PITTMAN TERRACE WATER QUALITY IMPROVEMENT PROJECT

ALTERNATIVES ANALYSIS REPORT

January 2017

Prepared by:

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1.0 INTRODUCTION

Pittman Terrace is a steep neighborhood that sits on Lake Tahoe's east shore directly below US Highway 50. For over a decade, residents in the neighborhood have expressed concern about sediment laden stormwater runoff traveling through their neighborhood and into Lake Tahoe. In 2015, the Nevada Tahoe Conservation District applied for and successfully received funding to plan, design, and construct the Pittman Terrace Water Quality Improvement Project (WQIP). The primary goal of the Pittman Terrace WQIP (Project) is to treat stormwater before discharge to Lake Tahoe. The Project will employ a combination of stormwater treatment, outfall stabilization, and road operations in both NDOT Right-of-Way and the lakeside Pittman Terrace community. PLRM v1.1 Baseline modeling indicates the NDOT HWY 50 catchment is a high priority catchment due to being a high pollutant loading and directly connected catchment.

The objectives are as follows:

1. Stabilize the eroding channels and dirt paths within the Pittman Terrace neighborhood to convey runoff from Highway 50 without contributing additional pollutants and transporting those pollutants to Lake Tahoe.
2. Partner with the Pittman Terrace Homeowners to install stormwater treatment infrastructure in conjunction with their planned road repaving project.
3. Through PLRM modeling and catchment registration, garner Lake Clarity Credits for NDOT and Douglas County.

1.1 PROJECT LOCATION

The Pittman Terrace Water Quality Improvement Project (Project) is located within Douglas County, Nevada, T14NR18E Sec27. The nearest cross streets are Highway 50 and Friedhoff Street. The Project encompasses private, county, and state (Nevada Department of Transportation and Nevada Division of State Lands) property. Though the neighborhood only has ¼ mile of roads and 16 single family homes, its location on a steep hill directly adjacent to Lake Tahoe and immediately below the 4 lane US Highway 50 has 5 stormwater outfalls that are directly connected to Lake Tahoe. The steep slope and majority private ownership limits stormwater treatment opportunities. See Figure 1 below for Project vicinity.

Figure 1. Project Area Vicinity Map

1.2 PROJECT FUNDING

The Project received funding from the Nevada Division of Environmental Protection (NDEP), the Nevada Department of Transportation (NDOT), and the Nevada Division of State Lands (NDSL). The funding amounts are listed in Table 1.

Table 1. Funders and Funding Amounts

Funder	Funding Amount
Nevada Division of Environmental Protection (EPA 319h)	$127,000.00
Nevada Department of Transportation	$242,009.20
Nevada Division of State Lands	$127,758.84

Project partners include the funders and jurisdictions listed above as well as the following regulatory agencies and stakeholders: Pittman Terrace Homeowners Association (PTHOA), Douglas County, and the Tahoe Regional Planning Agency (TRPA).

2.0 EXISTING CONDITIONS

The Project contains the residential neighborhood of Pittman Terrace with single family dwellings on mostly ¼ acre or smaller lots. The Project area accepts run-on from a portion of Highway 50 adjacent to and up gradient of the neighborhood, which produces a majority of the runoff and sediment loading. Another source of water volume comes from an approximately 350 acres natural drainage that passes under Highway 50. The neighborhood and Highway 50 right-of-way are constrained in area available for stormwater treatment by both available open space and steep slopes throughout the Project area.

2.1 LAND CAPABILITY

The USFS and TRPA developed the Bailey land capability system in the early 1970s based primarily on the official US Department of Agriculture (USDA) soils maps for the Tahoe Region (Bailey, 1974). Each soil type was assigned to a land capability class ranging from 1 to 7, with capability 1 being the most environmentally fragile and sensitive to development. Wherever land was found to be influenced by a stream or high groundwater, it was assigned to capability 1B, also known as "Stream Environment Zone" or SEZ. The Pittman Terrace WQIP Project is located within TRPA land capability classes 1A, 1B, and 2. The 1B area is located in the natural drainage area in the center of the project area. The upland watershed mainly comprises the class 1A capability which indicates land sensitive to development due to its steep terrain. The class 2 capability includes the residential parcels. Project improvements are anticipated to be constructed in the 2 land capability classes along or adjacent to existing roadways. Some improvements may be constructed in the eroding drainage for natural, residential, and highway run-off, which is currently labeled as 1B. No improvements may be constructed within the TRPA-delineated backshore.

2.2 EXISTING SOILS

The Natural Resources Conservation Service (NRCS) soil survey indicates that the Project area is located within soil map units 7101, 7412-7414, 7421-7424. Soil unit 7101 is Caverock sandy loam, 9 to 50 percent slopes and Hydrologic Group C. This soil is a very small portion of the Project watershed containing the geologic feature Cave Rock which spans Highway 50. Soil units 7412 through 7414 is Cagwin-Rock outcrop complex, extremely stony with varying slopes and Hydrologic Group B. Units 7421-7324 is Cassenai gravelly loamy coarse sand, very stony with varying slopes and Hydrologic Group A. See Figure 2 for soils map. Locations of infiltration features are planned on group A soils only, which are very fast draining soils. Figure 2 shows NRCS soils groups for the watershed area.

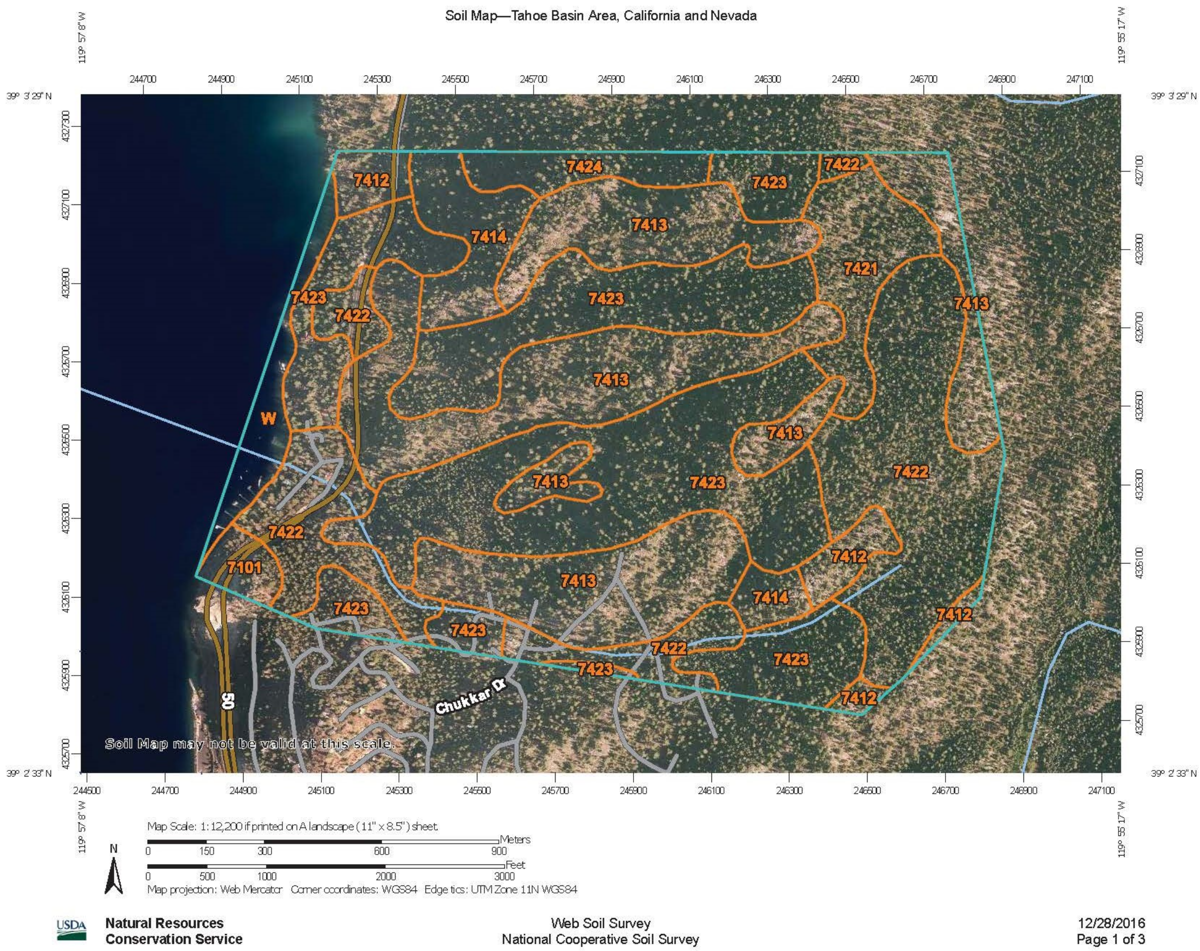
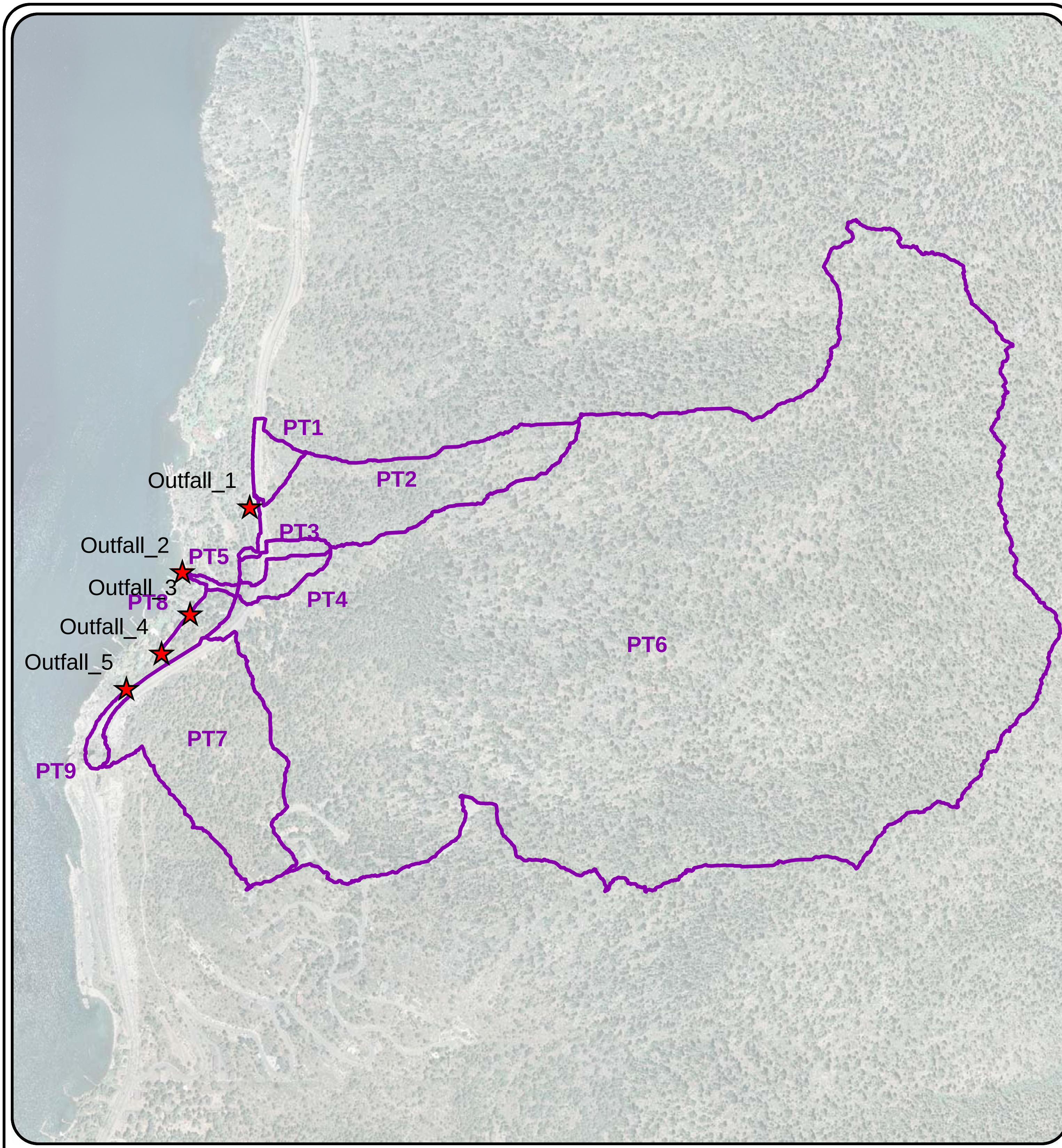


Figure 2. Project Area NRCS Soil Map Units. The area of interest is outlined in blue.

2.3 CATCHMENTS

The watershed area and sub-watersheds (or catchments) were delineated by NTCD using 2010 USGS 1 foot LiDAR and ESRI ArcGIS software ArcMap 10.3.1. Catchments were then refined to incorporate the effects of the existing drainage system under Highway 50 and throughout the neighborhood. Field verification and in person meeting with residents served as verification to the catchment delineation and hydrologic modeling. Figures 4 and 5 display the catchment boundaries with drainage areas in acres and outfall locations. There are five stormwater outfalls in the Project area. Only three of the outfalls were considered for treatment due to project constraints (topology, private property, etc.) or lack of outlet connectivity directly to Lake Tahoe. The outlets are numbered from north to south. The largest catchment, producing the most water is PT06 with approximately 350 acres. A natural drainage above Highway 50 is routed under the highway and through the neighborhood. The second largest catchment, PT07 with approximately 28 acres has limited opportunities for improvements. NDOT has constructed several sediment cans in the right-of-way in this catchment. Downstream of the right-of-way, topology and private property constrain any possible infiltration. See Section 3.0 Alternatives for a more detailed description of proposed improvements.



Legend

- Outfalls
- Catchments

FIGURE 3:
Pittman Terrace WQIP
Existing Catchments Overall

1 in = 917 feet

0 260 520 1,040 1,560 2,080 Feet

UTM Zone 10N	NAD 83	horiz. units: feet
Prepared by NTCD		December 2016

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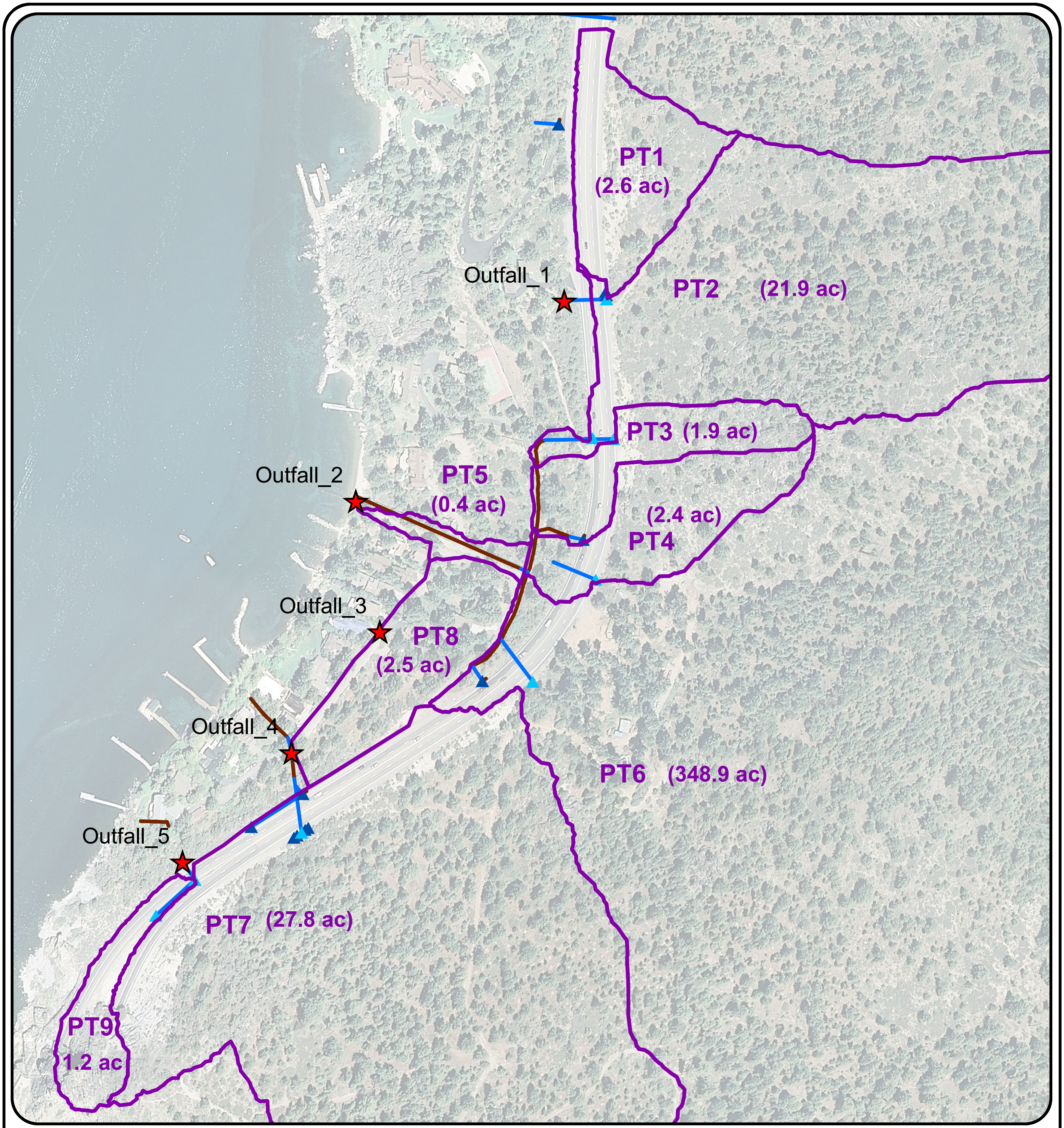

Legend

- Outfalls
- Catchments
- Ex Drainage Inlet
- Ex Sediment Trap
- Ex Conveyance Pipe
- Ex Conveyance Ditch

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FIGURE 4:
Pittman Terrace WQIP
Existing Catchments Detail

1 in = 292 feet

0 80 160 320 480 640 Feet

UTM Zone 10N	NAD 83	horiz. units: feet
Prepared by NTCD		December 2016

2.4 DESIGN FLOWS

Design flows including peak flow and volumes were calculated using the SCS method in the NRCS TR-55 Bulletin and utilizing HEC-HMS version 4.0.

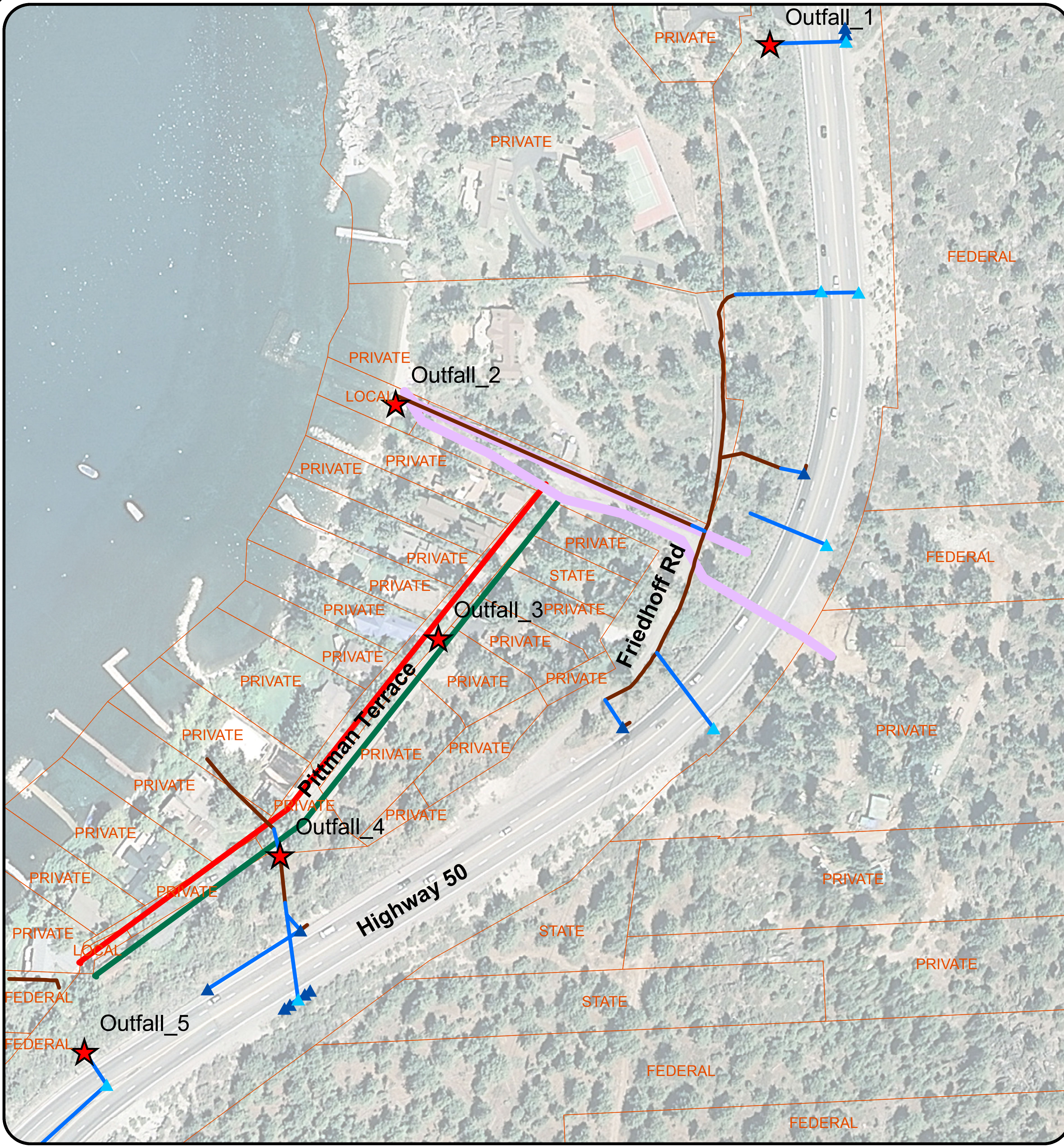
The contributing watershed to the Pittman Terrace WQIP project area is approximately 410 acres. The watershed was divided into nine (9) existing catchments based on outlets and proposed treatment locations. The peak flow and quantity of runoff for the 2, 25, 50, and 100 year -24 hour storm events were determined for each catchment and each outlet. The precipitation intensity, i, was determined using the National Oceanic and Atmospheric Administration's (NOAA's) Precipitation Frequency Data Server. The 25 year storm is the design storm for Project conveyance per Douglas County standards. All treatment facilities are designed to the maximum extent practicable. The design storm results for the outfalls in existing conditions are summarized below in Table 3. The HEC-HMS input and results of the volume peak flow for existing conditions and all alternatives are displayed in Appendix A: Preliminary Hydrology (HEC-HMS).

Table 2. Existing Conditions Design Storm (25 year, 24 hour) HEC-HMS Results

Outfall	Drainage Area (mi^2)	Peak Flow (cfs)	Volume (ac-ft)
1: North Hwy 50 (no improvements)	0.004	0.5	0.3
2: Main Drainage Path	0.587	3.9	2.5
3: Neighborhood Drainage	0.004	0.1	0.1
4: Draining PT07	0.043	0.4	0.3
5: Draining PT09 (no improvements)	0.002	0.7	0.2

2.5 UTILITIES

Existing utilities pose constraints to options for stormwater treatment within the Project area. There are many existing utilities both running through the neighborhood and along Highway 50. Conflicts with utilities are undesirable from a cost and scheduling standpoint. Figure 5 shows the approximate locations of utilities and stormwater conveyance system within the Project area. Figure 4 may not be a completed representation of all possible utility conflicts as, at the time of this report, NTCD had not received responses from all known utility companies.



LEGEND

- Outfall
- Existing Water
- Existing Sewer
- Existing UG Electric
- Parcels

Existing Stormwater Improvements

- Drainage Inlet
- Sediment Trap
- Conveyance Pipe
- Conveyance Ditch

FIGURE 5: Pittman Terrace WQIP Known Neighborhood Utilities

1 inch = 167 feet

0 105 210 420 Feet

NAD 83

horiz. units: feet

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Prepared by NTCD

December 2016

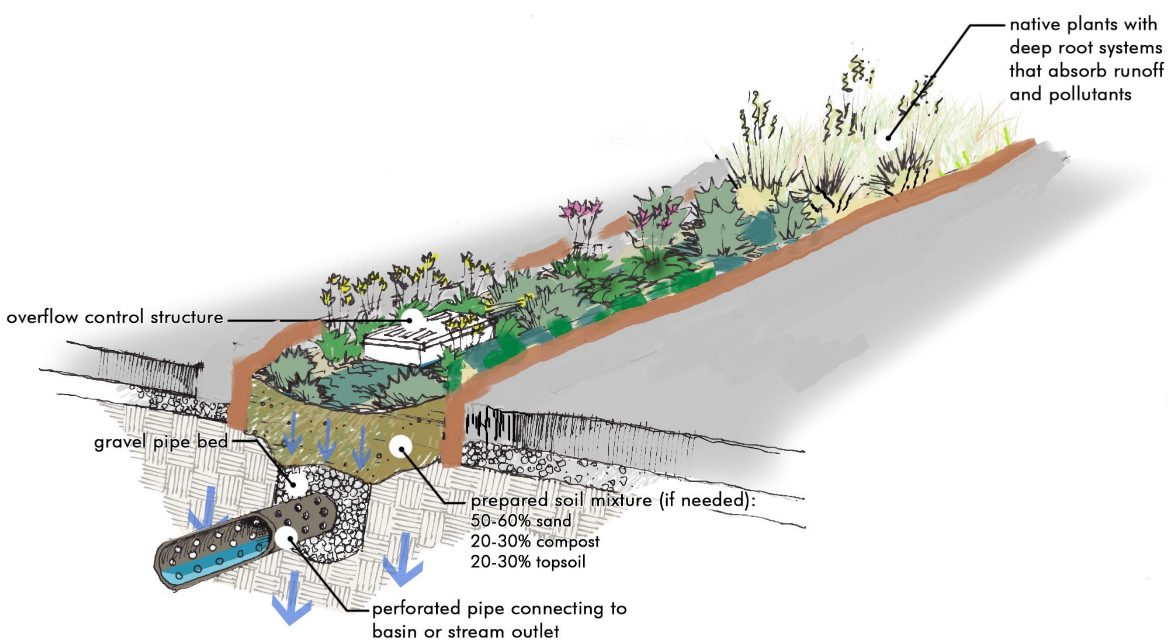
3.0 ALTERNATIVES

The following sub-sections detail Project alternatives. All alternatives were conceived with Project objectives in minds and the goal of maximizing stormwater treatment given project constraints. Most treatments are focused on stabilizing the neighborhood channels and treating highway and residential run-off before it combines with natural drainage. Alternatives are numbered in order from simplest to more complex design based on constraints and costs.

3.1 ALTERNATIVE 1: IN-LINE DITCH INFILRTATION TREATMENTS

Alternative 1 includes in-line ditch infiltration improvements for the neighborhood, the addition of sediment traps at existing drainage inlets on Highway 50 that currently are without sump, an infiltration feature retrofitted to existing highway sediment traps, and an infiltration vault for neighborhood runoff.

In-line ditch treatments involve promoting infiltration within the existing ditches while maintaining conveyance for larger storms. Inline treatments could include bioswales or French drains, a perforated pipe surrounded by rock. Picture 1 below shows an illustration of a bioswale.



Picture 1. An illustration of a potential in-line treatment.

The treatment schematic in Picture 1 could be with vegetation or rock or with or without the perforated pipe. The best suited configuration will be determined through the design process. Pictures 2 and 3 display different concepts of what potential in-line treatments could look like with rock or vegetation.


Pictures 2 & 3. Example in-line treatment.

The main channel that discharges to Outfall 2 has too much runoff to be contained in an infiltration feature. Instead, Alternative 1 proposes to armor the channel and create step-pools within the existing channel to slow and spread the runoff, decreasing the amount of erosion and promoting infiltration. Pictures 4 and 5 show a more natural looking step pool configuration built with rock. Picture 6 shows a step pool series built with concrete.

Pictures 4 & 5. Example rock step pools

Picture 6. Example step pools

Although the sediment traps do not give additional credits in PLRM, they are still valuable from a maintenance and function standpoint. The sediment traps serve as pre-treatment for any infiltration feature downstream. Without the pre-treatment, infiltration features will be prone to frequent clogging and will be less effective in treating fine sediment.

Another component of Alternative 1 is an infiltration feature retrofitted to NDOT's current sediment trap treatment of catchment PT07 along Highway 50. The infiltration feature would be designed to take water offline into additional perforated pipes and sediment traps. Given constrained space in the shoulder, the infiltration feature will be designed to treat stormwater to the maximum extent practicable.

The last component of Alternative 1 is an infiltration vault added to the existing drainage inlet on Pittman Terrace. This drainage inlet is permanently clogged and currently causes flooding in the road before runoff escapes down a driveway and between two houses towards the lake. Adding an infiltration vault would allow for more storage of runoff and would improve the problem. Existing utilities would be a constraint to this improvement. The vault size would be confined to the extent of the utility conflicts.

Alternative 1 would provide lower construction and maintenance costs but would provide less treatment and therefore the least FSP reduction. A concept level schematic of Alternative 1 is given in Figure 6. The costs and benefits of the alternatives are weighted in Sections 4 and 5.

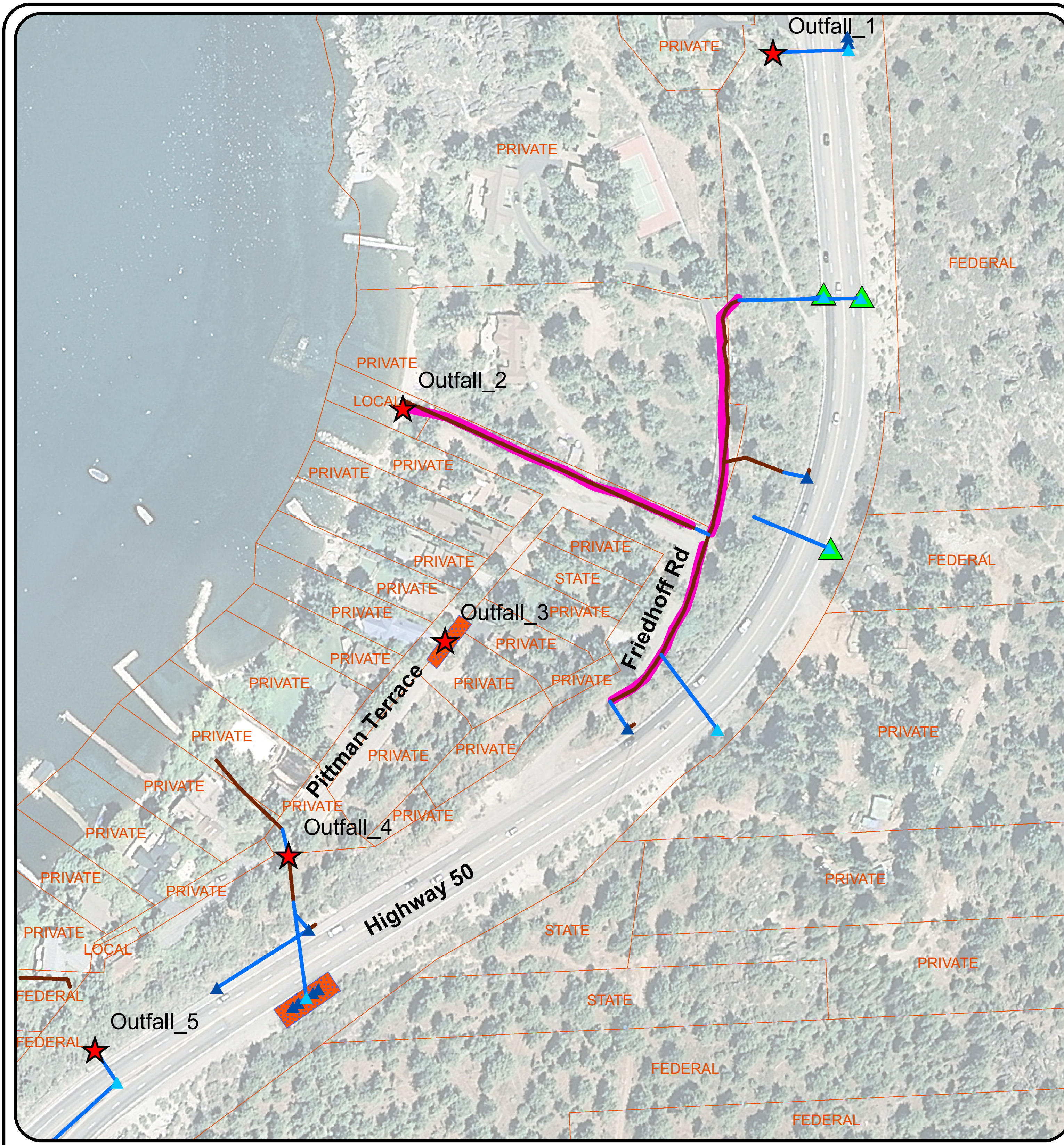
3.2 ALTERNATIVE 2: IN-LINE DITCH TREATMENTS WITH SMALL BASINS

Similar to Alternative 1, Alternative 2 includes constructing the Highway 50 sediment traps, in-line infiltration treatments, a retrofitted infiltration feature to capture road drainage in catchment PT07, and an infiltration vault for neighborhood runoff. Alternative 2 replaces some ditch infiltration treatments with small infiltration basins along the existing northern neighborhood drainage ditch. The basins would provide more infiltration and be easier to maintain than solely using the ditches for treatment. Basins could be in-line or off-line depending on elevations. The biggest constraint to this alternative is that the land required to construct these basins is partially privately owned. The private property would need to have an easement established or be acquired to continue with this alternative. A concept level schematic of Alternative 2 is given in Figure 7. Picture 7 shows and example of a small offline basin. The basin pictured was constructed for the NTCD managed Incline Village Green Streets Project.

Picture 7. Example small basin

3.3 ALTERNATIVE 3: RESTORE CHANNEL THROUGH STATE PARCEL

Alternative 3, similar to Alternatives 1 and 2, includes construction of the Highway 50 sediment traps in-line infiltration treatments, a retrofitted infiltration feature to capture road drainage in catchment PT07, and an infiltration vault for neighborhood runoff. Alternative 3 differs in including the restoration of the natural channel through a state owned (NDSL) parcel. A culvert would be constructed under Friedhoff Road and then into a cascading channel on the NDSL parcel. A second culvert would need to be constructed under Pittman Terrace to join the newly constructed channel to the existing drainage leading to Outfall 2. See Figure 8 for a schematic of Alternative 3. Realigning the natural drainage towards its more historic pathway would help separate the neighborhood and highway runoff from cleaner forest runoff. Proposed infiltration treatments would be more effective. There would also be less erosive pressures on the existing drainage pathway.



LEGEND

- Outfall
- Proposed In-Line Treatment
- Proposed Vault/Infiltration Treatment
- Proposed Sed Trap
- Parcels

Existing Improvements

- Drainage Inlet
- Sediment Trap
- Conveyance Pipe
- Conveyance Ditch

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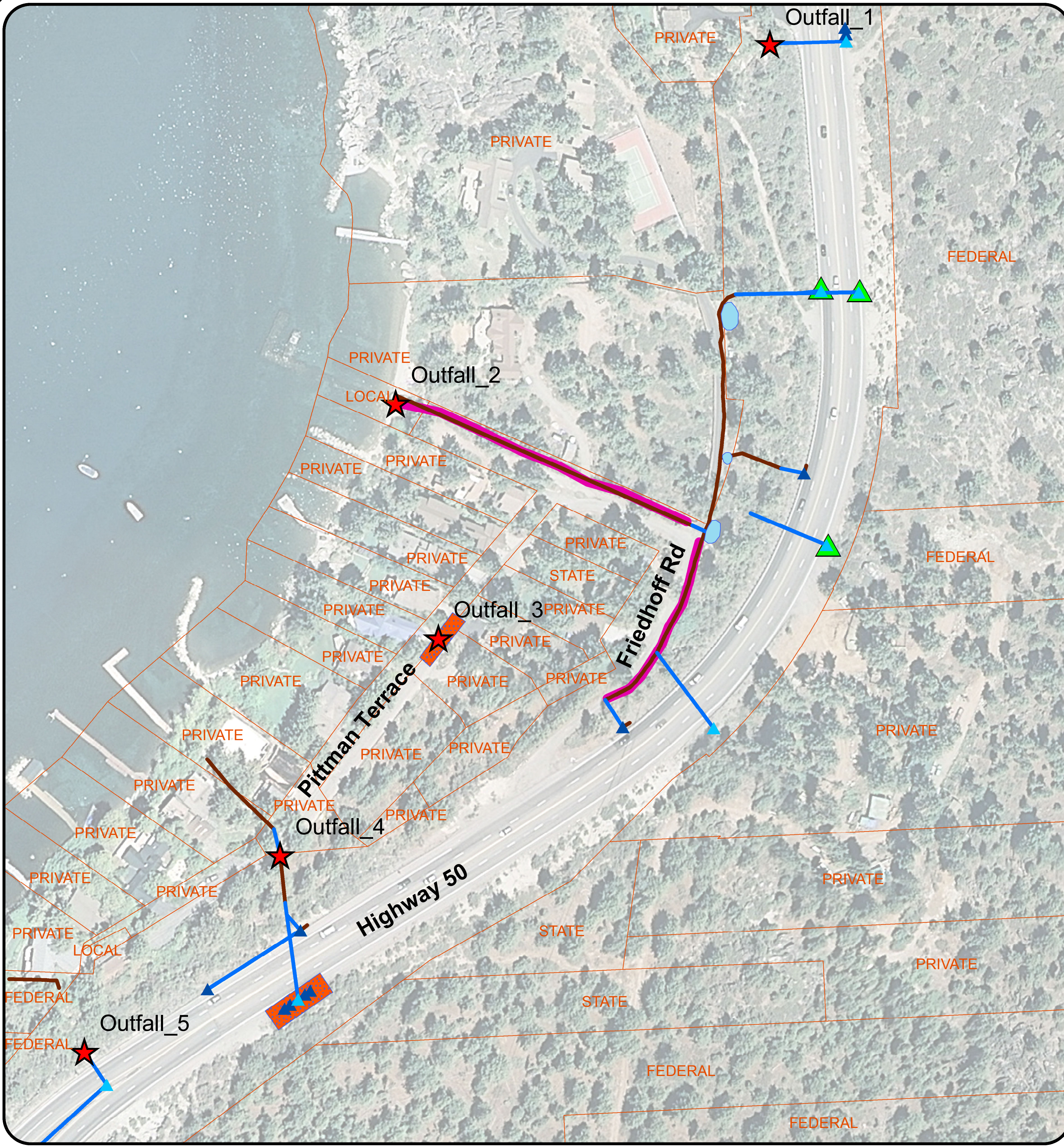
FIGURE 6:
Pittman Terrace WQIP
ALT 1 - DITCH INFILTRATION

1 inch = 167 feet

0 105 210 420 Feet

NAD 83		horiz. units: feet
Prepared by NTCD		December 2016



LEGEND

- Outfall
- Proposed Basins
- Proposed In-Line Treatment
- Proposed Vault/Infiltration Treatment
- Proposed Sed Trap
- Parcels

Existing Improvements

- Drainage Inlet
- Sediment Trap
- Conveyance Pipe
- Conveyance Ditch

FIGURE 7:
Pittman Terrace WQIP
ALTERNATIVE 2 - BASINS

1 inch = 167 feet

0 105 210 420 Feet

Prepared by NTCD

December 2016

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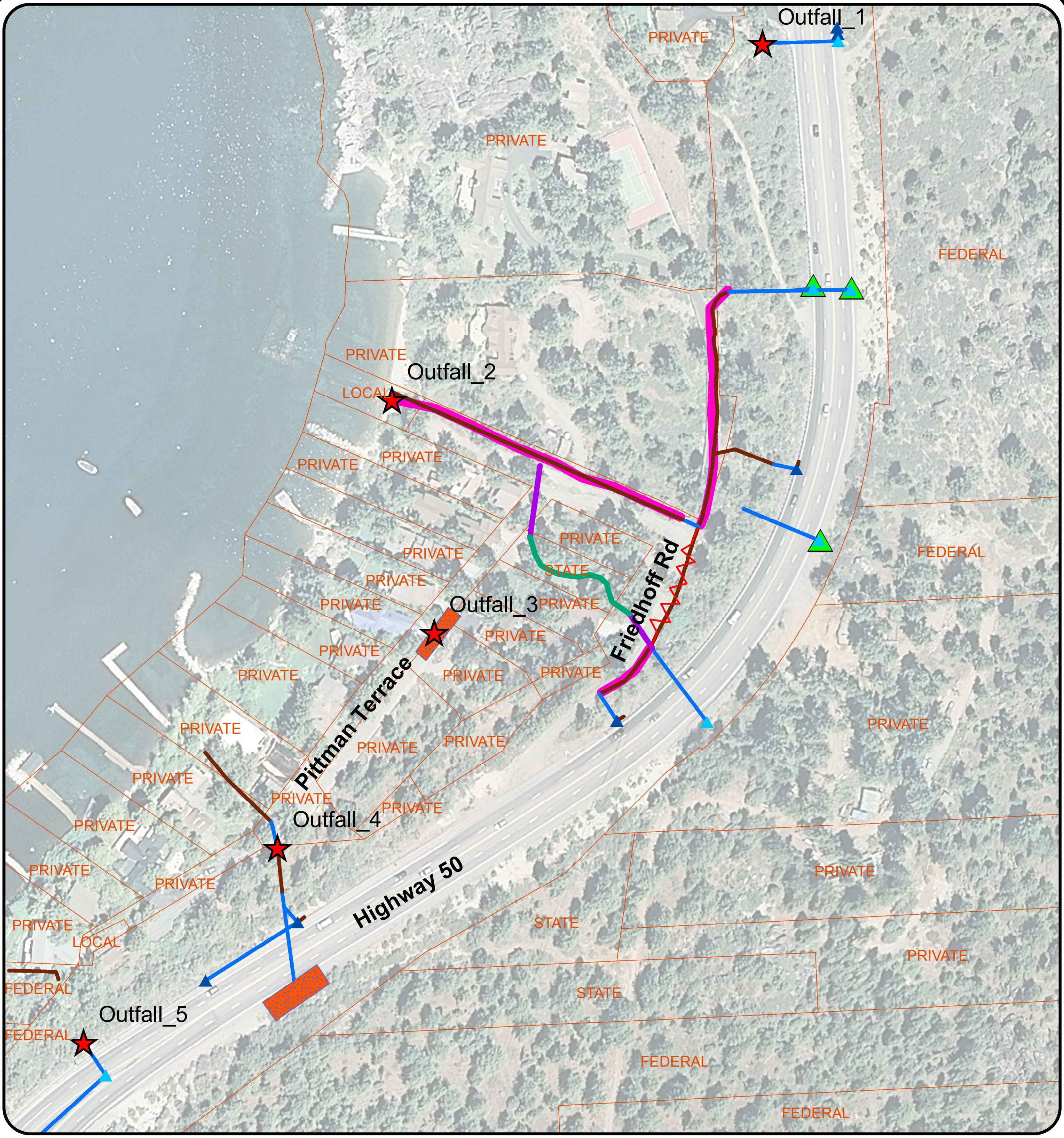
horiz. units: feet

NAD 83



LEGEND

- Proposed Remove Ditch
- Propose Creek Restoration
- Outfall
- Proposed Vault
- Proposed Culvert
- Proposed In-Line Treatment
- Proposed Sed Trap
- Parcels

Existing Improvements

- Drainage Inlet
- Sediment Trap
- Conveyance Pipe
- Conveyance Ditch

FIGURE 8:
Pittman Terrace WQIP
ALT 3 - Channel Restoration

1 inch = 167 feet

0 105 210 420 Feet

NAD 83

horiz. units: feet

Nevada Tahoe Conservation District

Prepared by NTCD

December 2016

4.0 SELECTION CRITERIA

The primary goal of the Project is to treat stormwater before discharge to Lake Tahoe with the main pollutant of concern being FSP. NTCD considered four equally weighted criteria to evaluate alternatives including constructability, water quality/PLRM score, design and construction costs, and maintenance costs. Scoring and selection of the preferred alternative is discussed in Section 5.

4.1 WATER QUALITY /PLRM SCORE

Table 3 details the results of the PLRM v2.1 model used to calculate the relative FSP reduction for each alternative as compared to the existing conditions. See Appendix B for more detail on PLRM modeling and assumptions.

Table 3. PLRM Results

	Water Quality Parameter			
Scenario	**FSP [lbs/yr]**	**FSP Load Reduction [lbs/yr]**	**Ave. Annual Removal % FSP**	**Est. PLRM Credit**
Baseline/Existing Conditions	4807			
Alt 1: Ditch Infiltration		1936	40.3%	10
Alt 2: Ditch Infiltration with Basin		2192	45.6%	11
Alt 3: Channel Restoration		1904	39.6%	10

Assumptions/Notes:

1. *Did not take into account private party BMPs. They remained at 7/19/5 for SFR/MFR/CICU respectively throughout the modeling*
2. *SFR/MFR/CICU % DCIA was estimated using PLRMv1.1 inputs and number of parcels discharging to the road vs. total number of parcels within sub-watersheds assuming each parcel is same size.*
3. *Based on NRCS soils maps, these load reductions and credit estimates are based on the higher default infiltration results.*

4.3 DESIGN & CONSTRUCTION COSTS

The construction costs detailed in Table 4 represent a conceptual design estimate for the three alternatives. More research is needed give an accurate estimate of potential costs for Alternative 2 but the assumption has been made that the land could be acquired by either easement or donation. Both Alternatives 1 and 2 fit within the allotted $385,000 construction budget. Alternative 3 goes substantially above the current budget and funding.

Table 4. Conceptual Construction Costs

ENGINEER'S OPINION OF PROBABLE COSTS - Conceptual Design								
Pittman Terrace Conceptual Alternatives Analysis								
Prepared By: Nevada Tahoe Conservation District								
Date: January 13, 2017								
			Alt 1: Ditch Infiltration		**Alt 2: Ditch Infiltration with Basins**		**Alt 3: Channel Restoration**	
Description	**Unit**	**Unit Cost**	**Quantity**	**Extension**	**Quantity**	**Extension**	**Quantity**	**Extension**
Mobilization/Demobilization	LS	10%	1	$ 23,300	1	$ 21,500	1	$ 35,800
Temporary Erosion Control	LS	5%	1	$ 11,700	1	$ 10,800	1	$ 17,900
Traffic Control	LS	4%	1	$ 9,300	0	$ 8,600	0	$ 14,300
Demolition	LS	$ 2,000	1	$ 2,000	1	$ 2,000	1	$ 2,000
Ditch Infiltration	LF	$ 200	536	$ 107,200	233	$ 46,600	385	$ 77,000
Step Pools and Rock-Lined Channel	LF	$ 150	390	$ 58,500	390	$ 58,500	390	$ 58,500
Remove and Replace Fencing	LF	$ 40	160	$ 6,400	160	$ 6,400	160	$ 6,400
Install Hwy Sediment Traps	EA	$ 8,400	3	$ 25,200	3	$ 25,200	3	$ 25,200
Retrofit Existing Hwy Sediment Traps	LS	$ 10,000	1	$ 10,000	1	$ 10,000	1	$ 10,000
Infiltration Vault	EA	$ 15,000	1	$ 15,000	3	$ 45,000	5	$ 75,000
Basin Grading	CY	$ 50	0	$ -	250	$ 12,500	0	$ -
Restore/Build Channel	LF	$ 200	0	$ -	0	$ -	176	$ 35,200
Culvert, Friedhoff Rd	LF	$ 300	0	$ -	0	$ -	60	$ 18,000
Culvert, Pittman Terrace	LF	$ 400	0	$ -	0	$ -	100	$ 40,000
Utility Potholing	LS	$ 6,000	1	$ 6,000	1	$ 6,000	1	$ 6,000
Revegetation	SF	$ 0.50	6,300	$ 3,150	5,600	$ 2,800	9,000	$ 4,500
		Subtotal		$ 277,750		$ 255,900		$ 425,800
		Contingency (35%)		$ 97,200		$ 89,600		$ 149,000
		Total		**$ 374,950**		**$ 345,500**		**$ 574,800**

4.4 MAINTENANCE COSTS

Maintenance costs were established based on average BMP maintenance cost data derived for Washoe County by Northwest Hydraulics Consultants for the jurisdiction's Stormwater Loading Reduction Plan. This was the most comprehensive nearby data that was available. Table 5 details annual costs to maintain each alternative and the 20 year cost of maintenance in 2017 dollars. Actual cost of maintenance will increase with inflation and worker salaries.

Table 5. Estimated Maintenance Costs in 2017 Dollars

Alternative Description	Cost Per Year	20-yr Cost
Alt 1: Ditch Infiltration	$2,460	$49,201
Alt 2: Ditch Infiltration with Basins	$1,927	$38,543
Alt 3: Restore Channel	$1,629	$32,573

All alternatives include the costs of maintaining three new sediment traps, a vault, and the infiltration feature retrofitting exiting highway improvements. Because ditch infiltration is the most costly to maintain, Alternative 1 has the highest maintenance costs. Alternatives 2 and 3 are less expensive because basins and natural channels are utilized.

5.0 PREFERRED ALTERNATIVE

A summary of alternatives is provided in Table 6 below. Alternatives are described in the above section and shown in Figures 6-8.

Table 6. Alternative Overview

Alternative	Parameter					
	Annual Maintenance Costs	Construction Costs	FSP Relative Load Reduction [lb/yr]	Estimated PLRM Credits	$/lbs FSP*	$/credit**
Alt 1: Ditch Infiltration	$2,460	$374,950	1,936	10	$195	$37,741
Alt 2: Ditch Infiltration with Basins	$1,927	$345,500	2,192	11	$158	$31,584
Alt 3: Channel Restoration	$1,629	$574,800	1,904	10	$303	$57,643

* Costs based on annual construction plus first year maintenance costs and annual load reduction of FSP [lb/yr]

** Costs based on annual construction plus first year maintenance costs and estimated PLRM credit

The scores were assigned to each alternative's evaluation criteria. The results are given below in Table 7. All three criteria were equally weighted and scored on a one to ten scale; ten being the highest, most desirable number and one being the least desirable number.

Table 7. Preferred Alternative Scoring

	Evaluation Criteria			
Alternatives	**PLRM Score**	**Construction Cost Score**	**Maintenance Score**	**Total Score**
Alt 1: Ditch Treatments	4	7	5	**16**
Alt 2: Ditch Treatments with Basins	5	8	6	**19**
Alt 3: Channel Restoration	4	2	8	**14**

Although Alternative 3 provides the most FSP reduction, it scored as the lowest ranked alternative primarily due to the high cost of its implementation. Furthermore, not enough secured funding is currently available to implement this alternative. Alternative 1 scored the second highest because it provided less water quality treatment than Alternative 2 at a slightly higher cost. Alternative 1's projected costs and extents are within the existing construction budget and land ownership, respectively. Alternative 2 is the highest ranked alternative. Alternative 2 ranked highest in both the water quality and construction costs criteria and second place in the maintenance costs. However, an assumption was made for this analysis that the private property needed for Alternative 2 could be acquired at minimal to no cost. If the private property owner is uncooperative, this alternative may not be financially feasible.

NTCD recommends moving forward with Alternative 2 because this alternative maximizes treatment. Once owner cooperation is measured, more accurate costs of Alternative 2 will be established. If additional costs for Alternative 2 are found to be beyond the current construction budget of $385,000, additional funding should be sought or Alternative 1 should be considered the preferred alternative.

6.0 PERMITTING

The Project will require permits from the TRPA, NDOT, and Douglas County.

TRPA EIP PROJECT PERMIT

The Project will require a TRPA EIP Project Review Application and Initial Environmental Checklist. Permit review will occur once the TAC meets and reviews the 90% design plans.

STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

The area of disturbance associated with the implementation of the preferred alternative is expected to be under an acre in size; therefore, a Stormwater Pollution Prevention Plan (SWPPP) may not be necessary. As the Project develops, the total disturbance area will be reassessed to assure SWPPP requirements are met.

NDOT PERMIT

Due to construction within the NDOT right-of-way, the Project will require an NDOT encroachment permit. Permit review will occur once the TAC meets and reviews the 90% design plans.

DOUGLAS COUNTY PERMIT

Due to construction within the Douglas County right-of-way, the Project will require a Douglas County Site Improvement Permit.

7.0 REFERENCES

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APPENDIX A: PRELIMINARY HYDROLOGY (HEC-HMS)

Table A.1 Pittman Terrace Existing Conditions HEC-HMS model input for SCS Method					
Pittman Terrace Catchment Number	**Total Area [Mi^2]**	**Composite Curve Number (CN)**	**Impervious %**	**Lag Time [min]**	*Notes*
PT01	0.004114	64.7	26.19%	8.51	North-most Highway catchment
PT02	0.034188	46.4	1.64%	8.64	Drains to proposed Basin 1
PT03	0.002898	57.5	12.55%	5.62	Drains to proposed Basin 2
PT04	0.003796	55.7	9.05%	5.37	Drains to proposed Basin 3
PT05	0.000662	55.3	12.95%	1.07	Just upstream of Outfall2
PT06	0.545100	38.2	0.67%	14.86	Largest watershed with natural drainage
PT07	0.043445	41.4	6.32%	7.83	Existing Highway Improvements
PT08	0.003869	51.9	5.88%	4.25	Neighborhood Drainage
PT09	0.001817	81.0	26.16%	5.10	No Improvements

Table A.2: HEC-HMS Existing Conditions Results for Outfalls

Outfall. Description	Drainage Area (mi^2)	Frequency Storm	Peak Discharge (cfs)	Volume (ac-ft)
1. North (no improvements)	0.004114	2 year, 24 hour	0.1	0.1
		25 year, 24 hour	0.5	0.3
		50 year, 24 hour	0.7	0.3
		100 year, 24 hour	1.0	0.4
2. Main Drainage	0.586644	2 year, 24 hour	0.1	0.0
		25 year, 24 hour	3.9	2.5
		50 year, 24 hour	6.5	5.2
		100 year, 24 hour	9.8	9.0
3. Neighborhood	0.003869	2 year, 24 hour	0.0	0.0
		25 year, 24 hour	0.1	0.1
		50 year, 24 hour	0.1	0.1
		100 year, 24 hour	0.9	0.2
4. Existing Highway Improvements	0.043445	2 year, 24 hour	0.0	0.0
		25 year, 24 hour	0.4	0.3
		50 year, 24 hour	0.6	0.6
		100 year, 24 hour	0.9	0.9
5. From Cave Rock (no improvements)	0.001817	2 year, 24 hour	0.2	0.1
		25 year, 24 hour	0.7	0.2
		50 year, 24 hour	0.8	0.3
		100 year, 24 hour	1.0	0.3

APPENDIX B: PITTMAN TERRACE PLRM RESULTS MEMORANDUM

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TO: MONICA GRAMMENOS

FROM: DOMI FELLERS

SUBJECT: PITTMAN TERRACE PLRM RESULTS

DATE: 1/22/2017

CC: MEGHAN KELLY

Hydrology catchments and PLRM catchments are different. PLRM does not provide any volume runoff or pollutant loading from forested upland (no development), thus all catchments with only forested upland land use, which is labeled Erosion Potential 1 through 5 in PLRM, were removed from PLRM.

The upper portion of catchments PT6b and PT7b had some of Cave Rock Estates land use (single family residential) included. This land use area was removed from the Pittman Terrace catchments for two reasons: 1) this area is modeled and registered with Douglas County's Cave Rock BMP Registration and 2) this area was deemed not connected to NDOT's Hwy 50 during the 2010 Stormwater Asset Inventory project.

Originally the catchments were divided so that NDOT right-of-way and private parcel land use, above and below Hwy 50, was modeled separately. However, the catchment sizes below Hwy 50 were too small for PLRM to function correctly. Thus, some PLRM catchments have both NDOT right-of-way and private parcel land use, and the catchments are still just under the recommended 1 acre. I am unsure how NDOT will register this project within the Lake Clarity Crediting Program, but we can discuss this issue as the project progresses as the private parcel land use is very minimal.

Seven PLRM scenarios were developed:
1. Existing Conditions
2. Alternative 1
3. Alternative 1 with low infiltration rates
4. Alternative 2
5. Alternative 2 with low infiltration rates
6. Alternative 3
7. Alternative 3 with low infiltration rates

The Existing Conditions scenario provides PLRM results as the catchment conditions are on this day, December 20, 2016. The Alternatives 1, 2 and 3, see Report Figures, provide PLRM results with high infiltration rates of 0.4 inches per hour (in/hr) and 0.5 in/hr, which is the default infiltration rate for infiltration basins and pervious channels respectively. The Alternatives 1, 2 and 3 with low infiltration rates provide PLRM results with slow infiltration rates of 0.1 inches per hour (in/hr) and 0.05 in/hr, which are low infiltration rates for both infiltration basins and pervious channels.

Due to the complexity of the catchments, a mixture of stormwater treatment options within PLRM v2.1 are being utilized, specifically the stormwater treatment (SWT) BMP icons and the distributed facilities. The SWT BMP icons include the BMP treatment features: dry basin, infiltration basin, wet basin, cartridge filter, bed filter and treatment vault. The SWT BMP icons treat stormwater runoff from the entire catchment, meaning they treat stormwater runoff from all land uses pervious and impervious: single family residential, multi-family residential, commercial, roads, trails, ski runs, vegetated turf, etc.

The distributed facilities treat only impervious road stormwater runoff. The distributed facilities are located in Step 5: Road Drainage with two SWT options: draining to infiltration facilities or draining to pervious channels.

Depending on the Alternative analysis, the PLRM load reduction results are a combination of infiltration basins, draining to pervious channels and draining to infiltration facilities.