Arkansas River Corridor Projects
Overall Public Safety

TO: Tulsa County

COPIES: File

FROM: CH2M HILL

DATE: December 2, 2009

PROJECT: 386594

Introduction

Tulsa County, as part of the Arkansas River Corridor Master Plan (Carter & Burgess, 2004; C. H. Guernsey and Company et al., 2005), is undertaking an improvement project on the Arkansas River. The primary goals of the overall project are to improve least tern habitat, improve fish habitat and fish passage, improve the function of the river system itself, enhance economic development, increase recreational opportunities, and increase connectivity between the river and surrounding communities. The conceptual project components are described in detail in the Technical Memorandum (TM) entitled Baseline Project Summary for the Arkansas River Corridor Project (CH2M HILL, 2009). Key components include:

- Design of habitat improvements along the corridor
- Design of bank stabilization in select areas
- Design of a new Sand Springs low-head dam, pedestrian bridge, and amenities
- Design of modifications to Zink Dam and lake with whitewater features
- Design of a new South Tulsa/Jenks low-head dam, pedestrian bridge, and amenities

With improved recreation opportunities and enhanced economic development (e.g., retail stores) comes an increased number of visitors to the area. The designers of the new infrastructure would consider public safety a key element of the design. Examples of concerns include public risks from flooding and fast water, as well as potentially unsafe currents near the dams.

According to the Phase II Master Plan and Pre-Reconnaissance Study (USACE Tulsa District, 2005):

> *Public safety is also a primary concern for the design and construction of a low water dam. Historical incidents with the former re-regulation dam on the Arkansas River and recent rescues below Zink Dam during high river flows have generated some public concerns. Subsurface currents created below the dams are often responsible for most accidents;*

> *however, engineering techniques can significantly improve public safety. Engineering solutions for low water dams have improved greatly over the years contributing to a greater degree of public safety associated with low water dams. Future designs for the [low water dams] should include appropriate safety measures to create the safest possible structure.*

Safety would be incorporated into multiple project components to help reduce risk to the public and to meet the vision for the Arkansas River Corridor Project. A comprehensive, integrated safety plan, combined with construction of low-risk river features, would not only increase public safety but would increase the public's acceptance of the project.

The purpose of this TM is to present safety-related design concerns that the CH2M HILL Team would consider when developing design concepts for low-head dams and associated infrastructure in future phases of the Project.

Background

Tulsa continues to grow, and there is certainly the potential that the addition of low-head dams along the Arkansas River would encourage even more growth. The City had an estimated population of 384,037 in 2007 (U.S. Census Bureau, 2007); in that same year, the Tulsa Metropolitan Statistical Area had an estimated population of 905,755 (Morgan, 2008) and is projected to reach 1,000,000 residents between 2010 and 2012 (Bell, 2007). As development in the Arkansas River watershed continues, increased stormwater runoff is likely to contribute to larger and more frequent floods.

In the early 1980s, Tulsa was identified in a national study as one of the nation's most disaster-prone areas after having been declared a federal disaster area 9 times in only 15 years due to violent weather and other natural hazards (City of Tulsa, 2002). In November of 2002, the City of Tulsa finalized its Multi-Hazard Mitigation Plan (MHMP), which includes steps to reduce the likelihood of dam and levee failures, as well as a floodplain management plan and response plans for other natural disasters (R.D. Flanagan & Associates, 2002). Other area municipalities (i.e., Bixby, Jenks, and Sand Springs) and Tulsa County also developed an MHMP specific to their location and facilities (R.D. Flanagan & Associates, 2003, 2007a, 2007b, and 2005, respectively).

Existing Emergency Management

Tulsa's current emergency warning system works in cooperation with the National Weather Service, news media, and the Tulsa Area Emergency Management Agency (TAEMA). A computerized alert system includes numerous rain, stream, and detention gauges that report changes in gauge readings in real time. The system includes a hydrologic program that develops stream and flood forecasts, which are then provided to TAEMA for appropriate action before flooding occurs. One course of action is to sound sirens that have been placed throughout the City. The City also supports advanced public education efforts to help ensure that citizens are aware that flooding can happen in Tulsa and that floods require "prudent preparation" (City of Tulsa, 2002).

On larger rivers, including the Arkansas, flood monitoring and flood forecasting are performed by the National Weather Service, which is part of the U.S. Department of

Commerce's National Oceanic and Atmospheric Administration (NOAA). Flood threat predictions are disseminated on the NOAA Weather Wire or NOAA Weather Radio. NOAA Weather Radio is considered by the federal government to be the official source for weather information (City of Tulsa, 2002).

After the computerized alert system notifies TAEMA of a flood or other hazard, TAEMA has the responsibility to notify the public and staff of other agencies and critical facilities. Typical warning media used by TAEMA include:

- Outdoor warning sirens
- Sirens on public safety vehicles
- NOAA Weather Radio
- Commercial or public radio or TV stations
- Cable TV emergency news inserts
- Telephone trees
- Door-to-door contact
- Online postings (e.g., the existing River Parks User Alert page at http://www.riverparks.org/UserBoard/alerts.asp)
- Mobile public address systems

Multiple or redundant notification systems are generally more effective than using a single form of mass media. Redundant sources of information increase the probability that citizens will become aware of the dangerous situation and respond to the warnings in an appropriate manner. Outdoor warning sirens can generally reach the largest number of people with the greatest speed (except those around loud noise, such as at a factory or during a thunderstorm), but they do not explain the hazard. Effectively directing people in their next actions is a critical part of effective warnings. Radio and TV can provide extensive information, but people must be listening. Telephone "trees" are also fast and can provide useful information, but they can be expensive and do not work when phones lines are down. No warning system is effective without a timely means of threat recognition.

Concurrent with threat recognition and issuing warnings, a community should respond with actions that can prevent or reduce damage and injuries. Typical actions and responsible parties include the following:

- Activating the emergency operations room (emergency management, fire department swift water rescue team)
- Closing streets or bridges (police or public works)
- Shutting off power to threatened areas (utility company)
- Holding children at school/releasing children from school (school district)
- Passing out sand and sandbags (public works)
- Ordering an evacuation (mayor)
- Opening evacuation shelters (Red Cross)
- Monitoring water levels (Engineering Department)
- Security and other protection measures (police)

Area entities have developed emergency action plans (EAPs) within their MHMPs for potential emergencies specific to their location. These EAPs should be updated once the proposed low-head dams have been constructed. An EAP helps ensure that response

activities are appropriate for the expected threat. EAPs should be developed in coordination with the agencies or offices that are responsible for responding during an emergency and coordinated with development of their individual agency emergency response plans (ERPs). EAPs and ERPs should be updated annually to keep contact names and telephone numbers current and to make sure that supplies and equipment that may be needed remain available. The plans should also be critiqued and revised after disasters and training exercises to benefit from the lessons learned and changing conditions.

Public Agency Comments

For this exercise, CH2M HILL contacted multiple public-safety-related agencies to gather existing safety standards and obtain any additional recommendations related to safe design or operation provided by these agencies. The goal of this contact was to ensure that each of the agencies had input to the design of these features so the design can benefit from multiple perspectives. The following is a list of agencies from which input was requested:

- Tulsa County Sheriff's Department
- U.S. Army Corps of Engineers (USACE)
- Tulsa Area Emergency Management Agency
- Tulsa Police Department
- Tulsa Fire Department
- Jenks Fire Department
- Sand Springs Fire Department
- Oklahoma Water Resources Board
- Oklahoma Department of Emergency Management
- Tulsa City-County Health Department
- U.S. Geological Survey

In general, the people CH2M HILL spoke to were appreciative of the call and were interested in providing input to the design, not only in these initial stages but throughout the process. A summary of these calls is provided in Appendix A. Selected concerns/suggested actions included:

- Provide shoreline access.
- Limit impact to existing levees.
- Limit quick drawdowns.
- Limit public land access to the dam itself.
- Include system (e.g., buoys) to limit public water access to the dam itself.
- Incorporate lighting for water rescues.
- Incorporate coordination with Keystone Dam.

One of the managers with the USACE suggested that developing safety-related guidance and responses would likely be a developing process, requiring coordination with the Cities of Tulsa, Sand Springs, and Jenks and the TAEMA to obtain information required for an EAP for the proposed dams (USACE, 2009, personal communication).

Known Existing Requirements for Public Safety

Oklahoma Water Resources Board

Although the low-head dams would be relatively small, they would be considered to have a high hazard classification by the Oklahoma Water Resources Board (OWRB) Dam Safety Group because life loss is considered possible if one of the dams were to breach. Thus, the design must meet or exceed design criteria presented in the Oklahoma Administrative Code, Title 785, Chapter 25, for a high-hazard dam.

OWRB requires annual dam inspections for high-hazard dams. Owners of high-hazard dams are required to provide an adequate warning system and evacuation plan to protect downstream lives and property (OWRB, 2009). A written EAP must be submitted to and approved by local emergency management agencies, then filed with the OWRB. A sample EAP, obtained from OWRB (and adopted and modified based on a sample EAP published by the USDA-Natural Resources Conservation Service (June 2007), is provided in Appendix B. The OWRB also provides the following necessary forms on its web page:

- Application to Construct, Enlarge, Repair or Alter Dam and/or Spillway
- Notice of Completion of Works
- Dam Inspection Checklist

United States Army Corps of Engineers

According to USACE, "Every phase of the planning, design, construction, and operation of a dam will be accomplished to assure that it is safe, efficient, and reliable," and "it is essential that design guidance be geared to safety, considering both the upstream impacts of an imposed ponding and the downstream consequences of a dam failure" (USACE, 1991). USACE has defined appropriate inflow design floods, computed from probable maximum precipitation, that must safely pass a dam to meet set standards. This information then defines the appropriate height, freeboard, spillways, regulating outlets, and structural designs. This analysis is typically an iterative process, considering downstream impacts, upstream impacts, cost, and site-specific considerations, including avoiding flooding impacts to populated areas (USACE, 1991).

Additional USACE guidelines state that restricted areas prohibiting public access must be established for the hazardous waters immediately upstream and downstream of the dam, and that the extent of this area is based on hydraulic criteria and operational considerations as defined by USACE (USACE, 1996). An Operation Management Plan must be submitted to USACE to address potential public access and escape for both pedestrians and boaters (USACE, 1996). The Plan would address marking safe or unsafe areas, and the possible use of buoys, floats, physical barriers, audible warning devices, or other physical measures to prevent access. Signs and buoys must comply with the applicable USACE and Coast Guard regulations, respectively.

Considerations for Future Phases of the Project

Based on the existing emergency management system, public agency input, experience with similar safety requirements, and known design requirements, future phases of design work would need to include consideration of:

- An integrated public warning system to address dangerous or changing hydraulic flow conditions. The system would link flow monitoring devices and other prediction mechanisms among these dams, as well as with Keystone Dam upstream. The system would also incorporate audio systems, such as sirens or a public address system, visual systems such as flashing lights, and possibly gate controls to attenuate flow over the concrete face of the dam. This in-river warning system would supplement the existing system. More sophisticated rainfall-radar systems or other prediction-based systems may be added as well.
- A method to define the level of emergency, and thus the level of appropriate response required. Typically, emergencies are divided into three or four categories, each with associated triggers and responses. Examples of the basis of triggers are weather forecasts, rainfall intensity, observation by staff, and citizen reports. Communication of data by gauges may be automated via a Supervisory Control and Data Acquisition (SCADA) system. This SCADA system is discussed in more detail in the Control Scheme Considerations TM. Examples of responses include initiating meetings, mobilizing field crews, monitoring weather forecasts and cameras, and alerting local emergency responders.
- An Overall Safety Plan that would document the reduction of dam hazards as part of the dam design and construction. In addition to the known dam design requirement categories identified above, it would be important to address safety impacts to existing system levees resulting from dam construction and dimensions; and to address design considerations to reduce hazardous currents that could trap boaters or swimmers downstream of each dam.
- A method to physically define restricted areas via buoys or other physical or audible barriers.
- A method of escape should someone breach the restricted area boundary.
- A defined plan to ensure safety features continue to operate should power be lost.
- Emergency vehicle access to the pedestrian bridges, the individual dam facilities, and the river channel itself. Emergency vehicles should have clear, marked access to the pedestrian bridges. Emergency access to the river channel and lakes would be critical; this was the main concern of the local fire departments' swift water rescue teams.
- Onsite public protection near the river, such as lighting (discussed in more detail in the Control Scheme Considerations TM) and emergency call boxes.

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Appendix A
Detailed Call Summaries

Call To	Organization	Phone Number	Discussion
Russ Wyckoff	U.S. Army Corps of Engineers	918/669-7171	Russ stated he would like to be involved in the project but that the Reservoir Control Group would provide better input as they are the ones that control the releases at Keystone Dam. He said that we should make sure to consider power generation as a component of the operation and directed me to John Hickman.
John Hickman	U.S. Army Corps of Engineers	918/669-7142	John is the engineer who regulates the releases from Keystone Dam. John suggested the City may have an existing safety plan for Zink Dam that would be a good resource. He said they are typically most concerned with overtopping dams but, as he anticipates ours would be designed to overtop, this is not a concern. He directed me to COE Engineering Regulations ER 1110-8-2(FR) and ER 1130-2-520, Chapter 10, which can be found at www.usace.army.mil/publications. In a later email, John said he was not in the Reservoir Control Group and that I should talk to Kent Dunlap.
Kent Dunlap	U.S. Army Corps of Engineers	918/669-7408	I was unable to contact Kent.
Royce Johnson	U.S. Geological Survey	918/254-6651	USGS has existing flow monitoring efforts at the USGS gage on the 11th Street Bridge, gage number 07164500. This is for monitoring discharge and temperature at Keystone Dam; they then estimate gage height from discharge. USGE collected water quality information prior to now; that ended in 1997. The current monitoring is done in conjunction with the City of Tulsa, and it is daily data. Royce mentioned his concerns are more quality geared.
N/A	Tulsa County Sheriff's Department	918/596-9222	They directed me to TAEMA.
Mike McCool	Tulsa Area Emergency Management Agency (TAEMA)	918/596-9899	Mike said they do not currently have any emergency response plans for dams; that is the responsibility of USACE. He directed me to the following people with the USACE: • Pete Navesky, Emergency Manager for COE, cell phone: 202/341-0537 • Dr. Brett Cowan, Arkansas River Engineer, 918/669-7028 (the voice mail did not match Brett's name) • Randel Mead (goes by Randy), Dam Safety, 918/669-7145 • Joe Remondini, head of Floodplain Management Services, 918/669-7198 • Carolyn Schultz, works for Joe, 918/669-4919 Mike said TAEMA has siren incoders – they have a flood tone system with sirens along the Arkansas River and can do public announcement messages. Mike also suggested I obtain the floodplain maps from the City of Tulsa Public Works; he said their maps are "better than FEMA's", and that this information would be the most important thing for us to consider. Additionally, he told me the Tulsa, Sand Springs, and Jenks fire departments have swift water rescue teams. He also said Keystone Dam has 12 gates, and, when completely open with a full pool, can pass 960,000 cubic feet per second (cfs), although 305,000 cfs is the highest ever recorded. This was during the flood in October of 2006.
Randy Mead	U.S. Army Corps of Engineers	918/669-7145	Randy said that, downstream of the project area, levees have been taken off the system due to a lack of maintenance of their seepage control systems. He said the levees along the river are built of silt and sand and are not built to hold water for long periods of time. He suggested we make sure we are below the levees or have some sort of seepage control. Randy said we should not impact flows during high discharges and that we must not overtop the levees; perhaps we should use large leaf gates. He said we should not change the flood profile on the levees in high water events – that we need to be able to lower the water quickly, which presents its own problem that is potentially addressed by armoring with rip rap. There is definite potential for slope sloughing. His biggest concerns are that we do not impact the levee and that we have no quick drawdowns. He also suggested I speak to: • Wade Anderson, Assistant Dam Safety • Jim McHenry, Main Dam Safety • Jim Martell, Levee Safety Program Manager
Pete Navesky	U.S. Army Corps of Engineers	202/341-0537	Pete said that the Zink dam in Sand Springs, just upstream of the park, had a fence around it but people would climb on the dam, fish the pool, and drown. They built a bigger fence, but it continued. They then had to dynamite the dam (they ended up losing 3 or 4 people in the mid-80s). He said that, from an emergency perspective, regarding potential flooding issues, depending on the flow feeding them, the dams would generate an underwater eddy downstream of the dam, which is where drowning potential increases. We need to somehow prevent access for people to climb on the dam; this is his biggest concern. Some of the potential long term use is boating or canoeing, thus we would need a buoy system upstream of the gates to keep people several hundred feet away to ensure no boats go through the dam. Pete then directed me to: • Sue Haslett, the Tulsa District Chief of Planning and Environmental Division • Joe Remondini, Floodplain Manager for the District Following, Joe responded to an email sent by Pete and directed me to TAEMA, OWRB Dam Safety, and USACE Operations Division Safety Office.
R.B. Ellis	Tulsa Fire Department	918/596-9444	I was unable to contact R.B.

Call To	Organization	Phone Number	Discussion
Mark Joslin	Sand Springs Fire Department	918/246-2548	Mark said he was aware this design would be less hazardous than previous low water dam designs, to include less scouring. He said their biggest concern is shoreline access – from the dam downstream to the response area, they need shoreline access. The existing boat ramp is upstream of the dam, which would suggest they can not use their motorized boat as it would not go over the dam. Could we build it so it could? Their boat is a flat bottom boat with an outboard motor. They also have inflatable water craft (non-motorized, oar driven, although you can buy motors for them with an open bow, similar to Tulsa's); this is an Ocean ID boat that must be shore launched. Could they have access to the dam and launch this boat from the top of it? Their existing boat would work in the reservoir we create upstream of the dam. Night time creates vision challenges, so lighting would be key. would there be audible sirens at certain flow levels? We would need markers or other protection upstream of the dam to keep boats from getting near the dam. Almost all of their staff have water rescue training and are at the technician level. Could we set it up so they can do some training in the river on a regular basis so they can see the operations and such?
Gary Friedel	Jenks Fire Department	918/298-1491	Gary is the Chief; he said access features are the most important aspect for him. They need robust areas to get access easily. They have a rapid deployment craft, like a whitewater raft, and would be getting a motorized boat once the dam is built. They would really like to be involved in the design process, giving input as it progresses.
Yohanes Sutent	Oklahoma Water Resources Board, Dam Safety Group	405/530-8800	Yohanes directed me to Chapter 25 of their rules, as well as their rules regarding dam classification and associated regulations. If there is a chance for loss of life at all, the dam would be classified as hazardous and has to meet or exceed their design standards.
N/A	Oklahoma Department of Emergency Management	405/521-2481	I was directed to the Tulsa County representative, Mike McCool, with TAEMA.
John Baker	Tulsa County Health Department	918/582-9355	John said this was not something for which they had any responsibility; he stated he could not think of any concerns they might have.
Clark Williams	Tulsa Police Department	918/596-1301	Clark asked that he have some time to think about his input, but has not responded at this time.
Wade Anderson	U.S. Army Corps of Engineers	918/669-7654	Wade is the Dam Safety Manager for the Tulsa District. He suggested we be sure to coordinate with the Keystone Dam Operators – if they let their dam go over a certain point, ours would overtop. Also, as the foundation would be sand, seepage problems at the dam and the abutments would be challenges.
Sue Haslett	U.S. Army Corps of Engineers	918/669-7666	Sue is Tulsa District Chief of Planning and Environmental Division. Sue suggested I speak to Joe Remondini, Bob Vandergriff, Brian Taylor and Cally Clark, all with the USACE.
Brian Taylor	U.S. Army Corps of Engineers	918/669-4950	Brian suggested I speak to Wade Anderson.
Jim McHenry	U.S. Army Corps of Engineers	918/669-7670	I was unable to contact Jim.
Jim Martell	U.S. Army Corps of Engineers	918/669-7171	I was unable to contact Jim.
Bob Vandergriff	U.S. Army Corps of Engineers	918/669-4698	I was unable to contact Bob.
Cally Clark	U.S. Army Corps of Engineers	918/669-7271	I was unable to contact Cally.

Appendix B
Sample Emergency Action Plan

SAMPLE
Draft Only - not for official use

Emergency Action Plan (EAP)

Name of Dam

National Inventory of Dams (NID) No. OK?????

Legal Description (Section, Township & Range)

_____ **County**

Reviewed and Updated:

_____
Dam Owner Representative
(Name & Signature)

_____
Date

_____
Emergency Management Official
(Name & Signature)

_____
Date

Copy ___ of ___

Contents

SAMPLE
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Basic EAP Data

Purpose:

The purpose of this EAP is to reduce the risk of human life loss and injury and to minimize property damage during an unusual or emergency event at the (name of dam) in -------- County.

Potential Impacted Area:

See Evacuation Map tab (Appendix ???) and People at Risk tab (Appendix ???)

- Houses located on _____
- Close Street ----------.
- Contact: ----------.

Dam Description:

Height: --ft.
Built: year?
Legal Description:
Latitude: ---------- Longitude: ----------
Dam Owner: _____.
National Inventory of Dams No. OK?????
See detailed design data in Appendix ?? (if available)

Drainage Area: ---- acres
Hazard Classification: High

Dam Operator: _____
Dam Designer: _____.

Directions to dam:

Please give clear directions

SAMPLE
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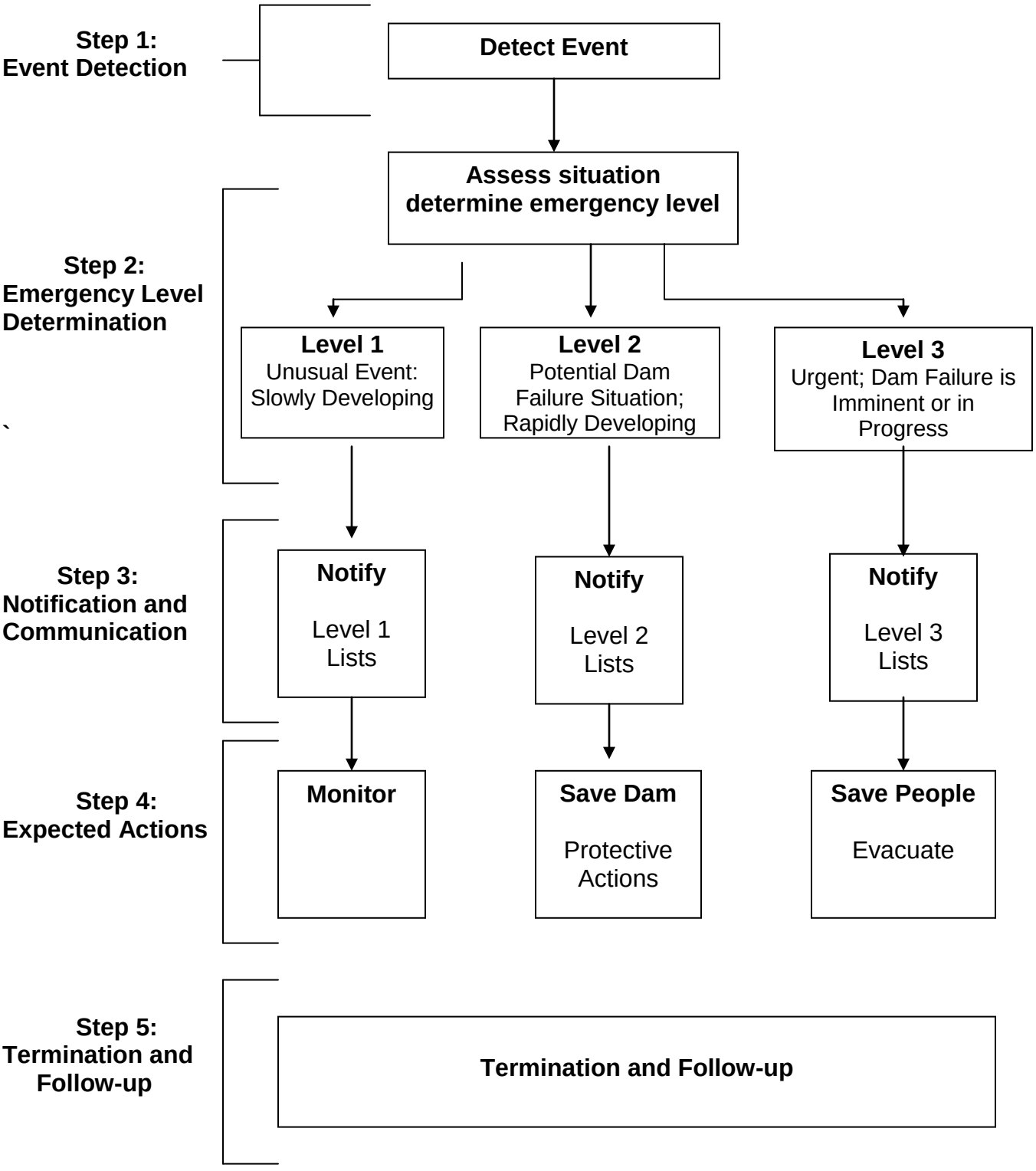
Emergency Action Plan Overview



_____ Dam, _____ County
mm/dd/yyyy

Roles and Responsibilities

Dam Operator's Representative [_____]

- ► As soon as an emergency event is observed or reported, immediately determine the emergency level (see Emergency Level Determination tab).
  - -- Level 1: unusual event, slowly developing
  - -- Level 2: potential dam failure situation, rapidly developing
  - -- Level 3: dam failure is imminent or in progress
- ► Immediately notify the personnel in the order shown on the notification flow chart for the appropriate level (see Notification Flow Charts tab).
- ► Provide updates of the situation to the Police/Sheriff dispatcher to assist them in making timely and accurate decisions regarding warnings and evacuations.
- ► Provide leadership to assure the EAP is reviewed and updated annually and copies of the revised EAP are distributed to all who receive copies of the original EAP.

Incident Commander [_____]

- ► Serves as the primary contact person responsible for coordination of all emergency actions
- ► When a Level 2 situation occurs: Prepare emergency management personnel for possible evacuations that may be needed if a Level 3 situation occurs.
- ► When a Level 3 situation occurs:
  - -- Initiate warnings and order evacuation of people at risk downstream of the dam.
  - -- Notify local emergency management services to carry out the evacuation of people and close roads within the evacuation area (see Evacuation Map tab)
- ► Decide when to terminate the emergency.
- ► Participate in annual review and update of the EAP.

Emergency Management Services [_____]

- ► Maintain communication with media
- ► When a Level 2 situation occurs:
  - -- Prepare emergency management personnel for possible evacuations that may be needed if a Level 3 situation occurs.
  - -- Alert public as appropriate
- ► When a Level 3 situation occurs:
  - -- Alert the general public of the emergency.
  - -- Immediately close roads and evacuate people located within the evacuation area (see Evacuation Map tab).
- ► Participate in annual review and update of the EAP.

Dam Operator's Technical Representatives [_____]

- ► Advise dam operator on emergency level determination if time permits
- ► Advise dam operator on remedial actions to take if Level 2 event occurs

State Dam Safety Agency [Oklahoma Water Resources Board]

- ► Advise dam operator on emergency level determination if time permits
- ► Advise dam operator on remedial actions to take if Level 2 event occurs and if time permits

The Five-step EAP Process

Step 1 Event Detection

This step describes the detection of an unusual or emergency even and provides information to assist the dam operator in determining the appropriate emergency level for the event.

Unusual or emergency events may be detected by:

- ► Observations at or near the dam by government personnel (local, state, or federal), landowners, visitors to the dam, or the public
- ► Evaluation of instrumentation data
- ► Earthquakes felt or reported in the vicinity of the dam
- ► Forewarning of conditions, which may cause an unusual event or emergency event at the dam (for example, a severe weather or flash flood forecast)

See Guidance for Determining the Emergency Level table for assistance in evaluating specific events to determine if they are unusual or potential emergency situations.

Step 2 Emergency Level Determination

After an unusual or emergency event is detected or reported, the dam operator is responsible for classifying the event into one of the following three emergency levels:

Emergency level 1 – Non-emergency, unusual event, slowly developing:

This situation is not normal but has not yet threatened the operation or structural integrity of the dam, but possibly could if it continues to develop. Technical support (Engineer) or state dam safety officials should be contacted to investigate the situation and recommend actions to be taken. The condition of the dam should be closely monitored, especially during storm events, to detect any development of a potential or imminent dam failure situation. The local law enforcement should be informed it is determined that the conditions may possibly develop into a worse condition that may require emergency actions.

Emergency level 2 – Potential dam failure situation, rapidly developing:

This situation may eventually lead to dam failure and flash flooding downstream, but there is not an immediate threat of dam failure. Law enforcement should be notified of this emergency situation and placed on alert. The dam operator should closely monitor the condition of the dam and periodically report the status of the situation to the law enforcement officials. If the dam condition worsens and failure becomes imminent, law enforcement must be notified immediately of the change in the emergency level to evacuate people at risk downstream.

If time permits, technical support and state dam safety officials should be contacted to evaluate and recommend remedial actions to prevent failure of the dam. The dam operator should initiate remedial repairs (note local resources that may be available – see Appendix B-1). Time available to employ remedial actions may be hours or days.

This emergency level is also applicable when flow through the earth spillway has or is expected to result in flooding of downstream areas and people near the channel could be endangered. Emergency services should be on alert to initiate evacuations or road closures if the flooding increases.

Emergency level 3 – Urgent – Dam failure is imminent or in progress:

This is an extremely urgent situation when a dam failure is occurring or obviously is about to occur and cannot be prevented. Flash flooding will occur downstream of the dam. This situation is also applicable when flow through the earth spillway is causing downstream flooding of people and roads. The law enforcement officials should be contacted immediately so emergency services can begin evacuations of all at-risk people and close roads as needed (see Evacuation Map tab).

See following pages for guidance in determining the proper emergency level for various situations.

Event	Situation	Emergency Level
Earth spillway flow	Reservoir water surface elevation at auxiliary spillway crest or spillway is flowing with no active erosion	1
	Spillway flowing with active gully erosion	2
	Spillway flow that could result in flooding of people downstream	2
	Spillway flowing with an advancing head cut that is threatening the control section	3
	Spillway flow that is flooding people downstream	3
Embankment overtopping	Overtopping flow not eroding the embankment slope; reservoir level expected to lower	2
	Overtopping flow not eroding the embankment slope; reservoir level expected to rise	3
	Overtopping flow eroding the embankment slope	3
Seepage	New seepage areas in or near the dam	1
	New seepage areas with cloudy discharge or increasing flow rate	2
	Seepage with discharge greater than 10 gallons per minute	3
Sinkholes	Observation of new sinkhole in reservoir area or on embankment	1
	Rapidly enlarging sinkhole	2
Embankment cracking	New cracks in the embankment greater than ¼-inch wide without seepage	1
	Cracks in the embankment with seepage	2
Embankment movement	Visual movement/slippage of the embankment slope	1
	Sudden or rapidly proceeding slides of the embankment slope	3
Instruments	Instrumentation readings beyond predetermined values	1
Earthquake	Measurable earthquake felt or reported on or within 50 miles of the dam	1
	Earthquake resulting in visible damage to the dam or appurtenances	2
	Earthquake resulting in uncontrolled release of water from the dam	3
Security threat	Verified bomb threat that, if carried out, could result in damage to dam	2
	Detonated bomb that has resulted in damage to the dam or appurtenances	3
Sabotage / Vandalism	Damage to dam or appurtenances with no impacts to the functioning of the dam	1
	Modification to the dam or appurtenances that could adversely impact the functioning of the dam	1
	Damage to dam or appurtenances that has resulted in seepage flow	2
	Damage to dam or appurtenances that has resulted in uncontrolled water release	3

Guidance for Determining the Emergency Level *

* Emergency level 1: Non-emergency, unusual event, slowly developing
* Emergency level 2: Potential dam failure situation, rapidly developing
* Emergency level 3: Urgent, dam failure is imminent or in progress

Examples of Emergency Situations

The following are typical examples of conditions that may occur at a dam that usually constitute an emergency situation. Adverse or unusual conditions that can cause the failure of a dam are typically related to aging or design and construction over-sites. Extreme weather events that exceed the original designed conditions can cause significant flow through the spillway or overtopping of the embankment. However, accidental or intentional damage to the dam may also result in emergency conditions. The conditions have been grouped to identify the most likely emergency level conditions. The groupings are provided as guidance only. Not all emergency conditions may be listed, and the dam operator is urged to use conservative judgment in determining whether a specific condition should be defined as an emergency situation at the dam.

Pre-existing conditions on this dam: This is a newly constructed dam designed with adequate spillway capacity for storms greater than the 100-year event. If the spillway should ever flow, the homes downstream along Air Depot may need to be evacuated.

Earth Spillway Flows

Emergency Level 2 – Potential dam failure situation; rapidly developing:

1. Significant erosion or head cutting of the spillway is occurring but the rate does no appear to threaten an imminent breach of the spillway crest that would result in an uncontrolled release of the reservoir.
2. Flow through the earth auxiliary spillway is causing flooding that is threatening people, homes, and/or roads downstream from the dam.

Emergency Level 3 – Urgent; dam failure is imminent or in progress:

1. Significant erosion or head cutting of the spillway is occurring at a rapid rate and a breach of the control section appears to be imminent.
2. Flow through the earth auxiliary spillway is causing flooding that is threatening people, homes, and/or roads downstream of the dam.

Embankment Overtopping

Emergency Level 2 – Urgent; dam failure situation; rapidly developing:

1. The reservoir level has reached the top of the dam and is projected to continue to lower.
2. Flow is occurring over the embankment, but it is not eroding the embankment slope.

Emergency Level 3 – Urgent; dam failure is imminent or in progress:

1. Flow is occurring over the embankment causing damage to the embankment slope.
2. The reservoir level has exceeded the top of the dam and is expected to continue to rise.

Seepage and Sinkholes

Emergency Level 2 – Potential dam failure situation; rapidly developing:

1. Cloudy seepage or soil deposits are observed at seepage exit points or from internal drain outlet pipes.
2. New or increased areas of wet or muddy soils are present on the downstream slope, abutment, and/or foundation of the dam, and there is an easily detectable and unusual increase in volume of downstream seepage.
3. Significant new or enlarging sinkhole(s) near the dam or settlement of the dam is observed.
4. Whirlpools or other evidence exists indicating that the reservoir is draining rapidly through the dam, foundation, or abutment.
5. The following known dam defects are or will soon be inundated by a rise in the reservoir:
   - ► Sinkhole(s) located on the upstream slope, crest, abutment, and/or foundation of the dam; or
   - ► Transverse cracks extending through the dam, abutments, or foundation.

Emergency Level 3 – Urgent; dam failure is imminent or in progress:

1. Rapidly increasing cloudy seepage or soil deposits at seepage exit points to the extent that failure appears imminent or is in progress.
2. Rapid increase in volume of downstream seepage to the extent that failure appears imminent or is in progress.
3. Water flowing out of holes in the downstream slope, abutment, and/or foundation of the dam to the extent that failure appears imminent or is in progress.
4. Whirlpools or other evidence exists indicating that the reservoir is draining rapidly through the dam, foundation, or abutment.
5. Rapidly enlarging sinkhole(s) are forming on the dam or abutments to the extent that failure appears imminent or is in progress.
6. Rapidly increasing flow through crack(s) eroding materials to the extent that failure appears imminent or is in progress.

Embankment Movement and Cracking

Emergency Level 2 – Potential dam failure situation; rapidly developing:

1. Settlement of the crest, slopes, abutments and/or foundation of the dam that may eventually result in breaching of the dam.
2. Significant increase in length, width, or offset of cracks in the crest, slopes, abutments, and/or foundation of the dam that may eventually result in breaching the dam.

Emergency Level 3 – Urgent; dam failure is imminent or in progress:

1. Sudden or rapidly proceeding slides, settlement, or cracking of the embankment crest, slopes, abutments, and/or foundation, and breaching of the dam appears imminent or is in progress.

Step 3 Notification and Communication

Notification:

After the emergency level has been determined, the people on the following notification flowcharts for the appropriate emergency level shall be notified immediately.

Communication:

Emergency Level 1 – Non-emergency, unusual event; slowly developing:
The dam operator and owner should contact their engineers and the Oklahoma Water Resources Board. Describe the situation and request technical assistance on next steps that should be taken.

Emergency Level 2 – Potential dam failure situation; rapidly developing:
The following message may be used to help describe the emergency situation to the law enforcement official or emergency management personnel:

> "This is _____.
> We have an emergency condition at (name of dam) in _____ County that is located ___ miles (east/west/north/south?) of----------.
>
> We have activated the emergency action plan for this dam and are currently under Emergency Level 2.
>
> We are implementing predetermined actions to respond to a rapidly developing situation that could result in dam failure.
>
> Please prepare to evacuate the area along low-lying portions along (street name or area name).
>
> Reference the evacuation map in your copy of the emergency action plan.
>
> We will advise you as soon as the situation is resolved or if the situation gets worse.
>
> I can be contacted at the following number _____. If you cannot reach me, please call the following alternative number _____."

Emergency Level 3 – Urgent; dam failure is imminent or in progress:
The law enforcement official should be contacted immediately, and the potential area flooded, if the dam should be taken:

1. Call the local law enforcement's dispatch center. Be sure to say, "This is an emergency." They will call other authorities and the media and begin the evacuation. The following message may be used to help describe the emergency situation to the local law enforcement official or emergency management personnel:

   "This is an emergency. This is __name of person_____.
   (Name of dam) located _____is failing. The downstream area must be evacuated immediately. Repeat, (nameof dam) is failing: evacuate the area along low-lying portions along _____ street.
   We have activated the emergency action plan for this dam and are currently under Emergency Level 3.
   Reference the evacuation map in your copy of the Emergency Action Plan.
   I can be contacted at the following number _____. If you cannot reach me, please call the following alternative number _____."

2. Do whatever is necessary to bring people in immediate danger to safety if directed by the law enforcement official (anyone on the dam, downstream from the dam, boating on the reservoir, or evacuees).

3. Keep in frequent contact with the law enforcement official and emergency services to keep them up-to-date on the condition of the dam. They will tell you how you can help handle the emergency.

4. If all means of communication are lost: (1) try to find out why, (2) try to get to another radio or telephone that works, or (3) get someone else to try to establish communications. If these means fail, handle the immediate problems as well as you can, and periodically try to reestablish contact with the law enforcement official and emergency services.

The following pre-script message may be used as a guide for the law enforcement official or emergency services personnel to communicate the status of the emergency with the public:

Attention: This is an emergency message from the _____. Listen carefully. Your life may depend on immediate action.
(Name of dam) located _____is failing. Repeat, (name of dam) located _____is failing.
If you are in or near this area, proceed immediately to high ground away from the valley. Do not travel on (street name/ area). You cannot outrun or drive away from the flood wave. Proceed immediately to high ground away from the valley or low areas.

Repeat Message

SAMPLE
Draft Only - not for official use

Emergency Level 1 Notification

Non-emergency
Unusual event, slowly developing

Dam Owner or Operator

Office Phone: _____
Home Phone: _____
Cell Phone: _____

1st **2nd**

Dam Owner's Technical Representative
(Name)

Office Phone: ----------
Home Phone: ----------
Cell Phone: ----------

Oklahoma Water Resources Board's Representative
(Name)

Office Phone: 405-530-8800
Home Phone: _____
Cell Phone: _____

Dam Owner's Engineer
(Name)

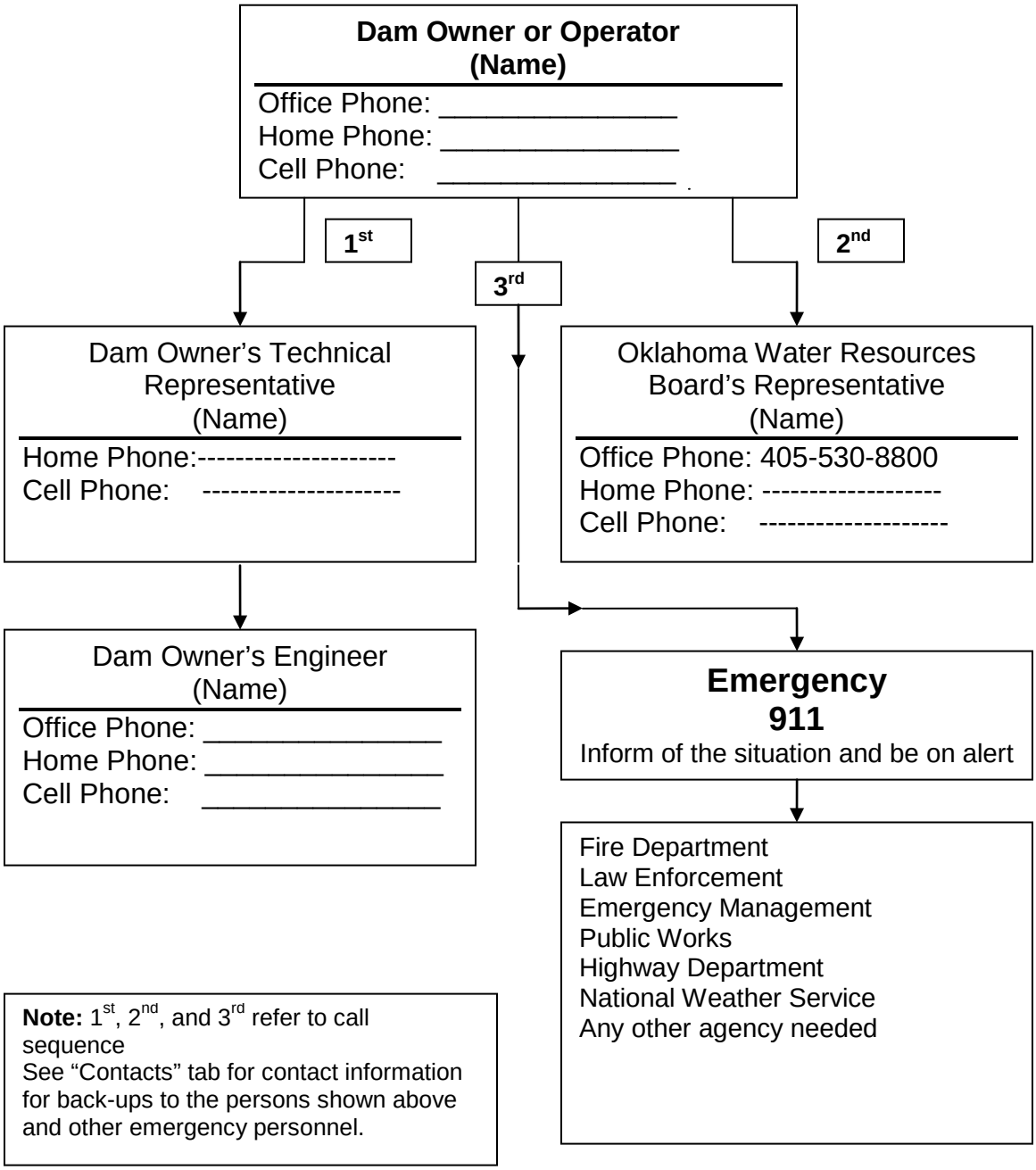
Office Phone: _____
Home Phone: _____
Cell Phone: _____

Note: 1st and 2nd refer to call sequence
See "Contacts" tab for contact information for back-ups to the persons shown above and other emergency personnel.

_____ Dam, _____ County
mm/dd/yyyy

Emergency Level 2 Notification

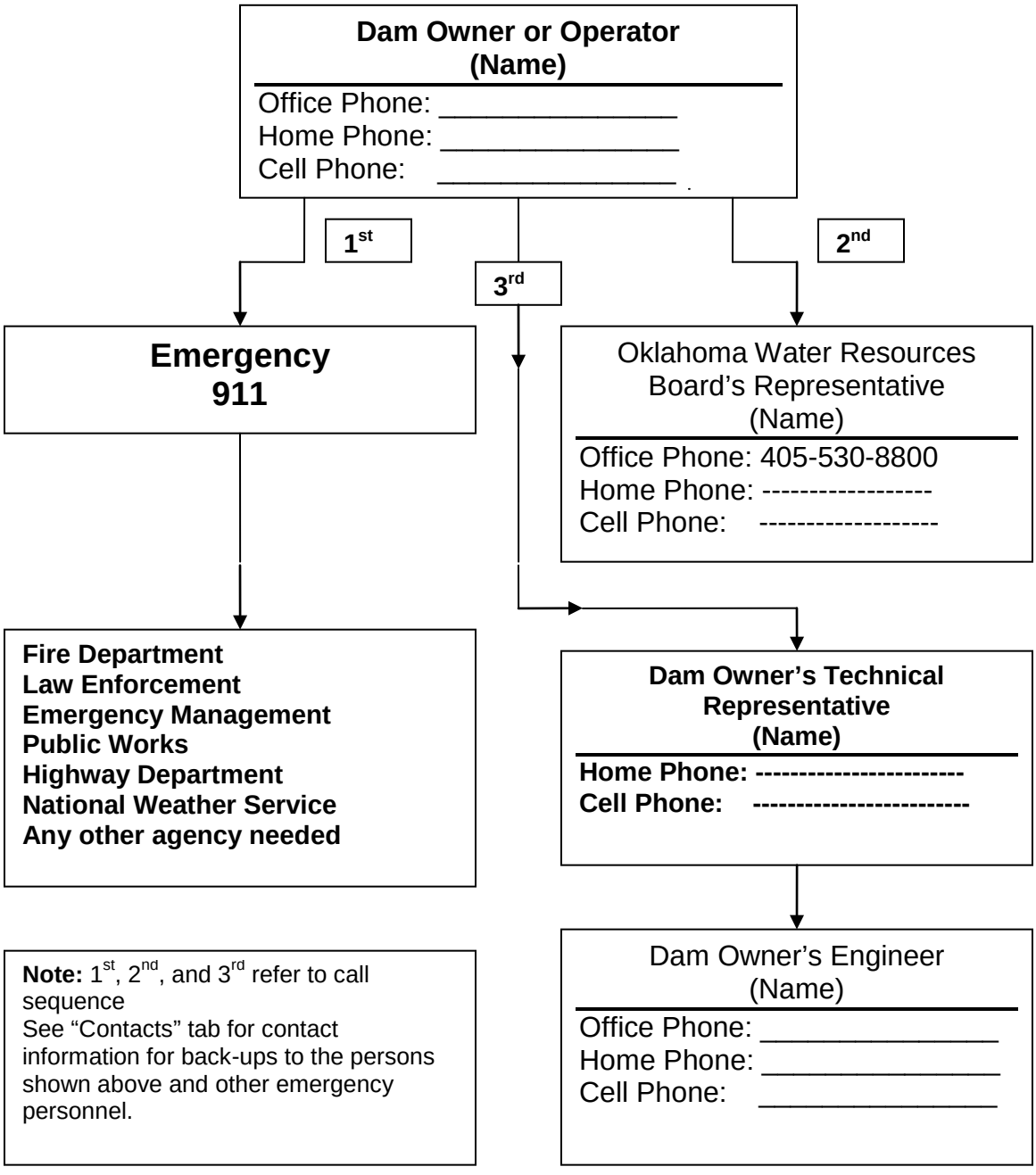
Emergency Event, potential dam failure
Situation; rapidly developing



Note: 1st, 2nd, and 3rd refer to call sequence
See "Contacts" tab for contact information for back-ups to the persons shown above and other emergency personnel.

Emergency Level 3 Notification

Emergency Event, potential dam failure
Situation; rapidly developing



SAMPLE
Draft Only - not for official use

Emergency Services Contacts

Agency / Organization	Principal Contact	Address	Office Phone Number	Alternative Phone Number
Oklahoma Water Resources Board	(Name)	3800 N Classen Blvd., Oklahoma City, OK 73118	405-530-8800	
Design Engineer of the Dam				
Dam Safety Engineer currently working with Dam Owner				
(Name of) County Emer. Management				
County Sheriff				
National Weather Service		1200 Westheimer Drive, Norman, OK	405-360-5928	
Natural Resources Conservation Service				

Step 4 Expected Actions

The dam owner or representative shall be notified on any unusual or emergency event at the dam. The owner or representative shall determine the emergency level and follow the appropriate actions. The Oklahoma Water Resources Board (OWRB) and/or Dam Safety Engineer should be contacted for technical consultation.

Emergency Level 1 – Non-emergency, unusual event; slowly developing:

A. The owner or representative should inspect the dam. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope of the dam. Also check the reservoir area, abutments, and downstream channel for signs of changing conditions. **If increased seepage, erosion, cracking, or settlement are observed, immediately report the observation conditions to the Dam Owner's Engineers and to OWRB dam safety engineer; refer to the emergency level table for guidance in determining the appropriate event level for the new condition and recommended actions.**

B. Record all contacts that were made on the Contact Checklist (Appendix A-1). Record all information, observations, and actions taken on the Event Log Form (Appendix A-2). Note the time of changing conditions. Document the situation with photographs and video if possible.

C. The owner or representative should contact their dam safety engineer or design engineer and request technical assistance to investigate the situation and recommend corrective actions. (May also contact the OWRB for assistance or possibly the Natural Resources Conservation Service, NRCS).

Emergency Level 2 – Potential dam failure situation; rapidly developing:

A. The owner or representative should contact their engineer, OWRB and the local NRCS office to report the situation and, if time permits, request technical staff to investigate the situation and recommend corrective action.

B. The owner or representative should contact 911 to inform the emergency personnel that the Emergency Action Plan (EAP) has been activated and if current conditions get worse, an emergency situation may require evacuation. Preparations should be made for possible road closures and evacuations.

C. Provide updates to the emergency services personnel to assist them in making timely decisions concerning the need for warning, road closures, and evacuations.

D. If time permits, the owner or representative should inspect the dam. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope of the dam. Also check the reservoir area, abutments, and downstream channel for signs of changing conditions. **If piping, increased seepage, erosion, cracking, or settlement are observed, immediately report the observed conditions to the dam owner's safety engineer and the OWRB; refer to the emergency level table for guidance in determining the appropriate event level for the new condition and recommend actions.**

E. Record all contacts that were made on the Contact Checklist (Appendix A-1). Record all information, observations, and actions taken on the Event Log Form (Appendix A-2). Note the time of changing conditions. Document the situation with photographs and video if possible.

F. If time permits, the following emergency remedial actions should be taken as appropriate:

Emergency remedial actions

If time permits, the following emergency remedial actions should be considered for Emergency Level 2 conditions. Immediate implementation of these remedial actions may delay, moderate, or prevent the failure of the dam. Several of the listed adverse or unusual conditions may be apparent at the dam at the same time, requiring implementation of several modes of remedial actions. Close monitoring of the dam must be maintained to confirm the success of any remedial action taken at the dam. Time permitting, any remedial action should be developed through consultation with the Owner's safety engineer and the OWRB. See Resources Available (Appendix B-1) for sources of equipment and materials to assist with remedial actions.

Embankment overtopping

1. Place sandbags along the low areas of the top of the dam to reduce the likelihood of overtopping and to safely direct more water through the spillway.

2. Cover the weak areas of the top of the dam and downstream slope with riprap, sandbags, plastic sheets, or other materials to provide erosion-resistant protection.

Seepage and sinkholes

1. Open principal spillway gate to lower the reservoir level as rapidly as possible to a non-erosive velocity. If the gate is damaged or blocked, pumping or siphoning may be required. (Not all dams are equipped with outlets, gates or valves and must be pumped or siphoned.)

Continue lowering the water level until the seepage stops.

2. If the entrance to the seepage origination point is observed in the reservoir (possible whirlpool) and is accessible, attempt to reduce the flow by plugging the entrance with readily available materials, such as hay bales, bentonite, soil or rock fill, or plastic sheeting.

3. Cover the seepage exit area(s) with several feet of sand/gravel to hold fine-grained embankment or foundation materials in place. Alternatively, construct sandbag or other types of ring dikes around the seepage exit areas to retain a pool of water, providing backpressure and reducing the erosive nature of the seepage.

4. Prevent vehicles and equipment from driving between the seepage exit points and the embankment to avoid potential loss from the collapse of an underground void.

Embankment movement

1. Open outlet(s) to lower the reservoir to a safe level at a rate proportionate with the urgency and severity of the condition of the slide or slump. If the gate is damaged or blocked, pumping or siphoning may be required. (Not all dams are equipped with outlets, gates or valves and must be pumped or siphoned.)

2. Repair settlement of the crest by placing sandbags or earth and rock fill material in the damaged area to restore freeboard.

3. Stabilize slides on the downstream slope by placing a soil or rock fill buttress against the toe area of the slide.

Earthquake

1. Immediately conduct a general overall visual inspection of the dam.

2. Perform field survey to determine if there has been any settlement and movement of the dam embankment, spillway and low level outlet works.

3. Drain reservoir if required.

Emergency Level 3 – Urgent; dam failure is imminent or in progress:

A. The owner shall immediately contact 911 and others shown on the notification flow chart.

B. The city or county official in charge of the emergency shall lead the efforts to carry out warning, close roads, and evacuated people at risk downstream from the dam (see Evacuation Map tab).

C. Emergency Management service personnel shall alert the general public and immediately evacuate at-risk people and close roads as necessary.

D. The owner shall maintain continuous communication and provide the city or county official with updates of the situation to assist him in making timely decisions concerning warning and evacuations.

E. The owner should record all contacts that were made on the Contact Checklist (Appendix A-1). Record all information, observations, and actions taken on the Event Log Form (Appendix A-2). Note the time of changing conditions. Document the situation with photographs and video, if possible.

F. Advise people monitoring the dam to follow safe procedures. Everyone should stay away from any of the failing structures or slopes and out of potential breach inundation areas.

Step 5 Termination

Whenever the EAP has been activated, an emergency level has been declared, all EAP actions have been completed, and the emergency is over, the EAP operations must eventually be terminated and follow-up procedures completed.

Termination responsibilities

The city or county official in charge is responsible for terminating EAP operations and relaying this decision to the owner. It is then the responsibility of each person to notify the same group of contacts that he or she notified during the original event notification process to inform those people that the event has been terminated.

Prior to termination of an Emergency Level 3 event that has not caused actual dam failure, the Owner's engineer should inspect the dam to determine whether any damage has occurred that could potentially result in loss of life, injury, or property damage. The OWRB dam safety engineer can assist in the inspection. If it is determined that conditions do not pose a threat to people or property, the owner's engineer may advise the city or county official to terminate EAP operations as described above.

The owner shall assure that the Dam Safety Emergency Situation Report (Appendix A-3) is completed to document the emergency event and all actions that were taken. The owner shall provide a copy of the completed report to the Oklahoma Water Resources Board.

Maintenance – EAP Review and Revision

EAP Annual Review

The owner will review and, if necessary, update the EAP at least once each year. The EAP annual review will include the following:

1. Calling all contacts on the three notification charts in the EAP to verify that the phone numbers and persons in the specified positions are current, The EAP will be revised if any of the contacts have changed.

2. Contacting the local law enforcement agency to verify the phone number and persons in the specified positions. In addition, the owner will ask if the person contacted knows where the EAP is kept and if responsibilities as described in the EAP are understood.

3. Calling the locally available resources to verify that the phone numbers, addresses, and services are current.

Revisions

The owner is responsible for updating the EAP document. The EAP document held by the owner is the master document. When revisions occur, the owner shall provide the revised pages and a revised revision summary page to all the EAP document holders. The document holders are responsible for revising outdated copies of the respective document(s) whenever revisions are received. Outdated pages shall be immediately discarded to avoid any confusion with the revisions.

EAP Periodic Test

The owner will host and facilitate a periodic test of the EAP at least once every 5 years. The periodic test will consist of a meeting, including a tabletop exercise at a location determined by the owner. Attendance should include the owner, key agencies, at least one representative of the local law enforcement agency, and others with key responsibilities listed in the EAP. At the discretion of the owner, other organizations that may be involved with an unusual or emergency event at the dam are encouraged to participate. Before the tabletop exercise begins, meeting participants will visit the dam during the periodic test to familiarize themselves with the dam site.

The tabletop exercise will begin with the facilitator presenting a scenario of an unusual or emergency event at the dam. The scenario will be developed prior to the exercise. Once the scenario has been presented, the participants will discuss the responses and actions that they would take to address and resolve the scenario. The narrator will control the discussion, ensuring realistic responses and developing the scenario throughout the exercise. The owner should complete an event log as they would during an actual event.

After the tabletop exercise, the five sections of the EAP will be reviewed and discussed. Mutual aid agreements and other emergency procedures can be discussed. The owner will prepare a written summary of the periodic test and revise the EAP as necessary.

Record of Holders of Control Copies of this EAP

Copy Number	Organization	Person receiving copy

Record of Revisions and Updates Made to EAP

Revision Number	Date	Revisions Made	Who

Appendixes – Forms, Glossary, Maps, and Supporting Data

Appendix A

- A-1 Contact Checklist
- A-2 Unusual or Emergency Event Log Form
- A-3 Dam Emergency Situation Report Form
- A-4 Glossary of Terms

Appendix B

- B-1 Resources Available
- B-2 Location and Vicinity Maps
- B-3 Project Map
- B-4 Evacuation Map
- B-5 Residents / Businesses / Highways at Risk
- B-6 As-Built Engineering Drawings or Plans of the Dam & Spillway
- B-7 National Inventory of Dams (NID) Data

Appendix A – 1
Contact Checklist

(Name of) Dam and Reservoir
_____ County

The following contacts should be made immediately after the emergency level is determined (see pages 7-10 for guidance to determine the appropriate emergency level for a specific situation). The person making the contacts should initial and record the time of the call and who was notified for each contact made. See the Notification Flowcharts for critical contact information and page 16 for contact information for other possible emergency services.

Emergency Level 1 **(see page 13)**

Contact	Person Contacted	Time	Contacted by
Dam Owner			
Project Engineer			
Oklahoma Water Resources Board			

Emergency Level 2 **(see page 14)**

Contact	Person Contacted	Time	Contacted by
Dam Owner			
Project Engineer			
Oklahoma Water Resources Board			
Natural Resources Conservation Service (NRCS)			
911			

(City or County)			

<u>Emergency Level 3</u> **(see page 15)**

Contact	Person Contacted	Time	Contacted by
911 (City or County)			
Project Engineer			
Dam Owner			
Oklahoma Water Resources Board			
Natural Resources Conservation Service (NRCS)			

Appendix A – 2
Unusual or Emergency Event Log
(to be completed during the emergency)

Dam name: ---------- County: ----------

When and how was the event detected?

_____
_____
_____

Weather conditions:

_____
_____

General description of the emergency situation:

_____
_____
_____
_____
_____
_____

Emergency level determination: _____ Made by: _____

Actions and Event Progression

Date	Time	Action / event progression	Taken by

Report prepared by: _____ Date: _____

Appendix A – 3

Dam Emergency Situation Report

(to be completed following the termination of the emergency)

Dam name: ---------- County: ----------
Dam location: _____
Date: _____ Time: _____

Weather conditions: _____

General description of the emergency situation:
_____
_____
_____
_____

Area(s) of dam affected:
_____
_____

Extent of dam damage: _____

Possible cause(s): _____

Effect on dam's operation: _____

Initial reservoir elevation:_____ Time: _____
Maximum reservoir elevation: _____ Time: _____
Final Reservoir elevation: _____ Time: _____

Description of area flooded downstream / damages / injuries / loss of life:
_____
_____
_____

Other data and comments:
_____
_____

Observer's name and telephone number: _____

Report prepared by: _____ Date: _____

Appendix A - 4: Glossary of Terms

Abutment That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer looking downstream from the dam.

Acre-foot A unit of volumetric measure that would cover one acre to a depth of one foot. One acre-foot is equal to 43,560 cubic feet or 325,851 gallons.

Bench Mark A permanent or temporary monument of known elevation above sea level, used as a vertical reference during construction and for topographic surveys.

Berm A nearly horizontal step (bench) in the upstream or downstream sloping face of the dam.

Boil A disruption of the soil surface due to water discharging from below the surface. Eroded soil may be deposited in the form of a ring (miniature volcano) around the disruption.

Breach An opening through a dam resulting from partial or total failure of the dam. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintended failure of the dam.

Conduit A closed channel (round pipe or rectangular box) that conveys water through, around, or under the dam.

Control section A usually level segment in the profile of an open channel spillway above which water in the reservoir discharges through the spillway.

Cross section A slice through the dam showing elevation vertically and direction of natural water flow horizontally from left to right. Also a slice through a spillway showing elevation vertically and left and right sides of the spillway looking downstream.

Dam An artificial barrier constructed across a watercourse for the purpose of storage, control, or diversion of water.

Dam Failure The uncontrolled release of a dam's impounded water. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters which adversely affect a dam's primary function of

impounding water is properly considered a failure. Such lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amendable to corrective action.

Dam Operator The person(s) or unit(s) of government that has responsibility for the operation and maintenance of the dam.

Drain **(Toe or foundation, or blanket drain)** A water collection system of sand and gravel and typically pipes along the downstream portion of the dam to collect seepage and convey it to a safe outlet.

Drainage area **(Watershed)** The geographic area on which rainfall flows into the dam.

Drawdown The lowering or releasing of the water level in a reservoir over time or the volume lowered or released over a particular period of time.

Emergency A condition which develops unexpectedly, endangers the structural integrity of a dam and/or downstream property and human life, and requires immediate action.

EAP **(Emergency Action Plan)** A formal document identifying potential emergency conditions that may occur at the dam and specifying preplanned actions to minimize potential failure of the dam or minimize failure consequences including loss of life, property damage, and environmental impacts.

Evacuation Map A map showing the geographic area downstream of a dam that should be evacuated if it is threatened to be flooded by a breach of the dam or other large discharge.

Failure The catastrophic breakdown of a dam, characterized by the sudden, rapid, and uncontrolled released of impounded water.

Filter Those layers of sand and gravel in a drain that allow seepage through an embankment to discharge into the drain without eroding the embankment soil.

Flood Hydrograph A graph showing, for a given point on a stream, the discharge, height or other characteristic of a flood with respect to time.

Floodplain The downstream area that would be inundated or otherwise affected by the failure of a dam or by large flows.

Flood Profile A graph (elevation view) showing the relationship of the water surface elevation and natural ground elevations for a discharge at a given location along longitudinal segments of a watercourse for a flood event. The flood event may either be a dam failure or a natural flow condition. Also see Water Surface Profile.

Flood Routing The process of determining progressively over time the amplitude of a flood wave as it moves past a dam or downstream to successive points along a river or stream.

Freeboard Vertical distance between a specified still water surface elevation and the top of the dam, without camber.

Gate **(Slide or sluice, or regulating)** An operable, watertight valve to manage the discharge of water from the outlet of the dam.

Hazard A situation which creates the potential for adverse consequences such as loss of life, property damage, and adverse social and environmental impacts. Impacts may be for a defined area downstream of a dam from floodwaters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. They may also be for a landslide around the reservoir perimeter.

Hazard Class **(or hazard classification)** A system that categorizes dams (high, significant, or low) according to the degree of their potential to create adverse incremental consequences such as loss of life, property damage, or environmental impacts of a failure or misoperation of a dam.

Headwater The water immediately upstream from a dam. The water surface elevation varies due to fluctuations in inflow and the amount of water passed through the dam.

Height, dam The vertical distance between the lowest point along the top of the dam and the lowest point at the downstream toe which usually occurs in the bed of the outlet channel. (OWRB regulations consider the height from the natural bed of the stream or watercourse at the downstream toe of the barrier (dam) or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the top of the dam.)

Hydrograph A graph showing the discharge, stage, velocity, or other hydraulic property with respect to time at a particular point on a watercourse.

Inflow Design Flood The flood hydrograph used in the design of a dam and its appurtenant structures, particularly the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Instrumentation The use of special devices to obtain critical scientific measurements of engineered structures. An arrangement of devices installed into or near dams that provide measurements to evaluate the structural behavior and other performance parameters of the dam and appurtenant structures.

Inundation Map A map showing areas that would be affected by flood conditions and/or by an uncontrolled release of reservoir water due to the failure of a dam.

Maintenance Maintaining structures and equipment in intended operating condition, equipment repair, and minor structure repair.

Notification To inform appropriate individuals about an emergency condition so they can take appropriate action.

Outlet Works (principal spillway) An appurtenant structure that provides for controlled passage of normal water flows through the dam.

Piping The progressive destruction of an embankment or embankment foundation by internal erosion of the soil by seepage flows.

PMP / PMF (Probable Maximum Precipitation / Probable Maximum Flood) The theoretically greatest precipitation or resulting flood that is meteorologically feasible for a given duration over a specific drainage area at a particular geographic location.

Reservoir The body of water impounded or potentially impounded by the dam.

Riprap A layer of large rock, precast blocks, bags of cement, or other suitable material, generally placed on an embankment or along a watercourse as protection against wave action, erosion, or scour.

Risk A measure of the likelihood and severity of an adverse consequence.

Seepage The natural movement of water through the embankment, foundation, or abutments of the dam.

Slide The movement of a mass of earth down a slope on the embankment or abutment of the dam.

Service Spillway A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir without significant damage to either the dam or its appurtenant structures.

Spillway (auxiliary or emergency). The appurtenant structure that provides the controlled conveyance of excess water through, over, or around the dam. A structure over or through which flood flows are discharged. If the flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.

Spillway Capacity The maximum discharge the spillway can safely convey with the reservoir at the maximum design elevation.

Spillway Crest The lowest level at which reservoir water can flow into the spillway.

Tailwater The body of water immediately downstream of the embankment at a specific point in time. The water surface elevation varies with discharge from the reservoir.

Toe of dam The junction of the upstream or downstream face (slope) of an embankment with the ground surface.

Top of dam (crest of dam) The elevation of the uppermost surface of an embankment which can safely impound water behind the dam.

Water Surface Profile A graph (elevation view) showing the relationship of the water surface elevation and natural ground elevations at a given location along longitudinal segments of a watercourse for a specific discharge. Also see Flood Profile.

Appendix B-1: Resources Available

Locally available equipment, labor, and material:

Equipment - Front-end loader, bobcat, dozer, backhoe, track hoe, graders, dump truck, etc.

Materials – Sand, gravel, clay barrow pit, bentonite, synthetic filter material, sand bags, etc.

Contractors (Ref. City Phone Directory):

(Name & Addresses of Contractor)

-
-
-
-
-
-

Appendix B-2: Location and Vicinity Maps

Appendix B-3: Flood Hazard Boundary Map

Appendix B-4: Residents / Property / Businesses / Highways at Risk

[Numbers below match locations on aerial map on the following page]

A major flood caused by a sudden breach of the dam is estimated to inundate the following properties downstream of the dam. These properties and home are marked on the evacuation map and are located_____
_____
_____

1. Name & Address Phone: _____

(List all residents, property/business owners, roads/highways at risk)

Appendix B-5: Engineering Drawings or Plans (if available)

Appendix B-6: National Inventory of Dam Data (NID)

(Can be provided by OWRB)

Appendix B-7: Other Project Documents