IRRIGATION AUDIT

"WATER DISTRIBUTION AND UNIFORMITY EFFICIENCY ANALYSIS"

FOR

TIERRA RIDGE COUNTRY CLUB

AUGUST 2013

BY

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TURF-VU®

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EXECUTIVE SUMMARY

The Management and Board of Directors of the Tierra Ridge Country Club have contracted Turf-Vu to assess the irrigation systems current water uniformity and distribution relative to the irrigation systems ability to achieve a desirable visual presentation, support positive conditions for healthy turf, provide desirable, competitive conditions for play and be as efficient as possible in managing water, its precious resource.

During the visual inspection portion of the golf course review it was apparent that there were abundant and definable wet and dry areas throughout the golf course. While some of these areas appeared to be related to the irrigation of areas that had both sun and shade within the range of the same irrigation sprinkler coverage, others that had soil variations and wind disruption problems, the majority of the wet and dry areas appeared to be directly related to the performance of the irrigation system.

To clearly distinguish these areas and to quantify the extent of the problem Turf-Vu® who, with their Hawk-Eye System, collected and analyzed far-infrared (far-IR) and color camera imagery. The Hawk-Eye System is a new technology that identifies, distinguishes and quantifies turf grass canopy temperatures from which, in dry climates, soil moisture conditions can be inferred.

The methodology used was to find a golf hole that was representative of the conditions found throughout the golf course, study it and extrapolate the finding so as to quantify the average uniformity of water distribution on the golf course and project the benefits and cost savings that would likely occur from improving the more efficient application of water.

The following study illustrates that 20% of the documented area was found to be dryer than is desirable to grow healthy, aesthetically pleasing, playable turf, while 50% was found to be wet or very wet for either the health of the plant or for the desired conditions for good playing conditions.

In this report phase we have projecting a 20% more efficient irrigation system that would achieve a possible annual savings of $105,835 by reducing water and power usage, not to mention a marked improvement in the aesthetics, health and playability of the golf course turf.

AUTHORIZATION, PURPOSE AND GOALS OF STUDY

The Management and Board of Directors of the Tierra Ridge Country Club have Turf-Vu to conduct a performance review of the golf course irrigation and pumping system. The purpose of this phase of the review is to assess the irrigation systems current water uniformity and distribution relative to the irrigation systems ability to achieve a desirable visual presentation, support positive conditions for healthy turf, provide desirable, competitive conditions for play and be as efficient as possible in managing this precious resource.

During the last three decades our industry has seen a considerable increase in the use of innovative irrigation technology to improve the efficient application of water on golf courses. We have seen almost yearly improvement in the development of the pressure compensating valve-in-head irrigation sprinklers, the innovation and improvement in personal computers based central irrigation control systems with such features as the control of water flow within the limits of the hydraulics and pumping systems and the use of weather stations to indicate the amount of water needed each day.

When considering the issues we found during the study we have applied the benefits we know exist in the use of the newest, most efficient technology when projecting improvements.

SELECTING THE STUDY AREA

During the visual inspection portion of the golf course review it was apparent that there were abundant and definable wet and dry areas throughout the golf course. While some of these areas appeared to be related to the irrigation of areas that had both sun and shade within the range of the same irrigation sprinkler coverage, others that had soil variations and wind disruption problems, the majority of the wet and dry areas appeared to be directly related to the performance of the irrigation system.

The criteria we used for selecting the test site was to have the area be a par 4 hole approximately 400 yards long that was reflective of the general turf conditions found throughout the golf course. This area would represent approximately 5% of the total course area. Second, the selected areas should have the general topography, turf, landscaping and climate consistent with most other areas of the golf course

We selected hole #9 on the championship course for the study.

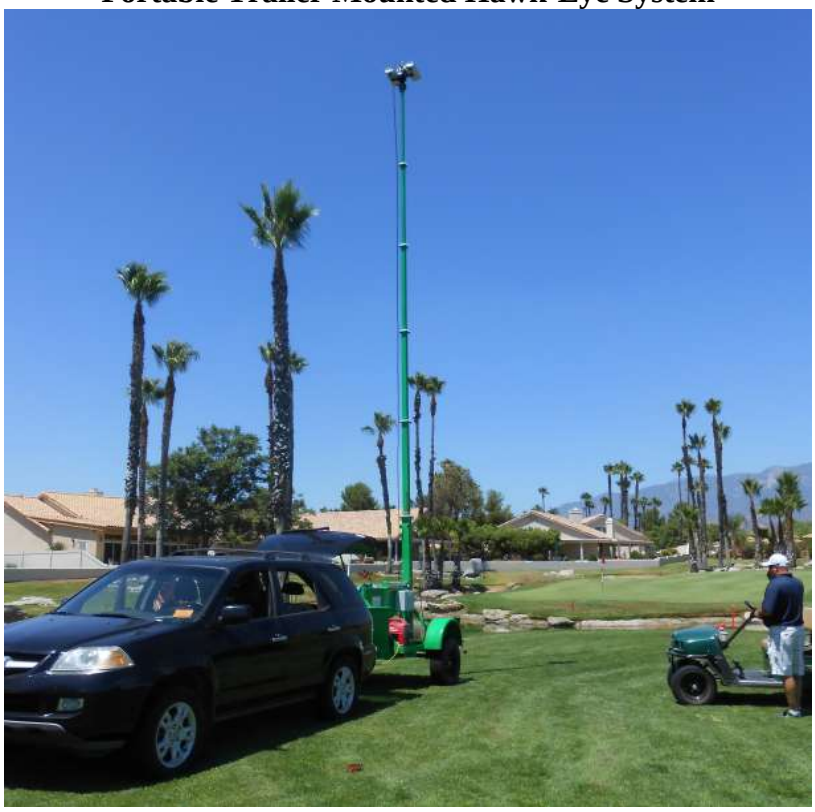
TECHNOLOGY AND EQUIPMENT USED FOR STUDY

To clearly distinguish these areas and to quantify the extent of the problem Turf-Vu® used their Hawk-Eye System. The Hawk-Eye is a unique remote sensing system with an in-situ meteorological sensing and visual, near-IR, and far-IR imaging capability. Turf-Vu®, a division of ItriCorp provides a web interface that allows one to view their imagery and decision aids in the field and across the internet. This is new technology to the turf grass management industry which facilitates the immediate identification of turf stress by allowing the user to

view and asses canopy temperature in real-time. In dry climates soil moisture conditions can also be inferred from the imagery.

The portable Hawk-Eye System can be powered by a small generator or batteries and is operated with a telescoping mast than can be raised to 35-50 feet for better perspective of the areas being viewed and studied.

Portable Trailer Mounted Hawk-Eye System



The Hawk-Eye System is a high quality, high resolution camera system with a very high pixel density capable of high resolution clear visual color, and thermal (far-IR) photographic images. The unit transmits its photo images locally by Wi-Fi hot spot and via a cellular card to the Internet.

Hawk-Eye's far-IR camera senses the real-time temperature signatures of the surfaces being monitored then displays these images in an array of colors from red (hot / infer very dry), orange, yellow, green, light blue, dark blue to purple (cool / infer wet / and or shady). The imagery is observed and collected in real-time by the field technician via the Hawk-Eye's Wi-Fi and data based for post processing. The imagery data is also made available via internet and stored in a online cloud service provided by Turf-Vu® for access by other analysts and consultants across the internet. Internet viewers can also view the real-time collection.

Experience has shown that these differential temperature signatures directly relate to leaf tissue moisture and in dry climates soil moisture conditions can be inferred. A far-IR hand held laser surface temperature sensor was used to validate the observed canopy temperatures and 'calibrate' the color palate. Then to correlate and quantify the thermal images to actual soil moisture we used a digital three point soil moisture meter. In addition to moisture we used a far-IR hand held laser surface temperature sensor to document the actual temperatures of the turf canopy.

STUDY PROCESS AND DATA COLLECTION

The study was conducted on August 7, 2013 between the afternoon hours of 1:00 – 4:00 PM.

An 'as-built' drawing of the irrigation system and data collection points are provided on page 6.

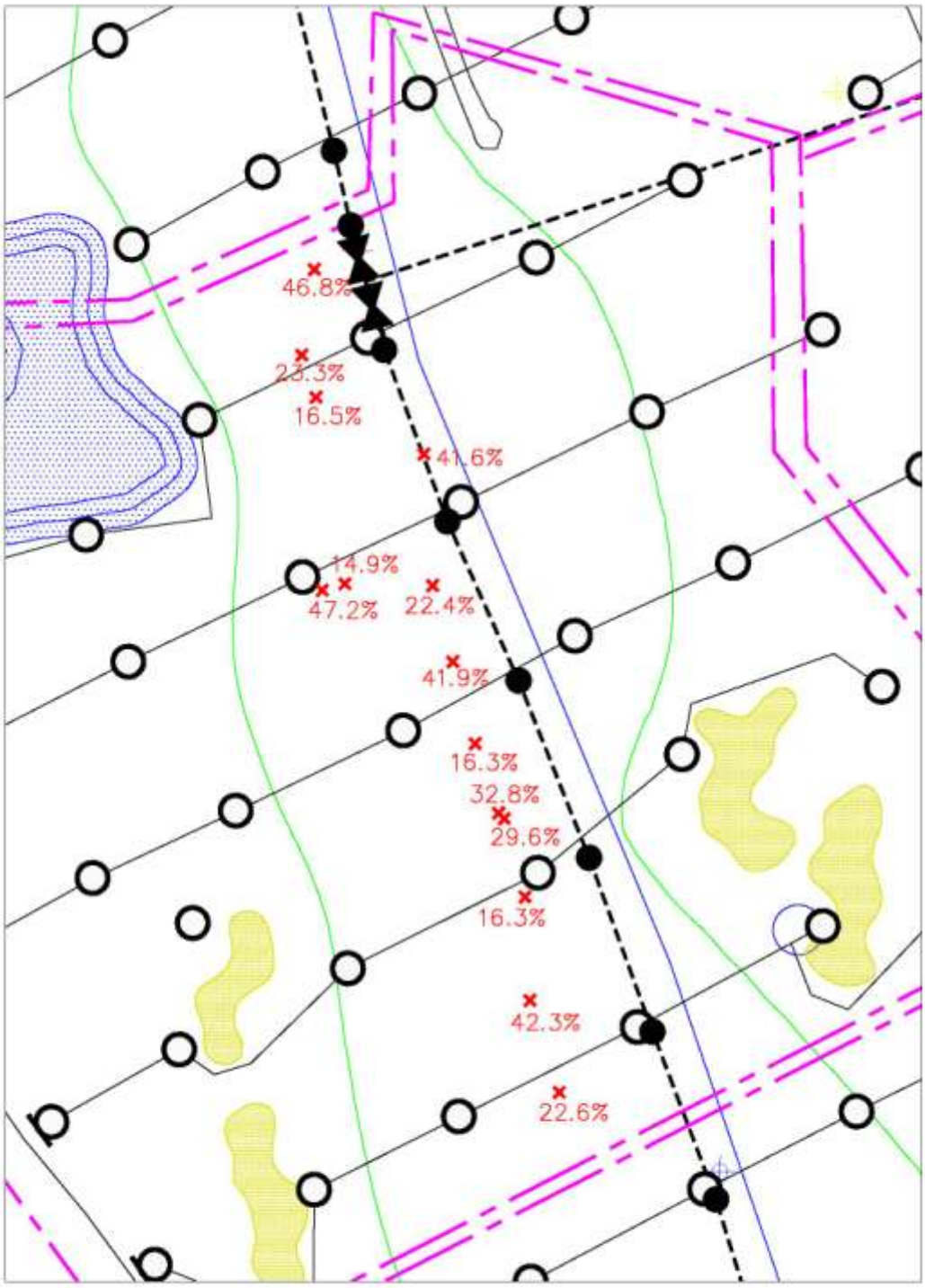
Weather conditions were warm (94°F), dry (27% RH), light winds (8 knots), unlimited visibility, and very few clouds (scattered high cirrus).

The Hawk-Eye was set up at four imaging stations on #9 fairway and collected both thermal (far-IR) and visual color photos. By placing reflective banners next to each irrigation head that are viewable in the thermal and the visual imagery it is possible to relate the thermal signatures of the fairway to individual irrigation sprinklers and the water/soil moisture patterns can be directly inferred.

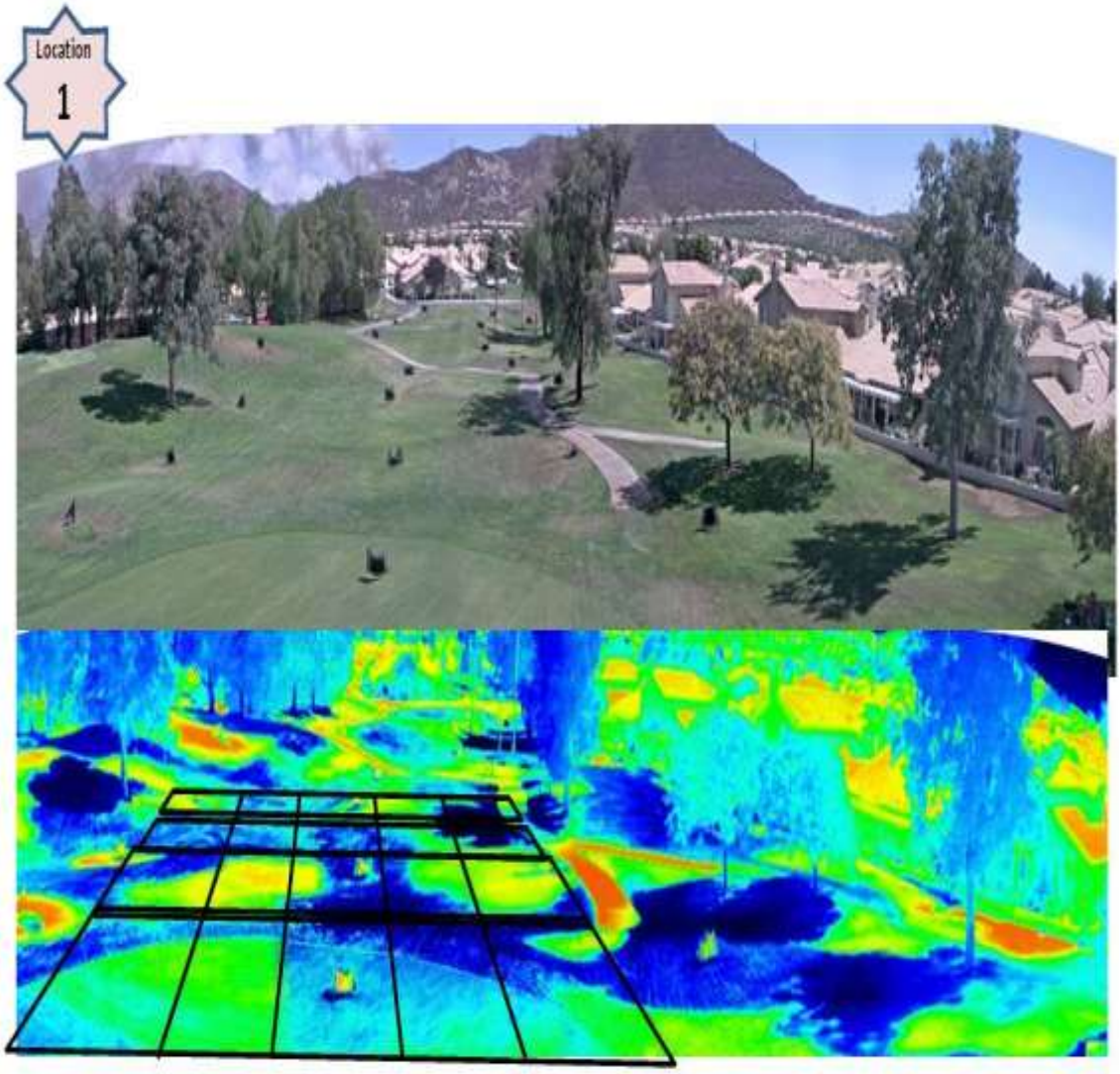
The mosaic images (see pages 7-10) were then integrated into a composite mosaic and processed to assess the thermal character and estimate the percentage of area occupied by the canopy temperatures over the extant of #9 fairway depicted by the colors: orange, yellow, green, light blue, and blue. The temperatures in view ranged between 80°F - 110°F. The table below lists the average temperature attributed to the color palate characterizing the canopy temperatures.

For the definable patterns in the mosaic imagery we measured representative canopy temperatures and soil moisture percentages (page 6) to quantify the differences for each of the areas of distinguishable color groups.

Color Classification	Canopy Temperature
Orange (very warm // infer very dry)	104° F
Yellow	98° F
Green	94° F
Light Blue	90° F
Blue (cool // infer very moist)	86° F

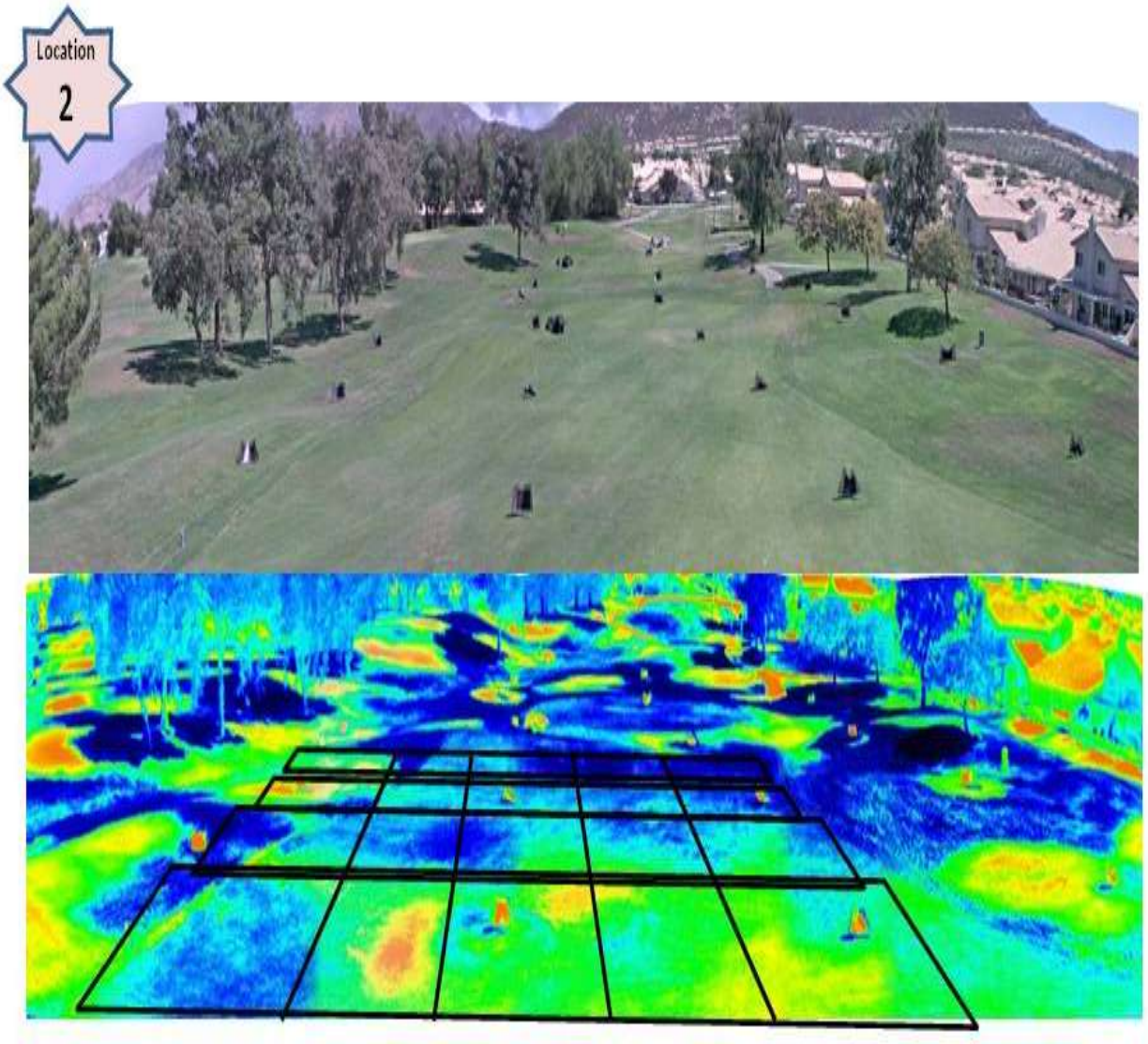


#9 Fairway – Soil Moisture Percentage



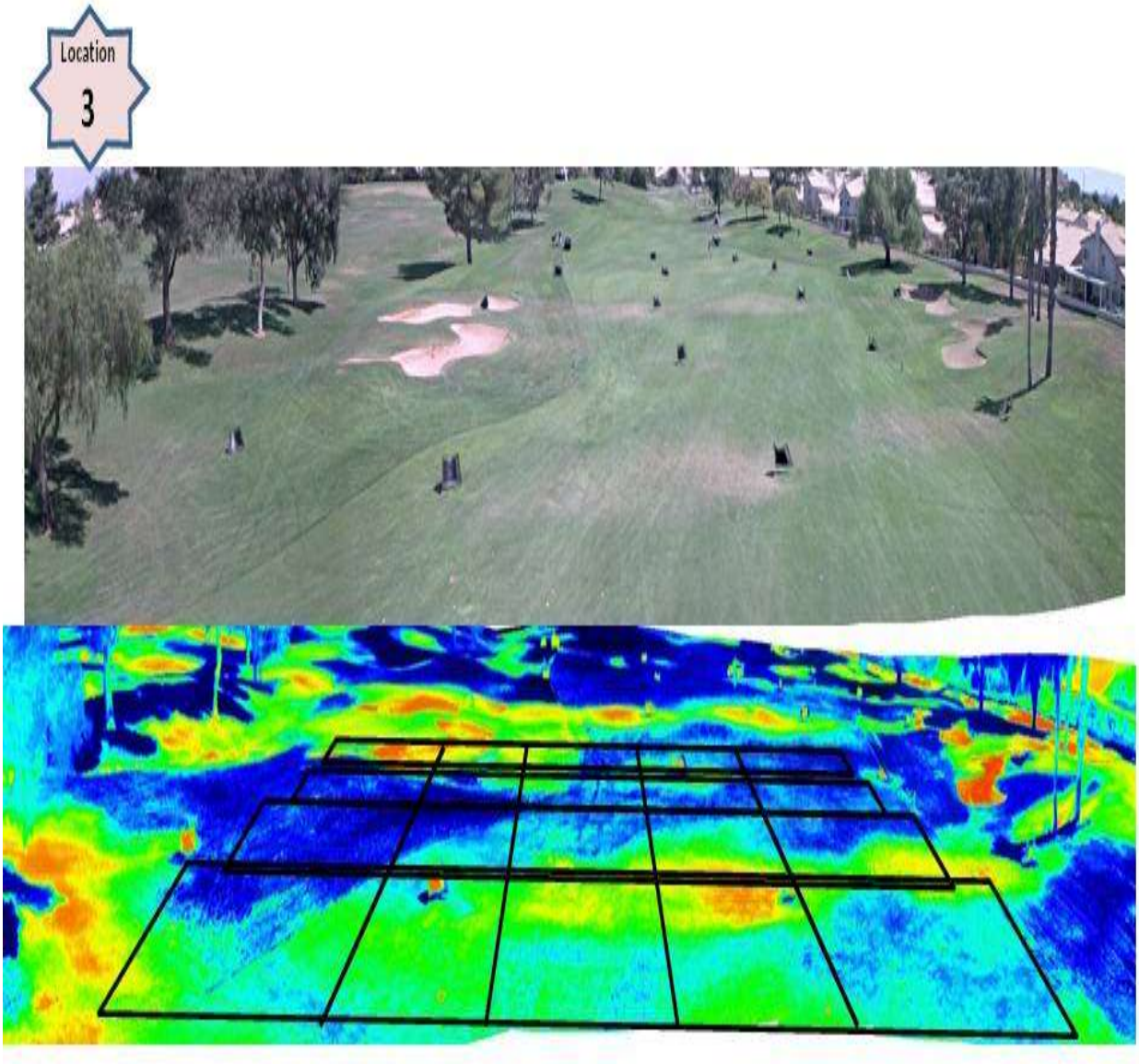
FACING TEE ON HOLE # 9

Classification	Canopy Temperature	% Coverage in Fairway
Orange (very warm // infer very dry)	104° F	10
Yellow	98° F	15
Green	94° F	30
Light Blue	90° F	25
Blue (cool // infer very moist)	86° F	20



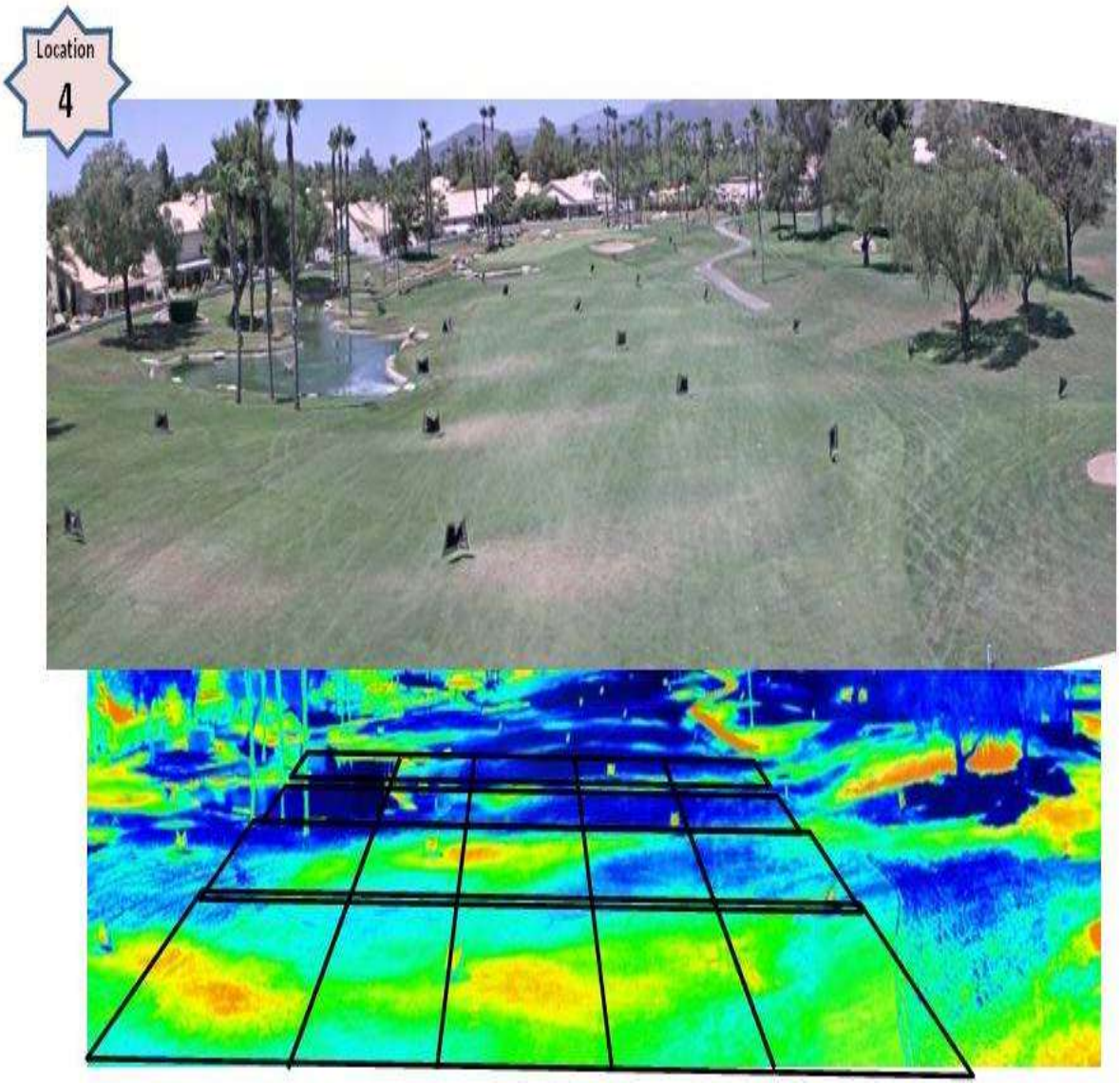
FACING TEE ON HOLE # 9

Classification	Canopy Temperature	% Coverage in Fairway
Orange (very warm // infer very dry)	**104° F**	**10**
Yellow	**98° F**	**5**
Green	**94° F**	**30**
Light Blue	**90° F**	**40**
Blue (cool // infer very moist)	**86° F**	**15**



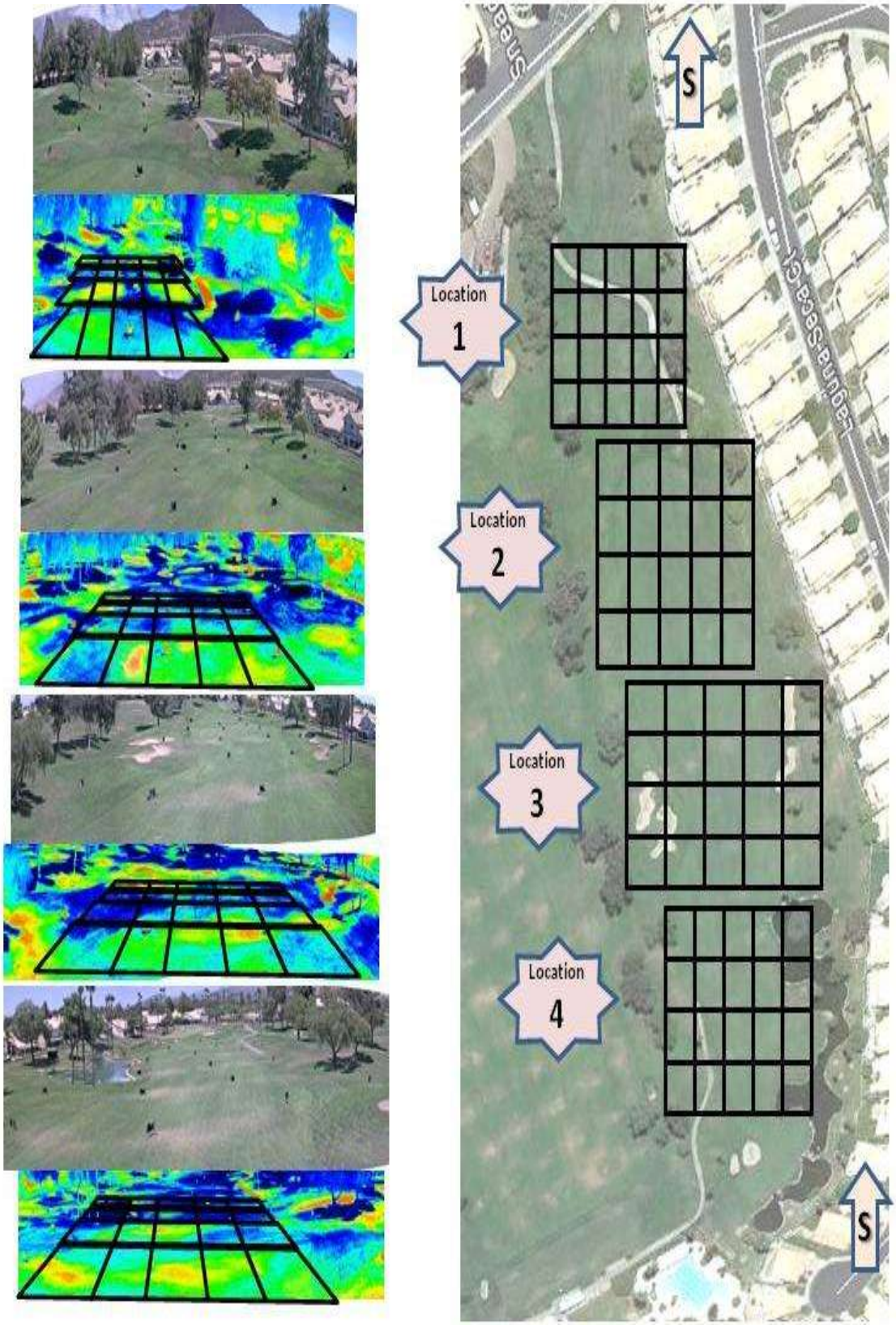
FACING TEE ON HOLE # 9

Classification	Canopy Temperature	% Coverage in Fairway
Orange (very warm // infer very dry)	**104° F**	**5**
Yellow	**98° F**	**5**
Green	**94° F**	**35**
Light Blue	**90° F**	**25**
Blue (cool // infer very moist)	**86° F**	**30**



FACING GREEN ON HOLE # 9

Classification	Canopy Temperature	% Coverage in Fairway
Orange (very warm // infer very dry)	**104° F**	**15**
Yellow	**98° F**	**5**
Green	**94° F**	**30**
Light Blue	**90° F**	**15**
Blue (cool // infer very moist)	**86° F**	**35**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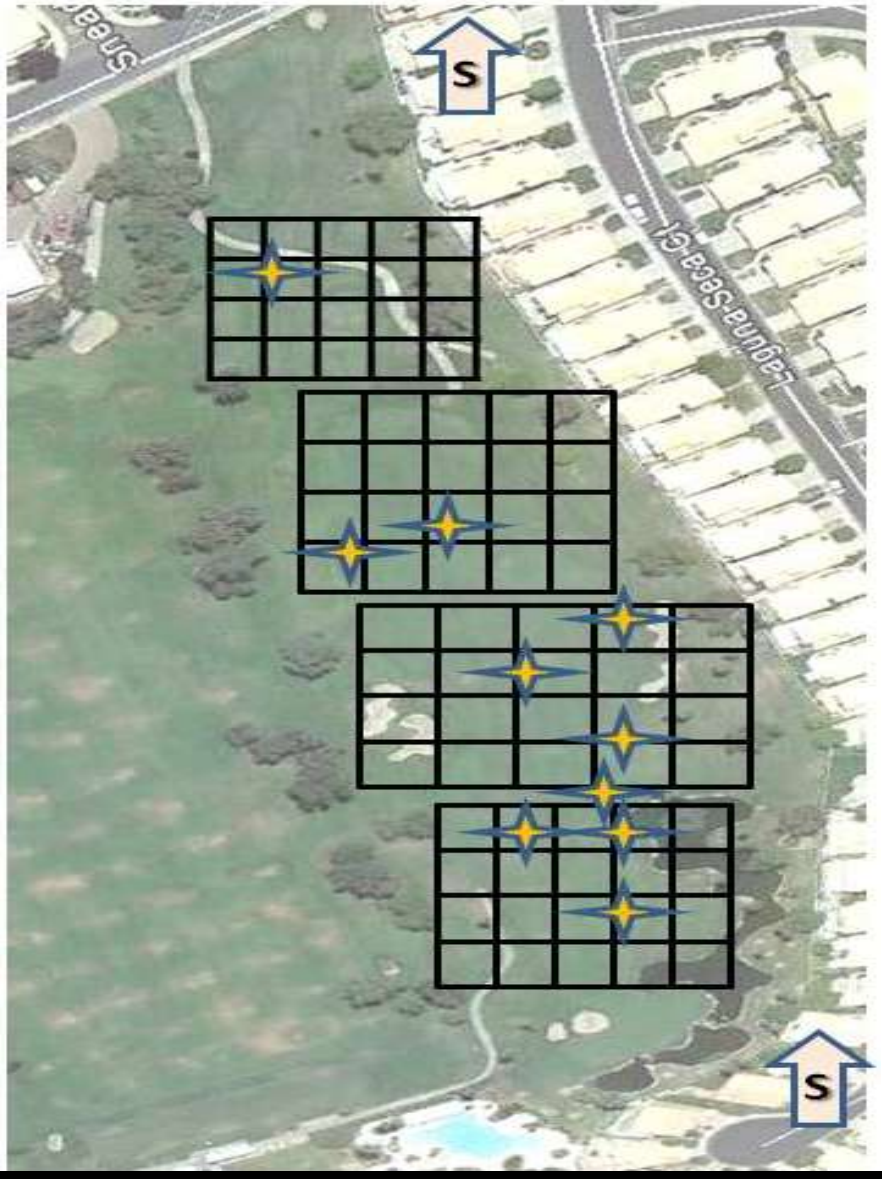

Overall Classification	Canopy Temperature	Inferred Moisture (% WC)	% Coverage in Fairway
Orange (very warm // infer very dry)	104° F	16 %	10 %
Yellow	98° F	23 %	10 %
Green	94° F	30 %	30 %
Light Blue	90° F	37 %	25 %
Blue (cool // infer very moist)	86° F	44 %	25 %

TIERRA RIDGE C.C. IRRIGATION AUDIT SUMMARY

WEATHER	STUDY TIME	1:00	4:00	PM	
	SOLAR (SUNLIGHT)	CLEAR / SUNNY	1760	PHOTONS	
	AIR TEMPERATURE	VERY WARM	94 to 96	DEGREES (F)	
	WIND	LIGHT WIND	3 to 5	MILES PER HOUR	
	HUMIDITY	DRY	27	PERCENT	
STUDY AREA	AREA STUDIED - #9 HOLE	8.37	ACRES	3.9% OF TOTAL ACREAGE	
	18 HOLE GOLF COURSE, EXECUTIVE COURSE AND DRIVING RANGE	214.65	ACRES	TOTAL ACREAGE	
STUDY RESULTS	**TEST AREA - HOLE #9 (CHAMPIONSHIP COURSE)**				
	FAR - INFRA RED PHOTO IMAGE RESULTS	DESCRIPTION	TURF CANOPY TEMPERATURE DEGREES (F)	PERCENT SOIL MOISTURE	PERCENT OF AREA STUDIED
	ORANGE	VERY DRY	104	16	10
	YELLOW	DRY	98	23	10
	GREEN	OPTIMUM	94	30	30
	LIGHT BLUE	WET	90	37	25
	DARK BLUE / PURPLE	VERY WET	86	44+	25
	PERCENTAGE OF OPTIMUM COVERAGE				30%

Turf-Vu®
Beautifully Healthy Turf
A Division of ItriCorp - No Boundaries

TIERRA RIDGE C.C. IRRIGATION AUDIT SUMMARY

HISTORIC WATER AND POWER USAGE350	AVERAGE ET / YEAR (THE AREA)	56.6	INCHES		
	TARGET WATER USAGE BASED ON 100% ET	1,012.2	ACRE FEET		
	ACTUAL ANNUAL AVERAGE WATER USAGE (5 YEARS AVERAGE)	1,242.5	ACRE FEET	$434,175	YEARLY
	ANNUAL AVERAGE ELECTRIC USAGE (5 YEARS AVERAGE)	N/A	KILOWATT HOURS	$95,000	YEARLY
	ESTIMATED CURRENT SYSTEM UNIFORMITY				< 50%
PROJECTED WATER AND POWER USAGE					
	PROJECTED ANNUAL AVERAGE WATER USAGE – 80% ACTUAL	994.0	ACRE FEET	$347,340	YEARLY
	PROJECTED ANNUAL AVERAGE ELECTRIC USAGE	N/A	KILOWATT HOURS	$76,000	YEARLY
	PROJECTED SYSTEM EFFICIENCY				80%
PROJECTED WATER AND POWER SAVINGS	ANNUAL AVERAGE WATER USAGE (5 YEARS AVERAGE)			$86,835	WATER
	ANNUAL AVERAGE ELECTRIC USAGE (5 YEARS AVERAGE)			$19,000	POWER
	TOTAL PROJECTED SAVINGS			$105,835	YEARLY

CURRENT DIFFICULTIES IN ACHIEVING IRRIGATION UNIFORMITY

In reviewing the collected data illustrated on pages 13-14 the analysis shows that there is approximately 40 acres (20%) of the two golf course that shows signs of water stress, whereas over 100 acres (50%) have moisture above optimal condition.

In reviewing the photo patterns on pages 7-10 it is clear that many of these inconsistencies are immediately adjacent to each other.

The primary goal of the Golf Course Superintendent's maintenance operation is to provide a consistent, healthy, aesthetically pleasing golf course with superior playing conditions. It is clear that this is not possible with the performance of the existing irrigation system as it currently functions.

If the superintendent increases water to decrease dry areas, wet areas would increase. On the other hand if the Superintendent manages the irrigation system to decrease wet areas, dry areas would increase.

Just like a surgeon or a mechanic, their ability to perform is dependent on both their training and having the right tools to do an effective, efficient job.

In the arid western US having an efficient irrigation system is paramount to providing a superior golf course year round. Clearly, improvements or replacement of the existing irrigation system is needed.

STUDY FINDINGS AND RECOMMENDATIONS

An analysis of the imagery illustrates that 20% of the documented area was found to be dryer that desirable to grow healthy, aesthetically pleasing, playable turf, while 50% was found to be wet or very wet for either the health of the plant or for the desired conditions for good playing conditions. Almost half of the irrigation water being applied is not being distributed such to produce an environment for desirable, healthy turf or conditions consistent with good playing.

We strongly recommend that the replacement of the pump station along with a comprehensive review of the entire irrigation system (hydraulic system, irrigation head and their nozzle performance, irrigation head placement and spacing along with the sprinkler field satellite function and location and the function and effective use of the central control system and associated wiring).

The purpose of this expanded study would be to find ways to achieve a marked increase in the efficient use and distribution of water thus greatly improving the course conditions by reducing wet and dry areas.

Also a competing goal would be to seek ways to make the application of water more efficient thus achieving a more responsible use of both water and power thus reducing costs and becoming a better environmental steward.

In this Phase I report we have projecting, what we feel it is a reasonable goal of making a 20% more efficient irrigation system that would, by reducing water and power usage, and better distribute water to the areas needed would create a much more aesthetically pleasing, health and playability golf course with a possible savings of $105,835 per year.

PROFILE OF AUTHOR'S CREDENTIALS

RANDY FREUND

Specializing in Golf Course Irrigation

Objective

Our goal is to assist the Golf Course in obtaining an efficient and reliable irrigation system. Starting with the preliminary planning, to the final programming of the irrigation computer. Leaving the Golf Course with a fully operational system to assist the Superintendent in maintaining the Golf Course to the highest possible standards.

Services

Complete irrigation design and construction documents; Global Positioned Satellite (GPS) generated Golf Course Base Maps; Field layout and observation; GPS generated irrigation As-Stakes and As-Built plans; Irrigation computer programming; Existing system analysis; Construction budgeting; and Annual operations expense.

All the above services are performed in house, by a professional ASIC member. None of these services are out-sourced.

Insurance

One million Professional Liability (Errors and Omission)
One million General Liability
One million Auto Liability.

Principals

Randy Freund

After receiving an Associates degree in Technology from Morrison Institute of Technology, in Morrison Illinois, Randy was employed by Formost Construction Co. (an international Golf Course Irrigation Contractor). Where his primary duties were Estimating, Design and Field Supervision. In June of 1990 Randy started his own Golf Course Irrigation Design Company. Over the past twenty three years Randy has been involved in all aspects of Irrigation Design and Consulting for golf courses, including Design, Field services and irrigation computer programming.

Professional Associations:

Professional member of the American Society of Irrigation Consultants (ASIC).
Member of the Irrigation Association (IA).
Golf Course Superintendents Association of America (GCSAA).

WM. KENT ALKIRE, II

Agronomy / Environmental Services / Design Coordination / Construction Management

EDUCATION

B.Sc., Soil Science, California Polytechnic State University, San Luis Obispo, California, 1975
A.Sc, Turf Management, Mt. San Antonio College, Walnut, California 1973
A.Sc, Plant Science, Mt. San Antonio College, Walnut, California, 1973

EXPERIENCE

June 1989 to Present

Golf Ventures International, Simi Valley, California. Golf Ventures International (GVI) is a golf course agronomy, design support and technical service company. GVI provides a wide range of agronomic, environmental, construction management, and other related golf course services. GVI specializes in assisted acquisition, development and remodel of golf courses into environmentally safe golf courses that are also aesthetically pleasing, economically functional and have a high standard of maintenance quality. Kent Alkire, principal of GVI, has more than a quarter century of experience in agronomy, golf acquisitions, golf course development support, construction and operation. Kent has provided services to over 290 golf courses and clients and has been involved in over 100 golf course construction or remodel projects working in over 36 states and 17 countries.

January 1991 to November 1994

Founding Partner, Environmental &Turf Services, Inc. Environmental & Turf Services was dedicated to Risk Assessment of Environmentally Responsible Integrated Golf Course Management Plans (IGCMP), Integrated Pest Management Plans (IMP), and Erosion Management Plans (EMP) developed by GVI. Environmental Scientists use a variety of Risk Assessment methods which include dilution calculator, computer modeling and others developed to help assess and refine the IGCMP, IMP, and EMP plans to achieve the standards of "no significant impact".

June 1989 to January 1991

General Manager / Superintendent, Simi Hills Golf Course. Alkire was responsible for all business and course management decisions. During the 3 years of management Alkire increased play 10% gross revenues 24% and net profits 10% while greatly improving the quality of the golf course condition.

August 1986 – April 1989

Western Regional Agronomist and Director of Environmental Services, Jack Nicklaus Golf Services. Worked with clients at project inception to help define unique project demands to be included in the construction specifications of the project; developed Integrated Golf Course Management Plans to help address impact issues related to entitlement and operation; represented clients on agronomic, environmental and technical issues as needed during planning, entitlement, construction and grow-in. Continued working with the client and the site staff of JNGS via monthly site visits to help refine and perfect the golf course from beginning of design, construction and through the opening of the course until maturity goals were met.

December 1983 – August 1986

Golf Course Construction Manager, Wood Ranch Golf Club. Oylmpia/Roberts Group. Helped refine the course design features; designed the landscape plans, routed the cart path, developed the sprinkler control program, designed the maintenance facility, defined the grassing types and limits, developed landscape and construction specifications, and supervised the construction process as the Project Manager for the Owner.

May 1979 – June 2007

Golf Course Superintendent. Managed crews, finances, and resources of the private, public and resort golf and country clubs listed below:

Wood Ranch Golf Club, Simi Valley, CA
Brentwood Country Club, Los Angeles, CA
Simi Hills Golf Club, Simi Valley, CA
Monterey Country Club, Palm Desert, CA
Candlewood Country Club, Whittier, CA
Tierra Rejada Golf Club, Moorpark, CA

March 1978 – April 1979

Soil Scientist, State of Idaho, Soil Conservation Service. Performed soil survey classification and aerial photo interpretation work in Caribou County, Idaho.

December 1977 – March 1978

Central Construction Controller/Auditor, HUD Disaster Relief Services. Provided temporary disaster relief services for the 1977 California flood victims. Specific duties included the processing of damage claims, claim validation, and repair funding.

March 1975 – December 1977

Associate Expert Land Suitability Officer, Peace Corps/United Nations. (Food and Agriculture Organization). Used and performed aerial photo interpretation to identify soil groups. Performed field soil survey work to classify soils and to identify site appropriate agricultural applications. Used field and climatological data to help construct a land use model to classify the entire country of Sierra Leone, West Africa into land suitability classification groups.

December 1974 – March 1975

Course Lecturer, Milton Margai Teachers Training College. Lectured in the subjects of Soil Science and Farm Management/Surveying in the country of Sierra Leone, West Africa.

February 1970 – December 1974

Head Irrigator and Equipment Operator, Glendora Country Club, Glendora, California. Worked as a full time and part-time employee while attending college.

January 1963 – January 1970

Manager/Worker, Alkire's Green Carpet Sod Farm and Nursery. Managed and worked in family owned business in Duarte, California in all facets of turf and landscape sales and production.

Memberships

USGA *Wildlife Sanctuary* *Sierra Club* *Arbor Day Foundation* *Nature Conservancy*

Thermal image data and analysis provided by Turf-Vu® (http://turf-vu.com) a division of ItriCorp

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Jim Etro / 703-489-8507 / j.etro@turf-vu.com