



HAYES & ASSOCIATES, INC.

Injury Biomechanics and Accident Reconstruction

September 12, 2003

Mr. Craig Hum
Los Angeles County District Attorney's Office
Torrance Branch
825 Maple Ave
Torrance, CA 90012

Re: *Palos-Verdes Fall Investigation*

Dear Mr. Hum:

At your request, I am writing this summary of my opinions in the above-referenced matter. My opinions are based on a high degree of engineering and medical certainty (and thus beyond a reasonable doubt) and founded on my professional education and on my academic and consulting experience in the fields of fall dynamics, injury biomechanics, anatomy and orthopaedics. I reserve the right to amend or supplement these opinions should additional information become available.

Qualifications

I am currently employed as Professor of Exercise and Sports Science and Adjunct Professor of Mechanical Engineering at Oregon State University in Corvallis, Oregon. I have a joint appointment as Adjunct Professor of Orthopaedics and Rehabilitation at Oregon Health & Science University in Portland, Oregon. I am also President of Hayes & Associates, Inc., 301 SW 4th Street, Suite 160 Corvallis, OR, 97333, an expert witness and consulting firm that specializes in injury biomechanics and accident reconstruction.

I graduated with a B.S. in Mechanical Engineering in 1964 and then an M.S. in Mechanical Engineering (Design) in 1966 from Stanford University. As an undergraduate and graduate student at Stanford University I took courses in engineering mechanics, dynamics and kinematics and thus I am familiar with the fundamental engineering principles that are used in the reconstruction and simulation of human falls and their associated injuries. I received a Ph.D. in Theoretical and Applied Mechanics (Biomedical Engineering) in 1970 from Northwestern University, where my course of study involved both medical and engineering courses, the latter again including advanced training in engineering dynamics and kinematics, and the former in anatomy, physiology and biomechanics. I then completed two post-doctoral fellowships, the first at the Laboratory for Experimental Surgery in Davos, Switzerland in 1970, and the second at the Department of Orthopaedics at the Karolinska Institute in Stockholm, Sweden in 1971.

From 1971 to 1976, I was Assistant Professor of Mechanical Engineering and Surgery (Orthopaedics) at Stanford University. From 1976 to 1979, I was Associate Professor of Orthopaedics and Bioengineering at the University of Pennsylvania. In 1979, I was named Director of the Orthopaedic

301 SW 4TH STREET SUITE 160 CORVALLIS, OR 97333

541-754-9645 • FAX 541-754-9949

WEB WWW.HAYESASSOC.COM • EMAIL WCH@HAYESASSOC.COM

Biomechanics Laboratory at Boston's Beth Israel Hospital and Associate Professor of Orthopaedic Surgery at Harvard Medical School and at the Harvard-MIT Division of Health Sciences and Technology. I was named Full Professor in 1985 and then the first recipient of the Maurice E. Mueller Professorship of Biomechanics at Harvard Medical School in 1988, a position I held until 1998, when I joined the faculties at Oregon State University and Oregon Health & Science University. I served as Vice Provost for Research at Oregon State from May 1998 through June 2001, when I resigned that administrative position in order to focus more fully on Hayes & Associates, Inc.

I have more than 30 years of teaching, research and consulting experience in fields ranging across mechanical engineering, experimental mechanics, accident reconstruction, occupant dynamics, injury biomechanics, human functional anatomy, and clinical orthopaedics. I have taught undergraduate, graduate, and post-graduate students in both engineering and medical school settings. I have lectured on the subject of injury biomechanics in a wide variety of post-graduate courses for engineers, medical students and residents, clinical orthopaedists, forensic scientists and accident reconstructionists. At Stanford, I taught courses in engineering mechanics, experimental mechanics and biomechanics. From 1985 to 1998 I was one of the three Course Directors of Human Functional Anatomy at Harvard Medical School.

I have served as Principal or Co-Principal Investigator on over 65 research grants from federal, foundation or industrial sources, all of them involving the biomechanics of the musculoskeletal system. Most of these grants have directly involved injury biomechanics. I have been funded continuously since 1990 by the National Institutes of Health for a research program entitled Fall Biomechanics and Hip Fracture Risk. This research has produced validated mathematical models for the dynamics of human falls and their associated injuries. Our research results have appeared in the peer-reviewed literature and are widely cited by scientists and experts in the field. I have authored or co-authored more than 185 peer-reviewed publications, over 60 chapters, and two books. I was the founding editor of the Journal of Orthopaedic Research and served as its Co-Editor-in-Chief from 1983 to 1995. The Journal is now the preeminent research journal in orthopaedics.

A true and correct copy of my *curriculum vitae* is attached as Exhibit 1.

Overview/Case Summary

I reviewed the following materials in connection with my work in the case: Los Angeles Sheriff's Department (LASD) Incident Report dated 11/8/00; LASD Supplemental Report, dated 12/5/00; Various LASD Lab Reports; Autopsy Report for victim Lauren Key-Marer, prepared by LA County Coroner's Office, dated 11/9/00; 14 color copies of autopsy photos of victim Lauren Key-Marer; Miscellaneous information about the incident location in Rancho Palos Verdes, CA; Color copies (numbered 1-13) of scene photos taken by the LASD on 11/10/00; Color copies (numbered 1-81) of scene photos and aerials taken by the LASD on 11/10/00; Color copies (numbered 81-122) of photos/perspective shots taken by the LASD on 11/16/00; Aerial survey data from the LA County Department of Public Works; Section Contours based on the aerial survey data.

The police report authored by Deputy Brothers of the Los Angeles County Sheriff's Department provides a summary of the events of November 8, 2000. The police responded to Palos Verdes Drive South/Cherry Hill Lane re: child over cliff. When they arrived, they saw a white male adult (later identified as Cameron Brown) standing next to a covered patio with several picnic tables. They saw a white female child (later identified as Lauren Key-Marer) lying on the picnic table located in the southeast portion of

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541-754-9645 • FAX 541-754-9949

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the patio. Mr. Brown told Deputy Brothers that he and his daughter went to Abalone Cove at 1400 hrs to do some hiking. He and his daughter left the playground area and started hiking east, upward to the cliff adjacent to Abalone Cove (Inspiration Point). During the approximately 15 minute hike, Brown indicated he had to warn his daughter two or three times to stay away from the edge of the cliff. When they reached the top of the cliff, his daughter started throwing rocks off the cliff. The next thing he knew, his daughter was gone. He did not think he saw her go over the cliff, but he knew that she did. He ran back up the cliff and down to the other side to where he thought his daughter had landed. He found her lying in the water below the cliff. Brown indicated that he stripped down to his underwear and went into the water to retrieve his daughter. He took the wet underwear off and put his clothes on and carried his daughter to the picnic tables near the archery range. Before doing so, he attempted CPR after he removed his daughter from the water. Mr. Brown walked along the rocky coastline with Sgt. Erickson and pointed out the area on the cliff where she fell from and where he retrieved her body.

From the anatomic findings and pertinent history, Dr. Chinwah's autopsy report of November 9, 2000, ascribed Lauren's death to multiple injuries and blunt force trauma. His anatomical summary was: 1) Abrasion, contusion, laceration - forehead/face; 2) Abrasion-chest, abdomen, extremities; 3) Massive skull fracture; 4) Intracranial hemorrhage; 5) Atlanto-occipital subluxation; 6) Fracture/subluxation - right wrist; 7) Contusion - lungs, liver; 8) Hemothorax, right; and 9) Laceration, spleen. He indicated that the body weighed 44 lbs with a crown to heel length of 109 cm (42.9 in). There was extensive abrasion/contusion of the forehead involving an area about 3-1/4 inch in diameter. There were multiple irregular lacerations on the forehead, some oriented horizontally, others diagonally. Three of the larger lacerations were gaping. Underlying irregular skull fractures were evident. Palpation of the left facial bone revealed fractures of the maxillary bone. In Dr. Chinwah's opinion the cause of death in this 4-year female was multiple blunt force traumatic injuries including massive skull fracture consistent with drop from a height. In his view, the autopsy findings were consistent with an assisted drop and not consistent with an accidental fall from the reported site of the incident. This opinion was supported by a site visit with their pediatric consultant, the coroner's investigation team, law enforcement officers and the Chief Medical Examiner-Coroner, wherein it was observed that the terrain was rugged and it was not likely that a 4-year old female would voluntarily hike there without experiencing fatigue. Further, given the circumstances, child endangerment was a consideration. Therefore, the manner of death was classified as a homicide.

A radiology consultation dated November 27, 2000, by Dr. Boger, revealed massive head trauma and fractures of the right wrist. From a limited radiographic survey of the skull, chest and right forearm, Dr. Boger indicated there was an elongated comminuted acute skull fracture involving the right and left sides of the head. There were also acute fractures of the distal radius and ulna. No old fractures or other evidence of old trauma were seen. Dr. Boger's Impression was: 1) No radiographic evidence of old skeletal trauma; 2) Acute skull fracture; and 3) Acute fractures of the distal right radius and ulna. A neuropathology report by Dr. Itabashi dated December 7, 2000, indicated that the gross impression was that of acute cerebral trauma, fall from estimated 250+ height on November 8, 2000. Skull fracture, massive, horizontal linear across frontal bone, extending into temporoparietal region on the right and across orbital frontal plates and left floor of temporal fossa into basioccipital bone. Horizontal cortical laceration across bifrontal poles, extending across left temporal lobe. Acute subarachnoid hemorrhage, very small amount, at sites noted above. Generalized brain swelling, moderate. Composite findings were

301 SW 4TH STREET SUITE 160 CORVALLIS, OR 97333

541-754-9645 • FAX 541-754-9949

WEB WWW.HAYESASSOC.COM • EMAIL WCH@HAYESASSOC.COM

consistent with a fall with impact on the forehead with skull fracture and fracture cortical laceration. No old pathology was found.

To familiarize myself with the location of this incident, I conducted a site inspection of Inspiration Point on October 7, 2002. Also in attendance were Craig Hum, LA County District Attorney's Office; Yvonne Smith, LA County District Attorney's Office; Danny Smith, LA County Sheriff's Department; Jeffrey Leslie, LA County Sheriff's Department. A photographic record was made of the parking lot, the playground area, the trails to Inspiration Point, the Point itself, (both from above and below the cliff face), the archery range, and the picnic tables where Lauren was first observed by the police. Digital video was also obtained from selected areas. Digital files have been archived and are provided on a CD attached to this report as Exhibit 2. Seen from a vantage point on one of the two rocky promontories that define the small inlet where Cameron Brown reported that he found his daughter (Fig. 1a), the cliff face projects upwards approximately 125 feet above water level to a point of departure that is hidden by the rocky outcropping to the right of the figure. The rocky inlet to the lower left is the region where Cameron Brown described finding his daughter. The inlet can also be seen from above from a vantage point at the approximate level of the point of departure.



Figure 1a) The cliff face viewed from below; 1b) The inlet where Lauren was reported to have been found

Analysis/Opinions

301 SW 4TH STREET SUITE 160 CORVALLIS, OR 97333
541-754-9645 • FAX 541-754-9949

WEB WWW.HAYESASSOC.COM • EMAIL WCM@HAYESASSOC.COM

The question you have asked me to address, to a high degree of engineering and medical certainty (and thus beyond a reasonable doubt), is whether on November 9, 2000, Lauren Key-Marer fell unintentionally to her death from Inspiration Point, or instead was pushed or thrown from the top of the cliff by her father, Cameron Brown.

To address this question, we based our analysis on the fact that Lauren's injuries serve as a "signature" to the events that produced them. From a careful review of the autopsy report and post-mortem photographs, we determined that Lauren's massive, traumatic injuries were consistent with a single, high velocity impact to the cliff face. Her injuries could not be explained from her sliding and tumbling down the cliff face or with multiple impacts to the cliff face before landing in the water of the inlet. Grounded in those conclusions, our approach to determining the mechanism of Lauren's fall was first to characterize in three dimensions the cliff surface from the point of departure (from which Mr. Brown said Lauren had fallen) to the rocky inlet where he said she was found. These cliff face surface contours were generated through an aerial survey requested by the LA County District Attorney's Office as commissioned by LA County Public Works. Once the cliff contours were known, the physics of projectile motion was used to determine whether Lauren could have slipped or tripped and fallen unintentionally (as reported by her father) and received the injuries that she did, or, instead was forcefully projected from the point of departure in order to impact the cliff face only once and then land in the inlet below.

Methods. An aerial survey of the cliff face was commissioned by the LA Department of Public Works and conducted by Psomas, Inc., a Civil Engineering consulting firm. The ground survey control for the aerial mapping was established by Psomas using a combination of GPS Control and Ground Survey Methods. Due to the tight site constraints, four aerial targets were established on top of the bluff, with measurements tied between these points and the GPS Control. These measurements were within accuracies of 0.03 feet horizontally and vertically. Additionally, several points were rayed out, utilizing reflectorless technology (i.e. the instrument uses a measurement mode which does not require a reflector on the point being measured), onto rock outcrops in the ocean and top of the bluff. These points provided a much wider base to supplement the primary photo control. The aerial photography for Inspiration Point was secured on January 31, 2003. Two stereo models were used to do the aerial mapping. One model was flown in the north/south direction and the other was flown over the Point in an east/west direction. A second flight was secured on February 17, 2003 after Psomas determined the east/west model perspective was insufficient for mapping the steep face of the Point. The new east/west model was flown with the photo centers placed farther south of the Point, which allowed for a better camera perspective on the steep face of the cliff. The camera used was a Wild RC30 equipped with forward motion compensation. The photo scale was 1:2000, which is approximately 1"=166'. The airplane was approximately 1000 feet above the ground. Psomas' International Systemap DIAP (Digital Image Analytical Plotter) softcopy photogrammetric workstations were used for the aerial mapping. The aerial film was scanned on a precision photogrammetric scanner at 9 microns resulting in a pixel ground resolution of .06'. The images were imported into the softcopy photogrammetric workstations and the stereo models were set based on 4 aerial targets. Additional field data such as high points on rocks, and tops of slopes were used for additional vertical control and verification of the integrity of the

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photogrammetric data. The expected horizontal accuracy of this mapping is approximately 0.17' and approximately 0.28' vertically.

Based on the aerial survey, and on police photographs and discussions with Detectives Leslie and Smith, the point of departure was identified and marked on aerial photos of Inspiration Point. The survey data were provided by Los Angeles County Public Works – Survey Division in AutoCAD DXF format (AutoCAD, San Rafael, CA 94903, Autodesk, Inc.). Using 3ds max (3ds max 5.0, Montréal, Québec H3C 2L7, Discreet, 2003) the survey data were then oriented to the aerial scene photos to determine the point of departure (Fig. 2). The AutoCAD file was opened in 3ds max over a background photo showing the aerial photo of Inspiration Point. The survey data were then rotated and scaled to the background photo by visually matching the contours on the aerial photo with the survey contours. The L.A. County Public Works Department then provided nine profiles of the cliff face radiating from the point of departure (Fig. 3). Only five of these profiles (B-F) were consistent with trajectories that originated at the point of departure and ended with landing in the inlet. These five contours were used in our analysis.

The basic physics of projectile motion were used to analyze the trajectory that Lauren's body would have followed had she either slipped (or tripped) and fallen or been launched from the point of departure. While the human body is a complex system of multiple segments (head, neck, thorax, extremities, etc.) connected by joints, fundamental physics tells us that despite this complexity, the center of gravity (the point where the mass of the body can be assumed to be concentrated) follows the same, perfectly parabolic trajectory as would a single particle moving in a gravitational field. Observe, for instance, that a tennis ball thrown upward and outward at any throw angle and initial velocity, always follows a parabolic arc. This same parabolic trajectory has been repeatedly demonstrated in studies of competitive divers and gymnasts who launch themselves into the air at varying speeds and angles. The motion of their center of gravity is always observed to conform exactly to the parabolic motion predicted by the physics of projectile motion.

The analysis of Lauren's potential trajectories from the point of departure thus reduced to a simple implementation of the equations of projectile motion. The free-flight motion of a projectile is usually studied in the x (horizontal) and y (vertical) axes, since the projectile's acceleration *always* acts only in the vertical direction. To illustrate these concepts, if we consider a projectile launched from a point (x_0, y_0) , the path is defined in x-y plane such that the initial velocity is v_0 . When air resistance is neglected, the only force acting on the projectile is its weight, which causes it to have a *constant downward acceleration* of $g = 32.2 \text{ ft/s}^2$. If we assume the projectile is launched at an initial angle, θ_0 , the equations of motion in the x and y direction are given by

$$x = x_0 + (v_0 \cos \theta_0) t \quad (1)$$

$$y = y_0 + (v_0 \sin \theta_0) t - \frac{1}{2} g t^2 \quad (2)$$

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where (x,y) is the position of the center of gravity as a function of time, (x_0, y_0) is the initial position of the point of departure, v_0 is the initial launch velocity, and α_0 is the initial launch angle. Plotting x and y for increasing values of time (t) can then be used to show the position of the center of gravity as it descends from the point of departure.

Predicting Lauren's trajectory then reduces to inputting reasonable assumptions for the initial velocity and launch angle into equations (1) and (2), and plotting the predicted trajectories superimposed on the contours of the cliff face. For this purpose, we considered a conservative representation of Cameron Brown's story that his daughter was throwing rocks and essentially followed the rocks off the cliff. Putting aside the fact that throwing a rock actually would have pushed Lauren's body back away from the cliff edge (for every action, there is an equal and opposite reaction), we represented this scenario by assuming that she simply fell horizontally from the point of departure moving off the cliff at a speed based on the average walking speed of 4.6 ft/s for 5-year old females (Eubanks and Hill, 1999). Note that this is a highly conservative assumption and would tend to have her projected even further than would be expected had she either simply slipped or tripped and gone over the edge feet or head first, respectively.

To determine the "initial velocity" (v_0) for one of the launch scenarios, we conducted an experiment in which a reasonably fit, 28-year old adult male (5'7"; 160 lbs) subject threw a 40 lb weight (comparable to Lauren's weight at the time of her death of 44 lbs) as far and as fast as possible. Multiple video trials indicated that a reasonable estimate of the maximum speed at which a child of Lauren's weight could be launched from the point of departure was 15 ft/s. To reflect the trajectories for an intermediate launch velocity, we also examined a launch velocity of 10 ft/s. Based on the pilot experiment and on preliminary analyses of the projectile motion, a launch angle of 22.5 degrees was used so as to maximize the throw distance.

301 SW 4TH STREET SUITE 160 CORVALLIS, OR 97333

541-754-9645 • FAX 541-754-9949

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Figure 2. Survey data placed over aerial scene photo to orient known point of departure with survey data.

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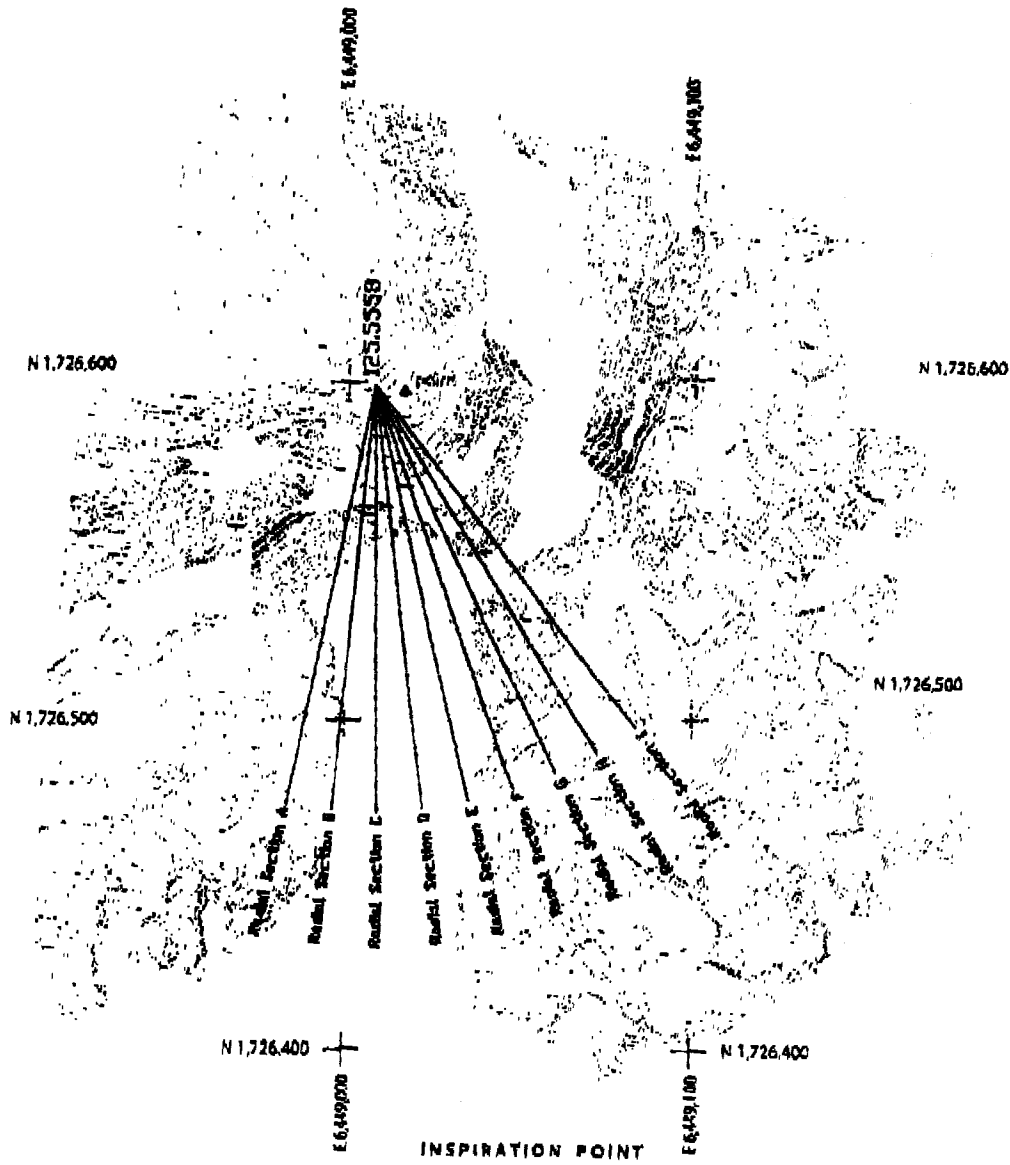


Figure 3. Cliff profiles radiating from the point of departure.

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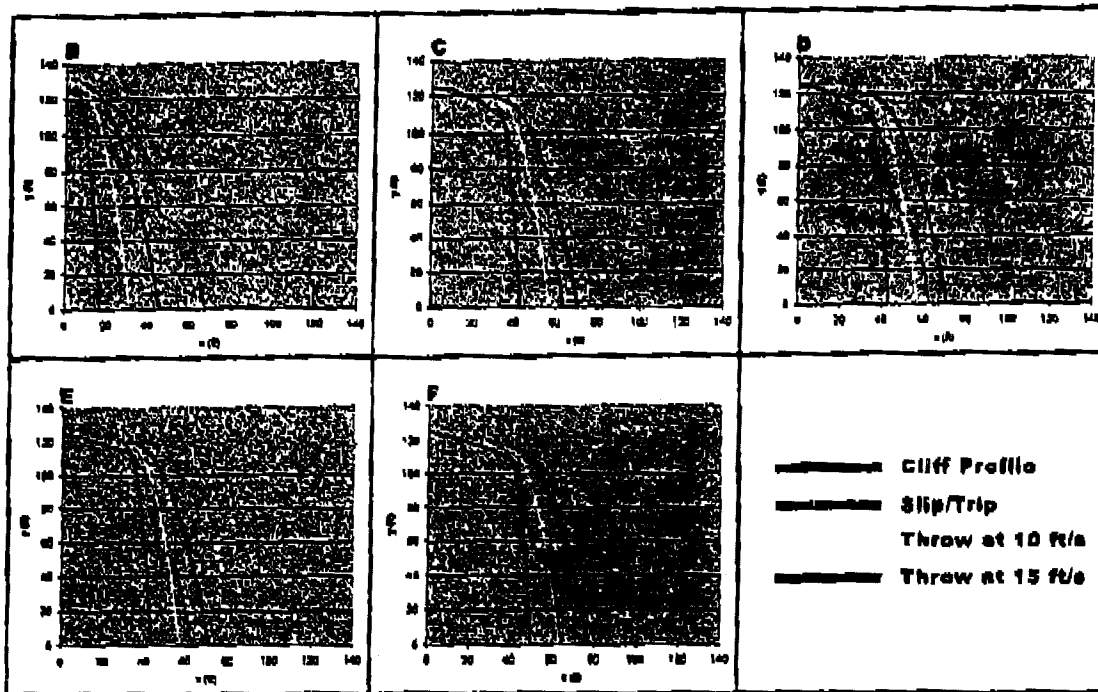


Figure 4. Cliff profiles B-F

Results. The question you have asked me to address is whether Lauren Key-Marer fell unintentionally to her death from Inspiration Point or instead had to have been pushed or thrown from the point of departure. To address this question, we calculated fall trajectories, predicted on the basis of the fundamental physics of projectile motion, for cases in which she slipped and/or tripped and fell with those in which she was forcefully launched (Fig. 4). In each panel of the figure, the cliff profile (for the sections shown in Fig. 3) is shown in black. The point of departure is at approximately the 120 ft mark while the water line is at $y=0$ ft. The green trajectories in each panel show the parabolic trajectory that would be predicted if Lauren had slipped or tripped with an initial, horizontal velocity of normal walking speed, and fallen unobstructed to the water below. The point at which the trajectory intersects the cliff face is the point at which Lauren would have impacted the cliff for that particular set of initial conditions. As demonstrated in Fig. 4, for each possible direction that Lauren could have slipped or tripped and fallen from the point of departure, she would have impacted the cliff face within just a few feet of the point of departure and thereafter would have either not fallen further (contour B) or slid and tumbled and suffered multiple impacts before landing in the water of the inlet below (contours C-F). Since the autopsy results indicate conclusively that she suffered a single massive impact to the cliff face, the possibility that Lauren slipped or tripped from the point of departure can immediately be rejected. We can therefore conclude that Lauren did not slip or trip from the point of departure on November 9, 2000, as described by her father.

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However, if Lauren was instead launched upward and outward from the point of departure at velocities consistent with a near maximal effort by a fit, adult male, our analyses predict that she could have either impacted the cliff face multiple times (contour B), or, depending on initial launch velocity, impacted the cliff face only once, or not at all (contours C through F). In these panels of Fig. 4, for example, an initial launch velocity of 10 ft/s would in each instance result in a single massive impact at heights above the water of from 40 to 55 ft., with rebound off the cliff and landing in the water of the inlet below. At the highest initial launch velocity (consistent with a maximal effort of a fit adult male), it would have been possible to launch Lauren with sufficient velocity to miss the cliff face entirely (the red trajectories in contours C-F). Moreover, the trajectories associated with the intermediate initial launch velocity are consistent with a single massive impact to the head and outstretched arm if we assume that Lauren (initially in an approximately vertical orientation, with her feet down) was projected outward and upward by a force applied just slightly above her center of gravity. Under these conditions, and given the predicted fall distance, there would be sufficient time for her to rotate from a feet down to a head down orientation at impact with the cliff. We can conclude therefore, that a launch velocity of 10 ft/s (an effort well within the capability of a reasonably fit, adult male), when applied just above the center of gravity with Lauren in an initially vertical orientation (as if after having been picked up), would explain not only her fall trajectory (including the single impact, rebound and landing in the inlet below), but also the massive injuries to her head and arm as she impacted the cliff in a vertical orientation in a head down, face inward orientation with her hand outstretched. Thus, our analyses lead to the inescapable conclusion that Lauren sustained the massive injuries to her head and wrist that resulted in her death as a consequence of having been launched from the point of departure at an initial velocity consistent with an effort well within the capabilities of an adult male.

Discussion. Our analysis of this incident is grounded in the conclusion that Lauren Key-Marer died as a consequence of a single traumatic impact with the cliff face at Inspiration Point. The autopsy findings, including the post-mortem photographs, provide conclusive support for this. The report indicates that she sustained a massive skull fracture, with intracranial hemorrhage and atlanto-occipital subluxation, along with a fracture subluxation of the right wrist. Photographs document the extensive gaping lacerations of the forehead and abrasions/contusions to the upper thorax. Lacerations and contusions elsewhere on the body are notably absent, with the very few that are shown on the thorax consistent with a single impact force concentrated entirely on the head and upper chest and only glancing scrapes to any other part of the body. Notably, there are no lacerations or abrasions on the back, a finding in keeping with a head down, face inward impact with the cliff. While these findings are completely consistent with a single, head down, face inward impact with the cliff, they are at the same time completely inconsistent with a fall that involved sliding, tumbling and multiple impacts with the cliff face.

Knowing that Lauren hit the cliff face only once we used the laws of projectile motion to establish first that a slip or trip from the point of departure (even if one assumes that Lauren slipped or tripped while walking off the cliff), would result in fall trajectories that would have produced impact within a few feet of the point of departure. This would have resulted in a slipping, tumbling fall, with multiple impacts and abrasions, lacerations and contusions to multiple body regions. Such injuries did not occur and therefore, on the basis of the autopsy results and fundamental physics, we can reject Cameron Brown's assertion that his daughter slipped or fell from the point of departure.

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541-754-9645 • FAX 541-754-9949

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We are then left with the question of how Lauren *did* sustain her fatal injuries. If she did not slip or fall, is there a mechanism by which she could have sustained these massive injuries, and, if so, is the explanation a plausible one, i.e. in keeping with the facts of the case, and the fundamental laws of physics? Turning once again to the laws of projectile motion and the injuries that Lauren actually sustained, we find that if she was thrown upward and outward at a launch velocity of about 10 ft/s (an effort well within the capabilities of a fit adult male) Lauren would not only have sustained a single impact to the cliff face about 70 feet down from the point of departure, but would have done so in a head down, face inward orientation that would not only explain the massive injuries to her head, neck and chest, but would also be completely consistent with both the lack of abrasions, contusions and lacerations elsewhere on her body *and* with her rebounding and landing in the inlet below. Moreover, at the point of impact with the cliff, Lauren would have been traveling at approximately 67 ft/s (45 mph), a velocity that is also consistent with the severe head and neck injuries she sustained. If Lauren had been launched at an initial velocity of 5 ft/s, the results would not have differed from the slip or trip and fall scenario. If she had been launched at an initial velocity of 15 ft/s (consistent with the maximal effort by an adult male), she could have missed the cliff face entirely.

I therefore conclude that to comport with the facts of the case, the fatal injuries that Lauren sustained, and the fundamental laws of physics, Lauren had to have been thrown outward and upward from the point of departure at an angle of about 22.5 degrees from the horizontal, starting in an initial vertical (feet down) orientation, with the force applied slightly above the center of gravity of her body (armpits) at a velocity of about 10 ft/s. Such a scenario is consistent with picking up a child with one hand under the buttocks and one hand on the low back and launching her outward using the dominant hand. We found experimentally that a reasonably fit adult male could quite easily apply sufficient force to a 40 lb object to achieve these launch velocities. In fact, it is only necessary to project a 40 lb mass about 2.3 ft on level ground, in order to achieve the fall trajectories shown in Fig. 4.

Opinions. Based on my review and analysis of this case, and on my academic and consulting experience in fall dynamics and injury biomechanics, I conclude, to a high degree of engineering and medical certainty, and thus beyond a reasonable doubt:

- 1) Lauren Key-Marer died as a direct consequence of a single, high speed impact to the cliff face at Inspiration Point; the impact produced massive head, neck and brain injuries, abrasions and contusions to the head and chest, and lacerations that were confined almost exclusively to the head and upper chest;
- 2) These injuries are inconsistent with a slip and/or trip and fall from the point of departure since such a scenario would have produced signs of multiple impacts over multiple body regions consistent with sliding, tumbling and multiple impacts with the cliff face;
- 3) Lauren's fatal injuries were, however, consistent with her having been thrown from the point of departure at an angle of about 22.5 degrees from the horizontal at an initial velocity of about 10 ft/s in an initial orientation with her feet down and the force applied slightly above her center of gravity. Based on the fundamental physical laws of projectile motion, such a scenario would have produced not only the single impact with the cliff face but one in which

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the impact occurred in a head-down, face inward configuration and was of sufficient severity to produce the fatal head and neck injuries that she in fact suffered;

- 4) The fall trajectory that would produce such an impact is well within the physical capabilities of a reasonably fit adult male and can be produced by picking up the child, supporting her under the buttocks and pushing forcefully at a point slightly above the waist and in an outward and slightly upward direction;
- 5) Since Lauren *could not* have slipped or tripped and fallen as described by her father, but *could* have sustained her fatal injuries by being pushed forcefully from the point of departure and based on the facts of the case and on the police and autopsy reports, I conclude that Cameron Brown threw his 4-year old daughter, Lauren, off the cliff at Inspiration Point on November 9, 2000.

Please note that I reserve the right to amend or supplement this report should additional information become available. Please let me know if I can provide any further information. If you have any questions, please feel free to contact me.

Respectfully Submitted,

Wilson C. Hayes, Ph.D.
Hayes & Associates, Inc.

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WEB WWW.HAYESASSOC.COM • EMAIL WCH@HAYESASSOC.COM

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