APPENDIX A

APPENDIX A
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APPENDIX B

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GLOSSARY

ACRE-FOOT OF WATER	af - The volume of water that will cover an area of one acre to a depth of one foot.
BACK COUNTRY RECREATION	Recreation use that requires few, if any, improvements and usually occurs in areas greater than 1 mile from established roads.
CFS	cfs - cubic feet per second.
DEQ	Utah State Department of Environmental Quality.
DISPERSED RECREATION	Recreation not limited to controlled, established recreation areas.
DRAINAGE AREA	The land area contributing runoff to a stream system.
EFFLUENT	Processed water coming out of a facility, finished water.
EPA	Environmental Protection Agency.
FECAL COLIFORM	Group of microscopic organisms found in the gut of warm blooded animals.
FEMA	Federal Emergency Management Administration.
FRONT COUNTRY RECREATION	Recreation that requires facilities, resulting in the concentrated use of an area, such as campgrounds.
HYDROLOGIC	Referring to the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
INFLUENT	Source water coming in to a facility, untreated water.
INTERCONNECT	Road, lift, tram, etc., that would allow easy access between ski resorts in neighboring canyons.
JVWCD	Jordan Valley Water Conservancy District.

MOU	Memorandum of Understanding.
MWDSLS	Metropolitan Water District of Salt Lake & Sandy.
OHV	Off-Highway-Vehicle.
TOTAL COLIFORM	Group of microscopic organisms generally found when fecal contamination from warm blooded animals is present, indicator organisms.
UDOT	Utah Department of Transportation.
USFS	Utah States Forest Service.
WATERSHED	For purposes of this plan, the term "Sandy City Watershed"means the land area that drains into existing or proposed Sandy City culinary water diversion points and includes, but is not limited to, Little Cottonwood Canyon, Bell Canyon, Middle Fork of Dry Creek, South Fork of Dry Creek, Rocky Mouth Canyon, Little Willow Canyon and Big Willow Canyon, as shown on page 1-5. Under Code 10-8-15, Sandy City's jurisdiction extends to the Sandy City Watershed as defined herein and to the watershed of the Provo River, including the trans-basin diversions for the Duchesne and Weber Rivers.
ZONING	The process used to establish or distinguish an area from other similar areas for a specific purpose.

APPENDIX C

APPENDIX C

ISSUES IDENTIFIED IN SCOPING MEETINGS

Meeting participants identified over forty issues during the public scoping meeting held on Wednesday, June 14, 2000 in Sandy City Hall.

This is a summary of public comment on the proposed Sandy Watershed Management Plan.

WATER RESOURCES

- Sandy City water rights and allocations (How much water does Sandy have, where is it located, and how is it being used?)
- Sandy City water needs (How much water does Sandy need, how is it obtained, and what percentage is "owned" by Sandy?)
- What percentage of Sandy's water comes from the watershed?
- Interlocal agreements and contracts (Conservancy Districts, neighboring communities, etc.)
- In-stream flow requirements
- Stream Status – Impaired or Non-Degradation Stream Status
- Conservation Strategies – Gray Water - xeriscaping - Aquifer Injection

WATER QUALITY

- Current watershed water quality
  - Canyon specifics? (varying uses and use levels, restrictions, diversion points?) camping, hiking, mines, development, facilities, etc.
- Trends?
  - Any connection between uses and water quality, diversion points?
- Method and location of monitoring stations
- Possible causes of water quality degradation
  - Snow Making, Salt, Human Impacts, Storm Water, Waste Water, Ski Resorts

WATERSHED USES

RECREATION

- Types of activities occurring and possible impacts to the watershed, level, and location of use (may vary canyon to canyon)

  camping - too close to stream in most cases (canyons are very narrow, limited opportunities); associated activities (fire pits, swimming, dishes, trash, etc.); heavy use at bottom, compacted areas, vegetative impacts, erosion; no restroom facilities

  hiking - heavy use at bottom, trail condition and use (impacts?) decreases with distance and elevation?; Sandy City approach to allowing use, Bonneville Shoreline Trail, trail head locations, improvements, access, private property concerns, signage, etc.

  picnicking - heavy use at bottom, near streams or reservoirs; few, if any improvements; associated activities (fire pits, parties, swimming, dishes, trash, etc.); heavy use at bottom, compacted areas, vegetative impacts, erosion; no restroom facilities

  horses - identify use areas, limited information available, research impacts

  dogs - identify use areas, limited information available, research impacts

RESIDENTIAL DEVELOPMENT

- Need to determine a coherent city approach to development
- Level and location of development occurring, possible impacts to the watershed (may vary canyon to canyon)
  - What guidelines or restrictions are in place?
  - How well do current City land use regulations and ordinances protect the watershed?
  - Question of inadequate guidelines/ordinances or enforcement?
  - Development above and adjacent to diversion points
  - Associated impacts include topography alteration, stream channelization, storm water runoff, fertilizers, septic tanks, etc.
  - Need to coordinate development with County (approval of location and septic systems) such as Dimple Dell area
  - Possible guidelines for:
    - flood plains
    - stream setbacks
    - storm water
    - sewer
    - slopes
    - vegetation removal
    - cuts and fill
    - erosion control

MINING

- Level and location of use (past or active sites), possible impacts to the watershed (may vary canyon to canyon)
  - Bells Canyon - several mines and overburden piles, possible iron oxide and hydrocarbons in water

WATERSHED MANAGEMENT STRATEGIES

- Sandy City priority to protect watershed?
- Regulations and enforcement?
  - What were the Bell Canyon Irrigation Co. policies and restrictions?
  - Watershed development guidelines addressing issues identified in residential section
- Cooperative partnerships with neighboring communities, conservancy districts, land owners, etc.
  - Fee for Use – Other Funding Mechanisms – Who has access?
- Security/Safety

EDUCATION

- Increase public understanding of watershed issues, signs, and enforcement, identify implementation "partners"
  - Neighboring Communities
  - Forest Service
  - Conservation District
  - Metropolitan Water District of Salt Lake & Sandy
  - Civic Groups
- Existing MOU's and Interlocal Agreements

PARTNERSHIPS

- Who else is involved and what resources do they bring to the table? (Funding, regulatory power, enforcement, land ownership, etc?)

OTHER ISSUES

- Agriculture
- Grazing

APPENDIX D

APPENDIX D

RELEVANT SANDY CITY LAND USE REGULATIONS

EXISTING SANDY CITY LAND DEVELOPMENT CODE

Existing Sandy City land use development policies and practices are reflected through the City's Land Development Code. These ordinances apply to all properties within the jurisdictional boundaries of Sandy City.

Due to the City's extraterritorial jurisdiction rights to protect its watershed resources, watershed management ordinances adopted by the City apply to all areas within the City's identified watershed boundaries.

Although the City currently has not adopted specific watershed protection ordinances, several of the City's existing land use regulations complement the community's watershed management objectives.

Sensitive Lands Overlay

The City's Sensitive Area Overlay Zone *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-2* identifies the following objectives:

1. Protect the public from natural hazards of storm water runoff and erosion by requiring....the minimal removal of natural vegetation.

2. Minimize the threat and consequential damages of fire in hillside areas by establishing fire protection measures.

3. Preserve natural features, wildlife habitat, and open space.

4. Preserve public access to mountain areas and natural drainage channels.

5. Retain natural topographic features such as drainage channels, streams,...trees, and other natural plant formations.

6. Encourage minimal cuts and fills.

7. Encourage a variety of development [and land use] concepts that are compatible with the natural terrain of sensitive areas and will preserve open space and natural landscape.

8. Establish land use management criteria that will encourage protection of natural elements while allowing a harmonious and satisfying residential environment.

9. Encourage location, design, and development of building sites to provide maximum safety and human enjoyment while adapting the development to the best use of the natural terrain.

Development Site Plan Review

Materials required as part of a Development Site Plan review for properties within the Sensitive Area Overlay include:

Soil Characteristics Report including flood history and proximity of project to known flood areas and drainage channels *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-8 (g)(1).*

Vegetation Report including location of existing vegetation, vegetation to be removed, vegetation to be planted, slope stabilization measures, and an analysis of environmental effects on slope stability, soil erosion, water quality, fish and wildlife, and fire hazard *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-8 (g)(2).*

Geologic Conditions Report identifying unique geological characteristics of the site and ground water features *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-8 (g)(3).*

Grading and Drainage Report including a storm water and erosion management plan *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-8 (g)(4).*

Floodplains

1. Develop standards required for development in or adjacent to FEMA-designated floodplains *Sandy City Land Development Code, Subdivision Design Standards, 15-35-9.*

2. No structures within FEMA-designated 100-year floodplains *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(2).*

3. Conditional use permits required for development (other than structures) within FEMA-designated 100-year flood plains *Sandy City Land Development Code, Floodplain Hazard Regulations, 15-20-12.*

4. Development encroachments in floodways are prohibited unless they are determined "non-impacting" by Sandy City *Sandy City Land Development Code, Floodplain Hazard Regulations, 15-20-16 (a).*

5. No cuts allowed within natural drainages unless adequate mitigation plans have been approved *Sandy City Land Development Code, Grading and Excavation Regulations, 15-19-5 (a)(4).*

Streams and Waterways

1. Alteration or relocation of natural waterways requires Public Utilities Engineering approval and permits *Sandy City Land Development Code, Subdivision Design Standards, 15-35-10 (B)* and Salt Lake County Division of Flood Control and Army Corps of Engineer approval and permits *Sandy City Land Development Code, Subdivision Design Standards, 15-35-10 (A).*

2. Alterations to streams/water courses require Salt Lake County Division of Flood Control and Water Quality approval and permits *Sandy City Land Development Code, Floodplain Hazard Regulations,15-20-13 (c)(1)* and State Engineer approval and permits *Sandy City Land Development Code, Floodplain Hazard Regulations, 15-20-13 (c)(2).*

3. Grading permit applications (preliminary and final grading plans) require a description of the location, width, direction of flow, and approximate location of banks for any potentially affected watercourses *Sandy City Land Development Code, Grading and Excavation Regulations, 15-19-3 (a)(5), (a)(10)* & *(b)(5).*

4. Grading and drainage plans are required for projects within sensitive areas that incorporate streams or waterways *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-8 (4).*

5. Conditional use applications for development within FEMA-designated 100-year floodplains must describe the extent to which streams/watercourses may be altered *Sandy City Land Development Code, Floodplain Hazard Regulations, 15-20-12 (d).*

6. Existing natural drainage systems [channels/ways] will be utilized, as much as possible, in [their] unimproved [natural] state *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(3)(D).*

Slopes

1. No development or grading permitted on slopes 30% or greater *Sandy City Land Development Code, Performance and Development Standards, 15-13-3 (P).*

2. Required setbacks from slopes of 30% or greater *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-6 (b)(1).*

3. No grading to occur on any land where natural slope is equal to or in excess of 30% *Sandy City Development Code, Performance and Development Standards, 15-13-3 (P)(4).*

4. No cuts and fills on slopes equal to or greater than 30% *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (f)(6).*

5. No vegetation to be removed on a continuous hillside, crest, or slope of 30% or greater unless recommended by the Engineering Department and approved by the planning commission *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c)(6).*

6. Erosion control measures must be implemented on cut and fill slopes *Sandy City Land Development Code, Grading and Excavation Regulations, 15-19-5 (e).*

Vegetation

1. Preconstruction vegetation removal plan must be approved by the Sandy City Planning and Engineering Departments *Sandy City Development Code, Performance and Development Standards, 15-13-3 (P).*

2. Construction plans to minimize vegetative cover disturbance *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(4).*

3. No vegetation shall be removed on a continuous hillside, crest or slope of 30% or greater unless recommended by the Engineering Department and approved by the planning commission *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c)(6).*

4. Loss of trees, groundcover, and topsoil shall be minimized on any grading project *Sandy City Land Development Code, Grading and Excavation Regulations, 15-19-6 (e)(1).*

5. Vegetation will be removed only when absolutely necessary *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c)(4).*

6. Revegetation guidelines must be observed *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c).*

7. All areas cleared of vegetation during construction will be revegetated *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c)(1).*

8. Property owners and/or developers are fully responsible for any destruction of native or applied vegetation *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (c)(9).*

Grading and Excavation

1. Grading and drainage for any lot must follow current Sandy City requirements as determined by the Sandy City Engineering Department *Sandy City Development Code, Performance and Development Standards, 15-13-3 (P).*

2. Minimum performance requirements are established for all grading and excavation *Sandy City Development Code, Grading and Excavation, 15-19-1.*

3. Site plans must include grading, drainage, and clearing plans (including vegetation removal) and be approved before such activities begin *Sandy City Land Development Code, Performance and Development Standards, 15-13-3 (P)(2).*

4. Grading permit applications (preliminary and final grading plans) require a description of the location, width, direction of flow, and approximate location of banks for any potentially affected watercourses *Sandy City Land Development Code, Grading and Excavation Regulations, 15-19-3 (a)(5), (a)(10) & (b)(5).*

5. Grading shall be kept to a minimum and shall not occur on any land where natural slope is equal to or in excess of 30% in accordance with the City's Sensitive Area Overlay Zone *Sandy Land City Development Code, Performance and Development Standards, 15-13-3 (P)(3) & (P)(4).*

6. No cuts or fills within 100-year floodplain or drainage channels without approved mitigation plans in place *Sandy City Development Code, Grading and Excavation, 15-19-5 (a)(4) & Sandy City Development Code, Grading and Excavation, 15-19-5 (b)(3).*

7. No grading, cuts, fills, or terracing allowed on a continuous hillside, crest or slope of 30% or greater unless otherwise approved *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (f)(6).*

8. No cuts and fills greater than 10 feet *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (f)(4).*

9. Grading and excavation design standards include maximum slopes (cuts and fills) no steeper than two horizontal to one vertical *Sandy City Land Development Code, Grading and Excavation, 15-19-5 (a)(1)(A)* & *Sandy City Land Development Code, Grading and Excavation, 15-19-5 (b)(4).*

10. Grading and excavation design standards include drainage and erosion control measures *Sandy City Land Development Code, Grading and Excavation, 15-19-5 (d) & (e).*

11. Preservation of natural drainage channels *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-2 (d).*

12. Retention of natural features including drainage channels and streams *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-2 (e).*

13. Natural drainage systems to be utilized in their unimproved state *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(3)(D).*

14. Use of natural vegetation, prohibition of excessive excavation and terracing *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-2 (f).*

15. Encourage minimal cuts and fills *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-2 (g).*

Erosion

1. Erosion control measures required during and after construction *Sandy City Land Development Code, Grading and Excavation, 15-19-3 (b)(6) & 15-19-4 (d),* and *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(5) & 15-14-8 (g)(4).*

Storm Water Management

1. Onsite storm water runoff collection facilities are required *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(3).*

2. Surface water runoff systems must be provided *Sandy City Land Development Code, Subdivision Design Standards, 15-35-7.*

3. Storm water drainage and management facilities must be approved by the Sandy City Engineering Department *Sandy City Land Development Code, Performance and Development Standards, 15-13-3 (P).*

4. Existing natural drainage systems [channels/ways] will be utilized, as much as possible, in [their] unimproved [natural] state *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (b)(3)(D).*

Road Location and Construction

1. Road location and construction will follow natural topography as nearly as possible *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-7 (g).*

Trail Location and Construction

1. Trails will follow natural topography, minimize vegetation disturbance, and control erosion. Trail cuts and fills may not exceed two feet in height. Community Development Department Director and City Engineer approval required prior to construction. *Sandy City Land Development Code, Sensitive Area Overlay Regulations, 15-14-6 (e)(1-4).*

Fire Protection

1. Development adjacent to public lands must provide access for fire protection vehicles and equipment *Sandy City Land Development Code, Sensitive Area Overlay, 15-14-7 (e)(4) & 15-14-7 (g)(7).*

Septic Tanks

1. Septic tanks are not permitted in primary recharge areas. They are allowed in other areas as approved/permitted by the Utah State Department of Health. *Sandy City Land Development, Drinking Water Source Protection Ordinance, 15-37-6 (G).*

2. Mandatory connection for facilities within 300 feet of an existing sewer system *Sandy City Land Development, Drinking Water Source Protection Ordinance, 15-37-6 (G).*

3. City Sewage Disposal Ordinance, Sandy City Municipal Code -Title 18, "mandatory connection" for facilities within 300 feet of existing systems.

Groundwater Protection

1. Groundwater protection measures must be observed *Sandy City Land Development Code, Drinking Water Source Protection Ordinance, 15-37; State-required Surface Water Protection Ordinance.*

Household Waste

1. Household hazardous waste (fertilizers, herbicides, pesticides, etc.) will be handled as per existing City/County regulations.

APPENDIX E

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WATER QUALITY BACKGROUND

Water Quality

Sandy City obtains a significant portion of its culinary water supply from canyon streams originating in the Wasatch Mountains. These canyons include Little Cottonwood, Bell, Middle Fork/South Fork of Dry Creek, Rocky Mouth, and Big Willow. Water from these canyons is treated in treatment plants and distributed to residents of Sandy City and Salt Lake County. Reliance on these water sources is such that the Sandy City Department of Public Utilities should closely monitor and regulate any activities that may threaten water quality. Though recreation activity in these canyons has increased, water seems to be of high quality.

As identified in Chapter 2, Recommendations, Sandy City will gather baseline data in order to monitor watershed use effects. This section presents a discussion of each of the selected key contaminant indicators which will be included in baseline studies. To define the significance of the data it is important to understand the potential sources of the indicator, and the transport and fate of the indicator in the mountain stream environment.

A. Coliform Bacteria

Coliform can be used as an indication of contamination because coliform tend to exist in high quantities within fecal matter (100 to 400 billion per day discharge by humans[1]), and thus provide a good indication or warning of possible contamination by other fecal-born species. Some water borne pathogens are difficult to detect or the tests may be complex, time consuming, and often not sufficiently sensitive or selective. Coliform testing is relatively simple and inexpensive, thus rendering it the method of choice.

Sources and Fate Of Total Coliform Bacteria

"The coliform group of bacteria includes all aerobic and facultative anaerobic, gram-negative, nonspore-forming rod-shaped bacteria that ferment lactose with gas formation."[2] Included in the coliform class of bacteria are the genera *Escherichia* and *Aerobacter*. Coliform bacteria have been found to increase in

viable bacterial numbers under favorable conditions in pipe distribution systems.[3] According to the American Water Works Association, "Finding coliform densities ranging from 1 to 150 organisms per 100 mL may be possible with their occurrence widespread in the distribution system."[4] There is a possibility that coliform could colonize in streams within the slower moving areas. Porous media such as rocks may provide a good surface to which the bacteria can attach and colonize. Total coliform life expectancies are on the order of days. Based on the results of deep well studies, many coliforms survive better in colder waters. Coliform life expectancies have not been verified in open stream flows.

"The use of coliforms as indicator organisms is complicated by the fact the *Aerobacter* and certain *Escherichia* can grow in soil. Thus, the presence of coliforms does not always mean contamination with human wastes. Apparently, *Escherichia coli* (E. coli) are entirely of fecal origin. There is difficulty in determining E. coli to the exclusion of the soil coliforms; as a result, the entire coliform group is used as an indicator of fecal pollution." [5] Therefore, total coliform presence in water is not proof of fecal contamination, however, total coliform will always be present when there is fecal contamination. Though the significance of coliform occurrences should not be ignored because they may indicate a potential pathway for pathogen penetration into the water supply, sole reliance on coliform occurrence may not be adequate in defining the source of the contamination. If coliforms occur repeatedly at levels higher than background, then perhaps a more stringent monitoring program should be employed in order to determine for certain that there is animal-based contamination.

Sources and Fate of Fecal Coliform Bacteria

Fecal coliforms are a subgroup of total coliforms, and are usually found in much lower numbers. They are more indicative of contamination from a warm-blooded animal source. Therefore, they can come from both humans as well as animals. However, even though fecal coliform testing may rule out soil borne coliforms, they may be from any warm-blooded animal source, as discussed previously, and not necessarily an indicator of a human source. "In many situations where human pollution is suspected on the basis of [fecal] coliform test results, the actual pollution may, in fact, be caused by animal discharges."[6] Fecal coliform density per gram of feces and average contribution per capita per day is provided on Table 1 for human beings and some warm blooded animals.

Table 1 Fecal Coliform Contribution Per Capita From Human Beings And Some Animals (After Tchobanolglous, 1987)		
	Average indicator density/g of feces	Average contribution/capita/day
	Fecal Coliform (10^6)	Fecal Coliform (10^6)
Human	13.0	2,000
Chicken	1.3	240
Cow	0.23	5,400
Duck	33.0	11,000
Pig	3.3	8,900
Sheep	16.0	18,000
Turkey	0.29	130

As can be seen from the table above, many animals have higher fecal coliform production than humans. Therefore, relying solely on fecal coliform counts as an indicator of human contamination may not be correct. Fecal coliform may be expected to live in a cold water environment for at least the duration of water flow from the upper reaches of the canyon to the canyon mouth in any of the Wasatch Canyons. Coliforms survive well in cold water (the colder the better) with a survival time on the order of days.[7] In order to minimize differential death rates, samples should be taken no further down stream than 24 hours of flow time from the source of pollution.[8] With these two items in mind, and the fact that these creeks take less than 24 hours to flow from top to bottom, survival of coliform from any source in the canyon is possible. However, no studies have been found confirming life expectancies of fecal coliform in cold highly oxygenated water.

B. Nutrients

Nutrients, specifically nitrogen and phosphorous, are essential to the growth of bacteria and plants.[9] Other trace elements such as iron (Fe) are also required for biological growth. However, nitrogen and phosphorous are the major contributors to the production of algae. Algae in turn can cause taste and odor problems within water being used for drinking purposes. Methods for controlling algal blooms or growth include addition of Chelated copper compounds or potassium permanganate to the water, or simply controlling the nutrient loading. Nitrogen is also required in metabolic processes of microbial populations. If the water lacks sufficient nitrogen and/or phosphorous, algae growth will be repressed. Waste waters or organic wastes are a good source of nitrogen for bacteria.

Nitrogen Sources and Fate

Nitrogen has its origins as atmospheric nitrogen. It is incorporated into terrestrial systems through nitrogen fixing bacteria, lightening, direct conversion to

ammonia, or fertilizer manufacturing processes. From there it enters the food chain where it is taken up by plants and eventually animals. Animals then discharge nitrogen in the form of urea or feces. Bacterial decomposition of the feces along with hydrolysis of the urea then convert the nitrogen to ammonia. Ammonia is then converted to nitrite and nitrate, or to nitrogen gas. Nitrate is especially soluble in water and therefore will move about freely within the aquatic system.

The United States Environmental Protection Agency (EPA) has determined that nitrate poses an acute health concern at certain levels of exposure.[10] The most common sources of nitrate in water include fertilizer, sewage, and wastes from humans and animals. Excessive levels of nitrate in drinking water may cause serious illness and sometimes death in infants less than six months of age. The EPA has set the drinking water standard at 10 mg/l for nitrate to protect against the risk of these adverse effects.[11] Elevated levels of nitrates are often used as an indicator of human effects on stream water quality.

Phosphorus Sources and Fate

Slope and stream erosion of phosphorous bearing soils (including top soils), and animal and human feces, are sources of phosphorous for the canyon streams. Three types of phosphate are usually of interest: ortho, poly, and organic. Orthophosphates are available for immediate biological metabolism without further breakdowns. Polyphosphates include molecules with oxygen atoms and two or more phosphorous atoms. Polyphosphates undergo hydrolysis in aqueous solutions and revert to orthophosphate forms; however, the hydrolysis is typically slow. Organically bound phosphorous is generally not available for algae growth without anaerobic bacterial conversion.

The major phosphorous removal processes in natural systems are chemical precipitation and adsorption while plants organically bind only small amounts. Phosphorous has a high tendency to bind with soil particles. Once it is bound, it is not likely to be readily released back into the environment. Orthophosphates are absorbed by clay minerals and certain organic fractions within the soil. Chemical precipitation with alum, iron, or aluminum also occurs, but at a slower rate. Sorption of phosphorous onto soils is the primary phosphorous removal process.

C. TURBIDITY

Turbidity is a measure of the suspended matter in water that interferes with the passage of light. Materials in the water that cause turbidity may range from small colloidal particles, to coarse dispersions. Much of the material that causes turbidity is inorganic matter, though a significant portion is also caused by organic matter. It is this organic matter that causes concern. The organic matter serves as food for bacterial colonies. As the colonies grow, additional turbidity is

introduced. Some of these organics may also induce the growth of algae, meaning they may contain large amounts of nitrogen and phosphorous.

Turbidity effects on water quality include: 1) Aesthetics, 2) Interference with filterability, and 3) Interference with disinfection. Aesthetically pleasing water instills confidence in the consumer that the water is pure and not polluted with wastes. As turbidity increases, the cost associated with filtering the water increases. Disinfection is impacted by turbidity also. If particles causing turbidity are in the water, then pathogenic organisms may not come into contact with the disinfectant. That is to say, that the organisms may be shielded within or by a particle.

The amount of raw water turbidity (suspended solids) may also determine the type of treatment required. Water with consistently high turbidity (greater than 5 NTU) requires conventional treatment like coagulation, flocculation, sedimentation, and filtration. Water with consistently low turbidity (less than 5 NTU) may be treated by direct filtration, which is basically conventional treatment without sedimentation. Direct filtration treatment plants are less costly to construct than conventional plants. Turbidity can be a significant issue with respect to operation costs. Higher turbidity requires higher dosages of coagulating chemicals, more frequent back washing, and it produces greater quantities of sludge for disposal. In addition, fluctuating turbidity levels (spikes) are difficult for plant operators to manage since fluctuating turbidity requires fluctuating levels of chemical feed. Watershed management practices that lower and stabilize turbidity levels are very important with respect to water treatment.

D. Metal Sources and Fate

Trace quantities of many metals are important in most waters and are required for biological growth. Some of these trace quantities include metals such as nickel (Ni), lead (Pb), manganese (Mn), cadmium (Cd), chromium (Cr), zinc (Zn), iron (Fe), copper (Cu), and mercury (Hg). However, a few of these metals are classified as heavy metals. Heavy metals are listed in Table 2 along with associated health concerns resulting from elevated concentrations.

Table 2
Heavy Metals

Metal	Health Concern
Barium (Ba)	Increase blood pressure and nerve block
Cadmium (Cd)	Carcinogen
Chromium (Cr)	Carcinogen
Lead (Pb)	Brain damage, Birth defects
Mercury (Hg)	Central nervous system damage, Birth defects
Silver (Ag)	Dis-coloration of skin and eyes

Heavy metals are classified as priority pollutants, meaning they are hazardous to human health at elevated levels. Even though they may be required in small quantities to support life, larger quantities may be toxic. Sources of heavy metals in canyon streams include: natural ground water flow through rock formations, mine tunnel discharges, vehicle fluid leakage (crank case oil, anti-freeze, etc.), and surface runoff from mining affected areas.

APPENDIX F

APPENDIX F

OTHER DOCUMENTS RELEVANT TO THE PLAN AREA

The Sandy City watershed planning process included identifying and reviewing documents and materials relevant to the watershed area and the City's water quality protection objectives. Listed below, documents 1-25 relate directly to Sandy's watershed resource management and land use issues. Brief overviews of these documents, including specific policies and objectives relevant to the City's planning efforts, were prepared by project consultants and compiled as an "Existing Document Report". As additional resources, documents/materials 26-39 were submitted/gathered by committee members and used throughout the plan development process as resource analysis references. This latter information may also be useful during plan implementation.

Copies of the *Existing Document Report* or any of the articles/materials listed below can be obtained by contacting the Sandy City Public Utilities Department or the group, agency or entity that prepared/published the resource.

Documents Relating Directly to Watershed Management/Land Use

1. Sandy City Land Development Code (November 1999)
2. Sandy City Parks, Recreation & Trails Master Plan (June 1996)
3. Sandy City Community Development Department Statistical Report (1998)
4. Salt Lake City Watershed Management Plan (November 1999)
5. Wasatch Canyons Master Plan (1989)
6. Sandy City Irrigation Study - *Water Rights and Agreements* (1994)
7. DEQ (Department of Environmental Quality) R309-605, Source Protection: Drinking Water Source Protection for Surface Water Sources (2000)
8. Wasatch-Cache National Forest Land and Resource Management Plan
9. Salt Lake County Ordinance Title VII, Chapter 1 thru 9 for Flood Control, Storm Drainage and Water Quality (June 1982)
10. Water Quality Data, Jordan Valley Water Conservancy District (2000)
11. Sandy City Water Management and Conservation Plan - *Executive Summaries* (May 1996)
12. Bell Canyon Creek Pressurized Irrigation Feasibility Study, Final Report (September 1998)

13. Hydrogeology of Recharge Areas and Water Quality of the Principal Aquifers along the Wasatch Front and Adjacent Areas, Utah (1994)
14. National Forest Service Materials - Special Orders regarding Wilderness Areas including the Lone Peak Wilderness Area and Special Orders on Camping/Camp Fire/Swimming/Animal Order Restrictions for the Wasatch-Cache National Forest (May and June 1997)
15. Town of Alta Dog Ordinance (March 2000)
16. Town of Alta General Plan (1992)
17. Town of Alta Zoning Ordinance
18. Guidance Report I: Riparian Buffer Programs, a guide to developing and implementing a riparian buffer program as an urban storm water best management practice (May 1993)
19. 1999 Summary of Operations, Jordan Valley Water Conservancy District
20. The Provo Canyon Scenic Byway Corridor and Watershed Management Plan (*draft* dated July 2000)
21. Preliminary Alternatives, Wasatch-Cache National Forest Plan Revision (August 2000)
22. Salt Lake City Watershed Ordinance
23. Map - Land Ownership in Bell Canyon to Little Willow above Wasatch (2000)
24. Map - Proposed Pepperwood Hills, Condominium (2000)
25. Map - Seven Springs, Residential Addition (2000)

Documents Utilized for Resource Analysis

Additional Documents Submitted by Committee Members

26. Materials on Impacts of Horse Recreation
    a. *Does Horse Manure Pose a Significant Risk to Human Health?*
    b. *Pathogens Excreted by Livestock and Transmitted to Humans Through Water*
    c. *The Prevalence of Shedding of Cryptosporidium and Giardia spp. Based on a Single Fecal Sample Collection from each of 91 Horses Used for Backcountry Recreation*
    d. Water Cooties
    e. *Scare Tactics*
    f. Letter to the Editor from Pegasus Veterinary Clinic
    g. *The Prevalence o f Cryptosporidium/ Giardia in the Trail Horse Population Utilizing Public Lands*
    h. *The Doctor from Outer Space*
    i. *It is all a lot of Horse Manure*
    j. *Genetic Polymorphism Among Cryptosporidium parvum Isolates: Evidence of Two Distinct Human Transmission Cycles*
    k. Various Email Documents
    l. *Cryptosporidium Parvum Fact Sheet*
27. Materials on Household Chemicals
    a. *With the Splash of VOCs*
    b. *Hazardous Wastes from Homes*

28. Watershed Management for Potable Water Supply: Assessing the New York City Strategy - prepared by the National Research Council (2000)
29. Aurora Reservoir Management Plan - prepared by Brown & Caldwell, dated November 22, 1996
30. Materials from EPA Source Water Protection Symposium: A Focus on Waterborne Pathogens, dated October 28-31, 1998
    a. *The Economic Costs of Cryptosporidium Contamination Drinking Water Supplies*
    b. *Sources of Environmental Contamination With Cryptosporidium: Potential Roles of Wild and Domesticated Animals*
    c. *Using Relative Risk and Outcome to Establish Priorities Among Watershed Control Activities*
    d. *Waterborne Disease and Liability Incurred by Drinking Water Suppliers*
    e. *What are the Emerging Pathogens in Water*
    f. *Health Effects of Emerging Waterborne Pathogens*
    g. *Tools for Source Water Protection: Regulation and Incentives*
    h. *Early Warning Systems: A Case Study - Artificial Intelligence Modeling Techniques*
    i. *A Tale of Two Watersheds*
    j. *Watershed Controls for the Salt Lake City Water Supply*
    k. *Guarding Against Cryptosporidium - A Watershed Protection Plan to Keep Cattle at Home on the Range in San Francisco*
    l. *Monitoring Streams for Effect of Wastewater Discharge and Rainfall on Giardia and Cryptosporidium in Illinois*
    m. *Relationship Between Waterborne Parasites (Cryptosporidium and Giardia) and Agricultural Production in North Saskatchewan River, Alberta, Canada*
    n. *Des Moines Water Works Urban Creek Studies*
    o. *Protecting Drinking Water Supply Sources: San Francisco's Water Quality Vulnerability Zones*
    p. *Cryptosporidium: Water Treatment and Watershed Protection - A Balancing Act*
    q. *Alternative Indicators For Delineation of Source - Specific Microbial Inputs Reservoirs*
    r. *Male-Specific Coliphage As Indicators of Watershed Pollution*
    s. *Watershed Management for Sydney's Water Supplies*
    t. *The Impacts of Multiple Use On Modesto Reservoir Microbial Water Quality*
    u. *Source and Occurrence of Pathogens in Watersheds*
31. Confirmation of Human-Pathogenic Microsporidia *Enterocytozoon bieneusi, Encephalitozoon intestinalis,* and *Vittaforma corneae* in Water, *Applied and Environmental Microbiology,* (September 1998), pp. 3332-3335 - prepared by Scot Dowd, Charles P. Gerba & Ian L. Pepper, University of Arizona

32. Microbial Quality and Persistence of Enteric Pathogens in Graywater from Various Household Sources, *Water Resources*, (1991), Vol. 25.1, pp. 37-42 - prepared by Joan B. Rose, Gwo-Shing Sun, Charles P. Gerba, & Norval A. Sinclair from University of Arizona
33. Modeling the Impact of Body-Contact Recreation on Pathogen Concentrations in a Source Drinking Water Reservoir, *Water Resources*, (1998), Vol. 32.11, pp. 3293-3306 - prepared by Michael A. Anderson, Mic H. Stewart, Marylynn V. Yates, & Charles P. Gerba
34. Water Quality Study of Graywater Treatment Systems, *Water Resources Bulletin*, (February 1995), Vol. 31.1, pp. 109-116 - prepared by Charles P. Gerba, Timothy M. Straub, Joan B. Rose, Martin M. Karpiscak, Kenneth E. Foster & Richard Brittain
35. Occurrence of Rotaviruses and Enteroviruses in Recreational Waters of Oak Creek, Arizona, *Water Resources*, (1987), Vol. 21.11, pp. 1375-1381 - prepared by Joan B. Rose, Rebecca L. Mullinax, Shri N. Singh, Marylynn V. Yates, & Charles P. Gerba
36. Assessment of Enteric Pathogen Shedding by Bathers During Recreational Activity and its Impact on Water Quality, *Quantitative Microbiology*, (in press) - prepared by Charles P. Gerba
37. Source and Occurrence of Pathogens in Watersheds - prepared by A.L. Mager, J. Standridge, S.M. Kluender, & L.L. Peterson, Wisconsin State Laboratory of Hygiene
38. Pollution Prevention Fact Sheet: Animal Waste Collection - provided by Florence Reynolds of Salt Lake City Public Utilities
39. Study Finds Animal Feces a Major Urban Water Polluter, *Environmental News Network*, (December 11, 1999) - prepared by Lucy Chubb

APPENDIX G

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RESOURCES

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