Appendix A

KINGS BEACH PIER
ALTERNATIVES
2015 CONCEPT PLANS

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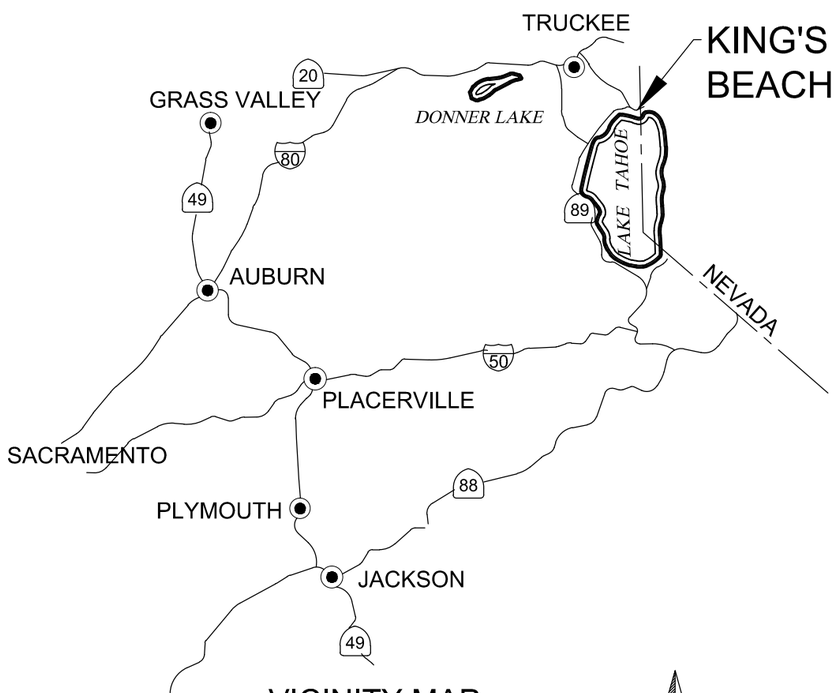
KING'S BEACH PIER FEASIBILITY ASSESSMENT

CONCEPT PLANS

AUGUST, 2015

PLACER COUNTY, CA



VICINITY MAP

N.T.S.

LOCATION MAP

0 5,000 10,000

HORIZONTAL SCALE: 1" = 5,000'

NOTES:

1. LEGAL BUOY LOCATIONS WERE OBTAINED FROM TRPA DATABASE.
2. SHOREZONE TOLERANCE DISTRICT BOUNDARIES WERE OBTAINED FROM TRPA DATABASE.
3. ALL PROPERTY BOUNDARIES WERE OBTAINED FROM CA STATE PARKS
4. BACKSHORE BOUNDARIES WERE DELINEATED USING THE TRPA WAVE RUN UP METHOD.

DATE	REVISIONS	NO.

SEAL: CONCEPT ONLY

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TITLE SHEET

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	TITLE

BACKSHORE DELINEATION

HIGH WATER: 6229.1'

LOW WATER: 6223'

NAVIGATIONAL TARGET: 6217'

EXISTING KINGS BEACH CCIP DRAINAGE SYSTEM 4

CALIFORNIA TAHOE CONSERVANCY

5

1B

EXISTING PIER

EXISTING FOX CLEAN WATER PIPE DRAINAGE SYSTEM

COON

CALIFORNIA TAHOE CONSERVANCY

1B

FUTURE KINGS BEACH CCIP DRAINAGE SYSTEM 6

CALIFORNIA DEPARTMENT OF PARKS AND RECREATION

5

FUTURE BOAT RAMP DRAINAGE SYSTEM

PROPOSED CENTRAL PIER OPTION

PROPOSED EAST PIER OPTION

BOAT RAMP

CALIFORNIA DEPARTMENT OF PARKS AND RECREATION

SHOREZONE TOLERANCE DISTRICT 7

SHOREZONE TOLERANCE DISTRICT 6

LEGEND

- EXISTING MAJOR (5') CONTOUR
- EXISTING MINOR (1') CONTOUR
- PROPERTY BOUNDARY
- BACKSHORE DELINEATION
- SHOREZONE TOLERANCE DISTRICT BOUNDARY
- PRIME FISH HABITAT BOUNDARY
- LAND CAPABILITY LINES
- 1B, 5 LAND CAPABILITY CLASSIFICATION
- EXISTING STORM DRAIN SYSTEM
- PROPOSED/FUTURE STORM DRAIN SYSTEM

NOTES:

1. "PRIME FISH HABITAT", AS DEFINED BY TRPA REGULATIONS, INCLUDES AREAS WITH GRAVEL, COBBLE, AND BOULDER SUBSTRATE THAT MAY BE USED BY NATIVE FISH SPECIES FOR SPAWNING, EGG INCUBATION, FEEDING, AND/OR COVER; VARIATIONS IN SUBSTRATE SIZES, SEASON, AND LAKE LEVEL AFFECT THE ACTUAL UTILIZATION OF HABITAT.

0 60 120

HORIZONTAL SCALE: 1" = 60'

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KING'S BEACH PLAN VIEW

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	

PLAN

SHEET 1 OF 7

Plot Stamp: 10/30/2015 9:04:44 - Peter Bechtold
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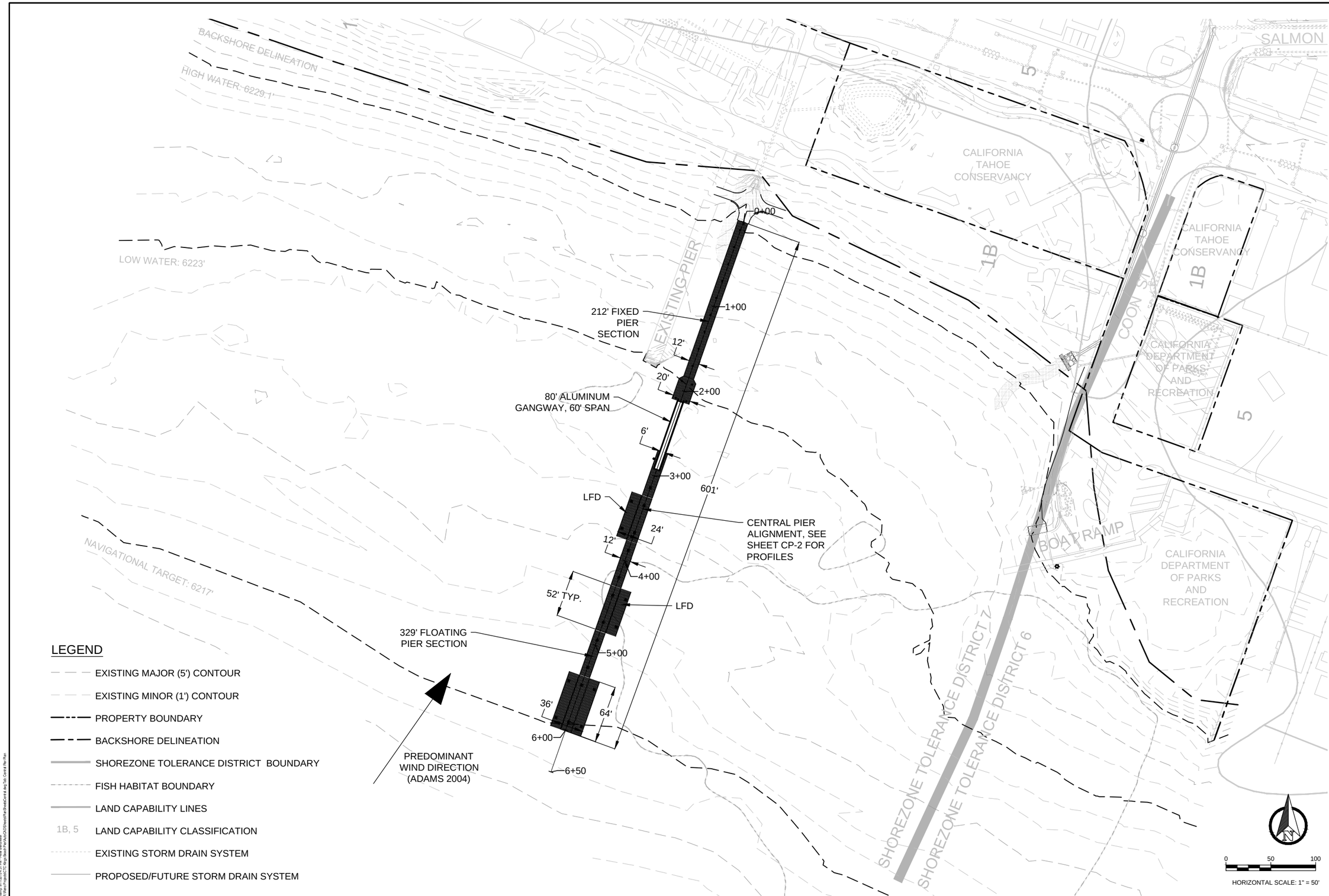

NO.	REVISIONS	DATE

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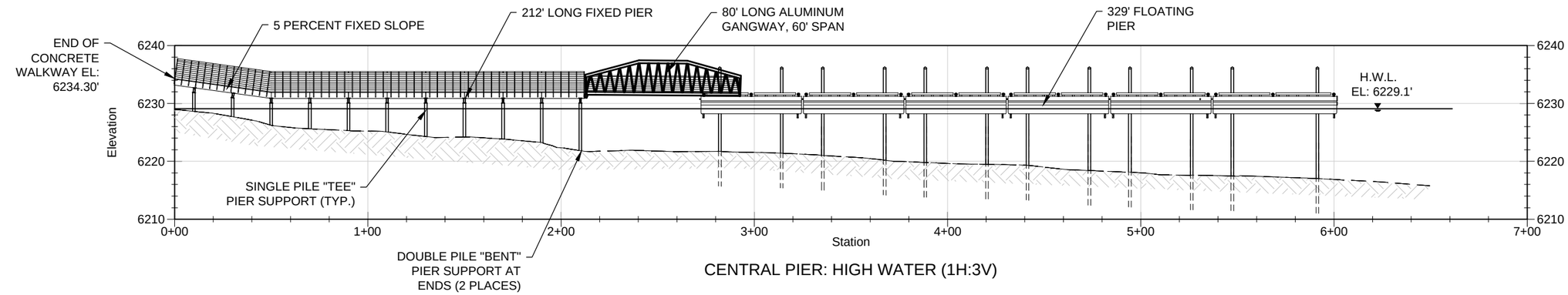
CENTRAL PIER PLAN

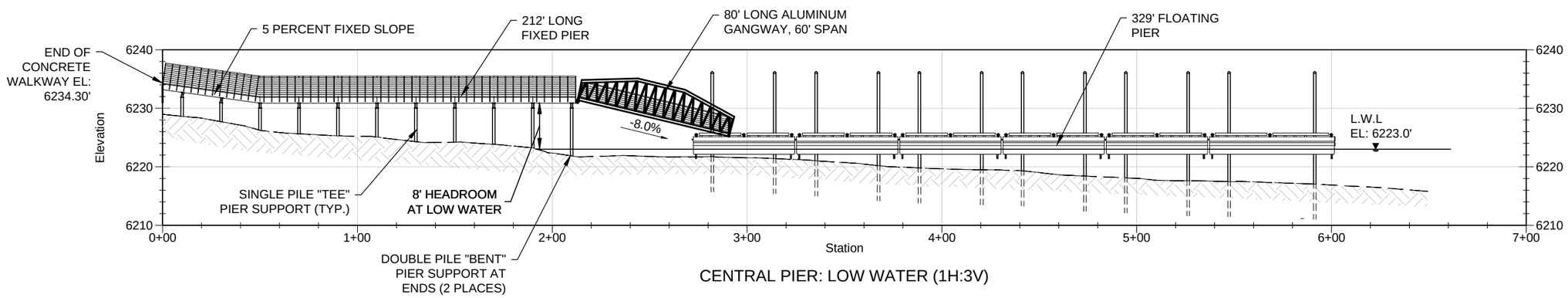
KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

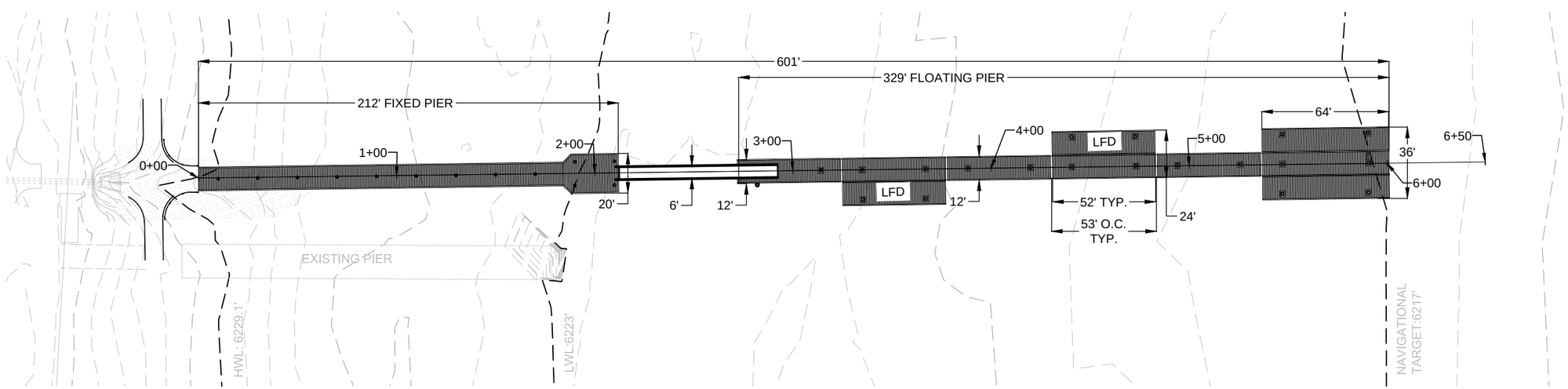
DATE:	AUG 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	CP-1
SHEET 2 OF 7	



CENTRAL PIER: HIGH WATER (1H:3V)



CENTRAL PIER: LOW WATER (1H:3V)



0 30 60

HORIZONTAL SCALE: 1" = 30'
VERTICAL SCALE: 1" = 3'

NO.	REVISIONS	DATE

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CALIFORNIA TAHOE CONSERVANCY

CALIFORNIA STATE PARKS

CENTRAL PIER (PLAN AND PROFILE VIEWS)

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	CP-2
SHEET	3 OF 7

Plot Stamp: 8/17/2015 4:12 PM - Peter Bierbaum
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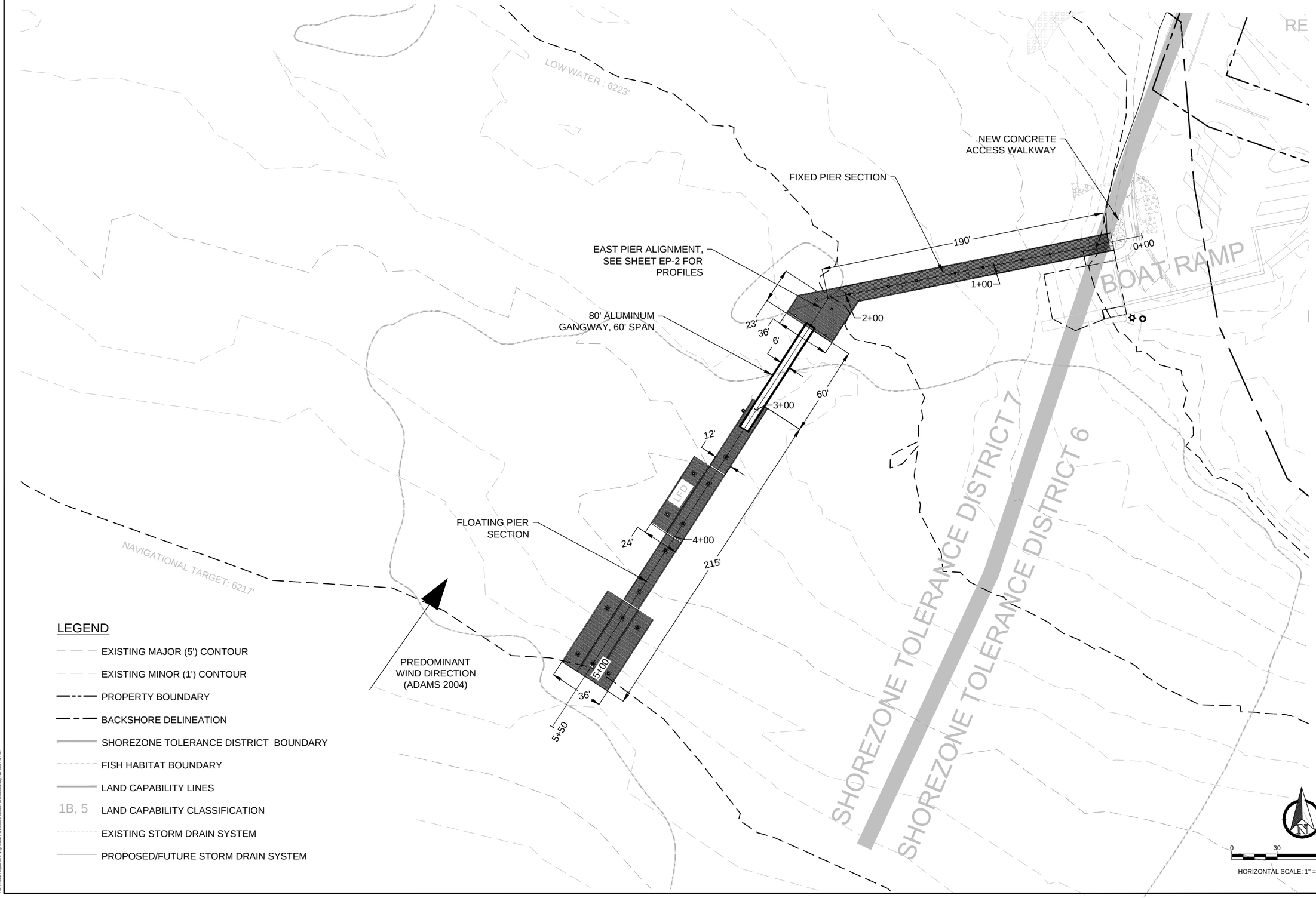

NO.	REVISIONS	DATE

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CALIFORNIA TAHOE CONSERVANCY

EAST PIER PLAN VIEW

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	EP-1
SHEET	4 OF 7

Plot Stamp: 8/12/15 4:02 PM Peter Brandvold
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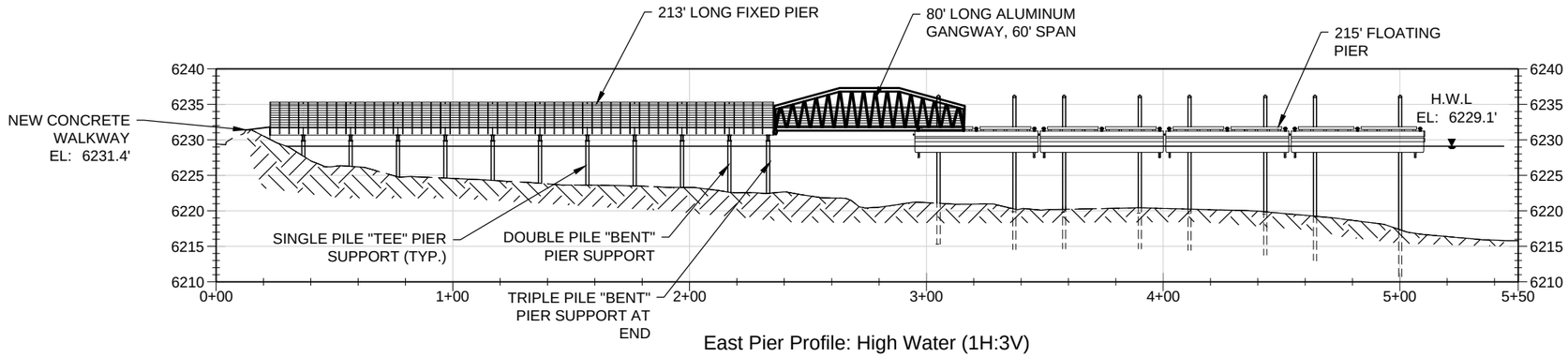
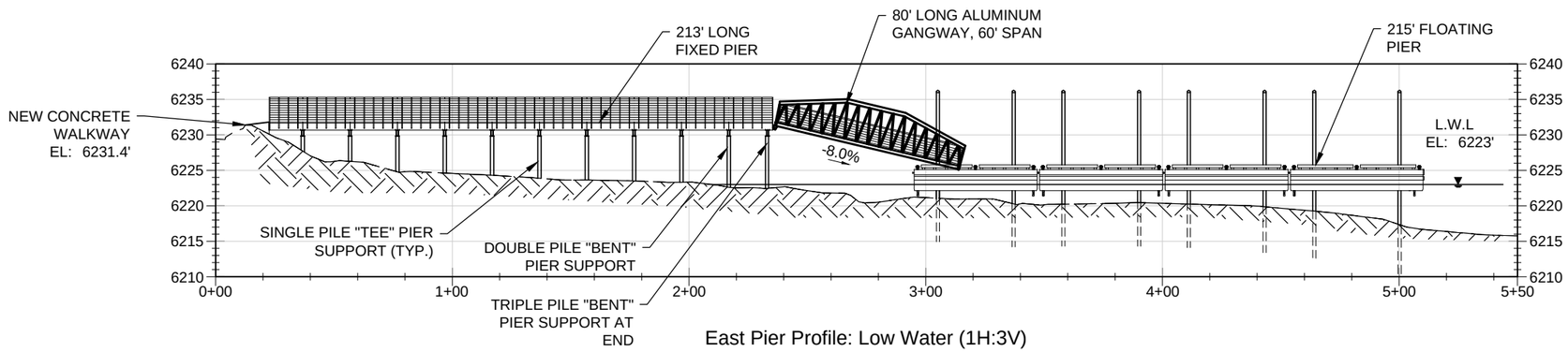
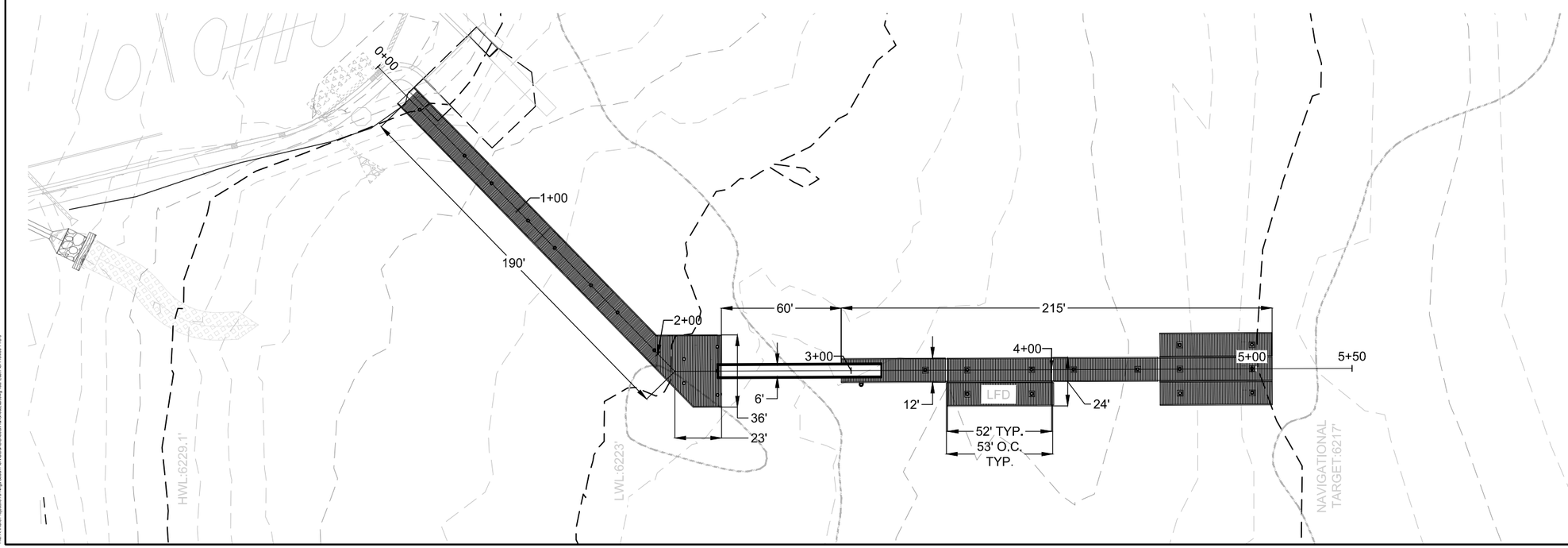
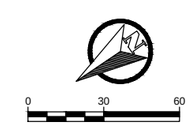


East Pier Profile: High Water (1H:3V)



East Pier Profile: Low Water (1H:3V)





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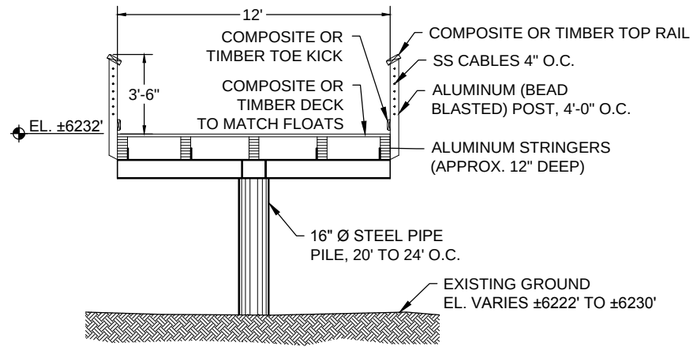
EAST PIER CONCEPT (PROFILE AND PLAN VIEW)

KING'S BEACH PIER FEASIBILITY ASSESSMENT

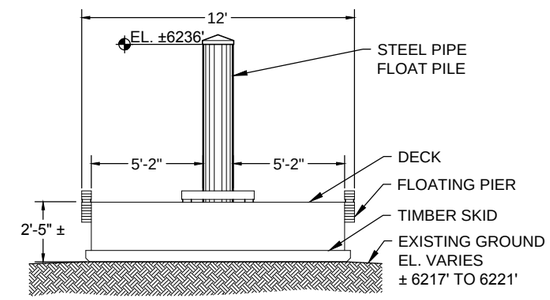
PLACER COUNTY, CA

DATE:	AUG. 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	EP-2

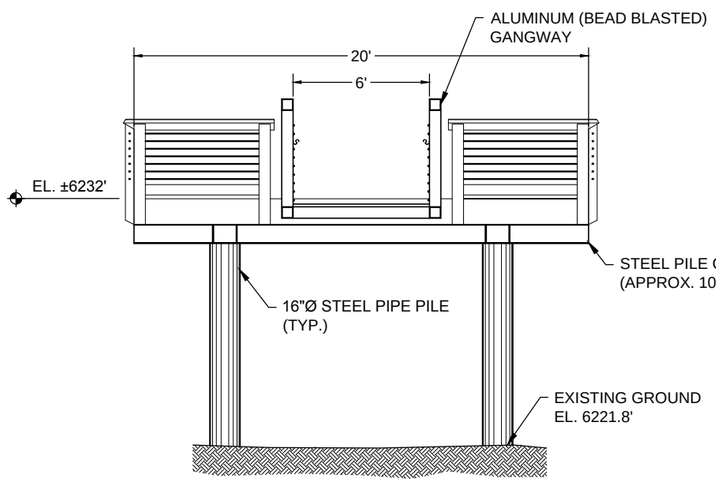
SHEET 5 OF 7



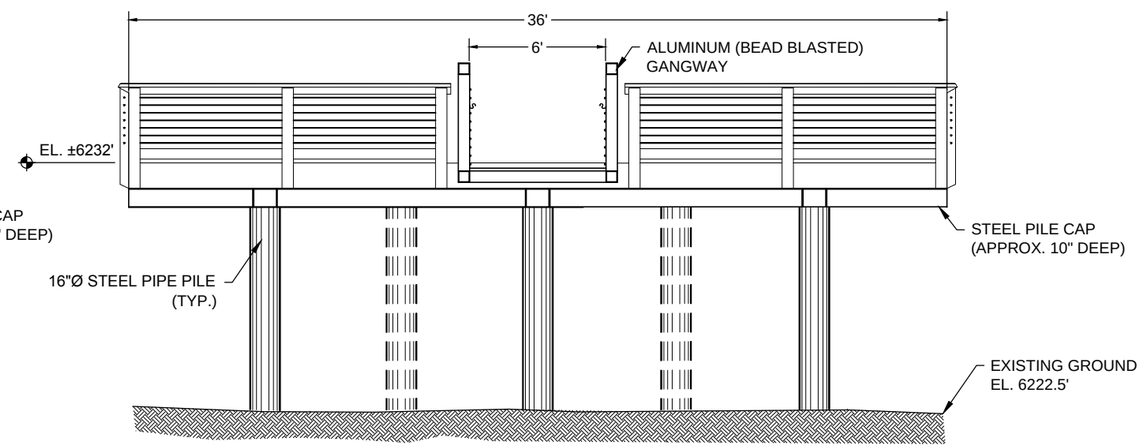
PIER SECTION
AT STEEL SUPPORT



FLOAT SECTION
AT SKID SUPPORT



PIER SECTION
'CENTRAL PIER' END



PIER SECTION
'EAST PIER' END

NOTES:

1. ORIGINAL DESIGN OF PIER SECTIONS AND COMPONENTS OBTAINED FROM TRANSPAC MARINAS INC. THE DESIGN PRESENTED HEREIN IS AS MODIFIED PER CALIFORNIA STATE PARKS REQUIREMENTS.

0 40 80
HORIZONTAL SCALE: 1" = 40'

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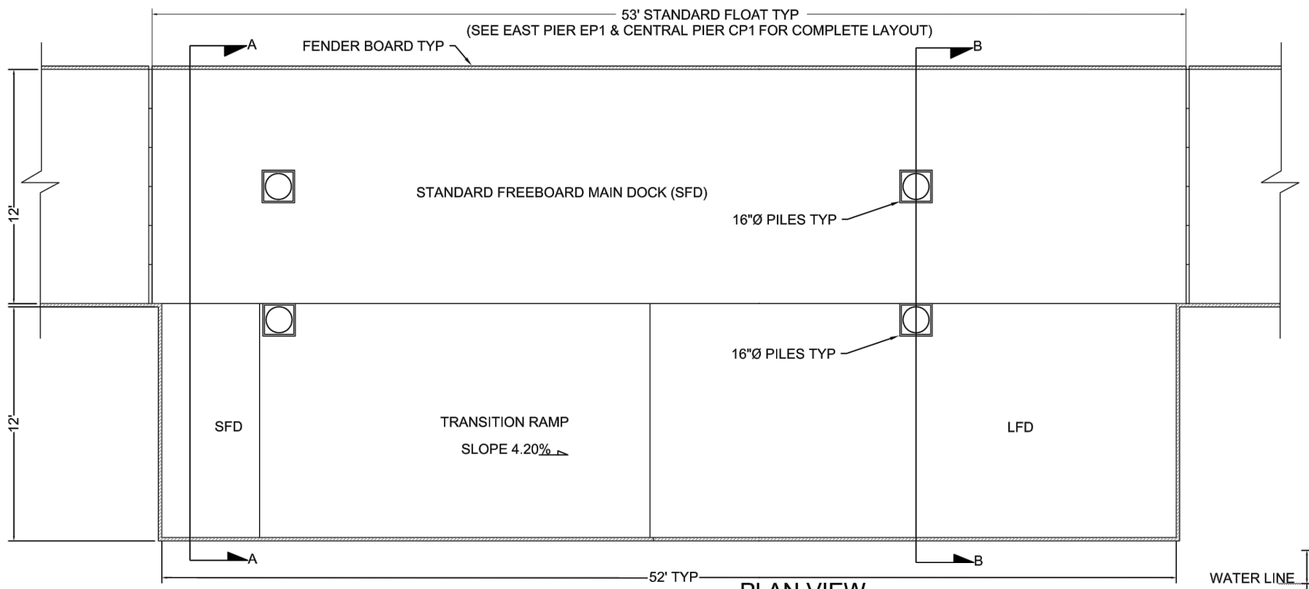
PIER SECTION VIEWS
KING'S BEACH PIER FEASIBILITY ASSESSMENT
PLACER COUNTY, CA

DATE:	AUG. 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	D-1
SHEET 6 OF 7	

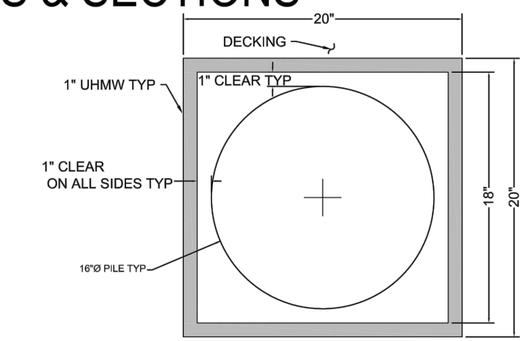
KING'S BEACH PIER PRELIMINARY PLANNING DETAILS & SECTIONS

PLACER COUNTY CALIFORNIA

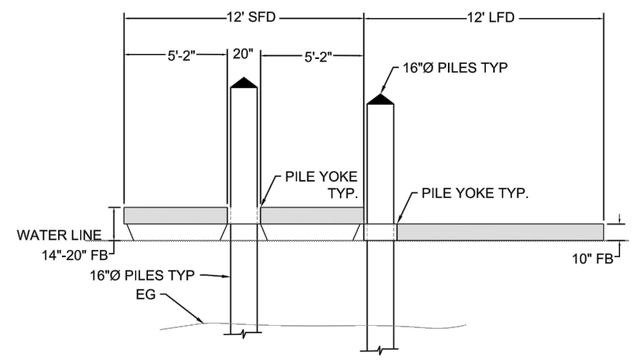
SEPTEMBER 02, 2015



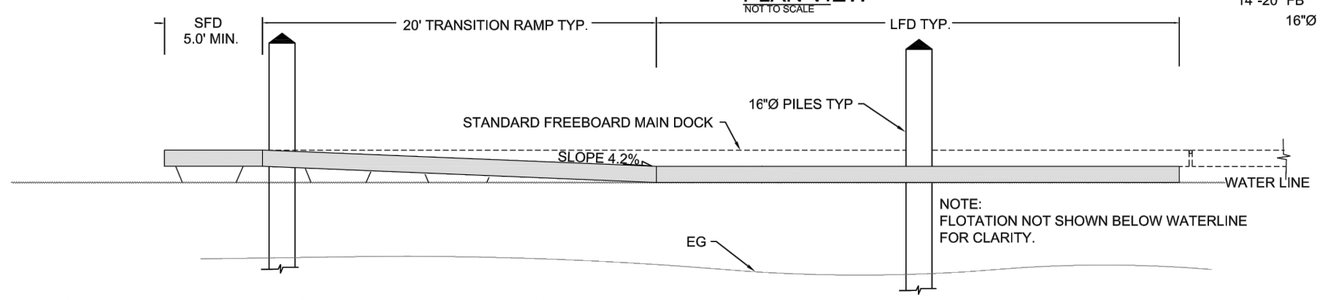
PLAN VIEW
NOT TO SCALE



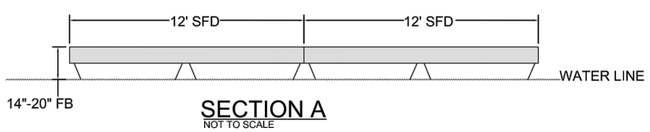
PILE YOKE DETAIL
NOT TO SCALE



SECTION B
NOT TO SCALE



PROFILE VIEW
NOT TO SCALE



SECTION A
NOT TO SCALE

DESIGN NOTES

FREEBOARD REQUIREMENTS PER DIVISION OF BOATING AND WATERWAYS GUIDELINES:
10" FOR LOW FREEBOARD FLOAT
14"-20" FOR STANDARD FLOAT

TRANSITION RAMP CALCULATIONS:

MAX DESIGN SLOPE 4.165%
DELTA = 20" STANDARD FREEBOARD - 10" LOW FREE BOARD
= 10" DELTA (.833')
TRANSITION RAMP LENGTH = DELTA/SLOPE = 0.833/.04165 = 20'

NOTES:
1. LFD DETAIL PROVIDED BY CALIFORNIA STATE PARKS

NO.	REVISIONS	DATE

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LOW FREEBOARD DOCK DETAILS

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	D-2
SHEET 7 OF 7	

Appendix B

KINGS BEACH STATE RECREATION AREA PRIME FISH HABITAT 2015 SURVEY MEMO

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Kings Beach Pier Feasibility Analysis – Prime Fish Habitat Survey

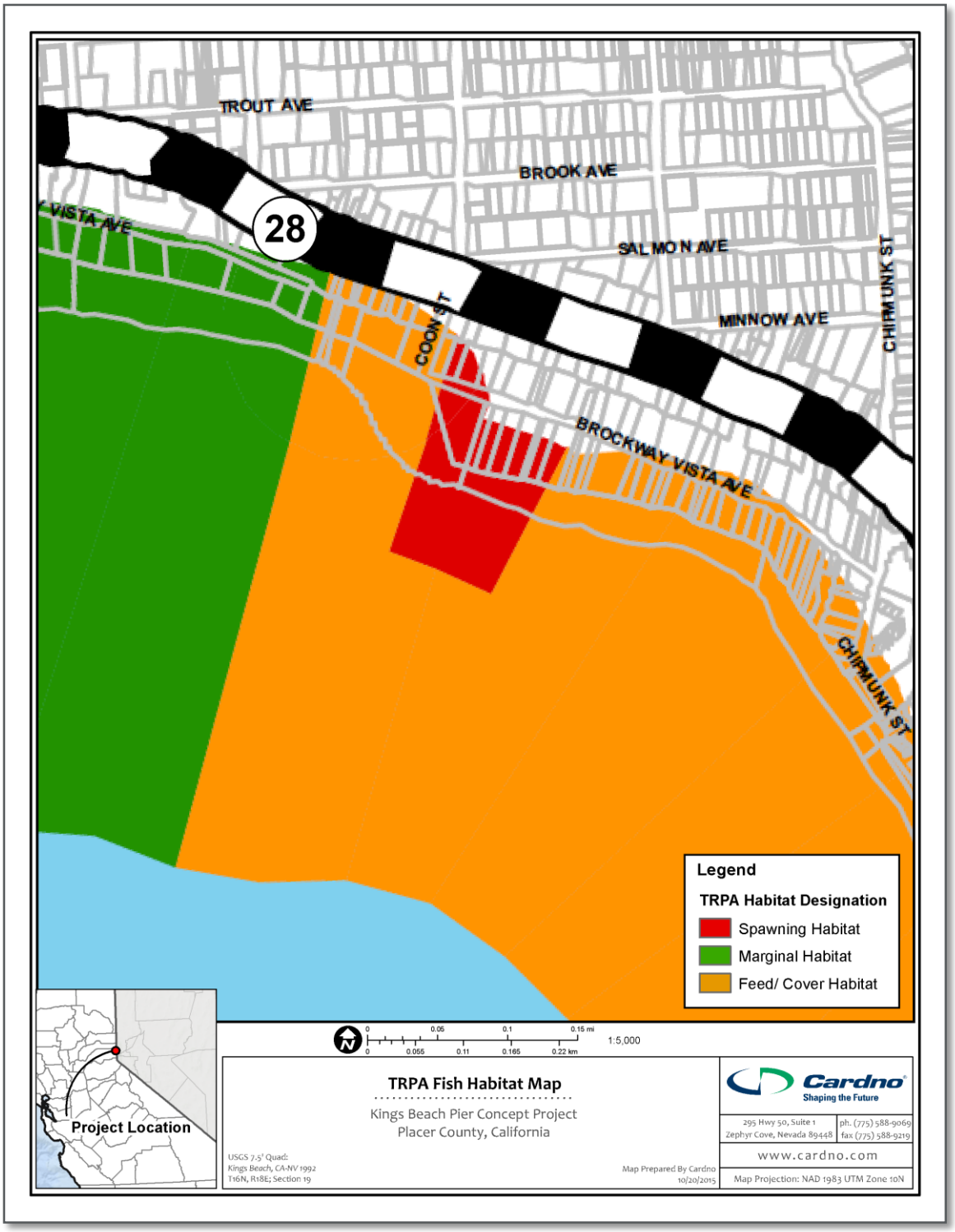
On February 13, 2015 a survey of fish habitat in the Kings Beach Pier proposed project area was conducted. Prior to the survey, a review of the 2009 TRPA Prime Fish Habitat map had indicated that 'Feed/Cover' and 'Spawning' habitats had been identified on the eastern side of the project area. The western side of the project area had been designated as 'Marginal' fish habitat. TRPA regulations (TRPA Code of Regulations 63.3.1) protect 'prime fish habitat' in the nearshore areas of Lake Tahoe. Prime fish habitat, including spawning habitat and feed/cover habitat, is indicated in the project area on the TRPA Prime Fish Habitat Map (Figure B-1) (TRPA 2009). Prime fish habitat areas protected by TRPA regulations consist of areas of gravel (2-64 mm), cobble (64-256 mm), and boulder (>256 mm) substrate used by native fish species such as Lahontan redsides (Richardsonius egregius), Tui chub (Gila bicolor), Tahoe sucker (Catostomus tahoensis), and Paiute sculpin (Cottus beldingi) for spawning, egg incubation, feeding, and cover. TRPA regulations require that destruction or impairment of Prime Fish Habitat to be mitigated at a 1:1.5 ratio. The Lahontan Regional Water Quality Control Board (LRWQCB) Basin Plan Discharge Prohibition #4 (Chapter 5.2) prohibits new pier construction in significant spawning habitats. An exemption to this prohibition is available for relocation of disturbance by existing piers (exemption d).

Survey Methods

The prime fish habitat survey was conducted using a Trimble® sub-meter GPS to map areas dominated by gravel, cobble, and boulders within the proposed project area (see attached photos at the end of this memo, Photo B-1). A fisheries biologist waded and snorkeled along the outer edge of habitat features occurring from the high water line out past the lake bed elevation of 6215 feet. Features were mapped east to the property line representing the boundary of the proposed project area and west past the existing pier into the area designated marginal habitat on the 2009 TRPA Prime Fish Habitat Map. Prime fish habitat extending east past the property line was not mapped. Three substrate photographs were taken along the western side of the main fish habitat feature (Photos B-2, B-3, B-4). Each photograph shows patches of substrate including gravel, cobble, and boulders that are representative of the overall substrate composition of prime fish habitat within the proposed project area. The photographs included a 6 inch (15 cm) ruler to indicate the substrate size composition of the habitat feature.

Prime Fish Habitat Mapping Results

The resulting 'Fish Habitat Map' shows a single major 'prime' fish habitat feature dominating the eastern side of the proposed project area. Much of this feature was not submerged due to low lake surface elevation at the time of the survey. The western side of the proposed project area consists of 'marginal' habitat dominated by sand (Photo B-1). According to the 2009 TRPA Prime Fish Habitat Map (Figure B-1), the large habitat feature on the eastern side of the proposed project area consists of both 'Spawning' and 'Feed/Cover' habitat. TRPA regulation define Prime Fish Habitat types based on the map delineations (TRPA 2009). Only the 4.64 acre portion with gravel or coarser substrate is identified as the 'prime fish habitat' represented at a courser resolution in the TRPA map (Figure B-2). The majority of the prime habitat zone is considered 'Feed/Cover' habitat, while the north-eastern edge of the prime habitat is considered 'Spawning' habitat (see Figure B-2, Figure B-3). Substrate composition is largely similar throughout the feature except for higher sand coverage and embeddedness on the western side of the feature compared to the eastern side.



Source: TRPA, 2001

Figure B-1 TRPA Designated 'Prime Fish Habitat' in the KBSRA

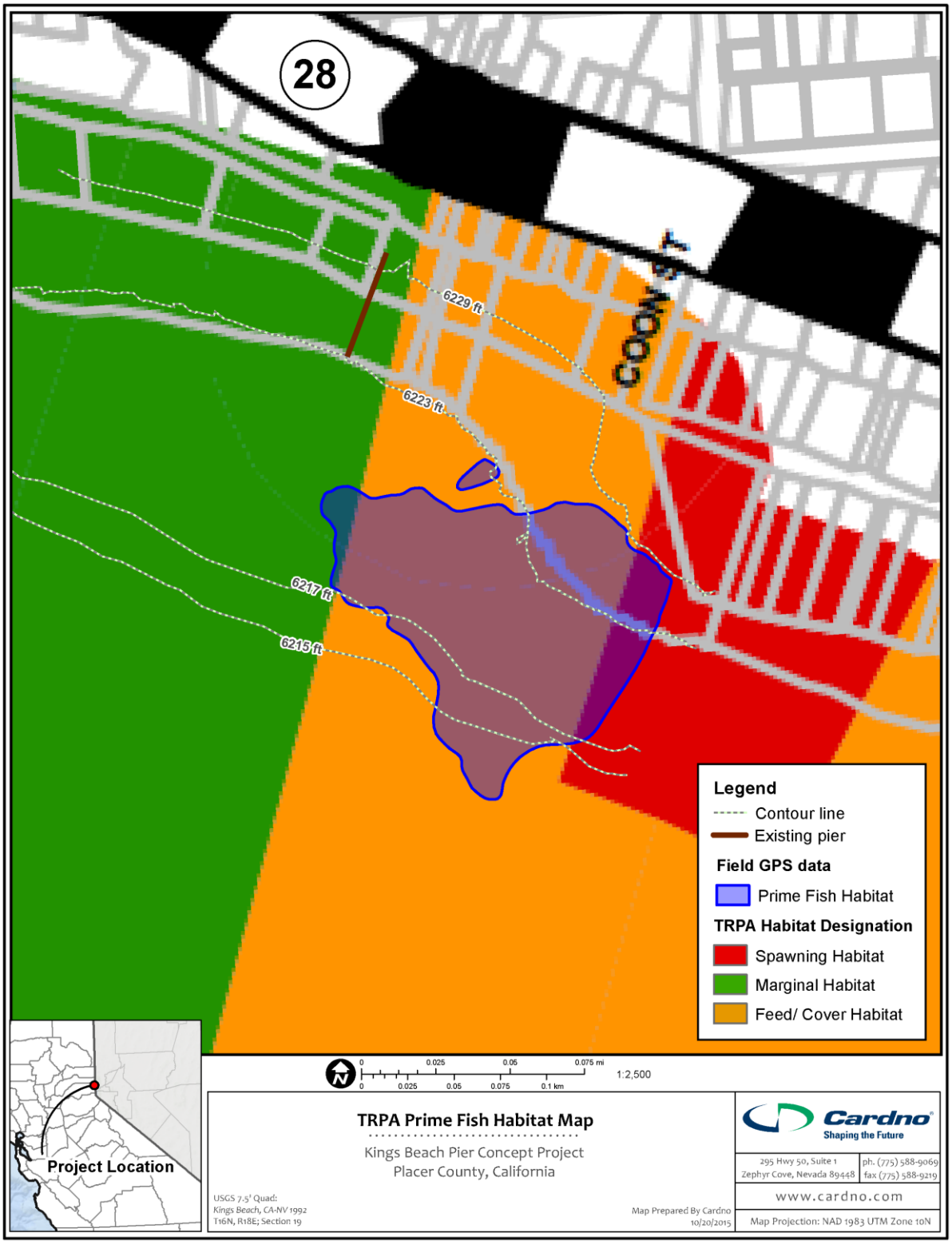
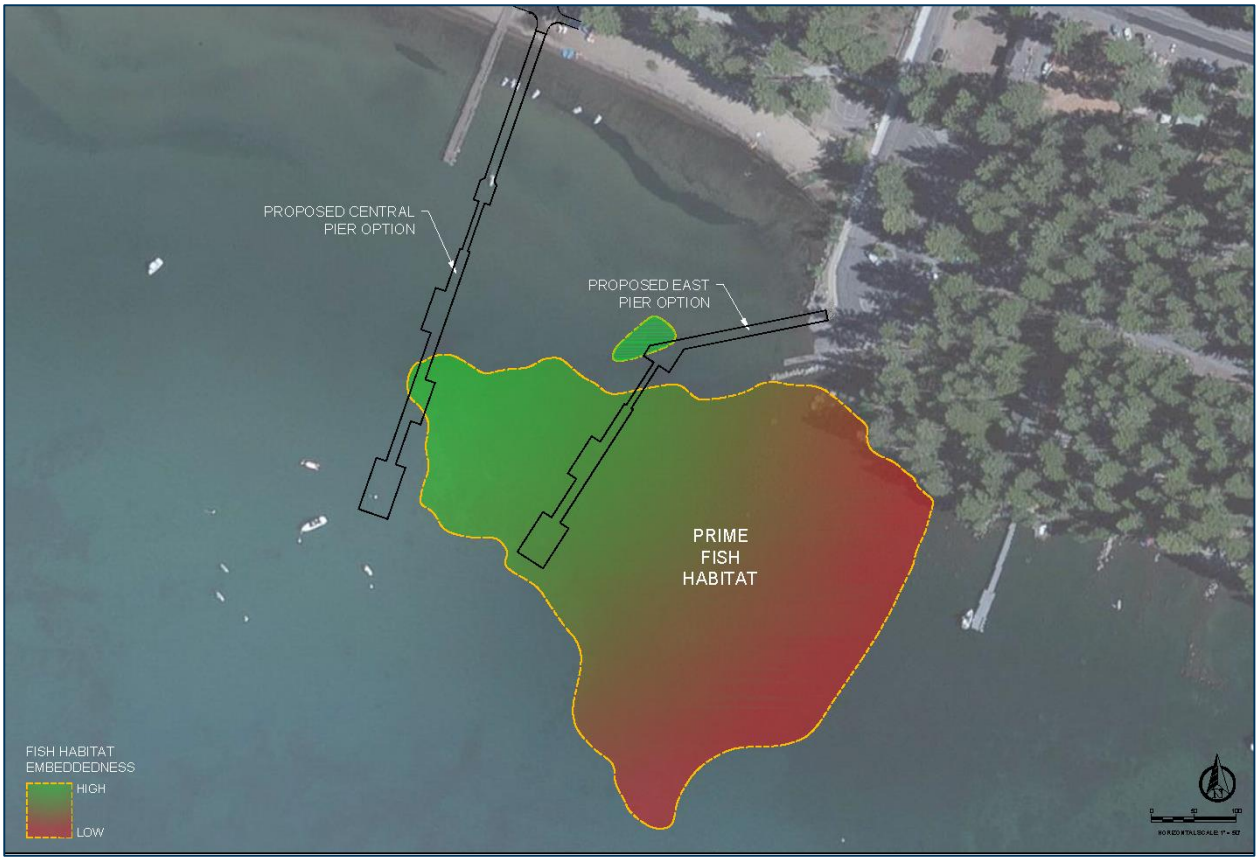


Figure B-2 Existing Fish Habitat in the KBSRA overlain on the TRPA Designated "Prime Fish Habitat" in the Vicinity



Source: Cardno, 2015

Figure B-3 Existing Prime Fish Habitat and Embeddedness in the KBSRA

Discussion

The 2001 study of the Project vicinity (Harding ESE 2001) noted an area suitable for fish spawning consisting of large substrates near and east of the boat launch facility. The 2001 report described the remainder of the study area as predominantly sand and silt substrate (<2mm diameter) that is unsuitable for spawning.

Actual utilization of the prime habitat zone for spawning, feeding, and cover varies with fish species, season, and lake level (Beauchamp et al. 1994, Moyle 2002). In general, larger substrates such as cobble and boulder present the best spaces for use as cover while gravels offer the best habitat for spawning and egg incubation (Moyle 2002, Evans 1969). However, substrate embeddedness, which is the degree to which gravel and cobble are 'embedded' in sand, also effects suitability as spawning habitat. Highly embedded substrates are less suitable for the incubation of eggs (Moyle 2002). The western portion of the identified prime habitat zone is highly embedded and the degree of embeddedness decreases gradually eastward (Figure B-3). This also supports the conclusion that high quality spawning habitat is restricted to the east edge of the site, along the KBSRA boundary.

In general the potential direct and indirect impacts of pier structures on fish habitat include: destruction of habitat due to piling placement; reduction of algal periphyton growth due to shading; disruption of migration to spawning habitat; and, degradation of substrate quality due to changes in erosion and sedimentation (littoral drift).

The existing pier is located entirely over sandy substrate and does not overlap any Prime Fish Habitat. The central pier location option lies dominantly over sandy substrate, but overlaps approximately 1,023 square feet (0.02 acres) of prime fish habitat (of highly embedded substrate suited for feeding/cover). The east pier location option intersects approximately 4,930 square feet (0.11 acres) of prime fish habitat (of high to moderately embedded substrate suited for feeding/cover). Shading and reduced periphyton growth on substrates used for feeding and cover in these areas could result (Kahler et al. 2000, Peterlin & Urbanič 2013). The area of prime fish habitat that would be shaded would be roughly the area overlapping with the structure. Grated pier deck surfaces that allow light to penetrate under the pier can be used to mitigate this impact (Gayaldo & Nelson 2006).

Direct displacement of feed/cover prime fish habitat would be required for approximately 4 pilings at the central location option or approximately 16 pilings at the east location option (Figure B-3). Neither pier option would overlie or directly impact spawning habitat.

There are some areas near the boat launch and along the east shoreline within the KBSRA that are modelled to experience minor (10-20%) wave height reduction under existing conditions (see main report and Appendix C for wind, wave and littoral drift information). However, these are primarily outside of areas identified as prime fish habitat. The central pier location is modelled to result in minor wave height reduction under the floating section, on either side of the fixed section, and along the shoreline. The east pier location is modelled to result in minor wave height reduction under the floating section, under and around the fixed section, and extending to a portion of the shoreline. The degree of wave height reduction is minor for either optional pier location, and not expected to have a substantive effect on littoral drift. Local modifications in sand and smaller substrate distributions could result, and be expressed by a change in the shoreline configuration and creation of a salient formation at the base of each pier option. A salient formation would occur in marginal habitat under the central pier alternative and occur near the boat ramp under the east pier alternative. A salient formation could potentially impact small areas of feed/cover habitat under the east pier alternative.

Under either location alternative, fish may utilize the proposed dock's floating section as cover. Tahoe fishes sometimes use overwater structures as cover, especially at high lake levels (Beauchamp et al. 1994). The floating sections would provide greater cover than most existing overwater structures. It is unlikely this impact would lead to any significant changes in local fish community. Juvenile fishes may also be attracted to pier lighting at night (Kahler et al. 2000). These behavioral impacts would not affect or mitigate any other impacts to prime fish habitat. TRPA regulations do not address impacts that may cause changes in fish behavior.

Substrate Photos:

Photo B-1: Facing east from the existing pier showing 'marginal' fish habitat dominated by sand in the foreground and 'prime' fish habitat in the background consisting of a rocky point and associated large substrate extending southwest from the shoreline.

Photo B-2: Substrate composition representative of 'prime' fish habitat within the proposed project area.

Photo B-3: Substrate composition representative of 'prime' fish habitat within the proposed project area.

Photo B-4: Substrate composition representative of 'prime' fish habitat within the proposed project area.

References Cited

Beauchamp, D. A., Byron, E. R., & Wurtsbaugh, W. A. (1994). Summer habitat use by littoral-zone fishes in Lake Tahoe and the effects of shoreline structures. North American Journal of Fisheries Management, 14(2), 385-394.

Evans, D. H. 1969. Life history studies of the Lahontan redside, Richardsonius egregius in Lake Tahoe.California Fish and Game, 55, 197-212.

Gayaldo, P. F., & Nelson, K. (2006). Preliminary results of light transmission under residential piers in Lake Washington, King County, Washington: A comparison between prisms and grating. Lake and Reservoir Management, 22(3), 245-249.

Harding ESE 2001. Biological Resources Inventory Report: Kings Beach Pier Project Placer County, California. Prepared for California Tahoe Conservancy (November 1, 2001).

Kahler, T., Grassley, M., & Beauchamp, D. (2000). A summary of the effects of bulkheads, piers, and other artificial structures and shorezone development on ESA-listed salmonids in lakes. Final Report prepared for the City of Bellevue.

Moyle, P. B. 2002.Inland fishes of California. Univ of California Press.

Peterlin, M., & Urbanič, G. (2013). A Lakeshore Modification Index and its association with benthic invertebrates in alpine lakes. Ecohydrology, 6(2), 297-311.

Picciani, J. and Burnside, L. 2001. Biological Resources Inventory Report: Kings Beach Pier Project, Placer County, CA. Prepared for the California Tahoe Conservancy. 48 pp.

Tahoe Regional Planning Agency (TRPA). 2009. Prime Fish Habitat Map. *Available at* www.trpa.org/wp-content/uploads/Fishhab_map.pdf

Tahoe Regional Planning Agency (TRPA). 2012 Tahoe Regional Plan Code of Ordinances, Shorezone, Chapters 80-86. http://www.trpa.org/documents/reisc/5_Comment%20References/CA_Department%20of%20Justice_references/TRPA%20Code%20of%20Ordinances.pdf

Appendix C

WIND WAVE AND LITTORAL DRIFT ANALYSIS

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Kings Beach Pier Concept Project
Wind Wave and Littoral Drift Analysis

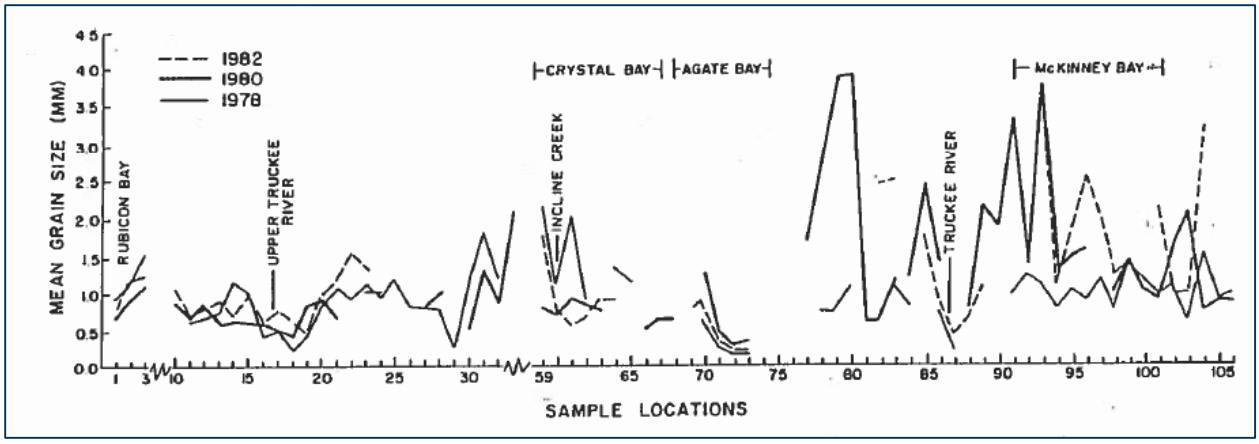
As part of the 2015 assessment of wind, wave, and littoral drift issues for the Kings Beach Pier Concept Alternatives Analysis, Cardno conducted extensive literature review regarding the prior study methods and results (PIE 2001), updated data sets regarding conditions at Lake Tahoe, changes in the regulatory context and requirements for design and potential impact analyses, and performed new calculations and numerical modeling for the Kings Beach State Recreation Area (KBSRA). This Appendix to the Comparative Alternatives Analysis Report provides our compiled background materials and details of the methods and results to supplement the key information summarized within the body of the main report.

Beach morphodynamics (i.e., shapes, forms, and processes) are controlled by an array of factors including the materials present at the water-beach interface and the geometry of the beach and shoreline. In addition, the prevailing wind directions and speeds are particularly important as they ultimately control wave heights, frequencies and angle of approach to the shoreline. With these factors in mind, a literature search was carried out to document the variables that could impact the feasibility of proposed pier conceptual designs and the central and east location options for the KBSRA.

Geologic Materials and Topography

The geologic history and structure of Lake Tahoe, and the geomorphic processes acting on it have shaped the overall basin and size, including the materials forming the lake bed at depth as well as the various materials comprising the shoreline. Along the north shore, including the section at Kings Beach the upland slopes and ridges are largely volcanic rocks, with alluvial and lake (lacustrine) deposits along the shoreline (Adams et al. 2004).

Kings Beach is located within Agate Bay, and is exposed to the longest fetch across Lake Tahoe (22 miles from the SW). The beach materials were shown in a study by Adams and Others (2004) to be completely dominated by sand size fractions (Table C-1). Materials with high sand content are easily mobilized, so this is of importance to the analysis of the feasibility of either pier location at Kings Beach. In addition, Osborne et al. (1985) reported analysis of foreshore sediments from all around Lake Tahoe, sampled in 1978, 1980, and 1982. Mean grain size in Agate Bay, particularly the area near Kings Beach, was small compared to most locations, between 0.3 and 0.8 mm (Figure C-1). Median particle sizes from the two stations in Agate Bay (locations 71 and 72) were in the medium and coarse sand fractions, respectively. In addition, the nearshore lakebed sediment sampled by Reardon and others 2014 indicated well-sorted, non-cohesive materials with no apparent bedforms present in the vicinity.



Source Osborne and Others, 1985

Figure C-1 Mean Particle Size for Beach Materials around Lake Tahoe

Table C-1. Mean Particle Sizes for Beach Materials at Kings Beach

Kings Beach	Kings Beach 5	10	756882	4346986	99.9	0.1	NA
Kings Beach	Kings Beach 6	10	756832	4347008	99.5	0.5	NA
Kings Beach	Kings Beach 7	10	756788	4347005	100.0	0.0	NA
Lake Forest	LF-1	10	749414	4340749	69.5	17.4	13.0

Source Osborne and Others, 1985

Despite the dominance of fine grained, non-cohesive sediments that could be subject to erosion and transport, a review of historic data (1939 to 2001) by Adams and Minor (2002) indicated that Kings Beach had an annual average sediment loss of just 39 cubic yards (CY) of sediment. This is low compared to other beaches around the lake. This study found that shoreline changes over the 60 year study period were discontinuous in space and included both accretion and erosion (all in areas of alluvium or older lacustrine deposits). Sediment calculations from Adams and Minor (2002) for areas exhibiting net erosion over the 60 year study period are shown below in Table C-2, and highlight the point that the erosion volumes for Kings Beach are amongst the lowest around the lake. The total mass of eroded sediment over the 60 year period studied was about 429,000 MT, approximately 92% of which was sand size particles. It should be noted, however, that estimates of active erosion around the lake vary widely, in part due to different study periods and assessment methods. Orme (1973) reported that 16.3% of Lake Tahoe shoreline is actively eroding, whereas Reuter and Miller (2000) estimated that 55% is actively eroding, and Adams and Others (2004) concluded that 67 % or more of the shoreline may have experienced erosion since the late 1800's (concentrated in wave-cut backshore terraces and steeper backshore slopes.

Table C-2. Lake Tahoe Shoreline Sediment Estimates for the1939 to 2001 Period

Location	Material type	Area (m^2)	Thickness (m)	Volume (m^3)	Mass (kg)
Nevada Beach-Stateline	old granitic beach sand	21,898	1	21,898	32,847,000
Stateline	old granitic beach sand	361	1	361	541,500
Bijou Park	old granitic beach sand	11,644	1	11,644	17,466,000
Al Tahoe-Regan Beach	old granitic beach sand	11,275	6	67,650	101,475,000
Upper Truckee River	granitic beach sand	31,643	1	31,643	47,464,500
Tahoe Keys	old granitic beach sand	1234	1	1234	1,851,000
Kiva Beach-Camp Richardson	old granitic beach sand	10,272	2	20,544	30,816,000
Baldwin Beach	old granitic beach sand	13,600	1	13,600	20,400,000
SE shore of Emerald Bay	glacial till	15,544	2	31,088	46,632,000
Emerald Bay-Vikingsholm	glacial till	8304	1	8304	12,456,000
Meeks Bay	old granitic beach sand	6996	1	6996	10,494,000
Sugar Pine Point	old granitic beach sand	4008	3	12,024	18,036,000
Homewood	volcanic beach sand	18,813	1	18,813	28,219,500
Tahoe Tavern	volcanic beach sand	9545	1	9545	14,317,500
Lake Forest	gravelly silt	1962	1	1962	2,943,000
Carnelian Bay	volcanic beach sand	8160	1	8160	12,240,000
Agate Bay	volcanic beach sand	4562	2	9124	13,686,000
Tahoe Vista	volcanic beach sand	3449	1	3449	5,173,500
Brockway	old granitic beach sand	1190	1	1190	1,785,000
Kings Beach-west side	volcanic beach sand	728	1	728	1,092,000
Kings Beach-east side	volcanic beach sand	903	2	1806	2,709,000
Glenbrook	old granitic beach sand	4471	1	4471	6,706,500
	TOTALS =	190562		28,6234	429,351,000

Source: Adams and Minor (2002)

The reason for the low erosion rate at Kings Beach lies in the configuration of the beach, which has a large, roughly triangular shaped shallow shelf that is and relatively flat (i.e. slopes to the south at an angle of about three (3) degrees). Waves breaking on shallow beaches tend to be spilling breakers rather than the plunging or surging breakers. On steeper beaches, plunging and surging breakers are associated with more energy and erosive power. As waves approach the lake shore, enter shallows and interact with bottom, the waves transform: their velocity and length decrease, and their height increases, but the wave period is constant. These waves break when they are over steepened, which occurs more frequently on steep versus shallow beaches (Figure C-2).

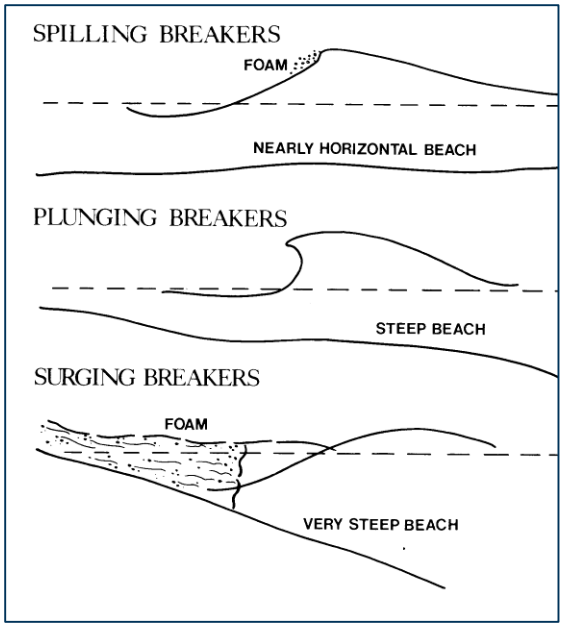


Figure C-2. Illustration of the Difference in Wave Breaking with Varied Beach Slope

Waves generated in the lake (deep water) are modified as they interact with the lake bed configuration in the nearshore; areas with wide, low angle shelves are exposed to less energy in the foreshore (e.g., at Tahoe City and to some degree, Kings Beach) than those that have steep slopes (e.g., north of Emerald Bay on west shore). The lakebed configuration of Kings Beach, therefore reduces immediate loss of beach sediment by modifying the incident wave field, thereby preventing deep water waves from reaching the shoreline, especially during low lake stands. Additionally, the offshore bathymetry at Kings Beach tends to bend the waves so their approach is nearly normal to shore over a substantial percent of time, which may contribute to the low volume of sediment transported laterally along the beach.

However, the geologic composition of materials, and the plan or map view of the shoreline also controls and reflects the net erosion. For example, bays or embayments in the map view of a shoreline configuration represent net erosion areas over geologic time frames, but the net erosion may have occurred during different water depths and therefore, under different wave generation and transformation conditions.

WIND-WAVES

Waves are periodic oscillations of the water surface. Natural wind-generated waves on an open water surface are composed of different wave groups, each with own height, period, and velocity. The formation and action of wind-waves is the primary beach erosion process at Kings Beach. Five factors influence the formation of these wind waves:

1. Wind speed
2. The uninterrupted distance of open water over which the wind blows without significant change in direction (called the fetch)
3. Width of the area affected by fetch
4. Wind duration - the time over which the wind blows across the fetch
5. Water depth

All of these factors work together to determine the following characteristics of the resulting wind waves:

1. Wave height (from trough to crest)
2. Wave length (from crest to crest)
3. Wave period (time interval between arrival of consecutive crests at a stationary point)
4. Wave propagation direction (compass angle of wind origin)

As such, it is important to understand the dominant wind speeds, directions and durations acting across the fetch for Kings Beach. The climate of Lake Tahoe is strongly affected by its regional alignment relative to large air masses and storm movements off the eastern Pacific Ocean, position at the crest of the Sierra Nevada, topography of the basin slopes, and the surface expanse and volume of stored water (Adams et al. 2004).

Until the early 2000's limited quantitative data was available concerning winds in the Lake Tahoe basin and how they affect wave generation. Adams (2004) provided a good summary of data available as of that date, including:

> Western Regional Climate Center (WRCC) data at Lake Tahoe Airport from 1992
> Wind velocity and direction recorded by TRPA from 1965 through 1967 at Lake Tahoe Airport
> Wind statistics reported by the US Coastguard Station at Tahoe City from January 1967 to September 1969
> Air Resource Specialists INC (ARS) collected data from three sites near Lake Tahoe including Bliss State Park, Thunderbird Lodge, and South Lake Tahoe Blvd

The study by Adams (2004) notes that two other studies regarding wind conditions at Lake Tahoe. First, a study by Mulberg (1984) that delineates seasonal wind patterns, and a guidebook article by Moory and Osborne (1984) that references the Mulberg study, and wind data from eight locations along the shore of Lake Tahoe. The data from both of these references, has however, not been found or made publicly available. Historic wind data from the Lake Tahoe basin is thus available for only a few locations and sporadic periods prior to the 1990s, and published wind data aside from summary figures and generalizations about the dominance of south or southwesterly winds are rare.

Additional wind data were downloaded by Cardno in 2015 for this study: buoy data from several mid lake sites: and monthly, annual wind rose data for mean and max winds at South Lake Tahoe airport (the longest fetch site (see Figures C-3a to C-3l), as well as at Homewood, Tahoe City (including the USCG), Tahoe Vista, and Incline Village. These data were reviewed to describe wind climate statistics in comparison to the wind statistics used in the prior study (Figure C-4).

South LT/Lake Tahoe AP Calif
January

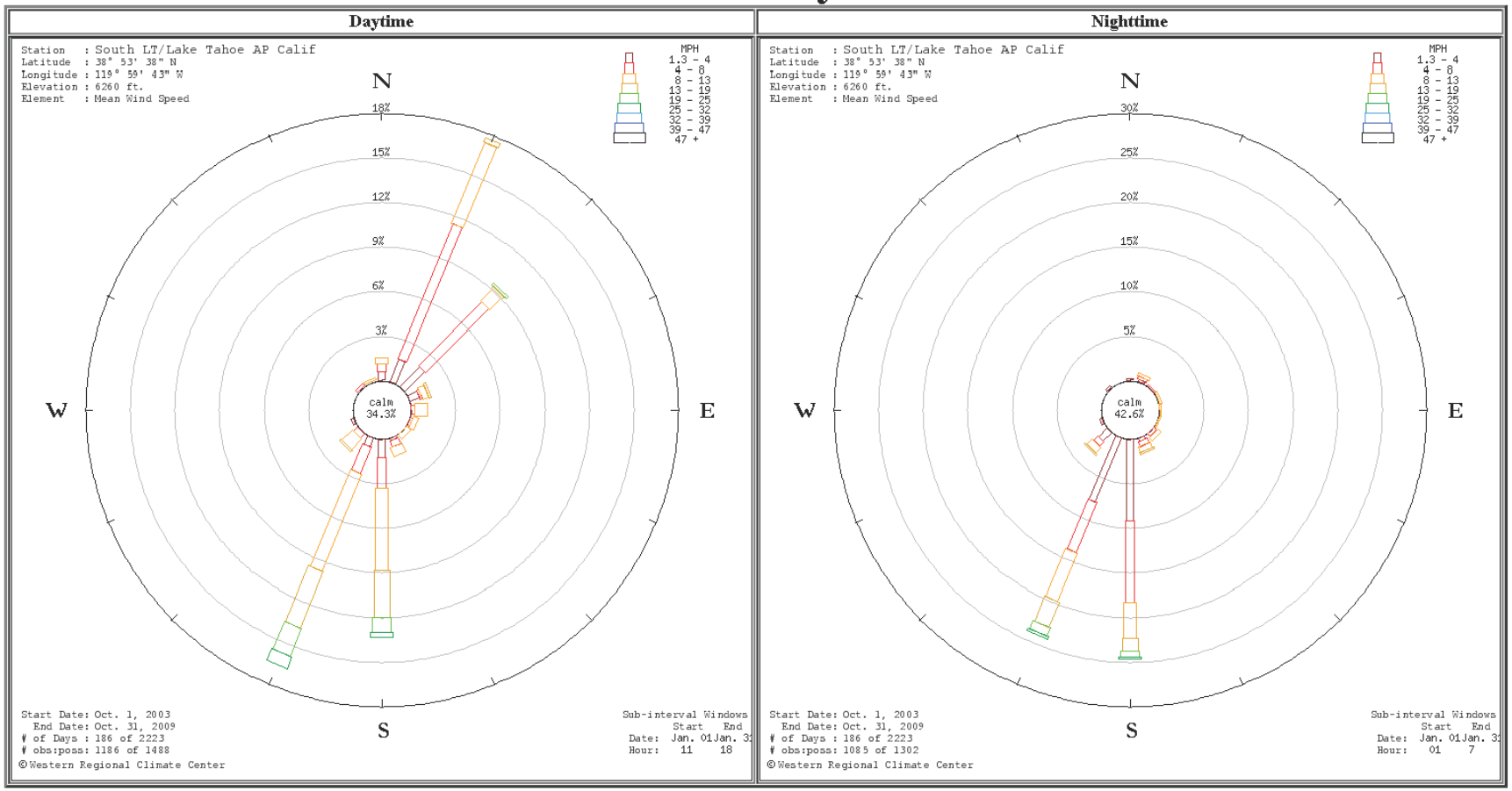


Figure C-3a South Lake Tahoe Wind Rose: January

South LT/Lake Tahoe AP Calif
February

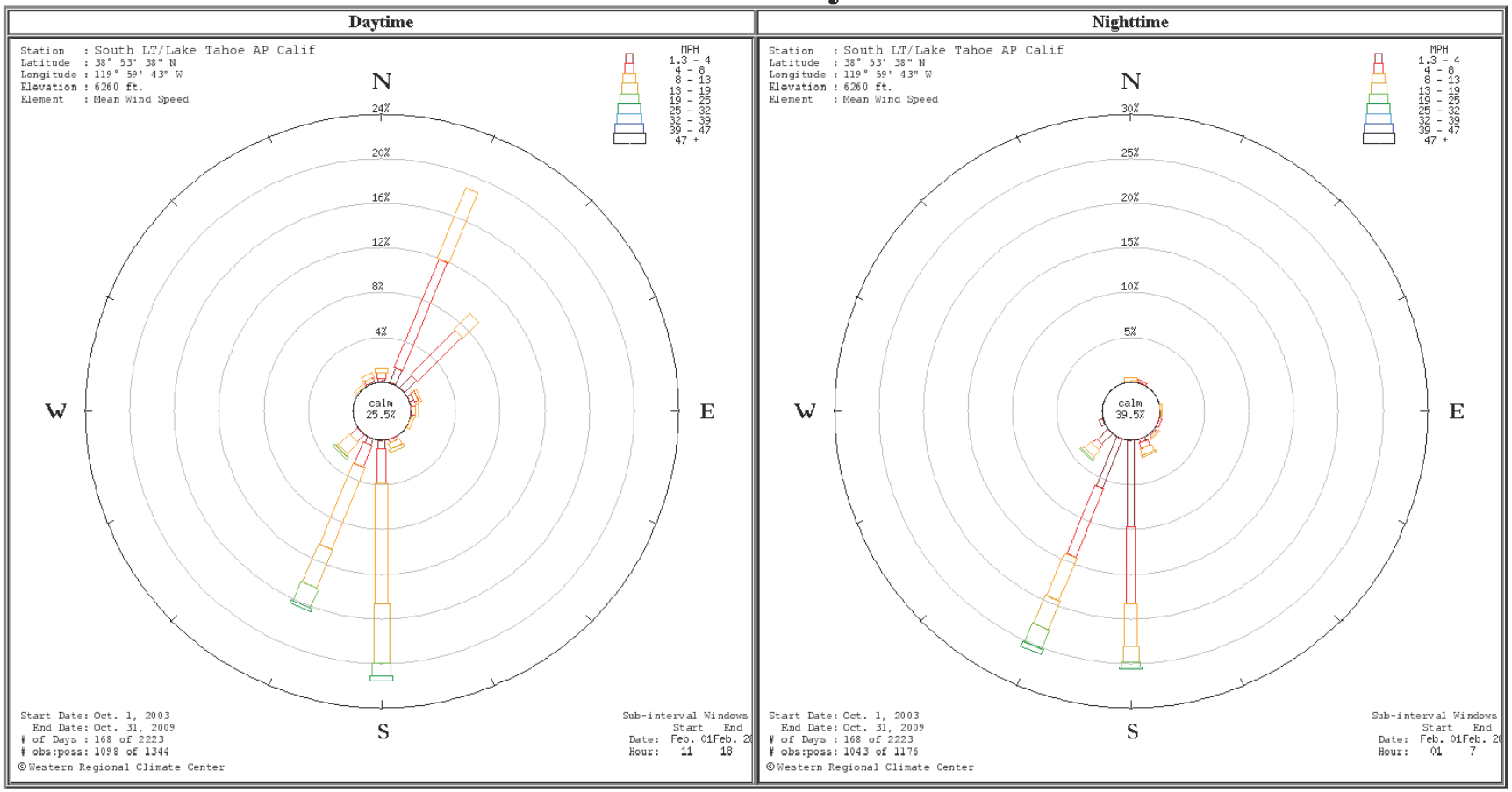


Figure C-3b South Lake Tahoe Airport Wind Rose: February

South LT/Lake Tahoe AP Calif
March

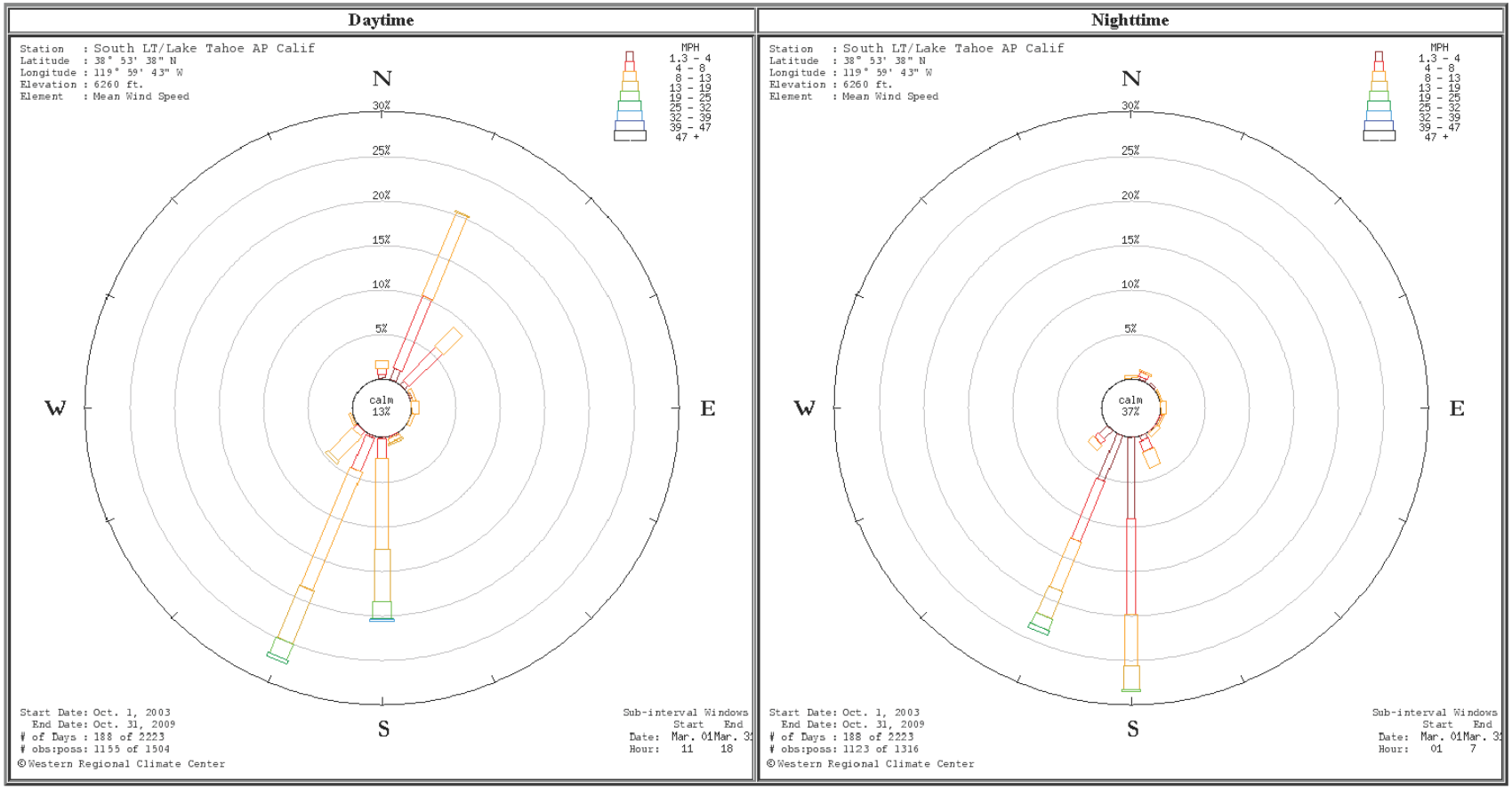


Figure C-3c South Lake Tahoe Airport Wind Rose: March

South LT/Lake Tahoe AP Calif
April

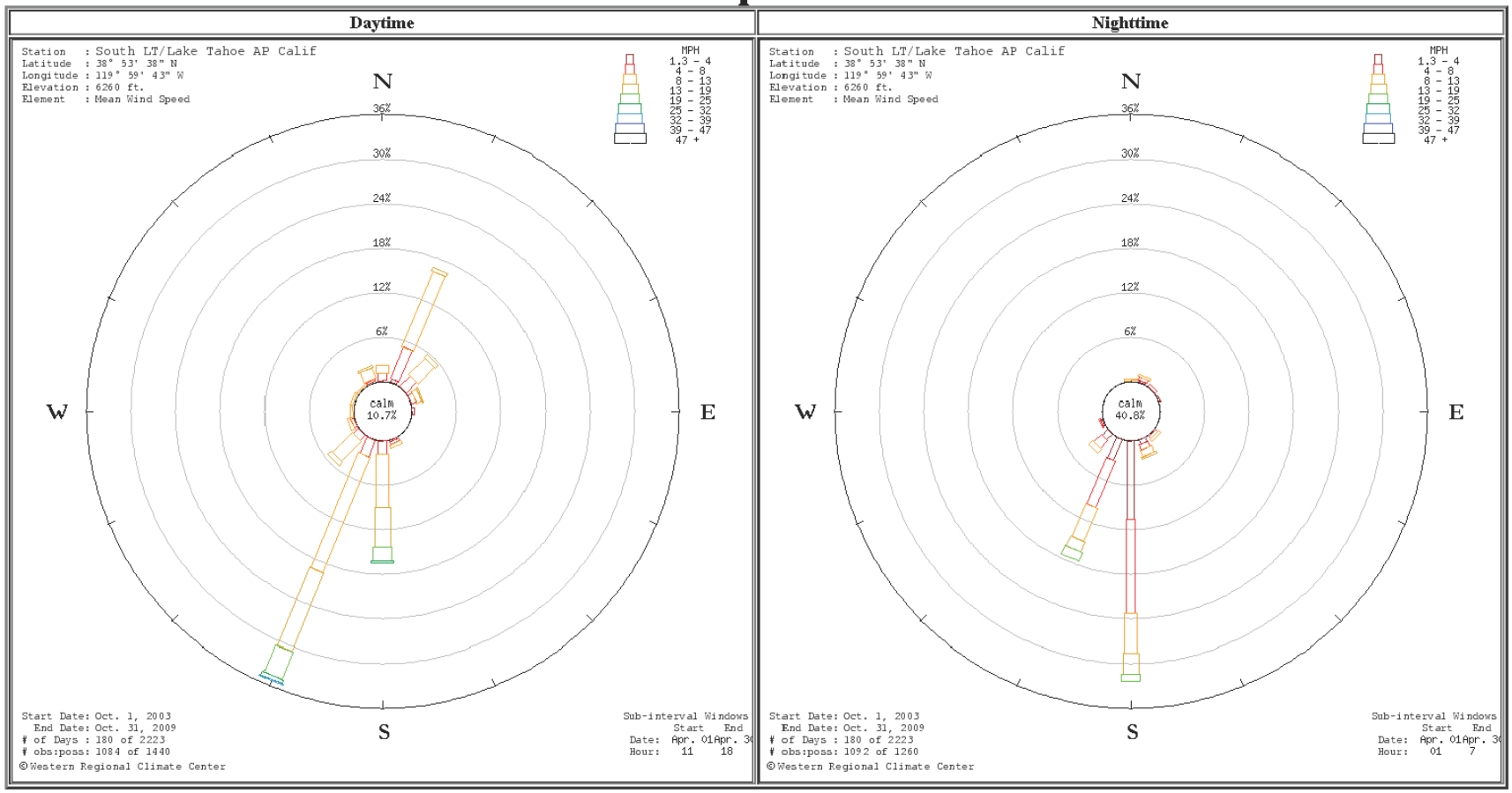


Figure C-3d South Lake Tahoe Airport Wind Rose: April

South LT/Lake Tahoe AP Calif
May

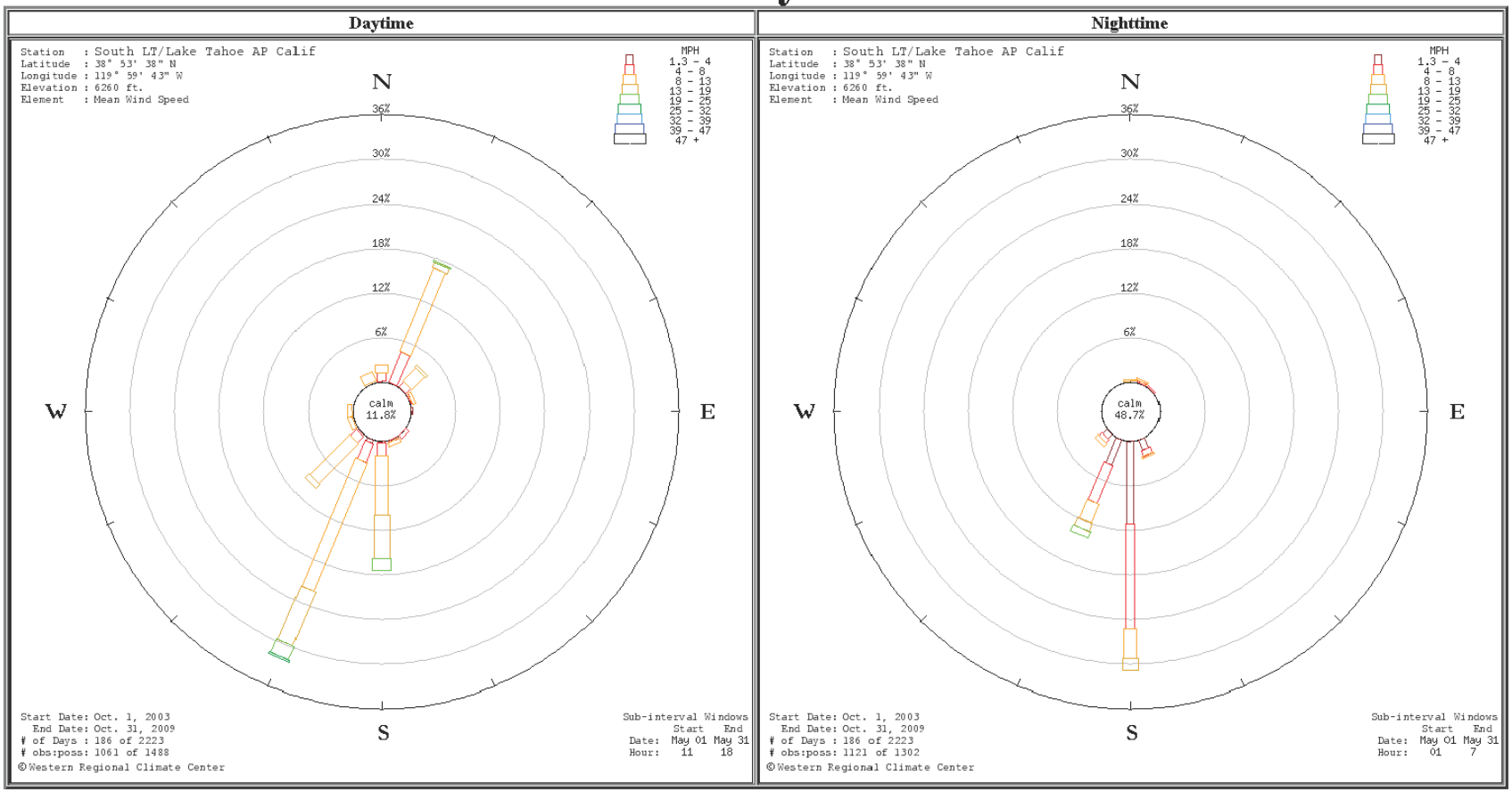


Figure C-3e South Lake Tahoe Airport Wind Rose: May

South LT/Lake Tahoe AP Calif
June

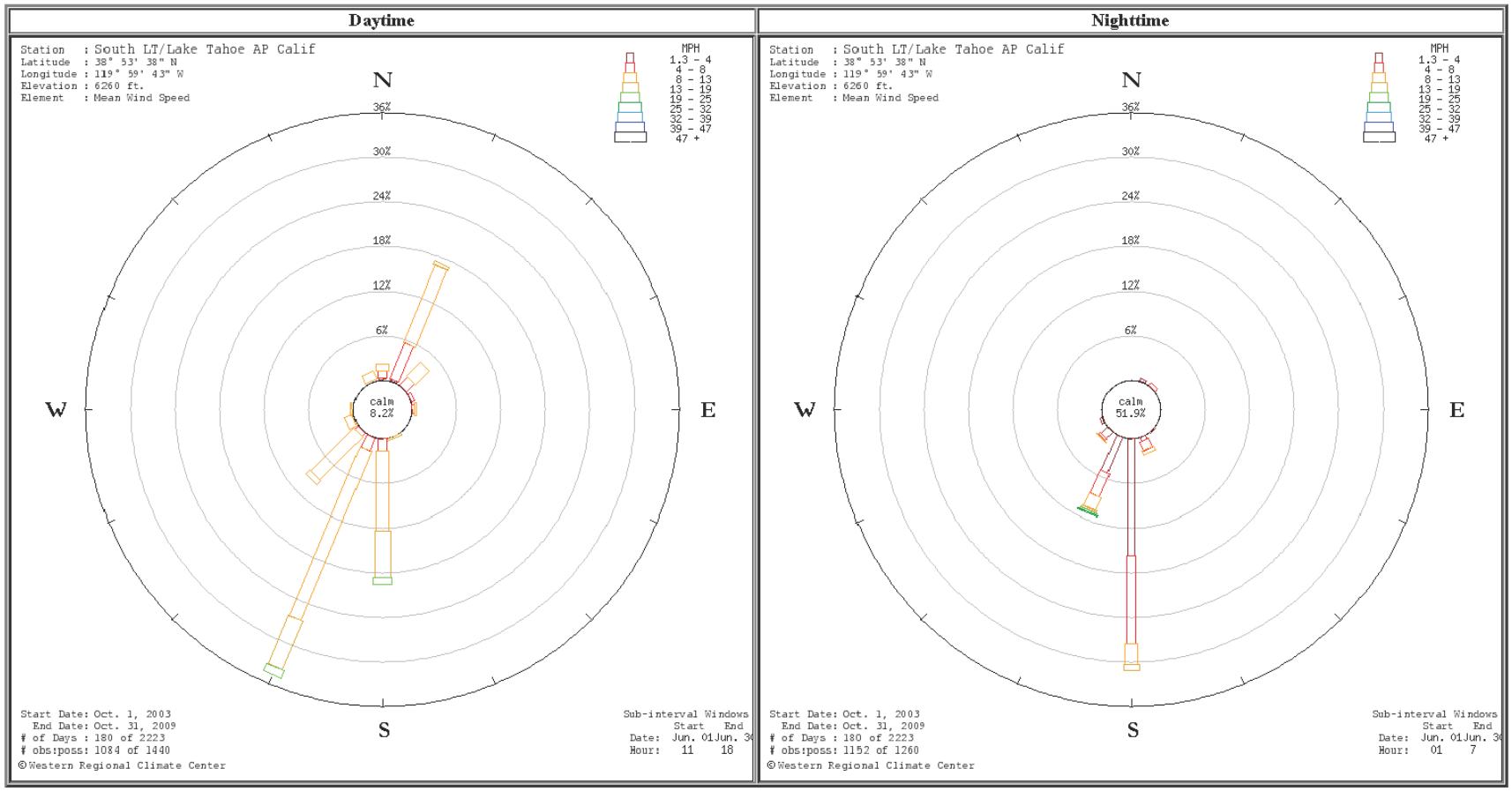


Figure C-3f South Lake Tahoe Airport Wind Rose: June

South LT/Lake Tahoe AP Calif
July

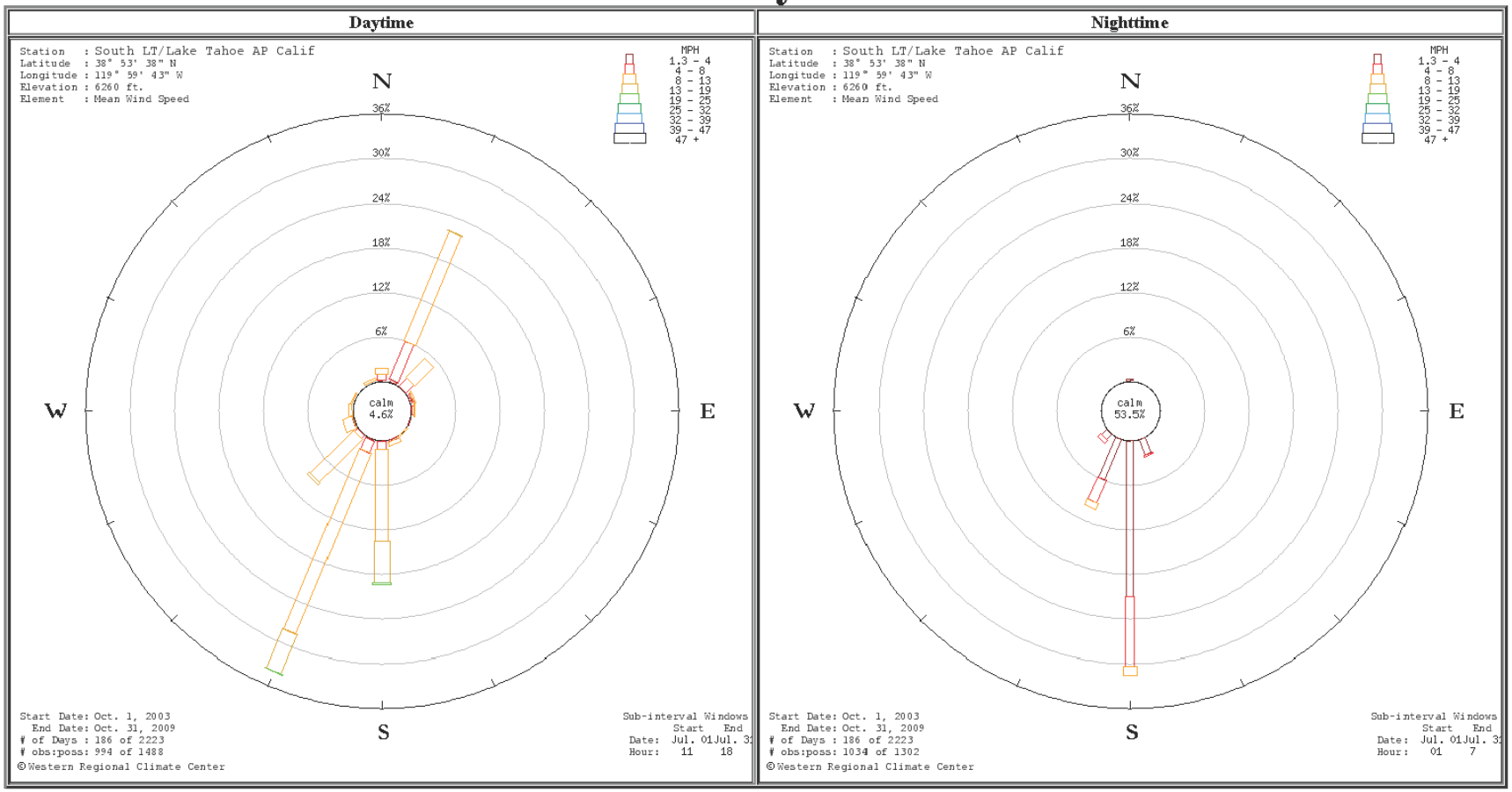


Figure C-3g South Lake Tahoe Airport Wind Rose: July

South LT/Lake Tahoe AP Calif
August

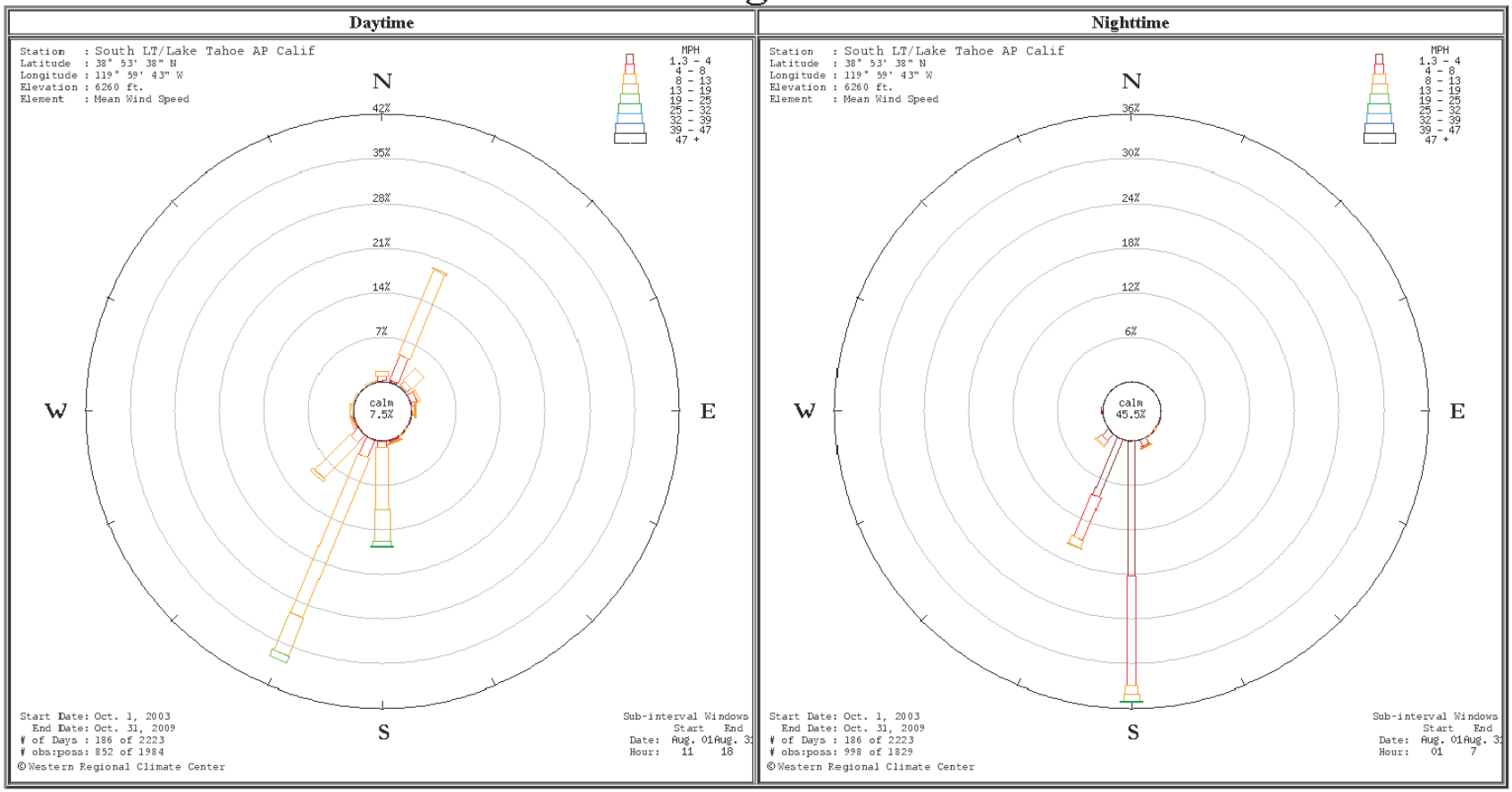


Figure C-3h South Lake Tahoe Airport Wind Rose: August

South LT/Lake Tahoe AP Calif
September

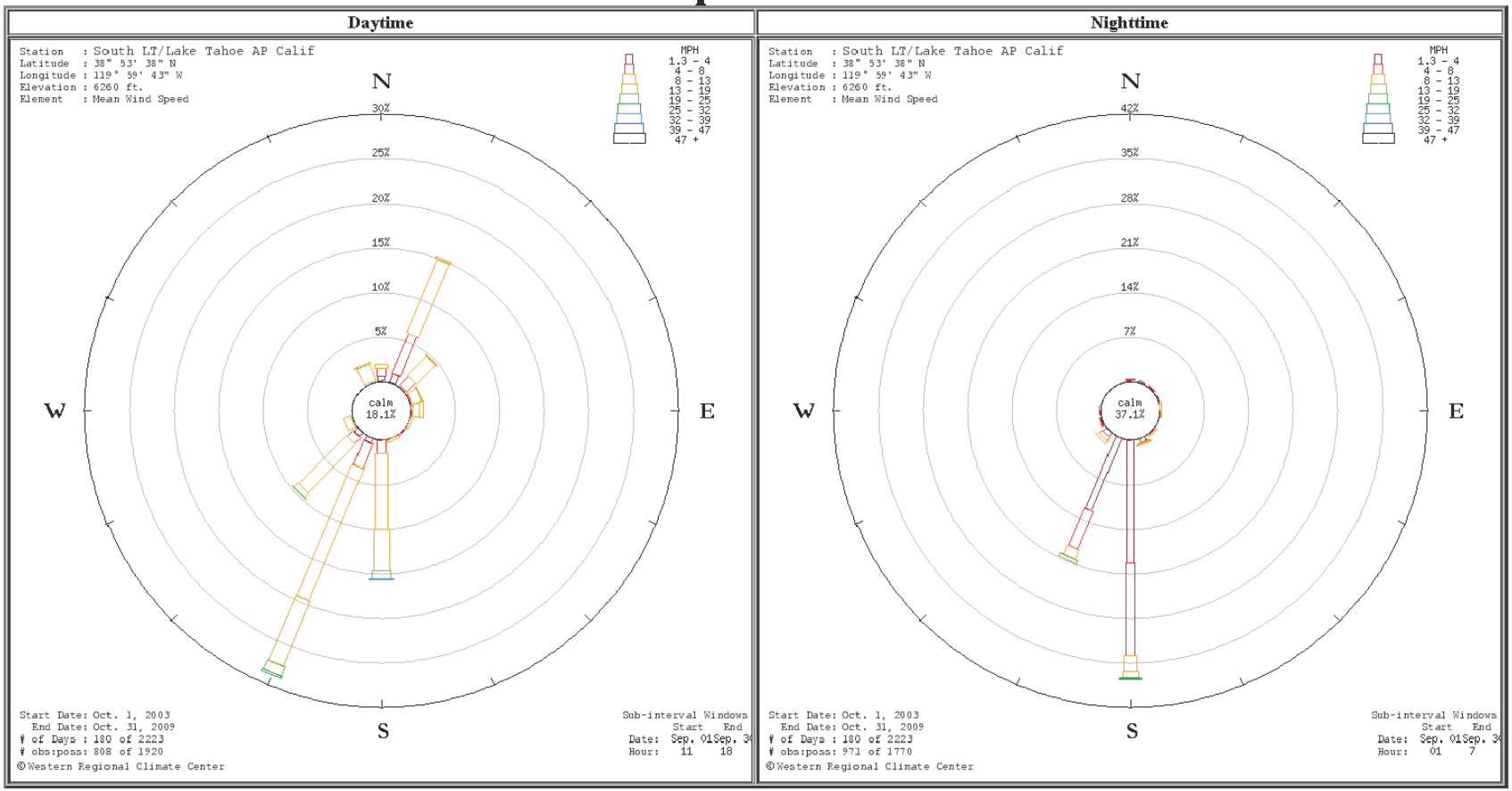


Figure C-3i South Lake Tahoe Airport Wind Rose: September

South LT/Lake Tahoe AP Calif
October

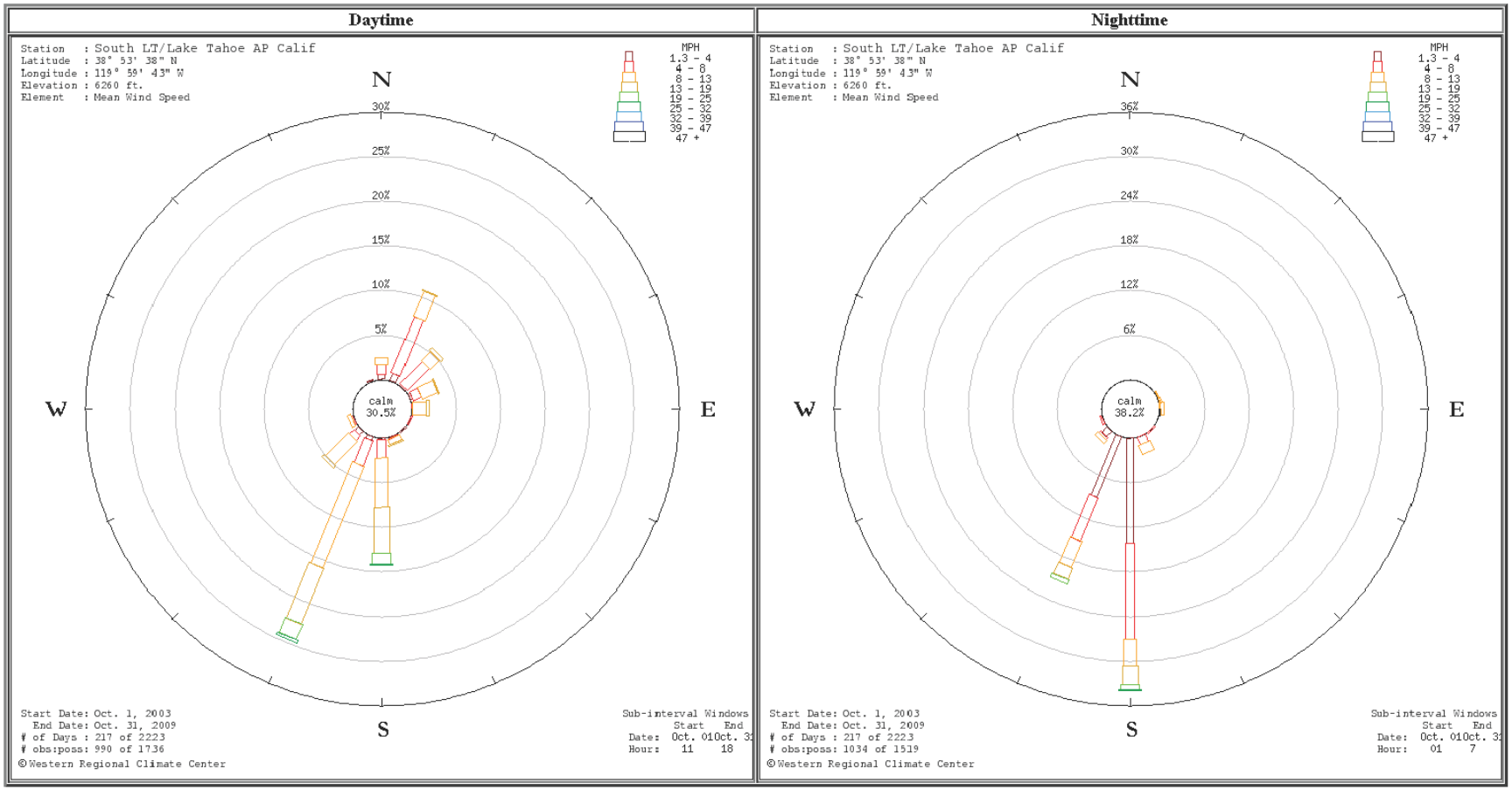


Figure C-3j South Lake Tahoe Airport Wind Rose: October

South LT/Lake Tahoe AP Calif
November

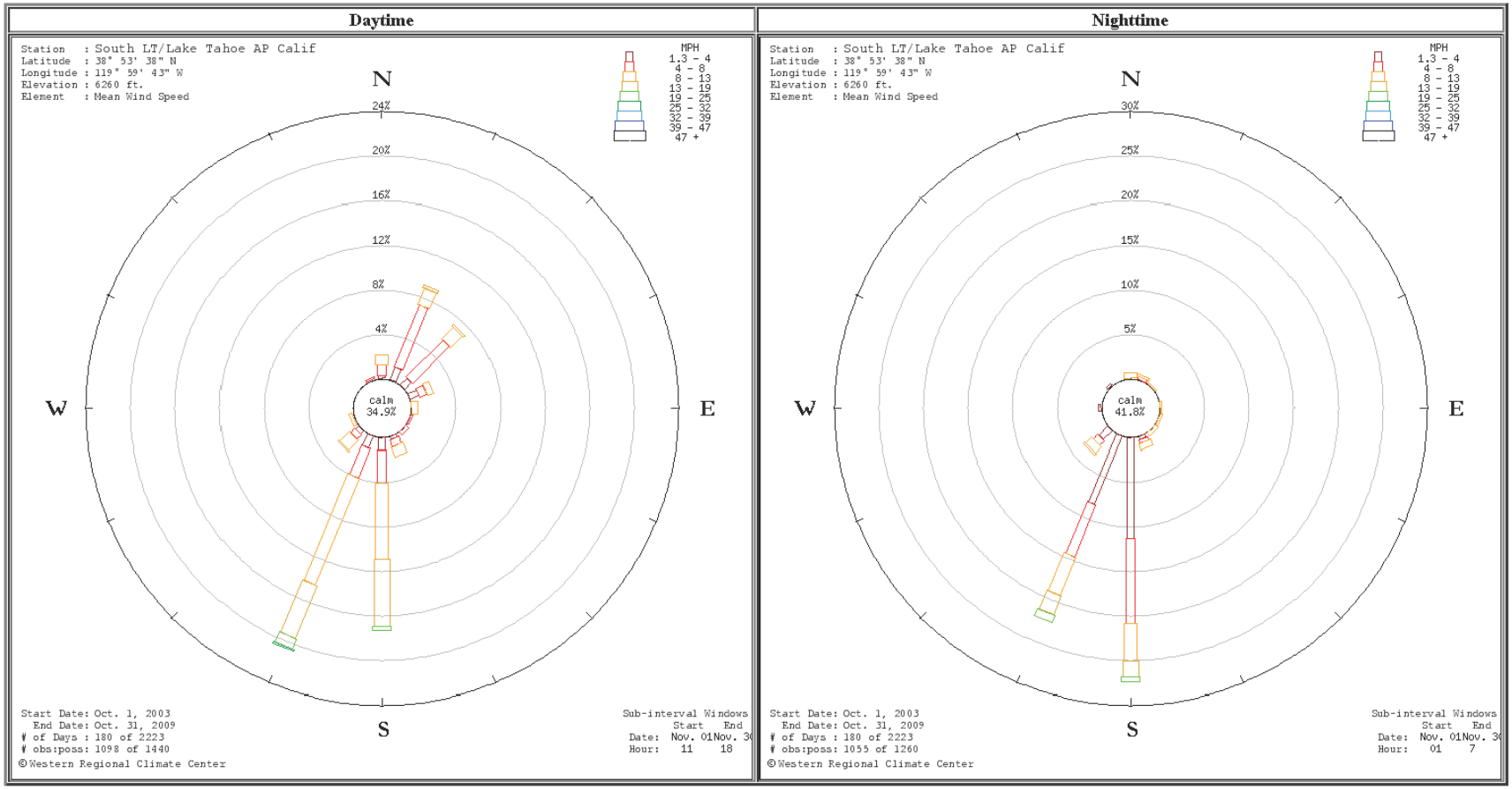


Figure C-3k South Lake Tahoe Airport Wind Rose: November

C

South LT/Lake Tahoe AP Calif
December

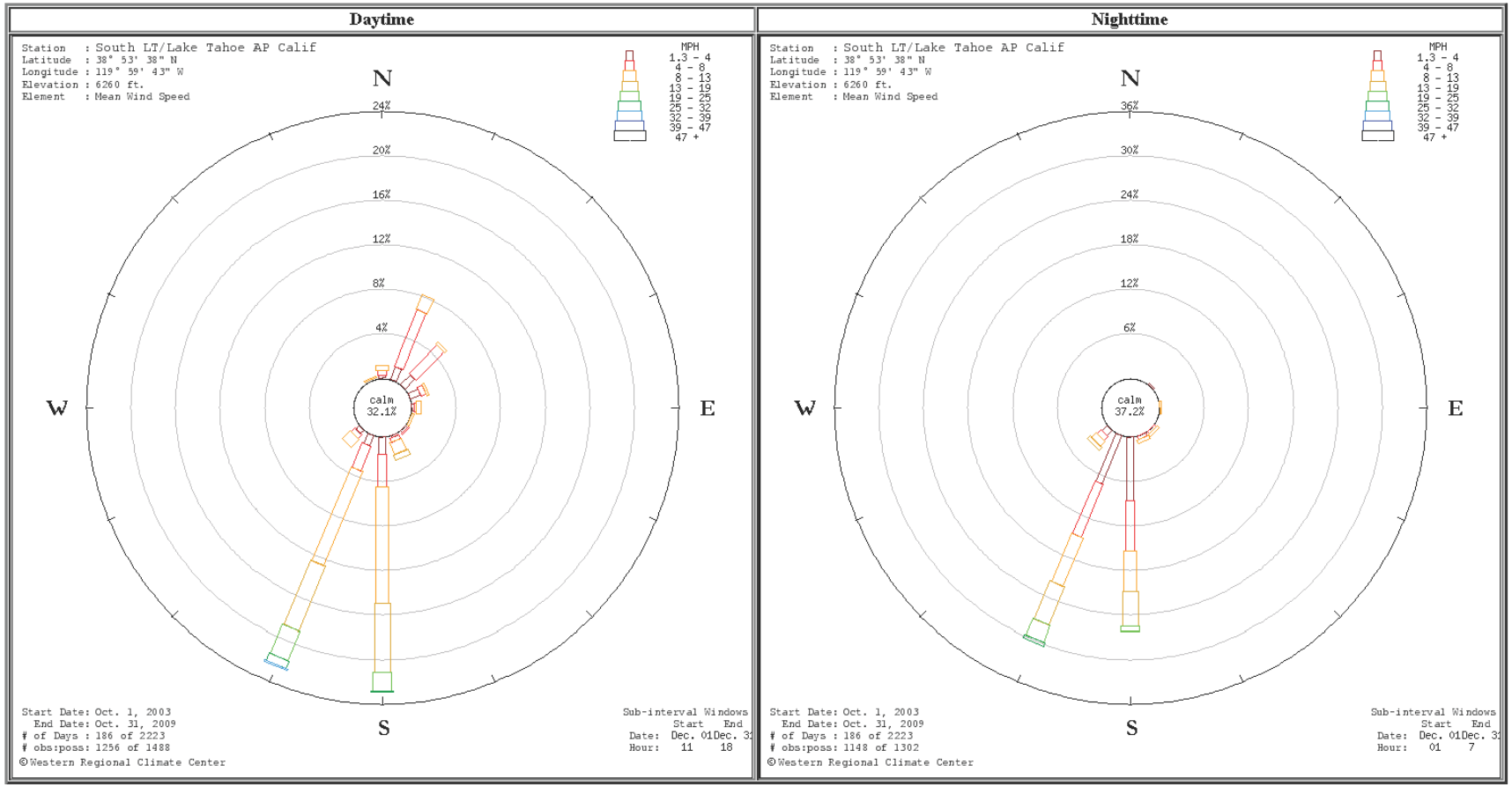


Figure C-3l South Lake Tahoe Airport Wind Rose: December

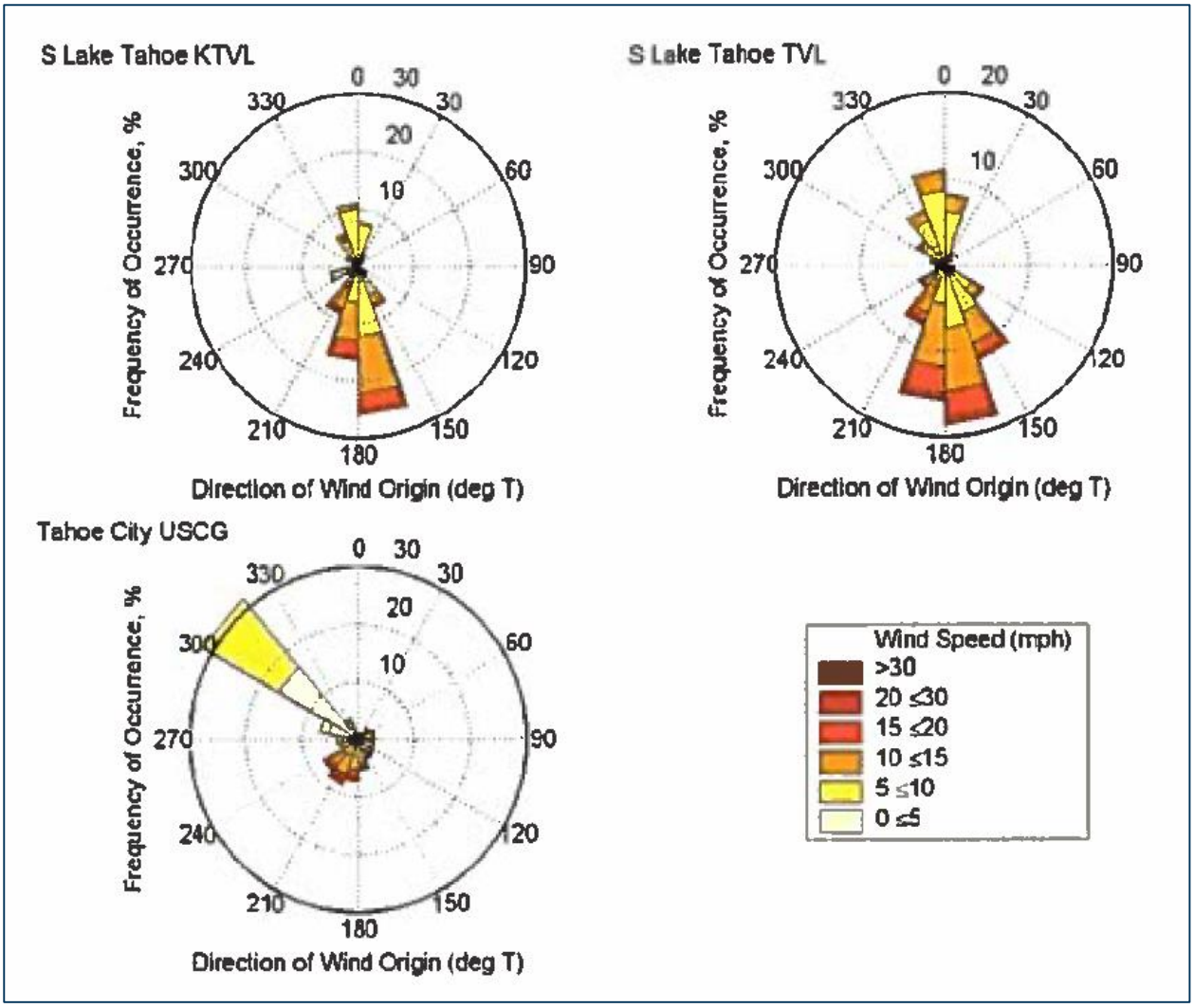


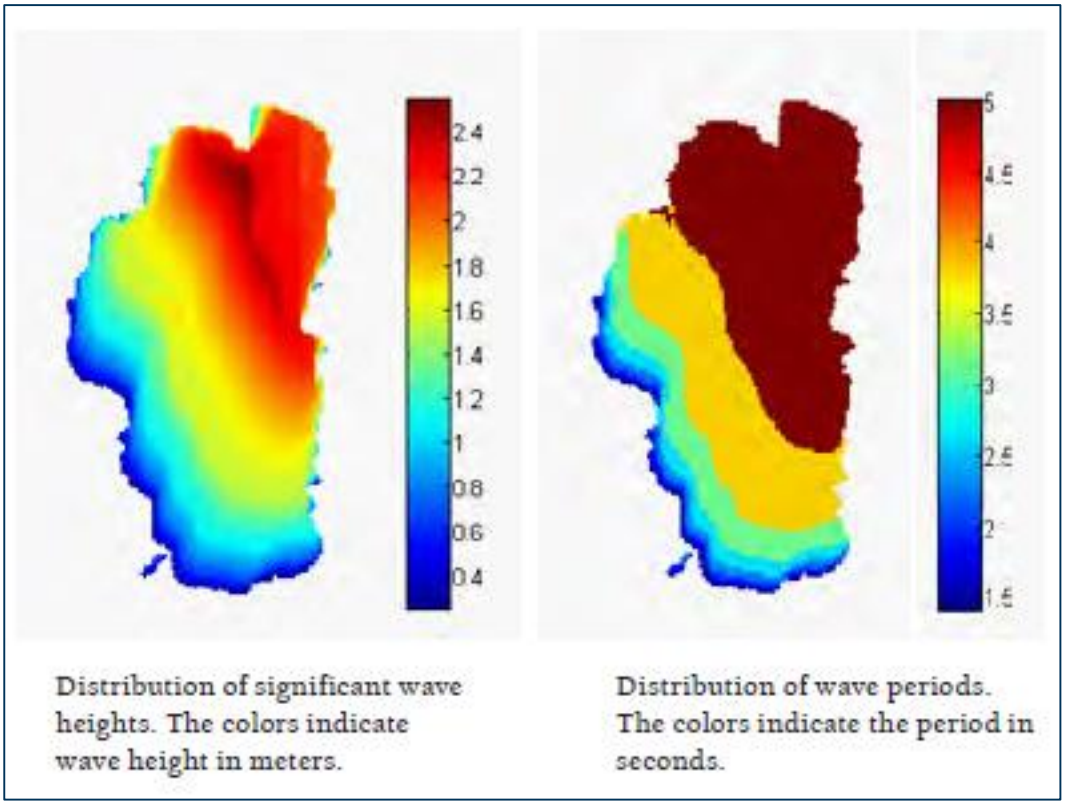
Figure C-4: Wind Speed and Direction Distributions used in the 2001 PIE Study

Schaldow et al. (2015) report on progress to-date in establishing nearshore network stations around Lake Tahoe and data collected from the four existing stations (Rubicon, Meeks, Homewood and Dollar Point) during the December 11, 2014 storm event (from the southwest) and December 30, 2014 event (from the northeast). The December 11 storm is pertinent for looking at KBSRA, with SW winds. Mid Lake wind direction and speeds at TDR2 buoy; (Dec 11th max wind speed ~19 m/s), with winds from 200 degree source direction) long duration of winds from same direction, with speeds over 10 m/s for over 12 hours. Wave measurements at the four sites on west and north shore, for Dec 11th storm, had waves over 0.1 m for entire storm and max wave height of just over 1.4m.

Empirical wave information for Lake Tahoe is sparse, although studies from the early 1970s forward have made various calculations based on maximum fetch distances and available wind data sets. Peak Spectral period (the period (frequency per second) associated with the maximum energy density of the wave observed can be predicted if wind velocity and duration and fetch are known (Adams, 2004). Orme (1973) estimated this using wind data, that waves of up to 2-3 m in height were possible, but were not actually observed. Another study Engstrom (1978) reportedly attempted to hindcast waves for Lake Tahoe, but because of the lack of wind velocity and duration data, both this study and the Orme (1973) results are considered to be preliminary (Adams, 2004).

Despite the general lack of data, it is generally recognized that large waves on Lake Tahoe are most frequently generated by winds from the west-southwest. The strongest winds generally occur in late fall and winter and are associated with large frontal storm systems, that may not necessarily coincide with when the lake is at seasonal maximum stand. Wind and wave data from the Adams (2004) study (three wave recording stations operating from January 2001 to January 2002) showed a strong relationship between winds and waves at Thunderbird and Incline sites, and this could be expected to be the case for Kings Beach also. The same study also concluded that waves on Lake Tahoe are clearly episodic, with long periods of calm and short, relatively windy periods.

Adams and Panorska (2004) noted that wave periods for the largest waves on Lake Tahoe are likely to be approximately 6.5 seconds, indicating they travel at approximately 10 m/s (22 mph). For recent ARkStorm study simulations, USGS wind data was analyzed using a customized version of the USACE's STWAVE model to simulate wave generation at Lake Tahoe (TERC 2014). This focused on determining the 'significant wave height' (average of the highest one-third of waves; with a wave 2 times the height every 12 hours and waves 1.5 times the height every 15 minutes). Kings Beach has a long fetch, and is in the zone for highest significant wave heights and wave periods (Moreno, as cited in TERC, 2014; see Figure C-5). For southwesterly winds (the longest fetch across the lake) at sustained speeds of 54.7 miles per hour (88.0 kmh), the maximum significant wave height predicted off shore of Agate Bay (and Kings Beach) would be about 7 feet (2.2 m), which indicates a likelihood that some waves in excess of 14 feet could be expected and an 11 foot high wave would break approximately every 15 minutes (TERC 2014).



Source: Moreno, cited in TERC, 2014

Figure C-5. Distribution of significant wave heights and wave periods for Lake Tahoe

Wave Transmission

Wave transmission and potential attenuation are also important factors in comparing the two pier alternatives for Kings Beach. The results of Cardno's study were summarized in the main report, but the technical analysis is expanded upon herein.

Based on present concept design plans (see Appendix A), the potential wave attenuation provided by the two pier design options (both having fixed and floating pontoon sections) is estimated using two separate numerical formulae. Note these are general transmission coefficients and do not discriminate between the two pier design options. Macagno (1953) estimates wave attenuation using the following formula (as depicted in Morey, 1998):

$$C_T = \left[1 + \left(\frac{k_W \; B_S \; \sinh\,(k_W \; D_W)}{2 \cosh\,(k_W \; D_W - k_W \; D_S)} \right)^2 \right]^{-\frac{1}{2}}$$

Where:

B_S = structure width (m)

D_S = structure draft (m)

D_W = water depth (m)

C_T = transmission coefficient

K_W = wave number

The equation was used to assess the wave attenuation provided by the floating pontoon sections of the two pier options for a range of water depths and wave periods. The results, presented in Table C-3 below, show that the governing factor is wave period. The piers provide little wave attenuation for waves of periods 4 seconds or longer (less than 12%), though significant wave attenuation may occur for wave periods of 2 seconds or lower. The generally low wave attenuation of the piers can primarily be attributed to the small draft of the piers, which is only one foot (12 inches). The larger waves, those that cause most sediment transport, typically have periods in the order of 6 seconds and transmission coefficients of 0.97.

Table C-3: Wave Attenuation Estimated using Macagno (1953)

Wave Transmission Coefficient (Ct)		Wave Period (s)						
		2	3	4	5	6	7	10
Water Depth (m)	1.0	0.35	0.71	0.88	0.95	0.97	0.99	1.00
	1.5	0.35	0.70	0.88	0.95	0.97	0.99	1.00
	2.0	0.34	0.70	0.88	0.95	0.97	0.99	1.00
	2.5	0.33	0.70	0.88	0.95	0.97	0.99	1.00
	3.0	0.31	0.70	0.88	0.95	0.97	0.99	1.00
	3.5	0.35	0.70	0.88	0.95	0.97	0.99	1.00
	4.0	0.35	0.70	0.88	0.95	0.97	0.99	1.00
	4.5	0.34	0.69	0.88	0.95	0.97	0.99	1.00
	5.0	0.34	0.69	0.88	0.95	0.97	0.99	1.00

Source: Cardno 2015

Potential wave attenuation provided by the two pier options was also estimated using the Weigel (1960) formula:

$$K_t = \sqrt{\frac{\dfrac{4\pi(y+d)/L}{\sinh 4\pi d/L} + \dfrac{\sinh 4\pi(y+d)/L}{\sinh 4\pi d/L}}{1 + \dfrac{4\pi d/L}{\sinh 4\pi d/L}}}$$

Where:

L = wavelength

d = water depth

y = structure draft

This equation was used to provide an alternative assessment of the wave attenuation created by the pier options in terms of the basic pontoon cross sections and drafts for a range of water depths and wave periods. The results, presented in Table C-4 below, again show that the piers provide only minimal wave attenuation for wave of period 4 seconds or longer. In fact, these results show that for wave periods of 4 seconds or longer wave attenuation ranges between 7-18% depending on water depth. More attenuation occurs in shallow water, because the structure draft represents a larger proportion of the water depth.

It is important to note though, that these equations are one dimensional. That is, they do not take into account the effect of waves diffracting around the ends of the pier, which will depend upon the plan-form layout - including the length of the pier, and the orientation of the pier to the incoming waves. Nor do they consider the projected length of each structure on the shoreline, which depends on the alignment of the attenuator sections and the direction of the dominant incident waves.

Table C-4: Wave Attenuation Estimated using Weigel (1960)

Wave Transmission Coefficient (Ct)		Wave Period (s)						
		2	3	4	5	6	7	10
Water Depth (m)	1.0	0.74	0.80	0.82	0.82	0.83	0.83	0.83
	1.5	0.76	0.85	0.87	0.88	0.88	0.89	0.89
	2.0	0.75	0.87	0.90	0.91	0.91	0.91	0.92
	2.5	0.74	0.88	0.91	0.92	0.93	0.93	0.93
	3.0	0.72	0.88	0.92	0.93	0.94	0.94	0.94
	3.5	0.74	0.88	0.92	0.94	0.94	0.95	0.95
	4.0	0.74	0.88	0.93	0.94	0.95	0.95	0.96
	4.5	0.74	0.88	0.93	0.95	0.95	0.96	0.96
	5.0	0.74	0.88	0.93	0.95	0.96	0.96	0.97

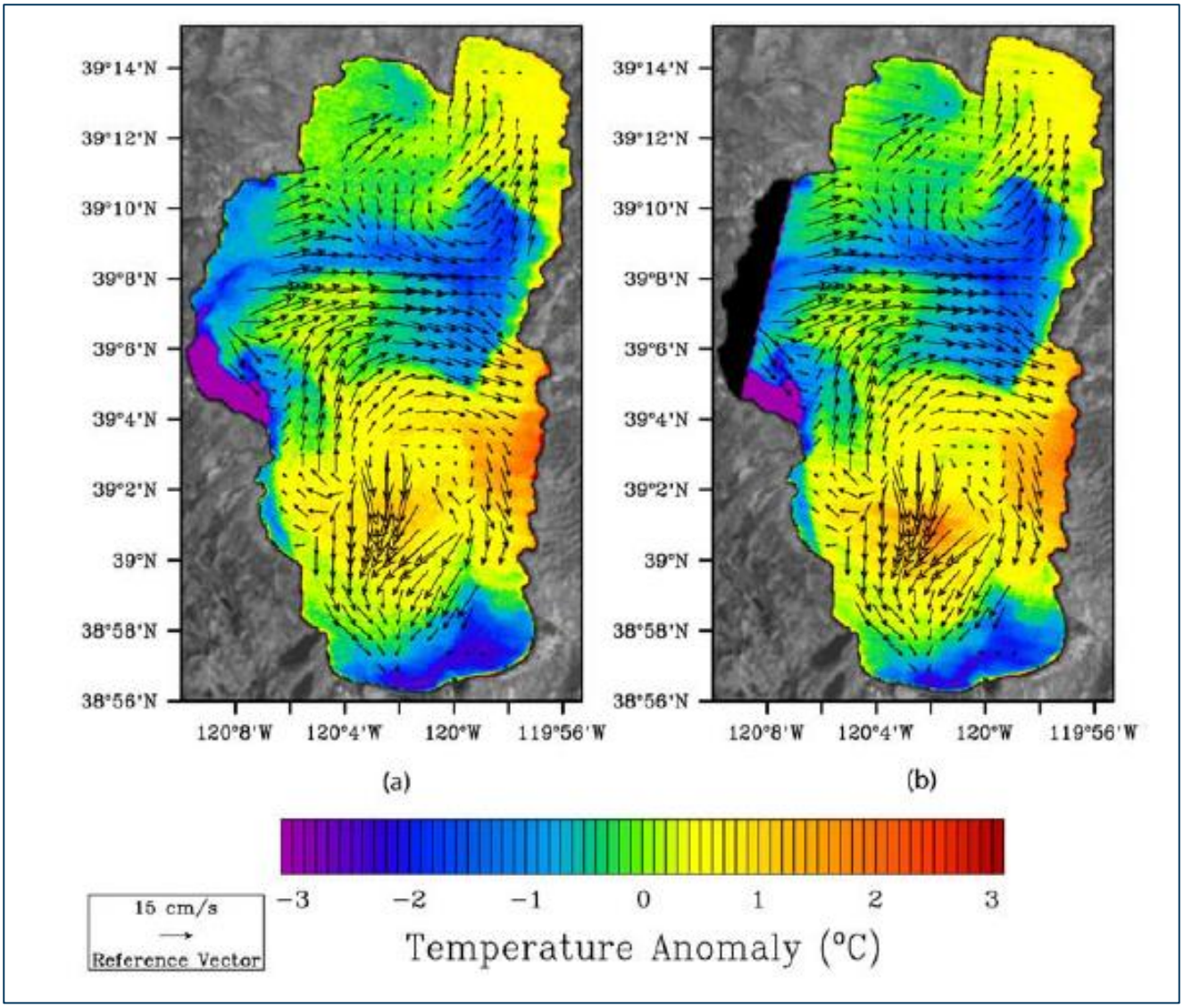
Source: Cardno 2015.

Consequently, the values presented in the tables above can be considered conservative, with wave attenuation likely to be less effective because, in reality, waves diffract around the outer ends of the pontoon sections of each pier option. At high water, the landward end of the pier is situated over 250 feet from the shoreline, providing significant opportunity for shoreward propagating waves to diffract around the ends of the pontoon sections before reaching the shoreline. There will be less wave diffraction caused effect at low water, when the landward end of the attenuator (i.e., the pontoon sections) is only 80 feet from the shoreline.

Circulation, Segmentation, and Littoral Drift

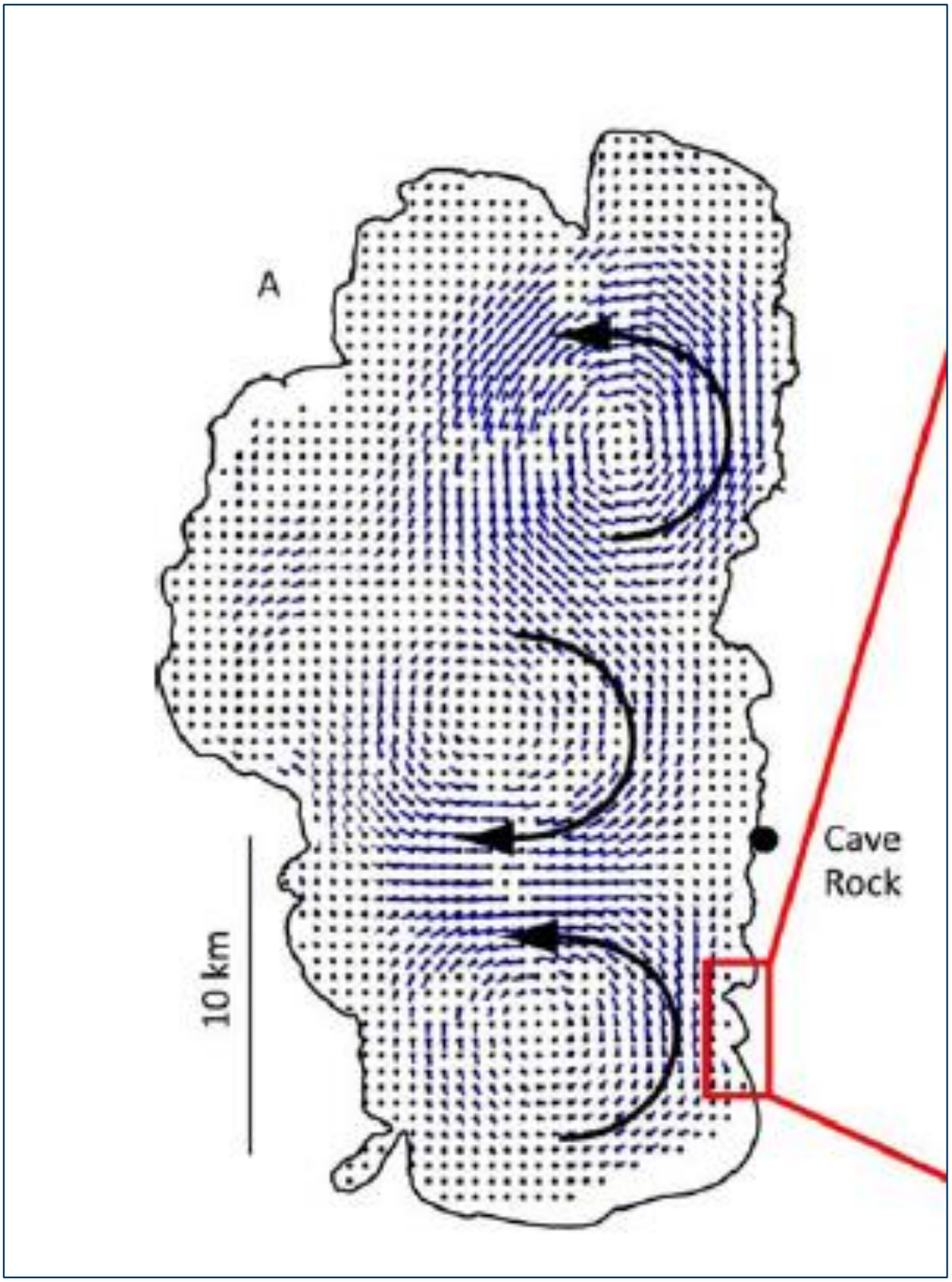
The general surface circulation of Lake Tahoe is driven by prevailing wind directions and speeds discussed in the previous section. In 2005 Steissberg and Others provided empirically based identification of surface currents and circulation patterns of Lake Tahoe (Figure C-4). Results of a surface drifter study they carried out from September to October 2001 showed that in the northern section of the lake the dominant surface currents were in a counter-clockwise circulation pattern, and a counter clockwise direction in the central and southern sections of the lake.

In addition to this study, Three-Dimensional (3-D) modeling using Si3D has also been developed for Lake Tahoe, and was recently refined to a 20m resolution for the basin-scale circulation in the deep lake (TERC 2014). The wind-driven circulation patterns (during the two-month study period mid-2008) in the surface mixed layer at the basin scale modeled by Hoyer et al. 2015 using the Si3D model consisted of three large counter-rotating gyres (Figure C-5).



Source: Steissberg et al. 2005

Figure C-4: Lake Tahoe General Surface Circulation



Source: Hoyer et al., 2015

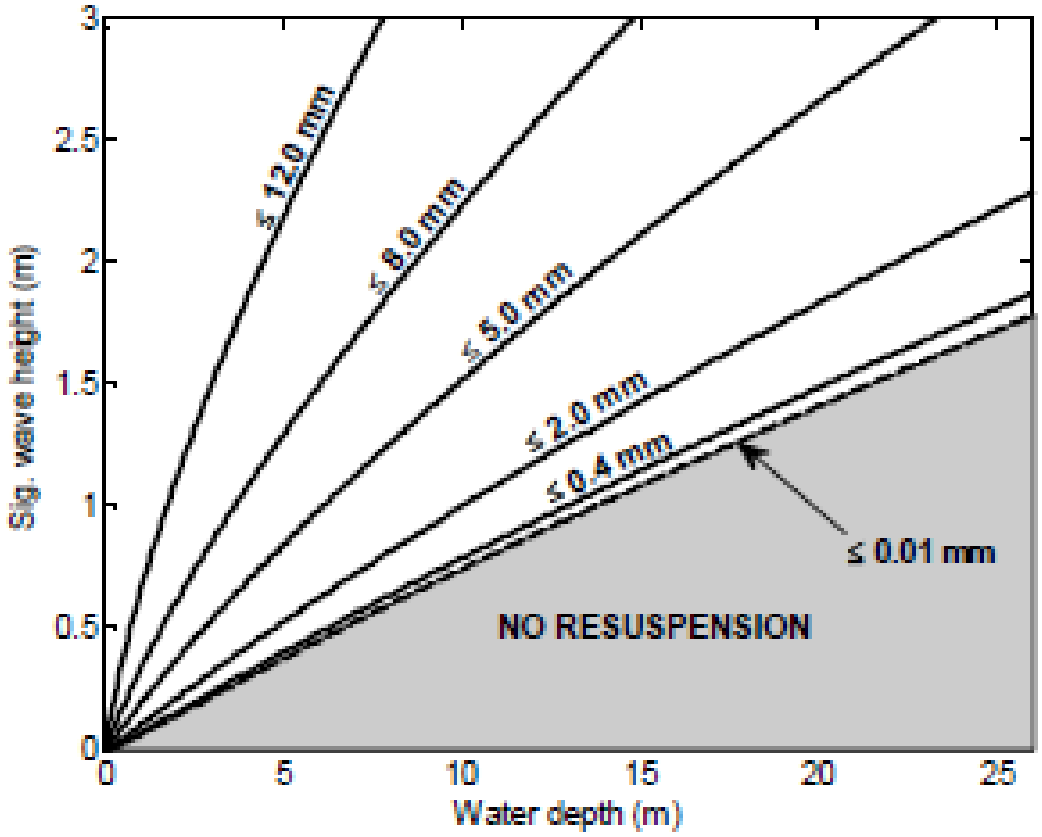
Figure C-5. Modelled General Circulation of Lake Tahoe

The shorezone of Lake Tahoe has been shown to be comprised of many small cells of local sediment redistribution (Orme, 1973 Osborne et al., 1985; Adams and Minor, 2002). The conclusions of these studies of littoral zone processes were summarized by Adams et al. (2004), who noted that the principal sediment source for major sand beaches is backshore erosion of young lacustrine and fluvio-glacial outwash.

The littoral cells around Lake Tahoe include many with bi-directional nearshore currents (including Kings Beach segment within Agate Bay), so the net longshore (parallel to shore) movement is limited (Osborne 1985). There is a large 'on-off' shore component of littoral drift but a small horizontal (longshore) component (Osborne et al. 1985); Sands formed by weathering of the local upslope rock are moved offshore during large storms that are stored in shelf deposits (i.e., where the shelf slope is not too steep/deep) that are a source to the foreshore during normal conditions.

In shallow waters, bottom shear stress due to wind-waves is greater than that due to currents (i.e., wind-waves are the main driver of sediment movement). Sediment resuspension within the nearshore would be expected to occur when excess shear stress occurs relative to the lake bed sediment sizes (Reardon et al, 2014). For example, Moory (2012) cites that to put medium and coarse sand in motion, a bottom current speed of 0.31 to 0.5 m/s would be required.

For a fixed wave height, sediment resuspension depends on water depth and for a fixed depth, resuspension depends on wave height; irrespective of water depth, the largest resuspension potential is associated with largest fetch (Figure C-6). The Reardon et al. 2014(submitted) study of wind-wave induced sediment resuspension found that fine particle dominance of suspended sediment concentration and particle size distribution was unchanged by storm-related resuspension.



Source: Reardon and others 2014 (submitted)

Figure C-6 Resuspension Potential Related to Wave Height and Water Depth

Lake Elevation and Associated Erosion

Long-term shoreline erosion is controlled not just by the wind-wave generation direction and speeds, or nearshore currents, but also by interactions between the spatial pattern of geologic materials and the spatial-temporal pattern of lake elevation and wave energy.

Lake levels modify the elevation at which waves hit the shoreline, and are thus an important factor to consider when talking about the feasibility of the two proposed piers. The lake level modifies the relative water depth and slope of the nearshore that the waves are exposed to, and of course, modifies the actual location at which the waves break, and where wave runoff occurs. Indeed, Adams (2004) concluded that lake level may be one of the prime controls on whether or not backshore erosion would occur, and commented that the largest erosive events can be expected to occur when lake is at or near maximum level and there are strong winds (Adams 2004).

To expand upon this further, during lower lake stands, wave action will impinge on the nearshore more than at higher lake elevations, resulting in net erosion that can mobilize materials that may move parallel to shore or out to the lake. Under low lake levels, wave-induced erosion within the foreshore/nearshore therefore becomes prominent and navigation is limited. Conversely, during high lake stands, wave action acts on the backshore and concerns about shoreline and structure (e.g., pier) protection are a high priority.

Over geologic time scales, Lake Tahoe has experienced wide fluctuations in lake elevation, and therefore changes in beach processes, net deposition and erosion. In modern history, modifications to the physical lake outlet since the late 1800s and to the legal management of the lake since the 1940s have affected lake levels and the potential for erosion of the backshore. Prior to the installation of a dam at Tahoe City in the 1880s, the natural spill elevation was about 6223 feet, in dense clay material. Between dam construction in the 1880s and the Truckee River Agreement in 1935, the lake level exceeded the present legal maximum of 6229.1 feet on five separate occasions for periods up to several months at a time (Adams et al. 2004). These early 1900s high lake stands likely caused substantial erosion, but there is limited mapping or photographic evidence to document or quantify such effects.

Review of relevant literature shows that during last 100 years lake has ranged from high of 6229.1 feet in July 1907 to lows below the natural rim in November 1992. On an annual basis, the climate of the Lake Tahoe basin is such that most of the annual precipitation is stored as a thick snowpack during winter months, and released during spring snowmelt. Lake levels respond to the spring snowmelt with levels increasing each spring and reaching an annual maximum in early summer, before declining slowly again until the next snowmelt season (Adams, 2004). The timing of these high lake levels is important because the configuration and bathymetry of the beach, the maximum potential for erosion at this location is at the onset of a storm, but when combined with a high lake level.

Analysis at Kings Beach

A coastal sediment transport analysis was conducted by Pacific International Engineering (PIE) (November 15, 2001). It provides relevant background and information about site beach morphology and processes and samples of sediments and the profile and beach state. Their study included the limited wind data obtainable at the time. Their empirical wave data collected at an offshore and onshore location for a couple of weeks in fall 2001 is presented as graphs of the wave heights and wave energy, but the time series of observed wave data or concurrent observed winds is not included so subsequent quantitative analysis has not been performed of those data. PIE used local wind data from South Lake Tahoe Airport, Truckee Airport and the Coast Guard Station at Tahoe City to conduct wave modelling using the ST WAVE modelling package.

The 2001 analysis indicated that:

> Sediments in the area are medium sand, with D_{50} = 0.25 mm.
> Breaking wave heights range from 0.8 – 8.2 ft.
> Wave periods range from 4 – 6 s.

The 2001 study performed STWAVE modeling of the lake-wide wind wave parameters and nearshore wave transformations to produce wave data (height, direction, period and depth) along the beach. However, they do not report the mean wave direction near the shoreline, and longshore sediment transport calculations can be sensitive to this. The model outputs were input to an analytical formula (CERC CEM III-2-11, Equation 2-7) for longshore sediment transport and coupled with climate statistics (wind speed, directions, durations for the limited data sets available at the time). Preliminary analysis of wave attenuation/longshore drift effects of a 550 foot long pier was made (consistent with the concept design at the time); considering both fixed and floating pier (attached to backshore) options. The Wiegel (1961) formula was used to determine that a fixed pier (with 4 to 6 foot gap spacing and 12 inch diameter piers) would have a minor effect on wave transmission (reduction of 1-8 percent). They cite using the Carr (1951) and Mocagno (1953) formulae to analyze the effects of a floating pier on wave attenuation, assuming waves arrive normal (perpendicular) to the structure (assumption that essentially represents the pier as parallel to shore). The results suggested a modest reduction (5 to 15%) at water depths between 10 and 22 feet, but increasing effect as water shallows and for a wider pier (24 feet versus 12 feet). The actual orientation of the pier would decrease the angle of wave incidence on the pier, thus reducing the effect from calculations that assume a perpendicular angle.

The STWAVE input and output files were not available for review or integration into new modelling in 2015, but some of the STWAVE results are presented in maps and graphs and reported in the tables of calculation results. The assumed pier lengths, orientations, and floating pier mooring system used by PIE in 2001 differ from the present conceptual design.

In 2015, Cardno performed updated analysis of wind data, verified wind direction and wave generation information, calculated and modeled wave attenuation and transformation, as reported within the body of the main report to which this is attached.

References Cited

Adams, KD, Minor, TB, and AK Panorska March 31, 2004. Shorezone Erosion at Lake Tahoe: Historical Aspects, Processes, and Stochastic Modeling. Final Report for the U.S. Bureau of Reclamation and Tahoe Regional Planning Agency.

Carr, J.H (1951) Mobile Breakwaters. *Proceedings of the Second Conference on Coastal Engineering*, pp 281-295.

Heyvaert, A.C., Reuter, J.E., Chandra, S., Susfalk, R.B., Schaldow, S.G., Hackley, S.H. 2013. Lake Tahoe Nearshore Evaluation and Monitoring Framework. Final Report prepared for the USDA Forest Service, Pacific Southwest Research Station.

Macagno, E.O (1954) Houles dans un Can Presentent un Passage en Charge. *La Houille Blanche*, Vol 9, No 1, pp 10-37.

Morey, B.J (1998). Floating Breakwaters: Predicting their Performance. Thesis Submitted to Faculty of Engineering & Applied Science. Memorial University of Newfoundland. January 1998.

Orme, A.R. 1973. Shorezone Plan for Lake Tahoe. TRPA, Zephyr Cove, NV.

Osborne, R.H., M.C. Edelman, J.M. Gaynor, and J.M. Waldron. 1985. Sedimentology of the Littoral Zone in Lake Tahoe, California-Nevada. Department of Geological Sciences, University of Southern California.

Pacific International Engineering, Inc. (PIE) November 15, 2001. *Draft* Coastal and Sediment Transport Analysis for Proposed Pier Replacement at Kings Beach, CA. Prepared for California Tahoe Conservancy and Harding ESE.

Reardon, K.E., Moreno-Casas, P.A., Bombardelli, F.A., Rueda, F.J., Schladow, S.G. January 31, 2014 (Submitted). Wind-driven nearshore sediment resuspension in a deep lake during winter. Submitted to AGU, Water Resources Research (provided by S.G. Schaldow).

Schladow, G., Roberts, D., Hargreaves, B. 2015. High Frequency, littoral zone water quality network in a large alpine lake-the response to an intense windstorm. Presentation at the

Steissberg, T.E., Hook, S.J., and Schladow, S.G. 2005. Measuring surface currents in lakes with high spatial resolution thermal infrared imagery. Geophysical Research Letters Vol 32:L11402.

Tahoe Regional Planning Agency (TRPA) May 2014. TRPA BMP Handbook: Chapter 8: Shorezone Protective Structures and BMPs.

U.C. Davis, Tahoe Environmental Research Center (TERC) 2014. Tahoe: State of the Lake Report 2014. Accessed at http://terc.ucdavis.edu/stateofthelake

U.S. Army Corps of Engineers (USACE) 1 August 2008 (Change 2). Engineering and Design Coastal Engineering Manual (CEM) [Manual No. 1110-2-1100].

Weigel, R.L (1960) Transmission of Waves Past a Rigid Vertical Thin Barrier. *Journal of Waterways and Harbours Division*. American Society of Civil Engineers, pp. 1-12.

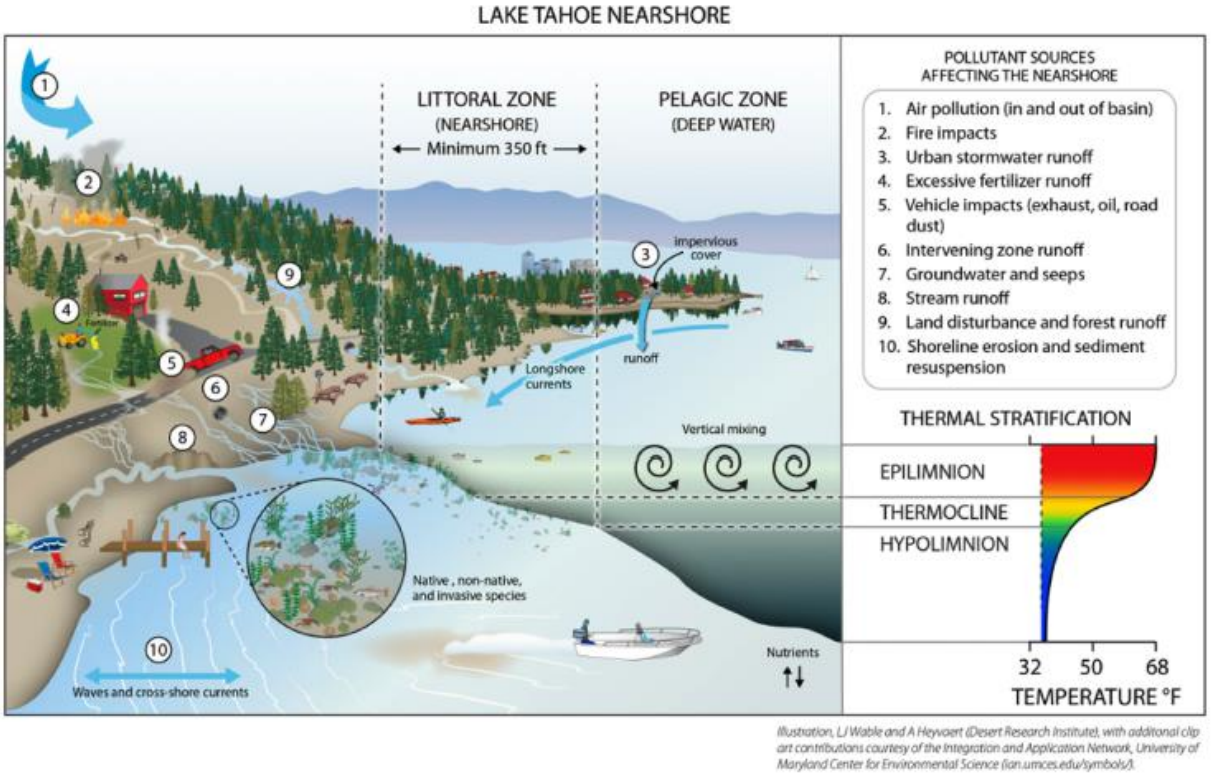
Wind and Wave Data Sources

http://laketahoe.jpl.nasa.gov/

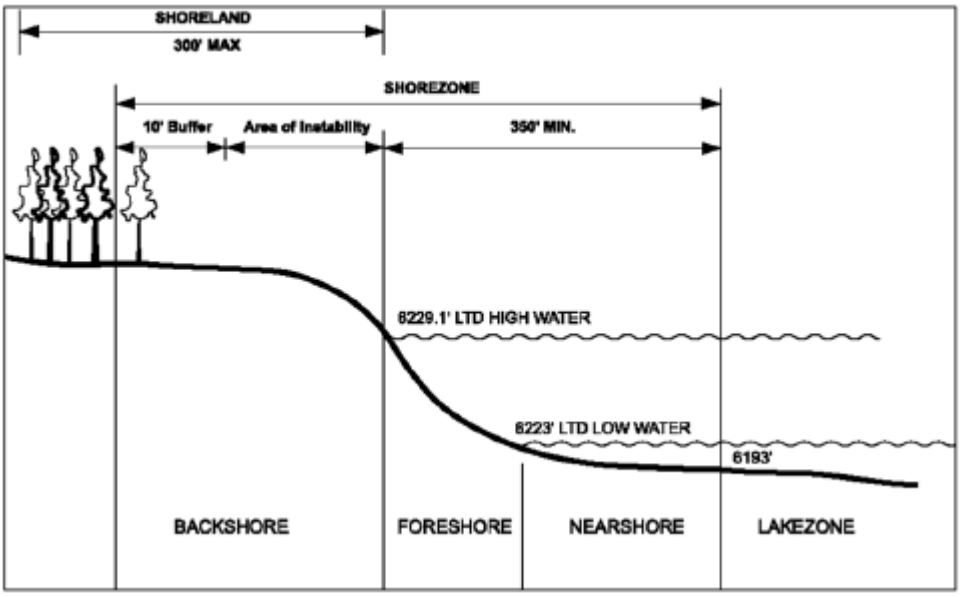
http://wrcc.dri.edu/climatedata/climtables/westwind/#CALIFORNIA

Glossary

Backshore	The lakeward limit of the backshore is at the high water elevation. The landward limit of the backshore is established using one of the following criteria, whichever establishes the wider backshore:
Wave Run-Up	The area of wave run-up, plus ten feet;
Instability	The area of instability, plus 10 feet. The area of instability is measured landward from the high water line a horizontal distance equal to 1.5 times the height of the bluff located adjacent to the shoreline. As an alternative, the area of instability may be determined through a report prepared by a licensed engineering geologist or soils engineer.
Foreshore	The area between the low and high water elevation (commonly associated with the beach face).
Lakezone	The area beyond (lakeward) the nearshore boundary; 350 feet lateral perpendicular distance from the shoreline or the area where lake bottom is lower than 6,293 feet (also known as off-shore).
Littoral Process	Redistribution of sediment within the foreshore or nearshore by waves and/or currents.
Longshore	Parallel to the shore
Nearshore	the area extending from the low water elevation of Lake Tahoe (6,223 feet) to a lake bottom elevation of 6,193 feet, but in any case, a minimum lateral distance of 350 feet measured perpendicular from the shoreline. In lagoons and lakes other than Lake Tahoe, the nearshore extends to a depth of 25 feet below the low water elevation.
Shorezone	TRPA designated planning/regulatory area including the nearshore, foreshore, and backshore of Lake Tahoe (See Figures Below)



Source: Heyvaert and Others, 2013


SHORELAND
300' MAX
SHOREZONE
10' Buffer
Area of Instability
350' MIN.
6229.1' LTD HIGH WATER
6223' LTD LOW WATER
6193'
BACKSHORE
FORESHORE
NEARSHORE
LAKEZONE

Source: TRPA

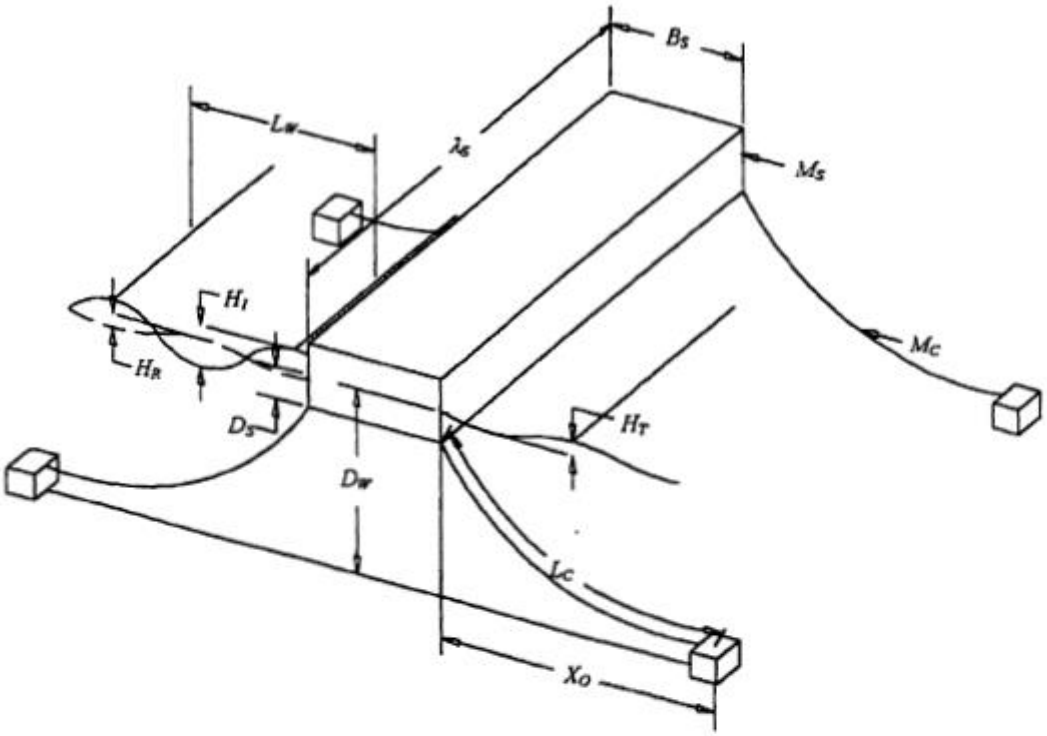


Figure 2.8: Floating Breakwater Nomenclature

Table 2.2: Floating Breakwater Nomenclature

Structural	Mooring	Wave
B_S - *width*	L_C - *chain length*	H_I - *incoming height*
λ_S - *length*	M_C - *chain mass/length*	H_R - *reflected height*
D_S - *draft*	D_W - *water depth*	H_T - *transmitted height*
M_S - *mass/length*	X_O - *horizontal distance*	L_W - *wave length*
T_S - *sidesway period*		T_W - *wave period*

+

Source: Morey 1998

Appendix D

KINGS BEACH PIER ALTERNATIVE 2015 SCENIC ANALYSIS DATA

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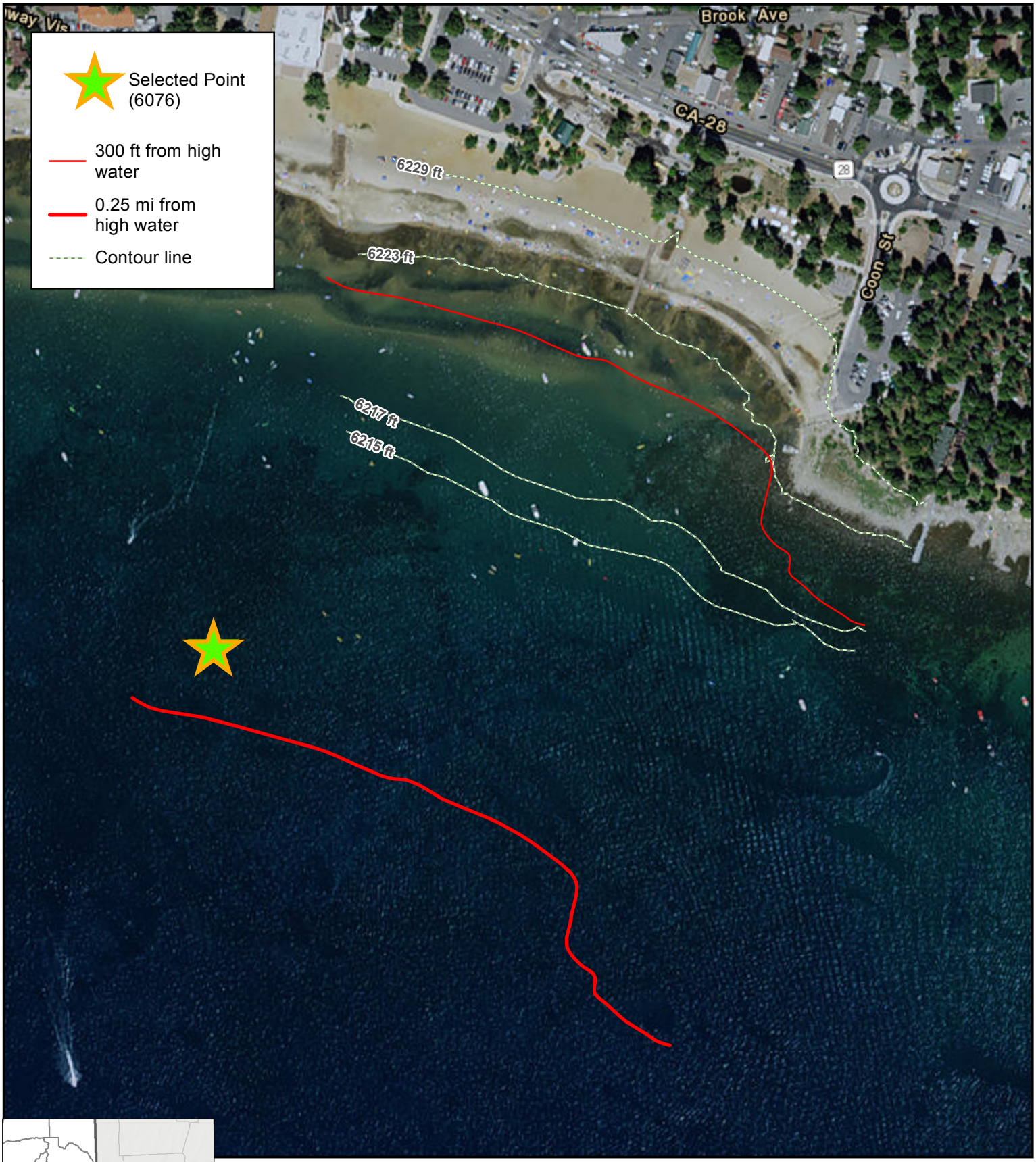

0 0.035 0.07 0.105 mi
0 0.035 0.07 0.105 0.14 km
1:3,400

Photo Location Map

Kings Beach Pier Concept Project
Placer County, California

USGS 7.5' Quad:
Kings Beach, CA-NV 1992
T16N, R18E; Section 19

Map Prepared By Cardno
11/24/2015

Cardno
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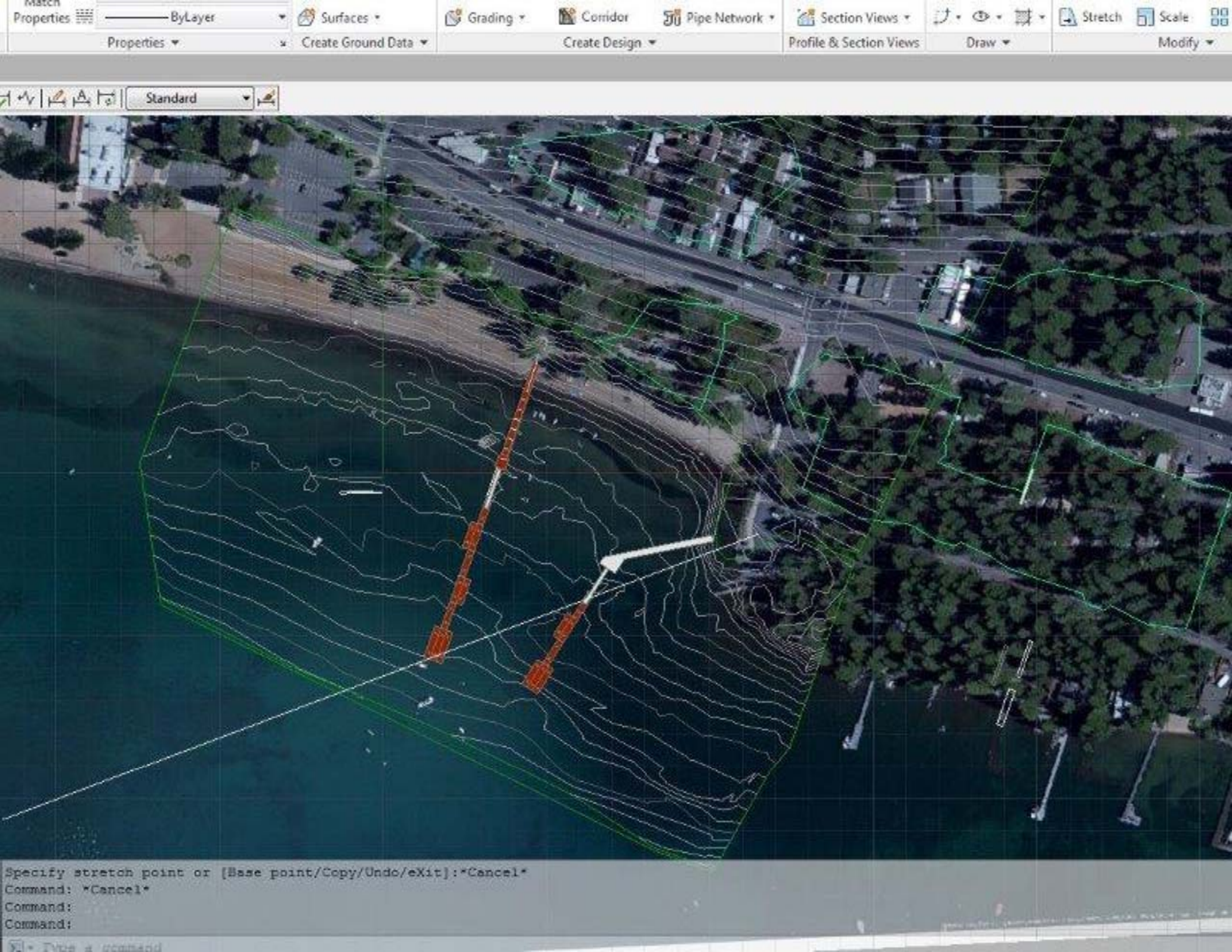
Zephyr Cove, Nevada 89448
ph. (775) 588-9069
fax (775) 588-9219
www.cardno.com

Map Projection: NAD 1983 UTM Zone 10N


Match Properties
ByLayer
Properties
Surfaces
Create Ground Data
Grading
Corridor
Pipe Network
Create Design
Section Views
Profile & Section Views
Draw
Stretch
Scale
Modify
Standard
Specify stretch point or [Base point/Copy/Undo/eXit]:*Cancel*
Command: *Cancel*
Command:
Command:
Type a command

Existing Pier (assume lake elevation 6226)					
Description			***Quantity***	***Area (SF)***	***Total (SF)***
Pier Posts	**Dia. (ft)**	**Height (ft)**			
Pier post (lake elevation 6226)	0.89	4.44	20	4.0	79.0
Pier post (lake elevation 6227)	0.89	3.44	2	3.1	6.1
Pier post (lake elevation 6228)	0.89	2.44	2	2.2	4.3
Pier post (high water - 6229.1)	0.89	1.45	2	1.3	2.6
Profile View	**Length (ft)**	**Width (ft)**			
Pier deck	207	1.06	1	219.9	219.9
Fence[1]	168	3.50	1	176.4	176.4
End View					
Pier deck	12	1.06	1	12.8	12.8
Fence [1]	10.33	3.50	1	36.2	36.2
TOTAL					**537.3**

Central Pier (assume lake evelation 6226)					
Description			***Quantity***	***Area (SF)***	***Total (SF)***
Pier Posts	**Dia. (ft)**	**Height (ft)**			
Pier post (fixed portion)	1.33	4.94	8	6.6	52.7
Pier post (floating portion)[2]	1.33	8.33	13	11.1	144.4
Profile View	**Length (ft)**	**Width (ft)**			
Pier deck (fixed portion)	212	1.06	1	225.3	225.3
Pier deck (float, includes low float dock)	329	1.67	1	549.4	549.4
Gangway[3]	80	varies	1	165.2	165.2
Fence[1]	212	3.5	1	148.4	148.4
End View					
Pier deck fixed)	20	1.06	1	21.2	21.2
Pier deck (float)	36	1.67	1	60.1	60.1
Gangway[4]	7	3.27	1	22.9	22.9
Fence	20	3.5	1	14.0	14.0
TOTAL					**1,403.5**

East Pier (assume lake evelation 6226)					
Description			***Quantity***	***Area (SF)***	***Total (SF)***
Pier Posts	**Dia. (ft)**	**Height (ft)**			
Pier post (fixed portion)	1.33	4.67	9	6.2	56.0
Pier post (floating portion)[2]	1.33	8.33	8	11.1	88.8
Profile View[5]	**Length (ft)**	**Width (ft)**			
Pier deck (fixed portion)	220.9	1.06	1	234.7	234.7
Pier deck (float, includes low float dock)	166.4	1.67	1	277.9	277.9
Gangway[3]	56.7	varies	1	130.0	130.0
Fence[1]	220.9	3.5	1	154.6	154.6
Pier End View[6]					
Pier deck (fixed)	35.4	1.06	1	37.5	37.5
Pier deck (float)	171.6	1.67	1	286.6	286.6
Gangway[3]	56.9	varies	1	130.0	130.0
Fence[1]	35.4	3.5	1	24.8	24.8
TOTAL					**1,421.0**

NOTES

1 Calculate fence as solid mass and then assume x% open; 80% proposed fence, 70% existing fence

2 Post extending above the float deck assuming top of post elevation 6236, lake elevation 6226, and depth of deck 1.67'.

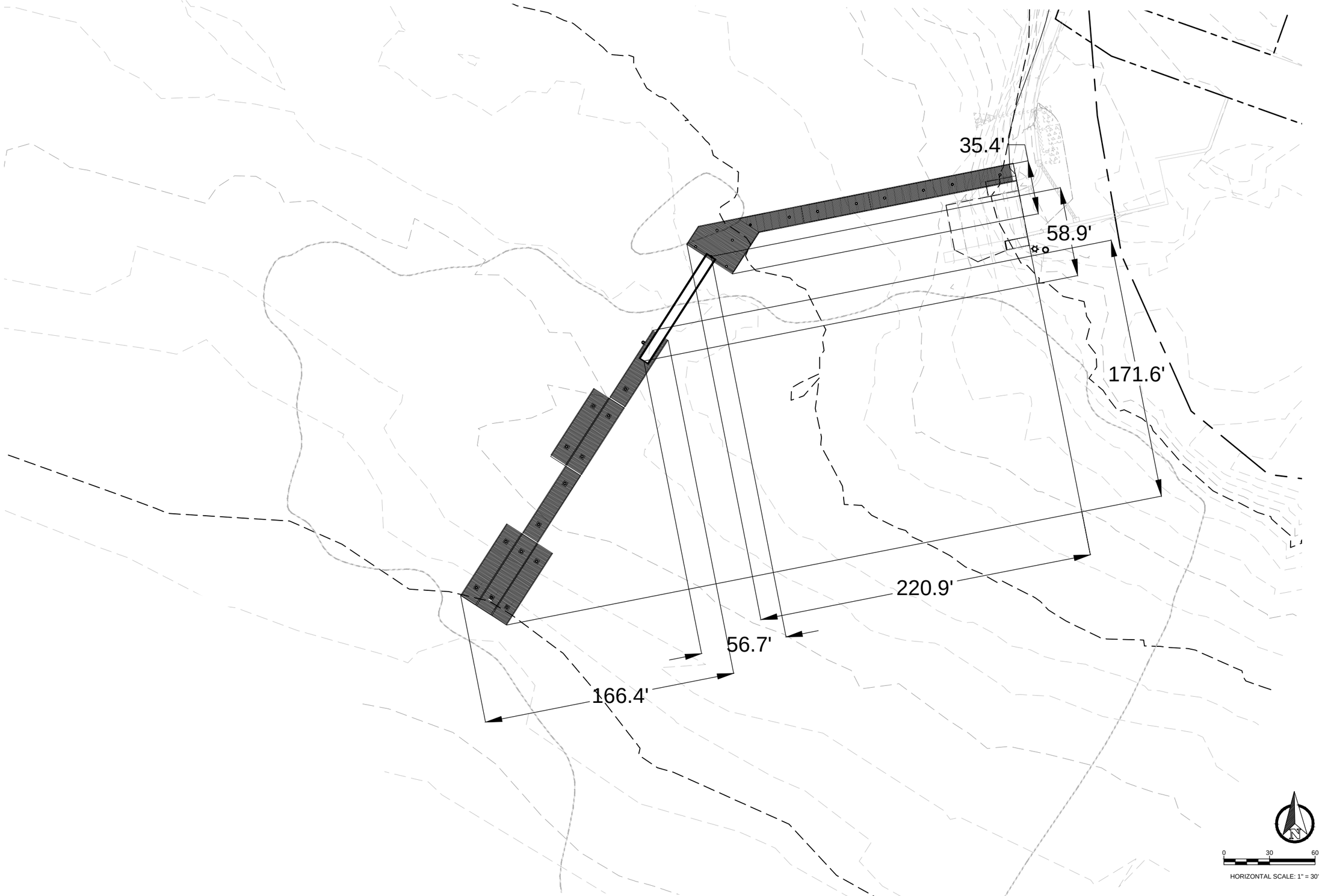
3 Gangway area profile calculated by CAD assuming 6' max height and 60% open; end view calculated based on area of visible gangway depth sloping between fixed pier and floating pier decks.

4 Gangway end view includes area between bottom of fixed pier and top of floating pier

5 Measured as viewed parallel to shore

6 Measured as viewed perpendicular to shore

Increase over Existing	
866.16	Central
883.64	East



NO.	REVISIONS	DATE

SEAL

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CALIFORNIA TAHOE CONSERVANCY

CALIFORNIA STATE PARKS

EAST PIER VISUAL MASS DIMENSIONS

KING'S BEACH PIER FEASIBILITY ASSESSMENT

PLACER COUNTY, CA

DATE:	AUG, 2015
DRAWN BY:	PB
CHECKED BY:	CM, VM
SCALE:	AS SHOWN
CARDNO JOB NO.	E313004004
FIGURE NO.	

EP-VM

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