

出國報告（出國類別：進修、業務接洽）

美國墾務局洽談合作計畫執行及參加大壩
安全等水利技術研習-大壩安全評估國際研
習班 (2019 Safety Evaluation of Existing
Dams (SEED) Seminar)

服務機關：經濟部水利署

姓名職稱：林元鵬副總工程司、林惠芬研究員、
林益生簡任正工程司

派赴國家：美國

出國期間：108年6月2日~108年6月15日

報告日期：108年9月

摘要

美國內政部墾務局目前是世界上從事大壩建設及安全檢查最權威單位之一，擁有豐富經驗。經濟部水利署與墾務局合作邁入第 32 年，為因應氣候變遷挑戰，水利署於去(2018)年與墾務局第 31 屆年會中提出數項新的合作案，將合作面向由工程技術擴大到管理層面，工作項目包含將風險引入水庫安全評估、共同開設國際訓練研習班、編撰塑性混凝土指引等。由於合作內容迥異於以往，遂派員赴美洽談、溝通，以順遂後續執行。

今年亦適逢美國墾務局擴大舉辦第 30 屆「大壩安全評估國際研習班」(The Safety Evaluation of Existing Dams Seminar, SEED)。SEED 研習班由該局具豐富實務經驗的工程師，介紹美國地區大壩安全檢查之政策與作為、潰壩後淹水模擬、以及安排大壩參訪等。美國有 69% 大壩為私有，早年管理與維護制度未完整建立前，發生一些失敗案例，造成下游生命財產損失，從案例檢討中知道災害發生前多僅有細微症狀，若未及時發現防範，會在很短時間內造成全面性潰壩災難。

美國大壩天然地理條件較臺灣優良，而臺灣水庫長年在面臨乾旱、強降雨、地震、淤積等問題挑戰下，對於水庫操作、管理、清淤、水力排砂等工作，已逐漸發展獨特與領先技術。

臺灣將於 108 年 9 月與墾務局、國合會首次共同開辦「2019 年水資源管理研習班-永續水庫(2019 Workshop on Water Resources Management-Sustainable Reservoir)」，預計招募 30 名各國學員，分享近年成就與尋求協助各國水庫改善合作機會，輸出國內技術及創造商機。參加本次研習班亦有近距離觀察課務安排細節的機會，並與 44 位，來自 11 個國家的各國學員互動交流，尋求未來擴大國際合作的機會。

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第一章 目的

美國內政部墾務局(U.S. Department of the Interior, Bureau of Reclamation；以下簡稱墾務局，USBR)成立於 1902 年，迄今已超過 117 年，以局徽上的「美國西部 17 州的水管理」(Managing Water in the West)為主要任務，負責 492 座大壩、338 座水庫(總蓄水容量超過 3,000 億立方公尺)的操作、維護與安全等工作，為世界上從事大壩建設及安全檢查最權威單位之一。

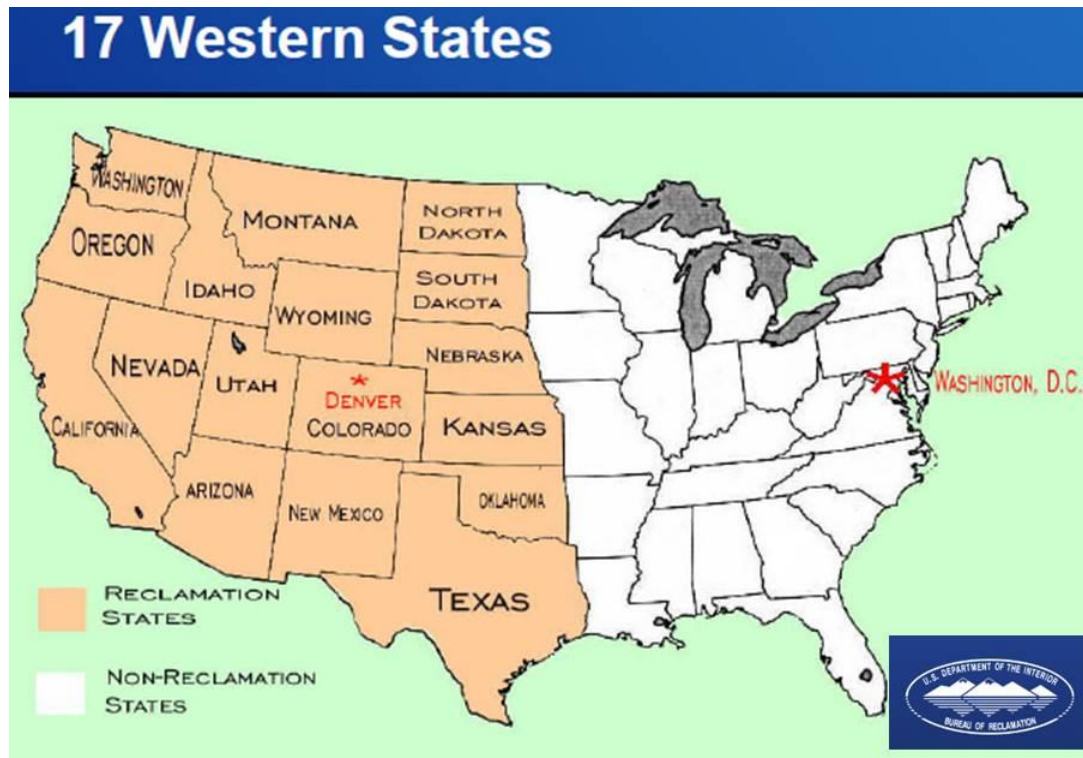


圖 1.美國墾務局負責管理水的 17 州及局徽。(圖片來源:墾務局 SEED 簡報)

臺灣水利單位與墾務局合作可追溯至民國 45 年石門水庫建設時，我國於 76 年由北美事務協調會(代表前臺灣省水利局)與美國在臺協會(代表美國墾務局)簽署「臺美水資源發展技術支援協議」，雙方政府水利部門合作關係已超過 30 年，對臺灣水利重大建設許多重要成果，包括鯉魚潭水庫、南化水庫、牡丹水庫、寶二水庫及湖山水庫等工程，我國大壩施工技術也獲得提升，在長年相互切磋交流中，奠定臺美之間深厚的情感。

本次出國目的如下:

一、洽談 2019 年「臺美水資源發展技術支援協議」第 6 號及第 8 號附錄後續執行事宜

經濟部水利署(以下簡稱水利署)與美國墾務局於 2018 年第 31 屆臺美水資源技術合作年會就 2019 年工作項目達成以下共識:

附錄 6:

- 臺美雙方合作訂定塑性混凝土規範。
- 臺美雙方合作研究在極端事件下水庫操作方法。
- 引入風險管理進行大壩安全評估

附錄 8

- 集水區逕流及土壤沖蝕數值模式開發(2/5)
- 河口水理及泥砂運移數值模式開發(2/5)
- 河川水力、河川復育及流域土砂管理(2/5)
- 技術訓練課程及技術諮詢

未來合作主題:

- 以共同招募國際學員為目標，臺美雙方可就大壩安全管理、永續水庫庫容(淤砂清除)、泥砂運移及管理主題合作開設訓練課程。

上述合作主題有多項為首次合作，如塑性混凝土、極端事件水庫操作方法、引入風險管理進行大壩安全評估、共同開設訓練課程等，為順遂本年度工作推動先行赴美與美方溝通。

二、參加大壩安全國際研習班

大壩安全評估研習班最早起源於墾務局針對內部員工進行的大壩安全教育訓練，由墾務局具有豐富實務經驗的工程師及地質學家擔任講師，後於 1989 年開始招募國際學員，累計已有超過 1000 名以上，來自 74 個國家的學員參訓，至今(2019)年適逢本研習班開辦 30 周年，墾務局也特別製作專刊回顧歷年辦理過程，並在參訪行程中安排觀摩不同的水壩與水資源計畫。

108 年 6 月 3 日至 12 日墾務局舉辦「大壩安全評估國際研習班」(The Safety Evaluation of Existing Dams Seminar, SEED)，包含室內課程、參訪大壩等水資源設施(海報如圖 2.)，參與學員計 44 名，分別來自 11 個國家，包括阿爾巴尼亞、澳大利亞、波扎那、巴西、加拿大、芬蘭、肯亞、馬來西亞、奈及利亞、臺灣和南非(依英文字母排列順序)。

三、觀摩及宣傳永續水庫國際訓練研習班

水利署已訂 108 年 9 月與墾務局、財團法人國際合作發展基金會(The International Cooperation and Development Fund；以下簡稱國合會，ICDF)首次共同開辦「2019 年水資源管理研習班-永續水庫(2019 Workshop on Water Resources Management-Sustainable Reservoir)」，預計招募 30 名各國學員。透過本次參加墾務局 SEED 研習班的機會，學習與觀摩舉辦國際訓練研習班辦理方式，並同時向 SEED 研習班 44 位來自不同國家的學員廣為宣傳，並電郵提供研習班資訊；此外，水利署也請墾務局協助將招生海報(圖 3.)，於其他國際研討會中發放宣傳。

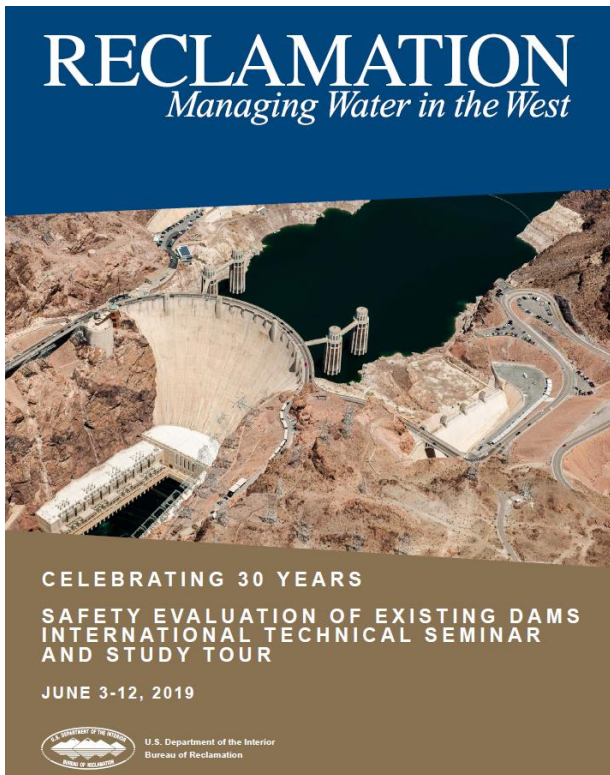


圖 2.美國墾務局 SEED 研習班海報。



圖 3.水利署與墾務局等合辦研習班海報。

第二章 過程

一、行程與成員

本次赴美人員及時間如下:

人員	時間	任務
林元鵬副總工程司 林惠芬研究員	2019年6月6日 -6月15日	1.洽談2019年「臺美水資源發展技術支援協議」第6號及第8號附錄後續執行事宜 2.觀摩國際研習班辦理方式及宣傳永續水庫國際訓練研習班
林益生簡任正工程司	2019年6月2日 -6月13日	1.參加大壩安全國際研習班 2.觀摩國際研習班辦理方式及宣傳永續水庫國際訓練研習班

主要行程如下表:

日期	地區	行程概要
6/2(日)	臺灣→ 美國丹佛	搭機啟程(林益生簡任正工程司)
6/3(一)	美國丹佛	室內課程概要 1.大壩安全評估國際研習班開幕、學員自我介紹 2.墾務局簡介(Overview of the Bureau of Reclamation) 3.大壩安全的歷史背景(Historical Background on Dam Safety) 4.安全專案簡介(Security Program Overview) 5.由大壩事故學習的教訓(Lessons Learned from Dam Safety Incidents) 6.設施操作與維護(Review of Facility Operation and Maintenance) 7.參訪墾務局工程研究實驗室、混凝土圓柱試驗室(Tour of the Bureau of Reclamation's Engineering and Research Laboratories Concrete Cylinder Test)
6/4(二)	美國丹佛	室內課程概要 1.大壩安全監測及評估失敗案例檢討(Identification of Failure Modes for Dam Safety Monitoring and Evaluation) 2.大壩安全風險分析和風險評估(Risk Analysis and Risk Assessment for Dam Safety)

		3. 如何決定洪水風險(Determining Flood Risk) 4. 地質與大壩安全(Geology and Dam Safety) 5. 水庫淤積、永續使用與大壩安全(Reservoir Sedimentation, Sustainability and Dam Safety) 6. 漂流木模型(Debris Modeling) 7. 歡迎晚宴
6/5(三)	美國丹佛	室內課程概要 1. 混凝土壩和附屬結構改善(Structural Modifications- Concrete Dams and Appurtenant Structures) 2. 大壩儀器監測(Instrumented Monitoring of Dams) 3. 大壩抗震設計與分析(Seismic Design and Analysis of Dams) 4. 大壩地震災害案例(Seismic Hazard Studies for Dam Safety)、地震預警與應變(Earthquake Notification and Response) 5. 墾務局洪泛模式與災害估計(Flood Inundation Modeling and Consequences Estimation at Reclamation) 6. 緊急應變計畫與演練(Emergency Action Planning, Exercises and Reporting) 7. 附屬設施檢查方法(Examination of Appurtenant Structures)
6/6(四)	美國丹佛	室內課程概要 1. 機械檢查維護與測試(Inspection Maintenance and Testing of Mechanical Equipment) 2. 混凝土壩檢查方式(Examination of Concrete Dams) 3. 土石壩檢查方式(Examination of Embankment Dams) 4. 滲流與內部沖蝕(Seepage and Internal Erosion) 5. 操作程序和大壩操作員訓練(Standing Operating Procedures and Dam Operator Training) 6. Hyatt 壩案例探討(Case Study Hyatt Dam Case Study) 7. Pueblo 壩簡介(Pueblo Dam Overview) 8. 室內課程結束與參訪注意事項(Technical Session Close Out - Study Tour information)
	臺灣	搭機啟程(林元鵬副總工程司、林惠芬研究員)
6/7(五)	丹佛→Pueblo	參訪 Pueblo 壩與模擬檢查(Site visit and Simulated Exam at Pueblo Dam)
	丹佛	與美方洽談 1. 臺美合作 6 號附錄塑性混凝土、大壩安全導入風險概念合作執行 2. 永續水庫國際研習班課程、分工
6/8(六)	丹佛→洛磯山	週末墾務局安排參訪洛磯山國家公園(Tour of Rocky Mountain National Park)
6/9(日)	丹佛→鳳	搭機至鳳凰城

	凰城	
6/10(一)	鳳凰城	1. 亞歷桑那州中部供水計畫 2. 參訪新 Waddell 壩(Visit New Waddell Dam) 3. 參訪鹽河計畫(Salt River Project)
6/11(二)	鳳凰城	參訪 Roosevelt 壩(Tour Theodore Roosevelt Dam)
6/12(三)	鳳凰城→ 拉斯維加斯	1. 洽談第 32 屆臺美年會辦理事宜及永續水庫國際訓練研習班 行政庶務 2. 參訪 Hoover Dam
	鳳凰城→ 臺灣	返程 (林益生簡任正工程司)
6/13(四)-6/15(六)	拉斯維加斯→臺灣	返程(林元鵬副總工程司、林惠芬研究員)

二、臺美 2019 年合作執行洽談

本次訪美與墾務局洽談合作紀錄重點摘述如下：

(一)年會及各工作項目籌辦：

1. 年會時間訂於 108 年 10 月 20 日該週，預訂由墾務局 Palumbo 副局長率團赴臺。
2. 附錄六預訂於 8 月 26 日該週赴臺，預訂 2-3 人，由墾務局附錄六聯絡官 Stephen Dominic 率隊，確定同行人員 Scott Stevens。
3. 與墾務局、國合會共同開辦之永續水庫訓練課程由 Tim Randle 及 Blair Greimann 擔任講師。本項工作經費由附錄六或八支應，美方內部討論後通知我方。

(二)塑性混凝土截水牆設計及施工技術指引

1. 本技術指引目的為經驗傳承，提供國內工程師用及未來工程(如烏溪鳥嘴潭)參考，完成後與國際社會分享。
2. 墾務局表示，該局塑性混凝土近 2-30 年實施案例僅 Meek Scabin Dam，將協助收集美國工兵團等其他單位資料，再據以協助。也表示，若我方將來進行期刊發表，願意給予技術協助及必要時聯合掛名，但細節仍有待進一步洽商。
3. 來臺訓練課程將涵蓋各式截水牆及塑性混凝土之設計及施工。

(三)納入風險管理之水庫安全評估

1. 對於水利署所提三年規劃構想，第一年曾文水庫、第二年石門水庫作為試作案例、第三年率定作法據以參考運用，墾務局原則表示認同。
2. 墾務局歷經 25 年嘗試全面導入風險管理，目前 8 年進行一次全面性檢查，每 4 年進行重

點檢查(導入風險前，每 4 年進行一次)。目前我方提出之風險評估架構與墾務局作法仍有差異，可針對重點部分先導入風險概念。本年度重點為學習如何實施、具體落實。


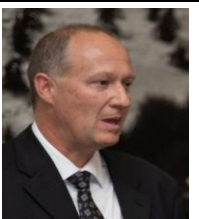
3. 來臺實務操作行程，受訓學員人數以 20 人為限。

(四)合作開設 2019 水資源管理-永續水庫研習班

1. 本(108)年度課程內容經雙方逐項討論，已全部敲定，原則對我方原規劃內容表示可行，而雙方亦達共識，課程應淺顯務實，以案例分析為主，且將配合於訓練前，先研提簡報資料由水利署彙集提供學員，以收成效，
2. 兩位美方講師來臺期間，美方授課程原則上均二人共同參加。第 9 天:上午 Tim、下午 Blair
3. 第 10 天:參加水週
4. 第 13 天:上午 Tim、Blair 共同掛名，將講述美國、日本、歐洲及湄公河案例。下午 2 人與我方代表共同參與討論。
5. 第 14 天:上午 2 人與我方代表共同參與討論。
6. 合開課程已向墾務局表達，以長期合作為目標，美方將協助向熟識之專業人士宣傳。今年將於 6 月 24 日舉辦之 SEDHYD 2019 國際研討會中發送傳單，傳單請我方提供。
7. 訪美期間積極宣傳本課程，目前已有相關水利人員表達強烈意願，請林益生簡正為窗口，研擬報名資訊，併同課程簡介，陳送核閱後，再寄送墾務局本次訓練全部學員，以增加參加人員。

(五)墾務局部門主管 **Karen Knight** (Director, Security, Safety and Law Enforcement) 於 108 年 12 月受地質單位邀請來臺演講(地質研討會)，將提前一天抵臺，希望 12 月 10 日參訪本署與墾務局合作計畫，經討論預計安排參訪石門水庫。後續請惠芬研究員擔任窗口連繫，綜企組安排行程。

與我方洽談之美國墾務局人員

	Name	Tim Randle
	Position	Manager of Sedimentation and River Hydraulics Group
	Organization	Technical Service Center, USBR
	備註	第 8 號附錄負責組長 永續水庫訓練課程聯絡官
	Name	Steve Dominic
	Position	Civil Engineer
	Organization	Technical Service Center, USBR
	備註	6 號附錄聯絡官

	Name	Scott Stevens
	Position	Civil Engineer
	Organization	Technical Service Center, USBR
	備註	專業領域：大地工程、大壩設計、安全分析
	Name	Angela Medina
	Position	Senior International Affairs Specialist
	Organization	USBR
	備註	資深國際事務官
	Name	Karen Knight
	Position	Director
	Organization	Security, Safety and Law Enforcement (SSLE)
	備註	12/11-13 來臺，預計 12/10 拜訪水利署



圖 4. 臺美 2019 年合作執行洽談及合影

三、室內課程摘述

室內課程自美國時間 108 年 6 月 3 日至 6 日計 4 天，課程在美國丹佛市 Sheraton 飯店內舉辦，學員多就近住宿該飯店(如圖 5.及圖 6.)，以下簡要摘述幾門課程的重點:



圖 5.研習班舉辦地點(Sheraton Denver West Hotel) 圖 6.研習班教室

(一)開幕式及學員自我介紹：由壩務局安全和執法處長 Karen Knight 女士主持(Safety Security and Law Enforcement Office)，並播放壩務局局長 Brenda Burman 所預錄的歡迎影片，隨後由來自 11 個國家的 44 名學員一一簡要自我介紹，以使學員間有初步的互相瞭解。

(二)壩務局簡介(講師 Jeanne Major)：由介紹壩務局的組織(如圖 7.)，壩務局主要使命是為了美國公眾的利益，以環境和經濟合理的方式管理，開發和保護水和相關資源。該局成立於 1902 年 6 月 17 日，迄今已有 117 年的歷史，主要負責美國西部 17 州的水管理，負責 492 座大壩、338 座水庫(總蓄水容量超過 3,000 億立方公尺)的操作、維護與安全等工作，並有 25,760 公里的運河、操作 53 水力電廠，176 臺發電機組(容量超過 1400 萬千瓦)，壩務局的官網是 <http://www.usbr.gov>。

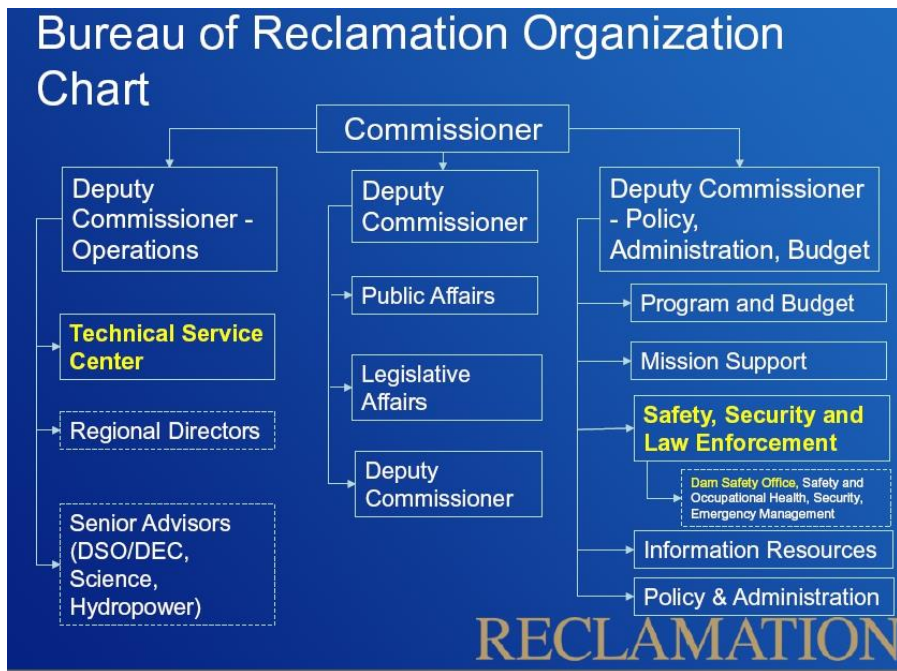


圖 7.壩務局組織架構

(三)大壩安全的歷史背景(講師 Tim Tochtrop)：介紹重大潰壩的案例，以及這些失敗案例如何催生大壩安全立法。經統計 69%的大壩屬私人擁有，20%屬地方政府，5%屬州政府，4%屬聯邦政府，2%為其它，正由於大部分大壩屬私人建設維管，所以早年在壩安全法令尚未齊全時，因為私人的維護操作不當，發生多次大壩損害及造成下游重大生命財產損失。甚至部分私有水壩是在損壞造成災害後，政府才知道有此水壩存在。

早年一連串的大壩失敗案例(如圖 8~圖 11)，促使加州及鄰近各州在 1929 年制定大壩安全法令。在 1963 年 Baldwin Hills 壩失敗後，加州又在 1965 年修法強化法令。

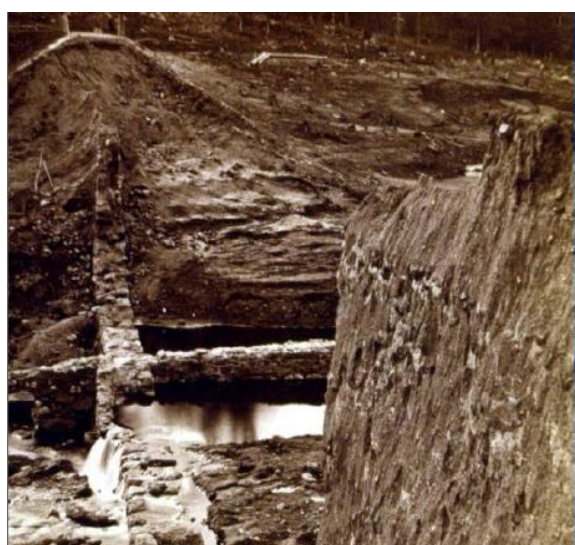


圖 8. Williamsburg 壩 1874 年損壞(139 人死亡)。



圖 9. South Fork 壩 1889 年損壞(2209 人死亡)。



圖 10. Austin 壩 1911 年損壞(甫完工 2 年，80 人死亡)。



圖 11. St. Francis 壩 1928 年損壞。(450 人死亡)

然而在 1970 年代幾次著名的大壩災害後(如圖 12~圖 15)，也促使聯邦政府採取行動，在 1972 年制定「國家大壩檢查法」(National Inspection of Dams Act)，授權美國陸軍工兵團(U.S. Army Corps of Engineers, USCE)進行大壩基本資料盤點及依風險高低

分類，但聯邦政府並未提供檢查所需的龐大預算。墾務局也在 Teton Dam 壩 1976 年損壞後建立大壩安全計畫。



圖 12. Lower San Fernando 壩 1971 年損壞(8 萬人撤離)。



圖 13. Buffalo Creek 壩 1972 年損壞(125 人死亡)。

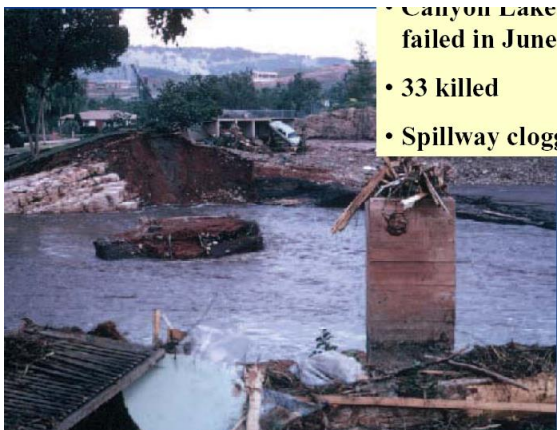


圖 14. Canyon Lake 壩 1972 年損壞(33 人死亡)。



圖 15. Teton Dam 壩 1976 年損壞(11 人死亡)。

美國國會其後在 1978 年根據 1972 年法案為工兵團撥款，以監督非屬聯邦政府的水壩檢查工作，在 1978 到 1981 年間共檢查了 9,000 多座高風險水壩。1979 年頒布的「聯邦大壩安全指南」(Federal Guidelines for Dam Safety)，則加強了全面一致性的大壩安全，並鼓勵在大壩安全決策中使用風險分析概念。1979 年卡特總統發布行政命令，建立聯邦緊急事務管理局(The Federal Emergency Management Agency，簡稱 FEMA)，負責協助聯邦機構和各州的大壩安全計畫，並向公眾和大壩業主提供有關大壩安全的信息。

為符合前述「聯邦大壩安全指南」和「國家大壩安全檢查法」的規定，墾務局已建立了一套基於風險的評估方法，針對現有水庫安全評估作業流程如圖 16，其每 8 年進行一次詳細的綜合評估，以協助優先分配資源。

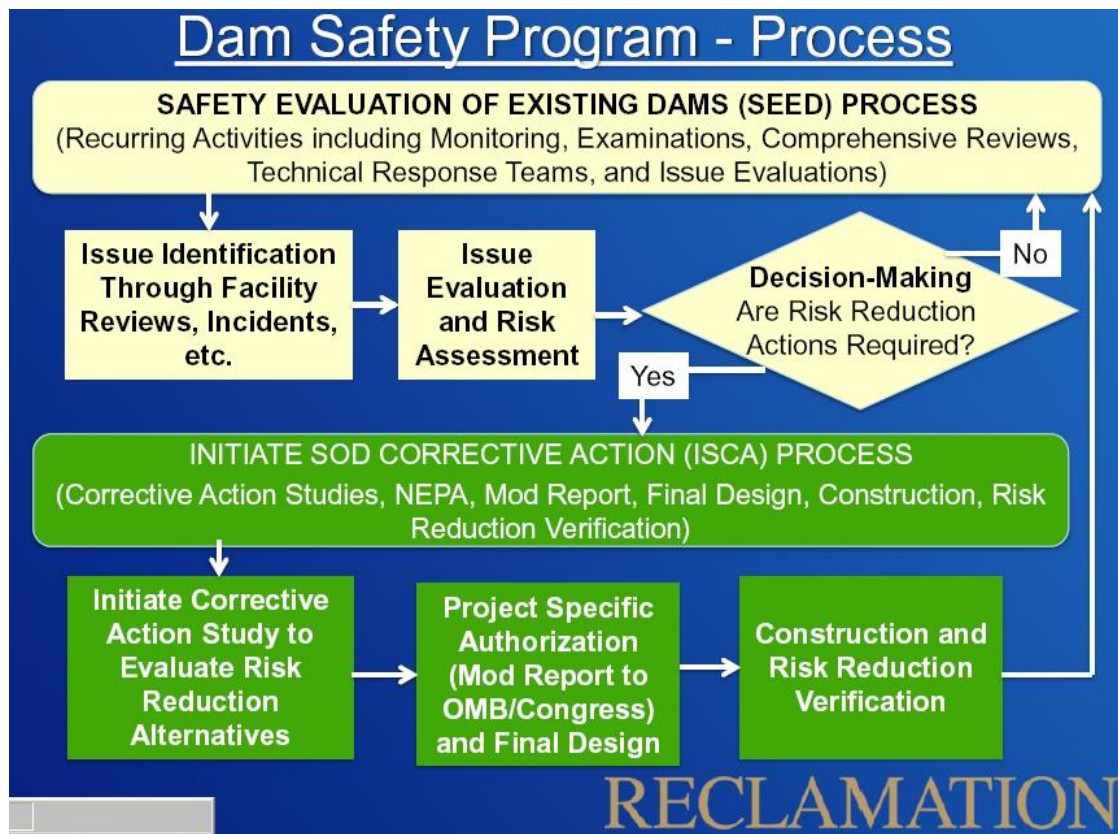


圖 16. 墾務局現有水庫安全評估作業流程。

(四) 由大壩事故學習的教訓(講師 Jay N. Stateler)：統計結果顯示大壩破壞模式有 1/3 為溢頂造成、1/3 為壩體或壩基滲漏管湧造成、1/3 為基礎不佳或其他因素造成，分別以不同案例介紹：

1. 溢頂破壞: 賓州 South Fork 土石壩，壩高 21 公尺，水庫容量 1520 萬立方公尺，1853 年完工時是當時世界上最大的壩之一，其後又在壩頂建造道路，並再降低壩頂 1 公尺，以拓寬道路為雙向道。1889 年 5 月 30~31 日的暴雨，造成水庫達到滿水位開始洩洪，但漂流木等異物堵塞排洪道，導致洪水溢頂沖刷大壩壩體，潰壩造成 9~12 公尺高的洪水，在 10 分鐘內沖向下游社區，造成 2209 人死亡。

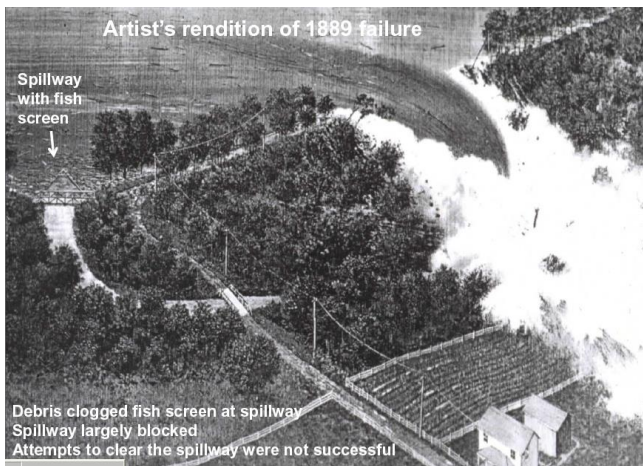


圖 17. South Fork 壩洪水溢頂。



圖 18. 下游受災情形及漂流木。

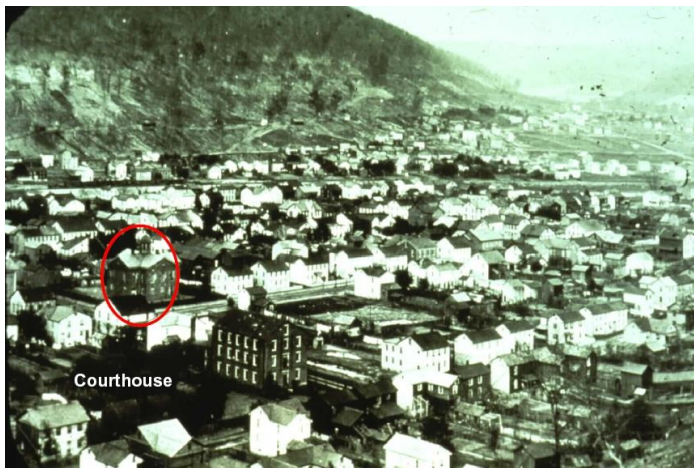


圖 19. 下游社區災害前。

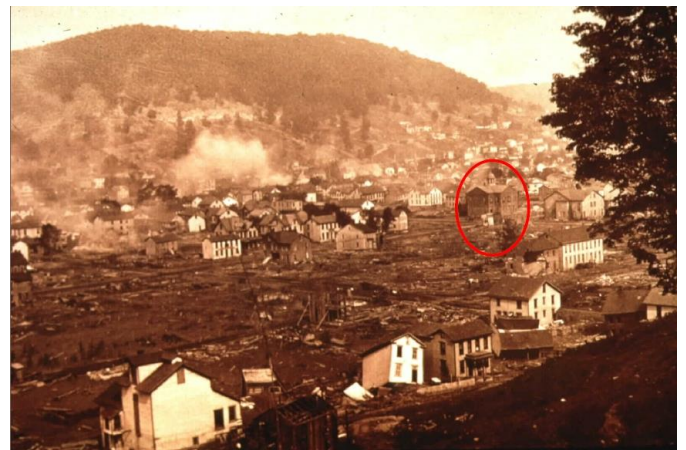


圖 20. 下游社區災害後。

- 壩體或壩基滲漏管湧: Teton 土石壩，位於愛達荷州，壩高 93 公尺，1975 年完工，原本預計以每天上升 0.3 公尺的速率蓄水，受暴雨及出水工尚未完工的影響，實際水位蓄升速度達到每天 1.2 公尺，在 1976 年 6 月接近滿水位，6 月 5 日早上 8 點 30 分發現大壩下游側坡趾處滲漏，其後雖然調派挖土機嘗試搶修填補，滲流仍快速增加，3 小時後，約在 11 點 55 分即造成壩頂崩毀，最大流量達到每秒 30,000 立方公尺(CMS)，造成下游 11 人死亡，超過 5 億美元的損失。其失敗的原因除了蓄水速度過快，無法即時阻止管湧惡化外，經檢討亦有灌漿蓋下的滲漏、水壓或不均勻沉陷裂縫引發管湧、岩層節理內滲漏等因素。



圖 21. Teton 壩從 08:30~11:55 潰壩過程及下游淹水情形

3.基礎不佳或其他因素:包括壩基地質條件不佳、壩旁邊坡滑動、地震破壞或液化等因素，
以下簡要介紹實際案例：

- (1)壩基地質條件不佳：Austin (Bayless)壩，位於美國賓州，壩高 15 公尺，1909 年完工，
混凝土重力壩，1911 年因為壩基礎弱面破壞，78 人死亡。(詳圖 22.)
- (2)壩旁邊坡滑動：Vaiont 壩，位於義大利，壩高 26 公尺，1960 年完工，混凝土拱壩，1963
年 10 月 9 日因庫區邊坡超過 2 億 7,000 萬立方公尺土方崩塌，造成湧浪越過大壩，
造成下游 2600 人死亡。(災害前後相片，詳圖 23.)
- (3)液化： Lower San Fernando 壩，位於美國加州，壩高 43 公尺，建於 1912 年，土石壩，
1971 年，壩身因 6.6 級地震產生超額孔隙水壓，造成土壤液化現象而損壞，講師特別
強調，土壤液化目前仍然是一個需要深入研究的課題，特別是對於以水力填築而成的
土石壩。
- (4)地震：臺灣石岡壩，199 年 9 月 21 日 7.6 級地震時部分壩身因斷層錯位而損壞，因屬

本國案例不另詳細介紹。

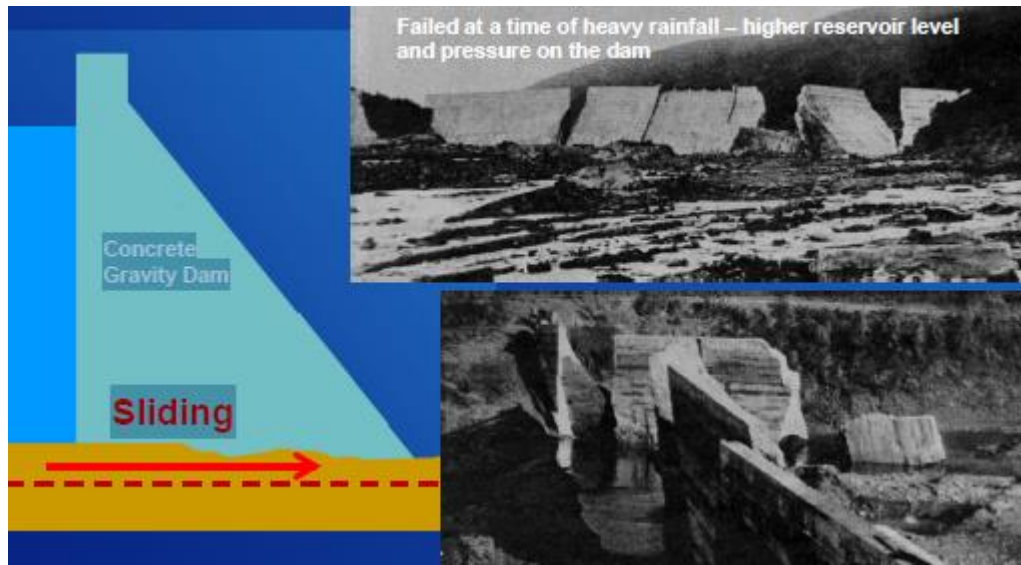


圖 22. Austin (Bayless) 壩因壩基地質條件不佳損壞



圖 23. Vaiont 壩因邊坡滑動，造成庫區湧浪越過大壩沖毀下游社區



圖 24. Lower San Fernando 壩因地震誘發液化造成損壞

- (五) 設施操作與維護(講師 Katherine Dahm)：以『從搖籃到墳墓』(Cradle to grave)的生命全周期概念，計算大壩從規劃、設計、施工、營運、維護和拆除的所有成本，其中操作與維護成本即佔總成本的 80%，遠大於施工成本，說明適當操作維護的重要性。
- (六) 參訪壩務局工程研究實驗室、混凝土圓柱試驗室：該實驗室位於丹佛市壩務局大樓後方，負責許多水工模型試驗，且均位於室內，水工模型製作精細，加上各種材料試驗室完善嚴謹，對於壩務局在工程設計及品質控制上，發揮甚大助益。(現場相片詳圖 25.~圖 28.)



圖 25.全體學員於實驗室前合影



圖 26. Shasta 壩水工模型(比例 1:60)



圖 27.全室內水工模型試驗室

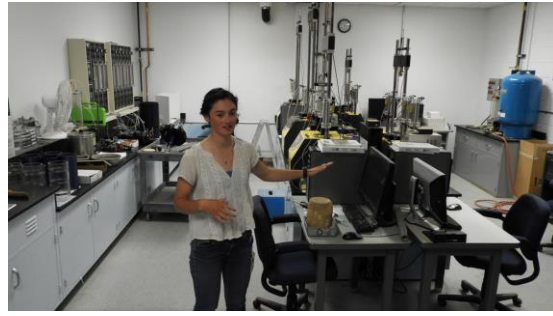


圖 28.土壤力學試驗儀器

(七) **大壩安全監測及評估失敗案例檢討(講師 Jay N. Stateler)**：以實際大壩損壞案例詳細探討各種失敗原因，講師也特別強調要先探討各種可能破壞因素後，才能決定如何有效且經濟的設置安全監測系統；也因為大壩破壞常在很短的時間內發生及擴大成災，所以監測不僅僅是抽測，而是需要一直持續進行。在一般正常狀況下，大壩安全主要有三項議題：(1)土石壩部分主要是滲流因素造成壩身材料流失，特別是界面處或埋管附近，(2)混凝土拱壩主要受基礎穩定影響，(3)水閘門等水工設施損壞。而在極端狀況下，大壩(包含土石壩與混凝土壩)主要都受洪水與地震等因素影響，造成破壞。

由於美國有 69%的大壩屬私人擁有，在建造期間為節省成本，可能對於大壩基礎的處理或各種維護工作不夠嚴謹，衍生後續潰壩災害。壩務局本次研討會對於大壩安全技術部分有非常詳細的課程內容，但私人興設大壩在設計建造時是否需向政府單位申請審核？政府在興建及營運期間的監督角色功能為何？在制度說明上似乎較為欠缺，在後續現場觀摩期間，曾向壩務局員工請教該部分制度如何運作？壩務局表示私人擁有大壩，大多分別由地方政府、州政府等管理，地方與州政府在人力與專業程度確實仍然有不足或待加強的問題，壩務局近年也持續協助州政府加強人員訓練與提供技術協助等。

(八) **大壩安全風險分析和風險評估(講師 Jeanne Major)**：經壩務局評估有 363 座大壩屬於高或顯著風險大壩，另外超過 50%以上大壩屬於超過 50 年的老舊設施，加上下游地區人口持續增加，所以緊急撤離計畫需考量短時間大量民眾的撤離動線，還要考慮民眾不可預期的行為模式。受資金限制影響，風險評估主要以減少人命損失為考量

重點，講師並介紹「事件樹」(Event Tree)與「壩務局大壩安全風險指引」，說明如何分類各種因素與評估風險值(如圖 29 及圖 30)。

Embankment Dam Overtopping Event Tree

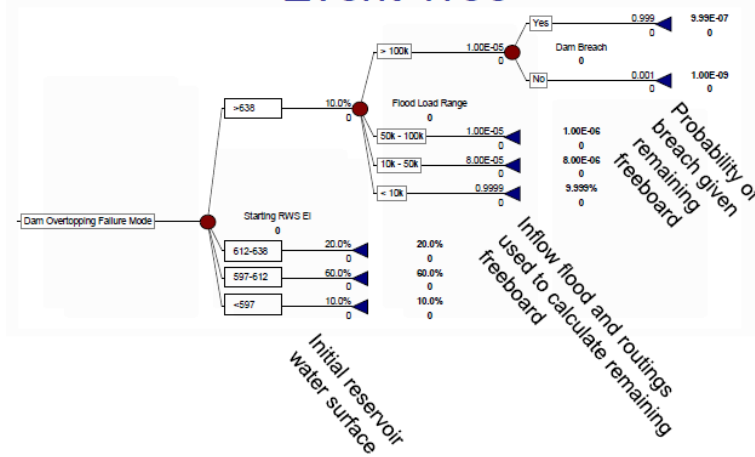


圖 29. 土石壩溢流事件樹

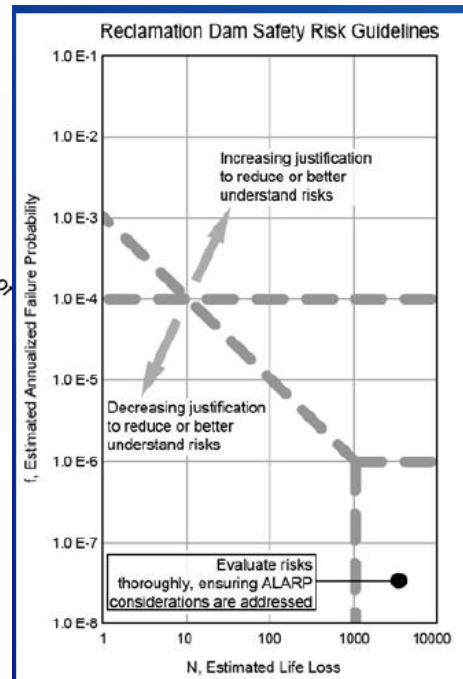


圖 30. 壩務局大壩安全風險指引

(九) 如何決定洪水風險(講師 Keil Neff)：壩務局一般以 100 年的洪水事件來評估較多人口的大型建物的風險，並以機率概念來決定水雨量，設計洪水(IDF)是基於風險，不是可能的最大洪水(PMF)，對於估計極端或異常事件需要花更多努力與投入，來降低估計的不確定性，詳細的指引手冊可參考該局官網

(<https://www.usbr.gov/ssle/damsafety/TechDev/DSOTechDev/DSO-04-08.pdf>)。最後，講師

也特別強調興建水壩雖然有風險，但同時也有利益，所以美國政府或私人仍持續新建大壩，以供給水資源利用。

(十) 地質與大壩安全(講師 Cassandra Wagner)：主要闡述大壩安全仰賴許多地質專業，地質學是一個基於過程的學科，很多失敗或成本過高大部分都與地質相關，特別是 70% 的混凝土壩失敗都是因為壩基礎的地質因素，該課程詳細介紹如何評估地質穩定性，以及透過歷史失敗案例，瞭解地質潛在失敗模式，但是地面下的地質條件存在高度不確定性，設計上不是所有結構都需以最糟的地質條件去設計，那樣將使得工程成本大幅增加，此時地質學家扮演非常關鍵的角色，必需根據最可能的條件評估現地狀況。

(十一) 水庫淤積、永續使用與大壩安全(講師 Blair Greimann)：介紹水庫淤積的迷思與過程、水庫永續的方法、政策指引、風險及案例分析等。首先以美國科羅拉多州 Paonia 水庫的淤積狀況說明水庫淤積的嚴重性(如圖 31.)。淤積除了是操作與維護的問題，但如果忽略不改善，就會成為大壩安全問題。關於水庫淤積常見的迷思有: (1) 水庫沉積只是世界某些地區的一個問題，(2)淤積是以固定速率發生，(3)淤積速度太慢而無需關注，(4)淤積監控過於昂貴，(5)在充滿淤積前水庫仍可使用，(6)淤積僅填塞水庫死水區，(7)水力發電不會受到淤積的影響，(8)什麼都不做是最便宜的選擇，(9)排放淤積物會抬高下游河床，增加洪水風險，(10)所有淤積物都是污染物，(11)保留大壩後方的淤積可能有利於下游生態系統等等。

在案例介紹中，特別介紹臺灣石門水庫排淤的措施(如圖 32.)，講師 Blair Greimann 也將是臺灣 108 年 9 月舉辦「2019 年水資源管理研習班-永續水庫」的美方講師之一。



圖 31. Paonia 水庫取水口淤積前後比較

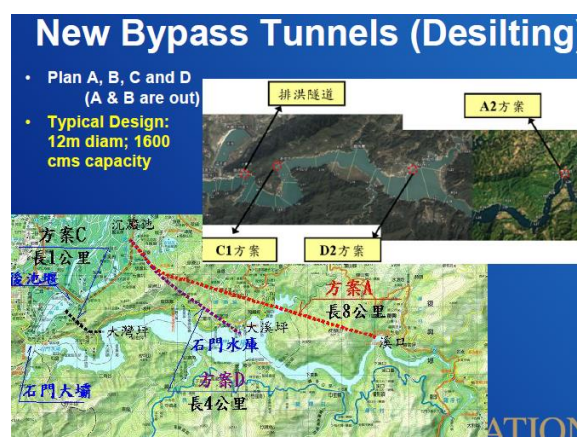


圖 32. 課程介紹臺灣石門水庫案例

(十二) 漂流木模型(講師 Kent Walker)：講師表示在這方面的歷史案例非常少，但其對水工設施影響甚大(如圖 33.及圖 34.)，希望透過水工模型試驗找出不同水工閘門開度及閘門前水深下，漂流木影響最小的操作方式。經試驗後 $GI=0.36$ 時，排洪較有效率(GI 算法詳如圖 34.)。另外，亦針對喇叭口溢流道進行水工模型試驗。(如圖 35.及圖 36.)



圖 33. San Clemente 壩壩前漂流木

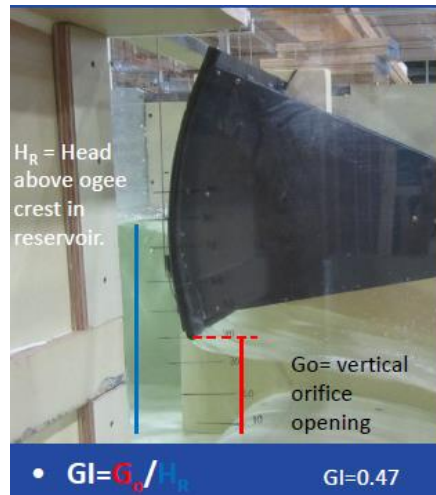


圖 34. GI 參數定義



圖 35. 閘門開度與漂流木水工模型



圖 36. 喇叭口溢流道水工模型試驗。

(十三) **混凝土壩和附屬結構改善(講師 Patrick Maier)**：常見的改善工作分別針對洪水、溢洪道及附屬結構等三面進行探討。(1)洪水方面，藉由基礎加固、壩頂增設導流墩等方式改善以允許少量洪水溢頂時，不對壩身造成損壞，亦可改善或增設排洪設施，以增加排洪能力。(2)溢洪道部分，主要缺失有穴蝕、上頂力及沖蝕等，課程中分別介紹改善方式與案例。

(十四) **大壩儀器監測(講師 Jay Stateler)**：就大壩監測方式進行探討，比較目視檢查與預埋監測設備的適用範圍，建議兩者就不同需求分別運用，以發揮互補作用。此外，也就各種破壞因素評估對應的監測方式，包括儀器的要求與比較等。(主要的壓力計型式比較詳如圖 37.)

	Open-Standpipe Piezometers	Hydraulic Piezometers	Pneumatic Piezometers	Vibrating-Wire Piezometers
Length of time in use	Long	Long	Moderate	Moderate
Precision of data	Moderate	Low	Low	High
Complexity of approach	Simple	Moderate	Moderate	Complex
Timelag in impervious soils	Long	Short	Very Short	Very Short
Construction interference in new dams	Substantial	Moderate	Moderate	Moderate
Central reading location	No	Yes (at low elev.)	Yes	Yes
Length from central reading location without problems	-	600 ft (200m)	600 ft (200m)	10,000 ft (3,000 m)
Time required for reading	Moderate	Short	Long	Short
Complexity if reading	Simple	Simple	complicated	Simple
Read negative pore pressures	No	Yes (at low elev.)	No	Yes
Maintenance requirements	Low	High	Usually Low	Low
Potential for future problems	Low	High	Moderate	Moderate

圖 37. 主要的壓力計型式比較

(十五) 大壩抗震設計與分析(講師 Dan Levish)：分別介紹土石壩與混凝土壩受到地震可能的影響、補救方式與地震過後如何檢查等，講義也提到臺灣 921 地震石岡壩案例。土石壩方面要注意動態反應、液化潛勢、震後穩定度、壩身變形、裂縫及管湧潛勢等。混凝土壩則需注意岩層基礎穩定性、滑動及傾覆潛勢、滲漏等課題。針對上述課題均有實例介紹補強措施。震後檢查部分，包括變形量測(目視或儀器量測)、調查裂縫、滲流(流量變化、發生地點與混濁度等)、壓力計讀數變化、檢查附屬構造物是否損壞、監測儀器是否受損、邊坡滑動等。

(十六) 大壩地震災害案例(講師 Dan Levish)：地震監測目的有(1)改善緊急應變作為、(2)偵測可能引起破壞的負載、(3)確定應變工作範圍與優先順序、(4)增加通知下游居民時間、(5)管理未來長時間風險與改善依據、(6)提供地震工程師分析數據、(7)驗證結構行為。在強震監測上需同時兼顧量測與即時傳輸。(Hoover 壩的監測佈設如圖 38.)

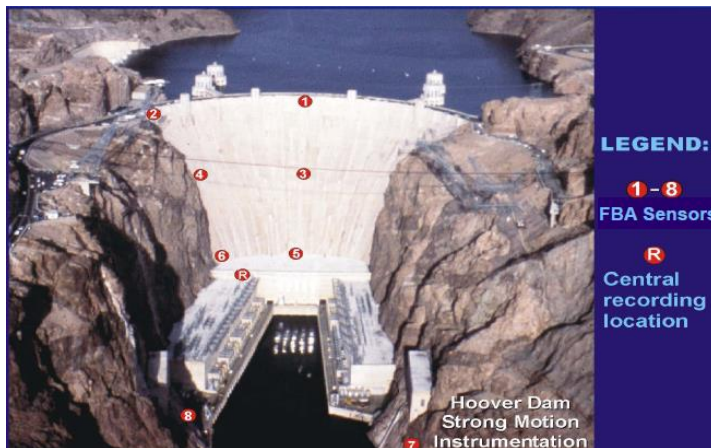


圖 38. Hoover 壩的地震監測佈設

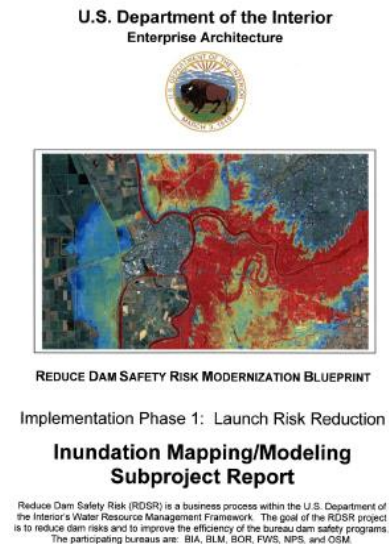


圖 39. 壩務局洪泛模式指引

(十七) 壩務局洪泛模式與災害估計(講師 Bruce Feinberg)：分別介紹 MIKE11、MIKE21 等模型及其與 GIS 連結、壩務局已出版洪泛模式指引(如圖 39.)，對於災損亦有估算方式(RCEM)，是由約 60 個歷史案例篩選分析而得到的方法，其中也包括如何估計人命損失。相關出版品可在壩務局網站中取得。

(<http://www.usbr.gov/ssle/damsafety/references.html>)。

(十八) 緊急應變計畫與演練(講師 Ben Claggett)：緊急應變計畫(Emergency Action Plan, EAP)是以書面文件包含大壩所有的應變程序，以便快速反應及通知。採取的步驟有(1)識別風險，了解可能出現的問題、(2)制定書面計畫，知道該怎麼做、(3)培訓人員，建立應變能力、(4)進行演練習，以測試人員反應、計畫內容，並找出缺點、(5)改進計畫內容，再進行培訓和持續改進。(EAP 流程如圖 40.) 應變層級分為四級：(1)級別 1: 無生命威脅的情況、(2)級別 2: 潛在生命威脅、(3)級別 3: 危及生命的緊急情況，此時需立即採取拯救人命的行動，(4)級別 4: 危及生命的緊急情況，潰壩，應變人員必須立即離開危險區域。

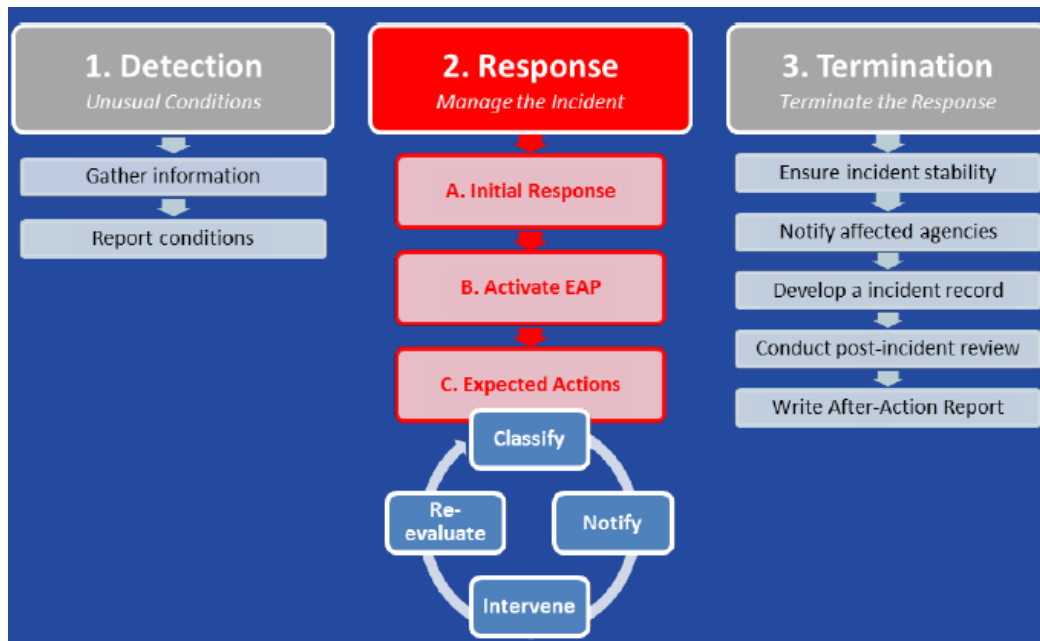


圖 40.緊急應變計畫流程

(十九) 附屬設施檢查方法(講師 Bill Dressel)：主要介紹水工設施檢查的目的、方法、常見缺失，並輔以實例及相片說明。

(二十) 機械檢查維護與測試(講師 Lucas Adams)：介紹常見水工機械(各種型式講義均有相片)及其檢查、維護方式。檢查項目主要有校準、鏽蝕、破損或裂縫、滲漏、潤滑。

(廿一) 混凝土壩檢查方式(講師 Jaron Hasenbalg)：先說明混凝土壩有重力壩、拱壩、扶壁式、綜合等四種形式，再介紹混凝土的各種問題、影響混凝土壩強度與耐久性的因素，最後指導檢查項目與哪些地方需要檢查。檢查地點與其項目有:基礎與墩座(檢查開裂、錯位、沉陷、細粒料隨滲漏移動等)、壩身上下游兩面(檢查裂縫、風化、剝落、水平裂縫或施工縫造成的滲漏)、廊道(檢查裂縫、位移、排水堵塞、接面或裂縫的滲漏、滲漏量變化等)、壩頂(檢查裂縫是否隨機且淺？是否很深？是否延伸到上下游表面、接縫處的垂直差異移動、橫向差異變位，最好能沿著護欄或扶手等觀察)。



圖 41.裂縫檢查標記。

圖 42.壩頂護欄變位。

(廿二) 土石壩檢查方式(講師 Paul Craig): 檢查應採系統化(一直線或梯形方式前進)查看所土石壩表面和周邊區域，並從各種破壞因素(如圖 43)說明對應檢查方式。例如: 滲漏可藉由目視壩身植生狀況初步判斷(如圖 44.)，檢視管壁、翼牆周圍等不同材質接合面。

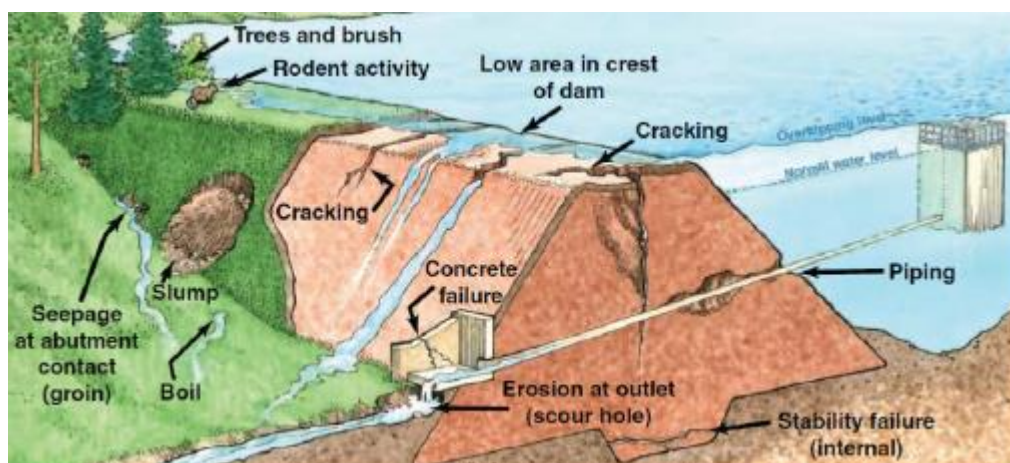


圖 43.土石壩各種破壞因素



圖 44.壩身植生較多範圍可能是滲漏區

(廿三) 滲流與內部沖蝕(講師 Dennis Hanneman): 內部沖蝕不易評估的原因有早期不易觀察到、土壤沖蝕是很多年長期現象、沖蝕開始後很難停止。從美國統 1985 年統計資料顯示超過 50 英尺的大壩失敗原因，壩身沖蝕即佔了 20%(如圖 45.)。壩務局已發生過 97 起土石壩壩身沖蝕案例(其中一次潰壩)，甚至有將近三分之一的沖蝕事故，在操作未滿 5 年時即發生。(主要防止沖蝕的方式如圖 46.) 美國聯邦緊急事務管理署 (Federal Emergency Management Agency, FEMA)已出版評估及監測手冊，可在官網下載

(<http://www.fema.gov/media-library/assets/documents/107639>)。墾務局將常見的內部沖蝕機制分類為四種:(1)沖刷(Scour)、(2)向後侵蝕管湧(Backward erosion piping)、(3)內部運移(Internal migration)、(4)內部不穩定(Internal Instability)。(詳如圖 47)，且講義中都有配合實際案例及相片說明，並介紹相對應的改善補強工法。

Percentage of Failure Causes for U.S. Dams Higher than 50 Feet							
Location	Flood Overtop	Found. Failure	Internal Erosion	Sliding	Struct. Failure	Spillway	Seismic
East	20	16	20	12	16	16	0
West	20	8	60	8	4	0	0

圖 45. 美國超過 50 英尺的大壩失敗原因統計。

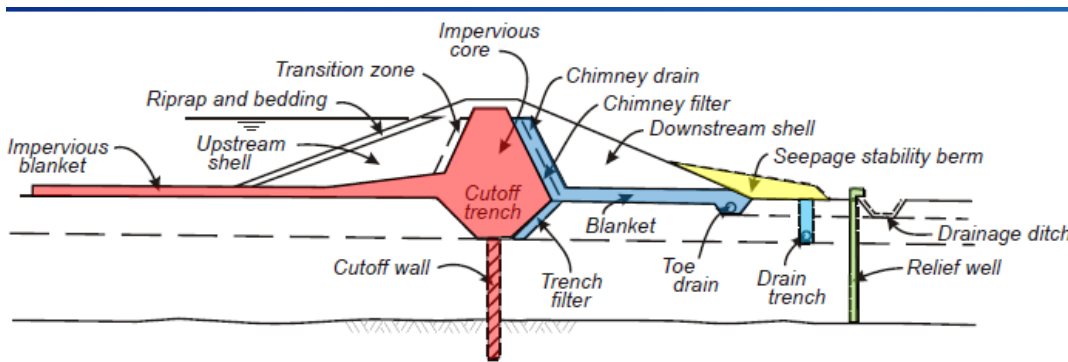


圖 46. 主要防止沖蝕的方式

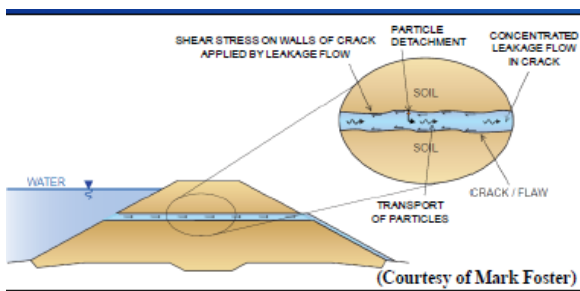


圖 47-1. 沖刷(Scour)

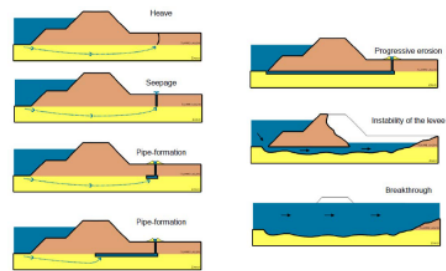


圖 47-2. 向後侵蝕管湧

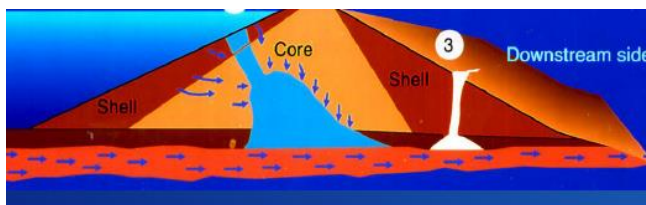


圖 47-3. 內部運移(Internal migration)

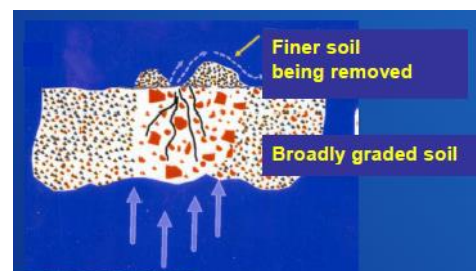


圖 47-4. 內部不穩定

(廿四) 操作程序和大壩操作員訓練(講師 Jay Stater): 操作標準流程(SOP)包括: 介紹各項

目、緊急行動計劃(EAP)、通訊錄、一般訊息、構造，機械和電力、結構行為和儀器、水庫操作、圖紙，地圖等。在員工訓練方面，至少每 4 年進行一次室內課程訓練(新的大壩操作人員則參加下一梯次課程)；至少每 8 年進行一次現場訓練。

(廿五)參訪安全須知：在開始現場參訪前，壑務局特別利用室內課程最後時間，對所有學員進行安全須知宣導及注意事項，並就隔天要參訪的 Pueblo 壩進行簡要說明。

四、現場觀摩摘述

在丹佛室內課程結束後，陸續參訪水庫有科羅拉多州的 Pueblo 壩(位於丹佛市南方約 170 公里)、亞利桑那州鳳凰城周邊的中部供水計畫、新 Waddell 壩、鹽河計畫、Roosevelt 壩等處，(參訪地點位置如圖 48.)，參訪前皆安排行程簡報，介紹該大壩的地理位置與特色，並充分告知可能之危害因子，諸如毒蛇、中暑、防墜等，讓學員們均能清楚瞭解。



圖 48.參訪地點位置示意圖

(一) 參訪 Pueblo 壩與模擬檢查：(壩型:土石壩及混凝土壩、壩高:76.2M、壩長 3,118M、庫容 0.44 億 M³，集水區面積:12,136KM²)

抵達 Pueblo 壩後，首先至遊客中心進行簡報，說明該壩基本資料及主要檢查方式與觀測設備，Pueblo 壩由壑務局建造，1975 年完工，位於科羅拉多州 Pueblo 西方

阿肯色河上，主要功能為灌溉、民生用水和休憩活動等多功能，長達 3 公里的壩身主要是土石壩，溢洪道部分則為混凝土壩，採自然溢流方式排洪，設計最大溢流量為 5,422 CMS (立方公尺/秒)，當日參訪分為三組同時進行(土石壩檢查、混凝土壩檢查、廊道檢查)，再以換組方式讓所有學員均能充分學習。同時亦發給學員土石壩及混凝土壩的檢查表，由壩務局人員依據檢查表重點，實地解說檢查要領。

在土石壩檢查教學時，壩務局人員介紹目視檢查方法與要領，該局建議除了壩身不宜有喬木外，在距離壩址 25 英尺(約 7.6 公尺)範圍內亦不要種植喬木，另外也可從壩身坡面變化、植生變化等推測該範圍可能能滲漏情形，以縮小範圍進一步做較詳細的檢測。(現場相片詳圖 49.~圖 56.)



圖 49. Pueblo 壩外觀及分組情形



圖 50. 土石壩檢查教學



圖 51.混凝土壩護欄變位觀測



圖 52.檢查廊道入口(鐵皮為防止冬季時壩上方冰柱掉落傷人，廊道內禁止拍照)



圖 53.土石壩上游面



圖 54.壩頂自由溢流道

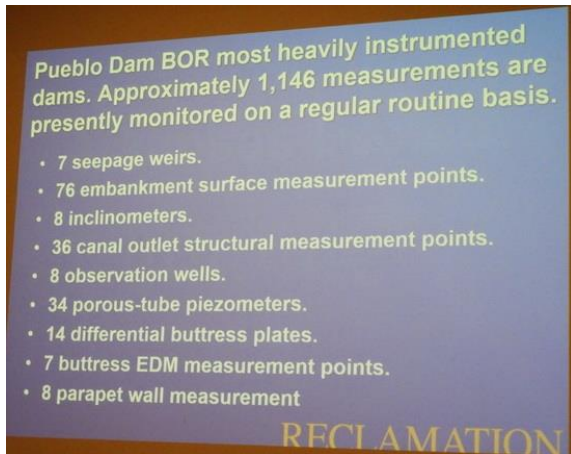


圖 55. Pueblo 壩觀測設備-1

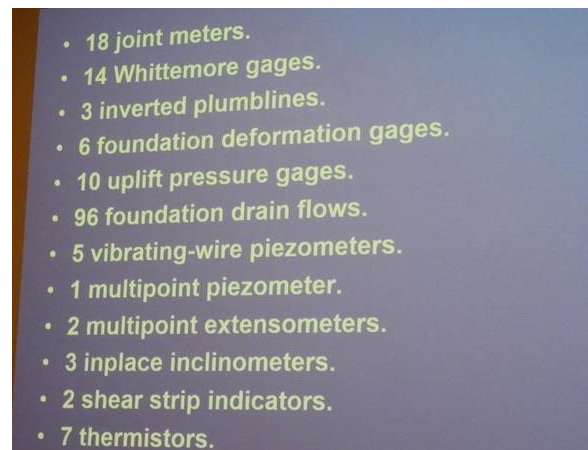


圖 56. Pueblo 壩觀測設備-2

參訪完 Pueblo 壩後，SEED 研習班搭乘飛機轉往亞歷桑那州鳳凰城，陸續參訪亞歷桑那州中部供水計畫 Central Arizona Project (CAP)、新 Waddell 壩、鹽河計畫、Roosevelt 壩等地，概述如下：

(二) 亞歷桑那州中部供水計畫：

6 月 10 日上午首先前往亞歷桑那州中部供水計畫(Central Arizona Project，以下簡稱 CAP)，簡報該州水資源供應系統及沿線相關水壩(如圖 57、圖 58)。亞歷桑那州降雨在山區每年最高約 760mm，而平原區則約為 510mm，州內最乾燥的西南地區每年降雨量不到 76mm，因此在 20 世紀初期，為了提供安全、穩定的供水，而成立了亞歷桑那州中部供水計畫 Central Arizona Project (CAP)，這是一個長約 540 公里的人工輸水系統(長度是巴拿馬運河的七倍多)，為該州 80%的人口提供服務。

在 20 世紀初期，科羅拉多河流域的七個州（亞利桑那州，加利福尼亞州，科羅拉多州，內華達州，新墨西哥州，猶他州和懷俄明州），就其水資源進行了談判。亞利桑那州獲得 280 萬英畝-呎水量(約 12.3 億立方公尺；一英畝-呎約等於亞利桑那州三個家庭的年供應量)。1968 年總統簽署法案授權墾務局建造 CAP，耗資超過 40 億美元(換算成今日幣值約 300 億美元)，將分配到水量的 53%(約 150 萬英畝-呎)運送到該州人口最多的地區，並減少地下水用於農業和其他活動的用途。1971 年，亞利桑那州成立中部水資源保護區（CAWCD，通常亦被稱為 CAP）以償還聯邦政府的建設成本，及接手操作及維護管理工作。CAP 由 15 名民選董事組成管理，日常營運則由近 500 名專業人員負責，沿線抽水加壓站操作及水量分配等工作，均由 CAP 辦公

室內的操作中心遠端控制(如圖 59.，因參訪時禁止拍照，故擷自網路，)，而全線 13 個全天候運作的巨大抽水加壓站，更使得 CAP 每年使用 28 億千瓦時的電力，成為亞利桑那州成為最大的電力消費者。

鳳凰城年降雨量約僅為 210mm，且氣候乾燥酷熱(參訪期間白天溫度均超過攝氏 40 度)，周邊土地均類似沙漠地形遍佈仙人掌，但受惠於 CAP 及 SRP(詳下述)提供穩定的水資源，該市人口已近 150 萬人，排名美國第五大城，也是全美增長速度最快的城市之一。CAP 的官網 (<https://www.cap-az.com/>)。



圖 57.簡報亞歷桑那州中部供水計畫

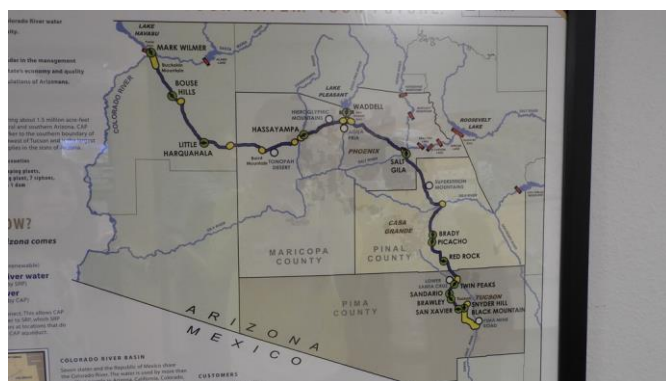


圖 58. 亞歷桑那州中部供水系統圖



圖 59.CAP 操作中心(擷自網路，參訪禁止拍照)



圖 60. CAP 輸水渠道

(三) 參訪新 **Waddell 壩**：土石壩，壩高 134 公尺，壩長：1,493 公尺，溢洪道設計流量：5,295 立方公尺/秒，庫容量約 13.7 億立方公尺。建於 1985 年至 1994 年之間，為上述 CAP 項目之一，建造目的是為了滿足不斷增加的用水需求，故在舊 Waddell 壩（1927 年建）下游約 800 公尺處增建新壩而成，庫容量也從舊壩的 1.85 億立方公尺，增加到目前的 12.3 億立方公尺，舊壩目前已淹沒在庫區中。(新舊壩如圖 61.)該壩位於 Agua Fria 上，除攔蓄該河流量外，也儲蓄科羅拉多河經由 CAP 系統泵送而來的

水量。

本次參訪時墾務局人員特別介紹水庫排放到下游 Waddell 運河(如圖 62.)，透過運河兩端不同水位高程的控制，可以雙向流動決定給水或引水，給水是提供下游運河水量，引水則是提供水力電廠發電使用。



圖 61.新、舊 Waddell 壩(擷自網路)



圖 62. Waddell 壩下游運河



圖 63. Waddell 壩壩頂

(四) 參訪鹽河計畫：鹽河計畫(Salt River Project，以下簡稱 SRP)成立於 1903 年，與上 CAP 類似，也是提供大鳳凰城地區用水需求，主要分別是 SRP 較早開始執行(1903 年開始)，在用水量不斷提高下，在 1968 年開始推動 CAP。另外，兩計畫水源不同，SRP 水源來自鳳凰城東側的鹽河流域，CAP 水源則多來自科羅拉多河跨域泵送而來。

在 19 世紀時，鳳凰城和附近地區的居民者，均依靠鹽河來維持農業活動，但該河常發生洪水和乾旱，1902 年美國羅斯福總統(Theodore Roosevelt)簽署「國家復墾法案」

(National Reclamation Act)，提供了聯邦貸款和專業來建設基礎設施，但要求將工程的債務平均分配給那些從中受益的人。除了興建主要項目 Roosevelt 壩之外，也建造和改善運河系統(總長度約 200 公里)。SRP 在鹽河上的四座水壩建成後，轉向較小的 Verde 河進一步擴建該項目。(SRP 官網 <https://www.srpnet.com/>)



圖 64.鹽河計畫位置圖



圖 65.SRP 辦公室



圖 66.室內簡報 SRP 背景

(五) 參訪 Roosevelt 壩：混凝土壩，壩高 109 公尺，壩長 369 公尺，洩洪道設計容量 4200 立方公尺/秒，庫容量約 20.4 億立方公尺。Roosevelt 壩是 SRP 的關鍵項目，舊壩壩高 85 公尺，在 1911 年完工時，是世界上最高的磚石壩(如圖 67.)。因 SRP 係由美國 Roosevelt 總統致力促成，故以 Roosevelt 為大壩和水庫命名。1996 年，為提高水庫容量在舊壩下游側重新鋪設混凝土，將壩高增加 23 公尺(77 英尺)，使庫容量增加 20% 以上，並提供防洪空間。然而，在完工後不久，該地區進入了長時間的乾旱期，一直到 2005

年才達到 90% 的歷史水位。



圖 67. 舊 Roosevelt 壩



圖 68. Roosevelt 壩現況

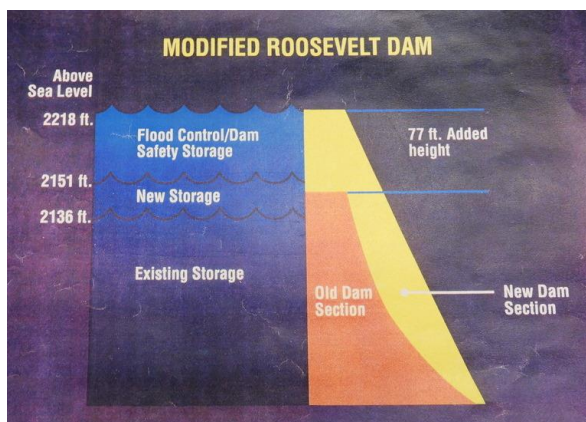


圖 69. Roosevelt 壩加高示意圖

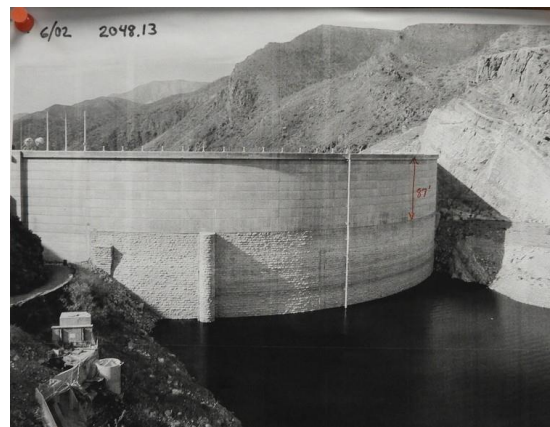


圖 70. 新舊壩身(上游側)

參訪時墾務局將學員分為兩組，進入壩區前先進行安全宣導及危害因子告知，學員均需佩戴安全帽、護目鏡及耳塞，以保護學員安全。參訪過程除介紹上述新舊壩建造過程外，亦說明相關水工設施改善措施；Roosevelt 壩的排洪設施，為左右兩側同時洩洪，藉由兩股水流互相撞擊而達到消能的目的，是墾務局唯一如此設計的方案。而新舊壩的檢查廊道亦可互相通聯。該壩亦設有一座豎軸式發電機。



圖 71. 參訪人員佩戴安全帽及護目鏡

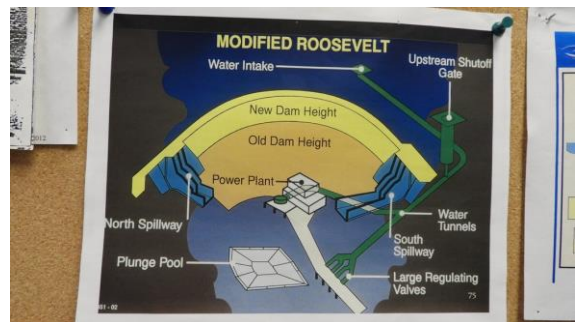


圖 72. 水工設施改善措施



圖 73. 對稱式兩座排洪口



圖 73. 操控室

第三章 心得與建議

一、臺美 2019 年合作執行洽談成果

- (一)2019 年會籌辦各項細節：順利敲定 Palumbo 副局長率團赴臺灣共同舉辦年會，時間訂於 10 月 20 日該週。
- (二)大壩安全評估導入風險評估：對於水利署所提三年規劃構想，第一年曾文水庫、第二年石門水庫、第三年率定作法據以參考運用，壑務局原則表示認同。今年附錄 6 美方專家（暫定 2~3 位）來臺，將以曾文水庫作為案例進行研析。
- (三)已敲定與美方合開訓練課程內容：合開課程以長期合作為目標，本年度課程內容經雙方逐項討論，已全部敲定，原則對我方原規劃內容表示可行，而雙方亦達共識，課程應淺顯務實，以案例分析為主，且將配合於訓練前，先研提簡報資料由水利署彙集提供學員，以收成效，美方將派 2 人來臺授課，並協助宣傳。
- (四)水利署積極宣傳未來與壑務局合辦訓練課程，已收成效。
- (五)塑性混凝土之應用：壑務局表示，該局實際實施案例並不多，表示將協助收集美國工兵團等單位，再據以協助。也表示，若我方將來進行期刊發表，願意給予技術協助及必要時聯合掛名，但細節仍有待進一步洽商。

二、大壩安全評估國際研習班

本次參加「大壩安全評估國際研習班」(The Safety Evaluation of Existing Dams Seminar, SEED)，除了課程學習到專業知識外，對於壑務局辦理該研習班已邁入三十屆所累積的豐富經驗，亦有近距離觀察課務安排細節的機會，對於未來臺灣水利署辦理相關國際研討會或研習班，均可借鏡與學習。此外，臺灣與美國在地理、氣候等先天自然條件不同，加上兩國間國情差異，也在大壩安全議題上發展出相異的結果。

大壩安全攸關下游廣大人口安全，且大壩災害發生前多僅有細微症狀，如何落實管理、即時監控預防，至為重要。壑務局目前是世界上從事大壩建設及安全檢查最權威單位之一，如何深化臺美間技術交流，並透過參加研習班的機會，與各國學員交流尋求擴大國際合作，均為本次出國研習重點目的。以下就針對上述面向，闡述此次出國心得與建議。

(一)借鏡美方舉辦研習班細節

1.細節用心與貼心

(1)小小國旗及胸針功效大

壠務局在課務安排上，已累積三十多年經驗，對於來自不同國家學員的需求均細心安排；值得一提的是，在課程報到時，壠務局特別為來自不同國家的每位學員，分別準備小國旗及象徵兩國合作的別針，讓各國學員備感溫馨，並藉此激發榮譽感，更加認真學習(如圖 74.、圖 75.)。

(2)客製化滿足學員需求

對於部分國家學員無法以信用卡或匯款方式，事先繳納課程費用者，壠務局亦允許報到時再以現金支付。在轉機前往鳳凰城時，行李託運費依美國航空規定只接受信用卡付費，壠務局亦協調航空公司成立臨時櫃臺，專人在機場收取現鈔，協助學員順利通行。部分學員因故需提前離開返國，或有身體不適情形時，壠務局亦均派專人協助。

(3)重視學員安全

在現場參訪前均會安排室內簡報，扼要說明計畫內容或水庫基本資料，使學員事先瞭解背景資訊；對於參訪過程安全防護亦極為重視，除了進行危害因子告知外，亦備妥所需個人防護用具(安全帽、護目鏡等)，確保學員安全。



圖 74.每位學員座位前擺放該國國旗



圖 75.準備兩國國旗小別針

2.注重環保與實用

在食宿等庶務安排上，壠務局除了重視細節外，亦重視環保措施，課程講義(共有上千頁簡報)採無紙化方式，只提供 USB 行動碟，收錄所有課程講義，同時亦有壠務局相關出版品及文宣等，讓學員獲得完整資訊，也減少不必要紙張浪費。會場佈置亦

採簡約實用原則，會場入口僅以簡單掛條指引，課程中均不提供一次性紙杯或餐具等。
(如圖 76、圖 77)

用餐安排上，室內用餐、歡迎晚宴均採自助餐方式，讓不同飲食需求者可以自行選擇及避免浪費，同時間也方便用餐時自由交談，促進學員間交流(如圖 78、圖 79)。現場觀摩期間，部分大壩位於偏遠地區，中餐均採簡單速食，且採紙袋包裝，不曾使用塑膠袋等一次性包裝，地點則就在水庫周邊涼亭用餐，讓各國學員在輕鬆環境中，自由交流，亦減少垃圾產出。(如圖 80、圖 81.)



圖 76.會場入口簡單指引



圖 77.會場茶水咖啡，不提出紙杯



圖 78.室內課程中餐場地



圖 79.歡迎晚宴



圖 80.現地參訪時中餐



圖 81.於庫區涼亭中餐

3.課程專業深入，提問討論踴躍

壟務局目前是世界上從事大壩建設及安全檢查最權威單位之一，擁有豐富經驗；本次研習班講師均由壟務局專業技術人員擔任講師(部分為壟務局退休技術人員)，課

程內容由淺入深，從大壩歷史失敗案例剖析，帶出大壩安全立法或制度建立過程，再逐一從不同項目(監測、地質、水文、地震等)，由實際負責專業人員講授，課程講義加入大量實例相片，可以讓不同領域學員均能得到豐富知識。

課程中講師均使用夾式麥克風，讓雙手可以自由操作電腦或以生動手勢，引領課程氣氛，對比國內許多講師均需一手拿麥克風講課，顯然更有效率。另外，每節課程時間均能控制得宜，在下課前 5~10 分鐘結束簡報，進行提問討論，各國學員發問踴躍，課間休息(或午餐時)亦持續和講師討論。

(二)臺美大壩安全議題異同

1.天然條件與國情差異

此次參訪美國科羅拉多州及亞歷桑那州，因屬大陸型氣候，降雨量偏少，但春季融雪時又常造成洪泛災害，故在一百年來興建許多水庫，主要水源為春天融雪、水質乾淨且穩定，沒有臺灣常見颱風豪雨侵襲，泥砂淤積問題亦不算嚴重，且非屬地震帶，建壩條件優良，加上都市外地區多地廣人稀，水庫庫容量遠大於臺灣既有水庫，例如：本次參訪新 Waddell 壩(庫容量約 13.7 億立方公尺，以下單位同)、Roosevelt 壩(約 20.4 億)，均為臺灣石門水庫(約 3.1 億，目前因泥砂淤積剩約 2.2 億)或曾文水庫(約 7.08 億，目前約 4.8 億)數倍以上。單僅 Roosevelt 壩庫容量即相當於全臺 95 座水庫總庫容量(依 106 年水利署年報數據)。

在國情方面，美國聯邦政府與州政府間對於大壩建設資金籌措及償還有較嚴格規定，並從使用者端收取費用支應，故其水價高出臺灣甚多，經詢墾務局人員表示，其兩口家庭，每月自來水費約 50~60 美元(約臺幣 1600 元)。

2.臺灣已發展出獨特技術

如上述，美國大壩天然條件明顯較臺灣優良，臺灣水庫長年在面臨乾旱、強降雨、地震、淤積等問題挑戰下，對於水庫操作、管理、清淤、水力排砂等工作，已逐漸發展獨特與領先技術。例如石門水庫的分層取水工、電廠防淤、阿姆坪排淤隧道等，持續增加水力排砂設施容量，促使水庫能永續利用(如圖 82、圖 83)。也因此，臺灣於 108 年 9 月與墾務局、國合會首次共同開辦「2019 年水資源管理研習班-永續水庫(2019

Workshop on Water Resources Management-Sustainable Reservoir)」，預計招募 30 名各國學員，分享近年成就與尋求協助各國水庫改善合作機會，輸出國內技術及創造商機。



圖 82.石門水庫電廠防淤



圖 83.曾文水庫防淤隧道

(三)落實大壩管理、監測等安全維護工作

美國有 69%大壩為私有，早年管理與維護制度未建立前，發生一些失敗案例，造成下游生命財產損失，且回顧失敗案例，災害發生前多僅有小量滲漏、管湧或輕微變形，這些細微症狀若未及時發現防範，會在很短時間內造成全面性潰壩災難。

臺灣地狹人稠，水庫下游均聚居大量人口，一旦發生壩體損害，將導致比美國更為嚴重災損，所以臺灣水利署等水庫管理單位，平時均謹慎進行大壩安全管理、檢查及監測工作。

另外，從課程中學習到的風險分析概念，儘管水庫管理單位已有許多努力，仍然會有許多潛藏未知風險、或因成本效益因素無法全面執行者，故對於水庫下游疏散避難計畫仍應預先研擬並定期演練，以減少可能的生命財產損失。

(四)深化臺美交流、擴大國際合作

墾務局成立已超過一百年，多年累積的實務經驗，使其成為大壩安全的先驅與權威，加上該局注重專業職能訓練與傳承、專業人員齊全、擁有全功能水工模型與試驗室，故應持續交流合作。墾務局與臺灣水利署合作關係已超過 30 年，臺美雙方互動頻繁，未來在交流上應可更深化並普及於基層年輕工程師。

本次報名參加 SEED 研習班的各國學員計有 44 位，來自 11 個國家，從交流互動中可以瞭解世界各國仍持續致力於水庫建設，例如：來自奈及利亞的學員(服務於該國政府部門)，即表示該國人口約 2 億人，目前有水庫約 400 座，仍有近 40 件水庫建設

計畫待推動。

參加 SEED 研習班除了學習美方專業知識外，因為行程超過十天且有多日現場參訪，墾務局在課程安排上均預留學員間交流時間，各國學員可在輕鬆氣氛下自由進行交流(如圖 84、圖 85.)，尋求未來擴大國際合作的機會，也是派員參加本研習班重要目的之一。



圖 84.與研習班各國成員交流互動



圖 85. 全體學員與墾務局工作人員合照

附 件

附 件 1. 參訓證明、學員名單、講師簡歷

附 件 2. 墾務局新聞稿、SEED30 周年專刊

RECLAMATION

Managing Water in the West

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**Safety Evaluation of Existing Dams
International Technical Seminar and Study Tour**

Angela M. M. M. M.

International Affairs Office

June 3-12, 2019

Date



U.S. Department of the Interior
Bureau of Reclamation

2019 Participant List

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Samwel Aluoch Otieno Alima	Kenya	Ministry of Water and Sanitation	Water Secretary	watersecretary2@gmail.com
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Simon Ndungu	Kenya	Ministry of Water and Sanitation	Assistant Secretary/Administration	kiharandungu@ymail.com
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Veronica Nwanneka Obuzor	Nigeria	Federal Ministry of Water Resources	Chief Technical Officer	obuzorveronica@gmail.com
Yi-Sheng Lin (Kevin)	Taiwan	Water Resources Agency	Senior Engineer	a200080@wra.gov.tw
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Zhan Shang-Shu	Taiwan	United Geotech, Inc.	Engineer	shangshu68@gmail.com

LIST OF PRESENTERS

Safety Evaluation of Existing Dams International Technical Seminar & Study Tour June 3-12, 2019

1. **Angela Medina**
Senior International Affairs Specialist
International Affairs Office
Bureau of Reclamation – Denver, Colorado, USA
E-mail Address: AMedina@usbr.gov
Bio Info: Angela Medina is a Senior International Affairs Specialist and manages the Bureau of Reclamation's International Visitor and Training Program. She joined Reclamation in 2001. Prior to Reclamation, Angela worked in the travel industry for 10 years.

2. **Annette Vigil**
International Affairs Specialist
International Affairs Office
Bureau of Reclamation – Denver, Colorado, USA
E-mail Address: AVigil@usbr.gov
Bio Info: Annette Vigil is an International Affairs Specialist in Denver, Colorado, with the Native American and International Affairs Office since September 2015. She has worked for the Bureau of Reclamation for 39 years in various capacities.

3. **Jeffrey Morris**
Program Manager
Native American and International Affairs Office
Bureau of Reclamation – Denver Colorado, USA
E-mail Address: jmorris@usbr.gov
Bio Info: Jeff Morris is the Program Manager of the Native American and International Affairs Office. He joined Reclamation in 2007 as an estimator in the Technical Service Center after 10 years in the private sector as a consulting engineer. He moved to the Design, Estimating and Construction Oversight and Value Program Office as the Value Program Manger where he sought to improve projects with cost effective, innovative solutions without sacrificing key objectives and functions.

His most recent position was the manager of the Design, Estimating and Construction Oversight and Value Program Office. While in this position, he served as a senior technical advisor to the Secretary of the Interior's Indian Water Rights Office. He also led more than 50 multidisciplinary teams of technical experts that sought to improve projects by identifying risk and uncertainty and innovative solutions to meet the unique needs of each client.

He is a licensed professional engineer in Colorado and Texas. Morris received a Bachelor of Science in Civil Engineering from the University of South Florida in 1995 and a Master of Science in Civil Engineering in 1997 from the University of Texas at Austin.

4. Karen Knight

Director, Security, Safety and Law Enforcement
Bureau of Reclamation – Denver Colorado, USA
E-mail Address: kknight@usbr.gov

Bio Info: Karen Knight, P.E., was named as the Director of Security, Safety and Law Enforcement for the Bureau of Reclamation on August 24, 2018. The Security, Safety and Law Enforcement Office is located in Denver, Colorado. It is responsible for protecting the public, Reclamation employees, and Reclamation facilities through the development and implementation of an integrated security, safety, and law enforcement program.

Knight most recently was the Chief of the Dam Safety Office in SSLE where she assumed that role in 2015. She oversaw five major dam safety projects which have been completed or advanced to construction.

She joined Reclamation's Technical Service Center in 1999 where she was team leader and lead designer for embankment and foundation safety modifications at Pineview Dam, Utah. She performed comprehensive facility reviews for 12 high hazard dams; and lead teams on issue evaluation studies, including comprehensive risk analysis, for a number of other Reclamation dams. She has facilitated comprehensive risk analyses for a number of Reclamation structures assessing static, seismic and hydrologic risk.

In 2004, Karen became Manager, Geotechnical Engineering, managing a group of engineers performing evaluation, analysis, design and construction support for Reclamation's embankment dams. She performed technical and managerial oversight, including Project Management Team duties, and peer review of up to two dozen projects at a time.

She became the Chief, Geotechnical Services Division in 2007 where she provided leadership over six interrelated groups of embankment dam and geotechnical engineers, engineering geologists, seismologists, geophysicists, and dam instrumentation and inspection specialists. The Geotechnical Services Division includes more than 100 staff and provides technical expertise throughout Reclamation for inspection, evaluation, analysis, risk analysis, and design and construction oversight for high hazard dams in Reclamation's inventory and numerous other significant and high hazard structures in the Department of Interior's portfolio.

Knight has a Bachelor of Science in Geological Engineering from the University of Missouri-Rolla and a Master of Science in Civil Engineering from Virginia Polytechnic Institute and State University. She is a registered professional engineer, a member of the American Society of Civil Engineers, the U.S. Society on Dams where she has served on the Board of Directors, and the Association of State Dam Safety Officials.

5. Jeanne Major

Civil Engineer
Geotechnical Engineering
Bureau of Reclamation – Denver, Colorado, USA
E-mail Address: JMajors@usbr.gov

Bio Info: Ms. Major is a geotechnical engineer and has worked for the Bureau of Reclamation since 1989. Primary areas of expertise include the evaluation, analysis and design of modifications to embankment dams, evaluation and mitigation of the rock foundations of concrete dams, and risk analysis. Ms. Major has a Bachelor of Science in Mining Engineering and Master of Science in Civil Engineering from the Colorado School of Mines.

6. Scott Stevens

Civil Engineer
Geotechnical Engineering
Bureau of Reclamation – Denver, Colorado, USA
E-Mail address: SStevens@usbr.gov

Bio info: Mr. Stevens is a geotechnical engineer with more than 30 years of professional experience. Primary areas of expertise include the evaluation, analysis and design of modifications to embankment dams, internal erosion, and risk analysis. He has a Bachelor of Science in Civil Engineering from Colorado State University and is a registered professional engineer in Colorado. Mr. Stevens current position is Technical Specialist.

7. Timothy Tochtrop

Program Manager, UC Region
Dam Safety Office
Bureau of Reclamation – Denver, Colorado, USA
E-mail Address: TTochtrop@usbr.gov

Bio Info: Tim Tochtrop attended Colorado State University and graduated in 1999 with BS in civil engineering. He worked for several years for a private firm in northern Colorado focusing on canal and dam rehabilitation for local water districts and municipalities. Tim joined Reclamation in 2003 as a geotechnical engineer with the Technical Service Center. In 2012 he transferred to the Dam Safety Office as the Upper Colorado Program Manager.

8. Matthew Tracy

Supervisory Security Specialist
Security Office
Bureau of Reclamation – Denver, Colorado, USA
E-mail Address: mtracy@usbr.gov

Bio Info: Matt Tracy graduated from Bellevue University with a Bachelor of Science in Criminal Justice Administration and Master of Science in Security Management. He worked as a deputy sheriff for six years and spent more than eight years in Iraq and Afghanistan training police. Matt joined Reclamation as the Security Manager for Hoover Dam in 2013. He joined the SSLE Security Office in 2015 and has recently accepted a position as the Supervisory Security Specialist.

9. Jay Stateler, P.E.

Senior Instrumentation Engineer
 Instrumentation and Inspections Group
 Bureau of Reclamation – Denver, Colorado, USA
 E-mail Address: JStateler@usbr.gov

Bio Info: Civil Engineer/Instrumentation Specialist – BOR Instrumentation and Inspections Group

- Experience: 37 years w/BOR, 3 years w/Fish & Wildlife Service, 1 year in private sector
- Licensed Professional Civil Engineer (Colorado)
- Member: United States Society on Dams (USSD), Technical Committee on Dam Surveillance (TCDS) of the International Commission on Large Dams (ICOLD)
- Outgoing Chairman: USSD Committee on Monitoring of Dams and Their Foundations
- Education: BSCE – Bucknell University, Graduate study – University of Minnesota and University of Colorado

Work experience with Reclamation includes:

- Design and technical support regarding instrumentation systems and monitoring programs, including participation in on-site dam operator training
- Evaluation of instrumentation data and visual monitoring information
- Senior Engineer/Team Leader for comprehensive dam safety inspections and evaluations for: 11 BOR dams, 15 Bureau of Indian Affairs dams, 1 Bureau of Land Management dam, 1 Fish & Wildlife Service dam, and 6 National Park Service dams
- Presentations on dam failure modes and instrumented and visual monitoring of dams at: (1) four ASDSO-sponsored regional dam safety seminars; (2) dam safety training programs presented in the states of California, New York, Texas, Florida, and Wisconsin; and (3) dam safety training programs conducted in Malaysia, India, Thailand, Indonesia, Sri Lanka, Taiwan, Laos, Jordan, New Zealand, and Australia

10. Katharine Dahm

Civil Engineer
 Manager, Operations and Maintenance Branch
 Bureau of Reclamation – Denver, Colorado, USA
 E-mail Address: kdahm@usbr.gov

Bio Info: Katharine Dahm is a Civil Engineer in the Bureau of Reclamation's Office of Policy. She supervises the Operations and Maintenance Branch within the Asset Management Division and is responsible for oversight of the operations and maintenance of Reclamation's assets, including High and Significant Hazard dams. She received her B.S. from the New Mexico Institute of Mining and Technology in Civil and Environmental Engineering and M.S. and Ph.D. from the Colorado School of Mines. She is a licensed professional engineer in the State of Colorado.

11. Keil Neff

Hydraulic Engineer

Water Resources Engineering and Management

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: KNeff@usbr.gov

Bio Info: Keil J. Neff, PE, PhD works as a hydrologic engineer in the Bureau of Reclamation's Technical Service Center primarily conducting flood frequency analyses to support dam safety risk management activities. Prior to working with Reclamation, Keil worked as a hydrologist for TVA, performing and managing complex hydrologic and hydraulic studies to support river management and dam safety objectives. His experience includes modeling hydraulic and hydrologic processes, assimilating data and integrating models, conducting flood inundation and downstream consequences assessments, and contributing to dam safety risk analyses. Keil is an active member of the United States Society of Dams, currently serving as Vice Chair on the Committee on Hydraulics and Hydrology.

12. Cassandra Wagner

Professional Geologist

Geotechnical Services Division, Engineering Geology Group

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: CWagner@usbr.gov

Bio Info: Cassandra Wagner, P.G., graduated from the University of Florida with a Bachelor of Science Degree in Geology, and is a registered professional geologist in the State of Wyoming. Cassandra is currently an Engineering Geologist at the Bureau of Reclamation, and previously worked as a geologist for the U.S. Army Corps of Engineers. Her primary focus has been in Dam Safety, including site characterization, field investigation, risk analysis and construction modification.

13. Blair Greimann

Hydraulic Engineer

Sedimentation and River Hydraulics Group

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: bgreimann@usbr.gov

Bio Info: Blair Greimann has been a Hydraulic Engineer in the Sedimentation and River Hydraulics Group at the Denver Technical Service Center (TSC) for the Bureau of Reclamation since 1998. He is currently the Technical Specialist of the group. His primary work is related to the analysis and design of large scale dam removal and river restoration projects. Some of the projects where he has performed a critical role include the San Joaquin River Restoration Program, the Klamath Dam Removal Studies, and Matilija Dam Removal. He is also a co-developer of the hydraulic and sediment transport model called SRH-1D (Sedimentation and River Hydraulics – One Dimension) and has applied it to the projects listed above as well as reservoir sluicing projects. He is currently engaged in the developing of reservoir sedimentation training and guidelines for the government of Laos.

14. Kent Walker

Hydraulic Engineer

Hydraulic Investigations and Laboratory Services

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: KWalker@usbr.gov

Bio Info: Kent Walker is a hydraulic engineer in Reclamation's Hydraulics Laboratory in Denver, CO. He completed his Master of Civil Engineering at Colorado State University's hydraulics laboratory in 2008 and has 12 years of experience in physical modeling and hydraulic engineering with both Bureau of Reclamation and the US Army Corps of Engineers. Kent has focused his career on dam safety research including vortex formation, debris interaction with reservoir outlet works and erodibility of non-cohesive soils on sloped embankments.

15. Patrick Maier

Civil Engineer

Waterways and Concrete Dams Group 2

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: PMaier@usbr.gov

Bio Info: Graduated from University of Colorado in 2008 with Bachelor of Science Degree in Civil Engineering - Structural. Graduated from University of Colorado in 2011 with Master of Science Degree in Civil Engineering - Structural.

Worked as construction superintendent/construction manager at Koelbel/Colonnade Construction from 1995 - 2008. Started working as an engineer at Reclamation in 2009. Currently working in Waterways and Concrete Dams Group 2.

Perform analyses and design work for concrete dams as well as spillways and outlet works for embankment dams. Work involves various types of hydraulic and structural analyses, risk analyses, developing designs and drawings, working on specifications packages and providing construction support for projects under construction.

16. David (Dave) Rees Gillette, PE, PhD

Geotechnical Engineer

Geotechnical Engineering Group 4

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: DGillette@usbr.gov

Bio Info: Dr. David Rees Gillette is a geotechnical engineer who has been in practice for over 30 years, 26 of them with Reclamation. During that time, he has worked on all aspects of embankment dams. Before Reclamation, he worked in consulting, mostly in embankment dams, mine tailings management, and mined-land reclamation. Dave holds a master's degree and PhD in geotechnical engineering from the University of Colorado in Boulder, and a bachelor's degree from Case Western Reserve University in Ohio. He is registered as a Professional Engineer in the state of Florida. Dave is Reclamation's technical lead for seismic analysis and design for embankment dams, and has also been active in developing methodology for dam-safety risk analysis. He is the author or coauthor of ten published papers, and has frequently been invited to speak or provide dam-safety training in the US, as well as in the Dominican Republic, Indonesia, and Sri Lanka.

17. Dr. Daniel (Dan) Levish, Ph.D.

Technical Specialist, Seismology, Geomorphology and Geophysics Group
Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: DLevish@usbr.gov

Bio Info: Dan is the Technical Specialist of the Seismology, Geomorphology and Geophysics Group. Dan has worked for Reclamation for 29 years primarily on flood and earthquake hazards for dam safety risk analysis. Dan has a B.S. in Geology from the University of California, Davis, a M.S. in Geomorphology from Colorado State University, Fort Collins, and a Ph.D. in Quaternary Geology from the University of Colorado, Boulder.

18. Bruce Feinberg

Hydraulic Engineer
Emergency Management and GIS Group
Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: BFeinberg@usbr.gov

Bio Info: Mr. Feinberg has worked at the Bureau of Reclamation since 1990. He specializes in flood inundation modeling and the estimation of life loss from dam failure and downstream hazard classification.

19. Ben Claggett

Disaster Recovery Manager
Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: BClaggett@usbr.gov

Bio Info: Ben holds a B.S. in Mechanical Engineering and is a licensed P.E. in the state of Colorado. He has worked for Reclamation for 15 years, having started in the Oklahoma-Texas Area Office as a civil engineer inspecting dams, canals, bridges, and pipelines. He specialized in emergency management products and services for five and half years in the Technical Service Center. Ben currently works in the Program and Emergency Management Office in Denver as the Reclamation Training, Testing, and Exercise Coordinator, as well as providing emergency management support to Reclamation offices as requested, including developing EAPs and conducting exercises.

20. Bill Dressel

Civil Engineer
Waterways & Concrete Dams Group
Bureau of Reclamation – Denver, Colorado, USA

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Bio Info: Mr. Bill Dressel is a civil engineer for the Bureau of Reclamation with the Waterways and Concrete Dams Group at the Technical Service Center in Denver, Colorado. He is responsible for the analysis and evaluation of concrete and embankment dams, dam foundations, and appurtenant structures. This includes performing risk analyses of dams and dam foundations for static, seismic, and hydrologic related failure modes. Mr. Dressel regularly performs or reviews structural, hydraulic, and geotechnical design and analyses for corrective measures to high hazard dams. He has served as the engineer of record or resident engineer on numerous federal and state dam safety projects.

Mr. Dressel holds a B.S. from the University of Colorado Denver and is a registered professional engineer in the State of Colorado with over 15 years of design and construction experience with an emphasis on dams, civil site work, and water supply infrastructure.

21. Lucas Adams

Mechanical Engineer

Hydraulic Equipment Group

Bureau of Reclamation – Denver, Colorado, USA

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Bio Info: Mr. Adams is responsible for all phases of design, procurement, fabrication, installation, testing, operation, and maintenance of large diameter steel pipe, penstocks, pumping plant manifolds, steel tanks, valves, air chambers, flow control and pressure regulating equipment.

Mr. Adams holds a B.S. from the Colorado School of Mines and is a registered professional engineer in the State of Colorado with over 10 years of design and construction experience.

22. Paul Craig

Geotechnical Engineer

Hydraulic Equipment Group

Bureau of Reclamation – Denver, Colorado, USA

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Bio Info: Paul Craig is a geotechnical engineer at the Bureau of Reclamation. He received his Bachelors of Science and Masters of Engineering degrees in Civil Engineering from Utah State University. After school Paul worked for 4 years for a private geotechnical engineering firm in Salt Lake City, Utah. Since 2009, he has worked at Reclamations Technical Services Center (TSC) in Denver, where his focus has been on dam safety engineering, with a majority of his work on the comprehensive review and inspection of dams.

23. Dennis Hanneman

Technical Specialist

Embankment Dams & Geotechnical Engineering Group 2

Bureau of Reclamation – Denver, Colorado, USA

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Bio Info: Dennis is a geotechnical engineer at the Bureau of Reclamation's Technical Service Center. He has been at Reclamation for 10 years and has worked on numerous dam safety risk analyses, designs, and construction modifications primarily to address internal erosion and seismic concerns. Dennis is one of the coauthors of the recent FEMA guidance document "Evaluation and Monitoring of Seepage and Internal Erosion (P-1032)." Prior to joining Reclamation, he worked on water, wastewater, transportation, mining, industrial, and commercial development projects while employed by several engineering consulting firms. Dennis received his B.S. degree in Civil Engineering from Colorado School of Mines in 1991 and his M.S. in Geotechnical Engineering from the University of Colorado at Denver in 2001.

24. Elizabeth M. Ouellette, P.E.

Geotechnical Engineer

Geotechnical Engineering Group

Bureau of Reclamation – Denver, Colorado, USA

E-mail Address: EOuellette@usbr.gov

Bio Info: Elizabeth is a geotechnical engineer for the Bureau of Reclamation in the Geotechnical Engineering Group at the Technical Service Center in Denver, Colorado. She has over 26 years of engineering experience with an emphasis on embankment dams. Her experience includes completing geotechnical analyses, performing dam safety risk analyses, and developing designs for construction modifications to address internal erosion, hydrologic and seismic concerns. Elizabeth holds a Bachelor of Science degree in Civil Engineering from the University of Colorado, Denver, and also completed graduate-level studies at the University of Colorado, Denver. She is a registered professional engineer in the State of Colorado.

Advancing dam safety globally, Reclamation hosts 11 countries for its International dam safety technical seminar and tour

Written by: Drew Nagle



In Denver, Colorado, international attendees join Reclamation's 30th annual dam safety technical seminar and study tour

The Bureau of Reclamation hosts its annual Safety Evaluation of Existing Dams International Technical Seminar and Study Tour from June 3 – June 12, 2019. This international technical seminar is designed for managers, administrators, engineers and geologists who are frequently responsible for the safety of dams and their design, construction, operation or maintenance.

Now celebrating its 30th year hosting this seminar, Reclamation welcomes 44 participants from 11 countries, which include Albania, Australia, Botswana, Brazil, Canada, Finland, Kenya, Malaysia, Nigeria, Taiwan and South Africa.

Reclamation's International Affairs Program routinely assists water resource agencies of other countries by providing reimbursable technical training and technical visitors programs for their staff. Reclamation's unique training programs often combines office assignments, field visits or study tours that cover Reclamation's Denver, regional and area offices.

For attendees, the seminar begins at the Denver Federal Center and includes a tour Reclamation's research laboratories as well as classroom presentations and discussions. In nearby Pueblo, Colorado, attendees will participate in a simulated examination of a dam led by Reclamation's staff. On their last day in Colorado, attendees will visit Rocky Mountain National Park.

Next, after traveling to the Southwest, attendees will visit the New Waddell Dam and Theodore Roosevelt Dam in Arizona, which are part of Reclamation's Central Arizona Project and Salt River Project. On its final day, the seminar will conclude with a unique tour of Hoover Dam.

Reclamation values this opportunity to host an international dialogue and facilitate technical knowledge-sharing, which helps us all enhance dam safety policies and procedures that warrant public confidence.

Learn more about Reclamation's international programs at www.usbr.gov/international.

Published on June 06, 2019

More Information about the Bureau of Reclamation

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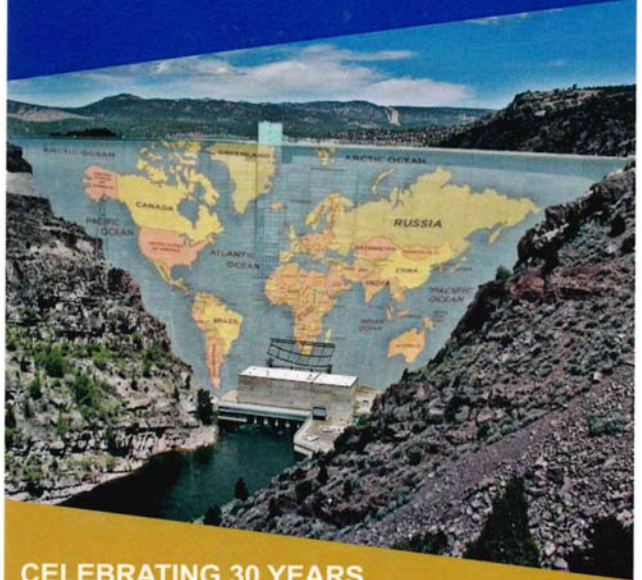
Phone 1-303-445-2139

E-mail inquiries should be sent to
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Avigil@usbr.gov

Information contained in this brochure
and information on future seminars
can also be located at:
<http://www.usbr.gov/international/seminars.html>

RECLAMATION

Managing Water in the West



CELEBRATING 30 YEARS

SAFETY EVALUATION OF EXISTING DAMS
INTERNATIONAL TECHNICAL SEMINAR
AND STUDY TOUR



U.S. Department of the Interior
Bureau of Reclamation

June 2019

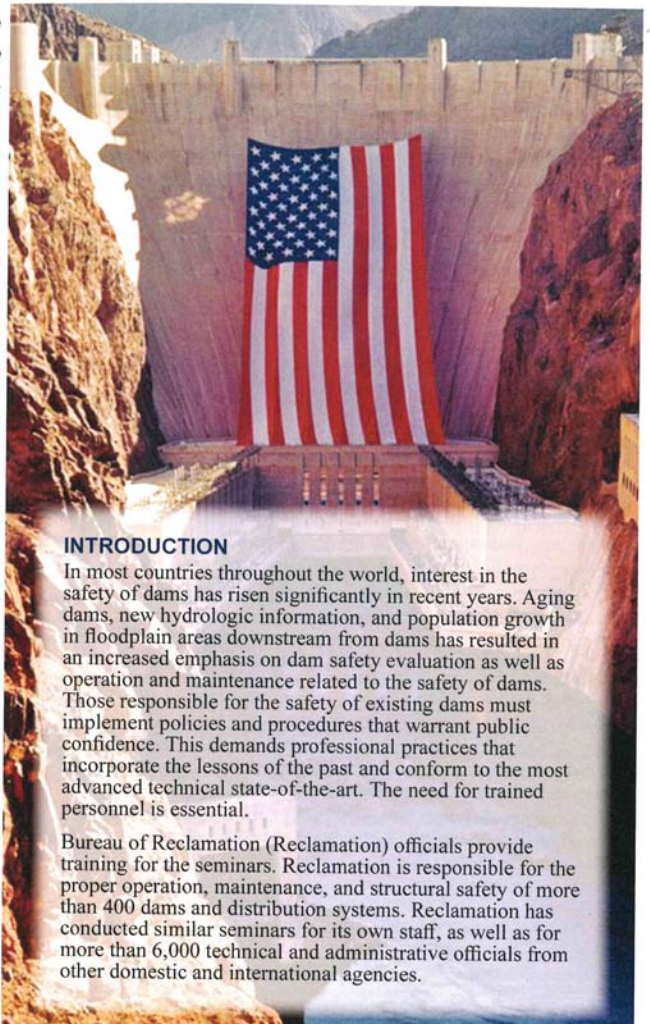
Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The Bureau of Reclamation manages, develops, and protects water and related resources in an environmentally and economically sound manner in the interest of the American public.

International Affairs Program Mission is to coordinate international activities for the Bureau of Reclamation and manage training and technical assistance programs in support of U.S. foreign policy goals.

Cover: Photograph of Flaming Gorge Dam which is located on the Green River in northeastern Utah about 32 miles downstream from the Utah-Wyoming border. The concrete thin-arch structure has a maximum height of 502 feet and a crest length of 1,285 feet, and contains 987,000 cubic yards of concrete. The top thickness is 27 feet, and the maximum base thickness is 131 feet. Image of world map imposed onto the dam in this photograph.



INTRODUCTION

In most countries throughout the world, interest in the safety of dams has risen significantly in recent years. Aging dams, new hydrologic information, and population growth in floodplain areas downstream from dams has resulted in an increased emphasis on dam safety evaluation as well as operation and maintenance related to the safety of dams. Those responsible for the safety of existing dams must implement policies and procedures that warrant public confidence. This demands professional practices that incorporate the lessons of the past and conform to the most advanced technical state-of-the-art. The need for trained personnel is essential.

Bureau of Reclamation (Reclamation) officials provide training for the seminars. Reclamation is responsible for the proper operation, maintenance, and structural safety of more than 400 dams and distribution systems. Reclamation has conducted similar seminars for its own staff, as well as for more than 6,000 technical and administrative officials from other domestic and international agencies.

EXECUTIVE SUMMARY



The Bureau of Reclamation has long been active internationally and is known worldwide for its breadth and depth of expertise. From its inception, Reclamation has shared its expertise with other nations and has had a comprehensive international program featuring activities such as technical assistance, training, visitor programs, seminars/workshops, and technology exchange.

Reclamation's International Affairs Program (IA) serves as the point of contact for all international activities for Reclamation.

BACKGROUND

Reclamation historically developed technical training programs for about 100 international trainees annually. One success, year after year continues to be Reclamation's well-regarded Safety Evaluation of Existing Dams International Technical Seminar and Study Tour (SEED). The SEED Seminar has been offered since 1989, with participation of well over 1000 technical staff from 74 countries.

The seminar objectives are to provide an overview of the institutional and technical requirements of a successful dam safety, operation and maintenance program; provide a model for establishing or improving a dam safety program; increase the technical capabilities of those responsible for dam safety; and present procedures and demonstrations, through site visits, for conducting dam safety examinations and evaluations.

The seminar technical sessions consist of case histories and structured discussions covering all aspects of a safety evaluation program led by Reclamation engineers and geologist with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety evaluation. The course outlines the hydrologic, seismic, geotechnical, electrical, mechanical and structural considerations of dam safety as well as operation, maintenance, surveillance, and emergency preparedness. Presentations, case histories, and walk-through abbreviated inspections of Reclamation dams are used to present the multi-discipline approach to an effective safety evaluation program.

The study tour has taken participants to Reclamations regions, visiting many iconic dams such as Grand Coulee Dam, Glen Canyon Dam, Folsom Dam, and Hoover Dam. The study tours have also featured visits to national parks such as Yellowstone National Park, Yosemite National Park, Black Canyon National Park and Rocky Mountain National Park.



TESTIMONIES

Canada – "The Seminar will absolutely have a profound effect on my career, and I am looking forward to putting what I have learned into action."

Australia – "Bringing together people from many backgrounds made the Seminar very interesting and thought provoking as I engaged with many of the inspiring speakers from your organization."

India – "While attending this Seminar, what I learned from the experience of Reclamation was too precious for me, especially instrumentation in dams, sedimentation control, flood management and water management of available water in terrain. The sedimentation is the big problem of Himalayan Rivers of India, hence an effective control over it is very important for our hydro projects in Himalayan region. The knowledge and information I took away with me to India was worth to implement and I did that successfully."

India – "After training, I was able to give training on dam safety, construction aspects, etc., to my team members and other engineers. Thank you, Reclamation, especially to your team for conducting such a wonderful sessions and tours."

ACKNOWLEDGMENTS

Reclamation values this unique opportunity to share dam safety knowledge and experience, and to provide guidance for participants interested in learning more about dam safety. Acknowledgements are made to the many Reclamation employees who have contributed to the IA over the years. Their contributions are testimonies to their desire to make a difference.

AUTHORITY

The authority for Reclamation to provide services to the Agency for International Development (USAID) is Part 1 of Public Law 87-195, the Foreign Assistance Act.

The authority for technical assistance other than for USAID programs is Section 607 of the Foreign Assistance Act of Public Law 87-195, which states that any agency of the U.S. Government is authorized to furnish services and commodities on an advance-of-funds or reimbursement basis to friendly countries or international organizations.

Authority to accept foreign visitors and trainees other than those sponsored by USAID is under Public Law 80-402, the U.S. Information and Educational Exchange Act of 1948 and Public Law 87-256, the Mutual Educational and Cultural Exchange Act of 1961.

1988/1989

IN THE BEGINNING—THE FIRST SEMINAR

The first International Technical Seminar on Dam Safety was held November 27, 1988, originally sponsored by the American Water Foundation in cooperation with Reclamation. Forty-three participants from 31 multiple international agencies participated in the first seminar.



A tour of Reclamation's Hydraulic Laboratory and instrument demonstrations were included with the lectures which covered safety examinations, risk-based analysis, dam instrumentation, and preventative maintenance training. Study tours were conducted, including a visit to Glen Canyon Dam, Arizona, part of the Colorado River Storage Project. Visits to surrounding dam sites were examined, including a VIP tour and examination of Hoover Dam and facilities, in Boulder City, Nevada.

Horseshoe Bend is located 5 miles (8.0 km) downstream from Glen Canyon Dam and Lake Powell within Glen Canyon National Recreation Area, about 4 miles (6.4 km) southwest of Page. The overlook is 4,200 feet (1,300 m) above sea level, and the Colorado River is at 3,200 feet (980 m) above sea level, making it a 1,000-foot (300 m) drop. The rock walls of Horseshoe Bend contain hematite, platinum, garnet, and other minerals.



1990/1991

The 1990-1991 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tour included 31 participants from multiple international agencies.

The first week of the seminar consisted primarily of classroom presentations and discussions held at the Hotel Denver Downtown.

The study tour began with travel to Arizona and site visits to Theodore Roosevelt Dam, Parker Dam and Stewart Mountain Dam.

Participants also enjoyed a special tour of New Waddell Dam construction site.

The study tour concluded with visits to Senator Wash Dam and a VIP tour of Hoover Dam.



Reach 11 Dikes, located near Phoenix, Arizona.



Senator Wash Dam, located about 18 miles northeast of Yuma, Arizona, on the California side of the Colorado River.



Havasu Pumping Plant, Parker, Arizona.



Pueblo Dam Pueblo, Colorado

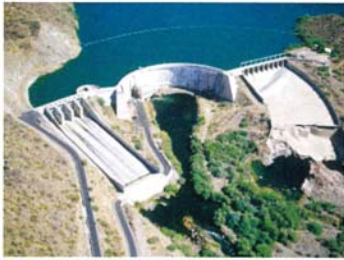
 **1992/1993**

The 1992-1993 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tour included 22 participants from multiple international agencies.

The first week of the seminar consisted of classroom presentations and discussions held at the Hotel Denver Downtown. The study tour, which spanned across three states; Arizona, Colorado, and Nevada, included Pueblo Dam, Hoover Dam, Theodore Roosevelt Dam, Coolidge Dam and Stewart Mountain Dam.



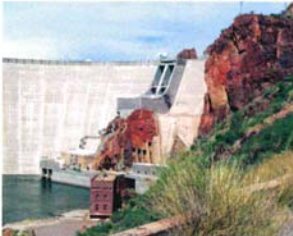
Concrete testing at Denver Engineering and Research Laboratory facilities, Lakewood, CO.



Top left photograph: Stewart Mountain Dam.

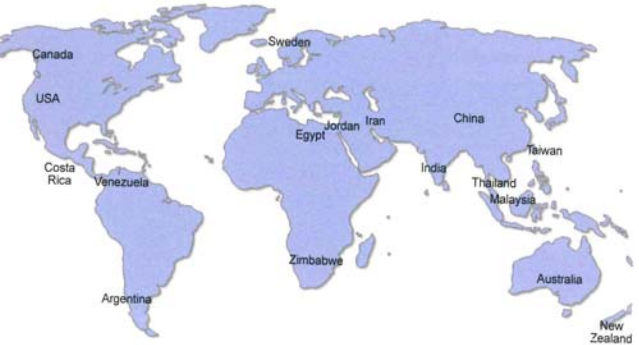
Bottom left photograph: Theodore Roosevelt Dam.

Bottom right photograph: Coolidge Dam.



 **1994/1995**

The 1994-1995 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tours included 76 participants from multiple international agencies with 26 participating countries.



The first week of the seminar consisted primarily of classroom presentations and discussions held at the Sheraton Denver West Hotel, Lakewood, Colorado. The study tour began with travel to the Grand Canyon National Park, where participants enjoyed free time to explore the park.

Travel continued on to Phoenix, Arizona, and the Phoenix Area Office, where staff provided an overview Central Arizona Project.

An overview of the Salt River Project, specifically related to Stewart Mountain Dam and operations, and geology was presented at the Salt River Project Offices. The study tour concluded with site visits to Stewart Mountain Dam and Theodore Roosevelt Dam.

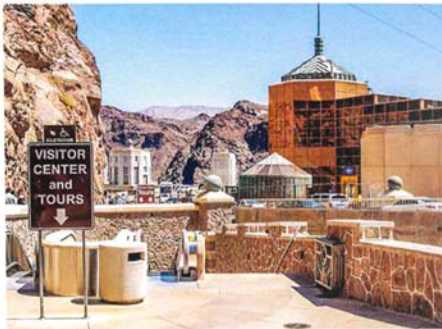


Reclamation's Phoenix Area Office (PAO)

 **1996/1997**

The 1996-1997 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tours included 55 participants from multiple international agencies.

The first week of the seminar consisted primarily of classroom presentations and discussions held at the Sheraton Denver West Hotel, Lakewood, Colorado. Participants took a tour of the Technical Service Center Research Laboratories before traveling to Las Vegas, Nevada. The study tour began with a tour of Hoover Dam and facilities in Boulder City, Nevada. Travel continued on to Phoenix Arizona via the Grand Canyon National Park.



Participants were provided a briefing on the Central Arizona Project before the simulated examination at New Waddell Dam. The study tour concluded with a briefing on the Salt River Project and site visit to Stewart Mountain Dam.



New Waddell Dam, Phoenix, Arizona.



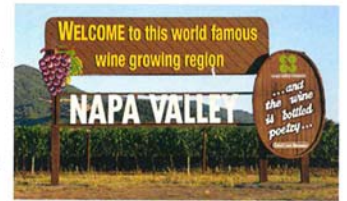
Glen Canyon Dam, Page, Arizona.

 **1998/1999**

The 1998-1999 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tours included 73 participants from multiple international agencies with 26 participating countries.

The first week of the seminar consisted primarily of classroom presentations and discussions held at the Comfort Inn Hotel, Denver, Colorado. Participants toured the Technical Service Center Research Laboratories on the first day of the seminar.

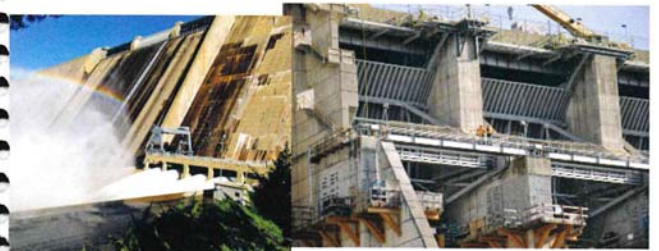
The study tour began with air travel to Sacramento, California, with tours of the historic Napa Valley 1879, the Merryvale Winery, and Hurds Candle Factory.



Participants traveled to Folsom Dam where they examined the failed spillway gate, repair of the spillway stilling basin, and the outlet works tube failure and repairs.

Travel continued to Mormon Island Auxiliary Dam to examine modifications and then to Fresno, California, for a tour of Friant Dam spillway gates.

The study tour concluded with visits to B.F. Sisk (San Luis) Dam and an examination of O'Niell Dam Modifications.



Friant Dam, Friant, Fresno County, California.

Folsom Dam, 23 miles east of Sacramento, California.



B.F. Sisk (San Luis) Dam 12 miles west of Los Banos, California.



2000

The 2000 Dam Safety, Operation, and Maintenance International Technical Seminar and Study Tour held August 14-24, 2000, included 32 participants from multiple international agencies with 18 participating countries.

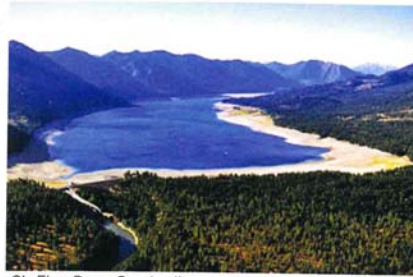
The first week of the seminar consisted primarily of classroom presentations and discussions held at the Comfort Inn Hotel, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory on the first day of the seminar.



Friday, August 18, 2000, participants attended a Colorado Rockies vs. Florida Marlins baseball game, closing out week one of the seminar.



The second week consisted of study tours and field trips beginning with air travel to Spokane, Washington. Participants traveled by motorcoach to Grand Coulee, Washington for a tour of Grand Coulee Dam and a laser light show in the evening.



Cle Elum Dam - Construction completed in 1933. It is a zoned earthfill dam with a height of 165 feet (50.2 meters) with a crest length of 1,801 feet (548.9 meters). Seepage issues are being monitored. Simulated dam safety exam will be conducted.



Kachess Dam - Construction was completed in 1912. It is a zoned earthfill dam with a height of 115 feet (35 meters) with a crest length of 1,400 feet (426.7 meters). Seepage issues are being monitored. Simulated dam safety exam will be conducted.



Keechelus Dam - Construction was completed on 1917. It is a zoned earthfill dam with a height of 128 feet (39 meters) with a crest length of 6,550 feet (1,996.4 meters). Modifications are planned to address internal erosion caused by seepage.

Travel continued on to Ellensburg, Washington for presentations on operation and maintenance management. Field trips for simulated dam safety examinations were conducted at Cle Elum Dam, Kachess Dam, and Keechelus Dam.



2001

The 2001 Dam Safety, Operation and Maintenance International Technical Seminar and Study Tour held August 13-23, 2001, included 32 participants from multiple international agencies with 18 participating countries.



The first week of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center, Lakewood, Colorado. Participants toured the Technical Service Center Research Laboratory the first day of the seminar.

Friday, August 17, 2001, participants traveled to Horsetooth Reservoir by bus for a tour and picnic lunch, returning to the hotel in Denver late afternoon.



Participants attended a Colorado Rockies vs. Florida Marlins baseball game, closing out week one of the seminar.



The study tour began with air travel to Salt Lake City, Utah. After a bus tour of downtown Salt Lake City and nearby dams, participants traveled to Park City, Utah, staying at the Radisson Hotel. Presentations on Operation and Maintenance Program Considerations, Dam Operator's Training, Preparation of Examination Reports, and Standing Operating Procedures were given by technical staff. Site visits and simulated exam reviews took place at Echo Dam and East Canyon Dam.

Travel continued by air to Las Vegas, Nevada, for a VIP tour of Hoover Dam and Powerplant. The seminar concluded with luncheon and open discussions on findings from dam examinations.



East Canyon Dam - Construction was completed in 1966. It is a double-curvature, thin-arch concrete dam with a height of 260 feet (79 meters) with a crest length of 440 feet (134 meters). Operation is integrated with overall Weber Basin project water requirements for irrigation, municipal and industrial power, and flood control.

Echo Dam - Construction completed in 1931. It is a zoned earthfill dam with a height of 158 feet (48 meters) with a crest length of 1,887 feet (575 meters). A powerplant was installed in 1987. The primary purpose of the dam is water conservation, however, it is also used for recreation purposes. Water from the Echo reservoir is released into the Weber River and is diverted into 41 privately built canals and laterals leading to the irrigable land.



2002

The 2002 Dam Safety, Operation and Maintenance International Technical Seminar and Study Tour held August 12-23, 2002, included 16 participants and 10 participating countries.



The first week of the seminar consisted primarily of classroom presentations and discussions held at the Warrick Hotel, Denver, and Reclamation Offices at the Denver Federal Center, Lakewood, Colorado. Participants toured the Technical Service Center Research Laboratory the first day of the seminar.

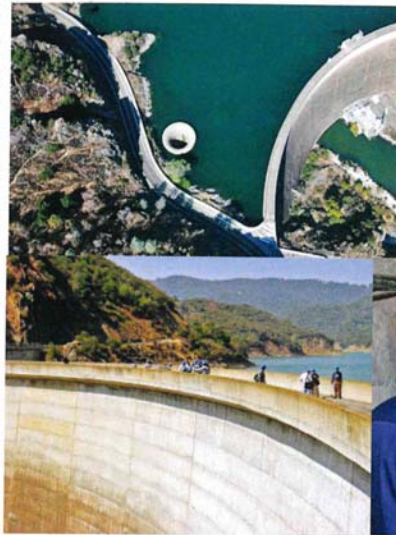
Friday, August 16, 2002, participants traveled to Horsetooth Reservoir for a tour and picnic lunch, returning to the hotel in Denver late afternoon.

The study tour began with air travel to San Francisco, California, and overnight stay at the Tuscan Inn, Fisherman's Wharf.



Participants enjoying Fisherman's Wharf, San Francisco, California.

Site visits and simulated exams included Monticello Dam, Contra Loma Dam and Martinez Dam. The seminar concluded with a breakfast banquet and wrap up session in San Francisco, California.



Monticello Dam - Construction was completed in 1957. It is a medium-thick arch concrete dam with a crest height of 456 feet (139 meters) with a crest length of 1,023 feet (312 meters).



Contra Loma Dam - Construction was completed in 1967. It is an earthfill dam with a structural height of 107 feet (33 meters) with a crest length of 1,050 feet (320 meters).



Martinez Dam - Constructed in 1947, it is an earthfill dam with a structural height of 62 feet (19 meters) and a crest length of 1,200 ft. (366 meters).

2003

The 2003 Dam Safety, Operation and Maintenance International Technical Seminar and Study Tour held September 15-25, 2003, included 18 participants from multiple international agencies with 12 participating countries.

A study tour to the states of Colorado, Utah, Wyoming, and Idaho focused on the dam safety program of Reclamation.

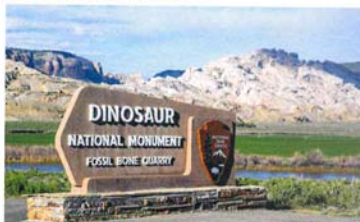
The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory the first day of the seminar.

The third day of the seminar, participants traveled to Downtown Denver for a catered picnic buffet at Coors Field and a Colorado Rockies vs. Houston Astros baseball game.



On September 20, 2003, the study tour began with travel through Rocky Mountain National Park to the Fairfield Inn, Steamboat Springs, Colorado.

Travel continued through Dinosaur National Monument and Visitor Center to the Best Western Dinosaur Inn, Vernal, Utah.

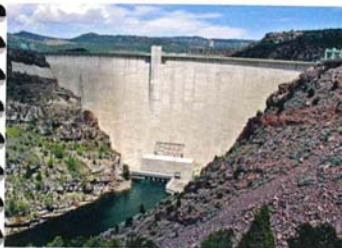


Site visits and abbreviated exams were conducted at Flaming Gorge Dam and Fontenelle Dam.

Jim Mumford, Dam Safety Coordinator, from the Pacific Northwest Region, provided a presentation on the Teton Dam Failure.



Participants traveled to the Teton Dam site and the Jackson Lake Dam area the last two days of the study tour and concluded with a close-out dinner in Jackson, Wyoming. Many of the participants extended their stay for a guided tour of Yellowstone National Park.



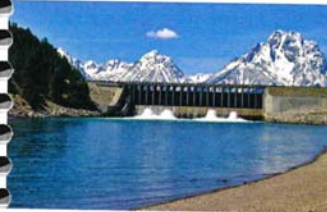
Flaming Gorge Dam located on the Green River in northeastern Utah near the Utah-Wyoming border. The concrete thin-arch structure has a height of 153 meters and a crest length of 391 meters.



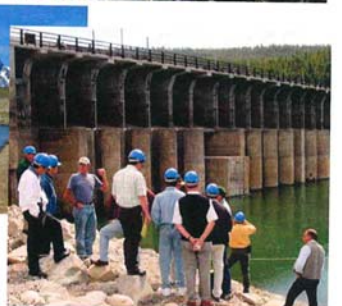
Fontenelle Dam, suffered a near failure due to seepage erosion in September, 1965.



Teton Dam, a 100-m-high embankment dam, completed in November 1975, failed catastrophically on June 5, 1976.



Jackson Lake Dam - 20-m-high dam, is a combined concrete gravity and zoned earthfill structure. Dam safety modifications, completed in 1991, included correction of inadequate seismic stability of the north embankment using dynamic consolidation and compaction piles.



 **2004**

The 2004 Dam Safety, Operation and Maintenance International Technical Seminar and Study Tour held September 13-23, 2004, included 24 participants from multiple international agencies with 11 participating countries.

A study tour to the states of Colorado, Nevada, and Arizona, focused on the dam safety program of Reclamation.



The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory that included a concrete cylinder break.

The study tour began on Saturday, September 18, 2004, with air travel to Las Vegas, Nevada.

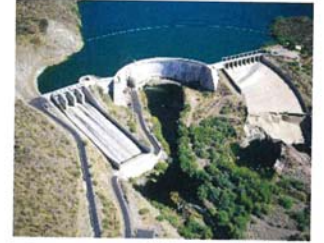
On Monday, September 20, 2004, participants traveled to Boulder City, Nevada, for presentations on Operation and Maintenance Program Considerations, Maintenance and Management, Standing Operating Procedures, and Dam Operator's Training. The day concluded with a VIP tour of Hoover Dam.



The study tour continued with a site visit and abbreviated exam of Davis Dam and powerplant, followed by a boat tour of the Colorado River from Davis Dam to Lake Havasu City, Arizona. Additional site visits and abbreviated exams were conducted at Parker Dam and Stewart Mountain Dam, located in Arizona. The Seminar concluded with a close out banquet dinner and social evening in Phoenix, Arizona.



Davis Dam and Powerplant.



Stewart Mountain Dam - Dam safety issues were identified in the mid-80's.



Parker Dam - a concrete arch dam with a structural height of 97 meters. Only 28 meters of the dam's structure is visible since 73 percent of the dam's structural height is below the original riverbed.

 **2005**

The 2005 Dam Safety, Operation and Maintenance International Technical Seminar and Study Tour held August 8-19, 2005, included 25 participants from multiple international agencies with 14 participating countries.



The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory that included a concrete cylinder break.



The study tour began on Saturday, August 13, 2005, with travel by motorcoach to Glenwood Springs, Colorado. Participants enjoyed free time to explore and enjoy the Glenwood Hot Springs Pool and the recreation beauty of the Colorado and Roaring Fork rivers.

August 14, 2005, participants traveled by motorcoach to Montrose, Colorado, stopping at Paonia Dam. Reclamation's Cureanti Field Division Office gave presentations on Operation and Maintenance Program Considerations, Dam Operator's Training, Preparation of Examination Reports, and Standing Operating Procedures. The day concluded with a site visit and abbreviated examination of Morrow Point Dam.



Paonia Dam - on Muddy Creek about 1 mile upstream of its junction with Anthracite Creek, which in turn forms the North Fork of the Gunnison River.



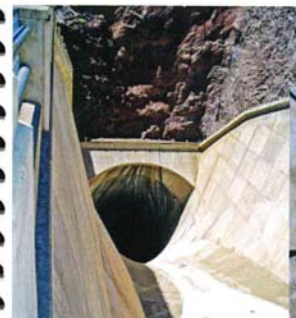
August 19, 2005, participants traveled to Boulder City, Nevada, for a special tour of Hoover Dam. The Seminar concluded with a close-out dinner at Battista's Hole in the Wall, Las Vegas.



Morrow Point Dam, 12 miles downstream from Blue Mesa Dam, is Reclamation's first thin-arch, double-curvature dam.



Animas-La Plata Project near Durango, Colorado.



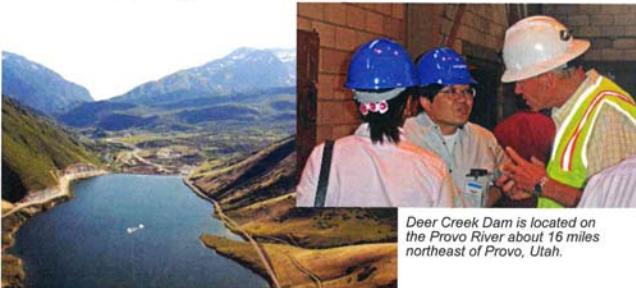
VIP tour of Hoover Dam and facilities, Boulder City, Nevada.

The 2006 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held August 7-17, 2006, included 27 participants from multiple international agencies with 12 participating countries.



The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory that included a concrete cylinder break.

The study tour began on August 13, 2006, with air travel to Salt Lake City, Utah, and a bus tour of downtown Salt Lake City. August 14, 2006, presentations were given on Operation and Maintenance Program Considerations, Dam Operator's Training, Preparation of Examination Reports, and Standing Operating Procedures. Abbreviated examinations were conducted at Deer Creek Dam, Jordanelle Dam, and Upper Stillwater Dam.



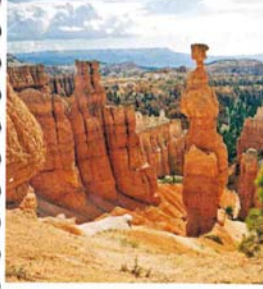
Deer Creek Dam is located on the Provo River about 16 miles northeast of Provo, Utah.



Jordanelle Dam - capacity of 320,300 acre-feet with a surface area of 3,068 acres.



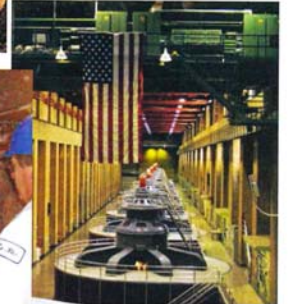
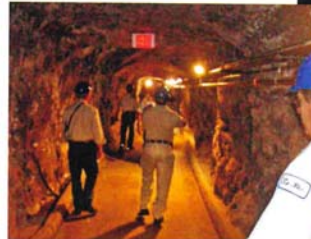
Upper Stillwater Dam - roller compacted concrete gravity dam located on Rock Creek.



Travel continued on to Bryce Canyon and Zion National Parks, with a final stop in Las Vegas, Nevada.



The study tour concluded with a briefing on the Boulder Canyon Project and a VIP Tour of Hoover Dam.



The 2007 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held September 17-27, 2007, included 43 participants from multiple international agencies with 16 participating countries.



The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory, that included a concrete cylinder break. The first week of the 2007 seminar closed with a picnic dinner at the residence of Leanna Principe, followed by a free day in Denver.



The study tour began on Sunday, September 23, 2007, with travel by air to Reno, Nevada, and an overnight stay at the Sands Regency Casino Hotel. The next morning, participants were provided an update of ongoing dam safety work in the Mid-Pacific Region before traveling to Prosser Creek Dam.



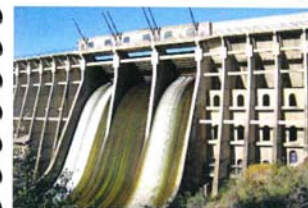
The study tour began on Sunday, September 23, 2007, with travel by air to Reno, Nevada, and an overnight stay at the Sands Regency Casino Hotel. The next morning, participants were provided an update of ongoing dam safety work in the Mid-Pacific Region before traveling to Prosser Creek Dam.



Photographs above: Visiting Lassen Volcanic National Park, a large hydrothermal area that exemplifies the dynamic, ever-changing geologic environment.

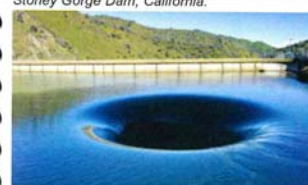
September 25, 2007, participants traveled to Shasta Dam for a special tour and then continued on to Lassen Volcanic National Park and Manzanita Dam.

Photographs below: Visiting Manzanita Dam (left) Shotcrete was placed to repair the 1910 era concrete in the Manzanita Lake Dam in order to reinforce and prevent leaking (right).



Stoney Gorge Dam, California.

The study tour continued with travel to Stoney Gorge Dam and Oroville Dam. Participants also enjoyed the famous Northern California Wine Country of Napa Valley and a visit to Lake Berryessa.



Lake Berryessa Glory Hole spillway.

The study tour concluded with a close-out dinner at the Firehouse Restaurant in Old Town Sacramento, California.



2008

The 2008 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held September 15-25, 2008, included 50 participants from multiple international agencies with 24 participating countries.

A study tour to the states of Colorado, Nevada, Idaho, and Utah focused on the dam safety program of Reclamation.



The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, Colorado, and Reclamation Offices at the Denver Federal Center. Participants toured the Technical Service Center Research Laboratory which included a concrete cylinder break. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.

The Study Tour began on September 20, 2008, with a bus tour of Rocky Mountain National Park.

September 21, 2008, participants traveled by air to Salt Lake City, Utah.



Prior to the site visit to A.V. Watkins Dam, participants were briefed on the damage from seepage in 2006.

Travel continued with an overnight stay in Idaho Falls, Idaho.



A presentation was given on the Teton Dam failure in 1976 and Reclamation's geomorphology and river hydraulics study during 1997-2000. Participants traveled to the Teton Dam site near Rexburg, Idaho to visit the Upper/Lower Mesa Falls.



Teton Dam near Rexburg, Idaho.



American Falls Dam, Idaho.

The study tour continued with travel to American Falls Dam where participants walked through an abbreviated exam.

The 2008 seminar concluded in Las Vegas, Nevada, with a VIP tour of Hoover Dam and a close-out dinner at the Tuscan Suites and Casino.



2009

The 2009 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held August 17-27, 2009, included 23 participants from multiple international agencies with 13 participating countries.

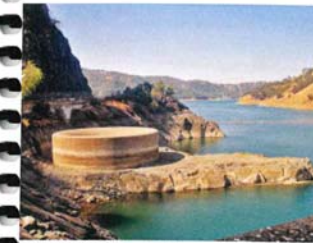


The first portion of the seminar consisted primarily of classroom presentations and discussions held at the Holiday Inn Denver West Hotel, Golden, and Reclamation Offices at the Denver Federal Center.



Participants toured the Technical Service Center Research Laboratory, which included a concrete cylinder break.

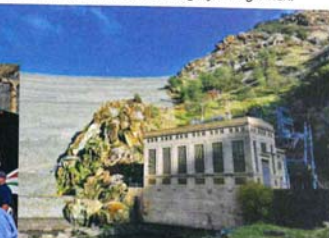
The study tour began with a tour of Rocky Mountain National Park and then travel by air to Sacramento, California. Site visits included Monticello Dam, Folsom Dam, New Melones Dam and B.F. Sisk (San Luis) Dam.



Monticello Dam - constructed between 1953 and 1957 and is notable for its classic, uncontrolled morning glory spillway - the largest in the world.



Folsom Dam - currently under construction, a new spillway is the key feature to improving Folsom's flood control ability. When completed, the spillway will operate in conjunction with Folsom Dam's spillway gates to release water earlier during an extreme storm, thus reducing hydrologic risk.



New Melones Dam - located 64 kilometers (40 miles) east of Stockton, California, is a rockfill dam. The dam and reservoir are operated and maintained by Reclamation as part of the Central Valley Project.



A special visit to Yosemite National Park was featured and participants enjoyed free time to explore the park.

On August 27, 2009, participants traveled to B.F. Sisk Dam and then continued on to San Francisco, California. The seminar and study tour concluded with a close out dinner at Annabelle's Bar and Bistro.

Yosemite National Park - one of the first wilderness parks in the United States, best known for its waterfalls.

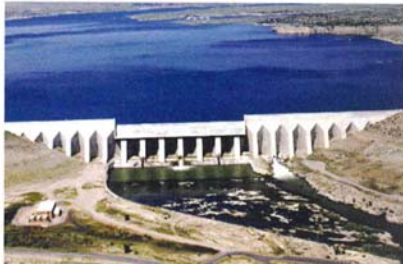
 **2010**

The 2010 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held August 23, 2010, – September 2, 2010, included 43 participants and 16 participating countries.



The first portion of the seminar was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center, and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of Reclamation's Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar.

The study tour began with travel by motorcoach to Pueblo Dam, Pueblo, Colorado, for a simulated examination, followed with travel to Gunnison, Colorado.



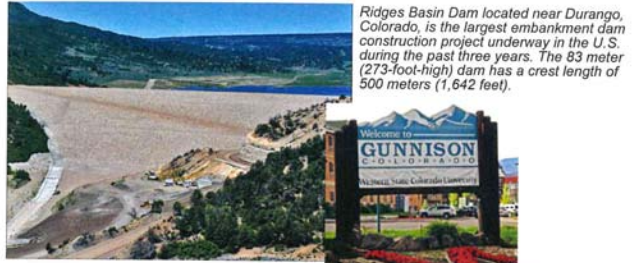
Pueblo Dam located on the Arkansas River about 10 kilometers (or 9.6km) (6-miles) upstream and west of the city of Pueblo, Colorado.

August 29, 2010, consisted of a site visit to Blue Mesa Dam travel to Durango, Colorado, with an overnight stay at the historic Strater Hotel. The study tour continued to Ridges Basin Dam followed by travel and an overnight stay in Cortez, Colorado.

Blue Mesa Dam is on the Gunnison river about 30 miles below Gunnison, and 1.5 miles below Sapinero, Colorado. The zoned earthfill embankment has a structural height of 390 feet, a crest length of 785 feet, and a volume of 3,080,000 cubic yards of materials.



The final days of the study tour took participants to Glen Canyon Dam, the Grand Canyon National Park and Hoover Dam. The seminar and study tour concluded with a close-out dinner at Maggiano's Little Italy.



Ridges Basin Dam located near Durango, Colorado, is the largest embankment dam construction project underway in the U.S. during the past three years. The 83 meter (273-foot-high) dam has a crest length of 500 meters (1,642 feet).



Glen Canyon Dam located in the state of Arizona, 24 kilometers (15 miles) upstream from Lees Ferry, is the key feature of the Colorado River Storage Project.

THANK YOU FOR VISITING GLEN CANYON DAM
Bureau of Reclamation Employees

 **2011**

The 2011 Safety Evaluation and Visual Inspection of Existing Dams International Technical Seminar and Study Tour held August 15-24, 2011, included 46 participants from multiple international agencies with 19 participating countries.

The first portion of the seminar, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center, and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. A field trip mid-week on August 17, 2011, took participants for site visits to Guernsey Dam and Glendo Dam, in Wyoming.

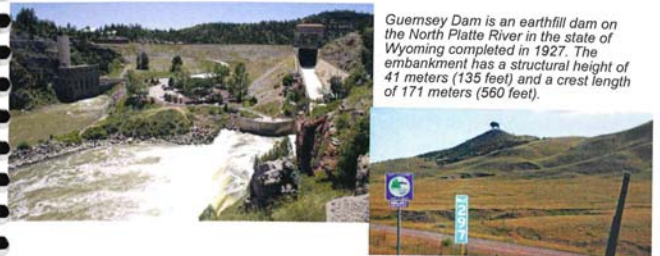


The study tour began with travel by air to Las Vegas, Nevada.

August 22, 2011, participants traveled to Boulder City, Nevada, and a VIP tour of Hoover Dam.



The study tour continued with travel by air to Spokane, Washington and a tour of Grand Coulee Dam and Powerplant. The seminar concluded with a close-out dinner at the Steam Plant Grill.



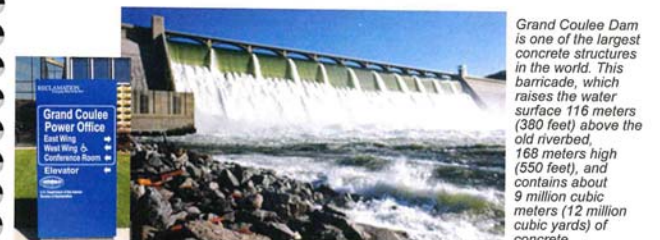
Guernsey Dam is an earthfill dam on the North Platte River in the state of Wyoming completed in 1927. The embankment has a structural height of 41 meters (135 feet) and a crest length of 171 meters (560 feet).



Glendo Dam is a zoned earthfill structure on the North Platte River about 6.4 kilometers (4 miles) southeast of Glendo, Wyoming completed in 1958. The embankment has a structural height of 58 meters (190 feet) and a crest length of 639 meters (2,096 feet).



Hoover Dam is a concrete arch-gravity dam in the Black Canyon of the Colorado River, on the border between the U.S. states of Nevada and Arizona.



Grand Coulee Dam is one of the largest concrete structures in the world. This barrage, which raises the water surface 116 meters (380 feet) above the old riverbed, 168 meters high (550 feet), and contains about 9 million cubic meters (12 million cubic yards) of concrete.

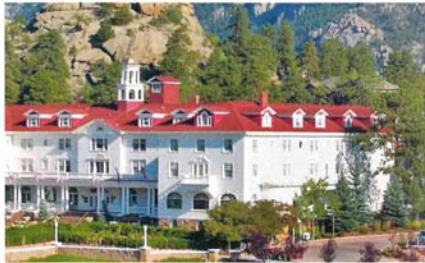
 **2012**

The 2012 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held August 20-27, 2012, included 17 participants from multiple international agencies with 11 participating countries.



The first portion of the seminar, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.

The study tour began on August 24, 2012, with site visits and simulated exams at Green Mountain Dam and Granby Dam. Participants then took a motorcoach tour of Rocky Mountain National Park with an overnight stay at the famous Stanley Hotel in Estes Park, Colorado.



Green Mountain Dam - Green Mountain Dam is on the western slope 21 kilometers (13 miles) southeast of Kremming, Colorado, on the Blue River, a tributary of the Colorado.



The study tour continued with travel by air to Las Vegas, Nevada. Participants enjoyed a VIP tour of Hoover Dam on August 27, 2011, and the seminar concluded with a close-out dinner at the Springhill Suites, Las Vegas, Nevada.



Granby Dam - Granby Dam is located on the Colorado River about 9.6 kilometers (6 miles) northeast of Granby, Colorado. It collects and stores most of the project water supply, including the flow of the Colorado River and water pumped from Willow Creek. There are 3,877 meters (12,722 feet) of auxiliary dikes. The reservoir has a capacity of 666 million cubic meters (539,800 acre-feet).



Hoover Dam - Hoover Dam and Lake Mead, spanning the Arizona-Nevada state line, are located in the Black Canyon of the Colorado River about 56 kilometers (35 miles) southeast of Las Vegas, Nevada. Built during the Depression; thousands of men and their families came to Black Canyon to tame the Colorado River. It took less than five years, in a harsh and barren land, to build the largest dam of its time. Now, years later, Hoover Dam still stands as a world-renowned structure. The Dam is a National Historic Landmark and has been rated by the American Society of Civil Engineers as one of America's Seven Modern Civil Engineering Wonders.

 **2013**

The 2013 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 11-18, 2013, included 18 participants from multiple international agencies with 7 participating countries.



The first portion of the seminar, June 11-14, 2013, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.

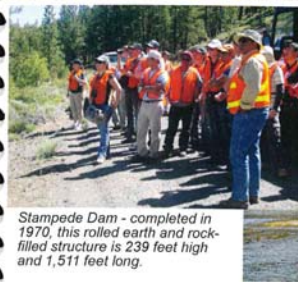


The study tour began with air travel to Reno, Nevada, and overnight stay at the Lake Tahoe Resort Hotel.

Site visits included Boca Dam and Stampede Dam, and a simulated examination at Prosser Creek Dam.



Boca Dam - completed in 1939 and has a height of 116 feet and a crest length of 1,630 feet. It provides flood protection for Reno and Sparks, Nevada.



Stampede Dam - completed in 1970, this rolled earth and rock-filled structure is 239 feet high and 1,511 feet long.



Top Left photograph: Nimbus Dam.



Bottom Left photograph: Mormon Island Auxiliary Dam.



Bottom Right photograph: Prosser Creek Dam site visit.

The Final day of the study tour featured site visits to Folsom Dam, Mormon Island Dam, and Nimbus Dam. The seminar concluded with a close-out dinner at the Delta King in Sacramento, California.

The 2014 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 9-16, 2014, included 32 participants from multiple international agencies with 13 participating countries.



The first portion of the seminar, June 9-12, 2014, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline

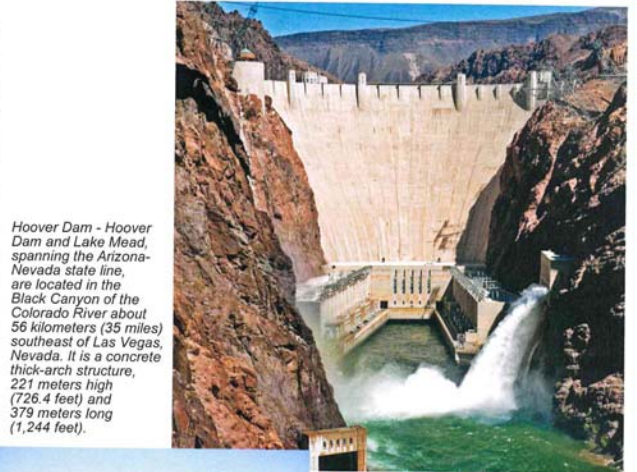


approach to an effective safety of dams program and prepare participants for the post session study tour.

The simulated exam was conducted at Pueblo Dam in Colorado.



The study tour concluded with air travel to Las Vegas, Nevada, and a VIP tour of Hoover Dam and a close-out luncheon.



Hoover Dam - Hoover Dam and Lake Mead, spanning the Arizona-Nevada state line, are located in the Black Canyon of the Colorado River about 56 kilometers (35 miles) southeast of Las Vegas, Nevada. It is a concrete thick-arch structure, 221 meters high (726.4 feet) and 379 meters long (1,244 feet).



The 2015 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 2-9, 2015, included 26 participants from multiple international agencies with 14 participating countries.



The first portion of the seminar, June 2-5, 2015, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.



The post session study tour took participants to the southern part of Colorado and included a special tour of the Black Canyon National Park.



Site visits included Ridgeway Dam, Silver Jack Dam, Morrow Point Dam and Blue Mesa Reservoir.

The 2015 study tour and seminar concluded with return travel back to Denver and a close-out dinner at Texas de Brazil.



Morrow Point Dam - 12 miles downstream from Blue Mesa Dam, Reclamation's first thin-arch, double-curvature dam.



Ridgeway Dam - Ridgeway Dam of the Dallas Creek Project, a rolled-earthfill dam was constructed on the Uncompahgre River in 1987.

Silver Jack Dam - Located on Cimarron Creek about 32 kilometers (20 miles) above the junction with the Gunnison River. The rolled-earthfill dam has a structural height of 53 meters (173 feet), a crest length of 320 meters (1,050 feet), and a volume of 97,390 cubic meters (1,278,140 cubic yards) of materials.



Blue Mesa Dam - Located on the Gunnison River about 48 miles (30 miles) below Gunnison. The zoned earthfill embankment has a structural height of 119 meters (390 feet), a crest length of 239 meters (785 feet), and a volume of 2,340,800 cubic meters (3,080,000 cubic yards) of materials.



2016

The 2016 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 6-15, 2016, included 36 participants from multiple international agencies with 9 participating countries.



The first portion of the seminar, June 6-9, 2016, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.



The study tour took participants to the Pacific Northwest Region of the United States. Participants traveled by air to Seattle, Washington and enjoyed the weekend exploring the international city of Seattle.



On June 12, 2016, participants traveled by motorcoach to Ellensburg, Washington. Site visits included Cle Elum Dam, Easton Diversion Dam, and a simulated examination at Kachess Dam, all part of Reclamation's Yakima Project.

The study tour concluded with a visit to Snoqualmie Fall, and close-out dinner.

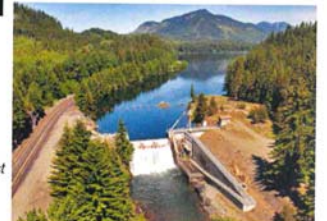


Site visit at Cle Elum Dam.



Site visit and simulated examination of Kachess Dam.

Easton Diversion Dam - located on the Yakima River near Easton, Washington, is a concrete gravity oggee weir, movable crest structure. This dam is 66 feet (20 meters) high and contains 5,800 cubic yards (4434 cubic meters) of concrete.



2017

The 2017 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 5-14, 2017, included 49 participants from multiple international agencies with 11 participating countries.



The first portion of the seminar, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar. Presentations, case histories, and a walk-through abbreviated examination were used to present the multi-discipline approach to an effective safety of dams program and prepare participants for the post session study tour.

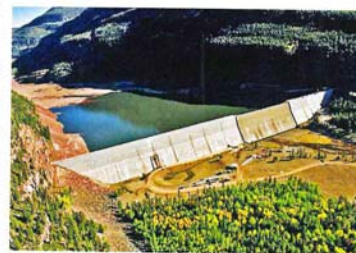
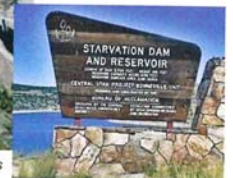
The study tour began on June 9, 2017, with a tour of Rocky Mountain National Park. Participants traveled by air to Salt Lake City, Utah, and then by motorcoach to Park City, Utah. Participants enjoyed a free day to explore beautiful Park City, home of the 2002 Winter Olympics.



June 12-13, 2017, consisted of site visits to Starvation Dam, Upper Stillwater Dam, Jordanelle Dam, Echo Dam, and East Canyon Dam, all part of Reclamation's Upper Colorado Region. The study tour and seminar concluded with travel to Las Vegas, Nevada, and a special tour of Hoover Dam.



Starvation Dam is a zoned earthfill dam located three miles northwest of Duchesne, Utah on the Strawberry River.



Upper Stillwater Dam is a roller compacted concrete gravity dam located on Rock Creek, about 31 miles northwest of Duchesne, Utah.

Jordanelle Dam and Reservoir, located on the Provo River about 6 miles north of Heber City.



The 2018 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour held June 4-12, 2018, included 33 participants from multiple international agencies with 12 participating countries.



The first portion of the seminar, was held in Denver, Colorado, at Reclamation Offices on the Denver Federal Center and consisted primarily of classroom presentations and discussions. Lectures, case histories, and structured discussions covering all aspects of a dam safety examination program were led by Reclamation engineers and geologists with extensive experience and knowledge in the areas of design, construction, operation, maintenance, and dam safety. A tour of the Technical Service Center Research Laboratories, including a concrete cylinder break was observed on the first day of the seminar.



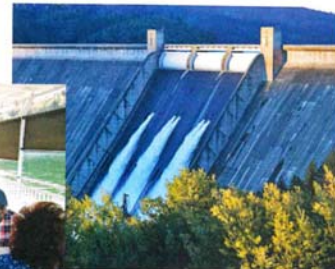
Participants traveled to Pueblo Dam, where Reclamation staff led an abbreviated simulated dam examination. The day ended with a BBQ dinner at Angela Medina's home.



The study tour began with a tour of Colorado's Rocky Mountain National Park.

Participants traveled by air to Sacramento, California. Site visits included Lewiston Dam, Trinity Dam, Keswick Dam and Shasta Dam, all part of the Central Valley Project, located in Reclamation's Mid-Pacific Region.

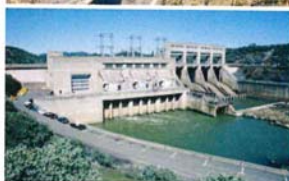
The seminar and study tour concluded with dinner and a tour of Lake Shasta.



Shasta Dam - located about nine miles northwest of Redding, California, on the Sacramento River.



Trinity Dam - located on the eastern Klamath plate, the oldest and easternmost of four eastward-dipping thrust sheets that comprise the Klamath Mountains province.



Lewiston Dam - built from 1960-1963 about 7 miles downstream from Trinity Dam.

Keswick Dam - constructed 9 miles downstream from Shasta Dam on the Sacramento River.

CELEBRATING 30 YEARS

The 2019 Safety Evaluation of Existing Dams International Technical Seminar and Study Tour, June 3-12, 2019, includes 44 participants from multiple international agencies with 12 participating countries.

In 2019 participants will go behind the scenes at many of Reclamation's most important projects. These include Pueblo Dam, which is just west of the city of Pueblo, Colorado, as well as New Waddell and Roosevelt Dams, which are both part of the Central Arizona and the Salt River Projects. The study tour will conclude with a VIP tour of the iconic Hoover Dam.



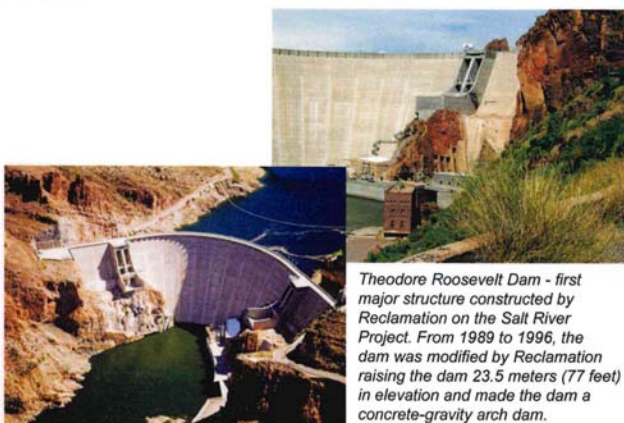
Trail Ridge Road in Rocky Mountain National Park.



Pueblo Dam - located on the Arkansas River in Pueblo County about 6 miles upstream and west of the city of Pueblo, Colorado.



New Waddell Dam - constructed between 1985 and 1994, stores Colorado River water for the Central Arizona Project, and also stores Agua Fria River runoff and provides flood protection by controlling river flows. The dam is on the Agua Fria River about 35 miles above the Gila River confluence and is located one-half mile downstream of the now submerged historic Waddell Dam.



Theodore Roosevelt Dam - first major structure constructed by Reclamation on the Salt River Project. From 1989 to 1996, the dam was modified by Reclamation raising the dam 23.5 meters (77 feet) in elevation and made the dam a concrete-gravity arch dam.