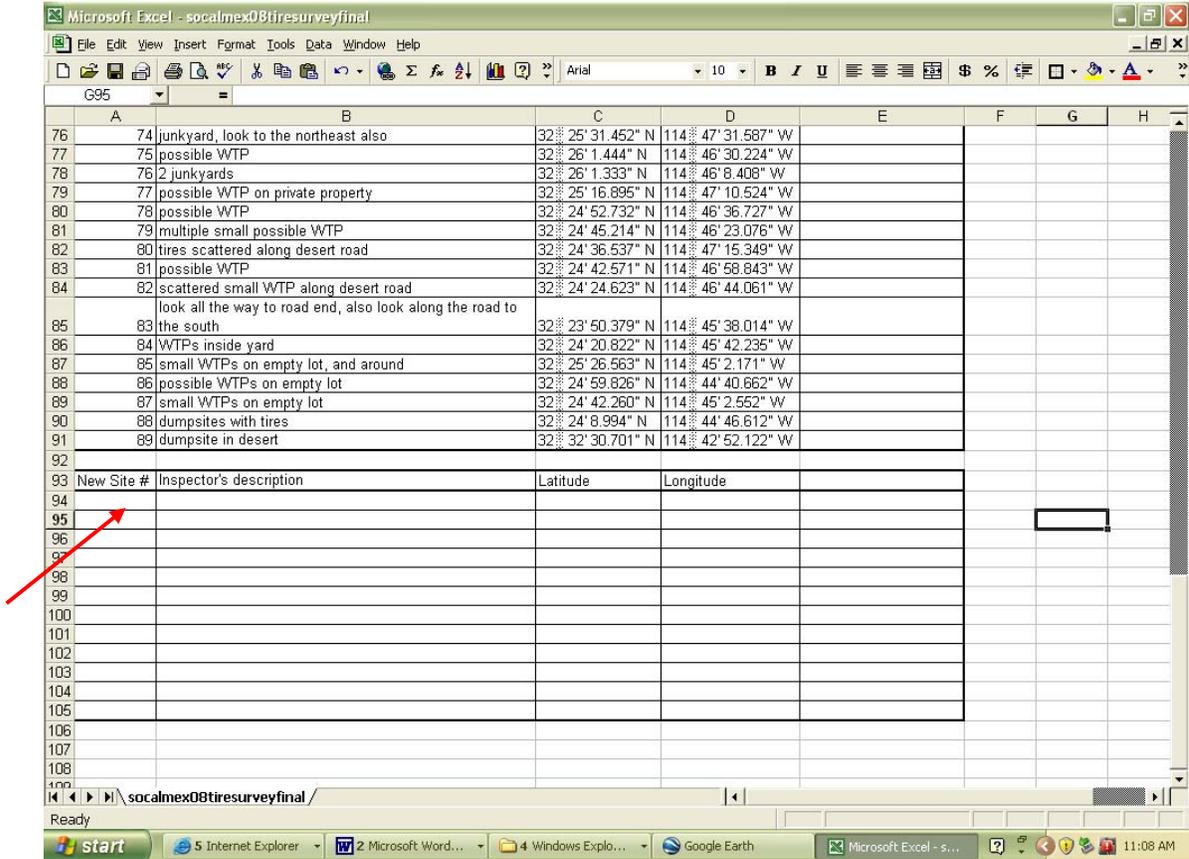
The snapshot contains a satellite view of the target site, latitude and longitude, and a brief description of what you may find. There may be more than one possible WTP per location. The red circles will indicate where the WTP are for each site. In the QuickBird satellite images, green vegetation will appear red. The red makes it easier to distinguish vegetation from other objects and can help guide you to the right location. Feel free to print the snapshots and take notes on them. Any notes you take on tire locations or alternate circles will be helpful. Either snail mail your notes to Becky Quinlan at 12205 269<sup>th</sup> Way NE, Duvall, WA 98019 or transfer them to an electronic file and e-mail them to [yogini97@yahoo.com](mailto:yogini97@yahoo.com).

When you have arrived at the location and determined what objects are at the target site, fill in the “Inspector’s notes” cell in the .xls spreadsheet.

Site	Analyst's notes	Latitude	Longitude	Inspector's notes
1	California/Mexico Border Area 2			
2	construction with much waste, high turnover, many possible piles	32° 27' 17.814" N	117° 0' 48.059" W	
3	possible WTP on a N/S line, high turnover	32° 23' 44.154" N	117° 2' 47.687" W	
5	3 large piles with others scattered	32° 20' 27.616" N	117° 1' 55.254" W	
6	4 possible WTP	32° 29' 41.927" N	116° 55' 49.966" W	
7	5 possible WTP	32° 29' 25.653" N	116° 55' 33.457" W	
8	6 possible WTP or burn on farm	32° 21' 15.070" N	117° 0' 8.091" W	
9	7 equipment yard	32° 34' 53.190" N	116° 38' 1.632" W	
10	8 equipment yard	32° 33' 22.821" N	116° 32' 28.025" W	
11	9 possible WTP	32° 34' 7.232" N	116° 31' 34.728" W	
12	10 possible WTP	32° 33' 55.902" N	116° 28' 0.149" W	
13	11 Transport storage with tires	32° 38' 33.887" N	116° 13' 39.023" W	
14	12 possible WTP	32° 37' 55.778" N	115° 40' 26.282" W	
15	13 possible WTP or vegetation	32° 37' 26.608" N	115° 40' 10.447" W	
16	14 possible WTP, all along track	32° 37' 12.868" N	115° 40' 8.962" W	
17	15 possible WTP, under power lines	32° 37' 5.407" N	115° 40' 19.659" W	
18	16 tires along N/S track crossing wash	32° 36' 38.404" N	115° 40' 0.092" W	
19	17 possible WTP	32° 36' 33.139" N	115° 40' 8.587" W	
20	18 huge system of tire dumps, look in wide area	32° 36' 36.574" N	115° 41' 24.020" W	
21	19 smaller WTPs scattered along road	32° 35' 37.567" N	115° 41' 40.898" W	
22	20 possible WTP	32° 35' 44.726" N	115° 40' 53.398" W	
23	21 WTP, known to have been cleaned up	32° 35' 54.902" N	115° 40' 5.565" W	
24	22 WTP, known tire disposal site	32° 35' 27.926" N	115° 40' 5.944" W	
25	23 dumpsite/equipment site for agriculture	33° 10' 13.458" N	115° 34' 16.908" W	
26	24 WTPs adjacent to race track	32° 35' 14.285" N	115° 36' 44.890" W	
27	25 multiple possible WTP on supply yard	32° 35' 0.680" N	115° 36' 17.774" W	
28	26 possible WTP, high turnover	32° 35' 18.448" N	115° 35' 46.111" W	
29	27 burns with possible WTPs	32° 33' 1.120" N	115° 31' 57.359" W	
30	28 tires or vegetation	32° 32' 27.376" N	115° 31' 53.087" W	
31	29 possible WTP or asphalt on private lot	32° 38' 41.631" N	115° 30' 15.316" W	
32	30 3 possible WTPs	32° 27' 29.791" N	115° 24' 8.432" W	
33	31 possible WTP in equipment yard	32° 36' 14.228" N	115° 25' 35.864" W	

Indicate whether there are tires at the location, what objects are at the location if they are not tires, and any notes on context you would like to make. Do not worry about making your notes brief; making them understandable to anyone who has not seen the site is better. If the targets are not tires, or you otherwise feel it would be helpful, please take a photograph of the location, using a wide enough angle to provide some context. Please do not zoom in on the object only (or if you do take multiple pictures). Label each picture with the site number.

Finally, when you submit your report, please include the completed .xls spreadsheet, photos, and any snapshot notes that you have taken. If you find WTPs not listed during your inspection, please photograph them, mark them using GPS coordinates or in a .kmz file, describe the location and include them at the bottom of the spreadsheet.



For Mexico, please note that there are regions where many property lines are delineated by tires. If you are in an area where this is the case and find tire piles of interest, please indicate in a separate column on the spreadsheet that these are in one of those tire-dense areas. It would help to know what number of tires constitutes a pile of interest in this context.

If you have any questions, feel free to contact Becky Quinlan by e-mail: [yogini97@yahoo.com](mailto:yogini97@yahoo.com) or by phone: (415) 640-3420.

# **Appendix D**

## **Illegal Dumping**

Another possible application for this method and imagery purchased for tire surveys is the detection or monitoring of illegal dumpsites. The following are pictures of dumpsites in California/Mexico Border Region 1 and their corresponding satellite images. In all satellite images, vegetation appears red and the red circles indicate the area pictured in the next figure.



**Figure D-1. Satellite image of California/Mexico Border Region 1, site 4 (Digital Globe, 2006).**



**Figure D-2. Metal debris at site 4 (Silva, 2007).**



**Figure D-3. Satellite image of California/Mexico Border Region 1, site 46 (Digital Globe, 2006).**



**Figure D-4. Debris at site 46 (Siefert, 2007).**



**Figure D-5. Satellite image of California/Mexico Border Region 1, site 123 (Digital Globe, 2006).**



**Figure D-6. Black wires at site 123 (Silva, 2007).**

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