

In the United States Court of Federal Claims

Sub-Master Docket No. 17-9001L

(Filed: December 17, 2019)

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IN RE UPSTREAM ADDICKS AND)	Post-trial decision; government-induced
BARKER (TEXAS) FLOOD-)	flooding on private property; application of
CONTROL RESERVOIRS)	factors identified in <i>Arkansas Game &</i>
*****)	<i>Fish</i> ; liability for a taking of a flowage
THIS DOCUMENT APPLIES TO:)	easement
)	
ALL UPSTREAM CASES)	
)	
*****)	

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OPINION AND ORDER

LETTOW, Senior Judge.

This case brings to the court the occasionally recurring question of the extent and the nature of government-induced flooding on private property necessary to rise to the level of a Fifth Amendment taking of a flowage easement. Particularly, this post-trial decision assesses whether the government may be liable to private property owners in the Houston, Texas

metropolitan area for takings compensation following Tropical Storm Harvey.¹ Thirteen property owners were selected to serve as bellwethers for the hundreds of property owners who have filed suit raising similar claims against the government.

After making landfall in August 2017, Tropical Storm Harvey (“Harvey”) doused Houston with an average of 33.7 inches of rain over a four-day period. Many properties, including over 150,000 homes, flooded during the storm. Those affected included private property owners within the Addicks and Barker Reservoirs, west of Houston, upstream of the federally designed, built, and maintained Addicks and Barker Dams. During Harvey, the Addicks and Barker Dams collected storm water in their respective reservoirs causing properties within the reservoir to flood from the impounded water. At issue in this bellwether trial is the liability of the government under the Tucker Act, 28 U.S.C. § 1491, and the Takings Clause of the Fifth Amendment of the Constitution, for the damage to thirteen of these properties.²

The thirteen bellwether properties are representative of the hundreds of owners of “upstream” properties who brought suit against the United States in this court after Harvey. The property owners claimed that the United States was liable to them for an uncompensated taking, that is, the government-controlled inundation of their properties by the impounded floodwater from Harvey. The first complaint relating to Harvey and the Addicks and Barker Dams was filed on September 5, 2017. *See Y and J Props., Ltd. v. United States*, No. 17-1189L. Hundreds of such cases followed. Using case management techniques comparable to those employed in multi-district litigation, the Chief Judge of the court issued Management Order No. 1, consolidating these cases, and all related later-filed cases, within one master docket. *See In re Addicks and Barker (Texas) Flood-Control Reservoirs*, No. 17-3000L; *Y and J Props., Ltd. v. United States*, 134 Fed. Cl. 534 (2017). The Chief Judge then bifurcated the issues of liability and damages, initially setting a schedule to deal with liability. *See Order Regarding Judicial Assignment and Scheduling* (Nov. 20, 2017), Master Docket No. 17-3000L, ECF No. 70. Subsequently, the Chief Judge divided the Master Docket into two sub-master dockets, *see In re Addicks and Barker (Texas) Flood-Control Reservoirs v. United States*, No. 17-3000L, 2017 WL 6334791 (Fed. Cl. Dec. 5, 2017)—one for downstream properties, *In re Downstream Addicks and Barker (Texas) Flood-Control Reservoirs*, Sub-Master Docket No. 17-9002L, and, pertinent here, one for upstream properties, *In re Upstream Addicks and Barker (Texas) Flood-Control Reservoirs*, Sub-Master Docket No. 17-9001L.

¹When Harvey first made landfall on the Texas mainland on August 26, 2017, it was classified as a Category 4 hurricane. *See* Eric S. Blake & David A. Zelinsky, Nat’l Hurricane Center, *Tropical Cyclone Report: Hurricane Harvey* 3 (January 23, 2018), available at <https://www.hssl.org/?view&did=807581>. But “Harvey rapidly weakened over land to a tropical storm” within the first twelve hours and to a tropical depression by August 30, 2017. *Id.* Because the majority of the five-day downpour that the Houston area experienced coincided with *Tropical Storm Harvey*, the opinion will use this designation.

²The named defendant, the United States, is representative of all relevant government actors, including the United States Army Corps of Engineers (the “Corps”). Thus, references to the “United States,” the “government,” and the “Corps” all refer to defendant and its collective entities and actions.

Since the division, proceedings have moved apace in the upstream docket. In the spring of 2018, thirteen plaintiff properties were designated to serve as bellwethers for the cases.³ In February 2018, the government filed a motion to dismiss under the Rules of the Court of Federal Claims (“RCFC”) 12(b)(1) for lack of subject-matter jurisdiction and 12(b)(6) for failure to state a claim upon which relief can be granted. *See* Motion to Dismiss (Feb. 16, 2018), Sub-Master Docket No. 17-9001L, ECF No. 59. Although the court made some preliminary rulings in addressing that motion, resolution of the government’s motion to dismiss was deferred until trial, pursuant to the court’s authority under RCFC 12(i), in light of the fact-intensive inquiry this case required. *See In re Upstream Addicks and Barker (Texas) Flood-Control Reservoirs*, 138 Fed. Cl. 658, 672 (2018).

A ten-day trial was held in Houston, Texas, commencing on May 6, 2019, regarding the liability of the United States for the thirteen test properties. During the course of trial, on the afternoon of May 8, 2019, the court conducted a site visit of the dams that included the spillways and end points of both dams as well as the drainage canals that feed into the reservoirs, as well as seven of the test properties. Following post-trial briefing, *see* Plaintiffs’ Post Trial Brief (“Pls.’ Br.”), ECF No. 235; Defendant’s Post Trial Brief (“Def.’s Br.”), ECF No. 242; Plaintiffs’ Post Trial Brief Reply (“Pls.’ Reply”), ECF No. 246, the court heard closing arguments on September 13, 2019, in Washington, D.C. The issue of liability pertaining to the thirteen test properties and the government’s motion to dismiss are ready for disposition.

Overall, based on the facts and circumstances at hand, the government’s motion to dismiss is denied and the court finds the government to be liable for a taking of a flowage easement on the properties.

FACTS⁴

A. The Addicks & Barker Flood Control Project

1. The impetus for flood control measures.

Buffalo Bayou originates in eastern Waller County and western Harris County and flows in a generally eastward direction through a circuitous channel approximately 75 miles long.

³Originally, the court directed the parties to come to an agreement on ten test properties. *See* Case Mgmt. Order (Feb. 1, 2018) at 2-3, Sub-Master Docket No. 17-9001L, ECF No. 37. At the behest of the parties, the number was later increased to fourteen properties. *See* Order Approving Test Prop. Selection (Mar. 13, 2018), Sub-Master Docket No. 17-9001L, ECF No. 91. One of these fourteen plaintiffs voluntarily dismissed his suit, *see* Notice of Voluntary Dismissal (Aug. 24, 2018), Sub-Master Docket No. 17-9001L, ECF No. 136, and therefore thirteen plaintiff test properties remain.

⁴This recitation of facts constitutes the court’s principal findings of fact in accord with RCFC 52(a). Other findings of fact and rulings on questions of mixed fact and law are set out in the analysis.

Joint Stip. ¶ 84.⁵ After its confluence with South Mayde Creek in western Harris County, the bayou winds through downtown Houston, where it converges with the White Oak Bayou and continues east, eventually reaching the Houston Ship Channel and pouring into San Jacinto Bay, Galveston Bay, and the Gulf of Mexico. Joint Stip. ¶¶ 84, 85. The city of Houston is situated at the confluence of the two bayous and at the base of a fan-shaped system of streams that flow through a flat and “almost featureless plain,” contributing to the creation of a major flood hazard in the region. JX5 at 4.⁶ For much of the year, little or no water flows through the narrow streams in the Buffalo Bayou watershed, but during heavy rainfall the small stream channels cannot hold the water and “a general overflow along the banks” results. JX5 at 5. The soil composition in the region and the foliage it supports do not allow much water seepage and result in exceedingly poor natural percolation and drainage. *See id.* at 4-5. Close proximity to the Gulf of Mexico yields regular hurricanes and tropical storms, rendering the region susceptible to especially heavy rainfall events and attendant flooding. *See Tr.* at 614:7-23 (Test. of Jeff Lindner).⁷ Due to this combination of factors, between 1854 and 1935 six major floods occurred in the Buffalo Bayou watershed, including the City of Houston. JX5 at 6. Two particular storms and the flood devastation they created, one in May 1929 and the other in December 1935, prompted congressional action that led to the construction of the Addicks and Barker Dams. Joint Stip. ¶ 81.

In May 1929, a storm (“the 1929 storm”) produced rainfall ranging from six to twelve inches over the White Oak Bayou and Buffalo Bayou basins, causing flooding in downtown Houston and resulting in property damage within the city of \$1,392,000. Joint Stip. ¶ 82. About six years later, in December 1935, another storm (“the 1935 storm”) produced three days of rainfall dropping approximately fifteen inches throughout the basin. Joint Stip. ¶ 83. That storm generated flooding that killed eight people and caused property damage estimated at \$2,528,000. Joint Stip. ¶ 83.

The real possibility of a storm even larger than these events raised serious concern. The Corps noted in its 1940 Definite Project Report about the then-proposed dams that the Buffalo Bayou watershed was situated “in an area subject to all of the circumstances making possible large storms.” JX5 at 7.⁸ That same report stated that had the 1935 storm centered directly over

⁵On April 23, 2019, the parties entered into stipulations of fact “for the purposes of the trial of the thirteen claims in the Upstream Sub-Docket only, and [specifying that the stipulations] are not intended to be binding as to any other claim that falls within Master Docket No. 17-3000L, the Upstream Sub-Docket No. 17-9001L, or the Downstream Docket No. 17-9002L, or in any other action or proceeding.” Stipulations of Fact for Trial at 1, ECF No. 211. The stipulations number 116 and will be cited as “Joint Stip.” followed by the paragraph number.

⁶Citations to plaintiffs’ exhibits are identified as “PX___,” defendant’s exhibits are identified as “DX___,” and the parties’ joint exhibits are identified as “JX___.”

⁷The transcript of the trial will be cited as “Tr. ___:___;” showing the pertinent page and line number and the name of the pertinent witness.

⁸The Definite Project Report was issued in 1940 in connection with plans to construct the Addicks and Barker Dams.

the basin—rather than where it did over Westfield, Texas, about eighteen miles from Houston—it would have resulted in even more severe flooding. *See id.* Nor was there any “evident meteorological reason why the storm could not have centered over the basin.” *Id.* It was also recognized at the time that, due to the topographic and meteorological features of the region, any flood control system constructed for Houston could be subjected to storms equal to any of record in Texas, and greatly in excess of any so far experienced over the basin. *See id.* “[O]nly chance,” the Corps observed, had “prevented the occurrence of a storm over the basin much larger than the 1935 storm.” *Id.* The largest rainfall of record in the United States at the time Addicks and Barker were constructed occurred only ninety miles northwest of Houston at Hearne, Texas in 1899—under meteorological conditions that the Corps noted “could be approximated closely over the Buffalo Bayou watershed.” *Id.* The Hearne storm generated a maximum 31.4 inches of rain in a period of three days, with an average depth over an area of 1,000 square miles of 25.8 inches. PX777 at 4. A hydrology report prepared by the Corps in 1938 concluded that the 1899 Hearne storm was the “maximum probable storm” that might arise over the Buffalo Bayou watershed, also noting that should such a storm occur the average rainfall would be “almost twice the average of 15 inches that produced the record flood of 1935.” JX5 at 8. While conceding that the probability of the occurrence of a storm as severe as the Hearne storm in the Buffalo Bayou basin was “very remote,” the Corps also noted in its Definite Project Report that “ultimate protection against such a storm is desirable” though perhaps not feasible in “the initial stage” of flood control construction. *Id.* at 9-10. Without flood control measures, the Corps predicted “[c]onsiderable overflow” from storms that would produce “disastrous peak flows.” *Id.* at 8.

Another storm that occurred at Taylor, Texas in 1921 (“the Taylor storm”) constituted the greatest single-day rainfall ever recorded in the United States at that time, producing 23.11 inches in 24 hours. PX777 at 4. The Taylor storm did not cover as large an area as the Hearne storm, but the rainfall was more intense over a shorter period of time and the Corps noted in the 1940s that such depths of accumulated rain over a basin as small as Buffalo Bayou would be considerable. *Id.* at 5.

Against this background, Congress acted to initiate the implementation of flood control measures. Pursuant to the River and Harbor Act of 1938, Congress authorized the Corps to design and build the Addicks and Barker Dams as part of the Buffalo Bayou and Tributaries, Texas Project. *See* Pub. L. No. 75-685, 52 Stat. 802 (codified mainly at 33 U.S.C. §§ 540, 558(b), 558(c), 571, 701(k)). The purpose of the project, as defined by the Corps’ Definite Project Report published on June 1, 1940, was “to provide for complete control of floods on the Buffalo Bayou watershed and the protection of the city of Houston, Texas, and the Houston Ship Channel against the estimated probable maximum storm.” JX5 at 3.

At critical junctures in the ensuing lifespan of the dams, the Corps consistently echoed that the whole purpose for the construction and operation of the project was to prevent downstream flooding, especially in downtown Houston. *See, e.g.,* PX59 at 8 (USACE464077) (“The sole authorized purpose for [the] Addicks and Barker Reservoirs is to reduce potential flood damage along the downstream reach of Buffalo Bayou.”); PX59 at 21 (USACE464090) (“The dams are operated strictly to prevent downstream flooding.”); JX110 at 3-1 (USACE016311) (“The existing project, as authorized, provides for flood risk management, the protection of the City of Houston from flood damages, and the prevention of excessive velocities and silt deposits in the Houston Ship Channel Turning Basin.”).

2. *Project design.*

The original design of the project consisted of three detention reservoirs, a system of canals and levees, and channel improvements along Buffalo Bayou below the reservoirs. *See* JX5 at 12-13. The three detention reservoirs were to be built on White Oak Bayou and at the Addicks and Barker watersheds on Buffalo Bayou, which are seventeen miles west of downtown Houston and upstream of the confluence of Buffalo Bayou and South Mayde Creek. *Id.*; Joint Stip. ¶ 100. The Barker Dam would be located on Buffalo Bayou about 1.5 miles above its confluence with South Mayde Creek and the Addicks Dam would be located on South Mayde Creek about one mile above its confluence with Buffalo Bayou. *See* JX110 at 4-1 (USACE016316). North of and adjacent to the Addicks Reservoir watershed lies the 130 square mile watershed of Cypress Creek, which flows in an eastward direction toward its outlet into the San Jacinto River. *See id.* To prevent overflow from the Cypress Creek watershed into the Addicks Reservoir, an upstream levee was to be built. JX5 at 13. Additionally, approximately 7.4 miles of the Buffalo Bayou channel immediately downstream of the Addicks and Barker Dams was to be rectified and enlarged. JX110 at 3-3 (USACE016313). This channel rectification and enlargement was completed in 1948. *Id.*

Aspects of the original design, however, were not completed. Tr. 473:8-18 (Test. of Robert Charles Thomas, III). Neither the detention reservoir on White Oak Bayou nor the Cypress Creek levee were ever built, nor was a south canal that would divert the surcharge releases into the Houston Ship Channel. Tr. 191:16 to 193:5 (Thomas). Notably, the failure to complete the reservoir on White Oak Bayou has apparently had little effect on the Addicks and Barker Reservoirs, *see* Tr. 193:19-21 (May 6, 2019) (Thomas), but because the Cypress Creek levee was never completed, run-off can still flow from the Cypress Creek watershed into the Addicks watershed during major rain events, increasing the size of the flood pool in the Addicks reservoir, *see* Tr. 1539:3-11 (Test. of Richard Long). And, importantly, the deletion of the south diversion canal was also a major change from the original design because surcharge releases from the Addicks and Barker Reservoirs now have no place to go except down Buffalo Bayou or in the reservoirs themselves. Tr. 193:23 to 194:7 (Thomas).

The completed Addicks and Barker Dams are parallel u-shaped earthen embankments that rise almost imperceptibly over a distance of miles. *See* JX15 at 9-10 (noting that the Addicks and Barker embankments slope at a rate of about two to seven feet per mile). The size of the reservoir embankments was determined by reference to the rainfall produced by two previous storms: the Hearne storm and the Taylor storm. The Hearne storm, modified to account for the rainfall intensity rates in the Taylor storm, was used as “a basis of design,” the so-called “design storm.” PX777 at 5. The design storm would produce a maximum rainfall depth of 31.4 inches and served as the basis for the specifications of the dams that were ultimately constructed—meaning that the dams were built to contain the amount of water the design storm was projected to produce. *Id.*

Construction on the Barker Dam and Reservoir began in February 1942 and finished in February 1945. Joint Stip. ¶ 95. The Barker Dam consists of an earthen embankment that measures approximately 13.6 miles long and rises 36.5 feet above the stream bed at its highest point. Joint Stip. ¶ 97; JX23 at 3 (USACE318524). Its outlet at the time of completion consisted of five conduits which were 9-feet wide by 7-feet high and 190.5-feet long. JX23 at 3 (USACE318524). The Corps began construction on the Addicks Dam, located just north of the

Barker Dam, in May 1946. Joint Stip. ¶ 90. Completed in December 1948, the Addicks Dam consists of an earthen embankment that measures approximately 11.6 miles long and rises 48.5 feet above the stream bed at its highest point. Joint Stip. ¶¶ 90, 92; JX23 at 3 (USACE318524). When completed, its outlet consisted of five conduits which were 8-feet wide by 6-feet high and 252-feet long. JX23 at 3 (USACE318524). The dams were designed to release water through these outlet conduits, which could be controlled by gating, making it possible to limit discharges from the reservoirs and thereby reduce downstream flooding. JX22 at 1-2. The original design of both dams called for four of the five outlet conduits to be uncontrolled. *Id.*

Importantly, the embankment design of the Addicks and Barker Dams required the government to acquire land behind (upstream of) the dams, thus partitioning off the reservoirs that would hold the water held back by the dams. Behind the Addicks Dam, the United States acquired all land at and below an elevation of approximately 103 feet, which amounts to about 12,460 acres of property. Joint Stip. ¶¶ 94, 102. For the Barker Dam, the government acquired all land at and below an elevation of approximately 95 feet, amounting to 12,060 acres. Joint Stip. ¶¶ 99, 104. The Corps calculated the amount of land it purchased behind each dam by adding “[three] feet above the pools which would be produced by the 1935 storm transposed over each watershed.” JX5 at 26. At the time, the property behind the dams was almost exclusively used for ranching and rice farming. *See* Tr. 455:4-19 (Thomas). The government purchased much of it at prices between five to ten dollars per acre, and “[m]ore lands could have been purchased upstream for reservoir storage at relatively low prices, but urban development was not anticipated in this baron [*sic*] prairie land remote from Houston.” JX52 at 17 (USACE015146).

Significantly, the Corps calculated the amount of land it purchased based on a historical storm metric (the 1935 storm) that was different—and, notably, smaller—than the design storm metric (which combined the Hearne and Taylor storms) it used for engineering the dam embankments. *See* Tr. 199:12 to 200:25 (Thomas). In other words, the embankment design storm would generate more water than would the land-acquisition model storm. Put simply, the dams were designed to contain more water than the acquired land could hold. These differing metrics were not an oversight; rather, they were driven by a calculated decision. The Corps noted at the time that storms of intensities similar to the 1935 storm—which was used for calculating the land acquisition—were “expected” to “occur several times during the lives of these structures.” JX5 at 26. While observing that the land purchased was inadequate to contain the pool elevation which would be produced by the embankments’ design storm, it noted that “[a]lthough the design of the embankments is based upon the design storm rainfall of 31.4 inches, the occurrence of such a storm in the basin [can not] be expected to occur more than once in the lives of these structures.” *Id.* The Corps viewed the Hearne storm as representing the upper limit of possible storms that could occur in the region, *see* Tr. 1029:13-20 (Thomas), so when setting the land acquisition line it looked for a large storm “but not the worst ever, because [then the Corps] wouldn’t be able to afford all [its] projects,” Tr. 1060:22-25 (Thomas). If, however, the Corps did not design the project to survive the upper limit storm and such a storm did occur, it would create the possibility that the dams “could [] fill[] all the way up and catastrophically fail[].” Tr. 1061:7-10 (Thomas). While the Corps designed the project consistent with a much larger design storm, it considered it “unnecessary to acquire lands to the pool elevation which would be produced by the design storm.” JX5 at 26.

Several documents dating from 1938 provide further insight into the Corps' contemporary understanding of the likely recurrence of a storm akin to the Hearne storm.⁹ In one document evaluating an alternative flood control project that was never authorized or built (the so-called Triple Corridor Plan), the Corps observed that "[t]ransposition of [the Hearne storm] to the Houston area does not appear to be unreasonable" because such a storm "has already occurred but a short distance away." Pls.' Mot. to Reopen the Trial R. Ex. A at USACE2019_0000014. The Corps stated that it considered such a storm "likely to occur with a frequency of once every 50 years." *Id.*¹⁰ Likewise, the Galveston District engineer's office, in another of these 1938 documents, recognized that the primary meteorological criteria required for the occurrence of significant storms were satisfied in the Houston area, cautioning that "the susceptibility of the Buffalo Bayou area to a storm as great as the 1899 storm must be considered in designing any flood control works in the Houston area." *Id.* Ex. B at USACE2019_0000252.

Ultimately, in 1940, after conducting a cost-benefit analysis, *see generally* JX52, the Corps concluded that "[a]cquisition to a taking-line, [three] feet above the computed pool elevations for the 1935 storm centered above each reservoir, [wa]s considered advisable, since the savings in annual interest would be in excess of the probable damage from storms producing

⁹These documents did not come to light until several months after trial, through no apparent fault of either party. When they were discovered, the Department of Justice transmitted the documents to plaintiffs in the interest of transparency, all the while maintaining that it was not legally obligated to do so. Upon receipt, plaintiffs moved to reopen the trial record to include the documents as additional evidence. *See* Pls.' Mot. to Reopen the Trial R. to Include Additional Evidence from Late-Produced Documents, ECF No. 245 ("Pls.' Mot. to Reopen the Trial R."). The government opposed the motion, asserting that these documents had not been sought during discovery and that they lacked probative value because they concerned a flood control plan that was never authorized or constructed and were preliminary parts of an iterative review and analysis process. *See* Def.'s Opp'n to Pls.' Mot. to Reopen the Trial R. to Include Additional Evidence at 4-5, ECF No. 254 ("Def.'s Opp'n to Mot. to Reopen the Trial R."). The government also moved contingently, if the court were to admit the documents, that the court also admit a sworn statement of Mr. Robert Thomas providing "critical context" for the documents. Def.'s Opp'n to Mot. to Reopen the Trial R. at 2.

The decision of whether to reopen the record to submit additional proof is within the trial court's discretion. *See Zenith Radio Corp. v. Hazeltine Research, Inc.*, 401 U.S. 321, 331 (1971); *Confederated Tribes of the Warm Springs Reservation of Or. v. United States*, 101 Fed. Appx. 818, 822 (Fed. Cir. 2004). Upon consideration of the probative value of the evidence and the circumstances of its identification, the court GRANTS plaintiffs' motion to include the additional evidence. To prevent any undue prejudice, defendant's motion to admit the statement of Mr. Thomas providing context for the documents is also GRANTED.

¹⁰As noted in the statement of Mr. Thomas regarding these documents, this 50-year prediction as used by the Corps at the time does not necessarily refer to the expected return frequency of the storm, but to the 50-year planning horizon for the project. In other words, it means that the Corps believed the Hearne storm "was the worst rainfall that could occur during the 50-year planning horizon for the [Triple Corridor Plan] project." Def.'s Opp'n to Mot. to Reopen the Trial R. Ex. A ¶ 11.

pools greater than the taking-line limits,” JX5 at 26-27. The decision to acquire less land than that required to store the runoff contained and controlled by the dams was “considered an acceptable low-frequency risk because of the relatively remote rural project location.” JX52 at 5 (USACE015134). Thus, the Corps based its land-purchase decision, at least in part, on a calculation that “the expected damages of inundating pastures and rice fields” would be less than the cost of buying additional land. Tr. 200:21-24 (Thomas).

After its initial land purchase based on the 1935 storm calculations, the government made one last additional purchase at some time before 1945 during the preconstruction planning for the Addicks Dam. JX22 at 2. By that time, it had become evident that the levee on Cypress Creek would not be built, and the Corps determined that it would “be more economical to increase the capacity of Addicks Reservoir to accommodate Cypress Creek overflow and delete the diversion levee.” *Id.* To that end, the Corps acquired an additional three to four vertical feet of property in the Addicks watershed to contain the anticipated overflow from Cypress Creek. *See* Tr. 474:11 to 475:7 (Thomas).

B. Post-Construction Improvements and Operations

1. Dam modifications, evaluations, and safety reviews.

a. 1940s, 1950s, and 1960s: Additional gates added to both dams.

Due to development in the Houston area and opposition concerned with aesthetic effects, the original plans for the south discharge canal were shelved and the canal was not constructed. *See* JX22 at 2; PX42 at 1-2 (USACE541550-1); *see also* Tr. 208:4-11 (Thomas). This led to concerns about a potential flood threat in downtown Houston, as the area adjacent to Buffalo Bayou saw significant urban development during the 1940s and 1950s, and the Bayou could no longer sustain a large uncontrolled flow without flooding. *See* JX22 at 2. The original design of the Addicks and Barker Dams called for the inclusion of five outlet conduits at each dam, with four of the five allowing uncontrolled water flows. JX22 at 1-2. The fifth conduit was controlled using a gate included originally for emergency purposes. Tr. 197:20 to 198:6 (Thomas). With four conduits uncontrolled on each reservoir, a combined uncontrolled discharge of about 15,700 cubic feet per second would flow into Buffalo Bayou. JX44 at 4. To alleviate what appeared at the time to be temporarily, any possible resulting issues in Buffalo Bayou, two additional gates were installed on the conduits, marking a total of three gated conduits out of five in each reservoir. *See* JX22 at 2-3. By the time these additional gates were installed in 1949, the combined uncontrolled discharge from the reservoirs in the four total remaining conduits was 7,900 cubic feet per second, which was considered to be the maximum channel capacity at the time for Buffalo Bayou. *See* JX44 at 4; JX16 at 4. Additional development around Buffalo Bayou led to a lower calculated maximum channel capacity, and as a result, the two remaining uncontrolled conduits in each reservoir were gated in 1963. *See* JX22 at 2; JX16 at 4. This gating, while beneficial for the downstream protection of downtown Houston, also forces the prolonged storage of water in the reservoirs and increases each

reservoir's pool size. *See* JX15 at 44; JX16 at 4.¹¹ After all the gates were added, the Corps calculated that the maximum design spillway in Addicks and Barker was 114.6 feet (Addicks) and 106.4 feet (Barker), exceeding the government-owned land by 6.6 vertical feet in Addicks and 8.1 vertical feet in Barker. *See* JX16 at 1.

b. 1970s: Land development, outgrants, and increased concerns.

“Beginning in the late 1970’s, private land developers upstream from the reservoirs sought permission to extend channel improvements onto [government-owned land].” JX52 at 15 (USACE015144). Around 1981, the Corps began granting several of these easement requests, limited to a maximum flow capacity. *Id.* Presently, several upstream tributaries flow into Addicks and Barker extending onto government-owned land as a means to facilitate the movement of water off upstream property. Tr. 383:9-15 (Thomas); Tr. at 868:20-23 (Test. of Johnson-Muic). These easements—known as “outgrants”—while beneficial to the development of the upstream area generally, had a number of negative consequences for the Addicks and Barker Reservoirs. These effects included: (1) “increase[d] [] inflow of sediment into the reservoirs resulting in the loss of flood storage capacity,” JX52 at 15 (USACE015144); (2) “faster flood runoff into the reservoirs . . . [that] would result in more frequent impoundments,” *id.* at 16 (USACE015145); (3) “larger impoundments,” *id.*; and (4) “increase[d] flood damages resulting from reservoir impoundments,” *id.*

As one consequence of the outgrants, the late 1970s and early 1980s saw the beginning of rapid urbanization in the upstream areas, as the population of the Houston metropolitan area grew. The character of the land upstream of the Addicks and Barker Dams was beginning to shift from that of barren grazing lands and rice fields to a more urban-suburban development. *See generally* JX52 at 17 (reporting in 1995 how over the last 50 years, “extensive urbanization has occurred” in the upstream area). Additionally, scientific advances in hydrology and meteorology prompted the Corps to issue new policies and procedures pertaining to the determination of spillway capacities. *See generally* PX34 (referencing updated criteria such as 1966 Engineer Circular No. 1110-2-22).

These developments, *i.e.*, advances in science, changing meteorological forecasts, general wear and tear on the reservoirs, and upstream urbanization, collectively raised concerns with the Corps that flooding beyond the extent of government-owned land was highly probable, if not inevitable, during a severe storm. In 1973, the Corps lamented that the possibility of flooding lands in the reservoirs beyond the government-owned land was soon expected to become a public issue. *See* PX37 at 1. In a 1973 memorandum from the Corps’ Engineering Division Chief in the Galveston, Texas area, the Chief noted, “It is suggested that the project engineer research the background of the existing situation and develop a history and rationale for our operating concept of imposing flooding on private lands without benefit of flowage easement or other legal right.” *Id.* A 1974 Corps inspection report echoed similar thoughts. *See* PX38 at 5 (USACE233674) (1974 Buffalo Bayou Inspection Report) (“Development of the area will eventually place the Government in the position of having to flood the area within the reservoir

¹¹The Corps, in a 1960 study, had even recommended not adding additional gates, noting that “[t]hese gates would only provide a negligible amount of increased flood protection” and “would have more undesirable effects than benefits.” JX15 at 44.

with the accompanying damages in order to protect downstream improvements in the event of a severe future storm.”).

c. Late 1970s: Hydrology investigation.

Based upon the increased scrutiny, the Corps completed an extensive hydrology study on Addicks and Barker in 1977. *See* JX23 (1977 Hydrology Report). The study was deemed necessary “because it [was] apparent that urbanization of the subject watersheds will soon reach levels in excess of those considered in the original design[,] and updated hydrologic criteria prescribe more severe design standards than those addressed in the original.” *Id.* at 1 (USACE318522). The 1977 report calculated a dramatic increase to the maximum design spillway, *see* Tr. 497:15-21 (Thomas), and developed a higher probable maximum precipitation value, *see* Tr. 499:8 to 500:2 (Thomas). Both of these circumstances reflect the notion that then-current calculations (in 1977) for the possible amount of rain in the Addicks and Barker watershed and the potential size of the reservoir pools in each dam were significantly higher than originally calculated when the dams were built. The report also revealed serious safety issues with the dams, putting both upstream and downstream properties at risk. *See* Tr. 257:21 to 258:1 (Thomas).

d. 1980s: Embankment strengthening & dam modifications.

These concerns led the Corps to consider various measures. The first major modification of the dams came as a result of the permanence of the conduit gates. The Corps noted that one negative result of the added conduit gates was the prolonged storage of rainfall runoff behind the dams that resulted in the need for “emergency seepage control measures” at the pervious sections of the embankments and foundations of the dams. JX44 at 4. This seepage threatened the stability of the embankments and created a potential for failure of the dams in the event of a high reservoir pool. JX15 at 44. Emergency modifications to strengthen the embankments of the reservoirs were completed between 1977 and 1979. JX44 at 4. These improvements, however, were not the final time the embankments were modified.

Around the time of the completion of the improvements addressing seepage, the Corps’ concerns about the current embankment heights as not “safe” in both Addicks and Barker grew. PX42 (1978 Water Control Plan) at 1 (USACE541550). Specifically, the report noted that a recent study showed that “the spillway design flood would overtop the dam embankment with possible embankment failure” for both Addicks and Barker. PX42 at 2 (USACE541551) (Addicks), 2 (USACE541562) (Barker). Additionally, the report noted that scientific advances showed an even higher increased maximum size for the reservoir pool in each reservoir, both of which would exceed the reservoirs’ respective capacities. *Id.* (explaining that a reservoir pool of 118.1 feet was possible under existing conditions in Addicks and a pool of 110.3 feet was possible under existing conditions in Barker).

In the 1980s, the Corps considered a number of potential solutions to address these concerns. Seventeen alternative plans were considered, seven of which were developed more thoroughly. *See* PX51 at 5 (USACE013572) (1984 General Design Memorandum). These options included taking no action, degrading the ends of the dams to reduce maximum flood pools, diverting water to other channels, and raising and extending the embankments to impound more water. *Id.* Plan I, which consisted of increasing the existing spillway capacities and raising

low portions of the dam crests, was recommended first, *see* JX26 (1980 Corps Mem.), and included a plan to consider the purchase of real estate upstream of the reservoirs, *see id.* The Corps, however, deferred any decision to purchase upstream real estate. *See* PX48 (1980 Corps Telephone Record).

Consistent with the original purpose of the project, a 1981 Corps environmental assessment highlighted the Corps' focus on alleviating the risk for *downstream* flooding. *See generally* PX87. Emphasizing the great risk downstream to Houston, the report deemphasized the upstream risk by simply noting that "should this [standard size] storm occur, flooding would extend beyond the [g]overnment owned land upstream of the embankments." PX87 at 4 (USACE012909). The report also explained that "[t]he inadequacy of [g]overnment owned land upstream . . . to contain the water from the [standard size storm] was recognized in the original design of the reservoirs. However, it was considered at the time to be a limited problem, because the land's primary use at that time was for agricultural purposes and any damages . . . would be infrequent and relatively minor." *Id.* Ultimately, the Corps concluded that "[t]his problem does not affect the safety of the dams." *Id.*

Thus, despite potential risks upstream and because of the grave consequences downstream of dam failure, *see* Tr. 89:22 to 90:8 (Thomas), the Corps adopted a new alternative plan, Plan V(b), to raise the main embankments and to add additional erosion protections to the dams' auxiliary spillways, *see* PX51 at 8 (USACE013575) (1984 General Design Mem.). This work was completed in the late 1980s and did not increase the effective storage of the dams. *See* PX2284 at 2 (FB0000633) (1989 Mem.).

e. 1990s: Storms in the area and subsequent evaluations.

In the period leading up to and during March of 1992, a series of storms resulted in then-record flood pools in both the Addicks and Barker Reservoirs. *See* Tr. 363:20 to 364:2 (Thomas). A large portion of Houston suffered major flooding, and public concern for flooding of privately-owned land inside the reservoirs grew. *See* JX52 at II-1 (USACE015195) (1995 Reconnaissance Report). As a result, the Corps prepared a special report in May of 1992 to provide general background and an overview of anticipated flooding damages which could occur beyond government-owned property in Addicks and Barker. JX44 at 1 (USACE015073). One conclusion from the report calculated that, "[T]he Possible Maximum Flood would affect over 4,000 structures valued at approximately \$725 million and cause damages of \$245 million." *Id.* at 9 (USACE015081). The report detailed a number of options to consider as potential solutions for this upstream flooding problem, *see id.* at 10-16 (USACE015082-88), and suggested further evaluation of the options for their economic, environmental, and engineering feasibility, *see id.* at 16 (USACE015088). Concerned for public safety, one potential option included the creation of a public awareness program, noting that, "In the absence of a public awareness program, residents are likely to forget or ignore the flood threat. Turnover in home ownership could also result in a significant proportion of residents being unaware of the risk." *Id.* at 11 (USACE015083).

The year 1995 saw the completion of the Corps' Addicks and Barker Reconnaissance Report evaluating the options, ordered after the completion of the 1992 study. *See generally* JX52. The area surrounding the government-owned land was now "densely populated" and full of "residential and commercial urban developments." *Id.* at 7 (USACE015136). After

considering the various recommendations, including taking no action, purchasing flowage easements, land buyouts, channel enlargements, excavating the government-owned land, and/or adopting a flood warning and evacuation plan, *see id.* at 7-8 (USACE015136-37), the Corps decided to take no action upstream, finding “insufficient economic benefits to justify project modification,” *id.* at 19 (USACE015148).

f. 1990s and 2000s: Home elevation surveys.

Throughout the 1990s and 2000s, the Corps completed surveys of capital investments located within the standard project floodplain for the purpose of determining potential flood-damage estimates. *See* JX52 at 4 (USACE015224) (1995 Reconnaissance Report Appendix). The surveys looked at homes, businesses, and other structures, *see* Tr. 390:20 to 391:2 (Thomas), with over 95% of the structures inventoried in each reservoir being residential, *see* JX52 at 4 (USACE015224). “Information recorded during the field survey included the location of structures (*i.e.*, street address), ground elevations of structures, the flooding threshold of individual structures[,] and structure category types.” *Id.* In other words, the government was aware of where and at what elevation water could or would enter each property. *See* Tr. 100:5-10 (Thomas). One such field study was conducted and completed in July 1994. JX52 at 4 (USACE015224). Another study was completed in the early 2000s, when the Corps hired a private contractor to do elevation surveys for over 10,000 structures in the potential impoundment area. *See* Tr. 100:11-16 (Thomas). The Corps also prepared internal “Reservoir Structure” maps that depicted the elevations of these surveyed upstream structures. *See* PX268. As a result, the government gained an appreciation of the specific risks upstream in Addicks and Barker associated with a severe storm.

2. Community engagement about proximity to the dams.

Long before Harvey occurred, information about the possibility of flooding upstream of the dams and beyond the borders of the government-owned land was well known to the Corps and accessible by the public. At a basic level, it could be obtained in publicly available maps. Moreover, the Corps had discussed upstream flood risks with developers in the 1980s and 1990s. Harris County began warning the community about flood risks years before Harvey, and Fort Bend County began including warning language in upstream subdivision plats in the early 1990s. The Corps also engaged in public outreach efforts to inform the community about the risk of upstream flooding.

a. Publicly available maps.

Several types of publicly accessible maps graphically illustrated the flood threat long before Harvey occurred. For example, the Houston and Harris County Atlas Key Maps contain information enabling an astute map reader to understand the elevation of maximum flood pools at each reservoir, *see* DX795, and Key Maps are prevalent enough to be referenced by page on real estate listings in the Houston area, *see, e.g.*, JX76.

Likewise, the Federal Emergency Management Agency (“FEMA”) prepares Flood Insurance Rate Maps, showing areas expected to flood during storms of various intensities, based on data generated by a hydrologic modeling program. *See* Tr. 1904:12-21 (Test. of Philip Bedient). The maps denote zones expected to flood during storms with one percent or less

annual chance of occurrence, *see* Tr. 2353:6 to 2354:14 (Test. of Michael Nakagaki), and all the test properties fell within one of these zones at the time they were acquired by plaintiffs, *see* Def.'s Br. at 26-27 (identifying the map flood zone for each test property both at the time it was acquired and under the current flood zone maps). Additionally, topographic maps, known as "quadrangle maps," produced by the United States Geological Survey have identified areas upstream of the dams as subject to controlled inundation since the early 1970s. Tr. at 2283:10 to 2285:18 (Test. of Leslie Hansmann). These maps have been publicly accessible online since 2010 and were readily available for purchase or at universities and public libraries prior to that time. Tr. 2285:21 to 2286:7 (Hansmann).

b. Discussions with developers.

Throughout the 1980s and 1990s, representatives of the Corps interacted with various developers of the properties surrounding the reservoirs. *See, e.g.*, PX2284 at 1-3 (FB0000632-34) (documenting exchanges between the developer of subdivisions upstream of the reservoirs, noting the possibility of upstream flooding). The Corps compiled a fact sheet, *see id.* at 2 (FB0000633), to share with developers of the adjacent property to ensure that they "were fully aware of the capabilities of the project and size of the pools that could occur behind [the dams]," Tr. 1507:5-10 (Long). The fact sheet indicated that the design flood pool boundary exceeded the government-owned land. *See* PX2284 at 2 (FB0000633).

c. Harris County flood risk studies.

Flooding in the early 1990s resulted in increased public awareness of the flooding potential, *see* Tr. at 2397:5 to 2400:18 (Test. of Steven D. Fitzgerald), and prompted several studies by the Harris County Flood Control District, *see generally* JX54; JX60. The studies noted growing concern among "residents, business owners[,] and government representatives . . . regarding the level of protection [*sic*] that the reservoirs provide to the property upstream of the dams," JX60 at 1 (USACE795732), and concluded that the "primary flood threat" in the area was "the inability to drain the Addicks and Barker [R]eservoirs in an efficient manner," JX54 at 2 (USACE686046). One report emphasized that "[t]he maximum flood pool levels of the Addicks and Barker [R]eservoirs extend far beyond the limits of the government[-]owned land," noting that "more than 8,000 acres [are] within the reservoir 'fringe' areas between the limits of the government[-]owned land and the . . . maximum flood pools." *Id.* Harris County also engaged in public outreach, seeking to educate the public about flood risk through public meetings, where information about the potential for flooding from the reservoirs was included. *See* Tr. 595:16-23 (Lindner).

d. Subdivision plat warnings.

The risk of upstream flooding that could be produced by the reservoirs filling to their maximum pool level was well known to Fort Bend County officials. *See* Tr. 719:15 to 720:10 (Test. of Mark Vogler). During a meeting with the Corps in the early 1990s, a county engineer discussed "[t]he issue of intermittent inundation or flooding within the Corps' Barker Reservoir." JX45 at 1 (FB0006378). The Corps informed the engineer "that the Barker Dam was designed and/or modified to contain 8.7 more feet of water than was purchased by the Corps," which could "translate[] into the flooding of approximately 4,769 acres of land, not under jurisdiction of the Corps of Engineers." *Id.* In 1992, a Fort Bend Engineering Department report included a

“notice that this subdivision is subject to controlled inundation from Barker Reservoir.” DX122 at 2 (FB0000611).

Around this time, Fort Bend County began requiring the addition of warning language on subdivision plats to inform purchasers about the possibility, already known to developers, of upstream flooding due to Barker Dam operations. *See* Tr. 736:9 to 737:15 (Vogler). For example, the plat for one of the trial properties (Giron) stated that “[t]his subdivision is located adjacent to the Barker Reservoir and . . . [is] subject to extended controlled inundation under the management of the U.S. Army Corps of Engineers.” DX557 at 1 (FB0025541).

e. Public outreach discussing upstream flood risk.

The Corps began its own public-outreach efforts regarding the dams in the mid-1980s, directing its focus toward interested communities, businesses, and governmental entities. *See* Tr. 1498:20 to 1499:4 (Long). Thereafter, the Corps conducted “dozens and dozens” of public presentations in the greater Houston area, during which it discussed the project’s purpose, history, operations, and operational limitations. *See* Tr. 1498:20 to 1500:10 (Long). These public presentations also “included information on the storage capacity of the projects, and that, in severe storm events where [the reservoirs] stored large pools, that those pools could exceed the limits of government-owned land,” Tr. 1501:12-19 (Long), noting that “[w]ater stored behind . . . the dams [] would result in floodwaters in [] homes,” Tr. 1501:25 to 1502:2 (Long). After a series of storms caused flooding in the early 1990s, the Corps released a report to publicly emphasize the “order of magnitude of the anticipated flooding damages which could occur off of Government property assuming different flood events.” JX44 at 1 (USACE015073). Various documents published by the Corps during the 1990s identified the possibility of future flooding and the “potential threat of property damage upstream of the reservoir lands.” *E.g.*, JX52 at 7 (USACE015136).

The Corps continued to discuss and inform the public about the possibility of upstream flooding in the decade and a half leading up to Harvey. In the mid-2000s, it created an emergency coordination team to organize better with local agencies in the event of an emergency concerning reservoir operations. *See* Tr. 2406:3 to 2407:9 (Fitzgerald). Members of that team discussed the possibility of upstream flooding on multiple occasions. *See, e.g.*, Tr. 598:14-21 (Lindner) (discussing drills that were conducted in the event of flooding upstream); DX206 at 2 (USACE467209) (stating that “it is only a matter of time before the reservoirs flood off government-owned land”). In 2009, the Corps prepared presentation slides for public meetings which showed upstream flooding during large storms. *See* PX1597 at 18-29 (USACE755528-39). Again in 2010, the Corps held a series of public meetings where it showed slides illustrating the possibility of upstream flooding. *See* JX94 at 74-77 (USACE594433-36). Similar public meetings, where like information was displayed, were sponsored by Corps in the following years leading up to Harvey. *See, e.g.*, Tr. 1558:6-14 (Long); DX238.

3. Operating conditions and meteorological setting for Harvey.

a. Standard Operating Procedures & the Water Control Manual.

The general operations of the Addicks and Barker Reservoirs are governed by a Water Control Manual issued in 2012 (the “Manual”), *see generally* JX110, with the Corps serving as

the regulating agency, *see id.* at 1-2 (USACE016306). The Manual was prepared pursuant to a Corps regulation entitled “Water Control Management” dated 1982, *see* Tr. 63:24 to 64:3 (Thomas), and it explains the guiding procedures for how the Addicks and Barker Reservoirs should be controlled in varying situations. The 2012 Water Control Manual was in effect when Harvey made landfall. *See* Tr. 58:24 to 59:5 (Thomas).

The Addicks and Barker Reservoirs are normally dry, as they do not impound water except to alleviate flood risk. JX110 at 6-3 (USACE016334). The reservoirs and dams are part of a flood risk project and do not serve any other main purpose such as navigation or hydroelectric power. *See* Tr. 63:7-13 (Thomas). “In keeping with the primary objective of flood control for Addicks and Barker Reservoirs, the general plan for reservoir regulation will be to operate the reservoirs in a manner that will utilize to the maximum extent possible, the available storage to prevent the occurrence of damaging stages on Buffalo Bayou.” JX110 at 7-4 (USACE016338). This plan for storage includes all of the land in the reservoirs behind the embankments, including land the government does not own. *See* Tr. 67:12 to 68:3 (Thomas).

Under normal conditions, the reservoirs “operate with two gates set at one-foot openings to pass normal low flows . . . limit[ing] the discharge on each reservoir to approximately 100-250 [cubic feet per second].” JX110 at 7-4 (USACE016338). “The gates on both reservoirs will be closed when 1 inch of rainfall occurs over the watershed below the reservoirs in 24 hours or less, or when flooding is predicted downstream.” *Id.* The gates are kept closed until the gauging station on Piney Point Road, about eight-to-ten miles downstream of the outlets, is reading less than 2,000 cubic feet per second. *See* Tr. 989:13 to 990:8 (Thomas). At times, the Manual recommends instances of induced surcharges. *See* JX110 at 7-5 (USACE016339). An induced surcharge is “a release made to optimize the available [reservoir] storage and protect the integrity of the dams.” Tr. 103:6-9 (Thomas). That is, when the reservoir pools rise to a certain elevation, releases from the reservoir will be made gradually according to the induced surcharge schedule. JX110 at 7-5 (USACE016339).

b. The Addicks & Barker Dams and Reservoirs immediately prior to Harvey.

During Tropical Storm Harvey, the Corps operated the dams consistent with the instructions of the 2012 Water Control Manual. Joint Stip. ¶ 109. When Harvey hit the Addicks and Barker watershed, the reservoirs for each were empty. *See* Tr. 160:21-25 (Thomas). At the time, the Addicks Reservoir had a storage capacity for the government-owned land of 127,591 acre-feet of water, Joint Stip. ¶ 105, and the Barker Reservoir had a storage capacity for the government-owned land of 82,921 acre-feet of water, Joint Stip. ¶ 106. The Addicks Reservoir had a maximum capacity of 199,643 acre-feet of water, *see* JX118 at E-2 (USACE019883), and the Barker Reservoir had a maximum capacity of 209,600 acre-feet of water, *see* JX118 at E-4 (USACE019885), if the reservoirs were to fill to their highest elevations where the reservoirs meet the natural ground. The Addicks watershed is approximately 50% developed and the Barker watershed is about 60% developed, most of which is residential or related commercial and office use. *See* JX110 at 4-8 (USACE016323). The undeveloped areas of the watershed are primarily used for pasture land and general mixed agricultural purposes. *Id.*

c. Major storms prior to Harvey.

Several storms of substantial scope occurred in the region during the decades preceding Harvey. After listing a series of major storms, an operational assessment report issued by the Corps in 2009 observed that “had some of these events been centered over Addicks and Barker Reservoirs or the Upper Buffalo Bayou Watershed, the combined rainfall and runoff could have resulted in flood pools exceeding the limits of government[-]owned land and possibly exceeding the capacity of Addicks and Barker Dams.” PX59 at 5 (USACE464074).

In 1979, Tropical Storm Claudette dropped 43 inches of rain in 24 hours on Alvin, Texas—50 miles southeast of the reservoirs. *Id.* at 4 (USACE464073). The rainfall produced by Claudette was the highest recorded in the United States during a twenty-four hour period, *id.*, causing the Corps to conclude in 1984 that “[t]he [Projected Maximum Flood] on an empty pool is considered a probable occurrence when compared with the 1979 Claudette rainfall event,” JX31 at 2 (USACE487626). The Corps likewise acknowledged in 2009 that “[i]f this event had occurred over the Addicks and Barker watersheds, their reservoir capacities may have been exceeded.” PX59 at 4 (USACE464073). The Corps calculated that if Addicks or Barker were to receive the amount of rain dropped by Claudette, it would take between approximately 53 and 55 days to remove enough water to get it back on government-owned land. PX1597 at 40-42 (USACE755551-53).

Tropical Storm Allison struck about 50 miles northeast of the Addicks and Barker watershed in 2001, dropping almost 36 inches of rain in five days, and “could have potentially exceeded reservoir capacity had the storm event occurred directly over the reservoirs.” PX59 at 5 (USACE464074). In light of Claudette and Allison, the Corps recognized in 2009 that, although the reservoirs had never previously flooded off government-owned land, “we know it can and probably will happen at some point in time.” PX1597 at 46 (USACE755557).

Water in the reservoirs exceeded government-owned land for the first time when the April 2016 “Tax Day Storm” produced record flood pools. Tr. 166:6-10 (Thomas); *see also* DX295 at 10 (DEPO_0053700) (“At its peak Barker Reservoir occupied 102.5% of its government[-]owned land and 40.5% of its total storage capacity.”). The Tax Day Storm generated ten-to-sixteen inches of rainfall over a twelve-hour period, *see* JX134 at VII-4 (USACE869254), and although the flood pools exceeded government-owned land, the reservoir water did not inundate any structures, *see* Tr. 978:17-22 (Thomas).¹² Nonetheless, in the Corps’

¹²Even so, at least one of the test properties suffered flooding during the Tax Day Storm, *see* Tr. 1764:11-18 (Test. of Elizabeth Burnham), and some streets flooded during the storm, *see* JX134 at VII 3-4 (USACE869253-4). This result may have been attributable to local stream flooding or other local circumstance rather than conditions in the reservoirs themselves.

Additional uncontrolled flows occurred on the road surfaces, which act as part of the drainage system in Houston, being specifically built at lower elevations than buildings such that gravity naturally pulls the water down to the roads where they can push flows downstream. *See* Tr. 25:20 to 26:2 (Site Visit, May 8, 2019) (Test. of Captain Charles Ciliske).

assessment, for Buffalo Bayou at the time it “may have been the worst storm of record.” JX134 at VII-3 (USACE869253). A year later, Harvey exceeded that record.

C. Operation of the Addicks & Barker Dams During Harvey

1. Tropical Storm Harvey.

Harvey made landfall along the coast, near Rockport, Texas, around 10:00 p.m. on August 25, 2017, as a Category 4 hurricane (130 mile per hour winds), Joint Stip. ¶ 107; DX737 at 12 (FEMA078357), but weakened into a Tropical Storm within twelve hours of making landfall, Joint Stip. ¶ 108. Harvey, however, stalled over the Houston metropolitan area for four more days, maintaining its intensity, dumping record amounts of water on the area. *See* Joint Stip. ¶¶ 108, 113, 115. Over the five days, Harvey dropped an average of more than 43 inches of rain in a 2,000 square mile area, DX737 at 12 (FEMA078357), becoming the largest storm in the recorded history of the United States, *see* Tr. 2030:14-17 (Bedient).¹³ Within Harris County, Harvey poured an average of 33.7 inches of rain over a four-day period. DX682 at 5.

2. Corps’ response to Harvey.

During Harvey, the Corps operated the Addicks and Barker Dams according to the 2012 Water Control Manual. *See* Tr. 982:1-3 (Thomas). The gates on all five conduits were closed for Addicks and Barker at the beginning of the storm, as called for by the Manual. *See* Tr. 1446:10-15 (Long). On August 25, 2017, the Corps declared a general emergency, which included a dam safety emergency. Tr. 118:25 to 119:1 (Thomas). As a result, the Corps followed the Manual’s instructions for the initial emergency levels. Tr. 119:15-17 (Thomas).

With the forecasted impending rain, the Corps knew that flooding “beyond the government[-]owned land limits” in Addicks and Barker was imminent. JX146 at 2 (DOJ0008154) (Corps’ internal letter dated August 25, 2017 at 2:26 p.m.). On August 28, shortly after midnight, the Corps initiated releases of impounded water in both reservoirs, pursuant to the induced surcharge regulation in the Manual. DX649 at 1. At that point, the flood pools in the reservoirs had reached at least 101 feet in Addicks and 94.9 feet in Barker. *See* Tr. 983:11-16 (Thomas). Because these releases were limited, however, by the guidelines in the Manual to protect downstream Houston from additional flooding, the Corps was unable to release water fast enough to decrease the pool size given the high rate of incoming water. *See* Tr. 991:8-19 (Thomas). During Harvey, uncontrolled releases also flowed around the ends of the auxiliary spillway at the northeast end of the Addicks Reservoir onto private land. *See* Tr. 24:8 to 27:12 (Site Visit) (Ciliske); *see also* PX25 at 1 (USACE016691) (“Uncontrolled release[s] around the Addicks north[-]end emergency spillway w[ere] observed on August 29, 2017 when the reservoir reached [] 108 ft.”).¹⁴

¹³Tropical Storm Claudette in 1979 was roughly comparable in total rainfall, and was more intense but more localized. *See supra*, at 17.

¹⁴Testimony about the flows at the north-end auxiliary spillways of Addicks was ostensibly inconsistent due to the imprecise vocabulary used when describing spillway functions, *i.e.*, whether water flowed over or around at both the northwest and northeast auxiliary spillways

The flood pools in the reservoirs crested at a record pool elevation of 101.6 feet in Barker and 109.1 feet in Addicks on August 30, 2017. Joint Stip. ¶¶ 110, 111. When the threat subsided and flood pools dropped to safer levels, the Corps developed a drawdown plan to fully drain the reservoirs while still maintaining their integrity. *See* Tr. 992:4 to 993:4 (Thomas). The plan went into effect on September 3, 2017, and the Corps resumed normal operations on September 16, 2017. DX649 at 6-7. The reservoir water elevations far exceeded the extent of government-owned land in both Addicks and Barker. *See* DX683 at 1. Of the approximately one million homes in the Harris County, around 154,000 of them flooded from the impounded water. *See* Tr. 2451:19-24 (Fitzgerald). The Addicks and Barker flood control project, though, did prevent an estimated \$7 billion in projected losses downstream in Houston. *See* Tr. 164:24 to 165:8 (Thomas).

D. Background of the Thirteen Upstream Test Properties

The thirteen upstream test properties provide a sampling of the conditions at various locations inundated by the Addicks and Barker Reservoirs during and after Tropical Storm Harvey.

1. Banker residence.

The land owned by plaintiffs Christina and Todd Banker is a residential property situated within the Barker reservoir in Katy, Texas at 4614 Kelliwood Manor Lane. Joint Stip. ¶ 4. The finished first floor of the home is set at a 100.7-foot elevation. Joint Stip. ¶ 9. Flooding within the home attendant to Harvey reached approximately 1.1 feet. *See* PX526 at 46. The Bankers evacuated their home on the morning of August 28 and returned on September 4. Tr. 1709:23 to 1712:20 (Test. of Todd Banker). During that period, flood water was present in the home for approximately four days. DX608 at 164. In addition to structural damage to the home, much of the Banker's personal property was destroyed by the flooding, *see, e.g.*, Tr. 1717:24 to 1718:21 (Banker), and the home was uninhabitable for about seven months while it underwent remediation, Tr. 1717:12-18 (Banker).

2. Burnham residence.

The land owned by plaintiff Elizabeth Burnham is a residential property situated within the Addicks Reservoir in Houston, Texas at 15626 Four Season Drive. Joint Stip. ¶ 10. The finished first floor of the home is set at a 105.4-to-105.5-foot elevation. Joint Stip. ¶ 18. Flooding within the home attendant to Harvey reached approximately four to five feet. *See* PX526 at 46; Tr. 1773:21-24 (Test. of Elizabeth Burnham). Flood water was present in the home for at least seven days. *See* DX608 at 164; Tr. 1771:20-22, 1773:25 to 1774:5 (Burnham). Ms. Burnham's personal property as well as the home suffered substantial damage. *See, e.g.*, Tr.

of Addicks Reservoir. At the northwest auxiliary spillway, there was no flow around or over the ends, *see* Tr. 21:18-22 (Site Visit) (Ciliske), however, at the northeast auxiliary spillway, water flowed *around* the spillway, *see* Tr. 24:15-18 (Site Visit) (Ciliske), but not *over* it, *see* Tr. 24:8-14 (Site Visit) (Ciliske). The spillways are intentionally designed to have water flow over them, but not around. *See* Tr. 35:19 to 36:4 (Site Visit) (Ciliske).

1775:24 to 1776:21 (Burnham). The home was uninhabitable for a period of months, at which time Ms. Burnham sold the property “as is.” See Tr. 1780:15 to 1781:18 (Burnham).

3. *Giron residence.*

The land owned by plaintiff Juan Giron is a residential property situated within the Barker Reservoir in Katy, Texas at 4310 Cassidy Park Lane. Joint Stip. ¶ 19. The finished first floor of the home is set at a 101.5-foot elevation. Joint Stip. ¶ 23. Flooding within the home attendant to Harvey reached approximately one foot at the high-water mark. See Tr. 1675:7-11 (Test. of Juan Giron). Flood water was present in the home for approximately five days. See DX608 at 164. The Giron property suffered substantial damage to the home and much of what was inside was unsalvageable. See, e.g., Tr. 1678:19-22, 1680:3-5 (Giron). At the time of trial, Mr. Giron was still living in a trailer parked in his driveway. See Tr. 1646:20-21 (Giron).

4. *Holland residence.*

The land leased by plaintiff Scott Holland is a residential property situated within the Addicks Reservoir in Houston, Texas at 1923 Wingleaf Drive. Joint Stip. ¶ 24. The finished first floor of the home is set at an elevation between 107.8 and 107.9 feet. Joint Stip. ¶ 26. Flooding within the home attendant to Harvey reached approximately 1.5 feet. See PX526 at 46; Tr. 1845:23 to 1846:1 (Holland). Mr. Holland evacuated his home on August 28, a daunting process due to sutures in his stomach and chest still healing from a recent kidney surgery. Tr. 1836:7 to 1838:11 (Holland). Flood water was present in the home for about 3.5 days. DX608 at 164. The home suffered severe structural damage and much of Mr. Holland’s personal property was destroyed by the flooding. See, e.g., Tr. 1842:1 to 1844:4 (Holland). Because the home was uninhabitable and he was unable to afford repairs, Mr. Holland was forced to move away from Houston and reside in a small trailer, where he still lived at the time of trial. Tr. 1844:15 to 1845:11 (Holland).

5. *Lakes on Eldridge Homeowners Association.*

Lakes on Eldridge is a homeowners association that acquired its real property from the developer or builder of the Lakes on Eldridge residential subdivision, a gated community in Harris County situated within the Addicks Reservoir. Joint Stip. ¶¶ 27, 28. The property at issue includes a clubhouse and its associated amenities, a swimming pool, tennis court, volleyball court, and playground. Tr. 1386:3-16 (Test. of Sue Strebel). Flood water rose to about six feet above the volleyball courts, Tr. 1398:17-22 (Strebel), approximately six inches in the clubhouse, PX526 at 46, and was present on the property for at least four days, see Tr. 1401:22 to 1402:11 (Strebel). The clubhouse and various amenities required extensive repairs, see, e.g., Tr. 1390:19 to 1391:21 (Strebel), requiring the clubhouse facility and its amenities to close for eight months, Tr. 1390:5-12 (Strebel).

6. *Micu residence.*

The land owned by plaintiff Christina Micu is a residential property situated within the Barker Reservoir in Katy, Texas at 6411 Canyon Park Drive. Joint Stip. ¶ 31. The finished first floor of the home is set at a 99.8-foot elevation. Joint Stip. ¶ 36. Flooding within the home attendant to Harvey reached approximately two feet. See PX526 at 46. Ms. Micu and most of

her family evacuated the home prior to Harvey. Tr. 1296:11-25 (Test. of Christina Micu). Her husband gained access to the home via kayak on September 2 and she returned on September 5, Tr. 1298:22 to 1299:1 (Micu), finding mold growth and extensive destruction of personal property, *see, e.g.*, Tr. 1299:25 to 1300:10 (Micu). Flood water was present in the home for about ten days. Tr. 1300:24 to 1301:1 (Micu). The Micu family was forced to reside with a friend and then rent an apartment before moving back into their home a year after Harvey. Tr. 1306:21 to 1305:7 (Micu).

7. *Popovici residence.*

The land owned by plaintiff Catherine Popovici is a residential property situated within the Barker Reservoir in Katy, Texas at 19927 Parsons Green Court. Joint Stip. ¶ 37. The finished first floor of the home is set at a 102.2-foot elevation. Joint Stip. ¶ 42. No water entered inside the home, but it rose to the foundation and was within a couple inches of entering, Tr. 1239:2-5 (Test. of Catherine Popovici), and remained on the property between four and six days, Tr. 1242:2-12 (Popovici). The flooding around the home prevented ingress or egress and damaged wooden beams in the structure of the home. Tr. 1243:1-9 (Popovici).

8. *Sidhu residence.*

Plaintiff Kulwant Sidhu is the joint owner of 29 condominium units used as residential rental properties and situated within the Addicks Reservoir in Houston, Texas at 16111 Aspenglenn Drive. Joint Stip. ¶ 43. The property at issue in Mr. Sidhu's claim at trial consists of two of his 29 units: Unit 603 (a first-floor, downstairs unit) and Unit 604 (a second-floor, upstairs unit directly above Unit 603). Joint Stip. ¶¶ 44, 46. The finished first floor of the condominium building in which the two units are located is set at an elevation of 107.0 to 107.1 feet. Joint Stip. ¶ 49. No flood water reached the upstairs unit, Joint Stip. ¶ 48, and it was not damaged, Tr. 1748:5-7 (Test. of Kulwant Sidhu). Flooding within the downstairs unit attendant to Harvey reached approximately 2.4 feet, PX526 at 46, and remained for about 4.5 days, DX608 at 164. The flood damage required gutting and renovating Unit 603—a process that took nearly a year, during which time the unit could not be rented. Tr. 1741:23 to 1742:25 (Sidhu).

9. *Soares residence.*

The land owned by plaintiff Elisio Soares is a residential property situated within the Barker Reservoir in Katy, Texas at 20526 Indian Grove Lane. Joint Stip. ¶ 50. The finished first floor of the home is set at a 101.1-foot elevation. Joint Stip. ¶ 55. The Soares family was on vacation when Harvey happened, Tr. 1080:12-16 (Test. of Elisio Soares), and they could only access their home by kayak when they returned on August 31, Tr. 1080:17 to 1081:10 (Soares). Flooding within the home attendant to Harvey reached approximately 8.4 inches, PX526 at 46, and was present in the home for approximately four days, Tr. 1086:22-24 (Soares). In addition to structural damage to the home, a significant amount of the Soares family's personal property was destroyed. *See, e.g.*, Tr. 1091:12 to 1092:4 (Soares). The family was forced to live with friends for two weeks and then in the upstairs of the home, unable to cook meals, until January of the following year, and the home could not be repaired until May 2018. Tr. 1092:18 to 1093:23 (Soares).

10. Stewart residence.

The land owned by plaintiff Mitchell Stewart is a residential property situated within the Addicks Reservoir in Houston, Texas at 4719 Eagle Trail Road. Joint Stip. ¶ 56. The finished first floor of the home is set at a 108.9- to 109.0-foot elevation. *Id.* ¶ 61. Flooding within the home attendant to Harvey reached at least six inches, *see* PX526 at 46; Tr. 1600:13-15 (Test. of Mitchell Stewart), and the water was present in the home for approximately four-to-five days, *see* Tr. 1607:13-18 (Stewart). The Stewart family suffered damage to much of their personal property and their home required significant renovations including removing and replacing the first four feet of the home's sheetrock. Tr. 1603:25 to 1604:4 (Stewart). The Stewarts were displaced from their home for about five months. Tr. 1609:17-20 (Stewart).

11. Turney residence.

The land owned by plaintiff Robert Turney is a residential property situated within the Addicks Reservoir in Houston, Texas at 15910 Red Willow Drive. Joint Stip. ¶ 62. The finished first floor of the home is set at a 104.5- to 104.7-foot elevation. Joint Stip. ¶ 69. Flooding within the home attendant to Harvey was about five feet, *see* PX526 at 46, with the high-water mark reaching about six feet, *see* Tr. 2134:18-23 (Test. of Robert Turney). Flood water was present in the home for over a week. *See* DX608 at 164. The Turney property suffered great damage that required the entire interior to be gutted and rebuilt. *See* Tr. 2136:8-11 (Turney).

12. West Houston Airport.

The West Houston Airport Corporation is the owner of a commercial property situated within the Addicks Reservoir in Houston, Texas at 18000 Groschke Road. Joint Stip. ¶ 76. The finished first floor of the terminal building at the West Houston Airport is set at a 108.6-foot elevation. Joint Stip. ¶ 78. Flooding within the terminal reached a maximum of about 9.6 inches. *See* PX526 at 46. The flood water reached the terminal on August 29 and receded from the terminal by September 1. *See* Tr. 1885:17 to 1886:13 (Test. of Stacey Lesikar-Martin). Flood water remained on the runways until September 5, with the water receding from the property line on approximately September 7. *See* Tr. 1886:17-24 (Lesikar-Martin). The terminal itself suffered substantial damage, and damage occurred to numerous aircraft, service apparatus, and vehicles present at the airport at the time of the flooding. *See* Tr. 2121:6-25, 2124:8-14 (Test. of Woody Lesikar). The airport was not fully operable for seven-to-ten days' time, and repairs on the property took about a year. *See* Tr. 2121:6 to 2123:8 (Lesikar).

13. Wind residence.

The land owned by plaintiffs Kurt and Jean Wind is a residential property situated within the Addicks Reservoir in Houston, Texas at 5306 Sunbright Court. Joint Stip. ¶ 70. The finished first floor of the home is set at a 109.2-to-109.3-foot elevation. Joint Stip. ¶ 75. Flooding within the home attendant to Harvey reached approximately two inches. *See* PX526 at 46; DX608 at 164; Tr. 1633:12-14 (Test. of Kurt Wind). Flood water was present in the home for about two-to-three days. *See* Tr. 1635:10-11 (Wind). In addition to significant structural damage to the home, much of the Winds' personal property was destroyed by the flooding. *See* Tr. 1635:11 to 1636:24 (Wind). Due to the damage and necessary repairs, the home was uninhabitable for 11 months. *See* Tr. 1637:5-7 (Wind).

E. Expert Reports about the Storm

1. Dr. Bedient.

An expert in hydrology, hydraulics, and floodplain analysis, Dr. Philip Bedient testified on behalf of plaintiffs regarding the cause of flooding at each of the test properties during Harvey. *See generally* PX526; Tr. 1934:11-13 (Bedient).¹⁵ Dr. Bedient reached his conclusions by reference to a number of data sources, including slab elevations of the test properties, ground elevation data, water level gauges for creeks and the reservoir pools, aerial images from the National Oceanic and Atmospheric Administration, and eyewitness photographs and videos. *See* Tr. 1910:1 to 1911:17 (Bedient). Dr. Bedient’s methodology compared the reservoir pool elevation data obtained from United States Geological Survey gauges to the slab elevation survey data of each test property, and then confirmed those findings by reference to aerial images taken on August 30 and LiDAR data (technology for determining ground elevation at numerous points). *See id.* He concluded that the flooding at each test property was caused by the water impounded behind the Addicks and Barker Dams. Tr. 1948:3-12 (Bedient); PX526 at 46.

Dr. Bedient also addressed whether any of the test properties would have flooded without the dams impounding the rainfall waters or whether any of the properties flooded during Harvey independently of the reservoir pool levels entering onto the properties. He identified, and rejected, two other possible causes of the flooding: local drainage systems and riverine flooding. *See generally* PX526 at 47-54. His examination of the relevant local drainage systems’ capacities led him to the conclusion that they were capable of adequately handling rainfall much more intense than Harvey. *See* PX526 at 49. Likewise, Dr. Bedient concluded that “the riverine flooding that occurred during Harvey did not cause and would not have caused any of the [t]est [p]roperties to flood.” PX526 at 54. He reached this conclusion by estimating the flood level along each of the creeks in the vicinity of the test properties, and then comparing that elevation to the slab elevation of each test property, except the airport. *See* Tr. 1984:11-25 (Bedient). He noted that the airport was a unique situation because of the size of the property but nonetheless he concluded that because of a high bank attendant to a creek in that location, creek water did not cause the flooding. *See* Tr. 1985:18 to 1989:14 (Bedient). He confirmed this observation by reference to eyewitness testimony and by comparison to the Tax Day flood, which likewise did not produce airport flooding. *Id.* In sum, Dr. Bedient concluded that “[n]one of the test properties’ structures would have flooded but for the impoundment of rainfall runoff waters behind Addicks and Barker Dams.” PX526 at 7-8.

2. Dr. Nairn.

Dr. Robert Nairn, an expert in coastal and riverine engineering, with a specialty in numerical modeling across actual and hypothetical conditions, testified on behalf of the government using a numerical model of the storm and relevant waterflows. *See generally*

¹⁵Dr. Bedient is a professor of engineering at Rice University and teaches and performs research in hydrology. Tr. 1901:7-9 (Bedient).

DX608; *see also* Tr. 2628:22 to 2629:3 (Test. of Robert Nairn).¹⁶ Dr. Nairn looked at the water surface elevations at each of the test properties, specifically examining the rise and drop over time. Tr. 2636:14-21 (Nairn). Using various input data sets, including, *e.g.*, topography maps and a land cover data set, *see* Tr. 2647:15-20 (Nairn), and taking into account various water runoff impacts and parameters, *see, e.g.*, Tr. 2648:11-23 (Nairn), Dr. Nairn built a modeling system that applies mathematical principles of hydrodynamic equations to simulate rainfall and water movement, *see, e.g.*, Tr. 2655:10-16 (Nairn). Subsequently, after calibrating the model and relevant coefficients, *see* Tr. 2656:19 to 2657:20 (Nairn), Dr. Nairn ran the model for each of the properties and analyzed the outcomes of four different scenarios for Addicks and Barker: (1) the actual Harvey scenario; (2) the no-dam (“no project”) scenario; (3) the gates-closed scenario; and (4) the gates-open scenario, *see* Tr. 2636:14-24 (Nairn); *see also* DX608 at 92-93. Dr. Nairn’s main conclusion was that three out of the thirteen test properties (Burnham, Giron, and Micu) would have flooded even had the Addicks and Barker Dams not been built, due to the sheer amount of rainfall and riverine flooding, thus positing that the flooding of at least those three properties was not the result of the government’s actions relating to Addicks and Barker. *See* DX608 at iii, 129.

3. *Other testifying experts.*

Several expert witnesses testified at trial regarding the severity of the impact that flood damage had on the test properties. Dr. Glen Randall Bell, an expert in real estate damage and economics and real estate valuation (including severity), testified on behalf of plaintiffs about severity of the impact of the flooding on the valuation of plaintiffs’ properties. *See generally* PX660; *see also* Tr. 1360:5 to 1361:15 (Bell). His testimony and report focused on the severity of impact rather than on the specific quantification of any lost value. PX660 at 4; Tr. 1362:6-15 (Bell).

Additionally, Matthew Deal, an expert in real estate market studies and real estate valuation, conducted a market study appraisal analyzing supply, demand, and prices for specific property types in the area. *See generally* PX2205; Tr. 2188:4-15 (Deal). His research concluded “that properties that were inundated by flood waters suffered significant and immediate impairment that resulted in precipitous price reductions after flood waters had receded.” PX2205 (report cover letter).

David Hooper, a microbiologist who is an expert in preparing scopes of work for property damaged by water, was retained by the government to create models of the scopes of work that would be required on five of the test properties after the flooding. *See generally* DX602-607. His report considered “the overall quality of water; the amount of waters present within a residence; the duration of flooding; the ability for water to move via capillary action within a wall; as well as the presence of microbiological growth; and, lastly, application of industry standards in construction guidelines.” Tr. 2876:2-7 (Hooper). He developed estimates of the scope of work that would be required under various scenarios, such as if the reservoirs had not been in place at all, *see, e.g.*, DX602 at 17-18 (considering the Burnham property),

¹⁶Dr. Nairn is an engineer who works at Baird & Associates, Oakville, Ontario, Canada, on river and coastal engineering projects worldwide. Tr. 2625:15 to 2626:1 (Nairn).

concluding that the scopes of work would be very similar in the actual Harvey scenario and in the alternative scenarios, *see, e.g.*, 2922:2-4 (Hooper).

Andrew Ickert, an expert in hydrology, testified on behalf of the government about the character of the land in the Addicks and Barker watershed and greater Houston area. *See generally* DX600; *see also* Tr. 3083:21 to 3084:7 (Ickert). Mr. Ickert explained how development could impact the watershed overall, giving particular regard to increasing runoff flow rates and size, and the impact of this circumstance on the overall flood pool size. *See* Tr. 3084:11 to 3085:14 (Ickert).

William Kappel, an expert in meteorology, was called to testify by the government, regarding the magnitude of Harvey and the meteorological setting. *See generally* DX601 at 38-222; *see also* Tr. 1156:6-22 (Kappel). Specifically, Mr. Kappel testified about “the methodology and results of a detailed analysis of the storm precipitation in and around the region of [] Houston[,] Texas during the month of August 2017[, when Harvey hit].” DX601 at 44.

STANDARDS FOR DECISION

Under the Takings Clause of the Fifth Amendment, “private property [shall not] be taken for public use, without just compensation.” U.S. Const. amend. V. The Takings Clause applies the fundamental notion that the government cannot “forc[e] some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.” *Armstrong v. United States*, 364 U.S. 40, 49 (1960). Thus, “[w]hen the government physically takes possession of an interest in property for some public purpose, it has a categorical duty to compensate the former owner.” *Tahoe-Sierra Pres. Council, Inc. v. Tahoe Reg’l Planning Agency*, 535 U.S. 302, 322 (2002) (citing *United States v. Pewee Coal Co.*, 341 U.S. 114, 115 (1951)).

In a takings case, the plaintiff must establish two elements to have a viable claim. First, plaintiff must establish that he or she holds “a property interest for purposes of the Fifth Amendment.” *Caquelin v. United States*, 140 Fed. Cl. 564, 572 (2018), *appeal docketed*, No. 2019-1385 (Fed. Cir. Jan. 9, 2019) (citing *Members of the Peanut Quota Holders Ass’n v. United States*, 421 F.3d 1323, 1330 (Fed. Cir. 2005)) (additional citations omitted). After identifying a valid property interest, “the court must determine whether the governmental action at issue amounted to a compensable taking of that property interest.” *American Pelagic Fishing Co., L.P. v. United States*, 379 F.3d 1363, 1372 (Fed. Cir. 2004) (citations omitted).

“[N]o magic formula enables a court to judge, in every case, whether a given government interference with property is a taking.” *Arkansas Game & Fish Comm’n v. United States*, 568 U.S. 23, 31 (2012). And while there are some bright-line rules, *see id.*, the inquiry into whether a taking has occurred ultimately is a question of law based on factual underpinnings, *Caquelin*, 140 Fed. Cl. at 572, requiring the court to engage in “ad hoc, factual inquiries,” *Kaiser Aetna v. United States*, 444 U.S. 164, 175 (1979); *see also* *Arkansas Game & Fish*, 568 U.S. at 32 (“[M]ost takings claims turn on situation-specific factual inquiries.”).

A government taking can occur in many forms, ranging from the classic example of a permanent physical occupation of property, *see Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. 419, 426 (1982), to regulation which permanently deprives a property owner of all

economically viable uses of his or her land, *see Lucas v. South Carolina Coastal Council*, 505 U.S. 1003, 1019 (1992), or one that bars most such uses, *see Penn Cent. Transp. Co. v. City of New York*, 438 U.S. 104, 124 (1978). More specifically, takings can be broken down by their means, duration, and impact. That is, takings can be either (1) physically or by regulation; (2) permanent or temporary; and (3) categorical or non-categorical. *See Caquelin*, 140 Fed. Cl. at 573.

At the outset, to apply the proper analysis, the court must determine the type of taking alleged. *See American Pelagic*, 379 F.3d at 1372. Physical takings, as opposed to those by regulation, involve physical occupation, and can occur when the “owner [is] deprived of valuable property rights, even [if] title ha[s] not formally passed.” *Caldwell v. United States*, 391 F.3d 1226, 1235 (Fed. Cir. 2004). The distinction between permanent and temporary is a narrower one, in that on a sufficiently long timeline, every government action could be considered temporary. *See Caquelin*, 140 Fed. Cl. at 575. Generally, the word temporary “refers to those governmental activities which involve an occupancy that is transient and relatively inconsequential,” *Hendler v. United States*, 952 F.2d 1364, 1377 (Fed. Cir. 1991), while permanent refers to those governmental activities more substantial in nature, though they need not be “exclusive, or continuous and uninterrupted,” *id.* For example, the Supreme Court in *Nollan* concluded that a “permanent physical occupation” had occurred when the government essentially took an easement for public access across plaintiffs’ property that granted a “permanent and continuous right to pass to and fro, so that the real property may continuously be traversed.” *Nollan v. California Coastal Comm’n*, 483 U.S. 825, 832 (1987). Lastly, a categorical taking occurs when the government seizes the entirety of a landowner’s property, *see Caquelin*, 140 Fed. Cl. at 573, whereas a non-categorical taking occurs when the landowner is not completely deprived of all economic value, *see id.* at 574 (citing *United States v. Causby*, 328 U.S. 256 (1946)).

At issue here is whether the government’s actions constitute a physical, permanent, non-categorical taking for a flowage easement.¹⁷ The alleged taking is physical, in the sense that actual flood waters physically entered the property; permanent, in the sense that the government retains the rights to this flowage easement on a permanent basis with a continual right of re-entry; and non-categorical, in the sense that the property owners are not deprived of all economically viable use of their property as a result of the flowage easement. Further, this case presents a scenario of inverse condemnation, *i.e.*, where the landowner seeks to “recover[] just compensation for a taking of his [or her] property when condemnation proceedings have not been instituted.” *United States v. Clarke*, 445 U.S. 253, 257 (1980).

¹⁷Plaintiffs have alleged three separate takings: (1) a temporary, categorical, physical taking for the temporary flooding; (2) a permanent, categorical, physical taking for the destruction of plaintiffs’ personal property; and (3) a permanent, non-categorical, physical taking for the flowage easements on each property. *See* Pls.’ Br. at 59. The court, however, finds these distinctions unnecessary, as the first two alleged takings are simply the consequential result of the third. Thus, the court here will apply its analysis to the consideration of whether the government’s actions constituted a physical, permanent, non-categorical taking for a flowage easement.

Inverse condemnation cases in the flooding context, particularly those resulting from government-induced flooding either of a permanent or temporary nature, are not new to this court or others. *See, e.g., Arkansas Game & Fish*, 568 U.S. at 32-33 (citing *Pumpelly v. Green Bay Co.*, 80 U.S. (13 Wall.) 166 (1872), *United States v. Cress*, 243 U.S. 316 (1917), and *United States v. Dickinson*, 331 U.S. 745 (1947)). In 2003, the Federal Circuit decided *Ridge Line*, addressing the scenario of whether government-induced increased water runoff onto private property constituted a taking of a flowage easement by inverse condemnation. *Ridge Line, Inc. v. United States*, 346 F.3d 1346, 1355 (Fed. Cir. 2003). In *Ridge Line*, the Federal Circuit applied a multi-pronged test to determine whether a taking, and specifically not a tort, had occurred. *Id.* The first prong evaluates whether “the government intends to invade a protected property interest” or whether “the asserted invasion is the direct, natural, or probable result of an authorized activity and not the incidental or consequential injury inflicted by the action.” *Id.* (quoting *Columbia Basin Orchard v. United States*, 132 F. Supp. 707, 709 (Ct. Cl. 1955)). In other words, the government must intend to invade the property *or* the injury must be the foreseeable result of the action. *See Caquelin*, 140 Fed. Cl. at 576 n.18 (citing *Cary v. United States*, 552 F.3d 1373, 1377 (Fed. Cir. 2009), and *Ridge Line*, 346 F.3d at 1346). Second, “the nature and magnitude of the government action must be considered.” *Ridge Line*, 346 F.3d at 1356. This factor includes a requirement that “an invasion must appropriate a benefit to the government at the expense of the property owner, or at least preempt the owner[']s right to enjoy his property for an extended period of time, rather than merely inflict an injury that reduces its value.” *Id.*

With this background, the Supreme Court decided *Arkansas Game & Fish* in 2012, expounding a list of six factors to consider when determining the existence *vel non* of a compensable taking. *See* 568 U.S. at 38-40. The factors, subsuming the considerations of the *Ridge Line* test, include: (1) “time;” (2) “inten[t];” (3) “foreseeab[ility];” (4) “character of the land;” (5) “reasonable investment-backed expectations;” and (6) “severity.” *Id.* Although *Arkansas Game & Fish* concerned a taking which was temporary in nature, the same considerations remain relevant to the inquiry here, that is, whether the government’s actions with regard to Addicks and Barker constitute a compensable taking, albeit a permanent one.

ANALYSIS

The court will begin its assessment by determining if each plaintiff has established a cognizable property interest. Following this, the court will turn to the more fact-intensive examination of the *Arkansas Game & Fish* considerations to evaluate whether plaintiffs have met their burden of showing that they have suffered a compensable taking. Finding that the government’s actions in this case constitute a taking, the court will then consider whether defendant has any potential defenses to liability. The government argues that its actions do not constitute a taking because the Corps was acting under the police power and under the doctrine of necessity. The court concludes that these defenses are not applicable; therefore, the government is liable for the taking of plaintiffs’ properties.

A. *The Takings Analysis*

1. *Property interests.*

Plaintiffs must have a valid property interest at the time of the taking to be entitled to compensation. *See Wyatt v. United States*, 271 F.3d 1090, 1096 (Fed. Cir. 2001) (citing primarily *Almota Farmers Elevator & Warehouse Co. v. United States*, 409 U.S. 470, 473-74 (1973)). Plaintiffs are owners of private properties not subject to flowage easements.¹⁸ Ownership of the properties by each plaintiff respectively and the lack of a previous flowage easement are not in dispute. *See generally* Def.’s Br. at 93-97. The government, however, disagrees that plaintiffs hold compensable property interests under principles of both state and federal law. Namely, the government argues that: (1) the government has the right to mitigate against floodwaters under Texas law; (2) that plaintiffs have no right to be free from invasions because their ownership post-dates the dams’ construction; and (3) that the federal Flood Control Act of 1928, ch. 569, § 3, 45 Stat. 534 (codified as amended in relevant part at 33 U.S.C. § 702c), limits plaintiffs’ rights to compensation. *See id.*; *see also In re Upstream Addicks & Barker*, 138 Fed. Cl. at 667.

The government misstates the interplay of these laws with the Takings Clause. While the law cited in support of the government’s first contention, Tex. Water Code Ann. § 11.086(c), exempts the government from liability for diversions of water caused by the “construction and maintenance of levees and other improvements to control floods,” a conscious diversion of water by the government onto private properties in a reservoir by a flood-control dam is not within this exception. *Cf. Harris Cty. Flood Control District v. Kerr*, 499 S.W.3d 793, 807 (Tex. 2016) (“This is not a case where the government made a conscious decision to subject particular

¹⁸This description, *i.e.*, that plaintiffs are owners of private properties not subject to flowage easements, is in a nutshell a finding respecting the character of the land at issue. In other cases, the character of the land may be more complicated or may factor more heavily in the takings determination. What is most relevant to the takings inquiry here is that defendant had no legal right to cause flood waters to enter the properties. The character of the land in government flooding cases is usually defined by whether, inherently, the property is “especially susceptible to flooding.” *See, e.g., Caquelin*, 140 Fed. Cl. at 581. In this case, whether the private property is used as farm land, as a residence, or commercially does not bear on liability. *Id.* at 581 n.22. Defendant contends that the character of the land at issue is land that has always been “susceptible to flooding during extreme weather events” including “possible inundation associated with the pools impounded by the [Addicks and Barker] Project.” Def.’s Br. at 100-01. The government thus appears to be arguing that the character of plaintiffs’ lands is property located within a reservoir in an area of the country susceptible to storms. That plaintiffs’ properties may be susceptible to flooding during extreme weather events is of some relevance, but it is independent from the fact that plaintiffs’ properties are privately-owned land within a reservoir that only flooded in this case because of the government’s construction of the Addicks and Barker Dams (for a discussion on causation, see *infra*, at 35-39). Even if this geographical area is generally susceptible to flooding during extreme weather events, the character of plaintiffs’ land would not be *especially* susceptible to flooding without the construction of the dams. Therefore, the character of the land at issue in this case is most simply described as private property not subject to a flowage easement.

properties to inundation so that other properties would be spared, as happens when a government builds a flood-control dam knowing that certain properties will be flooded by the resulting reservoir. In such cases of course the government must compensate the owners who lose their land to the reservoir.”); *see also In re Upstream Addicks & Barker*, 138 Fed. Cl. at 667. The government’s second contention, that plaintiffs’ claims fail because they acquired their land after the completion of the Addicks and Barker Dams, also does not bar relief, *see id.*, 138 Fed. Cl. at 669, and is more appropriately addressed as a consideration in regard to plaintiffs’ reasonable investment-backed expectations. Lastly, defendants argue that “Section 702c of Flood Control Act of 1928 . . . supports the conclusion that landowners in the vicinity of a federal project constructed and operated to reduce flood risk lack a right to compensation for damages caused by floodwaters not fully controlled by the Project.” Def.’s Br. at 97. This argument is unpersuasive. The Flood Control Act of 1928 does not supersede or bar this court’s jurisdiction over takings claims for flooding. *See In re Upstream Addicks & Barker*, 138 Fed. Cl. at 668; *accord California v. United States*, 271 F.3d 1377, 1383 (Fed. Cir. 2001) (“Our review of the Flood Control Act of 1928 leaves us with the firm conviction that Congress did not partially impliedly repeal the Tucker Act.”) (addressing immunity in Tucker Act contract claims); *see also Scranton v. Wheeler*, 179 U.S. 141, 153 (1900) (“Congress may not override the provision that just compensation must be made when private property is taken for public use.”). The court finds defendant’s arguments unconvincing; therefore, plaintiffs have met their burden of establishing a valid property interest.

2. Takings factors.

a. Nature and magnitude of the government action.

i. Time & duration of the taking.

The time and duration of the government invasion is an important consideration in many takings cases. *See, e.g., Arkansas Game & Fish*, 568 U.S. at 38-39 (citing *Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. at 435 n.12; *Tahoe-Sierra*, 535 U.S. at 342; *National Bd. of YMCA v. United States*, 395 U.S. 85, 93 (1969)). Particularly, the time and duration of the government action may be a highly relevant inquiry when determining whether the action constitutes a tort or a taking in the context of temporary takings. *See Caquelin*, 140 Fed. Cl. at 579 (collecting cases applying the time factor in a temporary takings analysis). But when the taking is one of a permanent nature, as it is here, the time and duration of the invasion is essentially undisputed and manifestly supports the finding of a taking. The government, through its construction, maintenance, and operation of the Addicks and Barker Dams in the past, present, and future, has taken a permanent flowage easement on plaintiffs’ properties.¹⁹ Defendant argues that its actions had only temporary consequences, because flood waters from Harvey were only on the properties for a matter of days. *See* Def.’s Br. at 108-09. This

¹⁹The parties in their briefing for the motion to dismiss disputed whether plaintiffs’ claims related only to government inaction, as opposed to affirmative government actions, and thus would not state viable takings claims. *See* Def.’s Motion to Dismiss at 4; Pls.’ Opp’n to Motion to Dismiss at 17, ECF No. 99. For the reasons set forth in the court’s opinion deferring ruling on the motion to dismiss, *see In re Upstream Addicks & Barker*, 138 Fed. Cl. at 666-67, the court concludes that plaintiffs’ claims are properly based on government action, not inaction.

argument, however, fails to account for the fact that the government's actions have subjected plaintiffs' private properties to the possibility, rather probability, of government-induced flooding ever since the construction of these dams, throughout subsequent changes to the dams and reservoirs, and for at least the foreseeable future. The time and duration of the government's actions at issue here is *not* measured by "the length of time the water inundates the properties," as the government would have it, *id.* at 109; rather, it is measured by a permanent right to inundate the property with impounded flood waters. Thus, this factor weighs in favor of plaintiffs.

ii. Severity.

Another factor that warrants consideration in the determination of liability under *Arkansas Game & Fish* is the "[s]everity of the interference." 568 U.S. at 39. The severity factor aids in differentiating a taking from a tort. *See Ridge Line*, 346 F.3d at 1355 (noting that "[t]he tort-taking inquiry . . . requires consideration of whether . . . the government's actions were sufficiently substantial to justify a takings remedy"). In effect, it requires the court to assess whether the government's interference with plaintiffs' property rights "was substantial and frequent enough to rise to the level of a taking." *Id.* at 1357 (citation omitted). As the Supreme Court stated in *Portsmouth Harbor Land & Hotel Co. v. United States*, where the Court held that repeated firing of military guns over a beach resort could constitute a taking if frequent enough, "[w]hile a single act may not be enough, a continuance of them in sufficient number and for a sufficient time may prove [a taking]. Every successive trespass adds to the force of the evidence." 260 U.S. 327, 329-30 (1922); *see also Causby*, 328 U.S. at 258, 265 (holding that repeated overflights of governmental aircraft above a farm constituted a taking). In the flooding context, "property may be taken by the invasion of water where subjected to intermittent, but inevitably recurring, inundation due to authorized [g]overnment action." *Barnes v. United States*, 538 F.2d 865, 870 (Ct. Cl. 1976) (holding the government liable for taking a flowage easement) (citing numerous cases). Thus, intermittent inundation of land, as contrasted to continuous overflow, can give rise to a viable permanent taking claim. *See Cress*, 243 U.S. at 328. Moreover, even a single flooding event may give rise to a taking where the defendant uses a permanent structure to "purposely flood[] a property once and expressly reserves the right to do so in the future." *Quebedeaux v. United States*, 112 Fed. Cl. 317, 323 (2013). In that event, the "defendant's actions may be viewed not as an 'isolated invasion,' but rather as reserving a flowage easement over the affected property." *Id.* (internal citations omitted); *see also Nollan*, 483 U.S. at 832 (holding that a permanent physical taking occurred, "even though no particular individual [was] permitted to station himself permanently upon the premises," when the government reserved a "continuous right [of individuals] to pass to and fro").

Here, plaintiffs contend that "the [g]overnment's actions resulted in an invasion by flooding that preempted [their] right to use and enjoy the protectable real and personal property interests they owned in the manner expected" and were therefore "sufficiently severe to constitute a taking." Pls.' Br. at 52. To support this assertion, plaintiffs note that the government-induced flooding caused "[t]he disruption of their lives, the devaluation of their properties, the destruction of their real and personal property, and their displacement from their homes and businesses for an extended period." *Id.* at 59. They emphasize that the flooding "restricted access to and from their property, causing their eviction from their properties for a period long after the water receded due to necessary repairs [and] significantly limited use of that property." *Id.* On the other hand, the government asserts that the severity factor "favors a finding of no liability because repairable damage resulting from temporary flooding during a

single flood event is not the type of severe impact that can support a claim for compensation under the Fifth Amendment.” Def.’s Br. at 101. Stressing that each property was repaired or capable of repair by the time of trial, the government asserts that such “repairable” damage or “temporary harm” is “manifestly different from the type of injury that can support a Fifth Amendment claim.” *Id.* Additionally, the government maintains that some plaintiffs recovered “significant flood insurance” and received federal benefits that mitigated actual out-of-pocket expenses, and that the damage attributable to the government action was “relatively minor” for many of the properties. *Id.* at 102.

The flooding at issue here went well beyond a tort and was sufficiently severe to rise to the level of a compensable taking. The government’s suggestion that this flooding is not a compensable taking because it was temporary and confined to a single flood event carries no water. Even if a single event of this nature were insufficient to rise to a taking, the sheer frequency of significant storms in the region both before and since construction of the dams—the Hearne storm, the Taylor storm, the 1929 and 1935 storms, Tropical Storm Claudette in 1979, the 1992 series of storms, Tropical Storm Allison in 2001, and the Tax Day Storm—suggests that this was more than an isolated event, and that it is likely to recur. *See also* Tr. 1199:13 to 1200:7 (Kappel) (noting that Harvey’s maximum rainfall was not unprecedented in the region when Harvey occurred). Indeed, this was not the first time that water had exceeded government-owned land, and the Corps itself had fully anticipated a storm the likes of Harvey. The future recurrence of a similarly large storm, producing comparable rainfall, remains likely to occur again. *See* Tr. 1198:4-8 (Kappel) (stating that “[t]here is a probability that [a rain event similar to Harvey] could happen again in the future [over the Addicks and Barker watersheds]”); Tr. 1494:3-11 (Long) (noting the “inevitably recurring” continuation of storms “that are of large magnitudes that could have impacts similar to those of Harvey”). Nor is there any reason to expect that the government would, or that it ought to, operate the dams to release more water downstream any differently in a future storm than it did during Harvey. As noted previously, the Corps operated the dams as prescribed by the Water Control Manual. Hence, in the nearly inevitable event of a future storm of significant magnitude, it can be expected that the government would similarly impound water on plaintiffs’ properties to prevent what would be catastrophic flooding downstream. As a result, the likelihood of recurrent flooding is high, weighing strongly in favor of the finding of a compensable taking.²⁰

The significant harm caused to plaintiffs’ properties, almost entirely preventing their normal use and enjoyment, is also relevant to the severity analysis. Water measuring as much as several feet in some cases inundated plaintiffs’ homes—for as long as a week in multiple instances—destroying substantial personal property, causing structural damage, and rendering properties uninhabitable or unusable until repairs could be completed months or years later. And even in the case of the Popovici residence, where water came within inches but did not actually

²⁰The government also avers that plaintiffs suffered “no lasting infringement on their property rights” differing from those of “thousands of other Texans in nearby areas whose homes flooded.” Def.’s Br. at 102. But contrary to the government’s contention, the flooding on plaintiffs’ property did differ from that experienced by others because it was directly caused not by the storm itself but by the impoundment of water behind the dams, and that infringement is lasting because the government reserves the right to repeat the impoundment in the future.

enter the home, seepage around the foundation caused structural damage. *See* Tr. 1242:13 to 1243:6 (Popovici). Some homeowners expressed concern about the substances and materials absorbed into the soil from the composition of the water itself, which became putrid, smelling of “fecal material and dead animal material and chemicals.” Tr. 66:5-12 (Site Visit) (Popovici). Given that the water at the test properties was classified as Category 3 “black water,” *i.e.*, water with “a greater potential to harbor pathogens, including sewage, chemicals, fertilizer, [and] organic material,” these fears are not unfounded. Tr. 2892:14-24 (Hooper).

Furthermore, while water was present it prevented basic ingress and egress at all the properties, with some accessible only by watercraft. *See, e.g.*, Tr. 1299:1-12 (Micu). Notably, the amount of water that actually entered the structures is not reflective of, and actually much less, than the severity of the water level outside the structures in the lawn and streets. *See* Tr. 1952:24 to 1953:21 (Bedient). The streets in these areas were designed to serve as a drainage system that channeled water, and to that effect the elevation of street levels is lower than the elevation of structures by at least 18 inches, meaning that the water would be much deeper in the streets and lawns than in the structures themselves. *See id.*

Also relevant to the severity analysis is the substantial decline in property value caused by the flood event and the likelihood of similar events in the future. The court takes judicial notice of a recently enacted Texas law that requires a seller of residential real property to disclose to potential purchasers whether the property is located wholly or partially in a reservoir subject to controlled inundation by the Corps and whether the property has previously flooded. *See* Tex. Prop. Code Ann. § 5.008 (West, Westlaw through the end of the 2019 Reg. Sess. of the 86th Leg.). All the properties at issue here fall within these disclosure requirements and the adverse impact of the government-induced flooding on their market value is evident. Additionally, Dr. Bell testified at trial that flooding events of this kind generally cause a decline in property value of at least 20 to 30 percent, although he did not specifically opine on the properties involved here. Tr. 1353:13 to 1354:2 (Bell). While the government seeks to discredit his testimony as “decidedly qualitative, not quantitative,” Def.’s Br. at 104, the severity factor is by nature a qualitative inquiry, lacking any definite quantitative thresholds. Nor is the dollar amount of damages in issue at this juncture. Therefore, although Dr. Bell’s testimony did not provide quantitative analyses for the specific properties, there is little room to question his broad conclusions about the severe impact of this kind of flooding at these kinds of properties on market value. Simply put, the absence of specific quantitative calculations does not serve to discredit those conclusions. Likewise, Mr. Deal’s expert opinion concluded that plaintiffs’ properties “suffer[ed] permanent damage, damage that wouldn’t be healed by itself” and “would require [a] significant amount of investment and risk of capital in order to get them all the way back to [being] habitable.” Tr. 2210:6-10 (Deal). After inspecting the residential properties involved here, Mr. Deal identified nearby comparable sales and compared the two. *See generally* PX2205. He concluded “[t]hat the inundated properties suffered a significant diminution in price levels.” Tr. 2210:25 to 2211:22 (Deal).

The government maintains that the testimony of Dr. Bell and Mr. Deal simply “show[s] that the flood-related impacts to the [t]rial [p]roperties were temporary and repairable,” suggesting that such impacts do not rise to the level of a taking. Def.’s Br. at 105. But contrary to the government’s assertion, the fact that property has been or could be, with sufficient outlays, restored to its pre-flood condition is not a relevant consideration in the severity analysis. *See Arkansas Game & Fish*, 568 U.S. at 26-34 (finding a compensable taking even though the

damaged terrain could be repaired by “costly reclamation measures”); *see also Dickinson*, 331 U.S. at 751 (holding that “no use to which [plaintiff] could subsequently put the property by his reclamation efforts changed the fact that the land was taken when it was taken and an obligation to pay for it then arose”). Under the government’s theory, seemingly any takings claim based on government-caused damage to property could not be sustained if the damage were susceptible to repair. Even catastrophic damage can often be mended by enough time and expense, but the mere capacity for repair in no way mitigates the severity of the harm itself. Furthermore, the government’s argument that the ability to repair damages caused by flooding weighs against imposing liability on the Corps is also heedless of the recurrent nature of the flooding involved here. Plaintiffs may have—in many, if not most, instances—been able to repair their real property, if not their personal property, but the taking here involves more than the damage already incurred; it encompasses a loss of the property owners’ right to exclude future floodwater incursions onto their land and into their homes. Thus, that most of the bellwether plaintiffs were able to repair their property is likewise irrelevant to their inability to prevent future government-induced flooding on that property. It is not defensible to propose that an action which destroys property, all the while reserving the right to do so again, is not a taking simply because the property owner can, at great inconvenience and expense, repair the property after the fact. Moreover, the government fails to consider that some plaintiffs could not even afford to conduct the necessary repairs to render their homes habitable. Plaintiff Scott Holland, for example, could not afford to fix his property, was forced to move away, and continued living in a trailer at the time of trial. Tr. 1844:15 to 1845:11 (Holland).

Likewise, that some affected property owners recovered insurance money is not apposite to whether the government deprived plaintiffs of their right to use and enjoy their property. Insurance proceeds that mitigate the amount of out-of-pocket expenses incurred to repair damages in no way lessens the degree of harm caused by the initial infliction of that damage. The same is true of other government benefits plaintiffs may have received, such as FEMA grants. Independent awards of aid might have lessened the *ex post facto* cost of recovery for some plaintiffs and be relevant to damages, but that has little bearing on whether the government effected a taking initially.

Given the extensive damage caused to plaintiffs’ real and personal property, their inability to exercise the right to exclude floodwaters, the interference with their right to use and enjoy their property, the high likelihood of recurring floods, and the significant diminution of property values, the court finds that the severity calculus weighs in favor of finding a taking.

iii. Benefit to the government.

Another consideration in the takings analysis is whether the invasion “appropriate[s] a benefit to the government at the expense of the property owner,” *Ridge Line*, 346 F.3d at 1356, as opposed to inflicting a mere “consequential” injury, *id.*; *Armstrong*, 364 U.S. at 48. The line between which destructions of property by government action are compensable takings and which are simply consequential, and therefore subject to a tort analysis or not compensable, is not always easy to distinguish. But when the direct result of the government’s actions is the destruction of property for its own, and thus the public’s, benefit, the affected property owners are entitled to just compensation for a taking. *See Armstrong*, 364 U.S. at 48-49. In the case of *Addicks and Barker*, the government received a notable benefit at the expense of the upstream private property owners. That the dams protected downstream Houston is not the point. It

suffices to say that, consistent with the purpose for the construction of the Addicks and Barker flood-control projects, the government protected downstream properties from an estimated \$7 billion in losses during Harvey, *see* Tr. 164:24 to 165:8 (Thomas), while concurrently causing upstream properties to suffer from severe flooding.

The government argues that “the direct . . . result of the government action is to reduce the risk of catastrophic downstream flooding” and “[t]hat such [upstream] flooding occurred in connection with Hurricane Harvey was merely a consequential result.” Def.’s Br. at 82. But the precedents suggest otherwise. This is not a case where the damage to plaintiffs’ land was a residual effect of government actions on other property. *Cf. Southern Pac. Co. v. United States*, 58 Ct. Cl. 428, 432 (1923) (finding that the injury to plaintiff’s railroad from construction of a jetty nearby that may have altered ocean currents was not compensable as a taking because the injury was incidental and indirect to the government actions). Notably, here the same actions which benefitted the downstream properties are those which caused harm to plaintiffs. The damage to plaintiffs’ properties was the direct result of the government’s construction, modification, and operation of the Addicks and Barker Dams, reflecting the sheer fact that plaintiffs’ properties are, by government design, within the dams’ flood-pool reservoirs. The flooding suffered by plaintiffs and the associated “damages were not merely consequential. They were the product of a direct invasion of [the plaintiffs’] domain.” *Causby*, 328 U.S. at 265; *see also Cress*, 243 U.S. at 327 (“[T]his is not a case of temporary flooding or of consequential injury, but a permanent condition, resulting from the erection of the lock and dam, by which the land is subject to frequent overflows of water from the river.”). The invasion of the Addicks and Barker flood pools onto plaintiffs’ properties from the construction and modification of the dams and their operation during Harvey, appropriated a benefit to the government at the direct expense of inflicting significant injury to plaintiff property owners. Therefore, this factor weighs in favor of plaintiffs.

b. Intentional or foreseeable.

Arkansas Game & Fish next requires the court to assess “the degree to which the invasion is intended or is the foreseeable result of authorized government action.” 568 U.S. at 39. A taking occurs either where the government intended to invade the property or where the invasion is the “direct, natural, or probable result of an authorized activity and not the incidental or consequential injury inflicted by the action.” *Ridge Line*, 346 F.3d at 1355 (quoting *Columbia Basin Orchard*, 132 F. Supp. at 709). The presence of the disjunctive “or” in the *Arkansas Game & Fish* factors, *see* 568 U.S. at 39 (“intended *or* is the foreseeable result”) (emphasis added), makes evident that one of these circumstances must be present to support the finding of a taking. *See Barnes*, 538 F.2d at 871 (“[P]laintiffs need not allege or prove that defendant specifically intended to take property. There need be only a governmental act, the natural and probable consequences of which effect such an enduring invasion of plaintiffs’ property as to satisfy all other elements of a compensable taking.”) (internal citations omitted). Despite being separate inquiries, the two factors are interrelated—one cannot find intent without foreseeability; but what is an objectively foreseeable result may not have been the intended result. *See John Horstmann Co. v. United States*, 257 U.S. 138, 146 (1921) (“[I]t would border on the extreme to say that the government intended a taking by that which no human knowledge could even predict.”); *Columbia Basin Orchard*, 132 F. Supp. at 711 (“Such [results were] not the direct, natural or probable consequence[s] of the Government’s act, and for this reason no intent to take can be

implied.”). Here, both intent and foreseeability were present. Because foreseeability bears on intent, foreseeability is addressed first.

i. Foreseeability and causation.

Whether the asserted invasion is the “direct, natural or probable result of an authorized activity” is a critical part of the takings analysis. *Columbia Basin Orchard*, 132 F. Supp. at 709. Put in other terms, the court should determine here “whether the [flooding] on the claimants[’] property was the predictable result of the government action.” *Ridge Line*, 346 F.3d at 1356 (citing *Sanguinetti v. United States*, 264 U.S. 146, 149-50 (1924)). If the most that can be said is that the government’s actions are only “a contributing factor towards” the flooding, in contrast to the flooding being “the natural or probable consequence” of those actions, then “a tort action may lie in the proper forum for such an incidental or consequential injury,” but not an action for taking. *Columbia Basin Orchard*, 132 F. Supp. at 709.

The invasion asserted here by plaintiffs is that of impounded floodwaters entering onto their properties resulting from the Corps’ construction, modification, maintenance, and operation of the Addicks and Barker Dams. Plaintiffs contend that “the inundation of private properties from the reservoir pools behind each dam was the predictable result of the [g]overnment’s actions.” Pls.’ Br. at 30. Plaintiffs support this assertion by arguing that the Corps always “knew there would be recurrent storms of such a magnitude [as Harvey],” *id.* at 30, and that the foreseeability of plaintiffs’ properties flooding was obvious in light of the fact that the properties are located within the maximum pool size for the reservoirs, *see id.* at 38.

Defendant, in response, puts forth several postulates why the inundation was not foreseeable. Defendant first argues that the flooding of private properties in the reservoirs was not foreseeable because “Hurricane Harvey was an extraordinarily rare and large storm.” Def.’s Br. at 58 (heading) (capitals omitted). Further, defendant argues that, “[t]he relevant government action . . . for purposes of this [foreseeability] analysis should be at the time the Corps constructed the dams in the 1940s.” *Id.* at 79. The government avers that “[t]he agency’s knowledge at th[at] time [was] that [this] particular result is [] *possible*” and that “does not mean it is a *direct, natural or probable* result.” *Id.* at 80 (emphasis in original). Additionally, the government argues that the Corps did not foresee “the resulting damage when it constructed the Project in the 1940s” and that “[t]o find otherwise would hold the Corps responsible for unforeseen urbanization.” *Id.* at 81.

Defendant’s reliance on the contention that foreseeability in this scenario is most properly measured from the viewpoint of the government in the 1940s, at the time the Addicks and Barker Dams were constructed, is not appropriate because the foreseeability inquiry should not be so constrained. Most importantly, defendant misstates the underpinnings of the foreseeability analysis. Foreseeability—in contrast to intent, which more aptly accounts for subjective positions—is not simply measured from the viewpoint of the government; foreseeability is an objective inquiry. *See, e.g., John Horstmann Co.*, 257 U.S. at 146 (considering whether the results of the government actions could have been objectively foreseen); *Sanguinetti*, 264 U.S. at 147-48 (explaining how the foreseeability inquiry depends on whether there was “any reason to expect that such result would follow.”). That is, would an objective person reasonably foresee that the actual results which occurred would have been the direct, natural or probable results of the government’s actions? Whether the Corps subjectively foresaw the results may bear on

objective foreseeability, but it is not the only consideration. Therefore, it is irrelevant in this case whether foreseeability is measured in the 1940s, 1970s, or even in the 2000s, because at all of these points defendant should have objectively foreseen that the pools could and would exceed government-owned land.

Here, the evidence demonstrates the Corps was aware or should have been aware since the initial construction of the dams and at every point onward, that the flood pools in the Addicks and Barker Reservoirs would at some point (and thereafter) exceed the government-owned land, inundating private properties. As early as the 1940s, the Corps understood that storms of exceptionally large size were possible in the Houston metropolitan area. For example, the Corps noted in the 1940 Definite Project Report that the Buffalo Bayou watershed is situated “in an area subject to all of the circumstances making possible large storms” and that “only chance has prevented the occurrence of a storm over the basin much larger than the 1935 storm.” *See* JX5 at 7. The Hearne storm of 1899, which served as a basis for the design of the maximum pool size in each reservoir, occurred only 90 miles northwest of Houston. *See id.* (explaining that the Hearne storm occurred under meteorological conditions that the Corps noted “could be approximated closely over the Buffalo Bayou watershed”). Notably, the Corps considered that pool sizes beyond the extent of government-owned land were foreseeable in the 1940s during the lifetime of the structures, when they conducted a cost-benefit analysis, *see generally* JX52, ultimately determining that “the expected damages of inundating pastures and rice fields” would be less than the cost of buying additional land, *see* Tr. 200:21-24 (Thomas). To an objectively reasonable person, it was not a question of whether the pools would reach the level they did—it was merely a question of when and how often. Just as in *Cotton Land Co. v. United States*, “The events which occurred, although they took some time, were only the natural consequences of the [government’s actions]. If engineers had studied the question in advance[,] they would . . . have predicted what occurred.” 75 F. Supp. 232, 233-34 (Ct. Cl. 1948). Accordingly, even measuring foreseeability in 1940, as defendant advocates, leads to a conclusion that pools of a size at or close to Harvey were objectively foreseeable.

But the taking at issue here does not begin and end with the construction of Addicks and Barker. The Corps’ modification, operation, and maintenance of the dams was and is ongoing, continuing well into the years following the 1940s, and at each successive instance, the likelihood of occurrence of flood pools exceeding government-owned land grew. By the 1960s and 1970s, the Corps had a definite understanding that larger pool sizes were highly probable. A study by the Corps in the 1960s explained that the now-permanent gates on the reservoir conduits would lead to larger and more permanent pools. *See* JX15 at 44. In a 1973 memorandum, the Corps’ Chief of the Engineering Division in the Galveston, Texas district noted that the Corps should “develop a history and rationale for our operating concept of imposing flooding on private lands without benefit of flowage easement or other legal right.” *See* PX37 at 1. A 1974 Corps inspection report echoed similar thoughts. *See* PX38 at 5 (USACE233674) (1974 Buffalo Bayou Inspection Report) (“Development of the area will eventually place the [g]overnment in the position of having to flood the area within the reservoir with the accompanying damages in order to protect downstream improvements in the event of a severe future storm.”).

Later events only magnified the risk of flooding beyond government-owned land, rendering it virtually inevitable. Around March of 1992, a series of storms resulted in then-record flood pools in both the Addicks and Barker Reservoirs. *See* Tr. 363:20 to 364:2

(Thomas). This result, known as the “ratcheting effect,” demonstrated that one Harvey-sized storm was not necessary to create large flood pools—a series of consecutive moderate storms could have the same effect. *See* Tr. 363:20 to 364:11 (Thomas). The Corps in the 1990s and 2000s, aware of the increased risk, surveyed properties in the reservoirs located beyond government land to have a firmer idea as to the extent of the possible damage if flooded. *See* Tr. 100:5-16 (Thomas) (One such field study was conducted and completed in July 1994; another study was completed in 2003.). Not only is it evident that the Corps believed flooding beyond the extent of government-owned land was probable, it is unreasonable to contend otherwise.

It is true that Tropical Storm Harvey was a record-setting storm. But the evidence markedly shows that pools of this size and the attendant flooding of private property were, at a minimum, objectively foreseeable. Thus, Harvey’s magnitude does not exculpate the government of liability for its actions. Even so, the government suggests that “the *claimed losses* were not the direct, natural or probable result” because the Corps could not have foreseen “such significant development upstream of the reservoirs.” Def.’s Br. at 81 (emphasis added). Essentially, the government suggests that because the properties that flooded were more developed, *i.e.*, homes and businesses occupied the land as contrasted to the more rural fields of the 1940s, it should not be held responsible for the resulting damage. The government, however, misapplies the foreseeability inquiry. That the monetary amount of damages may be more significant than initially thought does not detract from the fact that it was foreseeable that the land would be invaded by floodwater. In short, just because the nature of the invaded land has changed from farm land to residential does not bear on the question of whether an invasion of such land should have been foreseen.

The parties also present opposing views on the causation analysis for the flooding at issue. Establishing causation is a vital component of the foreseeability inquiry. “In order to establish causation, a plaintiff must show that in the ordinary course of events, absent government action, plaintiffs would not have suffered the injury.” *St. Bernard Par. Gov’t v. United States*, 887 F.3d 1354, 1362 (Fed. Cir. 2018). Additionally, “the causation analysis must consider the impact of the entirety of government actions that address the relevant risk.” *Id.* at 1364. Therefore, the relevant question here is whether the flooding on plaintiffs’ properties would have occurred but for the government’s actions regarding Addicks and Barker.

Causation for all thirteen properties was originally contested, *see* Pls.’ Br. at 39-49; Def.’s Br. at 63-75, and expert testimony on the subject was presented from both Dr. Bedient for plaintiffs and Dr. Nairn for defendant. As for ten of the thirteen properties, defendant has essentially conceded that without the dams these properties would not have flooded. *See* Tr. 3258:8-12 (closing argument). Defendant’s expert opined that only the “finished first floors on *three* of the thirteen upstream Test Properties would have experienced some flooding even in the absence of the federal project.” DX608 at 166 (emphasis added). With respect to ten properties, plaintiffs’ burden of causation thus has been met: (1) Banker; (2) Holland; (3) Lakes on Eldridge; (4) Popovici; (5) Sidhu; (6) Soares; (7) Stewart; (8) Turney; (9) West Houston Airport Corporation; and (10) Wind.

The remaining three properties require a more thorough analysis: (1) Burnham; (2) Giron; and (3) Micu.²¹ The parties presented competing testimony about the causes of the flooding on these three properties. Plaintiffs argue that “Dr. Bedient’s work establishe[d] that each of the Test Properties’ [] flooding was in fact caused by the Addicks or Barker [D]am impoundment.” Pls.’ Br. at 43. In his report, Dr. Bedient concluded that “all of the test properties were flooded due to the impounding rainfall runoff waters by the [Corps] behind the Addicks and Barker Dams,” PX526 at 46, and such flooding was not a result of the local drainage systems or due to riverine flooding, *see id.* at 47, 49, 54. Contrastingly, defendant argues that flooding was unavoidable upstream due to the magnitude of Harvey. Def.’s Br. at 72. That is, defendant asserts that the flooding on these three properties cannot be attributed to the pools created by the Addicks and Barker Dams. *See id.* at 68-69 (arguing that the flooding on the three properties was attributable to alternative sources such as diversion channels and riverine flooding).

Dr. Bedient reached his conclusions by studying and analyzing real-time data collected during the storm, whereas Dr. Nairn reached his conclusions through modeling and projections. While modeling can be a useful tool for planning and analyzing hypothetical outcomes and at times may be able to provide more sophisticated insights than even real-time data, in the case at hand, Dr. Bedient’s analysis was more persuasive. Particularly, Dr. Nairn’s testimony suffered from a major flaw—a failure to fully capture what *actually* occurred. For instance, Dr. Nairn’s model concluded that flooding within the homes on the Giron and Micu properties due to riverine overbanking had already occurred as of August 27. *See* DX608 at 125-26. But live witness accounts and photographic evidence show that water did not enter either home until at least an entire day later. *See* Tr. 1999:14 to 2000:13 (Bedient). Additionally, Dr. Nairn’s model failed to account for stormwater drainage systems and improperly accounted for channel diversions and drainage projects. *See, e.g.,* Tr. 2002:14-25 (Bedient). These oversights render the model scenario different from the real-life scenario, and likely caused an overstatement of Dr. Nairn’s projections of riverine flooding. *See* Tr. 2004:19 to 2005:2 (Bedient); *see also* Tr. 1858:6-12 (Lesikar-Martin) (explaining that, in contrast to Dr. Nairn’s assertions, Bear Creek was not overflowing beyond its banks during Harvey). A predictive modeling system which relies on incorrect inputs and outputs used to align the model’s coefficients and factors, cannot provide reliable projections. Accordingly, Dr. Nairn’s model, which relies on input data that do not match what in fact occurred, cannot be fully reliable. Lastly, Dr. Nairn’s conclusions seem, in part, to agree with that of plaintiffs’ expert, Dr. Bedient, even as to the three contested properties. Dr. Nairn concludes that “[P]eak flood elevations at all of the upstream Test Properties are attributed to backwater due to high pool elevations in Addicks or Barker Reservoirs.” DX608 at iii (emphasis added). In other words, Dr. Nairn appears to agree that the water would not have been as high in each of the three contested homes but for the Addicks and Barker projects.

Defendant has alleged a number of errors in Dr. Bedient’s calculations. For example, defendant contends that Dr. Bedient failed to account for cumulative effects, and simply looked at discrete six- and twelve-hour time periods when collecting certain data. Def.’s Br. at 73. But these allegations do not suffice to discredit Dr. Bedient’s conclusions. Whether Dr. Bedient’s model fully accounts for intervening hours does not detract from the fact that his conclusions are

²¹Given that the causation issues were the same for all three properties, the properties can be discussed collectively with regard to causation.

more reliable because they align with what was actually witnessed.²² As such, plaintiffs have met their burden of showing that but for the Addicks and Barker project, flooding would not have occurred to the level it did on the three contested properties.

Defendant also puts forth in rebuttal one additional argument on causation. Defendant argues that because the government's actions that address the relevant risk must be considered in their entirety, plaintiffs' failure to account for the impact of the outgrants is fatal to their argument. *See* Def.'s Br. at 97-98 (citing *St. Bernard Par.*, 887 F.3d at 1364). Defendant argues that the outgrants that the "United States allowed to be built on the Project property were built to reduce flood risks to upstream properties," and because this is "government action [that] mitigates the type of adverse impact that is alleged to be a taking, it must be considered in the causation analysis." *Id.* (citing *St. Bernard Par.*, 887 F.3d at 1367). It is defendant, however, who fails to fully account for *all* the impacts of the outgrants. Defendant asserts that the outgrants mitigated the flood risk upstream. To an extent, that allegation is correct. They effectively allowed water to be removed from the upstream neighborhoods more rapidly. But the outgrants also had the effect of causing "more frequent" and "larger" impoundments in the reservoirs and "increase[d] flood damages resulting from reservoir impoundments." JX52 at 16 (USACE01545). Thus, it cannot be said that the government's granting of easements for drainage systems consequently built by developers and local entities, as a whole, provided a greater benefit than harm. As to the "but for" analysis, it would be wrong to say that but for the granting of the outgrants, plaintiffs would have been worse off. Notably, the evidence actually suggests the opposite. Moreover, in the counterfactual scenario where the federal government refused to grant these easements, the evidence suggests that upstream developers would have been required to seek other feasible remedies for drainage. *See* Tr. 817:1-11 (Vogler).

Thus, considering the totality of the evidence, plaintiffs have met their burden of showing causation for all thirteen properties. Plaintiffs have sufficiently demonstrated that the inundation of floodwaters onto their private property was the "direct, natural, or probable result" of the government's activity. *Ridge Line*, 346 F.3d at 1355.

ii. Intent.

Intent does not concern whether the government meant to abridge a private property right but whether it intended to occupy the pertinent property without lawful authority or excuse. *See LaBruzzo v. United States*, 144 Fed. Cl. 456, 474 (2019). Thus, the intent element is present if the government intended its physical occupation even if it did not intend to effect a taking. *See id.* As noted by the Supreme Court of Texas, "build[ing] a flood-control dam knowing that certain properties will be flooded by the resulting reservoir" is a "*conscious decision* to subject particular properties to inundation so that other properties [will] be spared." *Harris Cty. Flood Control Dist.*, 499 S.W.3d at 807 (emphasis added). The requisite intent to invade is present in

²²Similarly, defendant's assertions that Dr. Bedient's testimony relied upon flawed gauge data, *see* Def.'s Br. at 67, are unavailing. Defendant argues that "Dr. Bedient erroneously based his critique on uncorrected data for [the upper Buffalo Bayou gauge]." *Id.* But these gauges are regularly inspected, *see* Tr. 2173:10-15 (Test. of Jeffrey East), and are considered reliable, *id.* Even if the gauge was misreading, Dr. Bedient's report corrects any misreading by comparing and subsequently aligning the data with what was actually witnessed. *See* Tr. 3195:9-15.

such cases, and “of course the government must compensate the owners who lose their land to the reservoir.” *Id.* See also *Tarrant Reg’l Water Dist. v. Gragg*, 151 S.W.3d 546, 555 (Tex. 2004) (citing *City of Dallas v. Jennings*, 142 S.W.3d 310, 314 (Tex. 2004) (“[T]he requisite intent is present when a governmental entity knows that a specific act is causing identifiable harm or knows that the harm is substantially certain to result.”)). The government may not, however, intend an outcome which it did not subjectively foresee as a “direct, natural, or probable consequence” of its action. See *John Horstmann Co.*, 257 U.S. at 146.

Here, the Corps knew from the outset that the land it purchased was inadequate to hold the amount of water that would be contained in the reservoirs should the embankment-design storm occur. See JX5 at 26. It knew then that if such a storm transpired, the water produced would exceed government-owned land and flood private property. *Id.* But it appears doubtful that the Corps *subjectively* foresaw the occurrence of a storm event large enough to create pools that exceeded government-owned land—although, as already noted, such a storm was *objectively* foreseeable at that time, see *supra*, at 35-36. It certainly knew that such a storm was *possible* over the Addicks and Barker watersheds, see, e.g., Pls.’ Mot. to Reopen the Trial R. Ex. A at USACE2019_0000013-14 (recording the Corps’ observation that the occurrence of a storm like the Hearne storm was not “unreasonable”), but the Corps seems to have reckoned then that it was an *improbable* event, see JX5 at 9-10 (concluding that the occurrence of a storm as severe as the Hearne storm was “very remote”), or at least that it would not occur frequently. This conclusion is also inferable from the cost-benefit analysis the Corps conducted around this time. To perform such an analysis, the Corps needed to determine both how much it would cost the government to flood beyond government-owned land and how frequently that was likely to happen. Comparing the cost attributable to flooding rural land to what it would cost to purchase rights to the then-undeveloped land, the Corps determined that the cost of flooding was less. That the calculus reached the conclusion it did indicates that the Corps regarded such overflow as possible but that it was willing to take the ensuing risk. That calculus did not withstand the test of time. Nonetheless, the intent inquiry does not end there.

Intent is present here because, like foreseeability, intent is not measured at one singular point in time. Again, this is because the government action at issue is not simply the construction of the dams, but the totality of their construction, modification, maintenance, and operation over the project lifespan. The Corps subjectively knew by the 1940s, and particularly by the 1960s, that storms larger than the design storm were likely to occur over Addicks and Barker. See *supra*, at 17, 31, 36. From that time forward, it had subjective knowledge that pools exceeding government-owned land were probable at some point. Indeed, by 1973 the Corps expected the possibility of flooding off of government-owned land to become a public concern. See PX37 at 1. Thus, intent can be inferred here because the government knew flood waters would likely occupy plaintiffs’ private properties at some point.

Equipped with the knowledge that storms of the design storm magnitude were probable, the Corps did not stray from its primary objective to prevent downstream flooding (indeed, it probably could not), even when it knew that could well mean impounding water on private property. For example, the 2012 Water Control Manual, which the Corps followed during Harvey, instructs the Corps to operate the dams in a manner consistent with their original purpose: to protect downstream property by impounding water in upstream reservoirs. It states that “the general plan for reservoir regulation will be to operate the reservoirs in a manner that will utilize to the maximum extent possible, the available storage to prevent the occurrence of

damaging stages on Buffalo Bayou.” JX110 at 7-4 (USACE016338). Notably, the “available storage” that was to be “utilize[d] to the maximum extent possible” encompasses *all* land in the intended reservoir behind the embankments, including land the government has never owned. *See* Tr. 67:12 to 68:3 (Thomas). To accomplish its purpose of downstream protection, the Corps planned all along to impound water to the maximum extent of the available storage—a determination that never altered even when the Corps came to understand that rainfall events reaching the design storm magnitude were probable rather than merely possible. In short, the government had the requisite intent to invade plaintiffs’ properties because the Corps had been well aware that storms capable of overflowing government-owned land were likely to occur, and despite that knowledge it still intended to occupy the property concerned without lawful authority or excuse. *See LaBruzzo*, 144 Fed. Cl. at 474.

c. Reasonable investment-backed expectations.

A property owner’s “reasonable investment-backed expectations regarding the land’s use” is also a factor relevant to the takings inquiry under *Arkansas Game & Fish*, 568 U.S. at 39 (citing *Palazzolo v. Rhode Island*, 533 U.S. 606, 618 (2001)). As a threshold matter, plaintiffs assert that this factor should not even be considered here because the concept applies only to regulatory, not physical, takings. *See* Pls.’ Br. at 116-17 n.541. They correctly observe that “time and again, the Supreme Court has underscored the distinctness of [the physical and regulatory] lines of takings cases,” *id.* at 117 n.541, and there is no question that the reasonable investment-backed expectations factor is ordinarily applied in the context of regulatory, and not physical, takings. *See, e.g., Penn Cent.*, 438 U.S. 104. Noting this difference, the Federal Circuit stated in *Preseault v. United States* that “[t]he Government’s attempt to read the concept of ‘reasonable expectations’ as used in regulatory takings law into the analysis of a physical occupation case would undermine, if not eviscerate, long-recognized understandings regarding protection of property rights; it is rejected categorically.” 100 F.3d 1525, 1540 (Fed. Cir. 1996). *See also Palm Beach Isles Assocs. v. United States*, 231 F.3d 1354, 1364 (Fed. Cir. 2000) (explaining that “‘reasonable investment-backed expectations’ are not a proper part of the analysis” in physical takings cases); *Caquelin*, 140 Fed. Cl. at 582 (citing and quoting *Love Terminal Partners, L.P. v. United States*, 889 F.3d 1331, 1345 (Fed. Cir. 2018) (“The reasonable, investment-backed expectation analysis is designed to account for property owners’ expectation that the *regulatory* regime in existence at the time of their acquisition will remain in place, and that new, more restrictive legislation or regulations will not be adopted.”)) (emphasis added).

The precept plaintiffs reach from this line of precedents is that the inclusion of the investment-backed expectations factor in the *Arkansas Game & Fish* listing was not intended to translate that factor outside the regulatory takings context. They seek to diminish its enumeration as a relevant factor in *Arkansas Game & Fish* by noting the preamble to the list of factors, which states that the ensuing factors are relevant “[w]hen regulation or temporary physical invasion by government interferes with private property.” 568 U.S. at 38.

Even so, flooding cases can pose an exception to the quotidian rule that physical takings do not involve consideration of “reasonable investment-backed expectations.” Plaintiffs fail to take account of the context in which *Arkansas Game & Fish* arose. *Arkansas Game & Fish* plainly involved a physical, not regulatory taking, but the Court nonetheless included the factor as relevant for guiding the decision on remand. Although citing *Palazzolo*, a regulatory takings case, for inclusion of the factor, the Court applied it to the physical taking before it because it

had accepted the finding that the flooded area at issue had flooded previously. The prior flooding had occurred fairly often following Spring rains, but that flooding was transient and did not affect the growing season of the management area's forest. *See* 568 U.S. at 39. Extensive flooding that stretched over the growing season was quite a different matter. *Id.* Thus, the Court acknowledged the plaintiff's expectations that flooding at certain times and of limited duration was possible, but that the flooding involved in the taking claim was of a different kind than that which they could have anticipated or had previously encountered.

The context of the case at hand is strikingly similar. In this case, the properties are located in a geographical area that is generally susceptible to large storms and potential flooding, and the landowners were aware of that fact. But the flooding that caused the alleged taking before the court was different in kind from that which had occurred naturally and from what plaintiffs had reason to anticipate; it was more severe than any prior flooding and it was not the result of natural conditions but rather of deliberate government action. Reasonable investment-backed expectations are therefore as equally applicable here as they were in *Arkansas Game & Fish*.²³ Despite the evident tension of transposing this factor from the regulatory to the physical takings context, *Arkansas Game & Fish* clarifies that reasonable expectations are a relevant consideration in connection with physical takings cases of this particular nature.

Informing the application of the factor are two considerations. First, the landowner's expectations must be "reasonable," meaning that while this is a fact-intensive inquiry, "it is nonetheless an objective one." *Chancellor Manor v. United States*, 331 F.3d 891, 904 (Fed. Cir. 2003). Second, the matter at issue is a question of degree, that is "the extent to which the [government action] interferes" with those expectations. *Palazzolo*, 533 U.S. at 617. Significantly, it is not the case that a takings claim must fail simply because a property owner "acquired [] land while on notice that a taking was occurring or had the potential to occur." *In re Upstream Addicks & Barker*, 138 Fed. Cl. at 669 (citing *Dickinson*, 331 U.S. at 750); *see also Cooper v. United States*, 827 F.2d 762, 764 (Fed. Cir. 1987) (finding a taking where the plaintiff acquired property while on notice that the government-induced flooding was already occurring). The law offers the government no loophole whereby it may escape takings liability by putting landowners on notice of the risk that it could or would take their property. *See Palazzolo*, 533 U.S. at 626 (rejecting the "sweeping rule" that "a purchaser or a successive title holder . . . is deemed to have notice of an earlier-enacted restriction and is barred from claiming that it effects a taking."). In short, the government gains no immunity for an uncompensated taking by giving advance notice that it will take property. When the taking actually occurs, it still must provide compensation.

Even if notice had a bearing, plaintiffs would still prevail here because they neither knew, nor reasonably should have known, of the risk posed by the dams. The government nonetheless maintains that plaintiffs fail on this factor because "they lacked an objectively reasonable expectation that their properties would not flood in a Hurricane Harvey-like event." Def.'s Br. at

²³Perhaps the Supreme Court's inclusion of the words "investment-backed" invites too strong a reference to regulatory takings law. Simply referring to "reasonable expectations" would capture the context in which the Court used the factor in *Arkansas Game & Fish*.

106.²⁴ To support this contention, it emphasizes that plaintiffs had notice of the possibility of flooding, pointing out that “Harris and Fort Bend Counties have a long history of flooding during large storms.” *Id.* It also cites publicly available information demonstrating the possibility of upstream flooding during large storms, notifications proliferated by local governments, and the frequency with which residents in the region purchased flood insurance. *See id.* Plaintiffs counter that not one of them had any knowledge that their property was situated in a reservoir, *see* Pls.’ Br. at 117, and assert that there is no reason to think plaintiffs reasonably should have known about that particular risk, different from natural flooding. *See* Pls.’ Reply at 24. *See also* Tr. 1729:10-17 (Banker); Tr. 1758:15 to 1760:3 (Burnham); Tr. 1651:8-23 (Giron); Tr. 1834:14-16 (Holland); Tr. 1413:15 to 1414:5 (Lakes on Eldridge); Tr. 1293:24 to 1294:15 (Micu); Tr. 1225:2-17 (Popovici); Tr. 1738:9-17 (Sidhu); Tr. 1076:22 to 1078:3 (Soares); Tr. 1607:19-22 (Stewart); Tr. 2151:16-20 (Turney); Tr. 1626:1 to 1627:10 (Wind); Tr. 2120:20 to 21221:5 (Lesikar).

It is undisputed that plaintiffs did not know their properties were located within the reservoirs and subject to attendant government-induced flooding. The point of contention here is whether plaintiffs objectively ought to have known about that risk based on notice.²⁵ First, the government points to “[p]ublic documents” that discuss the “possibility of upstream flooding during large storms.” Def.’s Br. at 106. But the mere fact that information is available does not make it reasonable to assume that plaintiffs should have known about it or, if they did, that they would understand that it related to government-induced flooding. Even if plaintiffs are assumed to be aware of information in places such as Key Maps, FEMA Maps, or United States Geological Survey quadrangle maps—an assumption that is hardly a given—the import of data on these maps is far from obvious. For example, to infer the possibility of flooding from the Key Maps would require a baseline knowledge about property elevations, something the average homeowner does not generally know. It is highly tenuous to suggest that the average citizen should know how to read and understand the information in these maps or recognize that the map annotations refer to government-induced flooding rather than naturally occurring flooding.

Next, the government cites the subdivision plats, which indicate that land was subject to controlled inundation, as evidence that plaintiffs had notice of the risk when they purchased their property. *See, e.g.,* Def.’s Br. at 113-14. These subdivision plats are replete with miniscule

²⁴The court perceives the irony of the government’s simultaneous contentions that the Corps could not have anticipated a storm of Harvey’s magnitude but that plaintiffs ought to have foreseen the risk of their properties flooding in such an event.

²⁵At trial, the government sought to introduce the testimony of Dr. Gerald Galloway, a retired Brigadier General in the Corps, as an expert witness. The government proposed that Dr. Galloway testify as to “indicators that are available to laypeople that they could consider when making a decision such as purchasing property.” *See* Tr. 2544:10-12 (Test. of Gerald Galloway). The court declined to certify Dr. Galloway as an expert witness because the government did not satisfy its burden to show by a preponderance of the evidence that the testimony was based on scientifically valid principles rather than a subjective belief or unsupported speculation. *See* Tr. 2580:12 to 2581:17 (Galloway). Likewise, the proposed expert’s opinions about the subjective views of the landowners were far less credible than the testimony offered by plaintiffs themselves of their own personal knowledge and belief.

details. *See, e.g.*, DX557. Even if one were to examine the plats, which it appears no purchaser actually did, *see, e.g.*, Tr. 1295:6-9 (Micu); Tr. 1660:14-16 (Giron), it would take an uncommonly attentive eye to notice and comprehend the import of such a “disclosure.” Moreover, the government’s own witness, the Fort Bend County Drainage District’s Chief Engineer, testified that the plat language was not successful in informing the public of the risks involved. *See* Tr. 682:10-16 (Vogler). Additionally, the fact that the Corps discussed the possibility of upstream flooding with developers is not evidence that anyone who subsequently purchased that property also should have been apprised of the information. The government further cites the high rate of flood-insurance purchases compared to the national average, concluding that this demonstrates that “the possibility of upstream flooding has long been knowable in this region.” Def.’s Br. at 106. This argument also fails because no one disputes that the Houston region is, and long has been, especially flood prone. Because that general flood risk was well known, and because some residents purchased flood insurance to account for it, is simply not evidence that plaintiffs should have been aware of the specific risk associated with the very different type of flooding at issue here, namely, government-induced flooding.

Perhaps the government’s strongest argument on the issue of notice is the fact that both the Corps and local governments conducted public meetings, in which they disclosed information about the possibility of flooding, during the decades leading up to Harvey. Def.’s Br. at 106. But here, too, the government fails to show that plaintiffs should reasonably have known of the risk. The mere fact that meetings occurred does not mean they were effective at communicating the risk such that the public should have known about government-induced flooding; there is no evidence that these meetings were heavily attended or particularly well publicized in the community. And in rapidly developing suburbs of a large city like Houston, it is reasonable to expect a regular flow of people moving in and out of the area, further reducing the likelihood that new residents adapting to the area would know of the risk without an especially aggressive public campaign. That not one of the plaintiffs in this case was aware of the situation regarding government-induced flooding is also telling with respect to the effectiveness of these meetings, suggesting that it is quite reasonable to conclude that the average person in the community was likely unaware of the risk.

Having determined that plaintiffs’ investment-backed expectations were reasonable, the court next addresses the extent to which the government’s action interfered with those expectations. Plaintiffs purchased their property for the same varied reasons people generally buy real estate, *e.g.*, for a home to live in safely or as an investment. *See, e.g.*, Tr. 1704:12-19 (Banker) (noting that the property was purchased as home for retirement and was considered an investment that would appreciate). As already noted, the degree of interference with these expectations was acute—rendering properties uninhabitable for a significant time, requiring substantial outlays to perform repairs, and resulting in a significant diminution in the resale value of inundated properties. Subsequent developments prompted by the flooding, such as the recently enacted Texas statute mandating disclosure when property is situated in a reservoir, can further be expected to diminish property market value. Therefore, the court concludes that the government-induced flooding severely interfered with plaintiffs’ reasonable investment-backed expectations.

Overall, each of the factors identified in *Arkansas Game & Fish* supports the finding of a taking of a flowage easement on all thirteen of the bellwether test properties.

B. Defenses to Liability

The court must determine whether any of the government’s defenses would preclude the finding of liability. The government asserts two defenses. First, the government argues that its actions constituted an exercise of police powers, such that no viable taking claim exists. *See* Def.’s Br. at 87-91. Second, the government argues that “the doctrine of necessity [] ‘absolv[es] the State of liability for the destruction of real and personal property.’” *See id.* at 91-92 (citing *TrinCo Inv. Co. v. United States*, 722 F.3d 1375, 1377 (Fed. Cir. 2013)) (internal citations omitted). These defenses, however, are inapplicable to the case at hand.

The government first argues that “[p]articularly in an emergency, where the government action is part of an effort to reduce or mitigate *unavoidable* harms to the public, no viable taking claim exists.” Def.’s Br. at 88 (citing *Miller v. Schoene*, 276 U.S. 272, 279-80 (1928)) (emphasis added). But that argument cuts against the defense, because the flooding at issue here was not an *unavoidable* harm. Defendant asserts that in the situation at hand, the Corps had little to no choice on how to act when Harvey hit, and that in an effort to protect lives, the Corps operated the project in accordance with the 2012 Water Control Manual. *See* Def.’s Br. at 89-90. That is, the Corps could open the gates and risk more severe downstream flooding or keep the gates closed, as it did, flooding upstream properties. When Harvey struck, it was true that certainly “the actions available to the government for dealing with the relevant emergency were constrained by the design of the dams and impoundments, the Corps’ 2012 Water Control Manual, and the Corps’ normal operating procedures.” *See In re Upstream Addicks & Barker*, 138 Fed. Cl. at 669. But these constraints only existed because the Corps’ design of the dams contemplated flooding beyond government-owned land onto private properties. “Thus, it was not that the government had to respond to Tropical Storm Harvey as an emergency that necessitated the flooding of private land,” but rather that the government had made a calculated decision to allow for flooding these lands years before Harvey, when it designed, modified, and maintained the dams in such a way that would flood private properties during severe storms. *Id.* Defendant cannot now claim that this harm was unavoidable when it planned for years to impound floodwaters onto plaintiffs’ properties.

Similar reasoning applies to the government’s necessity defense. That defense rests on the notion that “in times of imminent peril—such as when fire threatened a whole community—the sovereign could, with immunity, destroy the property of a few [such] that the property of the many and the lives of many more could be saved.” Def.’s Br. at 91 (quoting *TrinCo*, 722 F.3d at 1377). Three requirements must be met for the necessity doctrine to apply: (1) “actual emergency;” (2) “imminent danger;” and (3) “actual necessity of the [g]overnment action.” *TrinCo*, 722 F.3d at 1379. That this case involved a severe tropical storm, and a record-breaking one at that, is not enough to infer an actual emergency. *See id.* at 1378 (rejecting this court’s “decision to extend the doctrine of necessity to automatically absolve the [g]overnment’s action in any case involving fire control”). Where, as here, the government is responsible for creating the emergency, granting the government immunity from liability under the necessity doctrine would “stretch[] the doctrine too far.” *Id.* Further, the term “emergency,” according to both common usage and definition, refers to “a state of things *unexpectedly arising*.” *Emergency*, *Oxford English Dictionary*, <https://www.oed.com/view/Entry/61130?redirectedFrom=emergency#eid> (last visited Dec. 17, 2019) (emphasis added). The invasion alleged here was by no means unexpected—the Corps knew that when a severe storm like Harvey came, flooding beyond the extent of government-

owned land upstream would result, in light of the design of the dams and the plans for their operation. Thus, the necessity defense cannot apply here, because it cannot be said that “necessity” existed in this case, when the flooding that occurred was the direct result of calculated planning.

CONCLUSION

For the reasons stated, the court finds that the government’s actions relating to the Addicks and Barker Dams and the attendant flooding of plaintiffs’ properties constituted a taking of a flowage easement under the Fifth Amendment. Thus, the court finds defendant liable.²⁶

Because liability and damages were previously bifurcated, a plan for addressing damages must now be put in place. The court proposes to adjudicate damages for five out of the thirteen test properties. To that end, the parties shall each propose three properties for consideration as to damages, thus providing to the court with a total of six candidates. The court will then select five test properties from the six properties proposed. Each party is requested to file with the court a notice detailing its three proposed test properties for damages and its respective arguments for selection of those properties as bellwethers by January 21, 2020.

It is so **ORDERED**.

s/ Charles F. Lettow

Charles F. Lettow
Senior Judge

²⁶The court had previously deferred resolution of the government’s earlier motion to dismiss, *see In re Upstream Addicks & Barker*, 138 Fed. Cl. at 672 (acting pursuant to RCFC 12(i), taking into account the fact-intensive inquiry involved). In light of the detailed post-trial findings of fact and conclusions of law in this decision, that motion to dismiss is DENIED.

Further, pursuant to the court’s previously stated reasons, *see supra*, at 8 n.9, Pls.’ Mot. to Reopen the Trial R., ECF No. 245, is GRANTED, subject to the inclusion of the sworn statement included in Def.’s Opp’n to Mot. to Reopen the Trial R., ECF No. 254. Also pending before the court is Def.’s Mot. to Correct [the Trial] Transcript, ECF No. 241. This motion is GRANTED as to those requests not opposed by plaintiffs, *see* Pls.’ Opp’n to Def.’s Mot. to Correct [the Trial] Transcript, ECF No. 243, but the requests for correction opposed by plaintiffs are DENIED.