GCSAA

BEST MANAGEMENT PRACTICES FOR UTAH GOLF COURSES

Utah Chapter

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Golf Course Superintendents Association of America

FALL 2019

Murray Parkway, Murray, UT; (Photo courtesy of Dave Carruth, Superintendent).

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Acknowledgements

Golf Course Superintendents Association of America

The Golf Course Superintendents Association of America (GCSAA) is the professional association for the men and women who manage and maintain the game's most valuable resource — the golf course. Today, GCSAA and its members are recognized by the golf industry as one of the key contributors in elevating the game and business to its current state.

Since 1926, GCSAA has been the top professional association for the men and women who manage golf courses in the United States and worldwide. From its headquarters in Lawrence, Kansas, the association provides education, information and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession and enhance the enjoyment, growth and vitality of the game of golf.

Environmental Institute for Golf

The Environmental Institute for Golf (EIFG) fosters sustainability by providing funding for research grants, education programs, scholarships and awareness of golf's environmental efforts. Founded in 1955 as the GCSAA Scholarship & Research Fund for the Golf Course Superintendents Association of America, the EIFG serves as the association's philanthropic organization. The EIFG relies on the support of many individuals and organizations to fund programs to advance stewardship on golf courses in the areas of research, scholarships, education, and advocacy. The results from these activities, conducted by GCSAA, are used to position golf courses as properly managed landscapes that contribute to the greater good of their communities. Supporters of the EIFG know they are fostering programs and initiatives that will benefit the game and its environment for years to come.

United States Golf Association

The United States Golf Association (USGA) provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open as well as 10 national amateur championships, two state team championships and international matches, and celebrates the history of the game of golf. The USGA establishes equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is one of the world's foremost authorities on research, development and support of sustainable golf course management practices.

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Introduction

As a demonstration of their commitment to protecting Utah's natural resources, Utah golf course superintendents have partnered with university scientists and state regulatory agencies to develop best management practices (BMP) for golf course management in Utah. This guide has been developed specifically for Utah golf courses but is not meant to serve as ordinance or law. The Utah BMP Guide is comprised of informational material, to be used in developing golf course management policies aimed at improving the sustainability of Utah's golf courses.

Golf courses contribute positively to the environment by providing large areas for water infiltration and wildlife habitat and contributing positively to improved air quality and reduced soil erosion. Golf courses also provide benefits to the surrounding community by improving aesthetics, providing area for physical recreation, reducing "heat island" effects, and contributing to the local economy.

Best Management Practices are science-based recommendations and are intended to present practical and sustainable management strategies for golf course superintendents, while continuing to ensure quality playing surfaces for golfers. Due to the highly variable environmental conditions across Utah, not all BMP are practical or necessary at all Utah golf courses. Additionally, because of budget and staff limitations, stakeholder and client expectations, and site-specific management decisions, not all golf courses can achieve all of the BMP. However, when relevant and feasible, small changes that meet the goals of BMP can be implemented. These BMP are meant to act as a starting point for golf courses in Utah to move toward sustainable practices; whenever possible, more robust measures can, and should, be taken to improve upon these environmental practices and to ensure the sustainable future of golf in Utah.

This document was developed using the latest science-based information and sources. The latest version of this document will be posted on the Utah Golf Course Superintendents Association Website as well as on the GCSAA BMP Website. As of the time of this publication, the information was the latest available. Some sources are updated regularly, and regulations may change. This document will be updated periodically, but changes may occur between updates.

Foreword

The drought may last another week or a million years. I did not care much either way – I was in this nightmare of hopeless dry till the end of it. Rain was not something I had known, at least in useful amounts on my golf course in 104 days but who is counting – who cares – it may as well have been dry forever. It seemed the relief of monsoon moisture would not come to Utah at all that dust bowl dry summer of 2018. The monsoon surge was stuck down somewhere off the Mexican Baja spinning, firing but with no heart to visit anywhere in the West. Most days I just settled for the hope that perhaps a few orographic white cumulous clouds might float overhead providing a moments sorry shade for my tired golf greens. Compounding dry was the constant smoke from a dozen fire complexes burning throughout the Strawberry Plateau. As a young man I had known summers of smoke in the Okanogan Country of Washington and Bitterroot of Montana but lately the constant heat, constant smoke, constant dry and constant anxiety of being a golf course superintendent was making me feel much more an old man.

That late afternoon in late July – I was sitting in my office. I had my chair tipped back and my feet kicked up on the edge of my desk. I often sit like that in the afternoon – trying to relax. I was looking at a large canvas photo hung in my office that my father had taken several years ago. The picture is of an endless field of alpine lupine resting high above a valley below. Purple as perfect as God and his son can create. In the middle of that purple was my son. He was resting in a backpack rising above my wife's long blonde hair. Their bodies, a mother and her son, floating on momentary flowers and framed by a small halo of blue sky surrounded by textured thunder clouds. At least in my experience a more perfect picture does not exist. But, as all wild flowers are fleeting in their beauty, so, too, is life. My father would die not all that long after he took that picture.

But, just a little bit in that picture – in my father's art – in those afternoons – there is something of his relic left for me. I certainly cannot visit with his ghost to talk about golf, kids, or even nothing. That opportunity vanished like a pickup truck driving into a phantom mirage of highway heat at the edge of the Great Basin salt country. But sometimes the butterflies seem far out of formation and tears sit, wanting some place to go, but they only sit. My father was a caring man, but crying was not a part of him, at the least the part he shared. Genetics and mannerisms seem to have passed well down the line. The land was dry and so, too, were my eyes. My almost-tears would almost-have to do.

Relaxing and quiet often seem in small quantity in the late afternoon for a golf course superintendent. My office would soon be surrounded by staff needing all manner of things – advice, direction, reassuring, scolding, money. It was unlikely I would have endurance for any of them, and I did not want to test my remaining patience. I awoke my awful black dog from her couch. My black dog sleeps more now than she used too – age makes us dream at unassigned times. We jumped into a golf cart and drove. Heading for the upper golf course and about the only place I knew would have relative quiet on that dry, hot, smoky July day.

There is a little par 3 – it is a heroic hole. It plays easy but golfers are very capable of failing at easy. Visually the golf hole shines. Golf course architecture, at least the kind I like, has little to do with playability and is more an exercise in framing the landscape. Using bunkers and mounds to direct your vision to the things that need to be noticed. Utah has ample supply of things that need to be noticed in both our recreation and our reconnection with wilderness. Recreation and wilderness require preservation, both as a physical space for play and as an idea for all.

I like the green and the surround area of this little Par 3. It is one of the few places with almost exclusive solitude from most everything. It reminds me what it was like the first day I came to the course with no homes or roads. And perhaps in some ways, reminds me of what it might have been like when the first sheep herding families settled the high valleys of Utah in the late 19th century. I spend time at this green often. At least for me, solitude and thought seem related. From this green I can look over the entirety of everything I know and even beyond to the edge of my map. In the distance I can see the Timothy hay fields with top-heavy inflorescence moving excessively in light wind. I can see an old dairy with a barn covered in original red linseed oil paint. The barn's decay has created something between shelter and reclamation. Its moldering roof is home to cows, horses, goats and one desolate donkey. The donkey is an odd and lonely creature that seems to find focus and purpose in a solitary depression. As I sit alone, I can see the donkey's point. Alone, at least in measured amounts, seems right and well and comforting.

The valley below the golf course has changed and grown - I can sure see that from the peaceful little green. There are new homes, new schools, new folks, and someday even a new freeway. This newness – some of it is good and perhaps some not, but the change is real nonetheless. Many of us have good jobs within the golf industry exclusively because of that change. And the change will continue. Utah may add upwards of a million folks before we reach half time of this century. And this growth would not be possible without the ditches and dams that control the water of our great hydraulic society.

Next to the green there is a spring, an artesian well. It is a wonderful little spring – water bubbles up – clean, honest water – older than most things. The water pools immediately – small lily pads, milfoil and even stinging nettle grow in the slow, cool, shallow water. Stinging nettle seems to be the first plant most children can call by name, as they only need an exposed leg to be certain of taxonomy. Above the spring, the hillside is sage and rock – brown and mustard colored – dull, calm in most ways. It does not take all that many crayons for a child to color the muted western landscape of their upbringing.

The animals that drink at the spring are as used to me as I am to them. Little bird's spittle around –red-winged blackbirds, I think they are called. Rabbits and marmots – even a skunk. There are other animals too – deer and elk, an occasional moose. Although, it has been a few years since the moose have been down to their historic range. It seems the moose struggle with changing climate perhaps in much the same way as the canary struggles for the coal miner. I fear for the moose, I do not think I will see them at the spring anymore. Two resident hawks look over the spring or perhaps look over the rabbits. At times, mostly winter, bald eagles fly above. Coyotes and cougar are there as well. Most things at one point or another seem to be at the spring. And I know each creature - their colors, their size, their calls, their habits, their hierarchy. I suppose they know me the same. There is at honest joy in knowing the habits of the wild things.

Solitude and thought do seem related – I find myself thinking back to my father and that picture in my office. My father died from cancer. He worked the potato fields of the Skagit Valley of Washington as a young man to earn money for college. He was good at college, as the alternative seemed a poor substitute for education for him and many of his generation. Very likely working those fields, he was exposed to a solid amount of some tough pesticides. He used to talk of biplanes simply dusting everything and everybody. But, at the time, those agricultural chemistries were safe. It seems all chemistries are safe when they are used. But hindsight often judges our declarations of bulk pesticide safety much more harshly.

My father's doctors always wondered about his brief agriculture career. My brother kind of always wondered about the chemicals in his photo lab. My sister always kind of wondered about the second-hand Winston smoke from his parent's habits. I did not see any real need to wonder - Darwin's cruel truth is unrelenting. And, besides, it does not make any real difference - his cancer's reason, as the finality of things, seemed enough.

The old-time hard-rock miners that pounded away at silver and gold ore with dynamite and blood in the Tintic District around Eureka, Utah used to call cancer "consumption." For my father, in the end, he was beat and consumed. There wasn't going to be another day for him to take anymore pictures. The beauty of Kodachrome film ended just as he would.

At the end of things - he just knew that it was over. Even though I didn't. He was sorry about it. For us mostly and perhaps partly for himself, but either way, he knew it. In some way he was ready to get on with whatever the end was but mostly he just seemed tired. The tired that pulls passion and everything away. The tired you can't fight or control or medicate. The tired that is just the end of it all.

I had seen that same tired in starving elk that overwinter next to my little spring. During the long, windless winter nights the cold air sinks and parks in the high valleys of Utah. The nights become endless and unwelcome – the moon seeming to provide the only warmth. What dry cheatgrass might to be found as forage is covered with chest deep snow. The snow is dry and loud and smells like earth. The night it hurts. A starving elk - it will go to sleep under a juniper tree, curl up in a ball, and simply die. We find them that way on the golf course in the late winter before the spring thaw puts water in the ditches and behind the dams. The elk – in death, they are as peaceful as when they placed themselves under those Juniper. I think the elk are tired and beat just like my father was. A real and unforgettable tired that overcomes will and consumes all. Such is the finality of things. Nature – human and wild – finds permanence and perfection on a bed of fallen berries under the juniper tree.

My father was an explorer and teacher. He spent a lifetime in the Cascade Mountains of Washington teaching students about nature and wilderness. "Mountain School" is how he would explain his wilderness training to me. My father understood, as did Muir, that children should be left alone to walk in nature, explore, and learn the welded beauty of life and death. And that hot July day it occurred to me that although I knew the spring and its creatures, I had only ever looked at the springs beginning and never wandered it length. Lewis and Clark made it 3700 miles from the red mud Mississippi outside St. Louis to the cold, wet Oregon coast below Astoria - I made it 50 yards.

I found a forgotten irrigation ditch. At least, it had been an irrigation ditch. The water was controlled by a wooden gate operated with a wheel attached to a spiral arguer made of black metal. The metal was now more rusted than black. The gamble oak and cottonwood whose roots had stolen shares from the ditch had engulfed most of the contraption. It looked perhaps from the 1930's, perhaps much older. I could not help but think about the families that built the ditch. Families who overwintered sheep and grew alfalfa on what now is a golf course. I wondered what the ditch meant to these families that built it.

As I thought about those original ranching families, I wondered what they lost sleep over in their time. I know for me, I do not lose sleep over much. I am as unfazed by most things as a deer eating road salt on a cold, empty, winter country road. But what does get me, what I do lose sleep over, is water. The water in the ditch. I lose sleep worrying about how we are using it. I lose sleep wondering whether we will have enough water – not just for the irrigation season, but for the future.

My mind even wonders to the early settlers of Utah. Folks held together only by a new religion. Driven, persecuted from the Illinois country that they knew, and forced west. These settlers came out of necessity and not of want. And they had only schooling in eastern farming traditions that where ill-suited, even reckless, in the rainless West. The Salt Lake Valley sage, heat, and nothingness of that 1847 summer must have been a ruthless awakening for the settlers. What did they lose sleep about at night? You bet it was water.

As such, pretty much the first thing the Mormon founders did upon arriving in the brown and mustard country was began building the first water encasements at City Creek and Mill creek. They understood then, as we do now, that the water, the water in the ditch, is the key to prosperity in the arid west. And those ditch builders had a choice to make – do they take the water, keep it, and profit directly from it? Laws of the time would have allowed, for they were "the first to use it – so they get it." Many folks in the west would profit greatly from The Doctrine of Prior Appropriation. Many would create Ditch Water Kingdoms ruling the lands and politics below. But in Utah, it was different – at least back then.

In Utah, the earthen dams were built, the wooden control gates installed, and ditches dug north and south off the great canyon's creeks that ran east to west. The snow that fell as wild torrents in the high country of the Wasatch Mountain Range would provide the Salt Lake Valley with summer water to grow the crops and fruit that meant the difference between survival and the permanent alternative. And the desert shall rejoice and blossom as the rose. The settlers of Zion made a choice to be good caretakers of the Ditch Water Kingdom they created, for the survival of all depended upon it.

The desert shall rejoice and blossom as the rose. Our hydraulic society allowed it to do just that, and it has continued to his day. The state of Utah – our golf and wilderness economy, our population, our standing in the nation, and even the world – grows with the water we put in the ditch. But anyone that has ever raised any number of roses, paying any sort of attention to their quality, knows that the rose is fickle. And even the most well-intentioned rose master will eventual harm that very thing that they intended to care for. The desert shall rejoice and blossom as the rose until one day, it wilts.

The water systems of the west are fragile. In many ways they were ill-conceived, ill-designed and more dependent on hope than sound hydrology. I think we are very close to, if not already, exceeding what water the land and our infrastructure can provide. We are on edge. The shortage of water in the Colorado River Basin, toxic algae blooms in Utah Lake, and the massive shrinking of the Great Salt Lake seem to be pretty clear evidence that we are exceeding things. Are we about to go over the edge with our water usage in Utah and the west? Hunter S. Thompson put it best when he wrote about the Hells Angels: "The Edge - There is no honest way to know where it is because the only people who really know where it is are the ones who have gone over." Falling off the edge is a tough way to learn things. But ultimately, we are going to find that edge – see where that little old demon lives – as it seems not all that much changes until we do.

We speak of our current drought in the west as historic, as unusual, as something that will come to pass. One good snow year like 1983 and the plywood gets bolted right back up to Glen Canyon Dam. That lake will never fill again. That plywood can get burned in a high-country campfire the night before the open elk hunt without worry. What is viewed by many as historic drought, I do believe is the current average.

It is easy to be a pessimist with water in the west – to be a reservoir is half empty type person. And there are plenty of examples of failure in water management in the west. Just ask the folks in the Owen's Valley of California or that dust bowl mother Dorothea Lange photographed, or the folks that lived in the shadow of Teton Dam. But, despite these failures and our current issues, I have always been optimist about water in the west – perhaps one of the few, and perhaps to a fault. I am an optimist not because I believe it will snow more or rain more – it won't. Not because I believe population growth will slow in our western cities – it won't. No - I am an optimist because I ultimately believe in the power of Americans to do great things and solve problems. I believe that as we press the edge and the survival of not just our irrigation-based industries, but in many respects, our great western hydraulic experiment, sits in judgement – people will decide to be great. People will decide to try as best they can to get along with things – find some sort of equilibrium that works. Acting in many ways as the Mormon settlers did with a watchful eye towards others and an understanding that conservation is ultimately survival. The desert shall rejoice and blossom as the rose – only if we are good caretakers of our Ditch Water Kingdom.

- Pat Christoffer is the Director of Agronomy at Red Ledges, Heber City, UT and a Past President of Utah Golf Course Superintendents Association.

The Ditch Water Kingdom *has been adapted from commentary on water usage on golf courses in Utah presented by Pat Christoffer at the 2018 Utah GCSA Annual Winter Conference.*

BMP INDEX

Planning, Design, and Construction

Regulatory Considerations

Construction and renovation of any urban system poses an inherent risk to surrounding ecosystems. Building or renovating a golf course requires careful protection of natural resources and implementing BMP into the planning, design, and construction of a golf course can result in an environmentally sustainable system.

Regulations impacting the planning, design, and construction of golf courses are in place at the local, state, and federal levels. Compliance with these laws will help protect and conserve the environment throughout the construction process and the life of the golf course. Early engagement between regulatory agencies, developers, designers, the public, and other stakeholders will help facilitate the design and construction process and will help mitigate the environmental impact of the build.

Air Quality

Air quality is a major concern throughout Utah. The Utah Department of Environmental Quality (UDEQ) Division of Air Quality (DAQ) aims to protect, maintain, and enhance air quality in Utah. A main source of concern is $PM_{2.5}$. $PM_{2.5}$ particulates are fine, inhalable particles with a diameter of 2.5 microns or smaller. These particulates can travel into the lungs where they can cause inflammation and damage to lung tissue, leading to both short- and long-term health effects. In November 2009, the EPA required the state of Utah to prepare State Implementation Plans (SIPs) for each nonattainment area (area that violate air quality standards) that had not reached compliance with the $PM_{2.5}$ 24-hour standard of 35 µg m-3. It was determined that the Salt Lake City and Provo nonattainment area plans would not attain the standard by the end of 2015. Both areas were reclassified from Moderate to Serious as of June 9, 2017. Utah has prepared new SIP revisions for the Salt Lake and Provo nonattainment areas and will need to demonstrate attainment of the $PM_{2.5}$ standard by December 31, 2019. The SIP includes provisions to ensure best available control measures throughout the nonattainment areas.

Golf courses in Utah fall under the small source exemption (R307-401-9), and as such, do not need air quality construction or operating permits; however, during construction of a golf course, care should be taken to minimize fugitive dust from dust-generating activities. If located in a $PM_{2.5}$ nonattainment area, the course must submit a fugitive dust control plan according to R307-309-6. If located in an attainment area and clearing an area greater than one-quarter acre, best management practices for reducing fugitive dust include planting a vegetative cover or providing synthetic cover, watering, or including wind breaks. The UDEQ can be reached at (801) 536-4400 with questions about air quality.

Stormwater Permits and Erosion and Sediment Control

The Environmental Protection Agency (EPA) protects streams, rivers and lakes from construction pollution under the Clean Water Act (CWA). UDEQ creates state-specific regulations. A Utah Pollutant Discharge Elimination

System (UPDES) Construction General Permit (CGP), which requires development of a Storm water Pollution Prevention Plan (SWPPP), is required for any construction-related disturbance greater than or equal to one acre or for projects that are part of a larger common plan of development, such as a housing subdivision. UDEQ's Department of Water Quality provides a SWPPP Template to facilitate the development of the plan. It's very important that the CGP requirements for erosion and sediment control are reviewed and incorporated into the SWPPP (see section 2.1). UDEQ can be contacted for additional stormwater-related information at (801) 536-4000.

Wetlands

Activities that impact wetlands are regulated under sections 404 and 401 of the federal CWA. The U.S. Army Corps of Engineers (USACE) regulates dredging and filling of waters in the United States under Section 404 of the CWA. Consultation with UDEQ's Wetland Program during the design phase of any construction activities expected to impact wetlands will assist in understanding the permitting process and will facilitate regulatory compliance and protection of sensitive wetlands.

Listed Species

In Utah, there are currently 42 endangered or threatened species protected by the U.S. Fish and Wildlife Service under the Endangered Species Act. An additional 166 species are listed as sensitive species by the Bureau of Land Management; 58 of these species are animals, and 108 of the sensitive species are plants. Sensitive species are not protected by the Endangered Species Act, but special care and management is warranted to prevent these species from being listed as endangered or threatened in the future.

Planning

Proper planning prior to a new construction or renovation project will help minimize unforeseen expenses and will maximize the long-term success of the operation. Coordination with regulatory agencies will ensure compliance with relevant regulations, and involving golf course superintendents, university scientists, and regional agronomists will enhance the development of an environmentally sustainable course.

BEST MANAGEMENT PRACTICES FOR PLANNING A GOLF COURSE

Assemble a Qualified Team

- The team might include, but not be limited to:
  - golf course superintendent
  - golf course architect
  - clubhouse architect
  - irrigation, environmental, and civil engineers
  - economic consultant
  - soil scientist
  - regulatory agency representatives
  - legal team

Determine Objectives

- Establish clear, detailed objectives for the build including the type of renovation or construction needed, a budget, a timeline, etc.

Complete a Feasibility Study

- Determine existing resources, evaluate finances, and identify labor, material, energy, and water needs for the planned build.
- Regulatory agencies may be contacted to determine pertinent regulatory requirements and/or restrictions.

Site Selection

- Diagnose the strengths and weaknesses of the potential site(s), including any regulatory constraints, such as the presence of endangered or threatened species.
- The selected site needs to meet the objectives outlined by the team and meet the feasibility assessment.

Design

The construction or renovation design needs to incorporate environmental stewardship, economic feasibility, and stakeholder needs.

BEST MANAGEMENT PRACTICES FOR DESIGNING A GOLF COURSE

Retain a Project Manager

- The project manager, likely a qualified golf course superintendent, will be responsible for integrating sustainable maintenance practices throughout the development, maintenance, and operation of the golf course.

Design the Course

- Alteration or removal of the existing native landscape and vegetation should be minimized whenever possible, but especially in out-of-play areas.
- Supplemental planting of native vegetation along stretches of fairways, out-of-play areas, and water sources may be used when appropriate.
- Nuisance, invasive, and exotic plants should be removed and replaced with species adapted to the site.
- Define play and non-play maintenance boundaries.

For information on nuisance plants in Utah, see Utah's Noxious Weed List.

Construction

Construction should be executed in a way that minimizes environmental impact. Coordination with regulatory agencies will ensure compliance with relevant regulations, and involving golf course superintendents, university scientists, and regional agronomists throughout the construction process will enhance the development of an environmentally sustainable course.

BEST MANAGEMENT PRACTICES FOR CONSTRUCTING A GOLF COURSE

Communicate with Stakeholders

- Conduct a pre-construction conference with interested stakeholders to outline your construction plan and address any questions or concerns.
- Maintain a construction progress report and communicate progress with stakeholders.

Select Qualified Contractors

- Use qualified contractors who are experienced in the special requirements of golf course construction. The Golf Course Builders Association of America might provide a starting point for finding candidates.

Schedule Construction

- Construction should be scheduled to maximize turfgrass establishment and site drainage, while allowing for efficient progress of the work.

Safeguard the Environment

- Use environmentally sound construction techniques that comply with environmental regulations.
- Use soil stabilization techniques to minimize soil erosion and maximize sediment containment.
- Temporary construction compounds should be built in a way that minimizes environmental impacts.
- Communicate the progress report with permitting and regulatory agencies throughout the construction process.

Stormwater and Runoff

Runoff from precipitation or irrigation events conveys pollutants such as sediment and nutrients into receiving waters and is referenced as nonpoint source pollution. Controlling runoff and stormwater on a golf course requires controlling the amount and rate of runoff leaving the course, storing irrigation water, controlling erosion and sediment, protecting and enhancing wildlife habitat, removing pollutants through settling or filtration, and addressing aesthetic and playability concerns. Not all runoff running through a golf course originates on-site, so it is important to identify any non-course related runoff or stormwater that may flow through the golf course.

BEST MANAGEMENT PRACTICES FOR PLANNING FOR STORMWATER ON GOLF COURSES

Stormwater/Runoff Prevention

- At the beginning of the construction project, a SWPPP must be completed as part of the CGP, to ensure compliance with Utah DEQ regulations.
- Reducing the amount of runoff produced on the site should be the first priority of the course design.

- Wherever impervious surfaces are incorporated, the design should also include methods to slow down the runoff and increase infiltration. For example, depressed landscape islands in parking lots and the use of pervious pavements such as brick or concrete pavers separated by sand and planted with grass can help store and infiltrate water and reduce the risk of runoff.
- High permeability concrete, crushed stone, and other permeable materials are available for cart paths and parking lots and should be incorporated into the design if possible.
- Runoff from gutters and roof drains can be directed to permeable areas to allow infiltration.

Stormwater Treatment

- Stormwater treatment is best accomplished by a "treatment train" approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.
- Vegetated swales can slow water runoff, allowing for infiltration and breakdown by soil organisms.
- Soil structure and depth to groundwater should be considered when designing retention basins. measures should be taken to prevent leaching or discharge to natural waters before contaminants can be removed.
- Retention basins can be incorporated into the design to help catch rain and runoff. These basins can also act as a source of irrigation for the course. When properly designed, these basins can be incorporated into the aesthetics and playability of the course.
- It is important to note that natural waters of the state cannot be considered treatment systems, however, and these waters must be protected according to the SWPPP.

Case Study: SWPPP

Matt Isbell - Stonebridge Golf Course, West Valley City, Utah

In 2012, West Valley City Parks and Recreation prepared a SWPPP covering all city parks and golf courses. The SWPPP included a stormwater management plan to address "on site management of potential pollutants as they relate to stormwater contamination." Items of concern for this plan included parking lots; maintenance facility lots; fertilizer and pesticide management; disposal food and beverage oils as well as engine oils; management of grass clippings, sand, and large particulates; gasoline and diesel spills; waste disposal; and training and record keeping. Specific practices include recycling collected clippings for tree mulch, managing liquid fertilizer/pesticide spills with sawdust or absorbents, collection and reuse of granular spills, and monthly safety/operational meetings with staff. The plan also lists all storm drains, summarizes maintenance activities and general schedules, details proper chemical/material storage guidelines, and outlines spill prevention and cleanup protocols.

SPILL LOG
STORM WATER POLLUTION PREVENTION PLAN
WEST VALLEY CITY
PARKS AND GOLF COURSES

DATE	LOCATION	WHAT SPILLED	PROPERLY CONTAINED & CLEANED	MANAGER NOTIFIED

Drainage

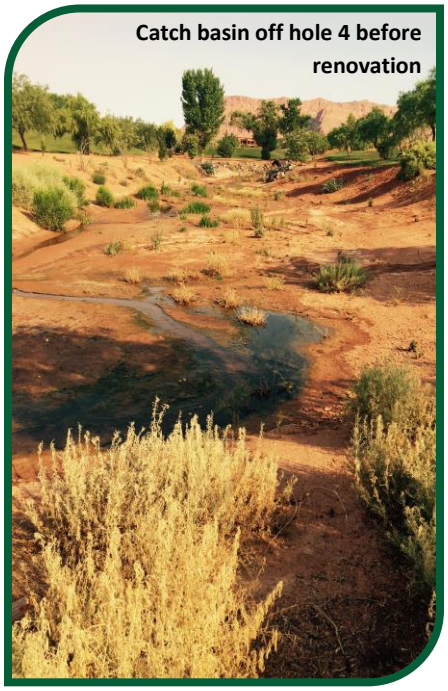
Adequate drainage is necessary for growing healthy turfgrass. The planning, design, and construction of a golf course should address issues such as runoff containment, buffer zones, and filtration techniques to achieve acceptable water quality. When planning and designing drainage systems, BMP should be established to address stormwater management (see section above).

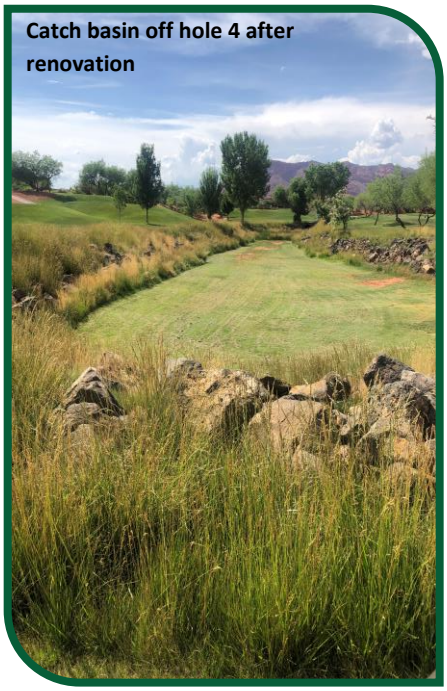
BEST MANAGEMENT PRACTICES FOR THE PLANNING, DESIGN, AND CONSTRUCTION OF DRAINAGE SYSTEMS

- Pay close attention to subsoil preparation, the placement of gravel, site slope, and backfilling.
- Internal golf course drains should not drain directly into an open water body, but instead should discharge through proper drainage and stormwater management devices, as outlined in the SWPPP and CGP, to remove nutrients and sediment.
- The drainage system should be routinely inspected throughout construction to ensure proper function.

Case Study: Drainage Renovation

Ross Laubscher – Entrada at Snow Canyon Country Club, St. George, UT





In 2012, Entrada subdivisions surrounding the country club observed intense rainfall events, which resulted in several million dollars of infrastructure damage. The area underwent a hydrologic analysis, which targeted multiple locations on the golf course, and it was determined that sedimentation and flooding concerns needed to be addressed. Hole 4 was renovated to establish a catch basin to store peak flows, reduce runoff velocity, and filter sediment. The area was lined with rip rap to prevent erosion and planted to help filter the water flowing through the basin.

Erosion and Sediment Control

The loss of topsoil from a site can cause various problems. Soil carried by wind and water transports contaminants with it. When sediment enters a water body, contaminants such as phosphorous can cause eutrophication. The sediment itself can also increase turbidity, which can have detrimental effects on aquatic plants and animals. Therefore, control measures should be documented in an erosion and sediment control plan, put in place prior to any soil disturbance, and properly maintained. throughout the construction and maintenance of the golf course.

BEST MANAGEMENT PRACTICES FOR EROSION AND SEDIMENT CONTROL DURING GOLF COURSE CONSTRUCTION

- Establish a Sediment Control Management Strategy.
- Develop a working knowledge of erosion and sediment control strategies to control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species, and designated environmental resources areas.
- Erosion and sediment controls outlined in the project's SWPPP, Construction General Permit (CGP), and Utah DEQ's BMP for Construction Sites should be followed.

Air Quality

Golf courses in Utah fall under the small source exemption (R307-401-9), and as such, do not need air quality construction or operating permits; however, during construction of a golf course, care should be taken to minimize fugitive dust from dust-generating activities. If located in a $PM_{2.5}$ nonattainment area, the course must submit a fugitive dust control plan according to R307-309-6. Regardless of whether the site is located within a nonattainment area, BMP should be followed to prevent dust particles from entering the air and reducing air quality.

BEST MANAGEMENT PRACTICES FOR MAINTAINING AIR QUALITY DURING GOLF COURSE CONSTRUCTION

- Plant vegetative cover where possible.
- Provide synthetic cover over bare soil.
- Water bare soil to prevent wind erosion.
- Apply chemical soil stabilizers.
- Incorporate wind breaks.
- Stabilize backfilling material.
- Limit and stabilize disturbed and bare soils.
- Limit dust from vehicle operations.
- Stabilize material during transport.
- Stabilize unpaved surfaces where equipment will track.
- When loading trucks, empty the loader bucket slowly and keep the bucket close to the truck to minimize the drop height while dumping.

Greens

BEST MANAGEMENT PRACTICES FOR THE PLANNING, DESIGN, AND CONSTRUCTION OF GREENS

- Greens locations should have adequate sunlight and drainage.
- Greens should be large enough to allow rotation of several hole locations to mitigate traffic stress.
- Root zone construction should be selected based on the needs of individual greens. Some examples of root zone construction options are:
    - United States Golf Association (USGA) greens, as outlined in USGA Recommendations for a Method of Putting Green Construction: 2018 Revision
    - Variable-depth root zones. Particularly suited for improving surface moisture consistency on a sloping green. Recommendations can be found at White Paper: Variable –Depth Root Zones for Golf Putting Greens
    - California
    - Push-up
    - Turfice

The number and size of bunkers might be based off the availability of resources for daily maintenance. When designing bunkers, consider the need for drainage, entry/exit points, wear patterns, and the color, size, and shape of bunker sand to ensure the bunker design meet the needs outlined by the planning team.

Maintenance Facilities

BEST MANAGEMENT PRACTICES FOR THE PLANNING, DESIGN, AND CONSTRUCTION OF MAINTENANCE FACILITIES ON GOLF COURSES

Pesticide Storage Facilities

- Pesticide storage facilities should be located away from groundwater wells or areas where runoff may carry spilled pesticides into surface waters and should not be built on potentially contaminated sites.
- Pesticide storage structures should be designed to keep pesticides secure and isolated from the surrounding environment.
- Pesticide storage structure should be a roofed concrete or metal structure with seamless metal or concrete floors sealed with a chemical-resistant paint and with a continuous curb to retain any spills.
- The structure should have a lockable door.
- Flow from floor drains should not discharge directly to the ground or be connected to the sanitary sewer line or septic system.
- Shelving should be made of plastic or painted reinforced metal.
- Exhaust ventilation and an emergency wash station should be incorporated into the design.

Design and construction of maintenance facilities should incorporate BMP to minimize the potential for contamination of natural resources. The pesticide mixing and storage facility, the equipment wash pad, and the fuel center are areas where BMP may be targeted. More information on BMP related to operation of these areas can be found in subsequent chapters.

Loading Pads and Equipment Storage

- A concrete mixing and loading pad should have a water-to-cement ratio no higher than 0.45:1 by weight.
- The sump should be small and easily accessible for cleaning.
- A parking area should be assigned for each piece of equipment to allow leaks to be easily spotted.

Wildlife

Golf courses occupy large urban land areas and provide links between urban and natural environments by providing food and shelter for various species. Maintaining wildlife habitat on golf courses helps protect biological diversity, which is especially important in urban landscapes. Planning for wildlife habitat and incorporating habitat into the design can help facilitate conservation of natural resources necessary for species in these urban environments.

BEST MANAGEMENT PRACTICES FOR PLANNING, DESIGN, AND CONSTRUCTION OF WILDLIFE HABITAT

- Identification of the surrounding wildlife species will help determine habitat needs (food, water, shelter, corridors) that can then be designed into the construction project.
- Utah's 42 threatened and endangered species and associated critical habitat should be high priority for preservation.
- Invasive nuisance plants should be removed and replaced with native or adapted species.
- Wildlife corridors should be preserved when possible. The site design should minimize crossing of wildlife corridors or incorporate crossings that allow for wildlife movement.
- Cart paths can be designed to minimize environmental impacts.
- Fences should have clearance between the ground and the lowest part of the fence to allow wildlife movement, except in areas where feral animals need to be excluded.
- Stream and river crossings can be minimized to protect banks and preserve water quality.
- Riparian buffers may be incorporated to protect water quality and provide food, nesting sites, and cover for wildlife.
- Bird houses, bat houses, bee "hotels", and nesting sites may be incorporated into out-of-play areas when possible.
- Gardens with pollinator-friendly plants can be included in the site design to provide pollinator forage, breeding and nesting sites, and aesthetic appeal.

Turfgrass Establishment

Establishing turfgrass stands can require greater inputs and maintenance than established turfgrass. Turfgrass establishment should be carefully planned so environmental risks are minimized. For example, caution should be exercised when applying nutrients during establishment because of the increased susceptibility of bare soil to nutrient loss via leaching and runoff. Likewise, over-watering should be avoided to prevent sediment erosion and runoff.

BEST MANAGEMENT PRACTICES FOR TURFGRASS ESTABLISHMENT

Species Selection

TWCA trial at Utah State University, Logan, UT, evaluating drought tolerance of Kentucky bluegrass cultivars (Photo courtesy of Paul Harris).

- Utah's climate generally favors cool season grasses; an exception might be extreme southern Utah, where conditions may be favorable for warm season species.
- Certified turf species and varieties that meet the objectives outlined by the planning team and that are adapted to the climate, pest pressure, traffic stress, playing season, etc. of the site should be selected.
- Numerous new turfgrass cultivars continue to be developed and released by turfgrass breeders. To evaluate different species and identify cultivars that perform well in Utah, extensive trials are conducted under the National Turfgrass Evaluation Program (NTEP). Results of NTEP trials conducted and evaluated by Utah State University are available on the NTEP website. Trials are also conducted in collaboration with the Alliance for Low Input Sustainable Turf (A-List) and Turfgrass Water Conservation Alliance (TWCA); these organizations provide lists of low-input, drought tolerant turfgrass varieties.

Seedbed Preparation

- Proper seedbed preparation can help avoid long-term problems with pests, soil erosion, and turfgrass quality.
- Debris, weeds, and pests that might hinder root growth, limit access to water and nutrients, or otherwise impair successful turfgrass establishment should be removed, if possible.
- Any existing or potential drainage issues should be corrected, when feasible, through grading and installation of drainage technologies.
- Ensure erosion and sediment control devices are in place and properly maintained.

Seeding

- Purchase certified seed.
- Cool-season turfgrass species are best established when seeded in late summer. This timing is ideal because soils are warm, nights are cool, and weed pressure is reduced. This also allows utilization of any fall precipitation that may occur, reducing irrigation requirements.
- Cool-season species can be seeded in the spring, which also allows the seed to take advantage of spring precipitation.
- During grow-in and establishment, more water is required than for established stands. Until the seedlings start to establish, water should be applied lightly and frequently. The goal is to keep the surface moist until germination. Irrigation frequency can then be reduced.

- Turfgrasses with relatively large seeds (i.e. tall fescue, perennial ryegrass, fine fescue) generally need fewer irrigation events during establishment than finer-textured seeds (i.e. Kentucky bluegrass, creeping bentgrass).
- Herbicide labels should be reviewed to ensure the product is labeled for use during establishment.
- Fertilizer should be applied to the turf surface. Incorporating nutrients into the root zone does not result in more rapid establishment and increases environmental risk.
- Slow-release nitrogen or light, infrequent soluble nitrogen may be used during grow-in.
- Mow when seedlings have reached a height one-third greater than the intended height of cut.

Sodding

- Sod can be topdressed to fill in the gaps between pieces. This will speed establishment and create a smoother surface.
- During dry weather, light and frequent irrigation is required until the sod takes root.
- Nutrient application can be delayed until the sod has rooted. Check for rooting by lightly pulling the corner of the sod.
- Irrigation frequency can be reduced when the sod cannot be pulled from the soil surface.

Plugging

- Sprigs can be "knifed-in" and rolled to facilitate root establishment.
- Fertilization may correspond to percent ground cover (i.e. increasing rate as cover increases).
- Mow as soon as sprigs have rooted at the second or third internode.

External Environmental Programs

Environmental management programs can help golf courses protect the environment. Golf courses can gain valuable recognition for their environmental education and certification efforts. Many golf course management companies have internal certification programs. External certifications and training programs also exist, including those offered by Audubon International's Cooperative Sanctuary Program, the Golf Environmental Organization, the Wildlife Habitat Council, the Groundwater Foundation Groundwater Guardian Green Site program, the Pollinator Partnership, and Leadership in Energy and Environmental Design (LEED) certification.

BEST MANAGEMENT PRACTICES FOR EXTERNAL CERTIFICATION PROGRAMS

- Obtain and review materials to determine whether the golf course can seek certification.
- If the course decides to seek certification, educate members about the certification program, and work with staff to establish facility goals that will lead to certification.

AIR QUALITY

Air quality is a major concern throughout Utah. The Utah Department of Environmental Quality (UDEQ) Division of Air Quality (DAQ) aims to protect, maintain, and enhance air quality in Utah. A main source of concern is $PM_{2.5}$. $PM_{2.5}$ particulates are fine, inhalable particles with a diameter of 2.5 microns or smaller. These particulates can travel into the lungs where they can cause inflammation and damage to lung tissue, leading to both short- and long-term health effects. Ozone can also contribute to poor air quality, especially during summer months when temperatures rise.

Regulatory Considerations

Utah is prone to issues with elevated ozone levels, particularly in the summer months. In winter, the state is susceptible to prolonged inversions, which can trap pollution in the valleys, leading to unhealthy air quality. Particulate matter can be a source of poor air quality year-round.

Golf courses in Utah fall under the small source exemption (R307-401-9), and as such, do not require air quality construction or operating permits; however, during construction of a golf course, care should be taken to minimize fugitive dust from dust-generating activities. If located in a PM2.5 nonattainment area, the course must submit a fugitive dust control plan according to R307-309-6. If located in an attainment area and clearing an area greater than one-quarter acre, best management practices for reducing fugitive dust should be followed. After construction is complete, golf course maintenance practices should continue to focus on limiting emissions and protecting air quality, especially during inversions or times when air quality is deemed unhealthy.

The UDEQ can be reached at (801) 536-4400 with questions about air quality.

Maintaining Air Quality

It is important to take measures to protect air quality throughout the year in Utah, where air quality can be of great concern. Likewise, it is important to protect golf manager and maintenance crew health during periods of poor air quality.

BEST MANAGEMENT PRACTICES FOR MAINTAINING AIR QUALITY

- Check the daily Air Quality Index and the Air Quality Index Forecast to find out if air quality is poor or if there are voluntary or mandatory restrictions in place. If so, reduce activities that add to air pollution. For example, limit the amount of motorized equipment used that day.
- Typically, ozone spikes with higher temperatures. On high-ozone days, complete as much outdoor maintenance as possible during the morning, when temperatures are cool and ozone is low. Restrict outdoor activity during hot afternoons, when ozone levels spike to unhealthy levels.

The Utah Department of Air Quality provides air quality monitoring apps for Android and iPhone.

ENERGY

Golf courses use several energy sources, including electricity, gasoline, diesel, natural gas, propane and heating oil. Golf course managers can take steps toward identifying options for conservation, efficiency, and cost savings in order to establish energy-efficient BMP. To address current needs and future energy reduction opportunities, managers should evaluate current energy conservation performance practices based on the following categories:

- Buildings, infrastructure and facility amenities such as the clubhouse, swimming pool, restaurant, parking lot, kitchen, offices, maintenance building(s), tennis courts, etc.
- Golf course and surrounding landscapes and related agronomic operations
- Irrigation systems

Several local and state opportunities exist to address energy efficiency and renewable energy sources. For example, the Governor's Office of Energy Development offers grants, scholarships, financing, and tax credits to switch to renewable energy sources.

An energy audit will likely include the following steps:

1. **Evaluate heating, ventilation, and air conditioning system efficiency.**
2. **Determine annual energy usage.**
3. **Itemize usage according to various categories.**
4. **Determine if energy usage during non-peak hours are maximized.**
5. **Compare usage with golf courses of a similar size.**
6. **Identify areas of improvement.**
7. **Implement energy-saving measures.**

Evaluating Energy Use

Determining energy use and establishing an energy conservation plan is a first step in addressing energy efficiency. An energy audit can be conducted to identify areas most in need of or most eligible for energy conservation. Utility providers can be a source of expertise in conducting an audit.

BEST MANAGEMENT PRACTICES FOR EVALUATING ENERGY USE AND EFFICIENCY

- Evaluate all energy providers (electricity, natural gas and liquid petroleum fuels) for costs, efficiency/assistance programs, and incentives.
- Install and/or check meters, gauges, etc. and make sure they are functioning properly.
- Monitor energy use by tracking data and evaluating billing meters.
- Develop an equipment inventory incorporating individual equipment's energy use, traffic patterns, etc.
- Establish a baseline for performance parameters to optimize irrigation pumps.
- Consider benchmarking performance against similar-sized facilities.
- Communicate energy use and conservation goals with staff and members.
- Consider alternative equipment, products, and practices.

Energy Management Plan

Once an energy audit has been conducted, establish an energy management plan for the facility based on current energy use baselines to optimize efficiency. Relate the policy to the entire facility, including the services the facility provides to its customers and community.

BEST MANAGEMENT PRACTICES FOR ESTABLISHING AND ENFORCING AN ENERGY MANAGEMENT PLAN

General

- Educate and motivate staff and members on energy efficiency practices.
- Identify incentives and programs from energy providers and state and local programs (local grants and tax credits, U.S. Green Building Council's LEED program, EPA EnergyStar Portfolio Manager, EPA WaterSense program, energy management software, services, etc.)
- Consider long-term costs in addition to acquisitions.
- Schedule reviews to evaluate future technology and fuel types, and practice recordkeeping.
- Incorporate new technology and upgrades when feasible.
- Consider alternative equipment, products, practices, and energy sources.

Infrastructure

- Maximize use of space.
- Inspect and repair leaks/maintenance.
- Monitor temperature/environmental settings (heat loss, etc.).
- Evaluate building automation systems, monitoring systems, etc.
- Add insulation where needed.
- Limit high-consumption activities during periods when demand is high.
- Ensure efficient lighting in both interior and exterior areas.
- Install LED lighting and/or retrofit devices and motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/Geo Thermal pumps for pools and spa.

Irrigation

- Audit irrigation system (see Water Conservation BMP).
- Understand that the irrigation pump is the largest user of energy. A well-engineered pump station is critical to reducing energy consumption.
- Upgrade or install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors.
- Schedule and operate pumps and irrigation in an efficient manner.
- Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls, and other irrigation components.
- Evaluate cleaning practices (dry vs. wet).
- Seek output reduction by watering less area.

WATER QUALITY MONITORING & MANAGEMENT

Golf courses are just one link in a stormwater management chain. The ability to detain large amounts of water requires accurate engineering and extensive construction to prevent physical or financial damage to the facility. Best Management Practices are intended to prolong the detention process as long as practical, harvest as much of the stormwater in surface or underground storage as reasonable, and to improve the quality of water leaving the property when possible.

Regulatory Considerations

Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.

A water-quality monitoring plan can be prepared to ensure the ongoing protection of groundwater and surface water quality. Sampling parameters are determined based on golf course operation and basin-specific parameters of concern. Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, and suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course. A single sample is rarely meaningful in isolation - ongoing, routine water sampling provides meaningful trends over time. It is strongly recommended that a certified laboratory be used even if the data are only for proprietary use and are not reported to any regulatory agency. If a golf course should ever want to produce data for an agency or go to court to defend the facility from unwarranted charges, those data must meet quality standards to be defensible as evidence.

Total Maximum Daily Loads (TMDLs)

The Clean Water Act requires states to establish water quality standards consisting of designated uses, chemical and biological criteria, and anti-degradation policies, designed to protect surface waters. If a lake, river or stream fails to meet these water quality standards, it is placed on a list of "impaired" waters. A Total Maximum Daily Load (TMDL) study is then implemented to determine the maximum amount of pollutant allowed to enter the impaired water body while still maintaining water quality.

The TMDL plan for an impaired water body includes:

- Confirming which pollutants are of concern.
- Determining the water body's pollutant loading capacity.
- Quantifying pollutant loading from all sources (point source and non-point source).
- Analyzing current pollutant loads and reduction needs.
- Establishing maximum allowable pollutant load to meet water quality standards.

For more information on impaired waters, the Clean Water Act, and TMDLs, see TMDL: What is a TMDL?, Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs), and UDEQ Division of Water Quality: Watershed Management Program

Wetlands

Wetlands account for approximately 1% of Utah's landscape, 75% of which surround the Great Salt Lake. Wetlands provide services such as flood mitigation, groundwater recharge, water quality enhancement, sediment settling and storage, and nutrient cycling. Wetlands also provide critical habitat for wildlife and economic and aesthetic value. Wetlands are protected areas; consult with the Utah Department of Environmental Quality Division of Water Quality to protect current wetland sites or to establish constructed wetlands on the course.

For more information on Utah's wetlands, see Utah Wetland Information Center, Water Quality Management Strategy for Wetlands: Wetlands Program, and Wetland Monitoring and Assessment: Wetlands Program.

Water Quality Protection

Controlling stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, it involves storing irrigation water, controlling erosion and sediment transport, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns. Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system; natural waters of the state, however, cannot be considered treatment systems and must be protected from polluted runoff. Stormwater treatment is best accomplished by a treatment train approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.

A water quality protection strategy should include proper documentation of the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, possible contamination sources, and other environmental considerations. Structural controls should be used to detain and treat stormwater and protect water quality. When properly implemented, structural controls reduce the amount of nutrients, pesticides, and sediment entering water bodies through techniques such as settling, biological uptake, and infiltration into the soil. Periodic inspection and maintenance of all structural controls are essential to ensure they function as designed. Water quality should be monitored periodically to ensure contamination of water bodies is not occurring and to address remediation efforts if contamination does occur.

BEST MANAGEMENT PRACTICES FOR WATER QUALITY PROTECTION

Planning

- Identify position of property in relation to its watershed, depth to water tables, and soil types.
- Identify flow patterns and indicate major drainages, catch basins, and impervious surfaces, and direct flow through treatment systems before it reaches surface waters.
- Locate and protect wellheads.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Internal golf course drains should not drain directly into an open water body, but should discharge through pre-treatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips, through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.

- The placement of bunkers and the shaping of contours surrounding a green should allow proper drainage and provide for the treatment and absorption of runoff from the green.
- More information can be found in the Planning, Design, and Construction chapter of the BMP guide.
- Ponds that are too shallow may reach high temperatures, which can lead to low oxygen levels and promote algal growth and excess sedimentation.
- Peninsular projections and long, narrow fingers may prevent mixing.
- Dry retention basins dry out between rain events, and can be established to help detain runoff, allow slow infiltration, and mitigate flood risk.
- Wet retention basins also help detain stormwater, in addition to maintaining a permanent supply of water, and can be used to remove contaminants, reduce flood risk, and add aesthetic value to the course.
- Including plantings in retention basins allows plant uptake of nutrient contaminants and adds aesthetic value and wildlife habitat.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal.
- Construct random small dips and ridges of a few inches to a foot to promote diversity within the plant community and provide a healthier and more productive littoral zone.

Buffer Zones, Swales, and Berms

- Install swales and slight berms where appropriate around the water's edge, to slow water flow and increase infiltration.
- Buffer zones can be established around surface water features to help slow runoff, increase infiltration, and trap sediment and nutrients before they can enter surface waters.
- Steeper slopes require greater buffer widths.

Buffer strip surrounding water feature at Fore Lakes Golf Course, Taylorsville, UT (Photo courtesy of T.A. Barker, Superintendent).

Chemical Use

- Care should be taken when applying pesticides or fertilizers near or in buffer strips to prevent movement of these chemicals into nearby water.
- Use integrated pest management strategies and native or naturalized vegetation wherever practical.
- Only licensed individuals or contractors are allowed to select and apply aquatic pesticides.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Irrigation directly striking or running off to water bodies should be minimized when possible, and no-fertilization buffers should be maintained along water edges.
- Superintendents should monitor designated waters in their area for point-source pollution.
- Secondary environmental effects on surface water and groundwater from chemical control of vegetation should be monitored and recorded.
- Apply fertilizer and reclaimed irrigation/fertigation appropriately to avoid surface water and groundwater contamination.
- Apply algicides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Treat dredged materials as a toxic substance. Avoid contact with turf.

Dissolved Oxygen

- To reduce stress on fish; keep DO levels above 3 ppm.
- Aerate shallow lakes at night to maintain acceptable DO levels while preventing water loss.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.

Maintenance

- Sod, spring, or reseed bare or thinning turf areas and mulch areas under tree canopies to cover bare soil.
- Mow lake and pond collars at a higher height to slow and filter overland flow to water bodies.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas where wind or runoff will not carry them back to the water.
- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.
- Remove excess sediments to reduce irrigation system failures and to protect beneficial organisms.
- Seek assistance from a specialist to design an appropriate water sample collection strategy.
- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Record observations of fish, wildlife, and general pond conditions.

Wetland Protection

The biological activity of plants, fish, animals, insects, bacteria and fungi in a healthy, diverse wetland is the recycling factory of many ecosystems. While wetlands do pose a special concern, their mere presence is not incompatible with the game of golf. With care, many golf holes have been threaded through sensitive areas, and with proper design and management golf can be an excellent neighbor. When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers.

BEST MANAGEMENT PRACTICES FOR WETLAND PROTECTION

- Natural waters cannot be considered treatment systems and must be protected (natural waters do not include treatment wetlands).
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Maintain appropriate silt fencing and BMP on projects upstream to prevent erosion and sedimentation.
- Establish a low- to no-maintenance buffer along non-tidal and tidal wetlands, springs, and spring runs.

For more information on protecting existing wetlands or establishing constructed wetlands, see Stormwater Wetlands for Golf Courses and contact the Utah Department of Environmental Quality Division of Water Quality at (801) 536-4340.

Aquatic vegetation provides wildlife habitat at Fore Lakes Golf Course, Taylorsville, UT (Photo courtesy of T.A. Barker, Superintendent).

Aquatic Plants

Ponds may be constructed on golf courses as water hazards or for landscape purposes, but they often have the primary purpose of drainage and stormwater management and are also often a source of irrigation water. Large aquatic plants provide aesthetic value, habitat, and water quality management to surface waters. Different types of aquatic plants have different functions in ponds. Submersed plants grow rooted to the pond bottom and are supported by the water; immersed plants are rooted to the pond bottom or the shoreline and extended above the water surface; floating plants are rooted to the pond bottom with their leaves floating on the water surface or may be completely free-floating on the water surface. Plant life growing on littoral shelves may help to protect receiving waters from the pollutants present in surface water runoff, and a littoral shelf is often required in permitted surface water-retention ponds. Floating plants suppress phytoplankton by absorbing nutrients from pond water and providing shade to the pond.

BEST MANAGEMENT PRACTICES FOR MAINTAINING AQUATIC PLANTS

- A comprehensive pond management plan should include strategies to control the growth of nuisance vegetation that can negatively affect a pond's water quality and treatment capacity.
- Plant a variety of aquatic vegetation along the pond landscape to stabilize the shoreline, provide wildlife habitat, increase aesthetic value, and promote contaminant prevention and uptake.
- Problem plants may be selectively controlled without damaging littoral shelves.
- Encourage clumps of native emergent vegetation at the shoreline.
- Remove filamentous algae by hand and/or by applying algaecide to small areas of algae (spot treatment).
- To reduce the risk of oxygen depletion, use an algaecide containing hydrogen peroxide instead of one with copper or endothall.

Sodic and Saline Conditions

All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly. Irrigation water can degrade when wells are pumped at high rates or for prolonged periods. Sometimes "up-coning" can occur from pumping, whereby saline water, rather than freshwater, is drawn into the well. Saline water typically is unsuitable for irrigation because of its high content of dissolved solids.

BEST MANAGEMENT PRACTICES FOR SODIC AND SALINE CONDITIONS

- Routinely monitor water quality to ensure that salt concentrations are at the acceptable levels.
- Mix surface water with affected groundwater to lower the total salt concentration of irrigation water.
- Consider fertilizer that uses soluble nitrogen forms with a relatively low concentration of salts in frequent applications.
- Consider a controlled-release fertilizer to reduce salt injury.
- Conduct routine soil tests to determine sodium adsorption ratio, exchangeable sodium percentage, electrical conductivity, and free calcium carbonate content.
- Select alternative turfgrass and landscape plants that are more salt-tolerant, especially in out-of-play areas.
- Reduce salt accumulations in the soil by flushing soils as needed with a higher-quality water source.
- Design irrigation systems to account for flushing of salt accumulation from soil.
- Amend soil and water to remove salt ions from affected areas.

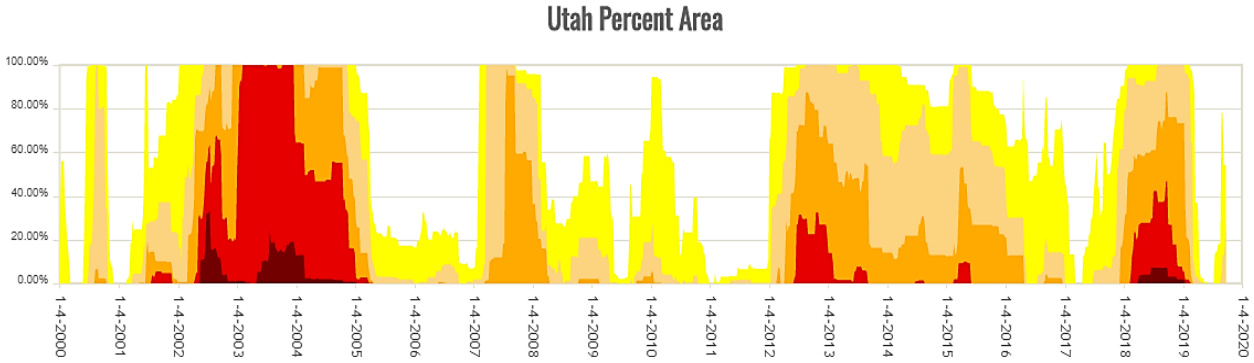
For more information on growing turf in saline conditions, see Growing Turf on Salt-Affected Sites.

IRRIGATION

Utah has historically combated periodic drought conditions and relies heavily on snowmelt runoff to provide water for irrigation. Because of this, implementation of irrigation and water conservation best management practices on Utah golf courses is extremely important and should be a top priority.

The supplemental use of water promotes plant health and enhances course playability and aesthetics. BMP related to irrigation can help conserve and protect water resources. Irrigation BMP also provide economic, regulatory compliance, and environmental stewardship advantages to those who integrate them into an irrigation management plan. If applied appropriately, irrigation-related BMP can help stabilize labor costs, extend equipment life, limit repairs, and reduce personal and public liability while protecting and conserving natural resources. Resource conservation integrates the strategic use of appropriate course and irrigation design, plant selection, computerized and data-driven scheduling, water quality protection, and alternative water supply options to maximize plant health benefits and reduce the potential for negative impacts on natural resources.

Percent area of Utah under drought conditions 2000-Present. Darker colors indicate more severe drought conditions. Map acquired from [The National Drought Mitigation Center - University of Nebraska-Lincoln](#).



Like many arid western states, Utah receives limited precipitation throughout the year. For example, Salt Lake City receives just over 16 inches of precipitation during the water year (October 1 through September 30) on average. Many areas of the state receive significantly less. During severe drought years, water supplies for irrigation may be severely limited.

Regulatory Considerations

Golf course designers and owners should contact federal, state, and local water use authorities pre- and post-construction to determine water consumption rights and permitting requirements. During planning and design, determine if alternatives to potable water sources are an option for irrigation. The irrigation system should be designed and maintained to efficiently meet peak water requirements under normal conditions and should be able to adapt to various water demands and potential restrictions on water use.

Golf course managers should determine whether local jurisdictions have prescribed water budgets for their location and work accordingly. Irrigation efficiency and reduction in energy use associated with irrigation systems and practices are desirable goals.

Irrigation System Establishment

A site-specific irrigation management plan should be established and should adhere to irrigation BMP. This plan should work in collaboration with city/municipality drought plans (for example, successive irrigation cuts to out of bounds areas, then roughs, then fairways, etc.) Rainfall may vary across the course; the proper use of rain gauges, rain shut-off devices, flow meters, soil moisture sensors, and/or other irrigation management devices should be incorporated into the irrigation management plan. The plan can be flexible to meet the site's peak water requirements and allow for operation modifications to address changes in seasonal irrigation needs or local restrictions.

BEST MANAGEMENT PRACTICES FOR ESTABLISHING AN IRRIGATION SYSTEM

Construction

- Construction must be consistent with the design.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified and their locations flagged.
- Only qualified specialists should install the irrigation system.
- Ensure heads are set at level ground and not on slopes.

Zoning

- Allow the putting surface, slopes, and surrounds to be watered independently.
- Turf and landscape areas should be zoned separately.
- For variable wind directions, triangular spacing applies water more uniformly than square spacing.
- Heads for turf areas should be spaced for head-to-head coverage.
- Distribution equipment (such as sprinklers, rotors, and micro-irrigation devices) in a given zone should have similar precipitation rates.

Pumping System

- Design operating pressure must not exceed the available source pressure and should account for peak-use times and supply-line pressures at final buildout for the entire system.
- Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values.
- Install variable frequency drive (VFD) systems to lengthen the lifespan of older pipes and fittings until the golf course can renovate the irrigation system.
- The system should have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Pumps should be sized to provide adequate flow and pressure.
- Pumps should be equipped with control systems to protect distribution piping.

- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should be conducted per manufacturer recommendations.
- Monitor pumping station power consumption and compare the power usage with the amount of water pumped. If more power is being used to pump the same amount of water, this is an indication that there is a problem with the pump motor(s), control valves, and/or distribution system.
- Quarterly checks of amperage by a qualified pump personnel may more accurately indicate increased power usage and associated problems.

Valves

- Isolation valves should be installed in a manner that allows critical areas to remain functional.
- Water conveyance systems should be designed with air-release valves.
- Equipment with check valves may be used in low areas to prevent low head drainage.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these areas can be hand-watered during severe droughts.

Heads and Distribution

- Water supply systems (for example, wells, and pipelines) should be designed for varying control devices, rain shutoff devices, and backflow prevention.
- Pipelines should be designed to provide the system with the appropriate pressure required for maximum irrigation uniformity.
- Pressure-regulating or compensating equipment must be used if the system pressure exceeds the manufacturer's recommendations.
- The first and last sprinkler head should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.
- Install part-circle heads along lakes, ponds, and wetlands margins to avoid overspray into water bodies.
- Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways and sidewalks.
- Update multi-row sprinklers with single head control to conserve water and to enhance efficiency.
- Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.
- Target 80% or better distribution uniformity and optimize effective root-zone moisture coverage.
- Application rate must not exceed the infiltration rate.
- Design may account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater for leaching purposes.

Metering

- Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, weather-based irrigation controllers, and/or other automated methods can be used to manage irrigation.
- Flow meters can be used to determine how much water is applied and should have a run of pipe that is straight enough - both downstream and upstream - to prevent turbulence and erroneous readings.

A well-designed irrigation system should operate at peak efficiency to reduce energy use, labor requirements, and operational cost, while maximizing water use and conserving water supplies.

Irrigation Water Supply

Golf course designers and managers should endeavor to identify and use alternative water supplies, when possible, to help conserve potable water supplies. Alternative water supplies should meet seasonal and bulk water allocations for grow-in and routine maintenance and use of non-potable water needs to be balanced with turf health and environmental protection. When necessary, sodic water system treatment may be included in the budget to address water quality and to protect irrigation equipment.

BEST MANAGEMENT PRACTICES FOR SELECTING AND MAINTAINING IRRIGATION SUPPLY

- Use alternative water supplies/sources to supplement water needs.
- Reclaimed, effluent, and other non-potable water supply mains must have a thorough cross-connection and backflow prevention device in place and operating correctly.
- Use salt-tolerant turfgrass varieties if salinity is an issue on the site.
- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Amend sodic water systems to minimize sodium buildup in soil.
- Flush soil with fresh water or use soil amendments to move salts out of the root zone.
- Routinely monitor shallow groundwater table for saltwater intrusion or contamination of heavy metals and nutrients.
- Post signage in accordance with local utility and state requirements when reclaimed water is in use.
- Account for the nutrients in effluent (reuse/reclaimed) water when making fertilizer calculations.
- Monitor reclaimed water tests regularly for dissolved salt content.
- Where practical, use reverse-osmosis filtration systems to reduce salts from saline groundwater.
- Monitor the quantity of water withdrawn to avoid aquatic life impairment.

Case Study: Irrigation Water Supply

Dave Carruth - Murray Parkway Golf Course, Murray, UT

Murray Parkway Golf Course collects surface- and ground-water from the I-215 freeway for irrigation use. When the water enters the golf course it is contaminated with salts, oil, garbage and silt. The water is collected in three successive ponds linked by streams planted with vegetation to provide additional filtration. The first pond captures sediment, trash, and oils; the next provides secondary filtration. When the water enters the main pond, it is suitable for irrigation use. This system provides about 85% of the irrigation water for the 150-acre course. Any excess water flows into the Jordan River. This collection method allows the course to cut costs on irrigation water, filters contaminants from stormwater before entering the Jordan River and the Great Salt Lake and provides visual interest for golfers.

System Maintenance

Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance, corrective maintenance, and record keeping. Maintaining a system includes documenting system- and maintenance-related details so that potential problems can be addressed before expensive repairs are needed. It also provides a basis for evaluating renovation or replacement options to improve system efficiency, conserve water, improve playability, and reduce operating costs.

BEST MANAGEMENT PRACTICES FOR IRRIGATION SYSTEM MAINTENANCE

Preventative Maintenance

- The system should be inspected routinely for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads.
- A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made.

- Monitor pump station power consumption over time to detect a possible increase in power usage. Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system. Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems.
- Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance. Not only is this information essential for identifying places that would benefit from a renovation, but it is also needed to compute current operating costs and compare possible future costs after a renovation.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Maintain air-relief and vacuum-breaker valves.
- Application/distribution efficiencies of irrigation water should be checked annually. Replace worn components before they waste fertilizer, chemicals, and water.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Collecting information on the cost of maintaining the system as part of system overall evaluation, allows for planning necessary upgrades, replacement etc. for comparison after changes are made.
- Ensure that control systems provide for emergency shutdowns caused by line breaks, and allow maximum system scheduling flexibility.
- Flush irrigation lines regularly to minimize emitter clogging.
- If fertigating, prevent microbial growth by flushing all fertilizer from the lateral lines before shutting down the irrigation system.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings).
- Clean and maintain filtration equipment.

Corrective Maintenance

- Irrigation audits should be performed regularly by trained technicians.
- A visual inspection can first be conducted to identify necessary repairs or corrective actions. It is essential to make repairs before carrying out other levels of evaluation.
- Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records.
- Gather together all of the documentation collected as part of the PM program, along with corrective maintenance records for analyses.
- Monitor water meters or other measuring devices for unusually high or low readings to detect possible leaks or other problems in the system. Make any needed repairs.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- If the system requires frequent repairs, determine why these failures are occurring and make corrections.
- Pressure and flow should be evaluated to determine that the correct nozzles are being used and that the heads are operating within manufacturer's specifications.
- Catch-can tests can be run to determine the uniformity of coverage and to accurately determine precipitation rates and resulting irrigation run times.
- Inspect for interference with water distribution.
- Inspect for broken and misaligned heads.
- Check that a rain sensor is present and functioning.
- Inspect the backflow device to determine that it is in place and in good repair.

System Renovation

- Correctly identify problems and their cost to determine which renovations are appropriate.
- Determine the age of the system to establish a starting point for renovation.
- Identify ways to improve system performance by maximizing the efficient use of the current system.
- Routinely document system performance to maximize the effectiveness of the renovation.
- Evaluate cost of renovation and its return on benefits both financial and managerial.

Irrigation System Programming and Scheduling

Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent excess water use that could lead to leaching below the root zone and runoff.

Responsible irrigation management conserves water and reduces nutrient and pesticide movement and loss.

BEST MANAGEMENT PRACTICES FOR IRRIGATION PROGRAMMING AND SCHEDULING

- The reliability of older clock-control station timing depends on periodic calibration of the timing devices.
- Rain sensors can shut off the system after 0.25 to 0.5 inch of rain is received.
- Install control devices to allow for maximum system scheduling flexibility.
- Irrigation quantities should not exceed the available moisture storage in the root zone.
- When possible, irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.
- Irrigation scheduling should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- Account for nutrients in effluent supply when making fertilizer calculations.
- Base plant water needs can be determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture levels.
- Use mowing, verticutting, aeration, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation distribution uniformity or a failed system device.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Avoid use of a global setting; make adjustments to watering times per head.
- Adjust irrigation run times based on current local meteorological data and computed daily ET rates.
- Use soil moisture sensors to assist in scheduling or to create on-demand irrigation schedules.
- Install soil moisture sensors in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- Place soil moisture sensors in a representative location within the irrigation zone. Install a soil moisture sensor in the driest irrigation zone of the irrigation system.
- Wired soil moisture systems can be installed at a depth to prevent damage from aerification.
- Periodically perform catch-can uniformity tests.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff onto other areas.
- Install emergency shutdown devices to address line breaks.

Water Conservation and Efficient Water Use

A drought management plan will help turfgrass managers reduce water use, protect critical areas, and maintain quality turf during extended drought conditions or periods of water restrictions.

Potable water supplies in many areas of the United States, including Utah, are limited, and demand for the resource continues to grow. The challenge golf course managers face is to find solutions to maintain the quality of the golf course while conserving water supplies. To prevent excess water use, irrigation scheduling should account for plant water requirements, recent rainfall, recent temperature extremes, and soil characteristics. Irrigation management and control devices need to be installed and programmed correctly for proper irrigation management. Some courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf. Similarly, existing golf courses can make an effort to convert out-of-play areas to native or adapted plants, grasses, or ground covers to reduce water use and augment the site's aesthetic appeal.

BEST MANAGEMENT PRACTICES FOR WATER CONSERVATION AND EFFICIENT WATER USE

Irrigation Practices

- Create a drought management plan for the facility that is integrated with local, municipal drought management plans; the plan should identify steps to be taken to reduce irrigation/water use and protects critical areas, etc.
- Document watering practices to show improvements in efficiency over time.
- Irrigation should provide only the water that is actually needed by the plants, or to meet occasional special requirements such as salt removal.
- Irrigation should not occur on a calendar-based schedule, but should be based on ET rates and soil moisture replacement.
- Rain and runoff captured in water hazards and stormwater ponds may provide supplemental water under normal conditions, though backup sources may be needed during severe drought.
- During drought, closely monitor soil moisture levels. Whenever practical, irrigate at times when the least amount of evaporative loss will occur.
- Communication should be maintained with water managers, golf course members, and the public to explain how you are improving irrigation efficiency and why.
- Cultural practices such as mowing height, irrigation frequency, and irrigation amounts should be altered, as needed, to promote healthy, deep root development, improve water infiltration, and reduce irrigation volumes.
- For fairways and roughs, use infrequent, deep irrigation to encourage deep rooting.
- Supplemental watering should be restricted to establishment of new plantings, hand watering of "hot spots" and watering in of chemicals, as needed.

Sensor Technology

- Irrigation controllers/timers may be reset as often as practically possible to account for plant growth requirements and local climatic conditions.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods can be used to manage irrigation.

- Central control systems can be installed on new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments at every head.
- Rain shut-off devices and rain gauges should be placed in open areas to prevent erroneous readings.
- Use multiple soil moisture sensors/meters for accuracy and to reflect soil moisture levels in different areas of the irrigation zone. A sensor should be installed in the driest area of the irrigation zone.
- Wireless soil moisture systems can be installed at an adequate depth to prevent damage from aeration.

Plant Selection

- Selecting drought-tolerant species and varieties of turfgrasses can help maintain an attractive and high-quality playing surface, while minimizing water use.
- Non-play areas may be planted with attractive, low-maintenance, drought-tolerant native or adapted noninvasive plants.
- Native and adapted plant species provide wildlife with habitat and food sources, and after establishment, normally require little to no irrigation.
- Control invasive plants or plants that use excessive water.

Careful selection of drought tolerant turfgrass varieties that require less water to survive can help reduce the need for irrigation, while maintaining a quality playing surface. The Alliance for Low Input Sustainable Turf (A-List), Turfgrass Water Conservation Alliance (TWCA), and National Turfgrass Evaluation Program (NTEP) all provide lists of low-input, drought tolerant turfgrass varieties.

Ponds and Wellheads

Surface waters and wellheads require protection and safe land-use practices in order to protect water sources from accidental contamination.

Incorporating lakes and ponds into the golf course can create significant aesthetic value and reduce operational costs. Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system and as a source of irrigation water. The size, shape, and depth of water features may all affect how they respond to environmental inputs. Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals.

Each pond has regions or zones (riparian zone, littoral zone, limnetic zone, and benthic zone) that significantly influence water quality and are crucial in maintaining the ecological balance of the system. It is important for the manager to understand their function and how water quality can be maintained if these zones are properly managed. Some of the challenges in maintaining the quality of golf course ponds are as follows: low dissolved oxygen, sedimentation, changes in plant populations, and nuisance vegetation. Surface water sources can also present problems with algal and bacteria growth, particularly as depths decrease through the irrigation season. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that may plug emitters.

BEST MANAGEMENT PRACTICES FOR ESTABLISHING AND MAINTAINING PONDS AND WELLHEADS

Establishing Ponds

- Develop an effective stormwater management system that complies with the requirements of municipalities, water management districts and other permitting agencies.
- When constructing drainage systems, pay close attention to subsoil preparation, placement of gravel, slope, and backfilling.
- Where practical, golf course drains should discharge through pretreatment zones and/or vegetative buffers to remove nutrients and sediment.
- Studies of water supplies and water flow on, near, and under the property are needed to properly design stormwater systems and water features, and to protect water resources.
- Peninsular projections and long, narrow fingers into ponds may prevent water mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels, algal growth, and excess sedimentation.
- In shallow or nutrient-impacted ponds, aeration equipment may be required to maintain acceptable dissolved oxygen levels in the water.

Pond Use and Maintenance

- Use leak controls in the form of dike compaction, natural-soil liners, soil additives, commercial liners, drain tile, or other approved methods.
- Maintain a riparian buffer to filter the nutrients and sediment in runoff from surrounding areas.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas where runoff will not carry them back to the pond.
- Prevent overthrowing fertilizer into ponds and practice good fertilizer management to reduce nutrient runoff into ponds, which causes algae blooms and ultimately reduces oxygen levels.
- Establish a special management zone around pond edges.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes where they are interconnected.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to reduce erosion and the resulting sedimentation.
- Aerate ponds and dredge or remove sediment before it becomes a problem.

Water Level Maintenance

- Provide an alternative source for ponds that may require supplemental recharge from another water source such as a well during high-demand periods.
- Estimated losses from evaporation and seepage should be added to the recommended depth of the pond.
- Manage ponds to prevent low levels that result in warmer temperatures and low oxygen levels.

Establishing Wellheads

- When installing new wells, contact the regulating authority to determine the permitting and construction requirements and required isolation distances from potential sources of contamination.
- Locate new wells up-gradient as far as possible from likely pollutant sources, such as petroleum storage tanks, septic tanks, chemical mixing areas, or fertilizer storage facilities.
- Licensed water-well contractors may be needed to drill new wells to meet state requirements, local government code, and water management districts' well-construction permit requirements.

Maintaining Wellheads

- Use backflow-prevention devices at the wellhead, on hoses, and at pesticide mix/load station to prevent contamination of the water source.
- Surround new wells with bollards or a physical barrier to prevent impacts to the wellhead.
- Inspect wellheads and the well casing at least annually for leaks or cracks; make repairs as needed.
- Maintain records of new well construction and modifications to existing wells.
- Obtain a copy of the well log for each well to determine the local geology and how deep the well is.
- Sample wells for contaminants according to the schedule and protocol required by the regulating authority.
- Never apply fertilizers or pesticides next to a wellhead.
- Never mix and load pesticides next to a wellhead if not on a pesticide mix/load pad.

Winterization and Spring Startup

Winterization of the irrigation system is important to protect the system and reduce equipment failures resulting from freezing temperatures.

BEST MANAGEMENT PRACTICES FOR WINTERIZATION OF AN IRRIGATION SYSTEM

- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.
- Flush and drain above-ground irrigation system components that could hold water.
- Remove water from all conveyances and supply and distribution devices that may freeze with compressed air or open drain plugs at the lowest point on the system.
- Clean filters, screens, and housing; remove drain plug and empty water out of the system.
- Remove drain plug and drain above-ground pump casings.
- Record metering data before closing the system.
- Perform pump and engine servicing/repair before winterizing.
- Recharge irrigation in the spring with water, conduct a catch-can test to audit the system, and inspect for corrective maintenance issues.
- Ensure proper irrigation system drainage design.

Non-Play Areas

Non-play and landscape areas provide easy opportunities to reduce water use on golf courses. Native and adapted drought-tolerant plantings can be used to conserve water in these areas. Older golf courses may have more irrigated and maintained acres than are necessary; with the help of a golf course architect, golf professional, golf course superintendent, and other key personnel, the amount of functional turfgrass can be evaluated and transitioned into low-input, low to no irrigation, non-play areas.

BEST MANAGEMENT PRACTICES FOR ESTABLISHING LOW-INPUT NON-PLAY AREAS

- Map environmentally sensitive areas and identify endangered or threatened species and state species of special concern.
- Designate 50% to 70% of the non-play areas to remain in natural cover according to the “right-plant, right-place” principle of plant selection that favors limited supplemental irrigation and on-site cultural practices.
- The most efficient and effective watering method for non-turf landscapes is micro- or drip irrigation.
- Routinely inspect irrigation systems in non-play areas for problems related to emitter clogging, filter defects, and overall system functionality.

For more information on native and adapted species suitable for the Intermountain Region, see the Intermountain Planting Guide. Although this publication primarily targets rangeland plantings, it also provides information on grass and forb species suitable for use in low-input, non-play areas on golf courses. Additional information is available through the USU Center for Water Efficient Landscaping's Water-Wise Plants for Utah Landscapes.

CULTURAL PRACTICES

Cultural management practices allow turfgrass managers to modify the playing surface to enhance water and air infiltration, remedy soil compaction, and improve plant health.

Cultural practices include mowing, verticutting, aerating, topdressing, and rolling. These practices are necessary to provide a high-quality playing surface and to enhance turf health. For example, heavily used areas can deteriorate because of compacted soil, thatch accumulation, and traffic stress. Cultivation practices are an important component of maintaining quality turfgrass on golf courses.

Mowing

Mowing is the most basic and the most important cultural practice on a golf course. Mowing can impact turf density, color, root development, wear tolerance, and growth. Frequent mowing will increase shoot density and tillering and decrease root and rhizome growth as a result of plant stress. Infrequent mowing can result in alternating cycles of vegetative growth followed by scalping, which can further deplete plant food reserves and lead to stress. Proper mowing height depends on the species and cultivar of turfgrass, intended use of the site, shade pressure, mowing equipment, time of year, weather, root growth, and plant stress. Failure to mow properly will result in weak turf with poor density, quality, and ability to recover from stress.

BEST MANAGEMENT PRACTICES FOR MOWING

Mowing Frequency and Height of Cut

- Mowing frequency should increase during periods of rapid growth and decrease during stress periods including during drought and heat stress, high traffic periods, aeration, shade conditions, etc.
- Tall grass should be mowed frequently, and height gradually decreased until desired height of cut is achieved, to avoid scalping and plant stress.
- Mowing height can be increased to improve the health of turf in shaded environments or during prolonged cloudy weather.
- The plant growth regulator trinexapac-ethyl improves overall turf health in shaded environments.

Mowing Equipment

- Reel mowers produce the best quality compared to other mowers and are commonly used on greens, tees, and fairways.
- Rotary mowers can be used for turfgrass stands being cut above 1 inch.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have high aesthetic requirements.
- Alternating mowing direction and pattern can help prevent wear and compaction and can affect the aesthetics of the course.
- Maintaining sharp, properly adjusted mowers will improve the quality of cut and will help prevent shredding leaf tissue.

Clipping Management

- Turfgrass clippings are a source of nutrients and generally contain 2-4% nitrogen on a dry-weight basis and significant amounts of phosphorus and potassium.
- Clippings can be returned to the turf surface unless the presence of clippings will affect play or the volume of clippings will cover the underlying turf canopy.
- Nutrients contained in clippings can be sources of pollution and should be handled properly to avoid deterioration of water quality.
- Collected clippings should be disposed of properly to prevent odor in play areas, fire hazards, or contamination of water bodies. Consider composting pesticide-free clippings or dispersing evenly in naturalized areas.

Aeration

Soil compaction can inhibit water and air infiltration and impact plant health and growth. Likewise, thatch accumulation can reduce root growth and can encourage disease and create undesirably soft playing conditions. Aeration practices disturb the soil or thatch and can help relieve soil compaction, thatch/organic matter build up, and improve water and air exchange. Aeration practices include core aeration, deep drilling, solid tining, and high-pressure water injection. Aeration frequency depends upon traffic intensity, thatch build up, black layer, and severity of soil compaction. Aeration is very beneficial but does affect the playability of the surface and takes some time to heal.

BEST MANAGEMENT PRACTICES FOR AERATION

General

- Groomers are effective at improving management of grain and improving plant density by cutting stolons.
- Different length tines may be used to vary aerification depth and prevent development of compaction layers in the soil profile.

Core (Hollow Tine) Aeration

- Core aerification removes small (0.25 to 0.75 inches in diameter) cores or plugs from the soil profile.
- Core aerification can be used, as appropriate, to relieve compaction and increase infiltration.
- High traffic areas may require more aerification events.

Hollow tine aeration at Fore Lakes Golf Course, Taylorsville, UT (Photo courtesy of T.A. Barker, Superintendent).

Solid Tine Aeration

- Solid tines cause less disturbance to the turf surface.
- Solid tining can help soften hard surfaces, but because no soil is removed, bulk density is not affected by solid tine aeration, and benefits are temporary.

Surface Cultivation

Surface cultivation practices are used to manage above-ground organic matter, improve water infiltration, impact the turf grain, and improve surface consistency and playability. While these methods are generally less disruptive than more aggressive aeration practices, they usually have low to no impact on soil compaction.

BEST MANAGEMENT PRACTICES FOR SURFACE CULTIVATION

Slicing and Spiking

- Slicing and spiking reduce surface compaction and promote water infiltration with minimal surface damage.
- Slicing is faster (but less effective) than core aerification.
- Slicing is best accomplished on moist soil.
- A spiker can break up surface crusts, disrupt algae layers, and improve water infiltration.

Vertical Mowing (Verticutting)

- Setting a verticutter to just nick the turf surface will reduce putting green grain.
- Shallow vertical mowing can be practiced on putting greens to prevent excess thatch accumulation.
- Deeper penetration of verticutter knives will stimulate new growth by cutting stolons and rhizomes.
- Initiate verticutting for thatch removal when the thatch layer reaches 0.25 to 0.50 inches in depth.
- For thatch removal, verticutting depth should extend into the soil below the thatch layer.
- Dethatching with a verticutter is an aggressive practice, and is not recommended for putting greens because of the extensive damage and recovery time required.

Topdressing

Sand topdressing, especially when combined with aerification, can help improve the soil structure, reduce compaction, increase infiltration, dilute organic matter, smooth out surface irregularities, protect turf crowns, and aid in turfgrass recovery.

BEST MANAGEMENT PRACTICES FOR TOPDRESSING

- Topdressing can follow core aerification and heavy vertical mowing to aid in turfgrass recovery.
- The amount of sand applied depends on the growth rate of the turf.
- Light, frequent topdressing can smooth out minor surface irregularities on putting greens.
- When possible, weed-free topdressing sand with a particle size similar to the underlying root zone should be used. Using finer material can result in layering and can have a negative impact on water infiltration.

See USGA's The Size of Topdressing Sand for more information on the impact of sand size. This spreadsheet, developed by PACE Turf, uses temperature-based growth potential to estimate the amount of sand that should be used for topdressing. Input the temperature and rainfall data from your site to get a general estimate of topdressing needs.

Rolling

Rolling can help smooth the putting surface and maintain speeds without lowering the height of cut. Daily rolling of putting surfaces following mowing can increase ball roll by 10%. Light-weight rollers typically have little impact on soil compaction unless the practice is over-utilized or used on saturated silt and clay soils. Rolling can also be used to remove dew off the playing surface.

BEST MANAGEMENT PRACTICES FOR ROLLING

- Use lightweight rollers to minimize compaction.
- Avoid rolling on saturated soils.
- Reduce rolling frequency when turfgrass is heavily stressed.

Shade Management

In general, most turfgrasses perform best in full sun and will exhibit reduced growth, thinning, or elongation in shaded environments. Excessive shade from structures or tree cover reduced photosynthesis and air circulation and can increase susceptibility to pest and disease issues.

BEST MANAGEMENT PRACTICES FOR SHADE MANAGEMENT

- Turfgrass managers should understand the variability in sun angles throughout the year and how this might affect turf growth and health.
- Conduct a shade audit to identify problem areas.
- Conduct a tree survey to identify each tree's species, location, health, life expectancy, safety concerns, maintenance requirements, impact on surrounding turf, etc.
- Prune tree limbs and roots as needed to reduce competition for sunlight, water, and nutrients.
- Trees located around tees and greens can be removed or thinned to promote turf growth.
- If unable to alter the amount of shade in a particular area, consider converting to a more shade tolerant species/variety.
- Application of trinexapac-ethyl may improve turfgrass quality in shaded areas.

NUTRIENT MANAGEMENT

Proper nutrient management plays a key role reducing environmental risk and increasing course profitability. Fertilization is required to achieve desirable turfgrass color, density, and growth, and to help turf recover from damage, increase resistance to stress, and improve playability. However, application of nutrients also increases the potential risk of contamination to the surrounding ecosystem. The goal of a nutrient management plan should be to apply the minimum amount of nutrients necessary to achieve an acceptable playing surface in a manner that maximizes plant uptake.

Fertilizers Used in Golf Course Management

Understanding the components of fertilizers, the fertilizer label, and the function of each element within the plant are all essential in the development of an efficient nutrient management program.

Label

- The Utah Fertilizer Act Governing Fertilizers and Soil Amendments regulates and enforces fertilizer labeling in Utah.
- Grade or analysis refers to the percent (by weight) of nitrogen (N), phosphorous fertilizer (P2O5) and potassium fertilizer (K2O) guaranteed to be in the fertilizer.
- Complete fertilizers contain N, P2O5, and K2O.

The fertilizer label may contain:

- **Brand**
- **Grade**
- **Manufacturer's name and address**
- **Guaranteed analysis**
- **"Derived from" statement**
- **Net weight**

Primary Macronutrients

Macronutrients are required in the greatest quantities and include nitrogen (N), phosphorus (P), and potassium (K). Understanding the role of each macronutrient within the plant provides a greater understanding of why these nutrients play such a key role in proper turfgrass management.

The Role of Nitrogen (N)

Nitrogen is required by the plant in greater quantities than any other element except carbon (C), hydrogen (H), and oxygen (O). Nitrogen plays a role in numerous plant functions including an essential component of amino acids, proteins and nucleic acids. The goal applying any nutrient is to maximize plant uptake while minimizing nutrient losses. Understanding the processes below will facilitate sound decision making and will ultimately lead to an increase in course profitability and a reduction in environmental risk.

- Mineralization: the microbial mediated conversion of organic N into plant-available NH4
- Nitrification: the microbial-mediated conversion of NH4 to NO3
- Denitrification: the microbial mediated conversion of NO3 to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH
- Volatilization: the conversion of NH4 to NH3 gas
- Leaching: the downward movement of an element below the rootzone
- Runoff: the lateral movement of an element beyond the intended turfgrass location

Nitrogen Sources

Understanding how certain N sources can be blended and applied is an essential component in an efficient nutrient management plan. Each N source is unique and therefore should be managed accordingly. Applying a slow-release N source delays N release either by requiring microbial degradation of the N source, by coating the N substrate which delays the dissolution of N, or by reducing the water solubility of the N source. Applying a polymer-coated urea in the same manner as a sulfur-coated urea greatly reduces the value of the polymer-coated urea. Similarly, applying 2 pounds of N from ammonium sulfate may cause burning, while applying 2 pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, application date, location, and turfgrass species all should be included in your nutrient application decision.

Sources of nitrogen commonly used for turfgrass fertilization.

Soluble Nitrogen Sources	Slow-Release Nitrogen Sources
Urea(46-0-0)	Sulfur-coated urea
Ammonium sulfate (21-0-0)	Polymer/resin-coated urea
Diammonium phosphate (18-46-0)	Urea-formaledhyde reaction products
Monoammonium phosphate (11-52-0)	Isobutylidene diurea (IBDU)
Calcium nitrate (15.5-0-0)	Compost
Potassium nitrate (13-0-44)	

Urease and Nitrification Inhibitors

Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N. Nitrification inhibitors reduce the activity of Nitrosomonas bacteria, which are responsible for the conversion of NH4 to NO2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N. These compounds are best applied to turfgrass sites that are not irrigated.

The Role of Phosphorous (P)

Phosphorus forms high-energy compounds that are used to transfer energy within the plant; as such, it can be a growth-limiting factor. Phosphorus may remain in an inorganic form or may become incorporated into organic compounds. Proper timing and rates should be implemented to reduce the risk of off-site movement of phosphorus, which can lead to eutrophication of surface waters. Fortunately, phosphorus binds tightly to native soils and organic matter, so the best way to prevent environmental contamination is to prevent runoff of phosphorous. Symptoms of P deficiency are reduced shoot growth and dark green color followed by reddish coloring on lower leaves. Phosphorous application rates should be based upon soil test results derived from documented correlations demonstrating a turf response to soil test phosphorous levels.

Phosphorous Sources

- **Diammonium phosphate**
- **Concentrated superphosphate**
- **Monoammonium phosphate**
- **Potassium phosphate**
- **Natural organics**

The Role of Potassium (K)

Potassium is of no environmental concern, but can be an economic concern, particularly when potassium is over-utilized, which can be quite common. Generally, potassium concentrations in turfgrass tissue are about one-third to one-half that of nitrogen. Potassium is not a component of any organic compound and moves readily within the plant. Potassium is key component of osmoregulation which has been documented to increase stress resistance.

Potassium Sources

- **Potassium sulfate**
- **Potassium chloride**
- **Potassium nitrate**
- **Potassium phosphate**

Secondary Macronutrients

Secondary macronutrients are essential to plant function and are required in quantities less than N, P, and K, but more than micronutrients. These include calcium (Ca), magnesium (Mg), and sulfur (S).

Secondary macronutrients required for turfgrass health.

Nutrient	*Role*	*Sources*
Calcium (Ca)	Primary component of cell walls and structure	Gypsum Limestone Calcium chloride
Magnesium (Mg)	Central ion in the chlorophyll molecule and essential for chlorophyll synthesis	S-Po-Mg Dolomitic limestone Magnesium sulfate
Sulfur (S)	Metabolized into the amino acid cysteine, which is used in various proteins and enzymes	Ammonium sulfate Elemental sulfur Potassium sulfate Gypsum

Micronutrients

Understanding the role of each micronutrient within the plant should provide a greater understanding of why these nutrients play such a key role in proper turfgrass management. Micronutrients are just as essential for proper turfgrass health as macronutrients, but they are required in very small quantities compared to macronutrients. Micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and Chlorine (Cl). Soil testing for micronutrients is not recommended and soil interpretations for these nutrients can be ignored.

Micronutrients required for turfgrass health.

Nutrient	*Role*
Iron (Fe)	Part of catalytic enzymes Required for chlorophyll synthesis Affects photosynthesis, nitrogen fixation, and respiration
Manganese (Mn)	Involved in photosynthesis Required as a cofactor for many enzymes Required for lignin biosynthesis
Boron (B)	Likely component of cell wall
Copper (Cu)	Involved in photosynthesis Cofactor for many oxidative enzymes
Zinc (Zn)	Structural component of enzymes Required for protein synthesis Affects carbohydrate metabolism
Molybdenum (Mo)	Related to nitrogen metabolism Required for structural and catalytical function of enzymes
Chlorine (Cl)	Required for oxygen-evolving reactions of photosynthesis Required for cell division in leaves and shoots

Soil Testing

Soil testing may (or may not) provide answers to your nutrient management questions. Through proper sampling, laboratory analysis, interpretation of results, recommendations, and record keeping, soil testing can be used as a tool to manage nutrients more efficiently. Because soil pH determines nutrient availability and microbial communities and activity, pH levels may be the most important soil test result for turfgrass managers. In most cases, a pH of 5.5 to 8.0 provides adequate nutrient availability for most turf stands.

BEST MANAGEMENT PRACTICES FOR SOIL TESTING

- Ten to fifteen soil samples should be randomly taken at a depth of six inches and blended together to provide a representative soil sample.
- Each soil sample should be taken from the same depth.
- Keeping soil tests from prior years will allow you to observe changes over time.
- To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca2+ and neutralizes acidity.
- To lower soil pH, products containing elemental sulfur should be applied.
- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

The goal of a nutrient management plan should be to apply the minimum amount of nutrients necessary to achieve an acceptable playing surface in a manner that maximizes plant uptake.

There are several soil testing labs in Utah - the Utah State University Analytical Lab and the Brigham Young University Environmental Analytical Lab are University-run labs, and there are several private labs available for soil testing as well. Regardless of which lab is used, it is important to remain consistent, as different labs can use different methods to test soils.

See Understanding Your Soil Test Report and Simplifying Soil Test Interpretations for Turf Professionals for more information on interpreting soil test results.

Nutrient Management

The objective of all nutrient applications is plant uptake and the corresponding desirable response. Calibration of sprayers and spreaders is essential to avoid applying too little or too much fertilizer which can result in damaged turf, excess cost, and potential for nutrient movement off-site.

BEST MANAGEMENT PRACTICES FOR NUTRIENTS

- Apply nutrients when turfgrass is actively growing.
- Apply slow-release N fertilizers at the appropriate time of year to maximize the products' release characteristics.
- Tees and landing areas often have higher fertility requirements because they suffer constant divot damage.

- Fairways and roughs often require fewer nutrient inputs because of their increased height of cut, less traffic, and clipping return.
- Exercise caution when fertilizing during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff.
- Be aware of the different types of spreaders (walk-behind, drop, bulk rotary, spray, etc.) and understand the advantages and disadvantages of each.
- Calibration reduces environmental risk and increases profitability.
- Spreaders should also be thoroughly cleaned after use due to the high salt content that corrodes metal parts and in keeping with the BMPs for equipment washing.
- Properly store, load, and clean-up fertilizers to reduce environmental risk.
- Avoid applying fertilizer to soils that are at, or near, field capacity or immediately prior to or following heavy rain events.

For more information on sprayer and spreader calibration, see Calibrating Your Fertilizer Spreader.

INTEGRATED PEST MANAGEMENT

Pest management on golf courses results in significant inputs of time, labor, and financial resources. Integrated Pest Management (IPM) is an environmentally sensitive approach to pest management that utilizes a combination of cultural, biological, genetic, and chemical controls. The goal of IPM is to reduce expenses associated with pest management, conserve energy and resources, and reduce risk to people and the environment, while maintaining the health of the turf. To achieve these goals, it is important for golf course superintendents to know what IPM is and how to implement it for different pest groups. Managers must be well-versed in pest identification, understand pest life cycles, which life stage to target, and conditions that favor pests, and know about all possible methods of controlling pests.

IPM focuses on the basics of identifying pests, choosing pest-resistant varieties of grasses and other plants, enhancing habitat for natural pest predators, scouting to determine pest populations and determining acceptable thresholds, and applying biological and other less toxic alternatives to chemical pesticides whenever possible. Chemical controls should have minimal effect on beneficial organisms and the environment and minimize the development of pesticide resistance. Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.

IPM records should include the following information:

- **Date and time of application**
- **Name of applicator**
- **Person directing or authorizing the application**
- **Weather conditions at the time of application**
- **Target pest**
- **Pesticide used (trade name, active ingredient, amount of formulation, amount of water)**
- **Adjuvant/surfactant and amount applied, if used**
- **Area treated (acres or square feet) and location**
- **Total amount of pesticide used**
- **Application equipment**
- **Additional remarks, such as the severity of the infestation or life stage of the pest**
- **Follow-up to check the effectiveness of the application**

Regulatory Considerations

Federal and state regulations cover anyone who manufactures, formulates, markets, and uses pesticides. Record keeping of pesticide use may be required by law. IPM principles suggest that turf managers keep records of all pest control activity so they may refer to information on past infestations or other problems to select the best course of action in the future.

Scouting and Thresholds

Golf courses are particularly sensitive to aesthetic damage, and golfers are often intolerant of anything that could affect the appearance of turfgrass and ornamental plants. IPM is an overall pest management strategy and is a last resort when threshold levels are exceeded. Monitoring for pests, or "scouting", should be conducted in all areas of the course, including putting greens, tees and fairways, roughs, and landscaped areas. Scouting methods include visual inspection, soil sampling, soap flushes and trapping for insects, and weather tracking, which is especially helpful for predicting potential disease outbreaks. Control should only be implemented when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated. The control strategy should reduce the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.

Increased education for golfers and maintenance personnel could raise their tolerance to minor damage without compromising plant health, play, and aesthetics.

BEST MANAGEMENT PRACTICES FOR SCOUTING AND ADHERING TO DAMAGE THRESHOLDS

- Observe and document turf conditions and scout for signs or symptoms of pests regularly, and use available pest thresholds to guide pesticide application decisions.
- It is essential to record or map the results of scouting in order to develop historical information, document patterns of pest activity, and document successes and failures.
- Train personnel to determine the pest's life cycle, and know which life stage to target.
- Direct control where the pest lives or feeds.
- Use properly timed preventive chemical applications only when your professional judgment indicates they are likely to control the target pest effectively, while minimizing the economic and environmental costs.
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.

For information on identification and management of Utah pests, see Common Turfgrass Pests of Utah and the Utah Plant Pest Diagnostic Lab. The Utah Plant Pest Diagnostic Lab also accepts samples for confirmation, if needed, for many pests. Check with your local county extension service for more information.

Record Keeping

In Utah, it is not required for golf course employees to have a license to apply general-use pesticides or to keep records of applications; however, it is still considered best management practices to record the results of scouting in order to develop historical information, document patterns of pest activity, and document pesticide application and efficacy. Certain pesticides are classified as restricted-use pesticides (RUP) - very few pesticides in this category are routinely used in turf maintenance, but if one is used, the employee applying the RUP will need a "non-commercial" license and must keep records. There is no "working under someone else's license" in Utah for RUPs.

The following record-keeping requirements are listed under the Utah Pesticide Control Rule (R68-7):

> *"Non-commercial applicators shall keep and maintain records of each application of any restricted-use pesticide. These application records must be recorded within 24 hours after the pesticide application is made. These records must include the following information:*
>
> *(a) Name and address of property owner;*
> *(b) Location of treatment site, if different from (a);*
> *(c) The month, day and year when the pesticide was applied;*
> *(d) Brand name of pesticide, EPA registration number, rate of formulation (undiluted pesticide concentrate product as sold by the manufacturer) applied per unit area, and total amount of diluted pesticide used;*
> *(e) Purpose of application (target site and pest to be treated);*
> *(f) The name, address, and license number of the certified applicator who applied the pesticide.*
>
> *Such records shall be kept for a period of two years from the date of application of the pesticide and shall be available for inspection by the commissioner's designee at reasonable times. The commissioner's designee shall, upon request, be furnished a copy of such records by the non-commercial applicator."*

BEST MANAGEMENT PRACTICES FOR IPM RECORD KEEPING

- Document, identify, and record key pest activities on key plants and locations.
- Determine the pest's life cycle, and know which life stage to target.
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document weather and turf conditions regularly, noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.

Turfgrass Selection

Selecting pest-resistant cultivars or plant species is an important part of IPM and can to reduced pesticide usage. Species grown outside of their zone of adaptation are more prone to pest problems. Species and cultivars should be managed under conditions similar to their intended use (for example, not exceeding mowing height limitations that a grass was bred for or selected for).

BEST MANAGEMENT PRACTICES FOR TURFGRASS SELECTION

- Select the most suitable turfgrass for existing conditions and one that adheres to design specifications.
- Select shade-adapted grasses and reduce fertilizer application and traffic in shaded areas.
- Reduce pest and disease pressures by addressing dead spots, air-circulation issues, and adjusting irrigation.

For information on varieties tested for pest resistance, see the National Turfgrass Evaluation Program.

Biological Controls

The biological component of IPM involves the release and/or conservation of natural predators, parasites, pathogens, and pollinators. Areas on the golf course can also be modified to better support natural predators and beneficial organisms.

BEST MANAGEMENT PRACTICES FOR UTILIZING BIOLOGICAL IPM CONTROLS

- Identify areas on the golf course that can be modified to attract, provide habitat for, and protect natural predators.
- Install flowering plants that can provide parasitoids with nectar, or sucking insects (aphids, mealybugs, or soft scales) with a honeydew source.
- Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Release insect-parasitic nematodes to naturally suppress mole crickets and white grubs.

More information on pollinators can be found in the “Pollinator Protection” chapter of this BMP guide.

Conventional Pesticides

IPM does not preclude the use of pesticides; however, pesticides should be viewed as one of many tools in the IPM toolbox and should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated based on established thresholds.

Pesticides include, but are not limited to, fungicides, insecticides, herbicides, nematicides, and rodenticides. Pesticides are designed to control or alter the behavior of pests. When, where, and how they can be used safely and effectively is a matter of considerable public interest. Pesticides should be chosen based on efficacy against the pest, mode of action, life stage of the pest, personnel hazards, non-target effects, potential off-site movement, and cost. Always follow the directions on the label. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide.

BEST MANAGEMENT PRACTICES FOR USE OF CONVENTIONAL PESTICIDES IN AN IPM PLAN

- Train employees in proper pest identification of pests and pesticide selection techniques.
- Check temperature and wind speed limitations on pesticide labels to make sure it is not too hot or windy to legally apply the product.
- Make note of any environmental hazards and groundwater advisories included on the label.
- Choose the product most appropriate for the problem or pest.
- Mix only the quantity of pesticide needed in order to avoid disposal problems, protect non-target organisms, and save money.
- Spot-treat pests whenever appropriate.
- Rotate pesticide modes-of-action to reduce the likelihood of resistance.
- Follow guidelines and advice provided by the Fungicide Resistance Action Committee, Herbicide Resistance Action Committee, and Insecticide Resistance Action Committee.

For more information on IPM and control of Utah pests, see Common Turfgrass Pests of Utah.

THE LABEL IS THE SINGLE MOST IMPORTANT DOCUMENT IN THE USE OF A PESTICIDE. STATE AND FEDERAL PESTICIDE LAWS REQUIRE FOLLOWING LABEL DIRECTIONS.

Disease

In the presence of a susceptible host and favorable environmental conditions, plant pathogens can cause significant damage to turfgrass stands. Turfgrass managers have multiple tactics and tools that can reduce the likelihood of disease. Cultural factors that can influence turfgrass stress and the likelihood of disease problems include organic layer management, fertility programs, water management, and mowing height selection. Healthy, well-managed turfgrass is less likely to develop disease problems. Disease outbreaks that do occur are less likely to be severe on turf that is healthy because it has better recuperative potential than stressed, unhealthy turf.

BEST MANAGEMENT PRACTICES FOR IPM OF TURFGRASS DISEASE

- Correctly identify the disease pathogen; this may require sending a sample to a diagnostic lab.
- Mitigate turfgrass stress by altering the environment through cultural practices.
- Fungicide use may be integrated into an overall management strategy for a golf course.
- Apply appropriate preventative fungicides when conditions favor disease outbreaks.
- Record and map disease outbreaks and identify trends that can help guide future treatments and focus on changing conditions in susceptible areas to reduce disease outbreaks.

For more information on turfgrass diseases common in Utah, and options for management, see Common Turfgrass Pests of Utah and Common Turf Diseases in Utah.

Weeds

Weeds compete with turf for space, water, light, and nutrients. They can also harbor insect pests and diseases.

BEST MANAGEMENT PRACTICES FOR IPM OF WEEDS

A successful weed management program prevents weeds from being introduced, promotes vigorous, competitive turf, properly identifies weeds when present, and uses appropriate herbicides, if necessary.

- Proper weed identification is essential for effective management and control.
- Select turf species or cultivars that are adapted to the prevalent environmental conditions to promote healthy stands and reduce weed encroachment.
- Adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures.
- To reduce weed infestation, address improper turf management practices, such as the misuse of fertilizers and chemicals, improper mowing height or mowing frequency, and improper soil aeration, and physical damage and compaction from excessive traffic.
- Proper fertilization is essential for turfgrasses to sustain density and vigor and to better resist diseases, weeds, and insects.
- Avoid scalping; it reduces turf density, increasing weed establishment.
- Weed-free materials should be used for topdressing.
- Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.
- Record and map weed infestations to help identify site specific issues for preventative actions.

For information on common turfgrass weeds and management options, see Common Turfgrass Pests of Utah.

Nematodes

Plant-parasitic nematodes are microscopic roundworms, usually between 0.0156 and 0.125 inch (0.25 and 3 mm) in length, and are difficult to control. Nematodes debilitate the root system of susceptible turfgrasses and can cause turf to be less efficient at water and nutrient uptake and make it much more susceptible to environmental stresses. Additionally, weakened turf favors pest infestation, especially troublesome weeds that necessitate herbicide applications. Over time, turf in the affected areas thins out and, with severe infestations, may die. The roots of turfgrasses under nematode attack may be very short, with few, if any, root hairs, or they may appear dark and rotten. Turfgrasses usually begin showing signs of nematode injury as they experience additional stresses, including drought, high temperatures, low temperatures, and wear.

BEST MANAGEMENT PRACTICES FOR IPM OF NEMATODES

- When nematode activity is suspected, an assay of soil and turfgrass roots is recommended to determine the extent of the problem.
- The application of a nematicide on golf course turf should be based on assay results.
- Divert traffic away from areas that are stressed by insects, nematodes, diseases, or weeds.
- Increase mowing height to reduce plant stress.
- Reduce/eliminate other biotic/abiotic stresses when nematodes are compromising the root system and plant health.

PESTICIDE MANAGEMENT

Pesticide use can be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred altogether as IPM.

When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, site characteristics, and its solubility and persistence in the environment.

Regulatory Considerations

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacture, distribution, sale, and use of pesticides. The Utah Pesticide Control Act and the Utah Pesticide Control Rule regulate state-level registration, transportation, storage, sale, use, and disposal of pesticides in the Utah. Pesticide applicators are required to complete education modules provided by Utah State University before testing for and obtaining a pesticide applicators license. In Utah, it is not required for golf course employees to have a license to apply general-use pesticides or to keep records of applications; however, certain pesticides are classified as restricted-use pesticides (RUP) - very few pesticides in this category are routinely used in turf maintenance, but if one is used, the employee applying the RUP will need a "non-commercial" license and must keep records. There is no "working under someone else's license" in Utah for RUPs. Contractors hired to apply pesticides on a course must be licensed whether applying general- or restricted-use pesticides.

Select pesticides that, when applied according to the label, have:

- **Low runoff and leaching potential.**
- **Limited impact on pollinators.**
- **No known effect on endangered species present on the facility.**

For more information on pesticide licensing in Utah, see the Utah Department of Agriculture and Food's Pesticide Program site and Utah State University's Pesticide Certification and License website.

More information on integrated pest management, scouting, licensing, and record keeping can be found in the "Integrated Pest Management" chapter of this BMP document.

Human Health Risks

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. The human health risk associated with pesticide use is related to both pesticide toxicity and the level of exposure. The risk of a very highly toxic pesticide may be very low if the exposure is sufficiently small. Remember, Risk = Toxicity x Exposure. Pesticide applicators should always read and follow label instructions, including specific information on PPE requirements and first-aid information, before applying a pesticide, in addition to following standard safe practices. Safety Data Sheets provide important information on hazardous chemicals. Practicing good work habits and adopting modern pesticide mix/load equipment can reduce potential pesticide exposure.

BEST MANAGEMENT PRACTICES FOR HUMAN HEALTH

- Select the least toxic pesticide with the lowest exposure potential.
- Read the pesticide label and comply with all listed directions. The label is the law.
- Store, handle, mix, and apply pesticides with caution and follow all safety precautions.
- Always use the appropriate personal protective equipment (PPE) when preparing and applying pesticides.
- Know the emergency response procedure in case excessive exposure occurs.

Personal Protective Equipment

PPE protects pesticide applicators from exposure through the skin, eyes, respiratory tract or from oral ingestion. Applicators should always read the pesticide label, which includes a list of legal requirements for minimum PPE for the specific pesticide. These can include specific types of clothing, goggles, and respirators required to protect the applicator from pesticide exposure.

BEST MANAGEMENT PRACTICES FOR USING PERSONAL PROTECTIVE EQUIPMENT

- Store PPE where it is easily accessible but not in the pesticide storage area.
- Provide adequate PPE for all employees who work with pesticides, including equipment technicians who service pesticide application equipment.
- Ensure that PPE is sized appropriately for each person using it.
- Make certain that PPE is appropriate for the chemicals used.
- Ensure that PPE meets rigorous testing standards and is not just the least expensive.
- Forbid employees who apply pesticides from wearing facility uniforms home where they may come into contact with children.
- Provide laundering facilities or uniform service for employee uniforms.
- The federal Occupational Safety and Health Administration (OSHA) requires employers to fit test workers who must wear tight-fitting respirators.
- If a respirator is required, make sure it fits properly and that the cartridges are still usable.
- Meet requirements for OSHA 1910.134 Respiratory Protection Program.

For more information on PPE, see Protective Clothing and Equipment for Pesticide Applicators, Pesticide Safety: Choosing the Right Gloves, Respirators for Handling Pesticides, and Fit Testing a Respirator for Pesticide Applications.

Environmental Fate and Transport

Environmental characteristics of pesticides can be determined by the environmental hazards statement found on product labels. The environmental hazards statement is found under the “Precautionary Statements” heading and provides information advising users of potential hazards associated with the use of the product. Environmental hazards generally fall into three categories: 1) general environmental hazards, 2) non-target toxicity, and 3) endangered species protection. Use the EPA's Endangered Species Protection Bulletins Live! tool to determine pesticide use limitations for protection of threatened and endangered species and critical habitat before applying pesticides.

Pesticides can move through the environment via air, water, and soil transport, or as residue on clothing, machinery, animals, and plants. To prevent pesticide transport, pesticide characteristics, site characteristics, and prevailing conditions should all be evaluated before application.

Pesticide characteristics, such as solubility, and site-specific characteristics, such as soil type, depth to the water table, geology, and proximity to surface water, should be considered before selecting and applying pesticides. For example, in Utah, irrigation water is often very alkaline, which may impede the performance of certain pesticides. Before applying a pesticide, evaluate the impact of weather as well as site-specific characteristics and pesticide-specific characteristics. Prevailing weather conditions, such as the chance of precipitation, the prevailing wind, and humidity, should also be evaluated with respect to the timing of pesticide applications. Check temperature and wind speed limitations on pesticide labels to see if environmental conditions restrict legal application of the product.

BEST MANAGEMENT PRACTICES FOR ENVIRONMENTAL FATE AND TRANSPORT OF PESTICIDES

Runoff and Leaching

- Weakly sorbed pesticides are more likely to leach through soil and reach groundwater.
- Strongly sorbed pesticides are likely to remain near the soil surface, reducing the likelihood of leaching, but increasing the chances of being carried to surface water via runoff or soil erosion.
- Understand pesticide sorption principles so that appropriate decisions can be made.
- Identify label restrictions that may pertain to your facility.
- Avoid using highly water-soluble pesticides.
- Exercise caution when using spray adjuvants that may facilitate off-target movement.
- Prevent spilling or over-application of pesticides.
- Prevent applying pesticides prior to heavy rain events and/or limit irrigation.
- Utilize buffer strips and retention ponds to slow water movement and reduce contamination of surface waters.

Drift

- Pesticides may be transported in the air as droplets, vapors, or on air-borne soil particles.
- Review the pesticide label for specific instructions on reducing drift.
- Select the appropriate nozzle type, spray pressure, spray angle, and spray volume to minimize spray drift.
- Avoid applying pesticides during high-wind events.
- Select pesticides with low-volatilization risk, especially when temperatures and wind speeds are high.
- Irrigate after application of volatile pesticides.
- Be aware of any areas surrounding the course (residential and agricultural areas, bee hives, etc.) that may be sensitive to pesticide drift.

For more information on preventing pesticide contamination of surface waters, see the “Water Quality and Management” chapter of this BMP document.

Pesticide, site, and weather conditions to consider when selecting and applying pesticides.

	Considerations
Pesticide	Active ingredient and concentration
	Solubility and adsorption potential
	Half-life
	Volatilization potential
Site	Soil type
	Proximity to surface water and well heads
	Depth to water table
	Runoff, erosion, and leaching potential
	Potential to impact pollinators
	Alkalinity of the irrigation source
Weather	Temperature
	Wind
	Humidity
	Potential for precipitation
Time and Number of Applications	Limit on the number of applications legally allowed in a season
	Re-Entry Interval (REI)

Pesticide Transportation, Storage, and Handling

Storage and handling of pesticides in their concentrated form poses the highest potential risk to ground or surface waters. For this reason, it is essential that facilities for storing and handling these products be properly sited, designed, constructed, and operated.

BEST MANAGEMENT PRACTICES FOR TRANSPORTING, STORING, AND HANDLING PESTICIDES

Transporting

- Do not transport pesticides in the passenger section of a vehicle.
- Never leave pesticides unattended during transport.
- Pesticides left unattended must be secured to prevent removal by unauthorized persons.

Storing

- The “Storage and Disposal” section at the end of a pesticide label may have specific storage requirements.
- Avoid purchasing large quantities of pesticides that require storage for greater than six months.
- Pesticides should be used based on the "first in, first out" rule and should not be stored for long periods.
- Ensure labels are on every package and container.
- Consult inventory when planning and before making purchases.
- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater.
- Store pesticides in a lockable concrete or metal building that is separate from other buildings.
- Locate pesticide storage facilities from other types of structure to allow fire department access.
- Storage facility floors should be impervious and sealed with a chemical-resistant paint.
- Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- Sloped ramps should be provided at the entrance to allow the use of wheeled handcarts for moving material in and out of the storage area safely.
- Shelving should be made of sturdy plastic or reinforced, painted metal; wood shelving should never be used, because it may absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided.
- Explosion-proof lighting may be required; light and fan switches should be located outside the building, so that both can be turned on before staff enter the building and turned off after they leave the building.
- Avoid temperature extremes inside the pesticide storage facility.
- Personal protective equipment (PPE) should be easily accessible and stored immediately outside the pesticide storage area.

Handling

- PPE should be worn at all times when handling pesticides.
- Place a spill containment kit in the storage area, in the mix/load area, and on the spray rig.

Emergency Preparedness and Spill Response

Develop a golf course facility emergency response plan which includes procedures to control, contain, collect, and store spilled materials.

Accidents happen. Advance preparation on what to do when an accident occurs is essential to mitigate the human health effects and the impact on the environment.

BEST MANAGEMENT PRACTICES FOR EMERGENCY PREPAREDNESS AND SPILL RESPONSE

- Prominently post "Important Telephone Numbers" including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill.
- Ensure an adequately sized spill containment kit is readily available.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Host a tour for local emergency response teams to show them the facilities, discuss the emergency response plan, and to seek advice on ways to improve the plan.

For injuries, medical emergencies, or fires, first responders/EMT should be notified. Pesticide spills or other pesticide mishaps should be reported to Utah Department of Agriculture and Food at (801) 538-7185. The UDEQ should be notified about reportable spills at (801) 536-4123. Spills that pose a threat to waters of the state should be reported directly to the Division of Water Quality at (801) 536-4300. CHEMTREC (800) 424-9300 can also be contacted for assistance, as needed.

Pesticide Record Keeping

Maintaining accurate records of pesticide-related activities (for example, purchasing, storage, inventory, applications, etc.) is essential. The Utah Department of Agriculture and Food provides a template for pesticide record keeping.

BEST MANAGEMENT PRACTICES FOR PESTICIDE RECORD KEEPING

- Keep and maintain records of all pesticides used to meet legal reporting requirements.
- Use records to monitor pest control efforts and to plan future management actions.
- Use electronic or hard-copy forms and software tools to properly track pesticide inventory and use.
- Develop and implement a pesticide drift management plan.
- Keep a backup set of records in a safe, but separate storage area.

Application Equipment Maintenance

Properly maintained and calibrated application equipment ensures the proper amount of pesticide is applied and mitigates environmental and human health concerns.

BEST MANAGEMENT PRACTICES FOR MAINTAINING PESTICIDE APPLICATION EQUIPMENT

- Ensure spray technicians are experienced, licensed, and properly trained.
- The size of the equipment (tank size, boom width, etc.) should be matched to the scale of the facility.
- Minimize off-target movement by using properly configured application equipment.
- Regularly check equipment for leaks and malfunctions.
- Properly calibrate all application equipment at the beginning of each season and after equipment modifications.
- Use recommended spray volumes for the selected pesticide and targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to account for walking speed, etc.

Mixing and Washing Stations

Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or run off the surface to contaminate water bodies. One of the best containment methods is the use of a properly designed and constructed chemical mixing center.

BEST MANAGEMENT PRACTICES FOR MIXING AND WASHING STATIONS

- Loading pesticides and mixing them with water or oil should be done over an impermeable surface, so spills can be collected and managed.
- Mixing station surfaces should allow for easy cleaning and the recovery of spilled materials.
- Pump the sump dry and clean it at the end of each day. Liquids and sediments should be removed from the sump and the pad whenever pesticide materials are changed to an incompatible product (that is, one that cannot be legally applied to the same site).
- Apply liquids and sediments as you would a pesticide, strictly following label instructions.
- Absorbents such as cat litter or sand may be used to clean up small spills and then applied as a topdressing in accordance with the label rates, or disposed of as a waste.
- Sweep up solid materials and use as intended.
- Unusable pesticides must be disposed of as hazardous waste.

Pesticide Disposal

The improper disposal of a hazardous waste can result in very high fines and/or criminal penalties.

Wash water from pesticide application equipment and any liquids or solids collected from mixing/washing sites must be managed properly, since these contain pesticide residues. The containers of some commonly used pesticides are classified as hazardous wastes if not properly rinsed, and as such, are subject to the many rules and regulations governing hazardous waste. However, pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. Federal law (FIFRA) and some state laws require pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. Under federal law (the Resource Conservation and Recovery Act, or RCRA), a pesticide container is not empty until it has been properly rinsed.

BEST MANAGEMENT PRACTICES FOR PESTICIDE DISPOSAL

- The “Storage and Disposal” section at the end of a pesticide label will list procedures for disposal of empty pesticide containers.
- Collect wash water (from both inside and outside the application equipment) and use it as a pesticide in accordance with the label instructions.
- The rinsate may be applied as a pesticide (preferred) or stored for use as makeup water for the next compatible application.
- Rinse pesticide containers immediately in order to remove the most residue.
- Rinse containers during the mixing and loading process and add rinsate water to the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Puncture empty and rinsed pesticide containers and dispose of according to the label.
- Most labels disallow reusing rinsed pesticide containers for any other purpose.

MAINTENANCE OPERATIONS

Pollution prevention requires proper storage, handling, and disposal of chemicals, solid waste, and wastewater. One of the key principles of pollution prevention is to reduce the unnecessary use of potential pollutants. Over time, the routine discharge of even small amounts of chemicals or nutrients can result in serious environmental and liability consequences, because of the accumulation of contaminants in soil or groundwater. More information regarding the design and construction of maintenance facilities can be found in the Planning, Design, and Construction chapter of this BMP manual.

Early engagement among developers, designers, local community groups and permitting agencies is essential to designing and constructing a golf maintenance and storage facility that minimizes environmental impact and meets the needs for the approval process.

Regulatory Considerations

The proper handling and storage of pesticides is important. Failure to do so correctly may lead to the serious injury or death of an operator or bystander, fires, environmental contamination that may result in large fines and cleanup costs, civil lawsuits, the destruction of the turf you are trying to protect and wasted pesticide product. Generating as little as 25 gallons per month of used solvents for disposal can qualify you as a "small-quantity generator" of hazardous waste, triggering EPA and state reporting requirements. The Utah Pesticide Control Rule outlines regulations regarding pesticide certification, applicator responsibilities, and the transportation, storage, handling, using and disposal of pesticides and pesticide containers for the state of Utah. Underground storage tanks for golf course facilities are regulated by EPA under the Technical Standards and Corrective Action Requirements for Owners and Operators of USTs (40 C.F.R. Part 280). Check with the Utah DEQ Division of Environmental Response and Remediation to see if state regulations are required.

Storage and Handling of Chemicals

Proper handling and storage of pesticides and petroleum-based products is important to reduce risk of serious injury or death of an operator or bystander. Fires or environmental contamination may result in large fines, cleanup costs, and civil lawsuits if these chemicals are not managed properly. Regulations regarding the transportation, storage, handling, use and disposal of pesticides and pesticide containers in Utah should be adhered to at all times.

BEST MANAGEMENT PRACTICES FOR STORAGE AND HANDLING OF CHEMICALS

Storage

- Store pesticides in a lockable concrete or metal building located away from other buildings, especially fertilizer storage facilities.
- Storage buildings should have appropriate warning signs and placards.
- Floors of chemical storage buildings should be impervious, sealed with chemical-resistant paint, and should have a continuous sill to contain spills and should not have a drain; a sump is acceptable.

- Use a chemical mixing center (a concrete pad treated with sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered) as a place for performing all operations where pesticides are likely to be spilled.
- Shelving should be plastic or reinforced metal; metal shelving should be painted to avoid corrosion.
- Wood shelving should never be used because of its ability to absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided
- Explosion-proof lighting may be required; locate fan and light switches outside the entrance to the building to facilitate ventilation of building before entrance of staff.
- Maintain detailed records of current pesticide inventory in the storage facility.
- Safety Data Sheets for the chemicals stored on-site should be stored separate from the storage room, but readily accessible on-site.
- Do not store large quantities of pesticides or chemicals for long periods of time.
- Follow a "first in, first out" principle to rotate products into use to ensure products do not expire.
- Store chemicals only in the original containers - never store them in any container that might be mistaken as packaging for food or drink.
- Store flammable pesticides separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers are properly labeled and stored within the facility.
- Arrange containers so labels are clearly visible.
- Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.

Handling

- Follow all personal protective equipment (PPE) statements on pesticide labels.
- Store PPE away from pesticide storage areas in an area that is easily accessible.
- Develop an emergency response plan and educate all golf course personnel regarding emergency procedures on a regular basis.
- Individuals conducting emergency chemical cleanups should be properly trained under requirements of federal Occupational Safety and Health Administration (OSHA).
- Rinse pesticide containers as soon as they are empty; pressure rinse or triple-rinse containers and add the rinse water to the sprayer.
- Shake or tap non-rinseable containers, such as bags or boxes, so that all dust and material fall into the application equipment.
- After cleaning them, puncture the pesticide containers to prevent reuse (except glass and refillable mini-bulk containers).
- Keep the rinsed containers in a clean area, out of the weather, for disposal or recycling.
- Store the rinsed containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers in counties where an applicable program is available, or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them.

For emergency (only) information on hazards or actions to take in the event of a spill, call CHEMTREC, at (800)424–9300. CHEMTREC is a service of the Chemical Manufacturers Association. For information on whether a spilled chemical requires reporting, call the CERCLA/RCRA help line at (800) 424–9346.

Equipment Storage and Maintenance

Storing and maintaining equipment properly will extend useful life and reduce repairs and prevent environmental contamination from occurring.

BEST MANAGEMENT PRACTICES FOR EQUIPMENT STORAGE AND MAINTENANCE

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit risk of fluid leaks contaminating the environment and to facilitate early detection of leaks that may require repair before causing significant damage to the turf or the environment.
- Seal floor drains unless they are connected to a holding tank or sanitary sewer with permission from the local wastewater treatment plant.
- Store pesticide and fertilizer application equipment in areas protected from rainfall to prevent contamination from residues.
- Store solvents and degreasers in lockable metal cabinets away from ignition sources in a well-ventilated area; these products are generally toxic and highly flammable - never store them with fertilizers or in areas where smoking is permitted.
- Keep an inventory of solvents and safety data sheets on-site but in a different location where they will be accessible in case of an emergency.
- Keep basins of solvent baths covered to reduce emissions of volatile organic compounds.
- When possible, replace solvent baths with recirculating aqueous washing units. Soap and water or other aqueous cleaners are often as effective as solvent-based products and present a lower risk to the environment.
- Always use appropriate personal protective equipment when working with solvents.
- Never allow solvents or degreasers to drain onto pavement or soil, or discharge into waterbodies, wetlands, storm drains, sewers, or septic systems.
- Collect used solvents and degreasers in containers clearly marked with contents and date; schedule collection by a commercial service.
- Blow off all equipment with compressed air to reduce damage to hydraulic seals.

Equipment Washing

All equipment used in the maintenance of golf courses and associated developments should be designed, used, maintained, and stored in a way that eliminates or minimizes the potential for pollution.

An equipment-washing facility can be a source of both surface water and groundwater pollution, if the wash water generated is not properly handled. Proper equipment washing practices can help prevent residues such as grass clippings, sediment, soaps, oil, fertilizers, and pesticides from polluting surface water and groundwater.

BEST MANAGEMENT PRACTICES FOR WASHING EQUIPMENT

- When possible, grass-covered equipment should be brushed or blown off with compressed air before being washed.
- A catch basin may be used to collect remaining grass clippings, which may then be collected and composted or removed to a designated disposal area.
- Wash pads should be rinsed with clean water after equipment has been washed.

- Wash water can be captured and used as a dilute pesticide per labeled site; alternatively, wash water can be pumped into a rinsate storage tank for use in the next application.
- Consider the use of a closed-loop wash-water recycling system.
- Wash equipment with a bucket of water and a rag to minimize the amount of water used and use only the minimal amount of water required to rinse the machine.
- Spring-operated shut-off nozzles and spray nozzles that generate high-pressure streams of water at low volumes can be used.
- Do not allow any wastewater to flow directly into surface waters or storm drains.

Fueling Facilities

Safe storage of fuel, including use of above-ground tanks and containment facilities, is critical to the protection of the environment. Underground storage tanks for golf course facilities are regulated by EPA under the Technical Standards and Corrective Action Requirements for Owners and Operators of USTs (40 C.F.R. Part 280). Check with the Utah DEQ Division of Environmental Response and Remediation to see if state regulations are required.

Waste Handling

Proper disposal of waste materials is critical for protection of water and natural resources. Facilities should routinely identify and implement waste-reduction practices and look for ways to increase recycling efforts.

BEST MANAGEMENT PRACTICES FOR HANDLING WASTE

- Purchase environmentally preferred products in bulk packaging when possible.
- In Utah, any mixed or diluted pesticide waste is considered hazardous and should be disposed of as such.
- Collect used oil, oil filters, antifreeze, solvents, and degreasers in separate marked containers and recycle.
- Recycle lead-acid batteries. If not recycled, batteries are classified as hazardous waste.
- Store other old batteries on impervious services where they are protected from rainfall and recycle as soon as possible.
- Recycle used tires, fluorescent tubes and other lights.
- Place containers for recycling paper products, aluminum cans, and glass or plastic containers at convenient locations on the golf course.

The Salt Lake Valley Landfill is the only landfill licensed to take hazardous waste, but use is restricted to courses within Salt Lake County. Golf course managers in Salt Lake County should contact the landfill beforehand at (385) 468-3862 to verify that the landfill will accept the chemicals requiring disposal. Companies like Clean Harbors may accept hazardous waste for a fee.

POLLINATOR PROTECTION

In Utah, pollinators include bees, moths, flies, beetles, wasps, desert bats, hummingbirds, and butterflies. Utah is home to 1,087 known bee species, with many more still being described. Many of these species are responsible for pollinating tree fruits, raspberries, squash, melon, and cucumbers produced in the state. Pollinators world-wide are facing various threats to their health, abundance, and distribution. For example, pesticides can have non-target effects on beneficial pollinating insects. Pesticide applicators, including those on golf courses, need to be mindful of the impact that pesticides may have on beneficial pollinator species and pollinator habitat. Pollinator conservation can be broken up into three facets: availability of floral resources, provision of nesting sites, and protection from pesticides, all of which can be addressed on golf course systems through the incorporation of BMP.

Most flowering plants, including a large portion of agricultural and horticultural crops, need pollination to reproduce and grow fruit.

For more information on pollinators in Utah, see Information About Utah Pollinators, Bees and Other Pollinators, and Plants for Pollinators in the Intermountain West.

Regulatory Considerations

Pollinator protection language is a requirement for pesticide labels, and following the label is mandatory. Pesticide applicators must be able to interpret pollinator protection labels and must be aware of honey bee toxicity groups. In addition to following legal requirements, pesticide applicators should understand the effects of pesticides on bees and other pollinators and the routes of potential exposure. Recordkeeping may be required by law to use some pesticides, but should be used regardless, to help keep track of pesticide use and efficacy.

Protecting pollinators on the golf course does not mean pesticides cannot be used; rather, care should be taken to balance turfgrass management with minimizing non-target effects on pollinators.

Implementing pollinator BMP is an important key to protecting pollinators because they reduce unnecessary pesticide usage and help minimize the potential of pollinator exposure.

For more information on best practices to protect pollinators when using chemical control, see Best Management Practices for Turf Care and Pollinator Conservation: Fast Facts.

For more information specifically on bees, see USDA Bee Biology and Systematics Lab: Bees, Bee Basics: An Introduction to Our Native Bees, and Making Room for Native Pollinators.

Establishing Pollinator Habit

Pollinators require nesting sites, water, and foraging options for all life stages. When practical, pollinator-friendly habitat should provide for a variety of pollinators. Increasing and improving pollinator habitat may simply require adding to existing plantings or may involve intensive efforts to establish a larger native or naturalized area. To convert existing out-of-play areas site preparation is key. More than one season may be required to reduce competition from invasive or other undesirable plants prior to planting, and to establish slow-growing native plants into the landscape.

Naturalized area planted with a native wildflower mix at Murray Parkway, Murray, UT (Photo courtesy of Dave Carruth, Superintendent).

BEST MANAGEMENT PRACTICES FOR ESTABLISHING POLLINATOR HABITAT

Provide Forage Sites

- Follow site preparation guidelines when renovating areas to ensure success.
- Choose south-facing sites whenever possible for establishing native areas.
- Plant a diverse assemblage of perennial and annual flowering plants with different heights, a variety of bloom color, and a succession of bloom.
- Place plants in masses to attract pollinators.
- Include grasses that act as larval hosts and larval food sources.
- Include trees that provide early-season pollen.

Provide Nesting Sites

- Leave small, exposed patches of bare soil.
- Leave dead trees, stumps, and posts if they pose no risk to people or property.
- Plant hollow-stemmed grass species and/or provide stem bundles of hollow plant stems like bamboo.
- Create or purchase bee blocks for solitary bees. Utah's USDA-ARS provides instructions on building nesting boxes and stick nests.

Provide a Clean, Reliable Source of Water

- Pollinators can use natural and man-made water features such as running water, pools, ponds, and small water containers.
- Water sources should be shallow or have a sloping side to prevent drowning.
- Irrigate at night and avoid flooding areas to protect ground-nesting pollinators.

For more information on establishing pollinator habitat in Utah, see Gardening and Landscaping Practices for Nesting Native Bees, Plants for Pollinators in the Intermountain West, Gardening for Native Bees in Utah and Beyond, Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province, and Xerces Society Resources.

Pollinator Protection Best Management Practices

Pollinators face numerous threats to their health, abundance, and distribution. Many pesticides can have non-target effects on beneficial pollinating insects, so pesticide applicators need to be mindful of the impact that pesticides used on golf courses may have on pollinators, and should take steps to protect pollinators whenever possible.

BEST MANAGEMENT PRACTICES FOR POLLINATOR PROTECTION ON GOLF COURSES

- Before applying a pesticide, inspect the area for both harmful and beneficial insect populations, and use pesticides only when a threshold of damage has been indicated.
- Consider biological control agents, lures, baits, and pheromones as alternatives to insecticides for pest management.
- Avoid applying pesticides during bloom or mow flowering plants before insecticide application.
- When pesticides are needed, refer to pesticide labels to determine pollinator-protection status, and select pesticides with a lower impact on pollinators.
- If a granular formulation will control the pest, choose it over liquid formulations. Granular versions of pesticides are known to be less hazardous to bees.
- Restrict applications to early morning or evening when pollinators are not as active.
- Avoid application during unusually low temperatures or when dew is forecast.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site translocation of pesticide.

The Pollinator Partnership provides resources for promoting pollinator heath. The Partnership also provides a Protecting Pollinators training module for pesticide applicators; this digital training covers the importance and status of pollinators, how pesticide applicators can help protect pollinators, how to minimize risk to pollinators when selecting and applying pesticides, and label language.

LANDSCAPE

Landscape (non-play) areas are an essential part of the overall course design, and an environmental landscape design addresses environmentally safe and energy-saving practices; therefore, environmentally sound landscape management is also economically important. Using native or adapted plantings that mimic natural ecosystems can reduce overall management inputs, attract pollinators, provide wildlife habitat, offer multi-season visual interest, and enhance out-of-play areas.

Species Selection

Native and adapted species can respond favorably to the soil, microclimate, rainfall, light patterns, and pests at the planting site; as such, the use of these plants can reduce overall management inputs. The goal of species-selection BMP is to maintain as close to a natural ecosystem as practical, while meeting the needs of a golf course.

BEST MANAGEMENT PRACTICES FOR LANDSCAPE SPECIES SELECTION

- Selection of landscape plants in Utah should address cold hardiness, drought tolerance, tolerance to alkaline soils, and pest tolerance.
- Use native and adapted plants that mimic the natural ecosystem when practical, while meeting the needs of the golf course.
- Select trees, plants, and grass species to attract and support surrounding wildlife.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers.
- Choose the most stress-tolerant species or cultivar for a particular area.

For more information on plants suited to Utah's climate, see the Intermountain Planting Guide, Water Wise Plants for Utah Landscapes, and Combinations for Conservation.

Design and Function

The fundamental principle for environmentally-sound landscape management is "right plant, right place."

When designing landscape areas, "right plant, right place" is the key to success. Placing a wrong plant in the wrong place increases maintenance requirements and costs. Gardens, window boxes, and container plantings can include a variety of plants of different heights, colors, and textures, and can supply nectar and habitat for various pollinators and wildlife. Garden plants, shrubbery, ground covers, and both native and non-native plants can provide a pleasing view as well as useful food, cover, or other environmental benefits to wildlife; they may also require reduced maintenance. Trees and shrubs provide temperature moderation through shade. When integrating turf areas into the landscape around the clubhouse, entries, and other non-play areas, design them for ease of maintenance and keep in mind that turfgrasses grow best in sunny areas. Consider the effect that tree and building shade may have on the health and function of the turf. Rain gardens can help capture and filter runoff around impervious surfaces, while providing visual interest and an educational opportunity for golfers.

BEST MANAGEMENT PRACTICES FOR DESIGNING LANDSCAPES

- Landscape design, when practical, should funnel runoff away from impervious surfaces and into the landscape to allow for infiltration and filtering of runoff water.
- Consider labeling native and low-input plants surrounding the clubhouse. This can provide an opportunity to educate the public on native, low-input planting options.
- Consider installing rain gardens or bioswales around buildings and other impervious surfaces, to slow, capture, retain, and filter runoff.
- Landscapes can be designed to minimize inputs such as irrigation, fertilizers, and pesticides.
- Landscape plantings should include a variety of heights, colors, textures, densities, growth habits, etc. to provide diverse habitat, food sources, and visual appeal.
- When possible, use native or adapted, low-input, low-maintenance plantings.
- Riparian buffers may contain a mixture of fast- and slow-growing native trees, shrubs, and grasses, and can be used to trap and remove upland sources contamination; supply food, cover, and shade for wildlife; and maintain healthy riparian ecosystems.
- All trees should be periodically evaluated for potential hazards; if necessary, hazardous limbs or trees should be removed.
- Use turf as a landscape element where needed.

For more information on bioswales and rain gardens, see Bioswales, Rain Garden Design Guide, and Designing a Rain Garden.

For more information on designing a water-wise landscape, see Designing a Low Water Use Landscape, Water Wise Plants for Utah Landscapes, and Water-Wise Landscaping: Plant Maintenance.

Planting and Management

Before planting, soil tests should be conducted to determine soil texture and nutrient levels. This can help guide plant selection, placement, and management. Soil amendments such as compost may be added to help improve the water holding capacity, organic matter content, overall soil health and structure. Fertilizers and soil pH-amending materials can be added as needed or indicated according to the soil test. Mulches may be used around gardens to increase moisture holding capacity and prevent weed growth.

BEST MANAGEMENT PRACTICES FOR LANDSCAPE PLANTINGS

- In perennial landscapes, soil amendment may be more difficult than amending turf soils. For new landscape plantings, assess and modify the soil as needed before planting.
- Plant selection, placement, and management should be appropriate for site conditions. In some cases, soil improvement can enhance water-use efficiency.
- Keep mulch 2 to 3 inches away from plants, to prevent fungal growth from excess dampness.
- Excess mulch or compacted mulch may be detrimental, causing water to shed away from the root zone and encourage overwatering.
- Whenever possible, plants may be grouped together based on irrigation demand.
- The percentage of landscaped area in irrigated high-water-use hydrozones should be minimized.
- Landscapes should be designed to optimize appearance, function, and health, rather than optimum growth; oftentimes growth may by limited by reducing irrigation, but form and function can be retained.

- Pruning and fertilizing will also benefit landscape plants while they are becoming established.
- Iron chlorosis is a common problem affecting ornamentals and trees in Utah's alkaline soils. Affected plants may display interveinal yellowing or bleaching of leaves, though symptoms can vary depending on the species affected. More information on symptoms, causes, and control can be found at IPM: Iron Chlorosis.
- Add proper soil amendments in garden areas to improve the soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers.
- Manage weeds, which will compete with desired plantings for resources, including nutrients, sunlight, and water.
- Establish herbicide tolerance of native species, and plan weed-management accordingly, taking care to follow BMP for IPM, water quality protection, and pollinator health.
- Herbicide labels should always be followed.
- Caution should be taken when applying herbicides to turf; some herbicides may also be taken up by tree roots, or surrounding landscape plants. Keep in mind that tree roots may extend beyond the dripline of the tree canopy.

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